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Tesis de Master:

Core-reduction strategies in chert procurement areas during MSA in Eastern Morocco: Sahb El Ghar 1 & 2.1 open air sites

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ABSTRACT

The Sahb El Ghar (SBG) open air sites are located 15 km from Aïn Beni Mathar village in Eastern Morocco. The sites were discovered in 2017 and since then a surface of $9m^2$ and $7m^2$ have been excavated at two localities (SBG 1 & SBG 2). The sites are situated in a slope exposed surface of a riverbank, which is also a primary chert procurement area. One archeological level was recorded in SBG 1 and three in SBG 2. A total of 6.164 lithics were collected between both localities, mainly in chert (Neogeone chalcedony > 98%). This preliminary technological work is based on the study of the core-reduction strategies of the 101 cores identified: 60 in SBG 1 and 41 in SBG 2 (level 1= 23, level 2= 6 cores, level 3= 12). The first part of the analysis is focused on the taphonomical attributes that provide us information about the formation and the post-depositional processes affecting these assemblages. Secondly, the detailed technological analysis of the cores has been performed following the *chaine opératoire* approach. The first results show similar core reductions strategies, specially between SBG 1 and SBG 2 level 1. The main core-reduction strategies used are the bifacial bipolar centripetal ones, associated to discoidal and Levallois knapping methods. The Levallois modalities are mainly recurrent centripetal and preferential flake production. Opportunistic knapping strategies (unipolar longitudinal and/or orthogonal with only two or three removals) as well as laminar strategies have been also documented. This work presents the first technological results of SBG 1 & 2 open-air sites and provides new data about the MSA technological behaviors of the region. Lastly, a comparison with the MSA technology of other synchronic MSA sites in caves and rock-shelters from the same region (Eastern Morocco) and the rest of Morocco have been done.

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1. INTRODUCTION

The Middle Stone Age (MSA) in the Maghreb is one of the main research topics in the Prehistory of the region. The MSA begins around the MIS 8 (315 Ka) in Africa until the end of MIS 3 around 57-20 Ka (Scerri & Spinapolice, 2019). One of the main features of the Middle Stone Age is the core prepared technique or complex knapping strategies (Levallois strategy), in which core shaped out in a predetermined by a special preparation of the core attempting to manufacture flake of predetermined size and shape, this technique probably raised the level of standardization and predictability in human behavior (Scerri, 2014). In North of Africa the mean features for the Early Middle Stone Age the discovery of the oldest dating fossils until now of our species, *Homo sapiens*, in Jebel Irhoud in Morocco, as well as early examples of complex culture and long-distance transfer of raw materials (Hublin et al., 2017; Richter et al., 2017). In the Maghreb region, the abundance and well-studied sites concerning this period present in Morocco characterize by the abundance of sites with lithic industries separated in two technocomplex, Aterian and Mousterian (Dibble et al., 2013).

1.1 Research history

The archaeological research in North Africa started in the mid-nineteenth century in Algeria and Tunisia, while the surveys in Morocco started in the beginning of the twenty century (Moser and Nami, 2003). During this period the excavation was focusing on the collection of artifacts and classified according to the European chrono-cultural Middle Paleolithic (Mousterian) to compare the different lithics assemblages in a supra-regional scale and links the European and North African Paleolithic artifacts (Holl, 2005 ; Hawkins, 2001). At the same time the anglophone researchers in South Africa they use a different classification for the South African paleolithic assemblages, establishing a new terminology in 1929 by Goodwin and Van Riet divided in three subunits: Early, Middle and Later Stone Age (Menghin, 1933; Ruhlmann, 1936).

1.2 Terminology

There is a diversity in the nomenclature due to geopolitical and research history, these nomenclatures caused a confusion and misunderstanding in the research. The francophones (French scholars) prefer to classify the North African assemblages as a Mousterian or Middle Paleolithic while the anglophone using the term of Middle Stone age or Mode 3 in south Africa, this issue has been affected the geographical area of research to understand the lithic assemblage of the continent. Today a big part of the researchers prefers to use the Middle Stone Age term to facilitate the understanding and the interpretation of all the African Paleolithic industries (Dibble et al., 2013; Garcea, 2004; Linstädter, 2003).
In this thesis we use the term of Middle Stone Age in a general way to describe the lithic assemblages from Sahb el Ghar 1 & 2, but we also use the traditional terms of Aterian (to refer

to the assemblages characterized by the laminar cores and tanged tools) and Mousterian (to refer to the typical assemblages characterize by the presence of Levallois and discoidal strategies) in order to contextualize our results in the frame of this chronocultural period in the region.

1.3 Geography

The Middle Stone Age lithic industries exist in a large geographic area bordered (fig 1.1) in the North by the Mediterranean coast, in the south by the Sahel, in west by the Atlantic coast and the Nile valley in the east (Debénath et al., 1986; Hendrickx et al., 1992).

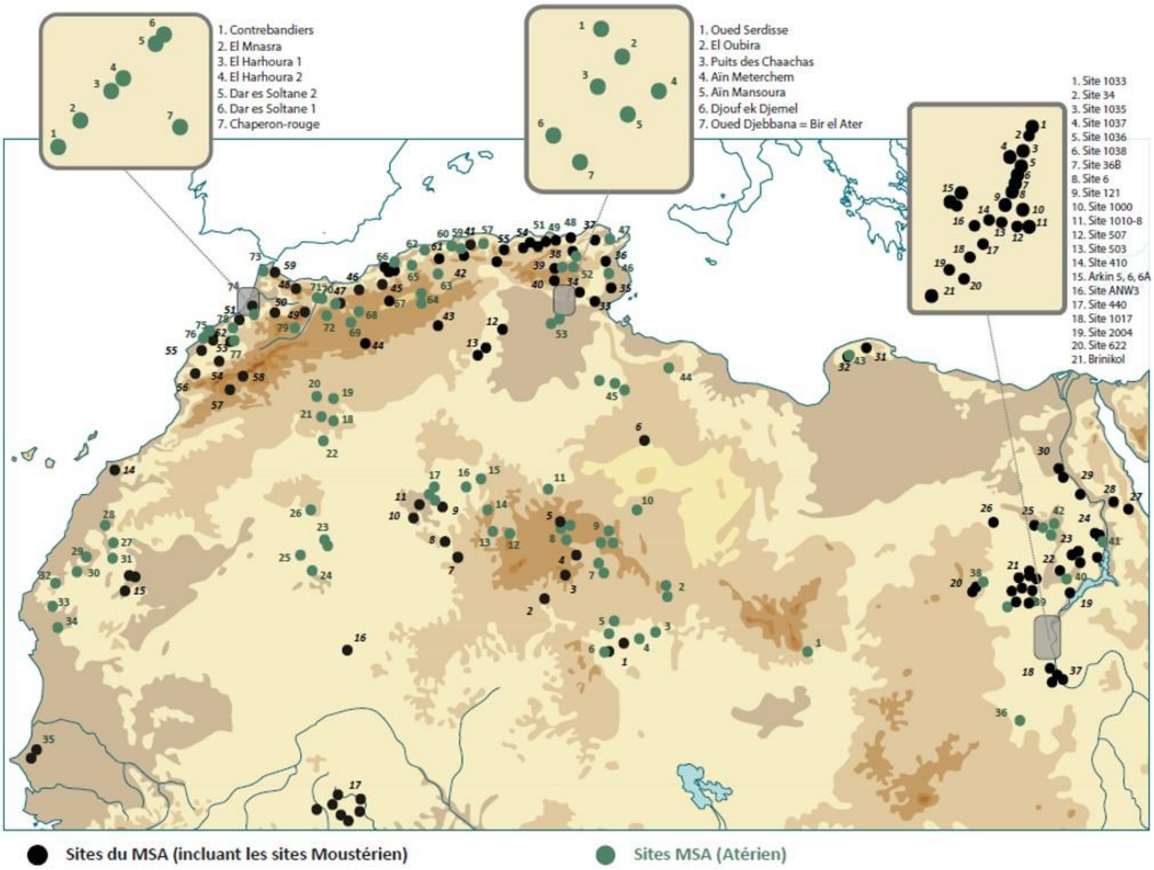

Figure 1.1 Geographical distribution of MSA sites (Mousterian, Aterian) known in North Africa (Aumassip, 2004 modified by Benarous, 2019)

1. Bougourou 2. Adrar Bous 3. Tadrart 4. Anaï 5. Tw1 6. Sha 7. Site Dédé 8. Esselessikine 9. Tiguelguemine 10. Gara Chorfa site 13 11. Oued Djaret 12. Touggourt-Km 50 13. M'zab 14. Laayoune 15. Adrar 16. Tilemsi T-A 60 17. Mékrou 18. Dongola 19. Abu Simbel 20. Bir Sahara 21. Bir Tarfawi (BT14, E86-1, E86-2, E86-3, E86-4, E87-1, E87-3, E87-4, E88-1) 22. Dungul 23. Kurkur, Arkin 5, Arkin 6 24. Wadi Kubbaniya (E-81-2, E-82-4, E-82-5, E-82-6) 25. Kharga 26. Dakhlat (E72-4) 27. Sodmein Cave 28. Nazlet Safaha 29. Beit Allam 30. Nazlet Khater (NK1, NK2, NK3) 31. Sidi el Hajj Creiem 32. Haua Fteah 33. Oued Akarit 34. El Gue ar 35. Sidi Mansour de Sfax 36. Aïn Mrho a 37. Sidi Zin 38. Aïn Metherchem 39. Feidj el Bo ena 40. El Oudiane 41. Ténès 42. Retaïmia 43. Brézina 44. El haÿ 45. Rhafas 46. Hassi Bellal 47. Taforalt, Ifri N'Ammar 49. Kifan bel Ghomari 50. Oued Khemis 51. Aïn Hallouf 52. Sidi Abderrahman (Cap Chatelier, Gro e du Rhinoceros) 53. Tit Mellil 54. Oued Bouskoura 55. Djebel Irhoud 56. Tissnit 57. Akka 58. Djebel Bani 59. Abri de Benzu

1. Ounianga Kebir 2. Yat, Kolokaya 3. Seggedim 4. Chemedour 5. Adrar Bous IV, V 6. Ekouloulef, Mouezout 7. Iberdjien, Tamakaw Tw2 8. Djanet, Admer, Assako 9. Tin Hanakaten 10. Uan Tabu 11. Tiouririne 12. Meniet 13. Amsir 14. Tadjmout 15. Hassi el Khenig 16. Oued Asriouel 17. Aïn Chebli, Reggan-Taourirt, Sali 18. Anchal 19. Zaouia el Kebira 20. Kheneg et Tlaïa 21. Hassi Ouchtat 22. Hassi el Hameida 23. Taoudeni (MT8, MT30) 24. Foum el Alba 12 25. El Mreyyé 26. Azarza 27. Jbeilat de Tourine 28. Azrag 29. Aderg 30. Tarf H'Mer 31. Arouakim 32. Jraif 33. Tiferchaï 34. Inkebden 35. Tiemassas, Cap Vert 36. Djebel Moya 37. Dongola (N2, N6, N91) 38. Bir Sahara 39. Bir Tarfawi 40. Dungul 41. Kubbanyia (E78-11) 42. Kharga (KO6E, Bulaq Pass, E76-4) 43. Haua Fteah 44. Wadi Gan 45. Oueds Zemzem, Soffegim, Merdum 46. Monas 47. Cap blanc 48. Pointe Noire 49. Demnet el Hassan 50. Kef oum Touiza, Col des chacals, La Patelle, Hammam Sidi Djeballa 51. Chetaïbi 52. Constan ro e des ours, Gro e du mouflon, Djebel Ouach) 53. Touggourt (Tg-km25-I, Tg-km-25-II) 54. Taza, Afou Bou Rhummel, Tamar Hat 55. Ali Bacha 56. Palestro 57. Les Allobroges 58. Aïn Benian 59. Les Falaises Rouges 60. Bérard 61. Sidi Saïd 62. Kouali 63. Koudiat bou Gherara 64. Guertoufa (Vignes Deloche, La pierre à sacrifices) 65. Karouba 66. Bou Aïchem, Polygone, Troglodytes, Franchet d'Esperey) 67. La Mouillah 68. Rhafas 69. Taforalt 71. Kifan bel Ghomari 72. Sefrou 73. Mugharet el Aliya 74. Témara 75. El Zhenzira 76. El Hank 77. Aïn Djemaa 78. Tit Melil 79. Aïn Maarouf

1.4 Lithic variability

The earliest Middle Stone Age lithic assemblages dated come from Jebel Irhoud 315ka and Benzu cave 250ka in the Northwest Africa. The lithics assemblages are dominated by a highly retouched artifacts, consists of Levallois technology with points obtained through retouch (Mousterian points), retouched pieces (scrapers) and denticulates (Hublin et al., 2017; Ramos et al., 2008; Richter et al., 2017) .

In the Northeast, the early industry documented in southwestern of Egypt at Bir Tarfawi and Kharga Oasis with a date of 230ka and in Nubian site of Sai8-B-11 with a date of 220ka (Hawkins, 2012; Peer et al., 2003). The technological characteristics in Kharga Oasis and Bir Tarfawi noted by the presence of Levallois strategies (preferential and recurrent modalities), Nubian points and retouched tools (Gifata point). At Sai8-B-11 site the lithic assemblage characterizes also with bifacial technologies including the Sangoan core axes and later and during the MIS 6 the blade product and Lupemban lanceolate foliates (Van Peer et al., 2003).

From MIS 5 sites increase in frequency. Three technocomplex have been defined in North Africa, beside the Aterian and Mousterian technocomplex, the Nubian complex was added as a third one in the Northeast. Characterize by the Levallois technology including the production of foliates in the early phases and points artifacts in the later phases. In Morocco the Mousterian assemblages have been describe with Levallois and discoidal technology with numerous side and end scrapers but with less number of retouched Mousterian points, denticulates and truncated pieces (Debénath et al., 1986; Peer, 2016). This type of technology is observed in Contrebandiers cave at the Atlantic coast, Taforalt, Rhafas in Eastern Morocco and Benzu Cave in Ceuta. The Aterian assemblages have been distinguish principally with the presence of tanged tools, however, additionally in the northwest Africa other features have been distinguish such as bifacial foliates, laminar technology and side retouched flakes this types have been observed in Ifri N 'Ammar (Fig 1.2), Taforalt in Eastern Morroco and Contrebandiers and el Harhoura in the Atlantic coast and Mugharet el Aliya (Blinkhorn and Grove, 2021; Bouzouggar et al., 2018; Doerschner et al., 2016; Moser and Nami, 2003; Scerri, 2017).

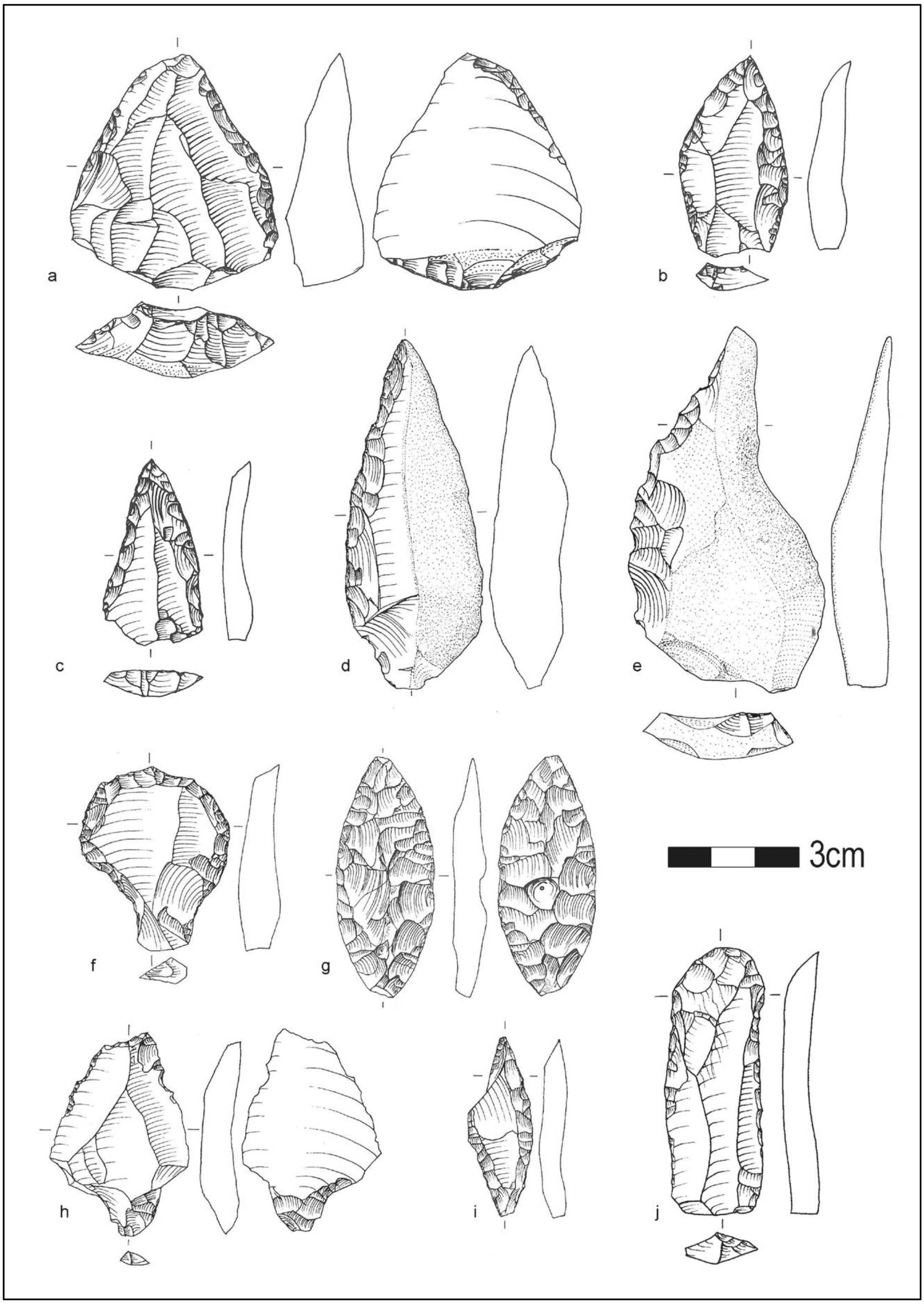

Figure 1.2 Artefacts from Ifri n'Ammar
a: convergent scraper; b: Mousterian point; c: elongated Mousterian point; d: elongated convergent scraper; e: denticulate; f: tanged endscraper; g: bifacial foliate; h: tanged retouched triangular flake; i: 'piercer'; j: endscraper on blade. From (Moser and Nami, 2003).

1.5 Middle Stone Age cultural artifacts

Beside of lithic assemblages, the evidence of pigments uses, bone industries and the use of marine shells as ornaments have been also documented (Fig 1.3) (Bouzouggar et al., 2007; Campmas, 2012; d'Errico et al., 2009; Hajraoui et al., 2012; Nespoulet et al., 2008). The use of pigments is known at least from MIS 7 onward, the site of Sai Island in northern Sudan shows evidence of pigments processing to powder associate with small pieces of iron oxide with traces of anthropogenic manipulation and chert pebbles showing percussion marks and traces of fine-grained yellow and red ochre. As well in El Mnasra site where small blocks of hematite with traces of percussion and abrasion have been documented with quartzite pebbles covered by fine layer of red pigment. In Eastern Morocco, at the Ifri N'Ammar site the same pattern has been documented in which hematite fragments have been recovered as well as several pebbles covered by red pigments (Peer et al., 2004).

The bone industries have been documented in north Africa from 100ka onwards. The Aterian sites characterize by bone tools collection such as bone retouchers, awls, and points in El Mnasra, Dar es Soltan and Ifri N'Ammar sites. The larger collection of bone tools has been observed in the Atlantic coastal site of Temara including scrapers, knifes, shaving tools, polishing tools, points and flakes (Bouzouggar et al., 2018; Campmas, 2012; Hajraoui et al., 2012; Nespoulet et al., 2008).

Marine shells beads have been documented from MIS 5 specially associated with Aterian assemblage. Perforated Nassariidae shells were recovered in Moroccan Atlantic coast sites of El Mnasra, Contrebandies and Bizmoune, as well as in Eastern Morocco in Taforalt and Rhafas (Bouzouggar et al., 2007; Campmas, 2012; Peer et al., 2004).

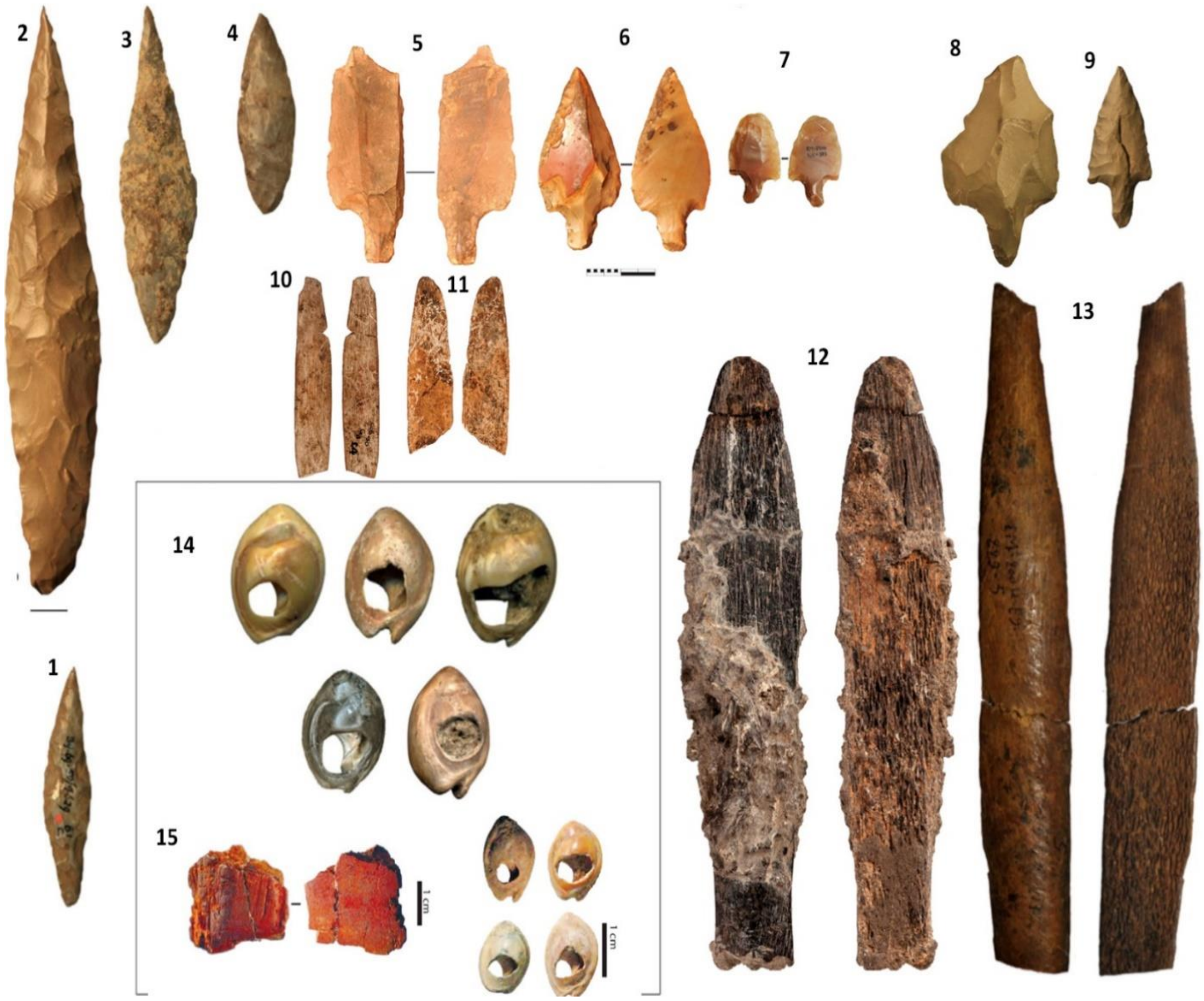

Figure 1.3. Middle Stone Age cultural artifacts (Scerri et al., 2018, Modified):
1-4 bifacial foliates from (1, Maghart el Aliya; 2-4, Adrar Bous), 5-7 Tanged tools from El Mnasra, 8-9 tanged tools from north Africa, 10-13 bone points from Dar es Soltane and El Mnasra, 14 Perforated *Trivia gibbosula* shells from Taforalt (Grotte de Pigeons) and Rhafas, 15 hematite fragment abraded, 16 *Nassarius sp*. from El Mnasra (Morocco)

1.6 Human Fossils

The Maghreb fossils record is limited and often lacking a direct date. With the exception of Jebel Irhoud fossils, the rest of humans remain dated according to the layres where they discovered and lithic assemblage associated with. For the Jebel Irhoud site, the excavation start onward from 1961 by Emile Ennouchi (Smith et al., 2007). The faunal remain that have been recovered include about 30 species, in wish some of them have a middle Pleistocene affinity. In 1967 and 1969 a small excavation has been done by Jacques Tixier, in wish 22 layer have been documented, the lower part of the stratigraphy revealed a human occupation with a lithic artifact classified as a Mousterian industry (Ben-Ncer and Hublin, 2003.; Groucutt et al., 2015; McDermott et al., 1996; Tattersall, 2009). From 2004 onward a systematic excavation and dated process have been done by Hublin and colleagues in wish change radically the date of the human fossils of the site. A total of 22 hominin specimens representing at least 5 individuals have been found (Fig 1.4). From those specimens the craniums Irhoud 1 and 2 is the most study with comparison with other hominins such as Neanderthals, archaic humans, and recent modern human. The thermoluminescence date obtained from burned lithic artifacts change the date dramatically to 315ka (Bruner and Pearson, 2013; Hublin et al., 2017; Richter et al., 2017; Smith et al., 2007).
For the other humans remains, the date attributed to the MIS 5-3, in Which most of them have been discovered in the coastal region of Temara associated with Aterian assemblage dated around 130 000 and 50 000 BP, including isolated human remains from El Harhoura 1 and 2, El Mnasra, Dar es Soltane 2 and Magharet el Aliya. In Eastern Morocco fossils have been discovered in Ifri N’Ammar (Campmas, 2012; Hawkins, 2001; Moser and Nami, 2010).

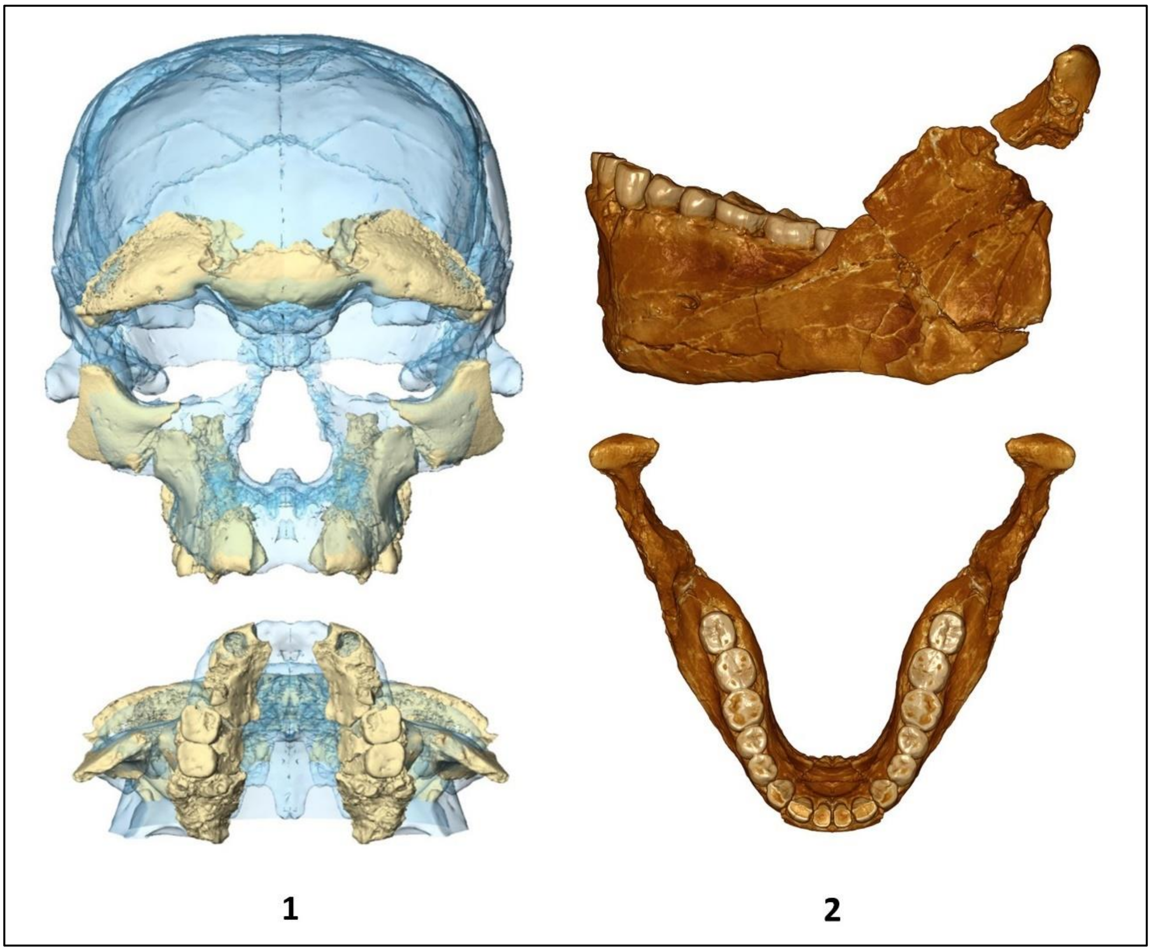

Figure 1.4. Human remains of JebeL Irhoud (Morocco). **1.**Facial reconstruction of Irhoud 10, **2**. Lateral and occlusal views of mandible Irhoud 11 (Hublin et al.,2017).

2. RESEARCH OBJECTIVES

During the last 15 years systematic fieldworks have been realized in the Aïn Beni Mathar-Guefaït basins, which have yielded numerous sites from the Early to the Later Stone Age. The excavations in this region have been poorly study before this period, namely Wengler during the 80’ and 90’(Wengler, 1993a, 1993b; Wengler and Vernet, 1992). The open air Sahb el Ghar 1 & 2 sites have been discovered in 2017 in Swiwina-Sahb el Ghar bassin. There are associated to the Middle Stone Age chrono-cultural period through the technological attributes and the geomorphological studies. Different archaeological stratified levels have been identified and provide substantial evidence of human occupations during this period. The sites had yielded a large number of lithic remains (N=5951, anthropogenic and non-anthropogenic material). The knapping material represent a 42.06% (N=2503) of the total assemblage.

The study of the lithic assemblages from SBG 1 and 2 sites will be used to answers some general research question regarding the MSA chronocultural period and the technological behaviors.:

- How were the SBG1 and 2 MSA assemblages formed?

- What the technological characteristics of SBG 1 & 2 lithic industries are?

- Which are the similarities and differences between these two localities?

- How can these assemblages be placed within the North African Middle Stone Age (especially in the context of Morocco)?

The studied material in this master thesis is focus only on the study of the core knapping strategies of both localities for mainly two reasons: (1) because the number of lithic remains is very high to analysis during the short time of a Master Thesis, (2) because the cores assemblage is a technical category that allow us to describe the technological behaviors of the total assemblages.

To answers those questions a taphonomical and technological analysis have been carried out on the core’s assemblage of both localities SBG1 & SBG2.

The core analysis will focus on three main points:

- Technological analysis approach to identify the different knapping strategies applied by the human groups in all the archaeological levels identified at each site.

- Comparison between the two localities to understand the similarities and differences of the technological behaviors.

- Contextualize them with other regional sites to understand the technological behaviors and the settlement pattern dynamics of the human groups during the MSA period in Morocco.

3. METHODOLOGY

The aim of this chapter is to describe the methods followed during the analysis of the lithic assemblages from both localities of Sahb El Ghar 1 (SBG1) and 2 (SBG2).

Lithic technologists have developed different approaches to understand the dynamics of making, using, reusing and discarding tools (Andrefsky, 2005, 2003; Bar-Yosef and Van Peer, 2009; Boëda, 1995; Inizan et al., 1999a). The characters of lithic assemblages in the eastern of Morocco is still unclear due to the limited number of well dated and studies sites. Although there is a wild variability of prehistoric cultures that existed from the Early to the Late Paleolithic period in this geographic area.

This study will focus on the cores recovered during the excavations at SBG1 and SBG2. Abandoned cores are an indicator of the last phase of reduction carried out and they provide information of the most recent stage of their usage (Inizan et al., 1999a, p. 50). Mostly, the reasons for stopping their exploitation and abandoning them can be related with physical faults, raw material quality, exhaustion, goal accomplishment or hazard leaving. It's likely that a single knapping concept was used during the reduction process, but this is not always the same, and several strategies are followed during knapping to achieve a balance between two pillars. First, to extend the use of the core over time by removing a larger number of flakes, and second, the removing of different kind of flakes in attempt to maintain the suitable morphological characters of the core (Hovers, 2009). Therefore, we use the *chaîne opératoire* approach to distinguish the operational sequences that can provide information about the processes, the objective, and human activities in Sahb el Ghar.

The *chaîne opératoire* is a widely adopted approach for the study of lithic assemblages (Bar-Yosef and Van Peer, 2009; Boëda, 1994, 1993; Hovers, 2009; Inizan et al., 1999; Kuhn, 1991; Rodriguez-Alvarez, 2004). The principle behind the *chaîne opératoire* analysis is to study the entire assemblage by placing each piece in their position of the reduction sequence, in other words, reflects the different actions carried out through the lifetime of a stone, from the collection of the raw material until the final production and abandonment of stone tools. This chapter consider the *chaîne opératoire* as a guiding structure for the analysis attributes, therefore, will describe the attributes and their measurements and categorization.

The attribute analysis describes the characteristics observed on each core at the abandonment stage (Andrefsky, 2005, n.d.; Burroni et al., 2002; Chazan, 1997; Hovers, 2009; Hurst and Kelly, 1961; Inizan et al., 1999a; Parush et al., 2018; Rodriguez-Alvarez, 2004; Shea, 2013). In this study, we combine attributes used to provide quantitative data about the technological characteristics to reconstruct knapping process by analyzing individually each core. The recorded attributes have been recorded in a Microsoft excel database for the statistical analysis of the assemblage. The attributes used have been separated in three categories:

1) Taphonomical attributes to describe the natural modification and diagenesis.

2) Technological attributes separated of the core as a hole unit.

3) Facial attributes by describing each knapping surface of the core separately.

3.1 Taphonomical attributes

Our taphonomical analysis focus on visible features on cores surface deriving from post depositional alterations, such as patination, rounding or abrasion, macro-fractures, and concretions (Table 1). Preliminary observation showed a high degree of similarity in terms of taphonomical characteristics between the two localities (Fig 3.1).

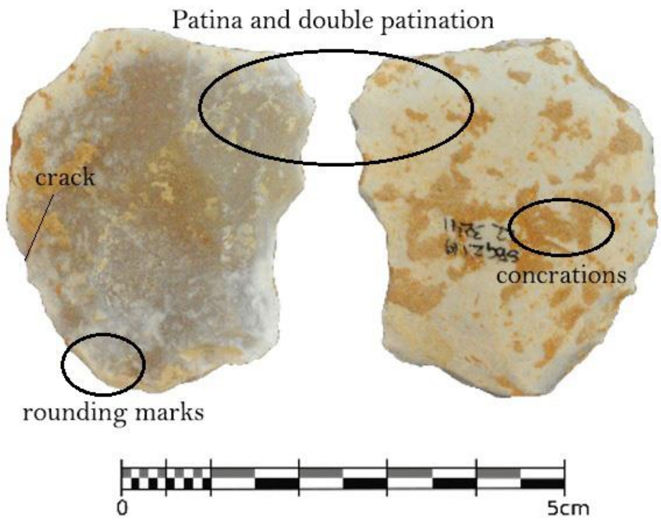

Figure 3.1. taphonomical attributes studies in SBG assemblages. Photos J.I.Morales\IPHES

<u>Patination:</u> the physical-chemical alteration of the cores surface has been recorded. Patination occurs when lithic assemblages are exposed to the atmosphere or humidity causing the growth of a white milky layer on the surface of the lithic (Burroni et al., 2002). The degree of the patination accrues depend on different factors, such as the soil's PH, the moisture, the range of temperatures the material is exposed to, and the length of the exposition (Hurst and Kelly, 1961). In SBG assemblage most of the cores show different degrees of patination and some of them even show a doble patination. (Fig 3.2) is an example of a cores with heavily patinated and double patination.

Figure 3.2. Core with high patination degree. Photos J.I.Morales\IPHES

Patination of the material investigated has been recorded in the following way (examples in Fig 3.3):

1. Patination: Yes\No.

2. Patination degree:

High: Most of the surface is a dull white color

Medial: some areas on the core surface show a mixture of blue-white color

Figure 3.3. Patination degree; from right to left: Medial, High

3. <u>Double patination</u> (Yes\No): here we record the different degrees of patination observed on different surfaces of the same core. Double patination can be evidence of a recycling dynamic (Shea, 2020, p. 44) which have been observed in some cases, however other are related with natural processes, therefore we add the recycling attribute in order to clarify and separate the natural double patina and double patination by recycling activities.

Recycling: as a process the recycling refer to the reuse of cores by modified discarded ones, it is difficult to recognize the process if the period between the two modifications is very short, however in this study we focus on the difference of patination surface as a main indicator.

Rounding\rounding degree: rounding or abrasion refers to the degree of degradation of lithic edges due to water transport and weathering (Shea, 2020). The study of rounding has been devised in two categories, the presence of rounding features (Yes\No) and the degree of rounding (slightly\ heavily).

Fractures: some samples show natural fracture due to the thermal expansion and contraction derived from wide temperature variations. Under these conditions, the stone start to go weaker over time and eventually cracks start to develop gradually (Burroni et al., 2002). On this study we focus on the presence or absence of macro-fractures observed directly or with a desk clamp magnifier lamp (Figure 3.1).

Concretions: some samples were covered by calcite concretions formed because of the precipitation of calcium carbonate in the material surface. The precipitation degree is variable between the levels and some materials have been treated using acid to eliminate the layers of concretions (Figure 3.1).

Table 1: Taphonomical attributes and attributes state apply in this study

Attributes	Description
Patination	Yes\No
Patination degree	High Medial
Double patination	Yes\No
Rounding	Yes\No
Rounding degree	Slightly Heavily
Fractures	Yes\No
Concretions	Yes\No

3.2 Technological attributes.

For the technological attributes, cores have been analyzed in two different perspectives: first, the elementary level (core as one unit) with five selected attributes: (1) core size, core morphology, cortex, faciality, facial relation; and (2) at the facial level with six attributes: facial cortex, number of scars, facial angle, deep characteristics, scar direction and perimetral continuity. All the attributes have been explained bellow (Table 2).

3.2.1 Elementary attributes:

Core maximal dimensions: the size of lithic artifact is one of the main attributes applied in lithic analysis as an informative to determine the stage of reduction (Andrefsky, n.d.). The core size has been divided in three attributes, length, width, and thickness measured in millimeter using a digital caliper to get a better accuracy. Each dimension has been measured in a straight-line representing the maximum dimension of the core (Figure 4).

Core morphology: the morphology of the cores has been examined in three transections plans, the horizontal, the transversal and the sagittal (Fig 3.4).

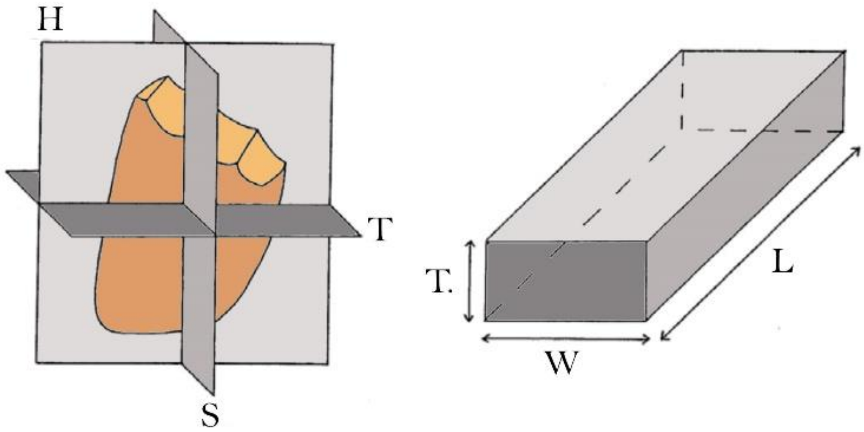

Figure 3.4. Core size and Morphology axis; L. Length; W. weight; I. Thickness; H. Horizontal; T. Transversal; S. sagittal (Chacón, 2009).

Cortex: the amount of cortex can help to identify the degree of which the core has been reduced and therefore the initial volume of the raw material selected. Two types of measurement have been considered. First, the presence of cortex in the core as a unit and the amount of cortex in each surface (facial cortex see below).

Faciality: we refer here to the number of faces that have been knapped, three categories have been identified: unifacial, bifacial and trifacial.

General polarity: we record here the management of the reduction through three characteristics. The first defines the polarity, the number of intervention planes. The second, the faciality, defines the number of exploitation surface. And the third, the dominant direction of the extraction (Fig 3.5). The examples of general polarity observed in SBG core are:

- For unifacial cores: unipolar unifacial longitudinal (UUL), unipolar unifacial opposed (UUOp), unipolar unifacial orthogonal (UUOr), unipolar unifacial centripetal (UUC).
- For bifacial cores: bipolar bifacial longitudinal (BBL), bipolar bifacial opposed (BBOp), bipolar bifacial orthogonal (BBOr), bipolar bifacial centripetal (BBC), bipolar bifacial multipolar (Multidirectional) (BBM).
- Fort trifacial: Multipolar trifacial multipolar (or multidirectional) (MTM)

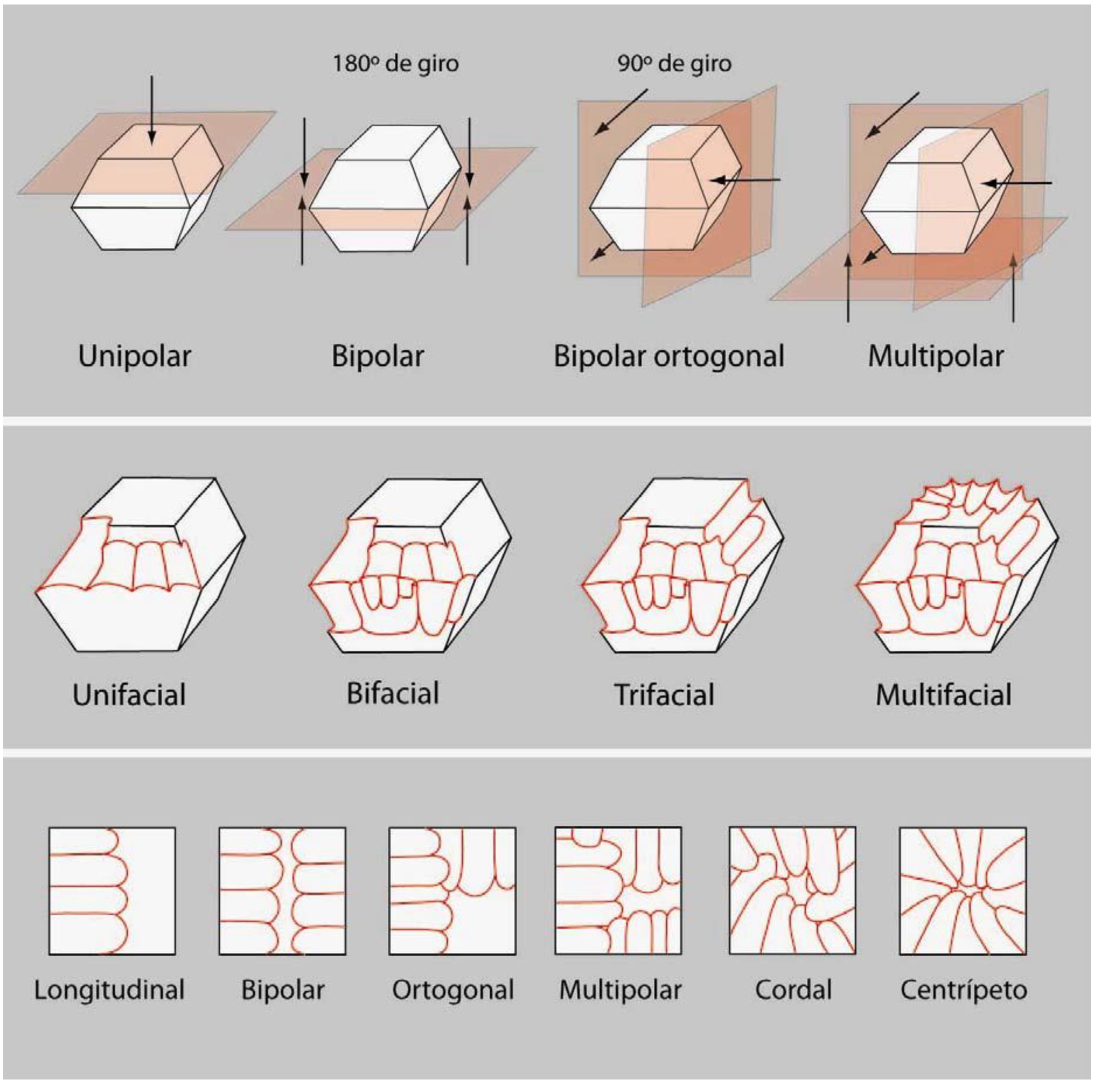

Figure 3.5. Different type describes in this study of faciality and facial relation (Chacón, 2009).

Symmetry: the symmetry of intersection plan between the knapped surface. Symmetry\ asymmetry

Hierarchization: we refer here in a core with two unequal surfaces with hierarchical order. One surface is used as a debitage surface and other as a striking surface.

Perimetral continuity: we refer here to the part of the proportion between knapped and unknapped zones measured in percentage and separated in four categories (fig 3.6).

- 1C: less than 25 %
- 2C: between 25-50%
- 3C: between 50-75%
- 4C: more than 75%

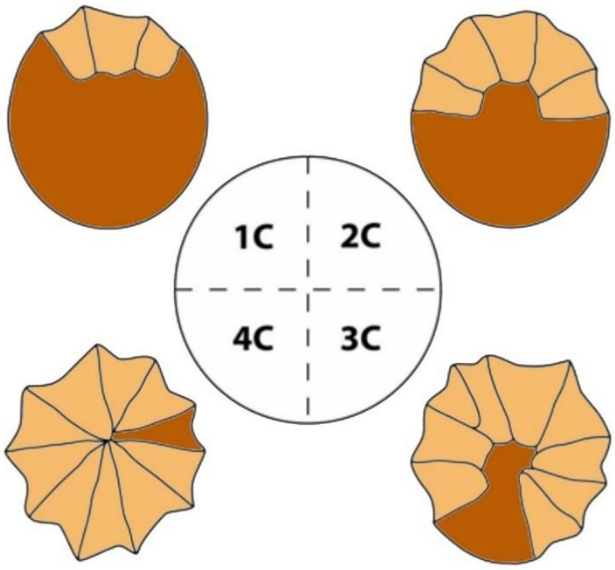

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Figure 3.6. The four categories of perimetral continuity (Chacón, 2009).

Reduction stage: this attribute allows us to understand the core use-life by examine the stage the cores have been abandoned (Inizan et al., 1999; Soressi and Geneste, 2011):

- Initial stage: we refer her to the phase of shaping out of the volume to be flaked by preparation the general morphology.
- Advanced stage: we refer here to core where the flakes have or still can be removed.
- Exhausted stage: we refer here to cores reaching the final phase of life-use where no flake can be removed.

Table 2. Technological attributes and attributes state refer in this study.

Elementary attributes	**Description**
Core size	L: Length W: Width T: Thickness
Core Morphology	Ci: Circular Ov: Ovoid Qu: Quadrangular Re: Rectangular Tr: Trapezoid Rh: Rhomboid Pe: Pentagonal
Cortex	0CTX: No cortex 1CTX: less than 25% 2CTX: Between 25 and 50% of the core 3CTX: Between 50 and 75% of the core 4CTX: more than 75% of the core
Faciality	Un: Unifacial Bi: Bifacial Tr: Trifacial
General polarity	UUL: Unipolar unifacial longitudinal UUC: unipolar unifacial centripetal BBC: Bipolar bifacial centripetal BBM: bipolar bifacial multipolar MTM: multipolar trifacial multipolar ……
Symmetry	Yes\No
Hierarchization	Yes\No
Perimetral continuity	1C: less than 25 % 2C: between 25-50% 3C: between 50-75% 4C: more than 75%
Reduction Stages	Initial Advanced Exhausted

3.2.2 Facial Attributes:

Facial cortex: the amount of cortex in each face is identified. To record this, we have determined first each face, being the first the most knapped one, and second we have estimated the degree of cortex present. It has been recorded as follows:

- 0ctx1, 0ctx2, octx3: absence of cortex
- 1ctx1,1ctx2,1ctx3: less than 25% cortex
- 2ctx1, 2ctx2, 2ctx3: between 25-50% of face surface
- 3ctx1,3ctx2,3ctx3: between 50-75% of face surface
- 4ctx1,4ctx2,4ctx3: more than 75% of surface

Scar number: the number of scars could indicate the minimum number of flakes detached before the abandonment. All the scars, independently of their size, have been recorded.

Facial angle (in degrees): we have described the angle of the scars in relation with the intersection plan, as much this angle approaches 90 degree. To expose the results, we have divided them in four categories (Fig 3.7):

- Plane (P): angle less than 35 degrees.
- Simple (S): angle between 35 and 55 degrees.
- Semi-abrupt (SA): between 55 and 75 degrees.
- Abrupt (A): between 75 and 90 degrees.

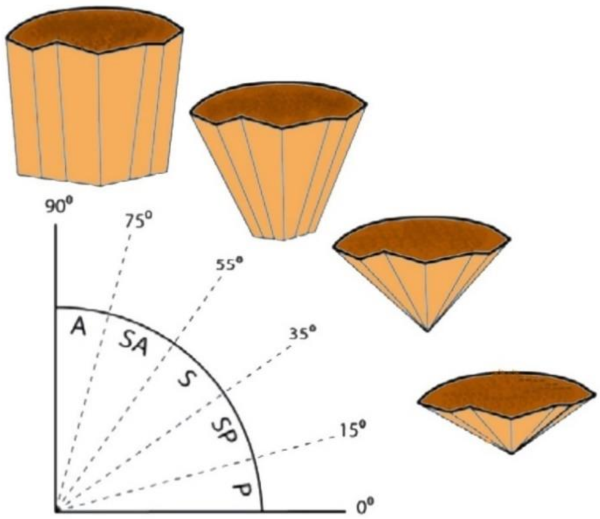


Figure 3.7. Different categories of facial angles (Chacón, 2009).

Extent of the removals: here we refer to the development of the scars on parallel with the intersection plan and the extension degree of the scars. Four categories have been defined and explained in (Fig 3.8) -mm: very marginal; m: marginal; p: deep; mp: very deep; t: total.

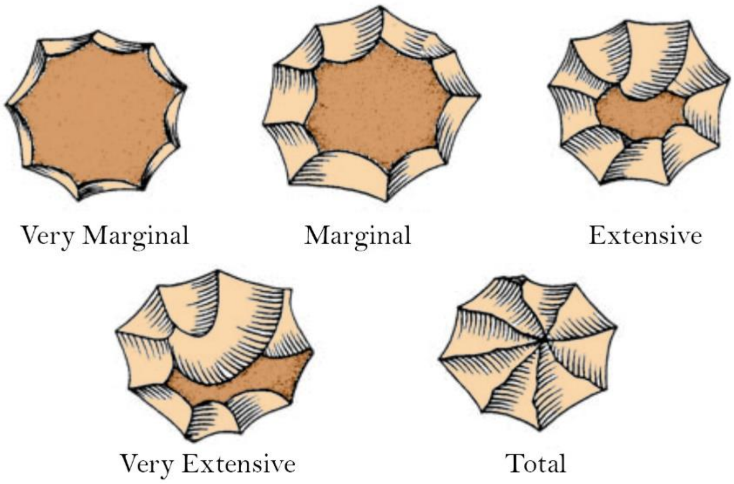


Figure 3.8. Modalities of centripetal degree attribute (Chacón, 2009).

Removals organization: defines the dominant direction of the scars. Six categories have been identified and explained in (Fig 3.9) -Longitudinal, Bipolar opposite, Bipolar Orthogonal, Multipolar, Cordal, Centripetal-.

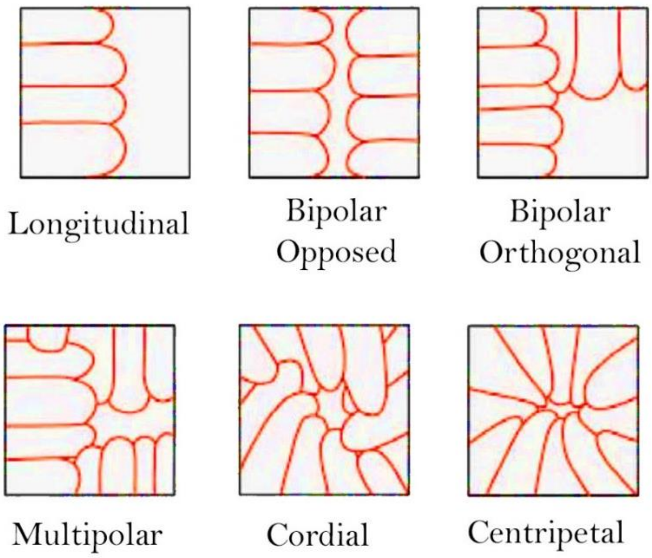


Figure 3.9. Scars directions (Chacón, 2009).

Table 3. Facial atributes

Facial Attributes	**descriptions**
Facial Cortex	0ctx1.0ctx2…: absence of cortex 1ctx1,1ctx2…: less than 25% cortex 2ctx1, 2ctx2…: between 25-50% of face surface 3ctx1,3ctx2…: between 50-75% of face surface 4ctx1, 4ctx2…: more than 75% of surface
Facial Angle	P1, P2…: Plane; angle less than 22 degrees S: Simple; angle between 22 and 45 degrees SA: Semi-abrupt; between 45 and 67 degrees A: Abrupt; between 67 and 90 degrees
Extent of removals	mm, very marginal m: marginal p: deep mp: very deep t: total
Number of scars	1,2,3,4,5….
Removals Organization	L: Longitudinal OP: opposite OR: Orthogonal M: Multipolar CO: Cordial CE: Centripetal

3.3 Core types:

Levallois cores: the Levallois core consist on the manufacture of flakes by a predetermined core form by specific preparation (Boëda, 1994, 1993). From a technological point of view six criteria establishes the definition of Levallois core by (Boëda, 1995; Chazan, 1997), (Fig 3.10):

1- The volume of the piece to be worked is conceived as two surfaces that meet at a plane of intersection.

2- The two surfaces are hierarchically related, one being the platform face (usually the more convex of the two) and the other being the production face.

3- The production face is organized such that the morphology of products is predetermined. This predetermination is based on the management of lateral and distal convexities.

4- The fracture plane for the removal of predetermined flakes is subparallel to the plane of intersection between the two faces.

5- The striking platform is organized to allow the removal of the predetermined flakes from the production surface. This requires that the intersection of the striking platform surface and the flaking surface must be perpendicular to the flaking axis of the predetermined flakes. At the level of technique, it is stated that the Levallois method is used only with a direct percussion hard hammer technique

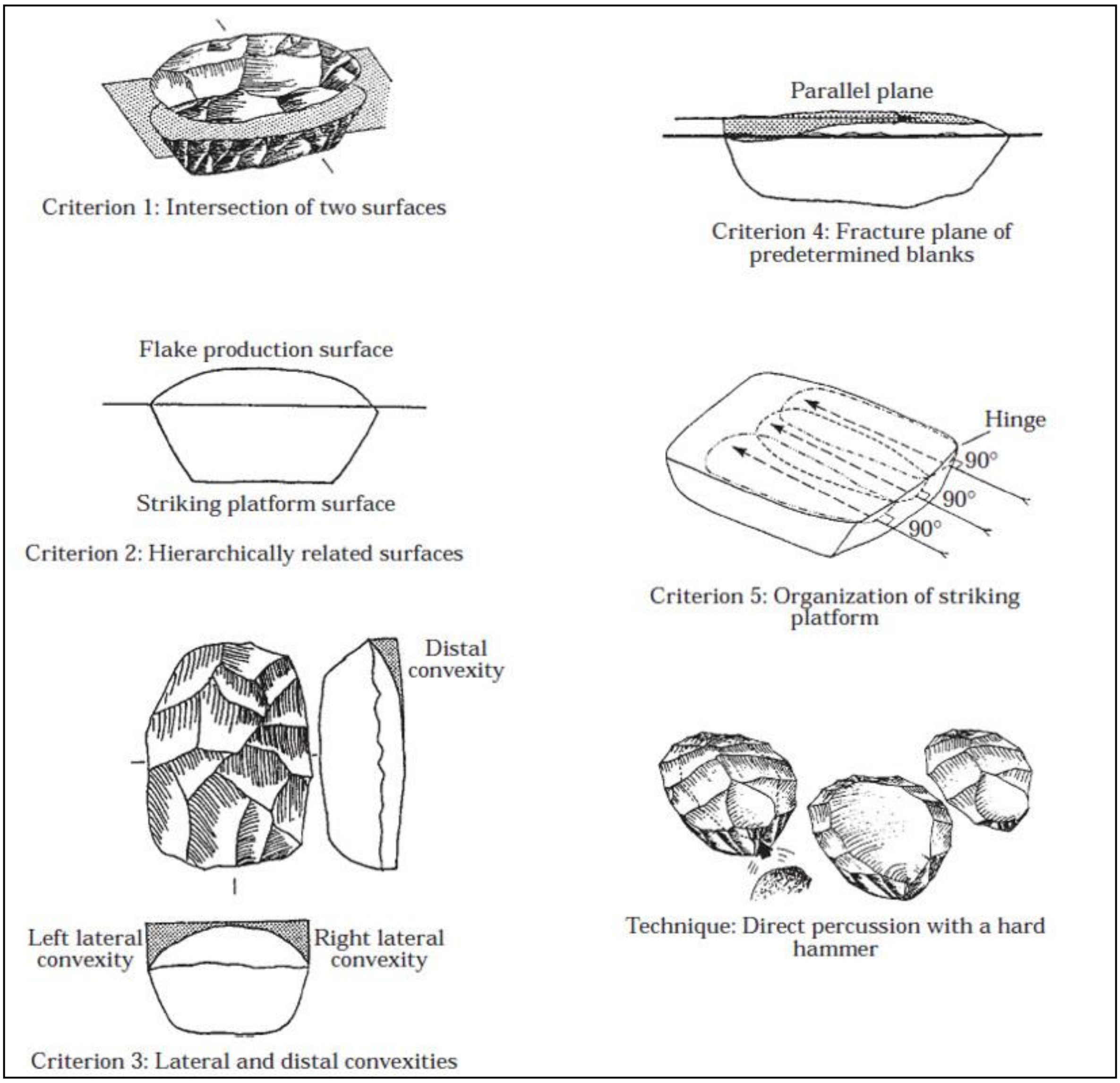


Figure 3.10. Levallois core criteria (After Boëda, 1995 in Chazan, 1997)

In SBG assemblage two mean strategy of Levallois system have been define according to the above criteria and descript below:

- Levallois of preferential flake: in which a single preferential flake is produced from each prepared debitage surface, the scar produced by this method spans most of the debitage surface (Fig 3.11).
- Recurrent Levallois core: or the multiple-flake Levallois debitage. A series of flakes can be produced from one debitage surface. The scars produced in the debitage surface will have different morphology related to the orientation, the position, the size, and the striking platform. We describe below the categories considered on this study:
    - Recurrent Unipolar Levallois: the debitage surface is characterized by a single direction of the scars due to the direction of removals.
    - Recurrent Bipolar Levallois: the debitage surface is characterized by two directions of the scars in which the flakes produced in this case attend to have a bipolar opposite or orthogonal directions.
    - Recurrent Centripetal Levallois: The debitage surface is characterized by multi directional centripetal scars in which the flakes extracted from this method attend to have a centripetal or cordal negative's direction.

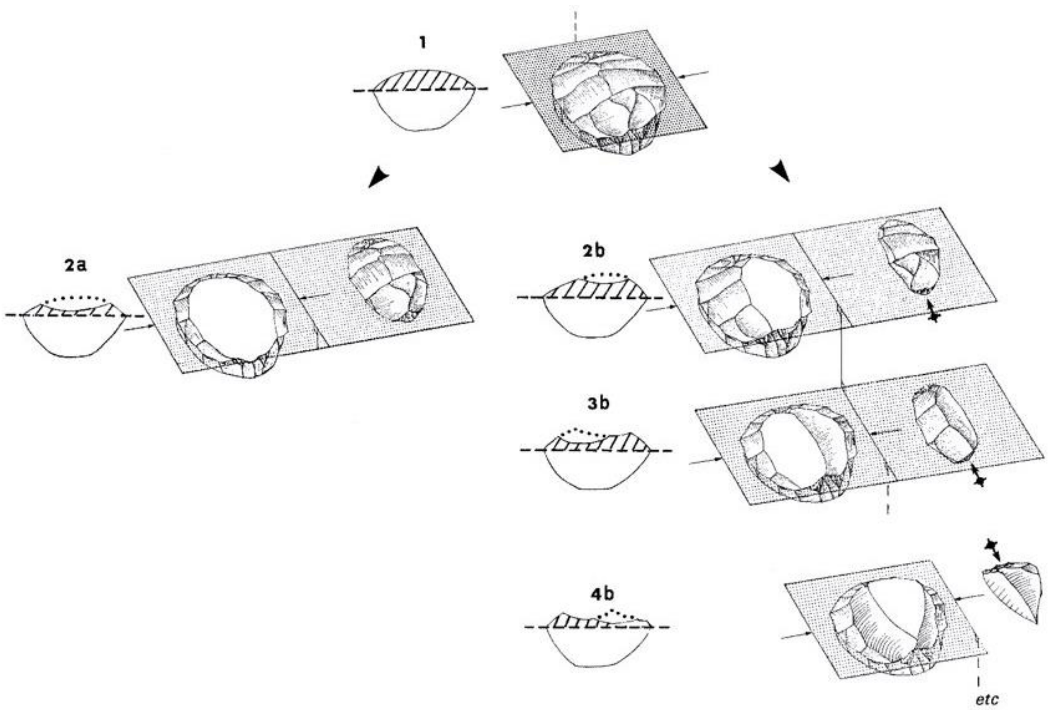


Figure 3.11. Levallois Core; 1. Prepared Core in hierarchical form; 2a. Levallois core of preferential flake; 2b,3b,4b. Recurrent Levallois core (3b. Recurrent Unipolar; 4b. Recurrent Bipolar), (Inizan et al., 1999a)

Discoidal cores: an elaborated core with certain degree of predetermination. The discoidal is not scientifically different from Levallois core, therefore we follow (Boëda, 1993) criteria to distinguish the Levallois core from discoidal core. In summary, we will describe the six criteria in the following points (Boëda, 1993):

1. The core is designed in two asymmetrical convex surfaces, intersecting, delimiting by the intersection plane.

2. The two surfaces are not hierarchized: one is conceived as surface of striking surface, but their roles can be inverted during a same operational sequence

3. The debitage surface is prepared in such a way that certain flakes obtained at a predetermined way. the predetermination consists in bittering a more or less pronounced peripheral convexity. this overall convexity has the role of controlling the lateral and distal detachment of each predetermined removal

4. The intersection plan between the striking plane and the debitage surface is parallel to the debitage axis (flaking axis)

5. The fracture plane of the predeterminant and predetermined flakes intersect the intersection plan of the two surfaces.

6. The discoidal flaking system employed by using a direct percussion by hard hammerstone

Laminar cores: we refer to a core organized in such a way to repeatedly produce laminar flakes, these flakes are characterized by a length at least equal to twice their width (Inizan et al., 1999a).

Opportunistic cores: this type of cores shows a non-organization of the flaking process, in which the removals have no systematic directions and present a short series of removals.

4. SITES PRESENTATION: SAHB EL GHAR 1 & 2 (Jerada Province, EASTERN MOROCCO)

4.1. Localization and geology

The high plateau of Aïn Beni Mathar (Fig 4.1 and 4.2) region located in the NW intra-atlas maghrebian Cenozoic depression between the middle-tell atlas in the north and high-Saharan atlas in the south, formed by conglomerates, lacustrine and marls of Miocene age, this formation is covered by an alluvial and lacustrine Mio-Pliocene sequence which formed by conglomerates, gypsum, marls, sandstones and palustrine limestone (Benito-Calvo et al., 2020). The Sahb El Ghar 1 (SBG1) and 2 (SBG2) sites situated in Swiwina basin at elevations of 900-950 m above sea level, with a surface of 8km^2 in the right margin of the Sahb El Ghar valley, engraved near 90 m in the top of the Plio-Pleistocene sequence (Chacón et al., 2019; Sala Ramos et al., 2017) (Fig 4.3).

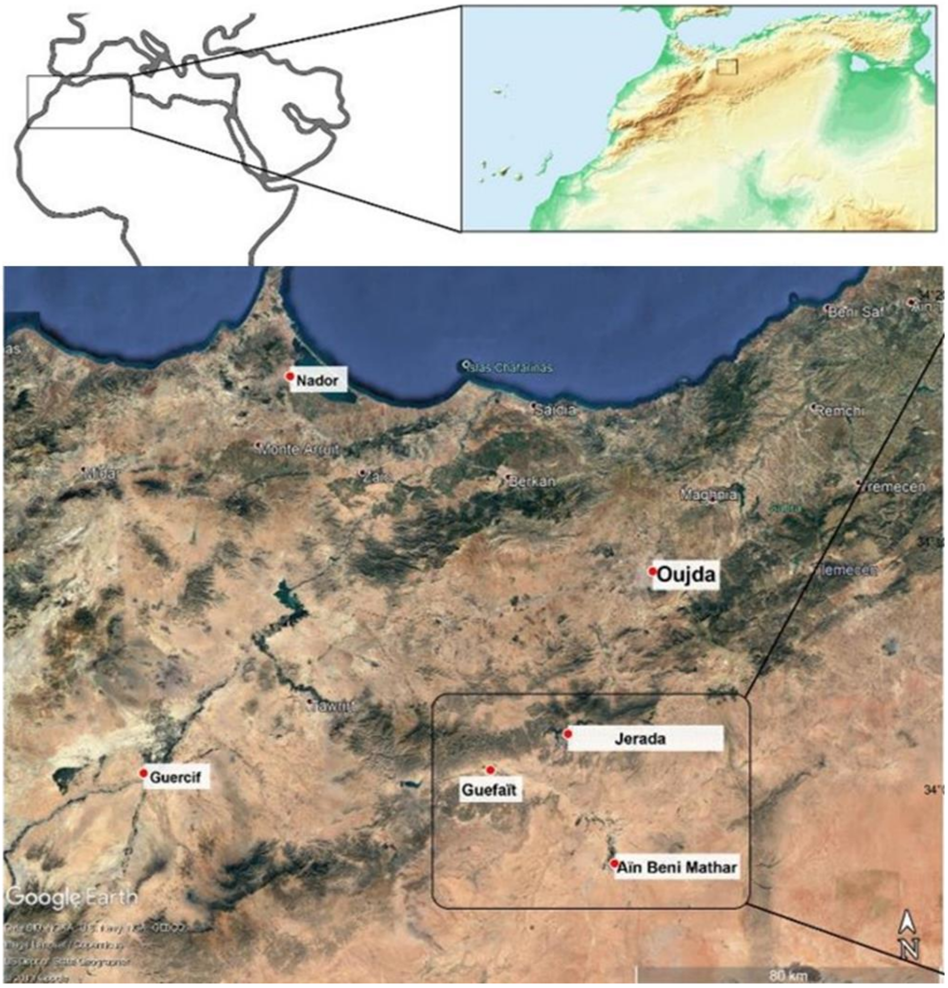


Figure 4.1. Location of the study area (Sala et al. 2021, accepted)

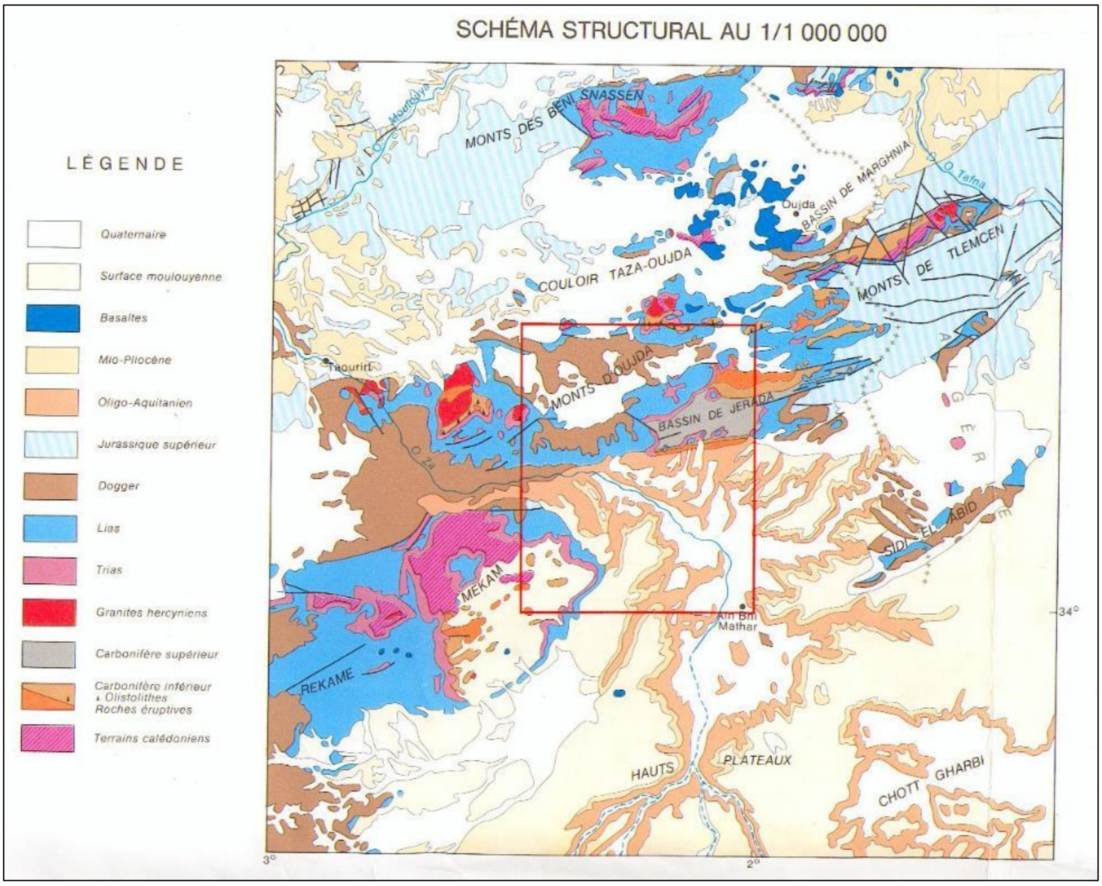


Figure 4.2. Geological map of the Aïn Beni Mathar area (Carte Géologique Marroc 1989)

Figure 4.3. General view of the Sahb El Ghar- Swiwina basin (Photos IPHES, A. Benito-Calvo/Cenieh)

4.2 Stratigraphic sequences

In SBG1 the Quaternary sequence lies on a bedrock composed of red mudstones, micritic limestones, intraformational breccia and sandy mudstones. The top of the bedrock is brechified by weathering, on which rest the Quaternary sequence. The latter consist of a lag composed of angular and subangular clasts of flint, and subrounded clasts of limestones including silty sandy matrix, followed by two units of fine sands, massives or coarse bedded, slightly carbonated, and including dispersed granules and flint clasts. The thickness of the units increases towards the west, where these slope sediments connect with the alluvial deposits of the Sahb El Ghar valley bed (Fig. 4.4). Only one archeological level has been identified (Chacón Navarro et al., 2019a) .

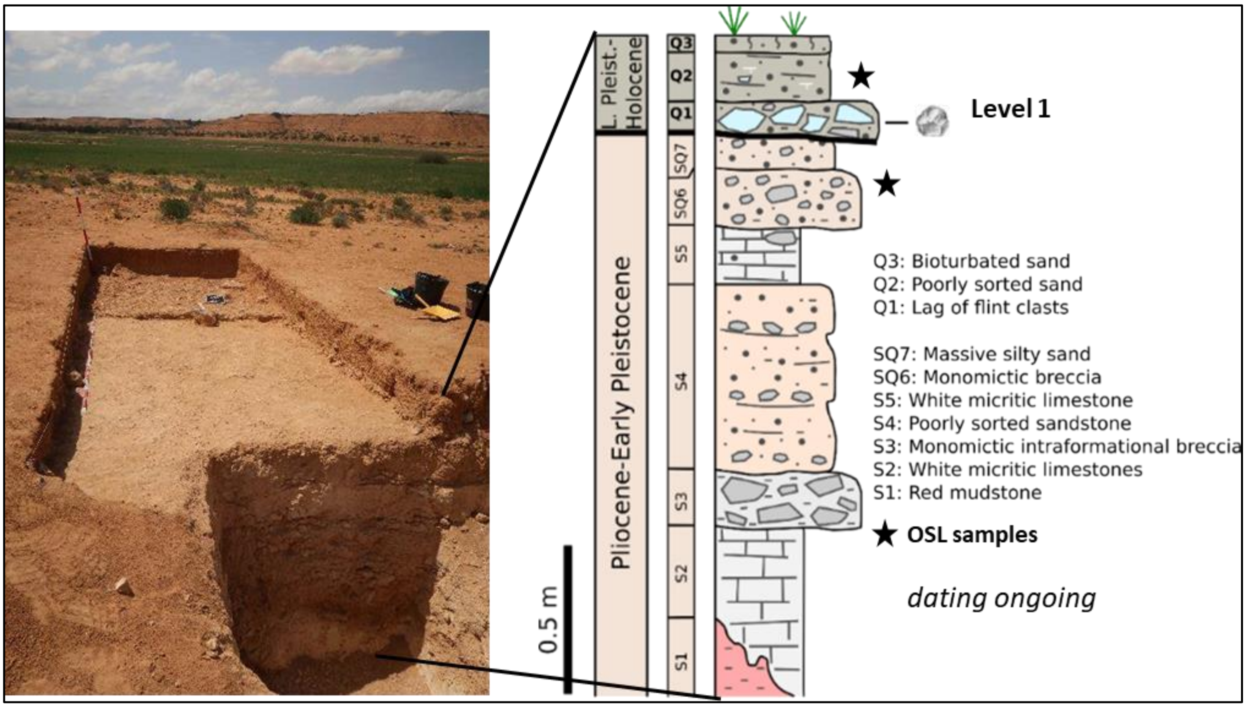


Figure 4.4. Stratigraphic sequence and excavated surface of SBG1.

In SBG2, the sequence starts with conglomerates and nodular limes affected by several calcrete levels where disperse lithic where located (Level 1, 2 and 3). Resting of these deposits a sequence of four mud layers develops, red-orange in color, and characterized by silty and sandy textures and massive or coarsely bedded structures. In the middle of this mud sequence, a lag of clasts is discernible in the site and along the channel of the stream (Benito-Calvo et al. Unpublish) (Fig. 4.5). Three archaeological levels have been identified (Chacón Navarro et al., 2019).

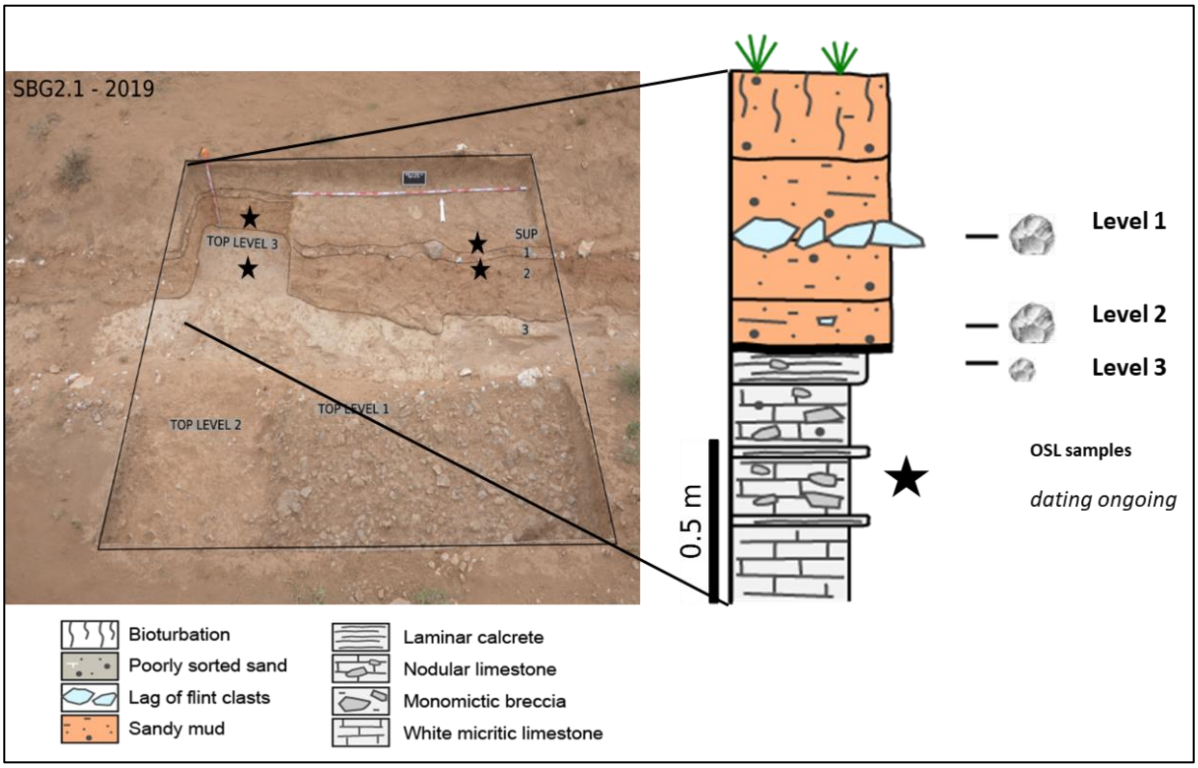


Figure 4.5. The stratigraphic sequence and excavated surfaces of SBG2.

4.3 Sites background

Systematics surveys and archaeopaleontological excavation in Jerada province started in 2006 in the frame of a bilateral research project between different Moroccan-Spanish institutions initially with the Université Mohammed Premier Oujda (UMP, Eastern Morocco) and the Institut Català de Paleoecologia Humana i Evolució Social (IPHES-CERCA, Catalonia, Spain). The project is intitled: Evolution of human settlement pattern dynamics during the Quaternary in Eastern Morocco: Aïn Beni Mathar – Guefaït (Jerada Province) (Chacón et al., 2018, 2019a, 2019b;) . The aim of the project was to understand and fil the gaps regarding the early human settlement in the north of African and the evolution from the Pleistocene to the Holocene by the reconstruction of the arrival and evolution of early humans in Jerada province (Chacón et al., 2019, Sala-Ramos et al, 2021, accepted). During the last fifteen years numerous open-air sites, caves and rock-shelters have been discovered providing new data about the human settlement during the Quaternary in the area (Fig. 4.6).

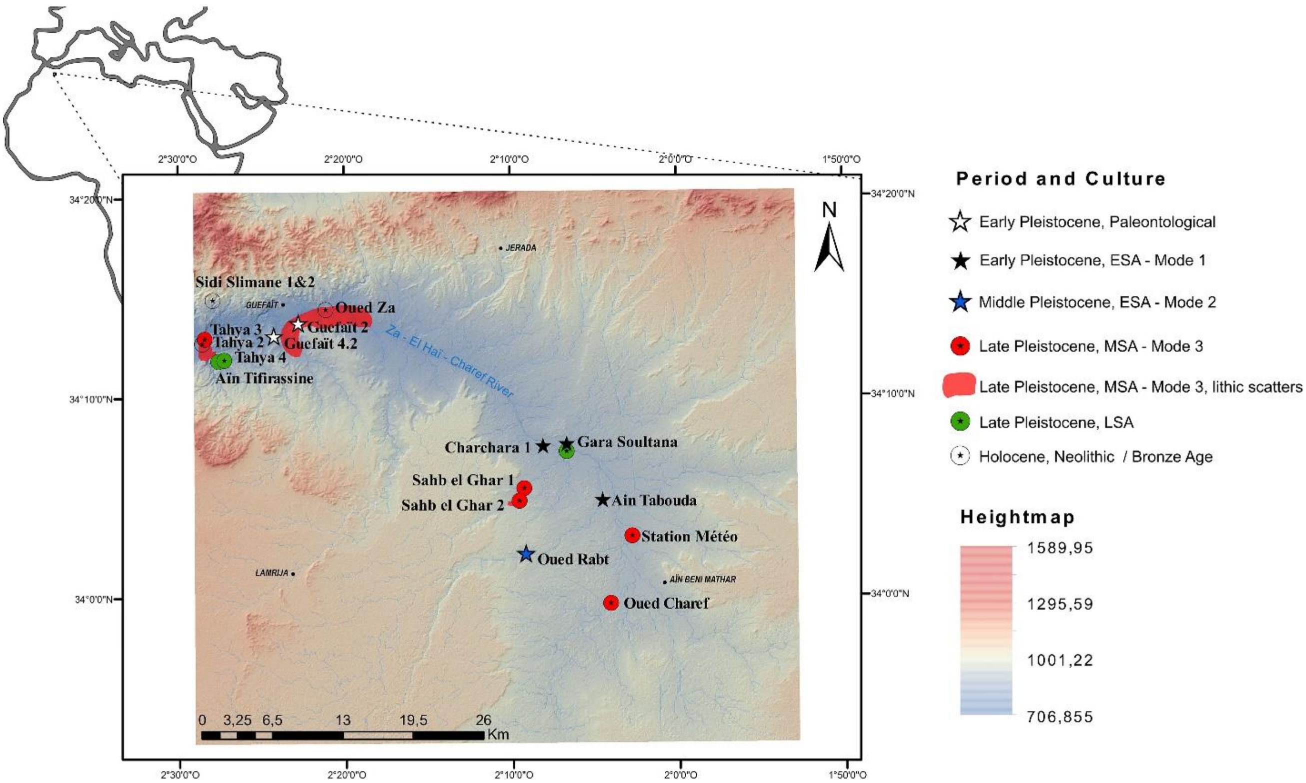


Figure 4.6. Localization of the different sites discovered and excavated since 2006 with their chronocultural attribution based on the technological attributes of the lithic assemblages and the geomorphological studies (Sala et al. 2021, accepted).

This Master thesis is only focused on the Middle Stone Age sites of Sahb El Ghar 1 (SBG1) and 2 (SBG2) which are in the Swiwina basin in Aïn Beni Mathar that cover an area of around 8km².

4.3.1 SBG1

It has been discovered during 2017 raw materials surveys, where a stratified level was exposed due to a construction work carried out in the small village to protect the houses from flooding of the Ghar river. The objective of the 2018 fieldwork was to excavate the site in 9m2 in order to know if the identified level correspond to the surface material and, second to know the chronocultural attribution through the studied of the archaeological record and to take samples for OSL dating methods (Chacón et al., 2019b). Two levels were identified, the first one was called ”superior level” and contained a mix of material in secondary position. The second one (Level 1) has a variable depth surface ranging between 5 and 12 cm, faunal remains are not preserved (Chacón et al., 2019) .

Figure 4.7. View during the excavation of SBG 1 in 2018 (up) (2) Detail of the excavation of Level 1 (down) (Photos A. Benito-Calvo/Cenieh & IPHES)

Lithic assemblage

The SBG1 site have been yielded a large number of lithic industry (Table 1). The total is N=2389, where the anthropogenic lithic products present a 57% (n=1051). Different types of flaking products have been documented including all the technological categories (Fig 4.8) and almost all the reduction stages: cores 5.71% (N=60), retouched pieces 30.07% (N=316), flakes 30.83% (N=324), flake fragments 5.65% (N=56), fragments 28.07% (N=295) (Table 4).

Table 4. Distribution of the SBG1 lithic assemblage by technological categories

	Cores	Retouched	Flakes	Frag Flakes	Fragments	Total
N	60	316	324	56	295	1051
%	5.71	30.07	30.83	5.33	28.07	100

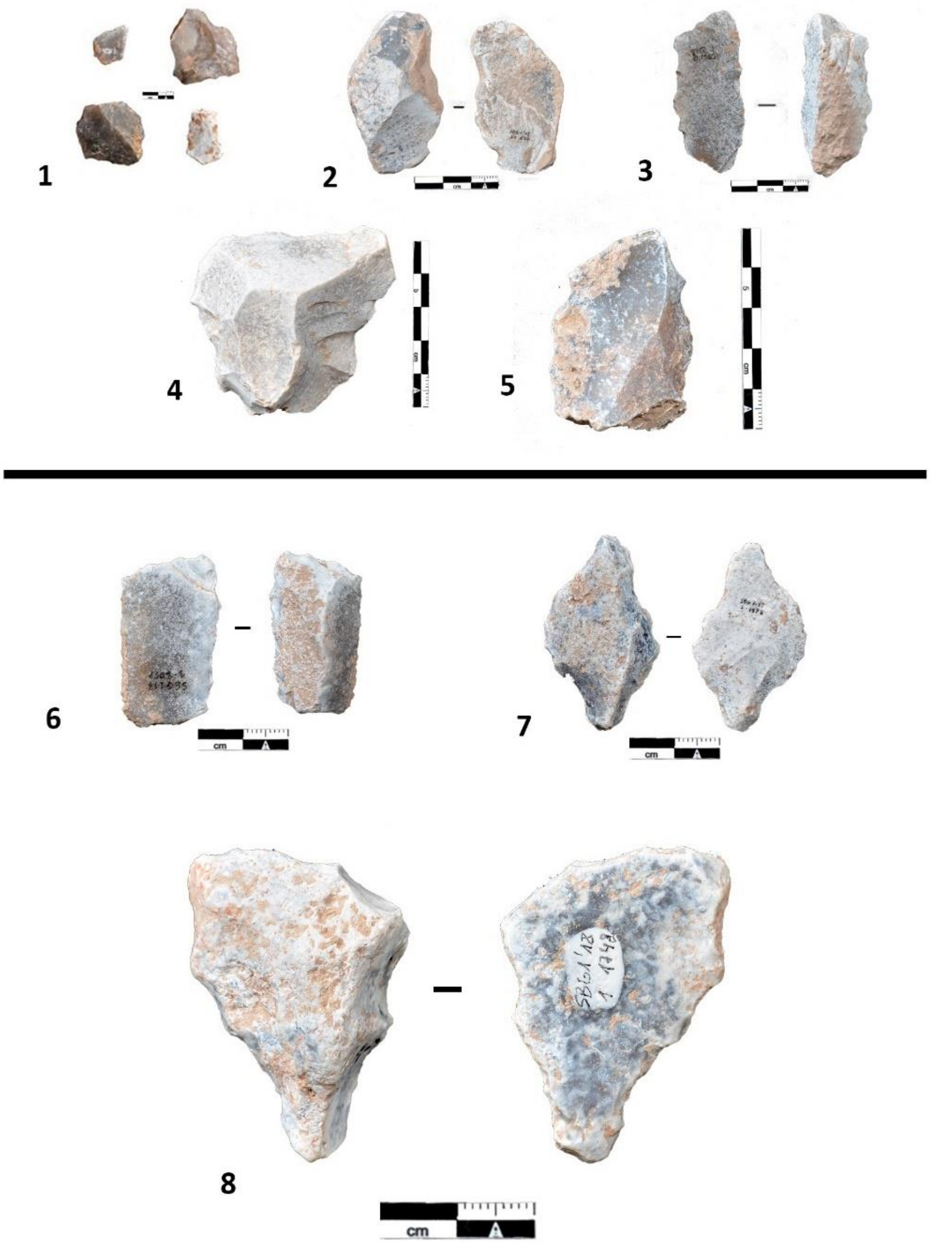


Figure 4.8. Artifacts from SBG1.L1. 1, Knapping products (1 &2 ordinary flakes, 3. denticulate, 4-5, Levallois flakes). 6scraper, 7 & 8. tanged tools

4.3.2 SBG2

The SBG 2 site was discovered during the surveys in the area realized in 2018.The site is located around 1.5 Km from the first locality (SBG1). The objective of the excavation at SBG2.1 was to demonstrate if there is a continuity of the human occupation in Swiwina basin and the possible relation with the first locality SBG1. The excavation took place in 2019 in a test-pit surface crossed by a small stream of 7m2. Three occupation levels have been identified. As SBG1 they were no fauna remains preserved (Chacón et al., 2019).

Figure 4.9. (1) View during the excavation of SBG 1 in 2019 (up) (2) Detail of the excavation of Level 1, 2 and 3 (down) (Photos A. Benito-Calvo/Cenieh & IPHES)

Lithic assemblage

The SBG2 lithic assemblage is on chert. A large number of pieces (anthropogenic and non-anthropogenic ones) have been collected. The flaking products is N=1753 (46.3%). The number of pieces is: 714 for level 1, 655 for level 2, and 384 for level 3. As well as in SBG1 different types of products have been documented including all the reduction stages, including retouched artifacts (denticulates, scrapers). Additionally, in SBG2.L1 important number of tanged tools have been documented (Fig. 4.10, 4.11, 4.12) (Chacón et al., 2019a, 2019b). Table 5 shows the distribution of the technological categories by level.

Table 5. Distribution of the SBG2 lithic assemblage by technological categories

		Cores	Retouched	Flakes	Frag Flakes	Fragments	Total
SBG2.L1	**N**	23	31	290	307	63	**714**
	%	3.22	4.34	40.62	43	8.82	100
SBG2.L2	**N**	6	5	229	296	119	**655**
	%	.92	.76	34.96	45.19	18.17	100
SBG2.L3	**N**	12	12	162	164	34	**384**
	%	3.13	3.13	42.19	42.71	8.85	100
Total	**N**	**31**	**48**	**681**	**767**	**226**	**1753**
	%	**1.77**	**2.74**	**38.85**	**43.75**	**12.89**	**100**

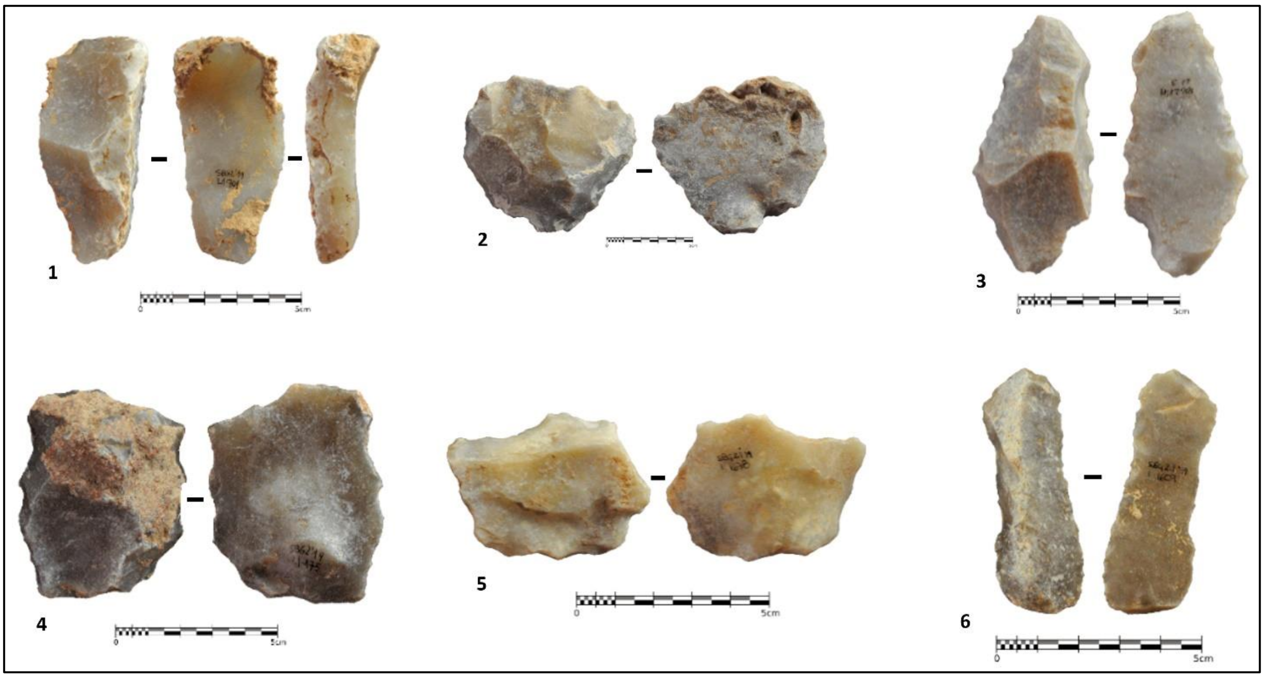


Figure 4.10. SBG2.L1 knapping products: 1&6 laminar retouched flakes, 2.Levallois flake,. 3. tanged point, 4, denticulate. 5. scraper.

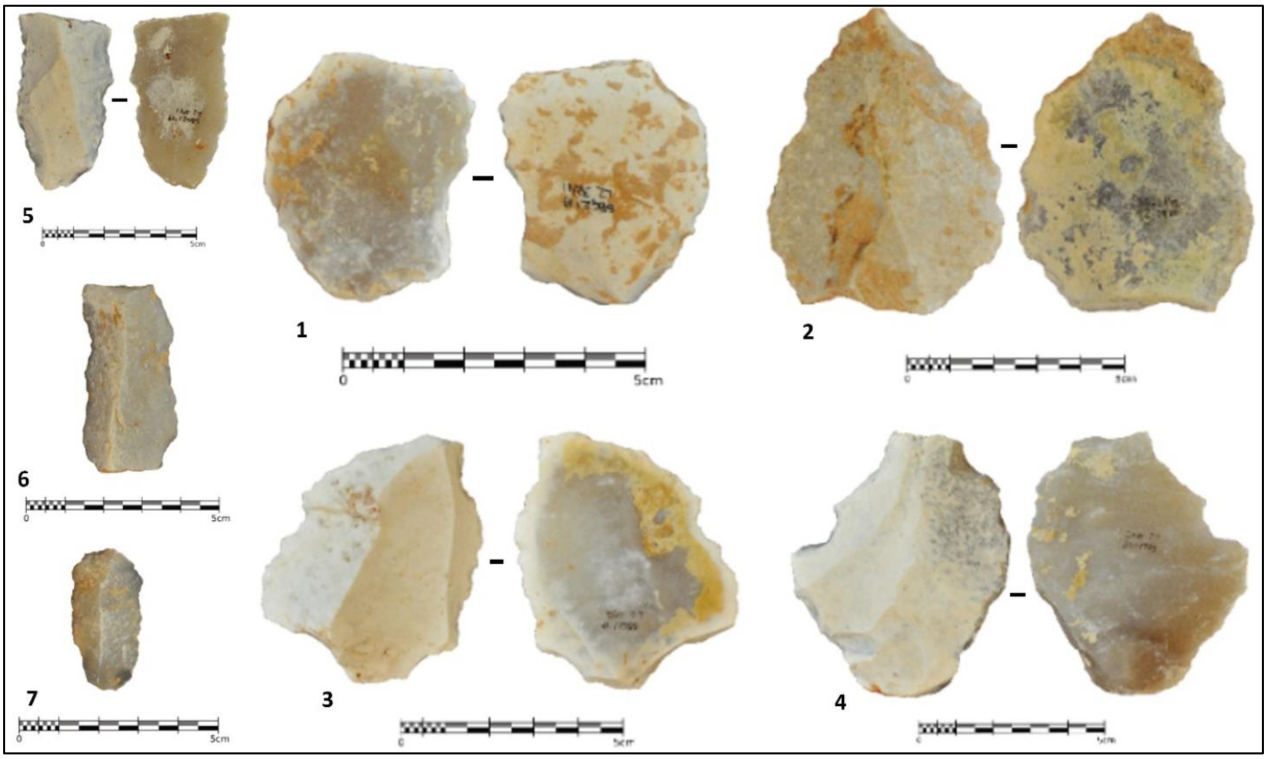


Figure 4.11. SBG2.L2 knapping products: 1 to 4 flakes (2-3-4 Levallois), 5-7 retouched flakes (denticulates & scrapers).

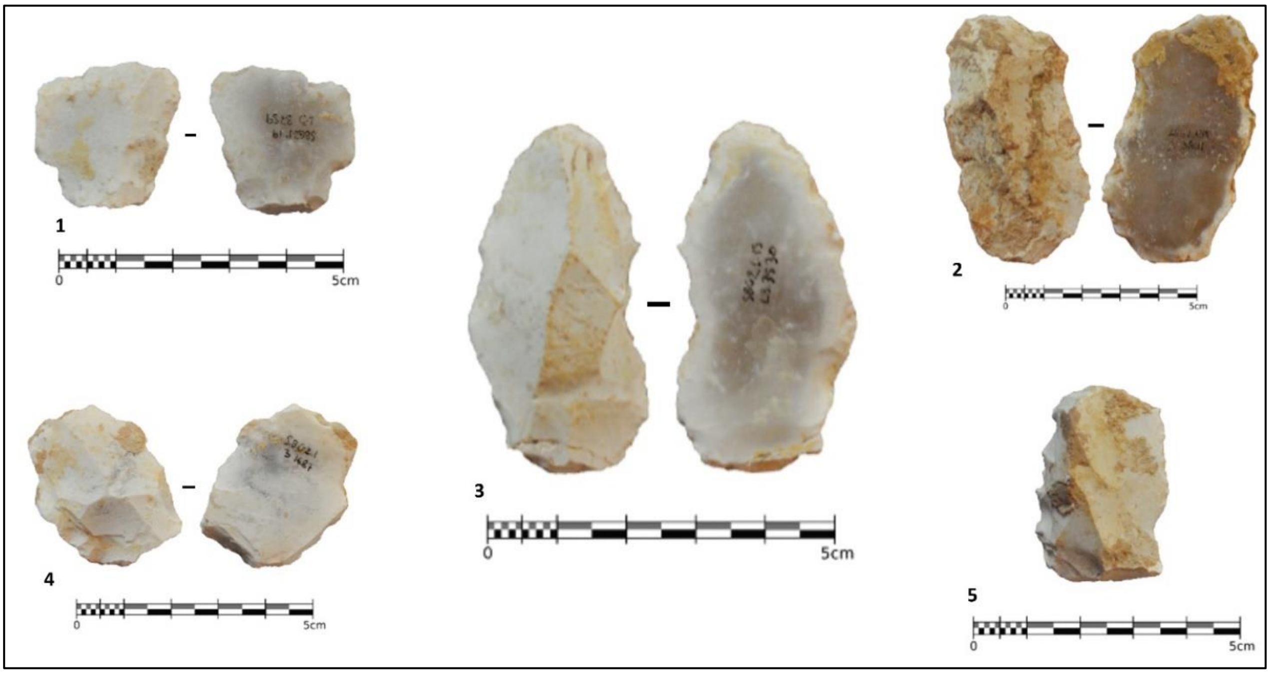


Figure 4.12. SBG2.L3 knapping products: 1,4 and3, Levallois flakes, 2. ordinary flake, 5, denticulate.

4.4. Raw materials

Raw material study have become an important discipline during the last decade, especially in development of behavioral approach, such as territories and influences zone and social interaction (Inizan et al., 1999b). The analysis is based basically on the raw material sources, variability, abundance and use. The study of Aïn Beni Mathar-Guefaït (ABM-GFT) raw material procurement areas has been carried out by systematic surveys on an area of around 100 Km to recognize the potential sources used by humans' populations in the area during the Quaternary (Soto et al. 2021).

The SBG 1 & 2 sites are located in the Swiwina basin, a huge chert procurement area in primary position. Regarding the material used in the SBG 1 & 2 lithic assemblages cherts are predominant in all the levels 99.1% (N=100), followed by only one core on rhyolite 0.9% (N=1) from the SBG1.L1.

Raw material procurement areas

The ABM-GFT area is an important region for the study of the Prehistory and Human evolution because the high number of archaeological sites discovered, covering from Early to the Holocene. The study of the potential procurement areas has included a part of the systematic surveys, the sampling and the characterization of the different raw material discovered (Soto et al. 2021). The results allowed to identify four potential procurements areas (Fig. 4.9):

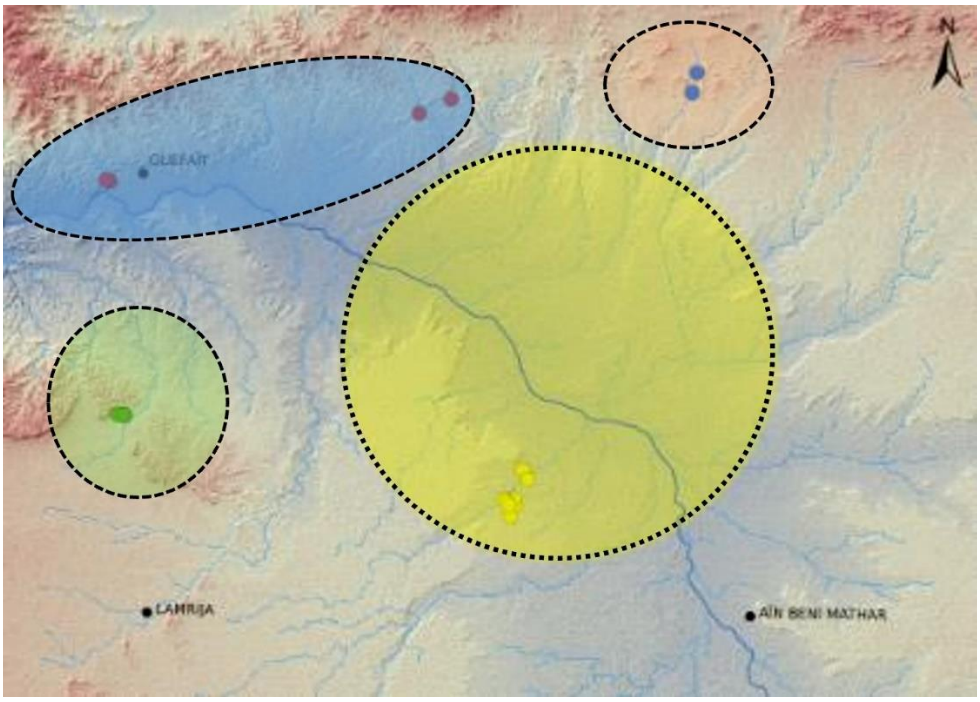


Figure 4.13. Raw material procurement locations. blue points, Ain Beni Mathar source. Green point, Hakam area. Yellow points, swiwina basin. Red points, Guefait area (M. Soto et al. 2021).

(1) Swiwina basin, it's an area with a range between 20-40 km2 formed by Neogene deposits consist by gypsarenites, secondary gypsums, gypsiferous marls and limestones. The raw materials in this area are founded in primary position and there

are mainly fine-grained cherts present in nodules or mega-nodules formations. The sites of SBG1 and SBG2 are located in this procurement area.

(2) Aïn Beni Mathar-Jerada, it's an area in a range of 20-40 km of radius, formed by carboniferous lithologies consist of biosparthic and microsparthic limestones. The raw materials in this area found mainly in secondary position: rhyolites, aphanitic equigranular basalts and hematite.

(3) Hakam area is located in the North-Northeast of the region with a range of 40-60 km of radius. It is formed by Triassic stromatolithic limstones and frequent chert veins (30-50 cm of thickness). The chert is fine grained, dark-grey to red-yellowish colored.

(4) Guefaït area is located in the north in a range of 20-80 km. It is formed by a Lias formation of recrystallized limestones and lithographic dolomites and jaspoid cherts. The cherts are fine-grained with a grey, red to white colors.

For the core assemblage from SBG1 and 2 sites, the two types of raw material observed are mainly from Swiwina (99.1%) and the only core of rhyolite could come from the Aïn Beni Mathar area where this type of stone has been identified (Fig. 5). even that in lot of simples study the support wasn't clear due to the advance reduction of cores; there is a high use of sub-primary raw material of weathering fragments or crioclasts as a flaking support especially in level 1 in both localities (Fig. 4.10 and 4.11).

Figure 4.14. The Raw material of SBG site. A. Mega-block located near SBG2. B. Nodule of silex located in swiwina basin near El Hai River. C. small blocks and fragments in Swiwina basin. Photos by M. Soto/MIAS-UAM & M.G. Chacón/IPHES.

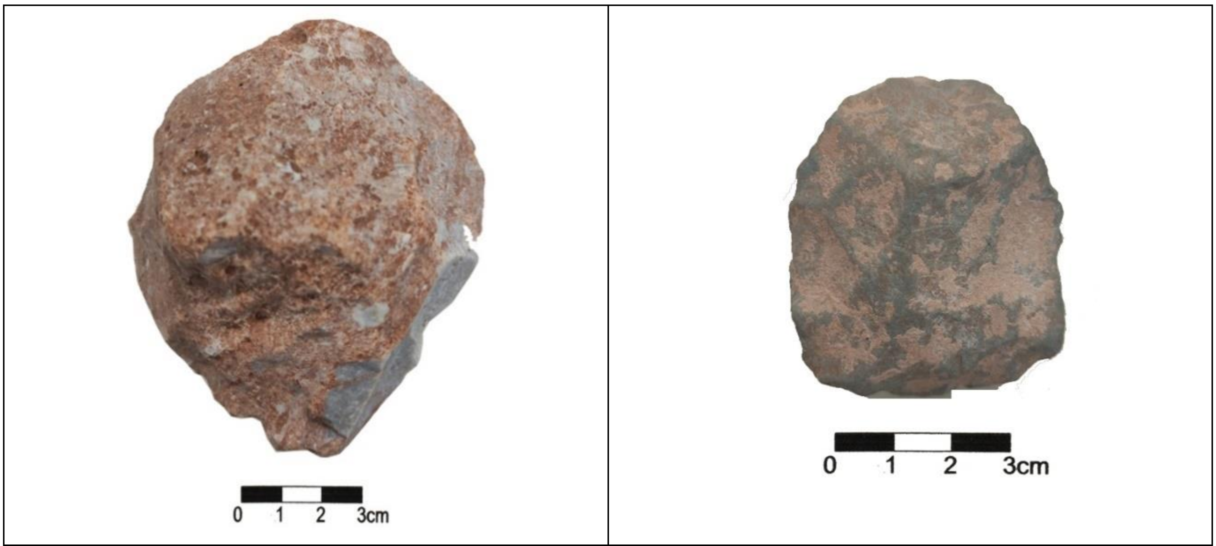


Figure 4.15. Chert core on a local weathering fragment (crioclast from Swiwina area). 2, Rhyolite core from Aïn Beni Mathar area.

5. MATERIALS

The assemblage that provided the data set for this study was recovered from the open-air sites Sahb el Ghar 1 (SBG1) and 2 (SBG2) at Ain Beni Mather region in the province of Jerrada. Excavation were conducted as a part of the Spanish-Moroccan project, directed by the IPHES-CERCA (Instituto Catalán de Paleoecología Humana i Evolució Social), in Tarragona, and Mohammed I University (Oujda, Morocco) (Chacón et al., 2018). the assemblage study results from the combination of data collected during the 2018 and 2019 fieldwork, Sahb El Ghar have been systematically excavated in two different localities with a distance of 1.5 km and covering a total of 9m^2 in each site, all the remains are essentially lithic industry with total absence of fauna. For SBG 1 regarding the surface material we identified one stratified archeological level yielded large numbers of cores and flakes with total of (n=2435) lithic artifacts. In the second locality SBG 2, three levels have been identified with a total number of (n=3786). With the large number of lithic industries, we focus in studying the technological and knapping process that have been yield in site through analyzing cores, core fragments, core on flake and core on flake fragments. The table below shows the number and percentage of cores categories in each level of both localities (Table 6).

Table 6. Distribution of core assemblage in SBG sites.

		Category			
		Core	**Core on Flake**	**Core on flake fragment**	**Core Fragment**
SBG1.L1	**N=60**	47	7	2	4
	%	78.3%	11.7%	3.3%	6.7%
SBG2.L1	**N=23**	15	5	-	3
	%	65.2%	21.7%	-	13%
SBG2.L2	**N=6**	5	-	-	1
	%	83.3%	-	-	16.7%
SBG2.L3	**N=12**	9	2	-	1
	%	75%	16.7%	-	8.3%

5.1 Data collection Procedure

During the field work, database was created in ARCH.e fieldwork system software and transformed to Microsoft excel software in order to renewal, complete and modified the database. the data collected during the excavation fieldwork, that have been used in this study are: site name, year, level, ID number for each simple with, X,Y,Z coordinate (Fig. 5.1).

Figure 5.1. desktop of the ARCH.e fieldwork system software.

The data have been exported to a Microsoft excel file where the rest of attributes describe in methodology chapter (3) have been added to modified and complete the laboratory analysis process. For the statistical analysis, we use IBM SPSS Statistics version 26 combine with Microsoft excel.

5.2 Material treatment

The cores treatment has been carried out in two different localities, the first during the fieldwork seasons where all the cores have been cleaned using water, brushes, and wood sticks as a first phases. The materials have been dipping in a water solution and scrub with brush or wood sticks in attempt to clean the material from sediments and concretions, then rested for 24 hours before marks them with (site name, year, level and ID number). In some cases, the first phase was not enough due to the concretions thickness layer in the material as have been observed specially in SBG2.L2 and SBG2.L3, therefore the second phase have been applied.

The second phase by an HCL solution. We use 1L of solvent contain 900ml of water plus 100ml of acid following the process below:

- Dipping the cores for 10 minutes in a solvent of 10%HCL.

- Take it out and cleaned by water with attempt to remove the concretion layer.

- Dipped again in a water solution to stop the chemical reactions for 24 hours.

- Take of the cores again and clean it with a paper sheet and leave it for other 24 to dry.

In some cases (2 cores of SBG2.L2 and 6 cores of SBG2.L3) the treatment with HCL solvent have been applied two times (Fig. 5.2).

Figure 5.2. HCL process applied to clean materials. 1. HCL solution, 2. material selected, 3. preparation of the solvent, 4. dipping the cores with solvent, 5. 10 min in solvent, 6. cleaning Material with water, 7. dipping in water solution.

6. RESULTS

6.1 General features

The SBG open-air site yielded 4.143 lithic products, divided in 2348 in SBG1 from a 9m^2 test-pit and 1.754 in SBG2.1 from 7m^2 test-pit (Level 1=715, level2=655, Level 3=384). The cores included in this analysis were recovered from both localities and represents the 2.44% (N=101) of the lithic assemblage, including 60 cores in SBG1 and 41 cores in SBG-2 (level 1=23, level 2=6, level 3=12).

The cores of the assemblage have been organized in four categories. The more frequents are cores 75.2% (N=76), followed by core-on-flake 13.8% (N=14), core fragments 9% (N=9) and core-on-flake fragments 2% (N=2). Table 1 represents the count per category in each level (Table 7).

Table 7. Categories of cores assemblage study in SBG1 &2 localities.

		SBG1		SBG2.1						Total	
		Level		Level							
		1		1		2		3			
		N	%	N	%	N	%	N	%	N	%
Categories	**Core**	47	78.3%	15	65.2%	5	83.3%	9	75%	76	**75.2%**
	Core on Flake	7	11.7%	5	21.7%	-	-	2	16.7%	14	**13.8%**
	Core on Flake fragment	2	3.3%	-	-	-	-	-	-	2	**2%**
	Core Fragment	4	6.7%	3	13%	1	16.7%	1	8.3%	9	**9%**
Total		**60**	**59.4%**	**23**	**22.7%**	**6**	**5.9%**	**12**	**11.9%**	**101**	**100%**

Two types of raw material were identified in the assemblage. The local high-quality chert is clearly the dominant one, representing the 99% of the material. A core on rhyolite is the only element documented in a raw material other than the local chert. Due to the extensive exploitation, only 55% of the cores' support have been identified. The dominant support for the manufacturing of cores are the cryoclastic chert fragments derived from the gelifraction action on the larger blocks, representing the 47.9% (N=48) followed by large flakes with the 6.9% (N=7) and nodules with the 1% (N=1).

The metric measurements of the cores volume (length*width*thickness) are quite variable, an overall mean varying between 370.1 cm^3 and 94 cm^3. The standard deviation (S.D) shows a variable distribution in each level. In SBG1.L1 the S.D is 142.9 which the small size cores are most abundant in the assemblage and five large cores fall outside the normal size range. In SBG2.L1 the S.D is 892.2 with an equality of size range related to the mean. In SBG2.L2 the S.D is 85.4 dominated by small cores. In SBG2.L3 the S.D is 80.4 with an equal distribution of the size range. The boxplot shows the outliers cores of the normal range, even these outliers do not represent the cores size range, however it's very important to provide information about the large cores managed by SBG stone knappers (Fig. 6.1).

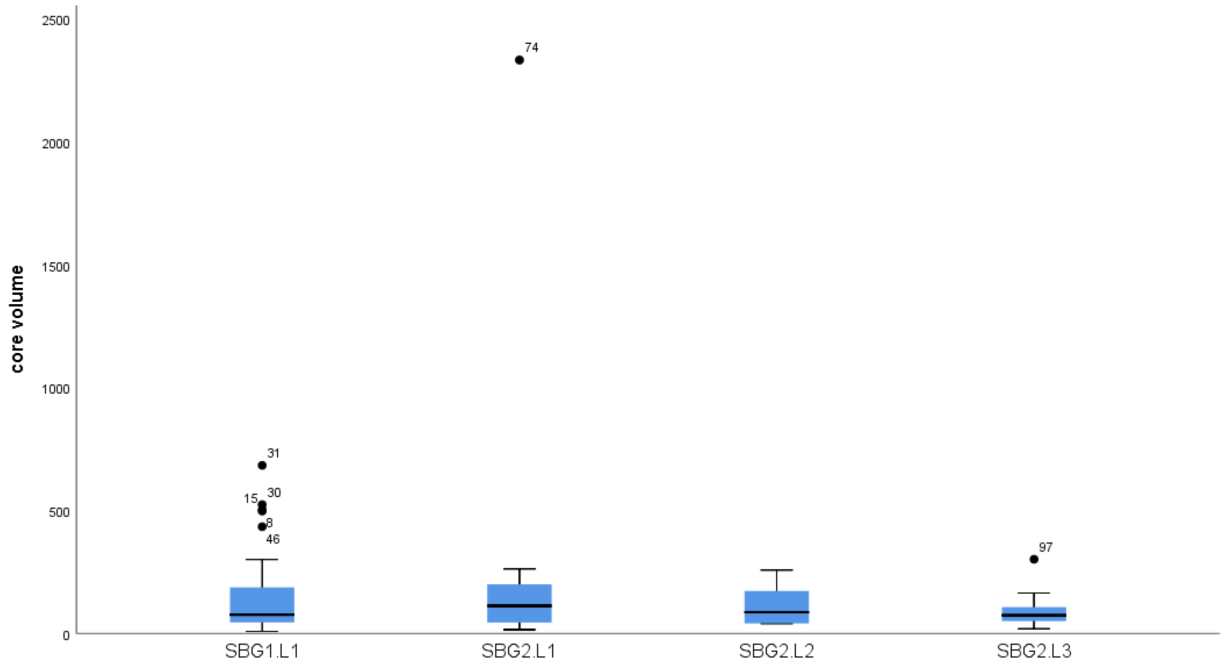


Figure 6.1. Boxplot of Length x width x thickness of cores in both localities.

The average of cores volume in the SBG 1 &2 assemblages is high in level 1 of both localities compared with level 2 and 3. Starting with SBG1.L1 there is a huge variability between the core volume, the average between the maximum volume is 684 cm3 and the minimum is 8 cm^3. The same in SBG2.L1 were the average between the maximum and minimum is 3853 cm^3 and 15 cm^3 respectively, these results indicate that the cores of both localities show a differentiation in the reduction management of the cores specially that the cores cases present more that 10% (Large cores) (Fig. 1 & 2), this variability is maybe caused due to palimpsest deposits of different human occupations timing. In SBG2.L2 and specially in L3 the variation of cores volume is much less different, in L2 the maximum size is 257 cm^3 and the minimum is 40 cm^3, with the same average in L3 the maximum size is 302 cm^3 and the minimum is 19 cm^3, these results and compared with previous one (S.D) refer to systematic core size before discarded. this systematic reduction will be explained and observed if it's related to a specific core reduction method in the other results.

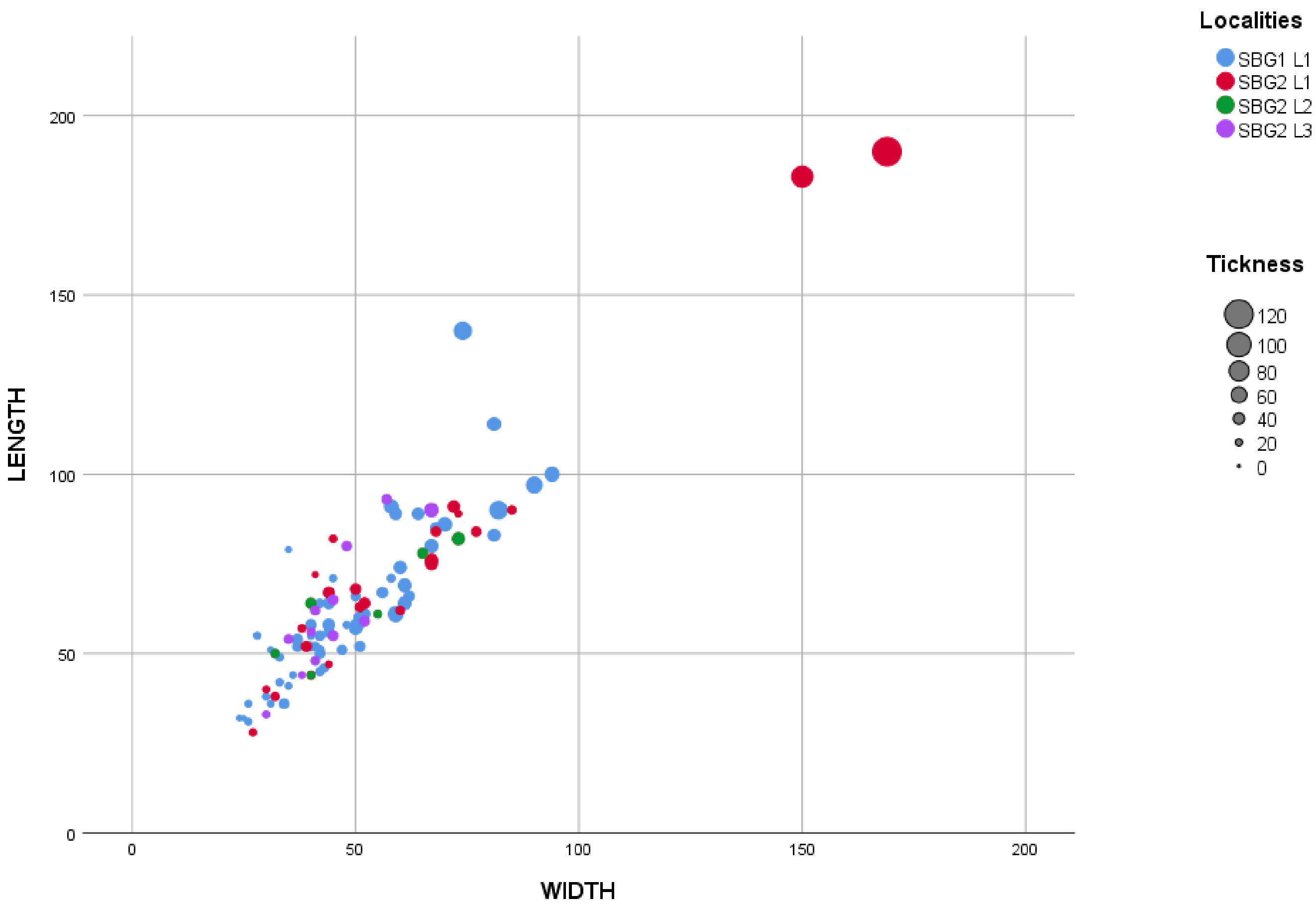


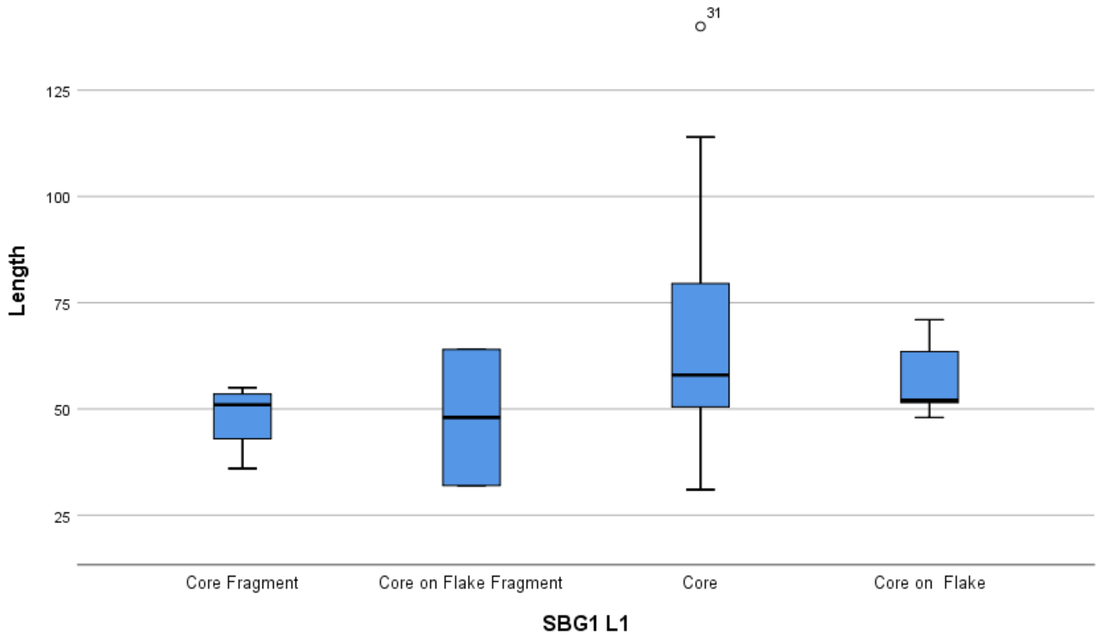
Figure 6.2. Distribution of the cores according to size dimensions in both localities.

6.2 Sahb El Ghar 1 (SBG1. L1)

The locality of SBG1 have been excavated in 2018, in a surface of $9m^2$ test-pit. Only one archaeological level has been identified. A total of 2390 lithics remains have been collected. The 44.3% (N=1061) has an anthropic origin and the 55.7% (N=1329) are natural fragments or geofacts. The cores studied from this site present the 5.7 % (N=60) of the knapped products.

Core size

Metric measurements of SBG 1 cores have been studied according to core type categories. The length mean differs between 58 mm and 48 mm. The standard deviation cores and core on flake fragments has similar values 22 and 23 respectively, but cores on flake and core fragments show the lowest value of 10 and 8 respectively. The width has a different variability between core types, the high value of mean observes in cores (58) followed by core on flake (41), core fragment (36) and core on flake fragments (33), for the standard deviation the high value observed in cores (17) followed by core on flake fragments (13), 8 in core of flakes and core fragments (7). The thickness mean differs between 36 observed in cores and 19 in core on flake fragment. The standard deviation varies from 14 in cores to 5 in core fragment categories (Fig. 6.3).



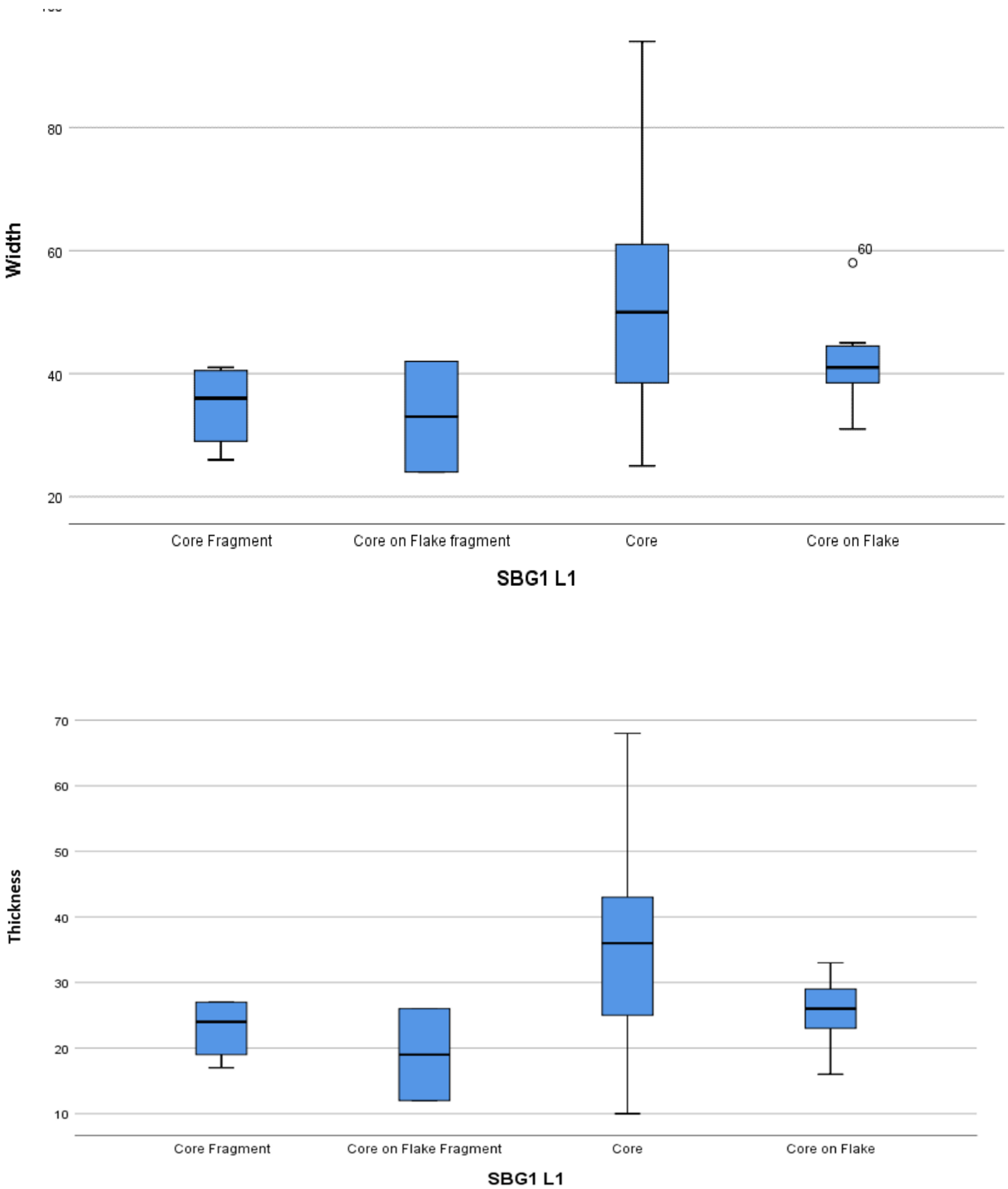


Figure 6.3. Boxplots of length, width, and thickness in SBG1.L1 according to categories**.**

6.2.1 Taphonomical attributes

Table 8. Taphonomical cores attributes in SBG1.L1.

Attributes	Stat	SBG1 Level 1	
		N	%
Patina degree	**High**	38	63.3%
	Medial	22	36.6%
Double patination	**No**	35	58.3%
	Yes	25	41.7%
Rounding degree	**Fresh**	6	10.0%
	Heavily	14	23.3%
	Slightly	40	66.7%
fracture	**No**	33	55.0%
	Yes	27	45.0%

The macroscopical analysis of SBG 1 assemblage show a high degree of patina 63.3% (N=38) and medial 36.6% (N=22) in which 41.7% (N=25) present double patina. The double patination observed in assemblage is caused by both post-depositional factors and re-use of some cores. Therefore, other analysis regarding recycling behavior have been added in the second part of the results chapter. Most of the cores show a slight degree of rounding 66.7% (N=40) followed by heavily with 23.3% (N=14) and fresh cores 10% (N=10). Because of the weathering process specially the seasonal temperature changes (cold and hot periods) and in order to understand the effect of it in the assemblage we add the Ice fractures attribute as an index for the core exposition in surface, the results show that 45% (N=27) of cores has a mark of fractures (Table 8).

The dominant types of alterations in SBG 1 assemblage are concretion 99% present as a thin layer caused by the precipitation of carbonate associated with the post-depositional process such as weathering and water activities in SBG 1. The second type is patina which resulted from water flew activity. The patina presents different degree in the assemblage. There is a predominance by high degree with a 63.3% of patina (these pieces present a total white layer on their surface) followed by median patina 36.6% (partial parts of patina in the surface). The rounding degree is the third type of alteration-Most of the core show a slight 66.7% or fresh 10% rounding edges. The ice fractures 45% are the final natural modifications observed in the assemblage normally caused by the withering specially the seasonal changes of cold and warm temperature in the area which effect the exposed material in surface.

6.2.2 Technological attributes

Core Cortex

The majority of cores in SBG 1 present cortex (Fig. 4). Very few cores show no cortex 6.7% (N=4) and only two cores 3.3% a high cortex degree (≥75% of cortex). Medium cortical cores (25-50% cortex) are the most abundant in the assemblage with a percentage of 38.3% (N=23), 28.3% (N=17) for core with less than 25% of cortex cores and 23.3% (N=14) for cores with cortex between 50-75%. The Figure 6.4 expressed the result of cortex percentage in the SBG 1 assemblage.

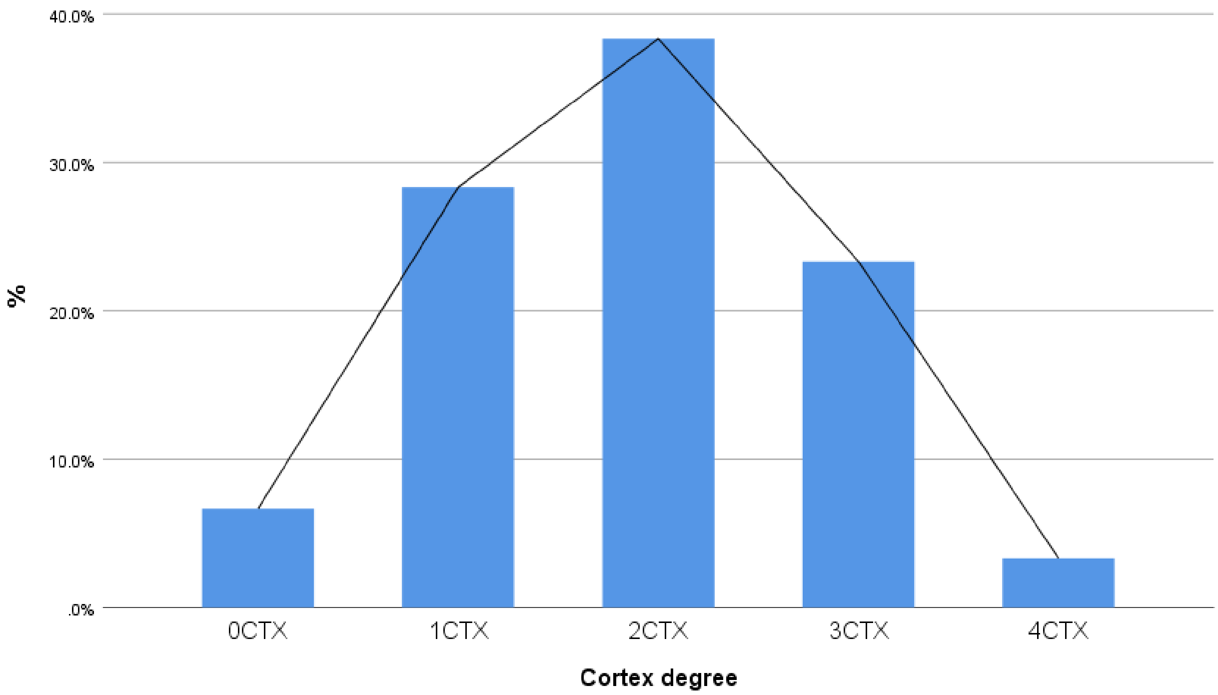


Figure 6.4. Bar-chart of cortex degree in SBG1.L1 assemblages.

Faciality & General polarity

The reduction strategies applied (Fig. 6.5) in SBG 1 site is dominate by bifacial cores (75 %-N=45), mainly bipolar bifacial multipolar cores (33.7%, N=20) and bipolar bifacial centripetal (31.7%, N=19) followed by bipolar bifacial longitudinal with a 6.7% (N=4) and bipolar bifacial opposed & orthogonal with one core of each strategy.

Unifacial cores are the second reduction strategy applied in the site with a percentage of 20% (N=12) distributed as follow: Unipolar Unifacial Centripetal cores 10% (N=6), Unipolar Unifacial Longitudinal 6.7% (N=4) and Unipolar Unifacial Orthogonal with two cores 3.3%. The trifacial cores are very few presented in the site with only 3 cores (5%) with the same reduction strategy Multipolar Trifacial Multipolar.

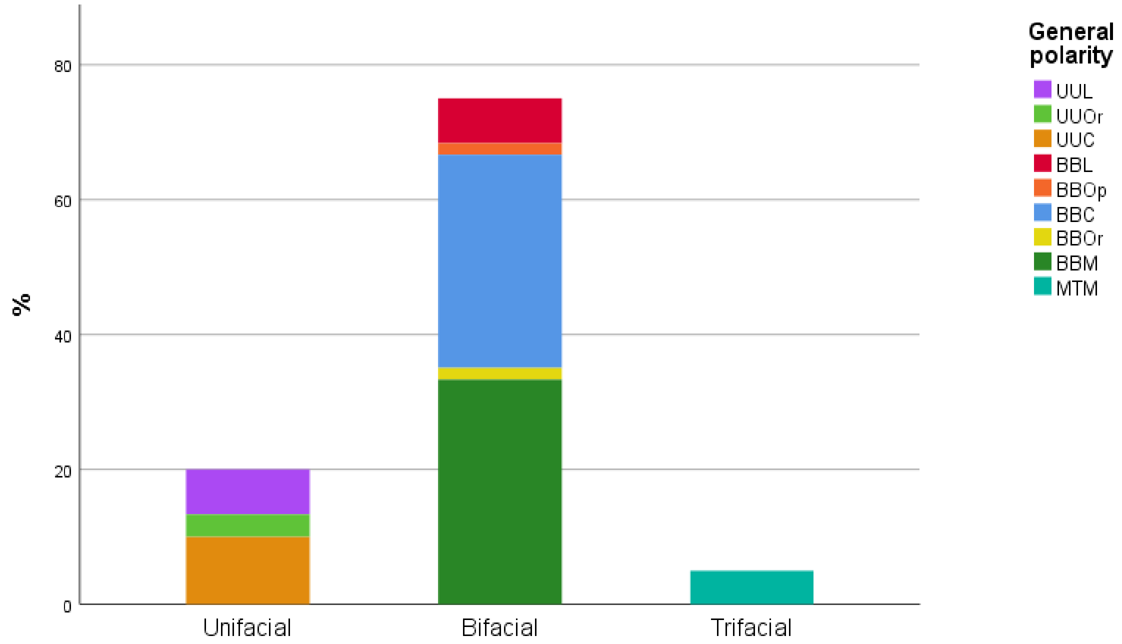


Figure 6.5. Staked bar of faciality by general polarity in SBG1.L1.

Morphology

There is not a predominance of a specific morphology in SBG1 core assemblage. All the study material has a variability between horizontal, transversal, and sagittal morphology (Fig. 6.6). First with the horizontal view of cores eight types have been identified. Pentagonal and triangular show the high frequencies with 23.3% (N=14) and 21.7% (N-13) respectively, followed by circular, rectangular, ovoid, and trapezoid morphology with a frequency between 13.3% and 10% (N= 8 and 6 respectively). Finally, three cores present rhomboid and semi-circular horizontal morphology each (5%).

The transversal morphology is mainly triangular 35% (N=21) and rhomboid 26.7% (N=16), followed by trapezoid and rectangular morphology with 20% (N=12) and 15% (N=9) respectively, and only two pentagonal cores (3.3%).

For the sagittal morphology six types are identified. The predominant are trapezoid 28.3% (N=17), triangular 23.3% (N=14) and rhomboid 20% (N=12), followed by rectangular 16.7% (N=10), pentagonal 10% (N=6) and only one circular core 1.6%.

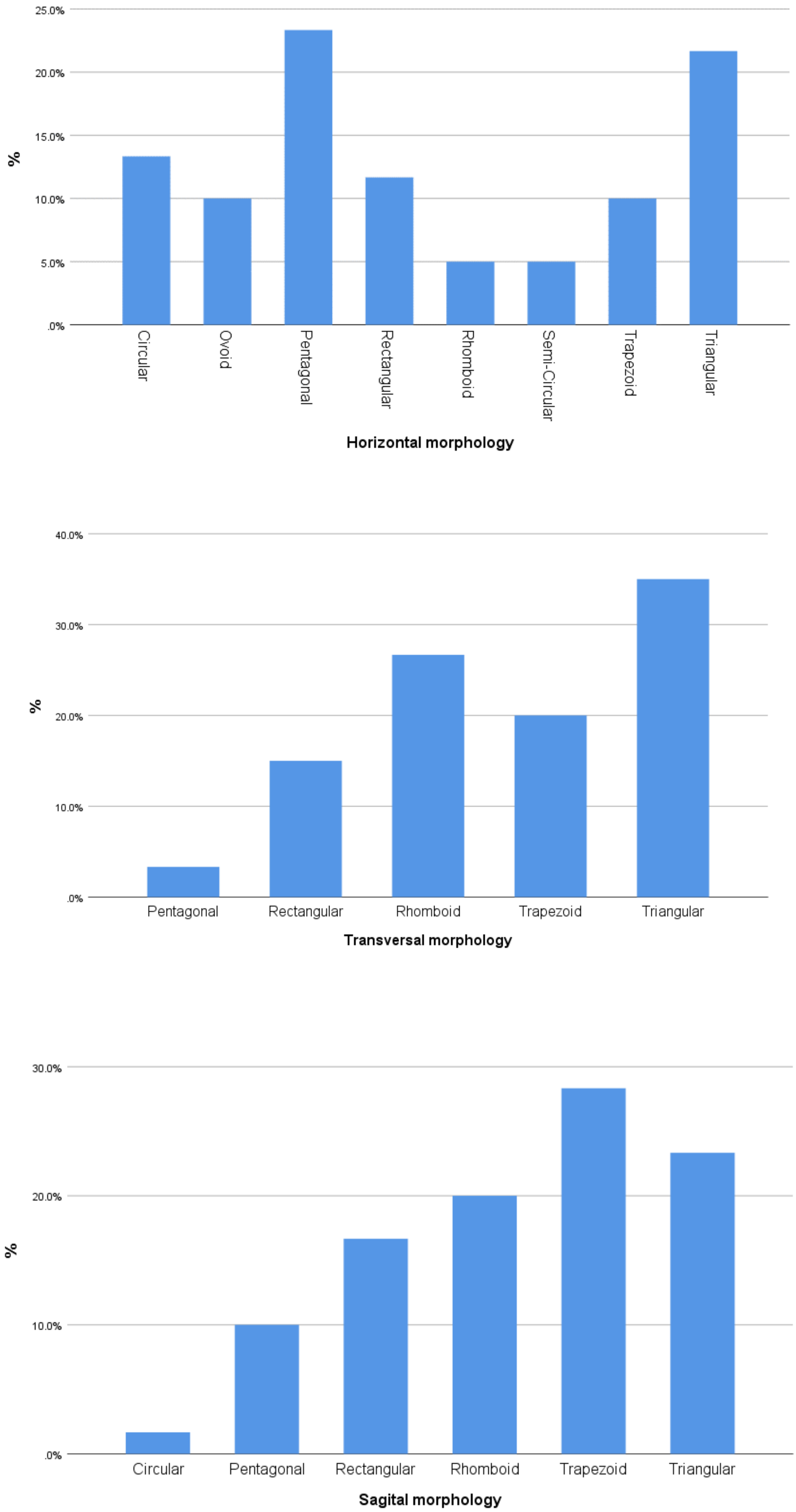


Figure 6.6. Bar-chart of horizontal, transversal and sagittal morphology of SBG1.L1 cores.

From this part of results the cores analyzed according to faciality separately taking into account five criteria in each surface, namely the angle, facial cortex, centripetal degree, number of negatives and removals organization.

Unifacial Cores

Table 9. Facial attributes of unifacial cores.

		UUC		UUL		UUOr	
		N	%	N	%	N	%
Facial cortex	**2CTX1**	3	25%	3	25.0%	1	8.3%
	0CTX1	3	25%	1	8.3%	1	8.3%
Angle	**Plane**	4	33.3%	4	33.3%	1	8.3%
	Semi-Abrupt	2	16.7%	-	-	1	8.3%
extent of removals	**mm**	-	-	1	8.3%	-	-
	mp	2	16.7%	1	8.3%	1	8.3%
	p	1	8.3%	2	16.7%	-	-
	t	3	25%	-	-	1	8.3%
Removals organization	**Orthogonal**	-	-	-	-	2	16.7%
	Centripetal	6	50%	-	-	-	-
	Longitudinal	-	-	4	33.3%	-	-

Facial cortex

The cortical cover is medium 58.3% (N=7) or absence 41.7% (N=5) for the Unifacial cores. grouping by reduction types UUC and UUOr have an equal number of cores with and without cortex 50% (N=3) and 50% (N=1) respectively, while UUL cores where the cortical types are dominant 75% (N=3) (Table 9).

Angle

To type of angle are identified in the unifacial cores. The predominant <re plane 75% (N=9) in which UUC and UUL show a high frequency with 33.3% (N=4) each, followed by semi-abrupt 25% (N=3). This type of angle is also recognized in two UUC cores and one orthogonal (Table 9).

The Extent of removals

The extend of removals shows the same result between the total removals and very extensive removals 33.3% (N=4) each, followed by extensive 25% (N=3) and one core with very marginal removals.

Removals organization

Three types of removals organization have been observed in the assemblage and the half of the unifacial cores presents a centripetal direction with 50% (N=6), followed by longitudinal 33.3% (N=4) and orthogonal directions with two cores 16.7% (Table 9).

Number of removals

The number of removals is very varying from 1 until 12. The mean of removals is 4.08 with a standard deviation equal to 3.28 (Table 10). grouping according to cores organization the UUL cores show only one removal (N=4). By the contrary, the UUC and UUOr show much more exploitation, in the two UUOr cores one with 4 removals and other with 8 removals, while the UUC cores contains five cores with removals number between 3 and 5 (Table 11) and one core with 12 removals. This high value suggests that UUC and UUOr have been exploited more intensive, especially in the case of the centripetal ones.

Table 10. descriptive statistics of removals number in unifacial core.

Mean	**S.D**	**Minimum**	**Maximum**
4.08	3.288	1	12

Table 11. Distribution of negative numbers according to unifacial categories cores.

		UUC			**UUL**			**UUOr**		
		N	**% By type**	**% In total**	**N**	**% By type**	**% In total**	**N**	**% By type**	**% In total**
Number of removals	**1**		-	-	4	100%	33%	-	-	-
	3	1	16.7%	8.3%	-	-	-	-	-	-
	4	2	33.3%	16.7%	-	-	-	1	50%	8.3%
	5	2	33.3%	16.7%	-	-	-	-	-	-
	8		-	-	-	-	-	1	50%	8.3%
	12	1	16.7%	8.3%	-	-	-			

Bifacial cores

The analysis of the bifacial cores has been separated according to the first and second surfaces. The first surface has been identified based on two criteria, first according to facial cortex in which the first surface has no cortical cover, and in the case of some cores characterized by the presence or the absence of cortex in both surfaces, the first surface has been identified according to the higher number of negatives.

First surface

Facial cortex

The cortex in the first surface is very low (Table 12), 62.2% (N=28) of bifacial cores have no cortex. On the contrary 37.8% (N=17) have a cortex with different degree, 8 cores with less than 25% of cortex, 6 with 25-50 % of cortex, and 3 cores with 50-75% of cortex. Related to the general polarity (Table 7), the bipolar bifacial centripetal cores show higher frequencies without cortex 78.9% (N=15) followed by bipolar bifacial multipolar cores 55% (N=11) and bipolar bifacial longitudinal 50% (N=2).

Table 12. percentage of cortical degree in first surface of bifacial cores.

		0ctx1	1ctx1	2ctx1	3ctx1
BBC	**N**	15	1	2	1
	% by type	78.9%	5.3%	10.5%	5.3%
	% in total	33.3%	2.2%	4.4%	2.2%
BBL	**N**	2	1	1	-
	% by type	50%	25%	25%	-
	% in total	4.4%	2.2%	2.2%	-
BBM	**N**	11	6	1	2
	% by type	55%	30%	5%	10%
	% in total	24.4%	13.3%	2.2%	4.4%
BBOp	**N**	-	-	1	-
	% by type	-	-	100%	-
	% in total	-	-	2.2%	-
BBOr	**N**	-	-	1	-
	% by type	-	-	100%	-
	% in total	-	-	2.2%	-

The angle

The simple angle is the most abundant in SBG1 bifacial core with a frequency of 46.7% (N=21) followed by semi-abrupt, 28.9% (N=13), plane, 13.3% (N=6) and abrupt angle, 11.1%, (N=5). Grouping by polarity (Table 13), The BBC cores contain the higher frequency 73.4% (N=14) of simple surface angle, followed by plane and semi-abrupt angles in two cores each (10.5%) and

1 core (5.3%) with an abrupt angle. The BBM cores are dominated by semi-abrupt surface angle, 50% (N=10), followed by the simple angle, 25% (N=5), 3 cores (15%) with abrupt and 2 (10%) with plane surfaces angle. The BBL cores show an equal distribution with one core of each of the angle types. While the single BBOp and BBOr cores show plane and simple angles respectively.

Table 13. percentage of the first surface angle types in bifacial cores.

		Abrupt	Plane	Semi-Abrupt	Simple
BBC	**N**	1	2	2	14
	% By type	5.3%	10.5%	10.5%	73.7%
	% In total	2.2%	4.4%	4.4%	31.1%
BBL	**N**	1	1	1	1
	% By type	25%	25%	25%	25%
	% In total	2.2%	2.2%	2.2%	2.2%
BBM	**N**	3	2	10	5
	% By type	15%	10%	50%	25%
	% In total	6.7%	4.4%	22.2%	11.1%
BBOp	**N**	-	1	-	-
	% By type	-	100%	-	-
	% In total	-	2.2%	-	-
BBOr	**N**	-	-	-	1
	% By type	-	-	-	100%
	% In total	-	-	-	2.2%

Extent of removals

The extent of removals in SBG1 is dominant by total extent in first surface with 62% (N=28) followed by a very extensive 15.6% (N=7) and marginal extent 11.1% (N=5). The 62% of total extent appear in high frequencies in bipolar bifacial centripetal cores 33.3% (N=15) followed by bipolar bifacial multipolar 24.4% (N=11) and finally bipolar bifacial longitudinal 4.4% (N=2). The table below show the distribution of extent of removals according to the general polarity (Table 14).

Table 14. percentage of the extent of removals in bifacial core first surface.

		m	mm	mp	p	t
BBC	N	2	-	1	1	15
	% by type	10.5%	-	5.3%	5.3%	78.9%
	% in total	4.4%	-	2.2%	2.2%	33.3%
BBL	N	-	-	1	1	2
	% by type	-	-	25%	25%	50%
	% in total	-	-	2.2%	2.2%	4.4%
BBM	N	3	-	4	2	11
	% by type	15%	-	20%	10%	55%
	% in total	6.7%	-	8.9%	4.4%	24.4%
BBOp	N	-	-	1	-	-
	% by type	-	-	100%	-	-
	% in total	-	-	2.2%	-	-
BBOr	N	-	1	-	-	-
	% by type	-	100%	-	-	-
	% in total	-	2.2%	-	-	-

Removals organization

Five types of removals direction have been identified in the assemblage (Table 15), the most abundant is centripetal direction 57.8% (N=26), followed by multipolar, longitudinal and opposed direction with almost the same frequencies (N=5, 5, 4) and orthogonal and cordal direction with three and two cores respectively.

The BBM are the cores with a higher variability in the organization of removals, the first surface is dominated by centripetal 35% (N=7) and multipolar directions 25% (N=5), followed by opposed direction 15% (N=3), orthogonal and cordal with the same value 10% (N=2) and one core with longitudinal direction 5%.

Table 15. percentage of directional removals in first surface of bifacial cores.

		Opposed	Orthogonal	Centripetal	Cordial	Longitudinal	Multipolar
BBC	**N**	-	-	19	-	-	-
	% by type	-	-	100%	-	-	-
	% in total	-	-	42.20%	-	-	-
BBL	**N**	-	-	-	-	4	-
	% by type	-	-	-	-	100%	-
	% in total	-	-	-	-	8.90%	-
BBM	**N**	3	2	7	2	1	5
	% by type	15%	10%	35%	10%	5%	25%
	% in total	6.70%	4.40%	15.60%	4.40%	2.20%	11.10%
BBOp	**N**	1	-	-	-	-	-
	% by type	100%	-	-	-	-	-
	% in total	2.20%	-	-	-	-	-
BBOr	**N**	-	1	-	-	-	-
	% by type	-	100%	-	-	-	-
	% in total	-	2.20%	-	-	-	-

Number of negatives

The mean of the number of negatives is high in the first surface of centripetal (7), multipolar (6) and longitudinal (5), suggesting an intensive exploitation in order to extend the core flaking potential, especially in centripetal (Fig. 6.7, Table 16), eight cores show a very high number between 7 and 11 of negatives, the rest (N=11) show a medium number between 4 and 6 negatives. In the bifacial multipolar, six cores are characterized by high number of negatives (between 7 and 9), the rest (N=14) show a medium value between 3 and 6 negatives. The longitudinal cores show an equal value (N=2) between high number of negatives (6 and 8) and low number of negatives, between 2 and 3. The opposed and orthogonal cores show the lowest number of negatives (3 each core).

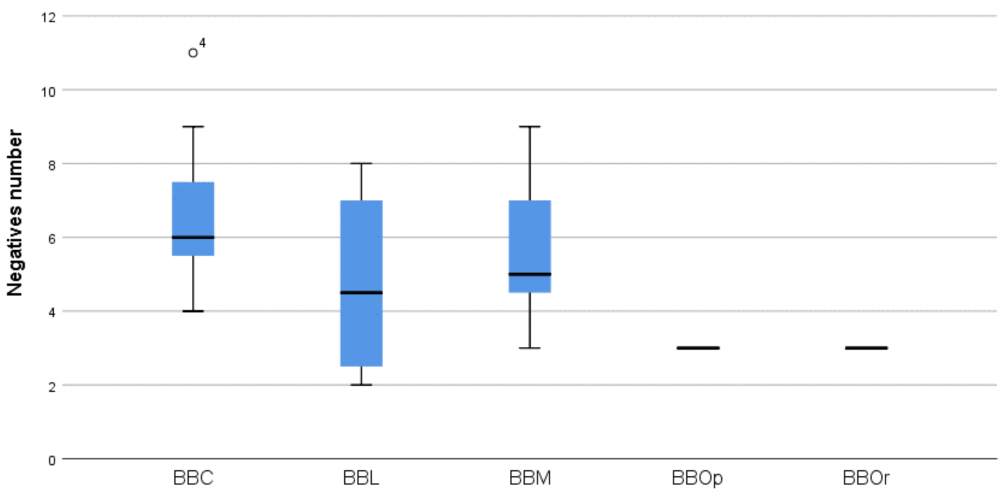


Figure 6.7. Boxplot of removals numbers in first surface of bifacial core types

Table 16. Distribution of the first surface negative's number in bifacial cores

		BBC		BBL		BBM		BBOp		BBOr	
		N	%	N	%	N	%	N	%	N	%
Number of negatives	2	-	-	1	2.2%	-	-	-	-	-	-
	3	-	-	1	2.2%	3	6.7%	1	2.2%	1	2.2%
	4	1	2.2%	-	-	2	4.4%	-	-	-	-
	5	4	8.9%	-	-	6	13.3%	-	-	-	-
	6	6	13.3%	1	2.2%	3	6.7%	-	-	-	-
	7	3	6.7%	-	-	4	8.9%	-	-	-	-
	8	2	4.4%	1	2.2%	-	-	-	-	-	-
	9	2	4.4%	-	-	2	4.4%	-	-	-	-
	11	1	2.2%	-	-	-	-	-	-	-	-

Second surface

Facial cortex

In bifacial cores, the second surface show a presence of cortex in the 91.1% of the cases (N=41). The frequencies of cortex are devised as follow, 31.1% (N=14) have a 25-50% cortex in the preparation surface, 28.9% (N=13) with 50-75% of cortex, 34.4% (N=11) with less than 25% cortex and three cores with more than 75% of cortex. Regarding the distribution according to polarity, all the bipolar bifacial centripetal show a high percentage of cortex remains, the bipolar bifacial multipolar core shows a regression in the corticality of the preparation surface and high frequencies of no-cortex in the assemblage. This result is presented in table 17.

Table 17. Percentage of cortex degree in second surface of bifacial cores.

		0CTX2	1CTX2	2CTX2	3CTX2
BBC	N	15	1	2	1
	% by type	78.9%	5.3%	10.5%	5.3%
	% in total	33.3%	2.2%	4.4%	2.2%
BBL	N	2	1	1	-
	% by type	50%	25%	25%	-
	% in total	4.4%	2.2%	2.2%	-
BBM	N	11	6	1	2
	% by type	55%	30%	5%	10%
	% in total	24.4%	13.3%	2.2%	4.4%
BBOp	N	-	-	1	-
	% by type	-	-	100%	-
	% in total	-	-	2.2%	-
BBOr	N	-	-	1	-
	% by type	-	-	100%	-
	% in total	-	-	2.2%	-

Angle

The semi-abrupt angle is most abundant in the preparation surface of bifacial cores 53.3% (N=24), followed by the abrupt angle 22.2% (N=10), simple 17.8% (N=8) and plane angle observed in three cores. The semi-abrupt angle observed in bifacial centripetal and bipolar bifacial multipolar cores appears almost with the same frequencies 26.7% (N=12) and 24.4% (N=24.4) respectively (Table 18).

Table 18. Percentage of the second surface angle types in bifacial cores.

		Abrupt	**Plane**	**Semi-Abrupt**	**Simple**
BBC	**N**	3	1	12	3
	% By type	15.8%	5.3%	63.2%	15.8%
	% In total	6.7%	2.2%	26.7%	6.7%
BBL	**N**	1	1	1	1
	% By type	25%	25%	25%	25%
	% In total	2.2%	2.2%	2.2%	2.2%
BBM	**N**	5	1	11	3
	% By type	25%	5%	55%	15%
	% In total	11.1%	2.2%	24.4%	6.7%
BBOp	**N**	1	-	-	-
	% By type	100%	-	-	-
	% In total	2.2%	-	-	-
BBOr	**N**	-	-	-	1
	% By type	-	-	-	100%
	% In total	-	-	-	2.2%

Extent of removals

The extent of removals results is similar with the corticality, because of abundance of cortex in the preparation surface. The extent of removals shows an abundance of marginal 26.7% (N=12), extensive 24.4% (N=11), very extensive24.4% (N=11), and very marginal 15.6% (N=7) removals respectively with a frequency of 91.1% of bifacial cores. The table 14 show the distribution according to general polarity (Table 19).

Table 19. Extent removals in second surface in bifacial cores.

		m	mm	mp	p	t
BBC	**N**	6	5	2	5	1
	% by type	31.6%	26.3%	10.5%	26.3%	5.3%
	% in total	13.3%	11.1%	4.4%	11.1%	2.2%
BBL	**N**	1	-	2	-	1
	% by type	25%	-	50%	-	25%
	% in total	2.2%	-	4.4%	-	2.2%
BBM	**N**	5	2	5	6	2
	% by type	25%	10%	25%	30%	10%
	% in total	11.1%	4.4%	11.1%	13.3%	4.4%
BBOp	**N**	-	-	1	-	-
	% by type	-	-	100%	-	-
	% in total	-	-	2.2%	-	-
BBOr	**N**	-	-	1	-	-
	% by type	-	-	100%	-	-
	% in total	-	-	2.2%	-	-

Removals organization

Five different removal organizations have been observed in the bifacial cores, dominated by centripetal 46.7% (N=21) followed by longitudinal 28.9% (N=13), orthogonal and opposed with the same value 11.1% (N=5) and multipolar direction in one core. Regarding the general polarity (Table 20), the diversity of removal organizations documented in bipolar bifacial multipolar cores is dominated by longitudinal direction in the preparation surface (20%) followed by opposed and orthogonal directions (8.9%) in both then centripetal and multipolar with two and one core respectively.

Table 20. Percentage of removals organization in second surface of bifacial core types.

		Bipolar Opposed	Bipolar Orthogonal	Centripetal	Longitudinal	Multipolar
BBC	N	-	-	19	-	-
	% By type	-	-	100%	-	-
	% In total	-	-	42.2%	-	-
BBL	N	-	-	-	4	-
	% By type	-	-	-	100%	-
	% In total	-	-	-	8.9%	-
BBM	N	4	4	2	9	1
	% By type	20%	20%	10%	45%	5%
	% In total	8.9%	8.9%	4.4%	20%	2.2%
BBOp	N	1	-	-	-	-
	% By type	100%	-	-	-	-
	% In total	2.2%	-	-	-	-
BBOr	N	-	1	-	-	-
	% By type	-	100%	-	-	-
	% In total	-	2.2%	-	-	-

Number of negatives

The mean of the number of negatives in the second surface is high in centripetal cores (6), followed by multipolar, longitudinal, and orthogonal with the same value (3) (Fig. 6.8). The centripetal cores show between 3 and 6 negatives in 13 cases, followed by 6 cores showing between 7 and 10 negatives. The multipolar cores show between 3 and 6 negatives in 12 cases, followed by seven cores with two removals each, and one core with 8 negatives. The longitudinal cores show low (1-2) and medium (3-6) number of negatives with equal value each (N=2), and the same happens in the case of opposed and orthogonal cores (Table 21).

Recycling

The cores showing evidence of recycling are not too much abundant in the assemblage. The 20% (N=9) of bifacial cores show recycling marks, by groups (Table 22) the higher frequencies are BBM cores with 35% (N=7), followed with one BBC and BBL cores with the 2.2% each. These results, compared with the organization of removals, can explain the diversity of removal patterns in BBM cores.

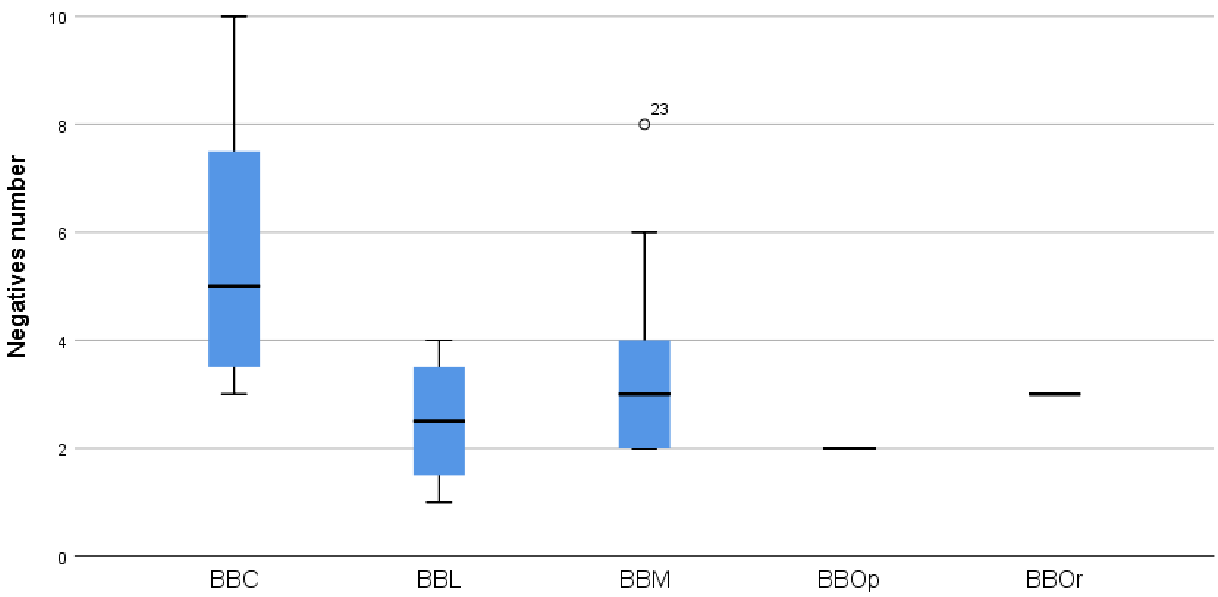


Figure 6.8. boxplot of negative number in the second surface of bifacial cores.

Table 21. Distribution of negative number in second surface of bifacial core types.

		BBC		BBL		BBM		BBOp		BBOr	
		N	**% By type**	**N**	**% By type**	**N**	**% By type**	**N**	**% By type**	**N**	**% By type**
Number of negatives	**1**	-	-	1	25%	-	-	-	-	-	-
	2	-	-	1	25%	7	35%	1	100%	-	-
	3	5	26.3%	1	25%	5	25%	-	-	1	100%
	4	2	10.5%	1	25%	5	25%	-	-	-	-
	5	4	21.1%	-	-	1	5%	-	-	-	-
	6	2	10.5%	-	-	1	5%	-	-	-	-
	7	1	5.3%	-	-	-	-	-	-	-	-
	8	1	5.3%	-	-	1	5%	-	-	-	-
	9	3	15.8%	-	-	-	-	-	-	-	-
	10	1	5.3%	-	-	-	-	-	-	-	-

Table 22.Ppercentage of recycling cores in bifacial types.

	Recycling					
	No			**Yes**		
	N	**% By type**	**% in total**	**N**	**% By type**	**% in total**
BBC	18	94.7%	40%	1	5.3%	2.2%
BBL	3	75%	6.7%	1	25%	2.2%
BBM	13	65%	28.9%	7	35%	15.6%
BBOp	1	100%	2.2%	-	-	-
BBOr	1	100%	2.2%	-	-	-

Symmetry and hierarchization

The symmetry in bifacial core is low, 20% (N=9). The BBC and BBM cores share the same value 8.9% (N=4) each, followed by bifacial longitudinal cores 2.2% (N=1). The 37.7% of the bifacial cores are hierarchized (N=17). Grouped by categories, the BBC cores have higher frequencies, 57.9% (N=11) than centripetal cores (24.4%), followed by BBM cores with 30% (N=6) of the multipolar cores (Table 23).

Table 23. Percentage of symmetrical and hierarchical bifacial cores.

		Symmetry			Hierarchization		
		Yes			Yes		
		N	% By type	% In total	N	% By type	% In total
General polarity	BBC	4	21.1%	8.9%	11	57.90%	24.40%
	BBL	1	25%	2.2%	-	-	-
	BBM	4	20%	8.9%	6	30.00%	13.30%

Trifacial cores

The frequencies of trifacial cores are very low in the SBG1.L1 assemblage presenting 5% (N=3). The trifacial cores are characterized by a large size, the mean is 66mm in length, 59mm in width and 49mm in thickness. The standard deviation equal to 12 in length, 9 in width and 7 in thickness (Table 24).

Table 24. Descriptive statistics of length, width, and thickness in trifacial cores

	Mean	Standard Deviation	Maximum	Minimum
Length	66	12	80	57
Width	59	9	67	50
Thickness	49	7	56	43

Surface cortex

The three cores show a variability in the cortical degree between the faces (Table 25). The first face is characterized by the total absence or low percentages (less than 25%) of cortex degree. The second face show a low degree of cortex, less than 25%, while the third surface have even a higher cortical degree (more than 75%).

Table 25. Cortical degree according to knapped surfaces in trifacial types

	Cortex degree							
	0CTX		1CTX		2CTX		3CTX	
	N	%	N	%	N	%	N	%
First face	2	66.7%	1	33.3%	-	-	-	-
second face	-	-	3	100%	-	-	-	-
third face	-	-	-	-	1	33.3%	2	66.7%

Angle

The surfaces angle of removals in all the cores is abrupt no matter the surface which has been knapped.

Extent of removals

The extent of removals differs in each surface, the first surface shows a total extension, 66.7% (N=2), and very extensive 33.3% (N=1) patterns, while the second and the third surfaces are characterized by extensive 66.7% (N=2) and very extensive 33.3% (N=1) patterns in each. These results indicate that the flaking strategies between the three surfaces is not totally different, the large size of the cores and the extent pattern show clear evidence of the application of extensive flaking systems in the cores (Table 26).

Table 26. Percentage of removals extent degree in each surface.

	extent degree					
	mp		**p**		**t**	
	N	**%**	**N**	**%**	**N**	**%**
First surface	1	33.3%	-	-	2	66.7%
Second surface	1	33.3%	2	66.70%	-	-
Third surface	1	33.3%	2	66.7%	-	-

Removals organization

Three types of directionalities of the removals appear in the trifacial cores, centripetal, orthogonal and longitudinal directions are equally observed in each core in the first surface. The second surface is characterized by longitudinal 66.7% (N=2) and centripetal directions, while the third surface show an orthogonal direction in two cores and longitudinal direction in one (Table 27).

Table 27. Percentage of removal's organization in each surface.

	Removals organizational					
	Orthogonal		**Centripetal**		**Longitudinal**	
	N	**%**	**N**	**%**	**N**	**%**
First face	1	33.30%	1	33.30%	1	33.30%
second face			1	33.30%	2	66.70%
third face	2	66.70%			1	33.30%

Negative numbers

The mean of the total removals in the trifacial cores is very high (13) with a standard deviation equal to 3 but is not distributed equally according to each surface (Table 28). The first surface shows a high number of removals, N= 6, in two cores and N=9 in one core, while the second and the third have a medium and low removal number respectively. These results show a preferential flaking surface in which the reduction of the core is systematically carried out from the first face (Table 29).

Table 28. descriptive statistics of the total removal's number.

Total scars			
Mean	**Standard Deviation**	**Maximum**	**Minimum**
13	3	16	11

Table 29. Distribution of removals number in each surface.

	Number of negatives				
	2	**3**	**4**	**6**	**9**
First face	-	-	-	2	1
second face	-	2	1		
third face	1	2	-	-	-

Summary

Unifacial cores

The unifacial cores, representing the 20% (N=12) of the assemblage, show a unipolar plane of knapping in which reduction is significantly dominated by centripetal (UUC) ones, followed by longitudinal (UUL) and orthogonal (UUOr).

The UUC cores generally are produced from ice fragment 66.7% (N=4) support and shows low percentages of cortex or even total absence and show a plane flaking angle while the removals' extent is even total or extensive, presenting a high number of small flakes (mean= 6). The main perimetral continuity is 4C and 3C (Table 30) which indicate a high rotational management of cores for flaking.

Table 30. Perimetral continuity in unifacial types.

	Perimetral continuity							
	1C		2C		3C		4C	
	N	%	N	%	N	%	N	%
UUOr	-	-	2	100%	-	-	-	-
UUC	-	-	-	-	3	50%	3	50%
UUL	4	100%	-	-	-	-	-	-

The UUL strategy is specially associated with large flakes as a support (or flake fragments), the cores show a medium degree of cortex with a plane flaking angle in which an extensive or marginal removal (one removal in each core) have been identified, the perimetral continuity is 1C which indicate that the unifacial longitudinal strategy is applied in order detach one longitudinal flake.

The two UUOr cores are produced from ice fragments supports, with medium presence or absence of cortex. The flaking surface is plane and semi-abrupt with total and extensive removals. The two cores show a different number of removals with eight removals in one case and four in the other, and the perimetral continuity is 2C on both.

Bifacial cores

The bifacial cores represent the 75% of the studied cores, in which five reduction strategies have been identified.

Bifacial longitudinal represent the 6.7% (N=4) of all the cores, the ice fragments are the main support with 75%, the cortex is observed in all the cores with perimetral continuity show a variation between 1C and 3C (Table 31). Two cores show a total number of removals in both surface equal to 4 with a plane and semi abrupt flaking angle with extensive extent in the first surface and marginal in the second. The other two cores show an extensive number of removals in both surface equal to 10 and 11 with a simple and abrupt flaking angle where there is a total extent of removal in the first surface and extensive, total in the second one.

Bifacial opposed and orthogonal strategies represent the 2.2% (N=1) of bifacial cores each. The orthogonal one has a simple flaking angle with three removals in each surface. The extent of removals is extensive in the first surface and marginal in the second one. There is a differentiation between both surfaces' angles, the first with a plane characterized by very extensive removals and the second with an abrupt flaking surface with two extensive removals.

Table 31. Perimetral continuity in bifacial types.

	BBC		BBL		BBM		BBOp		BBOr	
	N	%	N	%	N	%	N	%	N	%
1C	-	-	2	4.4%	1	2.2%	-	-	1	2.20%
2C	3	6.7%	1	2.2%	7	15.6%	1	2.2%	-	-
3C	5	11.1%	1	2.2%	5	11.1%	-	-	-	-
4C	11	24.4%	-	-	7	15.6%	-	-	-	-

Bifacial centripetal strategy represents 42.2% (N=19) of bifacial cores, applied in chert (N=18) and the one core in rhyolite (N=1). The 52.6% (N=10) show an ice fragment support, the 2.2% (N=1) is a nodule and the rest are non-identified. The first surface shows abundance of simple flaking angle 73.7% (N=14) with an absence of cortical cover 78.9% (N=15) and removals number mean equal to 7 characterized by a total extent, 78.9% (N=15), of the negatives. The second surface show an abundance of semi-abrupt flaking angle with high percentages of cortical cover (between 50% - 75%) and removals number mean equal to 6, differing between marginal 31.6% (N=6) and extensive 26.3% (N=5) extent. The perimetral continuity is dominated by 4C, 3C rotational, 57.9% (N=11), and 26.3% (N=5) respectively.

The bifacial multipolar strategy represents the 44.4% (N=20) of bifacial cores, 60% (N=12) produced from ice fragments support while the rest are non-identified, 17.8% (N=8). The first surface is characterized by an abundance of semi-abrupt flaking angle 50% (N=10) and non-cortical cover in 55% (N=11), the removals number mean is 5 with abundance of total 55% (N=11) and extensive 205 (N=4) extent, while the removal organization show a high variability. Centripetal 35% (N=7) and multipolar (or Multidirectional) 25% (N=5) dominates, followed by opposed (N=3), orthogonal 10% (N=2), cordial 10% (N=2) and longitudinal 5% (N=1) directions. The second surface is characterized by semi-abrupt flaking angle with a 65% of medium cortical cover. The removals number mean is 3 varying between marginal and extensive extent. The removals organization is dominated by longitudinal direction 45% (N=9), followed by opposed and orthogonal with the same value 205 (N=4), centripetal 10% (N=2) and multipolar 5% (N=1) directions.

The hierarchization and symmetry have been taken as criteria to distinguish the relationship between the two surfaces. The 57.9% (N=11) of BBC strategy is characterized by a hierarchical structure followed by BBM strategy with 30% (N=6). While the symmetry between the two surfaces in relation with the intersection plane are low in bifacial strategies in general, only four cores in BBC (21.1%), BBM (20%) and one BBL (25%) core show a symmetrical structure.

Trifacial cores

Trifacial cores have very low frequencies in SBG1.L1 assemblage 5% (N=3), two produced from ice fragments support (66.7%), while the other one is unidentified. The flaking angles between the three surfaces is abrupt, the cortical cover is medium or absent in the first and second surfaces while is high in the third face. The main number of removals in each face is 7, 3 and 3. The first surface is characterized by a 66.7% of extensive removals and a 33.3% of extent removals. The organizational of removals varies between the surfaces, orthogonal, centripetal and longitudinal in the first surface 33.3% (N=1) each. Longitudinal 66.7% (N=2) and centripetal 33.3% (N=1) in second surface. Orthogonal 66.7% (N=2) and longitudinal 33% (N=1) in the third surface.

Table 32. Perimetral continuity in trifacial types.

Perimetral continuity			
1C		4C	
N	**%**	**N**	**%**
1	33.3%	2	66.7%

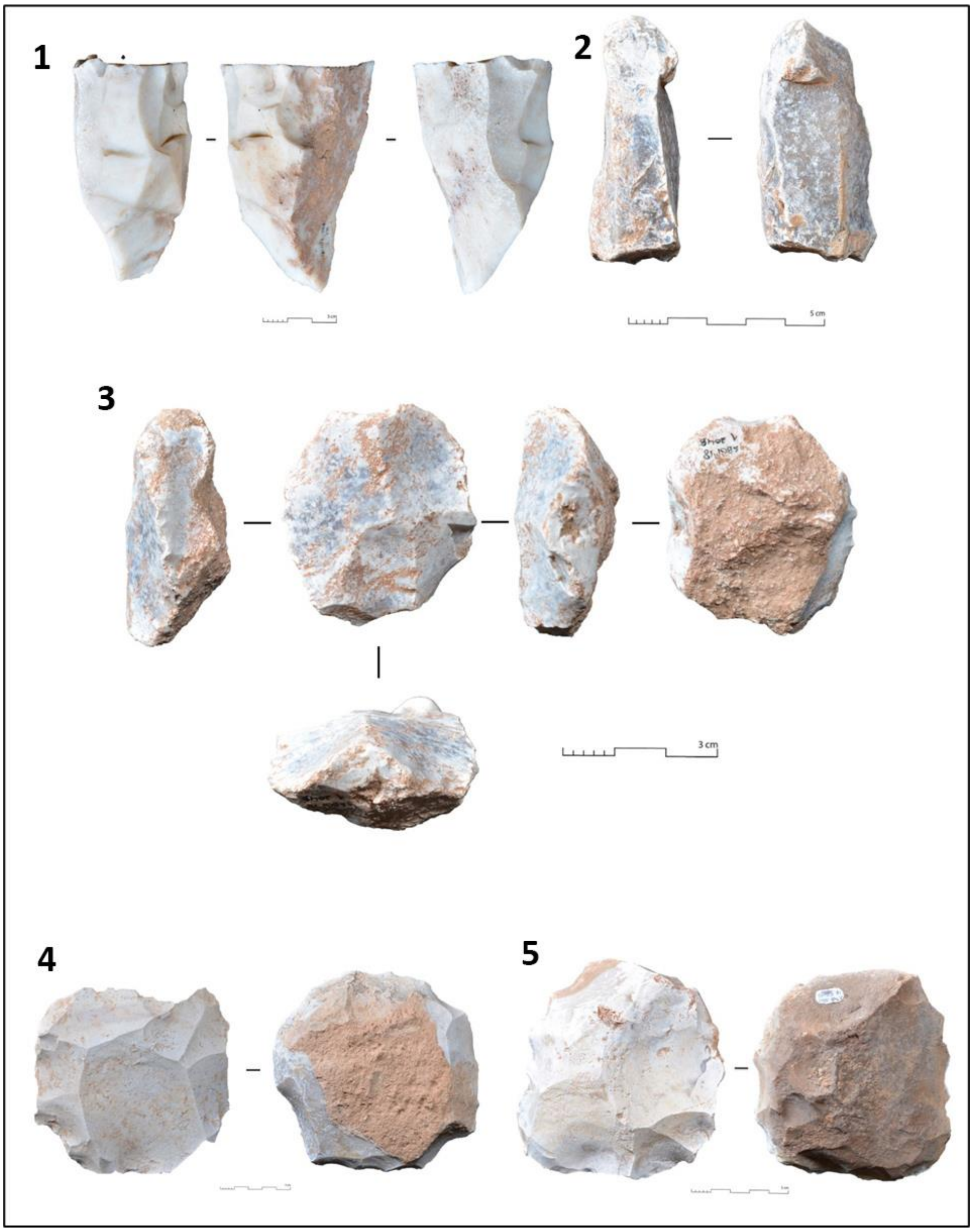


Figure 6.9. Examples of SBG1.L1 cores studied, 1&2. laminar cores, 3&5. Levallois recurrent centripetal, 4. Levallois preferential.

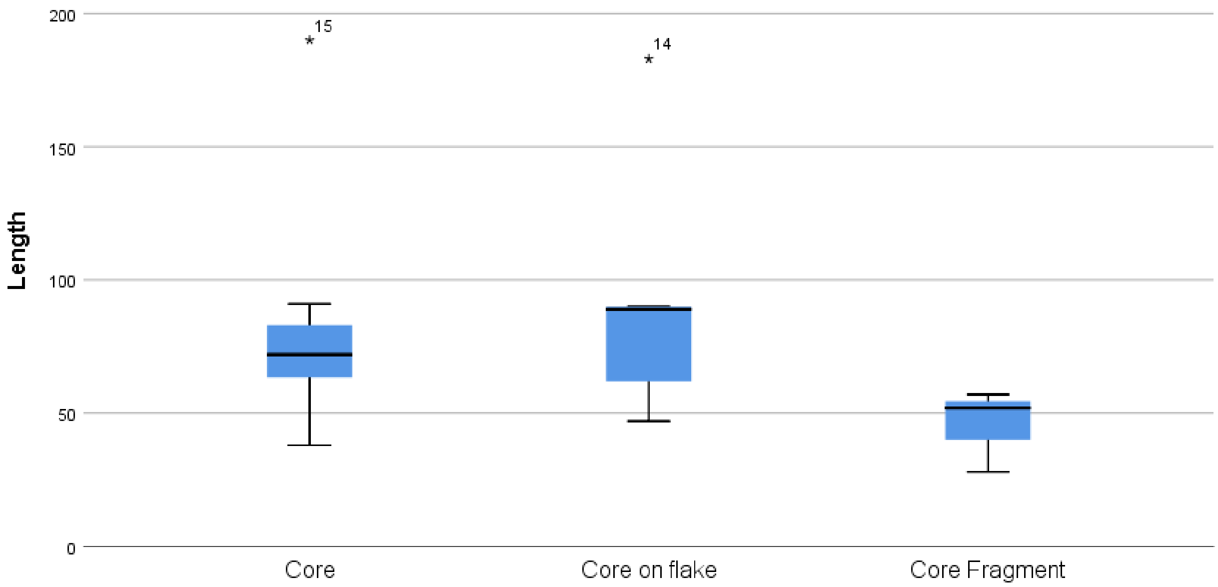
6.3 Sahb El Ghar 2 (SBG2)

The locality of SBG2 was excavated in 2019 in a test-pit of 7m^2. Three archeological levels have been identified and a total of 3777 lithics remains have been collected. The 46.4% (N=1753) has an anthropic origin and the 53.6% (N=2024) are natural fragments or geofacts. The cores studied from this locality represent the 2.3% (N=41) of knapping products.

6.3.1 Level 1 (SBG2.L1)

Core size

Metric measurements of SBG2.L1 cores have been study according to core type categories (Fig 6.10). The mean length differs between 94 mm and 46 mm. The standard deviation of the cores-on-flake is the highest (SD= 53), while in cores the SD=35 and in core fragments SD=16. The width mean differs between 82 mm and 35 mm, with standard deviation equals to 41 in cores-on-flake, 33 in cores and 7 in core fragment. The mean width differs between 37 mm and 25 mm, with a standard deviation equal to 28 in cores-on-flake, 25 in cores and 7 in core fragments. There is a huge similarity between the maximum and minimum dimensional measurements of the assemblage the maximum length is 190 mm, 169 mm in width and 120 mm in thickness, while the minimum is 28 mm in length, 27 mm in width and 14 mm in thickness.



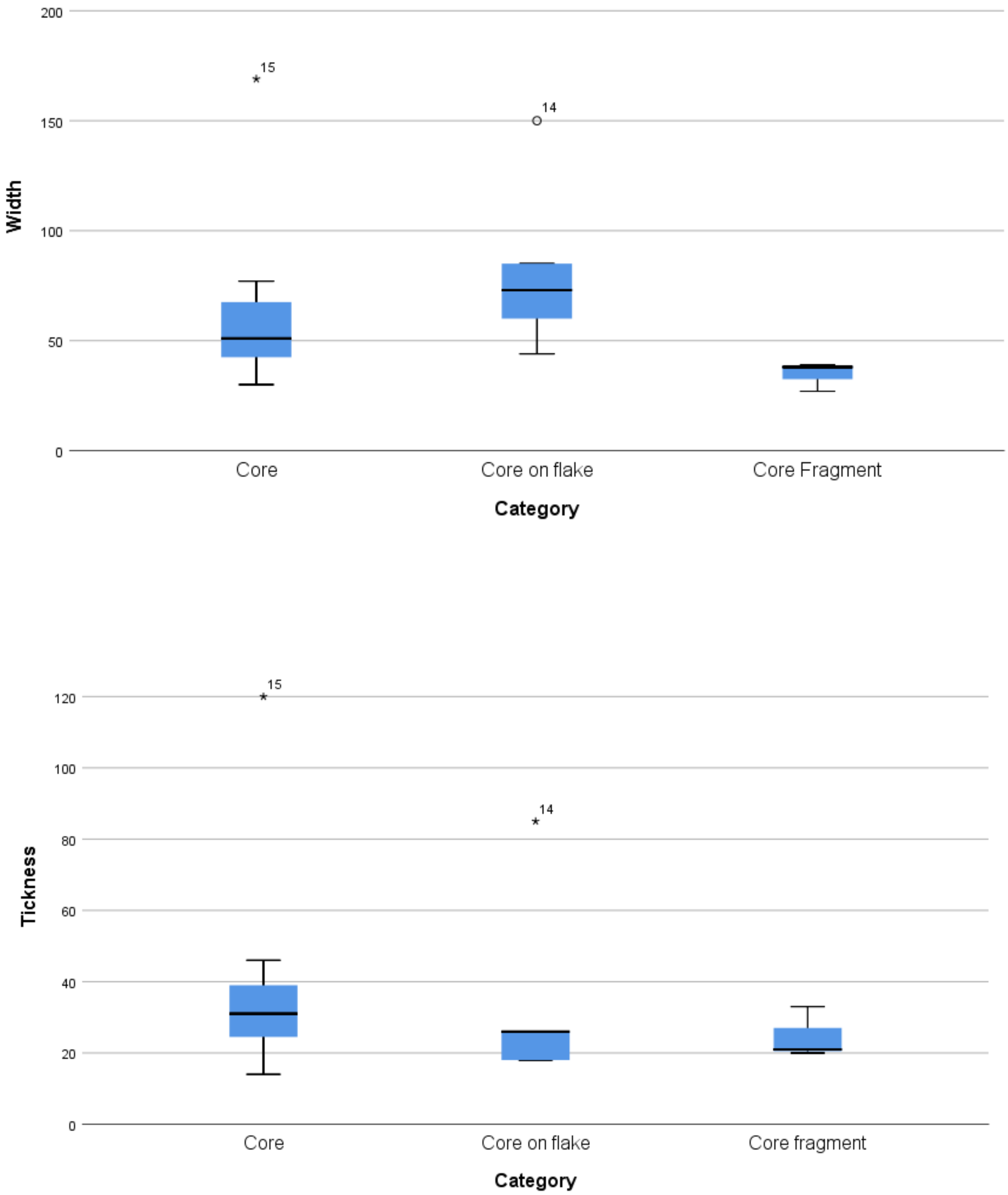


Figure 6.10. Boxplots of length, width, and thickness in SBG2.L1 according to categories

6.3.1.1 Taphonomical attributes

The dominant types of alterations (Table 23) in SBG2.L1 assemblage is patination. The 73.9% (N=17) show a high degree of patina and the rest 26.1% (N=6) show a medial degree in which most of the cores 82.6% (N=19) show a double patina presence. The second alteration is concretion. The 86.9% (N=20) have a thin layer of carbonate precipitation in their surface. And the third type is fractures due to the temperature seasonal change, 52.2% (N=12) of cores show small crioclastic fractures.

Table 33. Taphonomical cores attributes in SBG2.L1.

Attributes	State	SBG1.L1	
		N	%
Patina degree	High	17	73.9%
	Medial	6	26.1%
Double patina	No	4	17.4%
	Yes	19	82.6%
fracture	No	11	47.8%
	Yes	12	52.2%
Concretion	Yes	20	86.9%
	No	3	3.1%

6.3.1.2 Technological attributes

Core cortex

Most cores in SBG2.L1 have some extent of cortical cover (Fig. 6.11). Only 8.7% (N=2) show no cortex, and the rest show a variability in the cortical degree. The cores dominated by medium cortex (between 25-50%) represent a percentage of 47.8% (N=11), and cores with a cortex degree between 50% and 75% are the second dominant with a percentage of 30.4% (N=7). The 8.7% (N=2) of the cores show a low cortical degree (less than 25%) and the 4.3% (N=1) a high cortical degree (more than 75%). The Figure 4 expresses the results of cortex percentage in the SBG2.L1 assemblage.

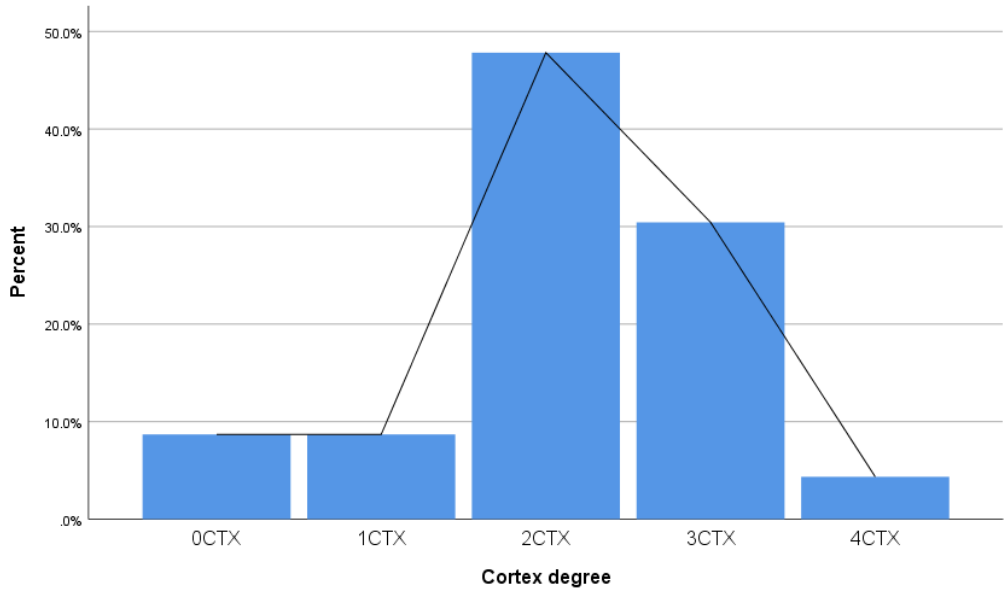


Figure 6.11. Bar-chart of cortex degree in SBG2.L1 cores.

Faciality & general polarity

Bifacial cores are dominant in SBG2.L1 (Fig. 6.12) with the 91.3% (N=21), mainly bipolar bifacial multipolar ones with 47.8% (N=11), followed by 26.1% (N=6) bipolar bifacial centripetal and bipolar bifacial longitudinal 17.4% (N=4).

The unifacial and trifacial strategies are very low in the assemblage with only one core each. The unifacial core is a unipolar longitudinal direction and the trifacial core is a multipolar multidirectional one.

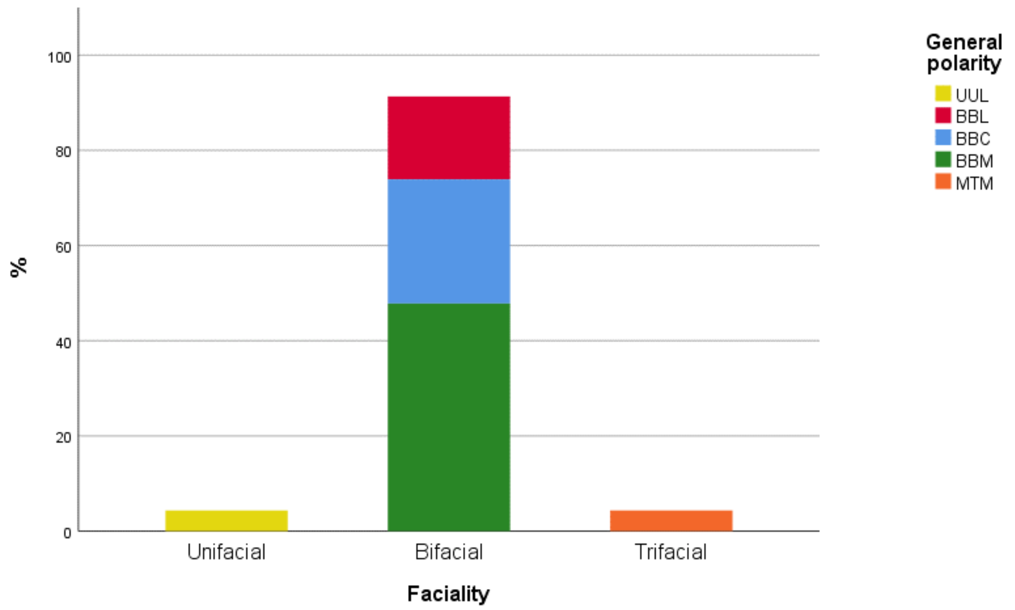


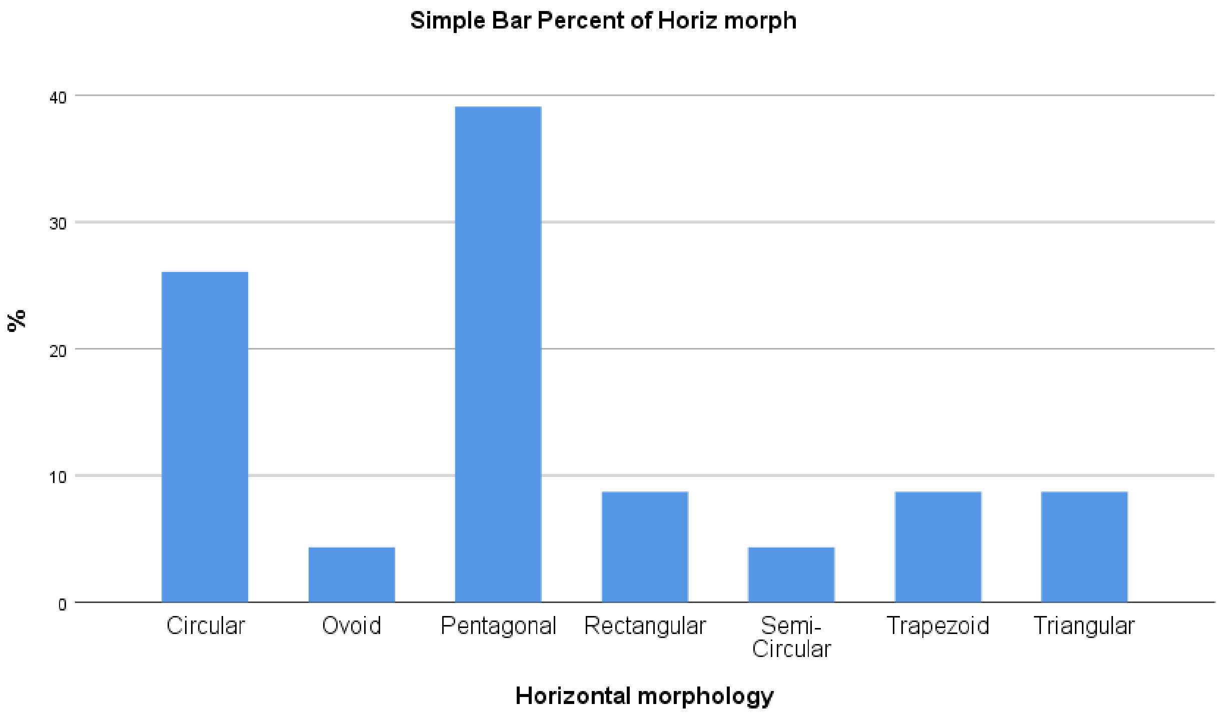
Figure 6.12. Bar chart of the faciality in SBG2.L1 according to general polarity.

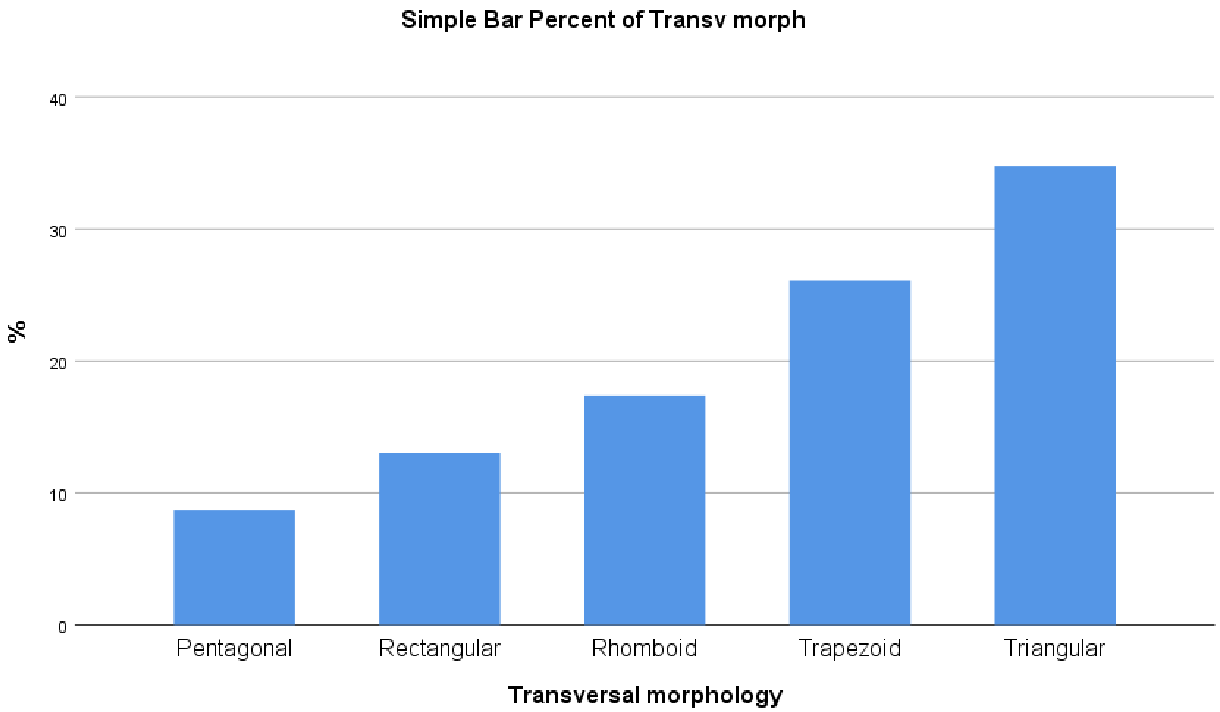
Morphology

As the same as SBG1.L1, SBG2.L1 have no predominance of a specific morphology within the core assemblage (Fig. 6.13). First with the horizontal view seven types have been identified, the pentagonal and circular show the highest frequencies with the 39.1% (N=9) and 26.1% (N=6) respectively. Rectangular, trapezoid, and triangular horizontal views represent 8.7% with 2 cores each, while the ovoid and semi-circular represent 4.3% (N=1) each.

In the case of the transversal view five types have been identified, dominated by triangular and trapezoid morphology with 34.8% (N=8) and 26.1% (N=6) respectively, followed by rhomboid with the 17.4% (N=4) and rectangular with the 13% (N=3), and two cores with pentagonal morphology representing the 8.7% (N=2).

In the sagittal view four morphologies were identified, dominated by triangular and trapezoid morphologies representing the 43.5% (N=10) and 26.1% (N=6) respectively, followed by rectangular with 17.4% (N=4) and rhomboid with 13% (N=3)


Simple Bar Percent of Horiz morph
%
0
10
20
30
40
Circular
Ovoid
Pentagonal
Rectangular
Semi-Circular
Trapezoid
Triangular
Horizontal morphology


Simple Bar Percent of Transv morph
%
0
10
20
30
40
Pentagonal
Rectangular
Rhomboid
Trapezoid
Triangular
Transversal morphology

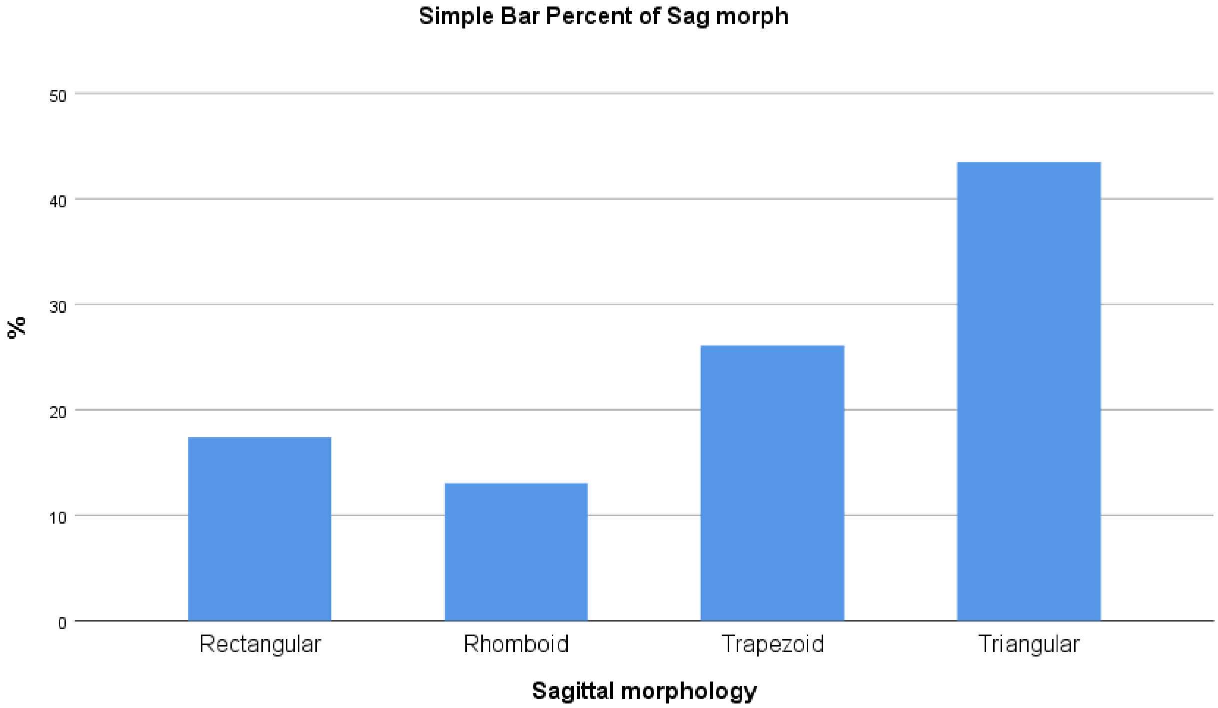


Figure 6.13. Bar charts of horizontal, transversal and sagittal morphology of SBG2.L1 cores.

Unifacial cores

Only one core has been identified as unifacial. The support is a large flake with a dimension of 38mm in length, 32mm in width and 25mm in thickness. Regarding the taphonomical attributes, the unifacial core is characterized by high patina degree with double patination presence, the edges show a slight degree of rounding with the presence of fractures and concretion in surface. In the technological attributes, there is a medium degree of cortex (between 25-50%), the morphology is rectangular, rectangular, trapezoid regarding the horizontal, transversal and sagittal views respectively. The flaking surface is plane with less than 25% of facial cortex cover. Three longitudinal removals have been distinguished and are characterized by a very extensive extent. There is no hierarchization or symmetrical structure and the perimetral continuity is 1C.

Bifacial cores

First surface

Facial cortex

The 61.9% of the cores show no cortex in the first flaking surface (N=13), while the rest have some variability in cortical degree. The 25.8% (N=5) show a medium cortex (between 25%-50%), followed by 9.5% (N=2) with a low degree (less than 25%) and 4.8% (N=1) high degree (between 50%-75%). Grouping by general polarities, the BBC first surface without cortical cover dominates with the 83.3% (N=5), only one core (16.7%) shows less than 25% of cortical cover. The BBL show a dominance of medium cortex (between 25%-50%) representing the 75% (N=3) followed by one core without cortex 25%. The majority of BBM first surface have no cortex 63.3% (N=7), while the rest show a variability in cortical degree, with the 18.2%

(N=2) of the cores showing a medium degree (between 25%-50%), followed by one core (9.1%) with low degree (less than 25%) and other with high cortical degree (between 50%-75%) (Table 34).

Table 34. percentage of cortical degree in the first surface of bifacial cores.

		OCTX1	1CTX1	2CTX1	3CTX1
BBC	N	5	1	-	-
	% By type	83.3%	16.7%	-	-
	% In total	23.8%	4.8%	-	-
BBL	N	1	-	3	-
	% By type	25%	-	75%	-
	% In total	4.8%	-	14.3%	-
BBM	N	7	1	2	1
	% By type	63.6%	9.1%	18.2%	9.1%
	% In total	33.3%	4.8%	9.5%	4.8%

The Angle

In the first surface of the SBG2.L1 bifacial cores, the simple angle is the most dominant with a frequency of 47.6% (N=10), followed by plane 28.6% (N=6), semi-abrupt 28.6% and abrupt angles 9.5% (N=2). Grouping by polarity, the BBC are characterized by a plane flaking angle 50% in three cores, simple by the 33.3% (N=2) and semi-abrupt in one core with the 16.7%. while in BBL cores the flaking angle is simple in the 50% (N=2), semi-abrupt in the 25% (N=1) and abrupt in the 25% (N=1). The BBM cores show a high variability in flaking angles are dominated by simple with the 54.5% (N=6) and plane with the 27.3% (N=3), one core shows semi-abrupt and abrupt angle each, representing the 9.1% (Table 35).

Table 35. Percentage of angle types in the first surface of bifacial cores.

		Abrupt	Plane	Semi-Abrupt	Simple
BBC	N	-	3	1	2
	% By type	-	50%	16.7%	33.3%
	% In total	-	14.3%	4.8%	9.5%
BBL	N	1	-	1	2
	% By type	25%	-	25%	50%
	% In total	4.8%	-	4.8%	9.5%
BBM	N	1	3	1	6
	% By type	9.1%	27.3%	9.1%	54.5%
	% In total	4.8%	14.3%	4.8%	28.6%

Extent of removals

The bifacial cores dominated by a total extent of removals represents the 57.1% (N=12), followed by very extensive with the 23.8% (N=5), and very marginal and marginal with the same frequency, the 9.5% (N=2) each. Grouping according to polarity, the BBC cores first surface show a dominant of total extent of removals with the 83.5% (N=5) and one core with very extensive extent and the 16.7% (N=1). The BBL cores show a high percentage with very extensive flaking removals, representing the 50% (N=2), followed by very marginal and total extent, representing the 2.55% (N=1) each. The BBM cores show a variability in removals extent and are dominated by the total type with the 54.6% (N=6), followed by to cores showing a total and extensive pattern with the 18.2% (N=2) each, and one core characterized by a very marginal extent 9.1% (N=1) (Table 36).

Table 36. Percentage of extent of removals in first surface of bifacial cores.

		m	mm	mp	t
BBC	N	-	-	1	5
	% By type	-	-	16.7%	83.3%
	% In total	-	-	4.8%	23.8%
BBL	N	-	1	2	1
	% By type	-	25%	50%	25%
	% In total	-	4.8%	9.5%	4.8%
BBM	N	2	1	2	6
	% By type	18.2%	9.1%	18.2%	54.5%
	% In total	9.5%	4.8%	9.5%	28.6%

Removals organization

In general, three types of removals direction have been identified in the first surface of bifacial cores, the centripetal direction is the most abundant with a frequency of 57.1% (N=12), the longitudinal direction is the second type with a 38.1% (N=8) followed by one core with cordial direction 4.8% (N=1). Grouping by polarity, the BBM show a diversity in the direction of the first surface, being the centripetal directional the most abundant with the 54.6% (N=6), longitudinal direction with the 36.4% (N=4) and one core with a cordial directional representing the 9.1% (N=1) (Table 37).

Table 37. Percentage of directional removals in first surface of bifacial cores.

		Opposed	Orthogonal	Centripetal	Cordial	Longitudinal
BBC	**N**	-	-	6	-	-
	% By type	-	-	100%	-	-
	% In total	-	-	28.6%	-	-
BBL	**N**	-	-	-	-	4
	% By type	-	-	-	-	100%
	% In total	-	-	-	-	19%
BBM	**N**	2	4	1	2	2
	% By type	18.2%	36.4%	9.1%	18.2%	18.2%
	% In total	9.5%	19%	4.8%	9.5%	9.5%

Number of negatives

The mean of the number of negatives in the first surface is five in centripetal cores and four in both longitudinal and multipolar, with a SD=2 in both centripetal and multipolar cores and SD=1 in bifacial longitudinal ones (Fig. 6.14). However, there is an intensive exploitation that can observed in some cores, in BBC four cores (66.7%) show a variability between five and seven removals, and only two cores (33.3%) have three removals. In BBL cores, the 75% (N=3) show three or four removals, and only one core (25%) shows six removals, the highest number of removals identified. The BBM cores are dominated by a low number of removals, between three and six, representing the 81.8% (N=9), the 18.2% (N=2) of the cores have between seven and eight removals (Table 38).

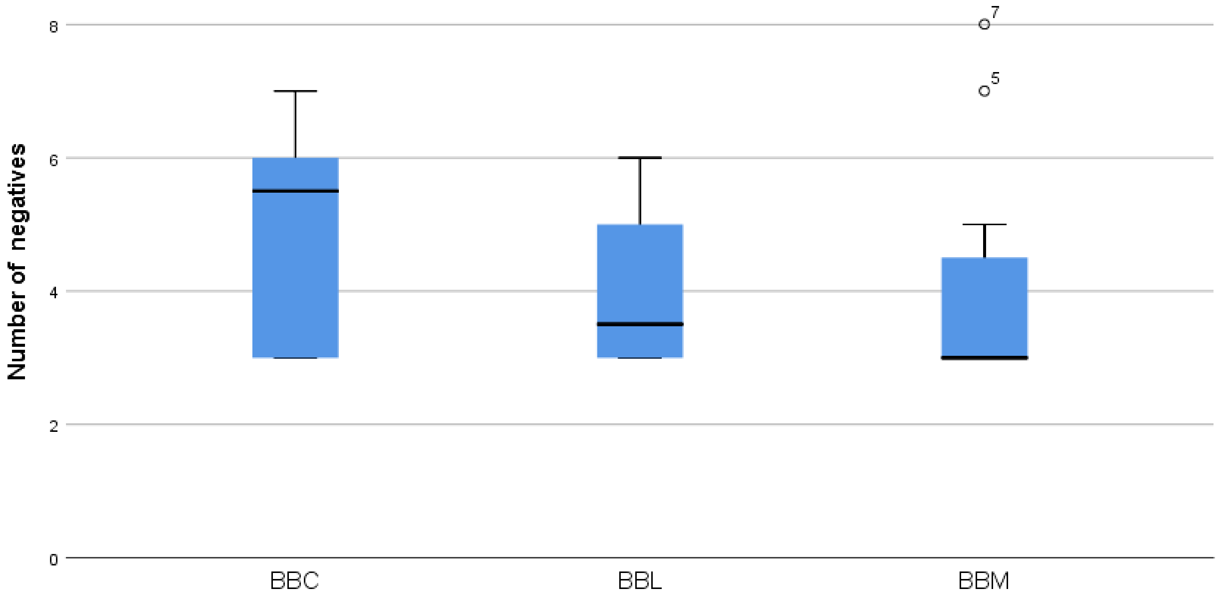


Figure 6.14. Boxplot of removals number in first surface of bifacial core types

Table 38. Distribution of the first surface negative numbers in bifacial cores.

		BBC		BBL		BBM	
		N	**% by type**	**N**	**% by type**	**N**	**% by type**
Number of negatives	**3**	2	33.3%	2	50%	6	54.5%
	4	-	-	1	25%	2	18.2%
	5	1	16.7%	-	-	1	9.1%
	6	2	33.3%	1	25%	-	-
	7	1	16.7%	-	-	1	9.1%
	8	-	-	-	-	1	9.1%

Second surface

Facial cortex

In bifacial cores, the second surface show a presence of cortex in all the cases (Table 39). The high cortical degree (50%-75% cortex) is dominant with the 47.4% (N=9), followed by medium (25%-50% cortex) with a percentage of 36.8% (N=7) and a low degree (less than 25%) present in the 15.8% (N=3) of the cores. By grouping according to general polarity, the BBC are dominated by a high degree, with the 60% (N=3), and medium degree, 40% (N=2), cortical covers. While the BBL and BBM shows some variability in cortical cover presence, in the case of BBL cores 50% (N=2) present a medium degree of cortex, plus two cores show a low 25% (N=1) and high 25% (N=1) cortical cover degree. On the other hand, the BBM show a dominance of high cortical degree with the 50% (N=5), followed by medium 30% (N=3) and low degrees in the 20% (N=2) of BBM cores.

Table 39. Percentage of cortex degree in second surface of bifacial core types.

		1CTX2	2CTX2	3CTX2
BBC	N	-	2	3
	% By type	-	40%	60%
	% In total	-	10.5%	15.8%
BBL	N	1	2	1
	% By type	25%	50%	25%
	% In total	5.3%	10.5%	5.3%
BBM	N	2	3	5
	% By type	20%	30%	50%
	% In total	10.5%	15.8%	26.3%

The angle

In the second surface of bifacial cores, most cases show a semi-abrupt flaking angle with the 66.7% (N=14), followed by abrupt, with the 19% (N=4), simple, the 9.5% (N=2), and one core with plane angle. Grouping by polarity, the BBC cores show a dominant of semi-abrupt angle presenting 83.3% (N=5) followed by 4.8% (N=1) core with an abrupt angle. The BBL cores show a 50% (N=2) of simple flaking angle in second surface, followed by semi-abrupt and abrupt in 255 (N=1) each. For the BBM the cores show a dominant in semi-abrupt angle as well presenting 72.7% (N=8), followed by abrupt with 18.2% (N=2) and one core with a plane angle 9.1% (N=1) (Table 40).

Table 40. Percentage of the angle types in second surface of bifacial cores.

		Plane	Simple	Abrupt	Semi-Abrupt
BBC	**N**	-	-	1	5
	% By type	-	-	16.7%	83.3%
	% In total	-	-	4.8%	23.8%
BBL	**N**	-	2	1	1
	% By type	-	50%	25%	25%
	% In total	-	9.5%	4.8%	4.8%
BBM	**N**	1	-	2	8
	% By type	9.1%	-	18.2%	72.7%
	% In total	4.8%	-	9.5%	38.1%

Extent of removals

The second surface in bifacial cores show a dominance of marginal extent, with the 33.3% (N=7), and very marginal with the 28.6% (N=6), followed by very extensive 23.8% (N=5). Extensive extent represents a frequency of 14.3% (N=3). Grouping by polarity, the BBC cores shows even a marginal, 50% (N=3), or very marginal, 50% (N=3), extent in second surface, while the BBL are dominated by very extensive extent presenting 50% (N=2), followed by very marginal and extensive extent with the same value, 25% (N=1) each. For the BBM cores there is some variability in extent of removals dominated by marginal, with 36.4% (N=4), and very extensive with the 27.3% (N=3), while the extensive and very marginal types represent the same value of 18.2% (N=2) each (Table 41).

Table 41. Percentage of extent of removals in second surface of bifacial core types.

		m	mm	mp	p	t
BBC	N	3	3	-	-	-
	% By type	50%	50%	-	-	-
	% In total	14.3%	14.3%	-	-	-
BBL	N	-	1	2	1	-
	% By type	-	25%	50%	25%	-
	% In total	-	4.8%	9.5%	4.8%	-
BBM	N	4	2	3	1	1
	% By type	36.4%	18.2%	27.3%	9.1%	9.1%
	% In total	19%	9.5%	14.3%	4.8%	4.8%

Removal organization

Three types of removals organization have been observed in the second surface, the centripetal direction is the dominant type with the 57.1% (N=12), followed by longitudinal with the 38.1% (N=8) and cordial direction, representing 4.8% (N=1). According to polarity, the BBM cores are the ones showing the highest variability in the removal's organization, the 54.5% (N=6) shows a centripetal directional, followed by longitudinal with 36.4% (N=4) and 9.1% (N=1) with cordial direction (Table 42).

Table 42. Percentage of removals organization in second surface of bifacial core types.

		Centripetal	Cordial	Longitudinal
BBC	N	6	-	-
	% By type	100%	-	-
	% In total	28.6%	-	-
BBL	N	-	-	4
	% By type	-	-	100%
	% In total	-	-	19%
BBM	N	6	1	4
	% By type	54.5%	9.1%	36.4%
	% In total	28.6%	4.8%	19%

Number of removals

The mean number of removals in the second surface is high in centripetal cores (6), followed by multipolar (4), and longitudinal (3), while the standard deviation is equal between BBM and BBC types (SD=3) and in BBL is 2. The number of removals of the second surface is high compared with the first surface (Fig. 6.15). According to polarity, the centripetal cores show a variability in which three cases (50%) shows between three and four, followed by two cores, 33.3%, with seven removals and one, 16.7%, with 10 removals. The longitudinal group is dominated by cores showing between one and three removals, representing the 75% (N=3) of the cases, followed by one core, 25%, (N=1) with five removals in second surface. The BBM cores show one removal in three cases, followed by seven cores with medium removals, between three and six. And one core with nine removals (Table 43).

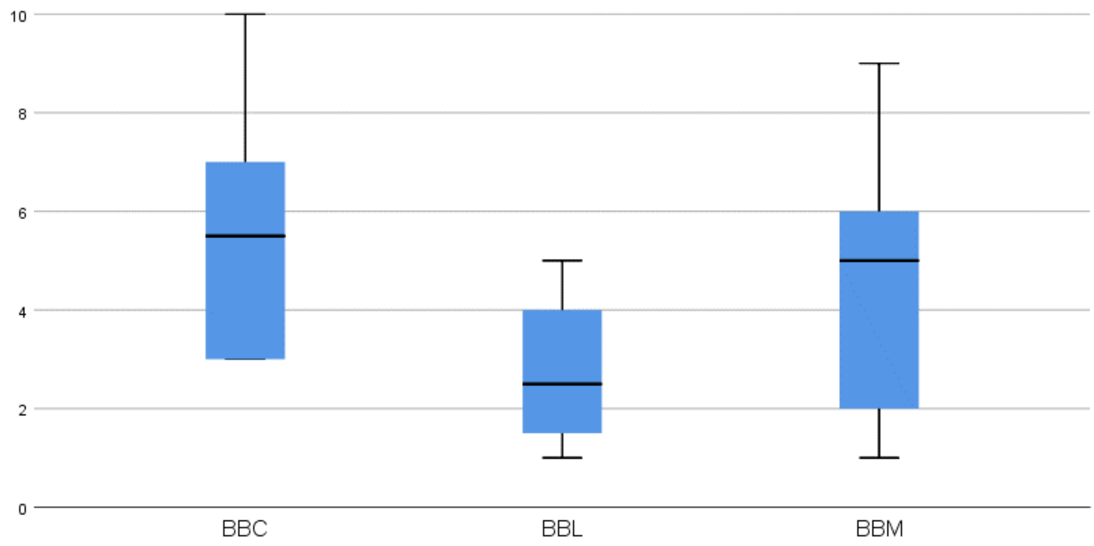


Figure 6.15. Boxplot on removals number in the second surface of bifacial core types.

Table 43. Percentage of negatives direction in second surface of bifacial core types.

		BBC		BBL		BBM	
		N	**% By type**	**N**	**% By type**	**N**	**% By type**
N. negatives	**1**	-	-	1	25%	3	27.3%
	2	-	-	1	25%		-
	3	2	33.3%	1	25%	1	9.1%
	4	1	16.7%	-	-	1	9.1%
	5	-	-	1	25%	2	18.2%
	6	-	-	-	-	3	27.3%
	7	2	33.3%	-	-	-	-
	9	-	-	-	-	1	9.1%
	10	1	16.7%	-	-	-	-

Recycling

The cores with evidence of recycling are not too much abundant in the assemblage. In the bifacial cores, the 23.8% (N=5) have some recycling evidence based in the double patination as an indicator. By categories only BBM and BBL shows re-using marks, in BBM a frequency of 27.3% (N=3) have recycling, while in longitudinal cores represents the 66.7% (N=2) (Table 44).

Table 44. Percentage of recycling cores in bifacial types.

	Recycling					
	No			Yes		
	N	% By type	% In total	N	% By type	% In total
BBC	6	100%	28.6%	-	-	-
BBL	2	50%	9.5%	2	50%	9.5%
BBM	8	72.7%	38.1%	3	27.3%	14.3%

Symmetry and hierarchization

The symmetry in bifacial cores is low, 19.1% (N=4), the BBL show the highest value, the 9.5% (N=2), followed by the BBC and BBM cores sharing the 4.8% (N=1) each. The 23.3% (N=5) of bifacial cores are hierarchized. Grouped by categories, the BBC cores have the higher frequencies 14.3% (N=3), presenting 60% of centripetal types. Followed by BBM cores with the 9.5% (N=2), representing the 40% of the multipolar types (Table 45).

Table 45. Percentage of symmetry and hierarchical in bifacial cores.

	Symmetry			Hierarchization		
	Yes			Yes		
	N	% By type	% In total	N	% By type	% In total
BBC	1	16.7%	4.8%	3	60%	14.3%
BBL	2	50%	9.5%	-	-	-
BBM	1	9.1%	4.8%	2	40%	9.5%

Trifacial cores

The same as the unifacial type, the trifacial are represented in the assemblage only with one core. The support is a crioclast measuring 190x169x120 mm. The first surface is characterized by an abrupt flaking surface without cortical presence, five removals have been counted and shows a bipolar opposed organization. The second surface is characterized by an abrupt flaking angle with less than 25% of cortex, three removals have been counted with a very extensive extent and longitudinal organization. The third surface is characterized by an abrupt flaking surface with less than 25% of cortical surface, three removals have been counted and is characterized by a very extensive extent and bipolar orthogonal organization.

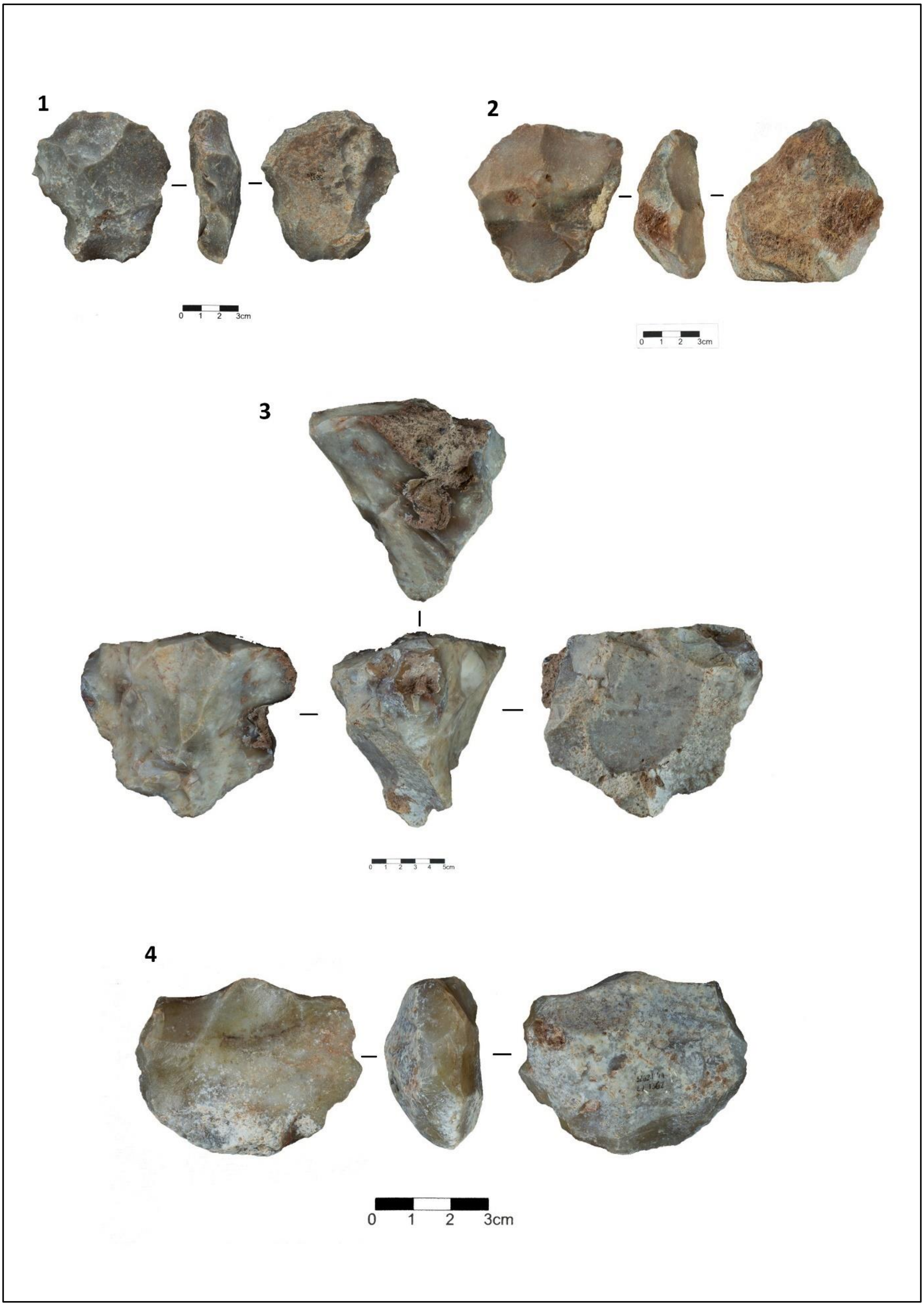


Figure 6.16. Examples of SBG2.L1 cores studied, 1.2 Levallois recurrent centripetal, 3 Multipolar trifacial multidirectional, 4 Opportunistic core.

6.3.2 Level 2 (SBG2.L2)

Core size

Metric measurements from the SBG2.L2 have been studied for all the cores because all the elements represented are complete cores, with only one case of a core fragment. The mean is 63mm in length, 51mm in width, and 31mm in thickness. While the standard deviation is similar between length (15) and width (16) and lower in thickness (8) (Fig. 6.17). Regarding the size variability, the cores from level 2 shows a low differentiation between the maximum and minimum dimensions compared with level 1 for length (between 82mm-44mm), width (between 73mm-32mm) and thickness (between 43mm-23mm).

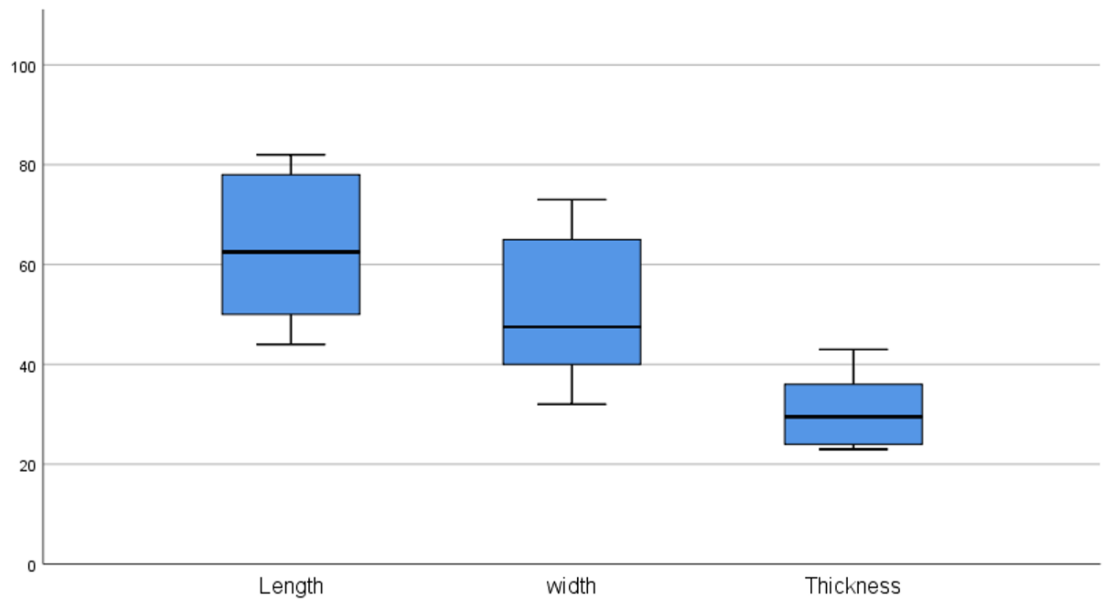


Figure 6.17. Boxplot of length, width and thickness of cores in SBG2.L2.

6.3.2.1 Taphonomical attributes

The dominant types of alterations in SBG2.L2 assemblage is concretion presenting 100% (N=6), being higher than SBG2.L1, and during cleaning some pieces have been cleaned two times with HCL solution (chapter 5). In the same pattern patina is present in all the cores with a variable degree, dominated by medial degree 83.3% (N=5), followed by one core with a high patination, while the double patina is present in most of the cores 83.3% (N=5). The third alteration type is rounding, with a very slight degree in the 83.3% (N=5) of the cases while one core is totally fresh. The fractures presence is very low in level 2 with only one case (Table 46).

Table 46. Taphonomical cores attributes in SBG2.L2.

		SBG2.L2	
		N	**%**
Patina degree	**High**	1	16.70%
	Medial	5	83.30%
Double patination	**No**	1	16.70%
	Yes	5	83.30%
Rounding degree	**Fresh**	1	16.70%
	Slightly	5	83.30%
Ice fracture	**No**	5	83.30%
	Yes	1	16.70%
Concretion	**Yes**	6	100.00%

6.3.2.2 Technological attributes

Core cortex

All the cores in SBG2.L2 present some degree of cortical cover (Fig. 6.18), the variability of cortex is dominated by a medium degree (25%-50% cortex) present in the 50% (N=3) of the assemblage, followed by high cortical degree (50%-75% cortex) with the 33.3% (N=3), and one core with low (less than 25%) cortical degree representing 16.7% (N=1).

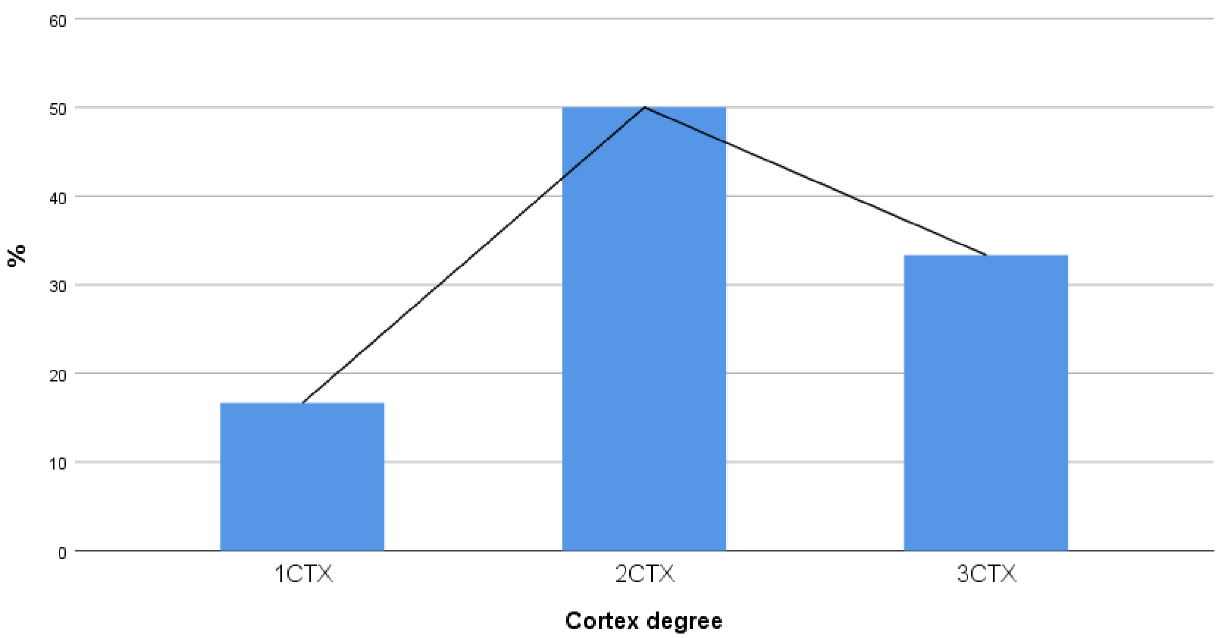


Figure 6.18. Bar-chart of cortex degree in SBG2.L2 cores.

Faciality & general polarity

SBG2.L2 is dominated by bifacial cores with 83.3% (N=5), mainly bipolar bifacial multipolar cores representing the 50% of bifacial cores, followed by bipolar bifacial centripetal with the 33.3% (N=2). The unifacial cores are only represented by one unipolar unifacial opposed core (Fig. 6.19).

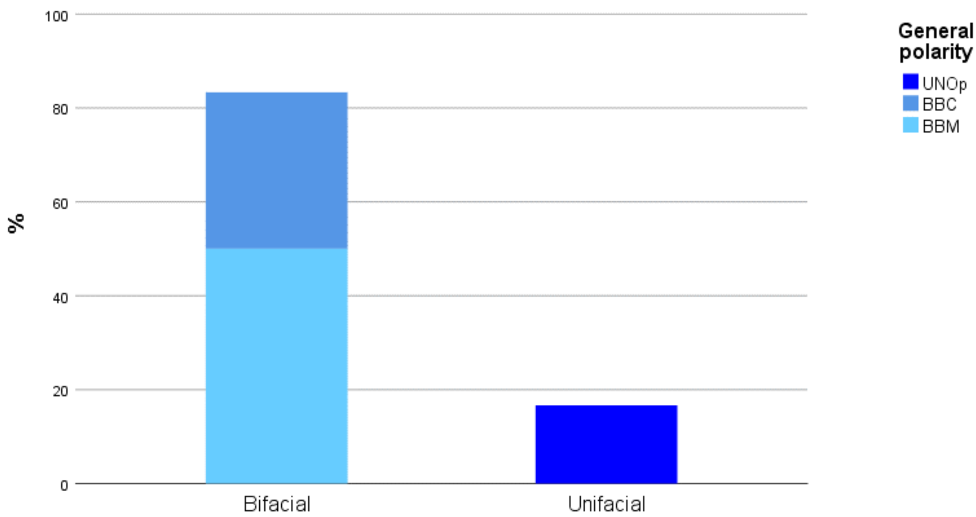


Figure 6.19. Staked bar of faciality by general polarity in SBG2.L2.

Morphology

There is a high variability between horizonal, transversal and sagittal morphologies, and no predominance of any specific morphology has been found (Fig 6.20). First with the horizontal view, the circular and rectangular morphologies are the most frequent with the same value presenting 33.3% (N=2) each, followed by pentagonal and rectangular ones presenting 16.7% (N=1) each.

The transversal view is represented by three types, dominated by the triangular morphology with the 50% (N=3), followed by rectangular, 33.3% (N=2), and rhomboid in one case.

The sagittal view is dominated by pentagonal shapes with the 66.7% (N=4), followed by rhomboid and triangular in one core each.

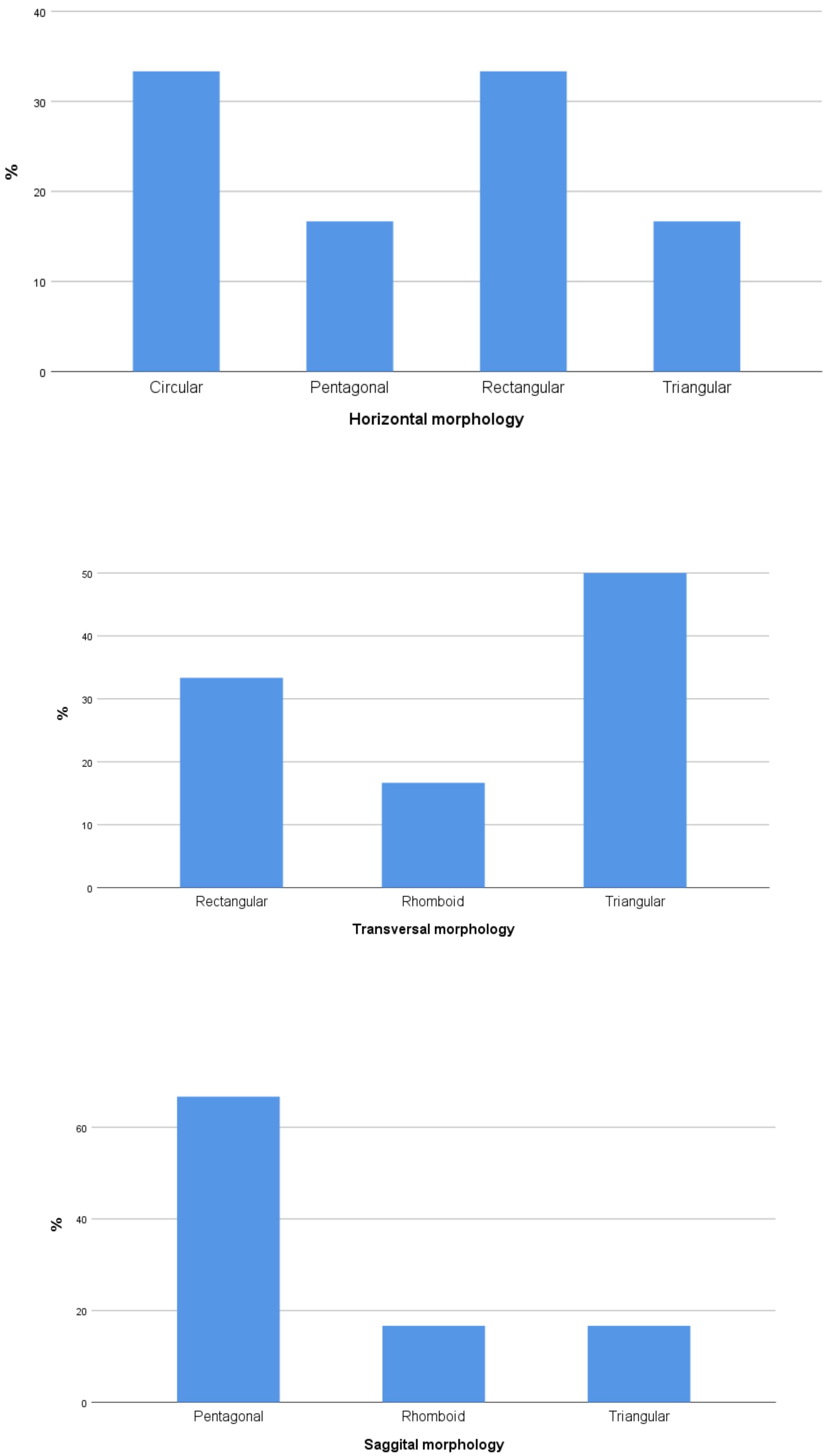


Figure 6.20. Bar-chart of horizontal, transversal, and sagittal morphology of SBG2.L2 cores.

Unifacial core

Only one core (16.7%) has been identified as an unifacial core. The support is unidentified, and measures 64x40x36mm. The flaking angle is plane with less than 25% of cortical surface. Three very invasive bipolar opposed removals have been identified.

Bifacial cores

The bifacial cores represent the majority of the SBG2.L2 assemblage with the 83.3% (N=5), the supports are not identified due to the extensive reduction of the volume. The technological results are divided according to the first and the second surface.

First surface

Facial cortex

The cortical cover in the first surface is absent in most cores, 60% (N=3). The rest show even a low (less than 25%) or medium (25%-50%) cortex cover, with the same value 20% (N=1) each. Grouping by polarity, in the BBC, one core show no cortical cover, and another a low cortex cover (25%-50%). The BBM is dominated by no cortical presence in the first surface, with 66.7% (N=2), and one core with medium cortex, representing the 33.6% (N=1) (Table 47).

Table 47. Percentage of cortical degree in first surface of bifacial cores.

		BBC			BBM		
		N	**% By type**	**% In total**	**N**	**% By type**	**% In total**
Facial cortex	**0CTX1**	1	50%	20%	2	66.70%	40%
	1CTX1	1	50%	20%	-	-	-
	2CTX1	-	-	-	1	33.30%	20%

Angle

The flaking angle of the first surface is mostly plane, 40% (N=2), or abrupt 40% (N=2), followed by simple 20% (N=1). Grouping by polarity, the bifacial centripetal shows one plane 50% (N=1) and one simple 50% (N=1) cases. The BBM cores are dominated by abrupt angles, representing the 66.7% (N=2) and followed by one core with a plane flaking angle 33.3% (N=1) (Table 48).

Table 48. Percentage of the first surface angle types in bifacial cores.

		BBC			BBM		
		N	**% By type**	**% in total**	**N**	**% By type**	**% in total**
Angle	**Plane**	1	50%	20%	1	33.30%	20%
	Simple	1	50%	20%	-	-	-
	Abrupt	-	-	-	2	66.70%	40%

Extent of removals

The first surface show two types of removals extent, total extent, with the 80% (N=4), and very marginal extent, with the 20% (N=20). According to categories, all the BBM cores show a total extent 100% (N=3), while the BBC cores show an equal value of very extensive and total extent 50% (N=1) each (Table 49).

Table 49. Percentage of removals extent of first surface in bifacial cores.

		BBC			BBM		
		N	**% By type**	**% In total**	**N**	**% By type**	**% In total**
Extent of removals	**mp**	1	50%	20%	-	-	-
	t	1	50%	20%	3	100%	60%

Removals organization

The information from the removal's organization is very limited compared with the first level. Three types of directional removals have been identified; the centripetal type is characteristic of the BBC cores 40% (N=2). The orthogonal type represents the 66.7% of BBM cores, while the opposed type is present in one BBM core (Table 50).

Table 50. Percentage of directional removals of first surface in bifacial cores.

		BBC			BBM		
		N	**% By type**	**% In total**	**N**	**% By type**	**% In total**
Removals organization	**Opposed**	-	-	-	1	33.30%	20%
	Orthogonal	-	-	-	2	66.70%	40%
	Centripetal	2	100%	40%	-	-	-

Number of negatives

The mean of the number of negatives is high in bifacial cores' first surface, particularly in BBC and BBM type, with values of 7 and 6 respectively. The standard deviation is very low between 1 and 2 in BBC and BBM respectively. The two cores of BBC show 6 and 7 removals each, as the same in BBM cores adding 1 core with 4 removals. These results, compared with the cores size, indicate that the reduction strategy applied attempt to extract numerous flakes by profiting the first surface which will be more explained with the perimetral results (Fig. 6.21, Table 51).

Table 51. Distribution of the first surface negative's number in bifacial cores.

		BBC		BBM	
		N	**%**	**N**	**%**
N. negatives	**4**	-	-	1	20%
	6	1	20%	1	20%
	7	1	20%	1	20%

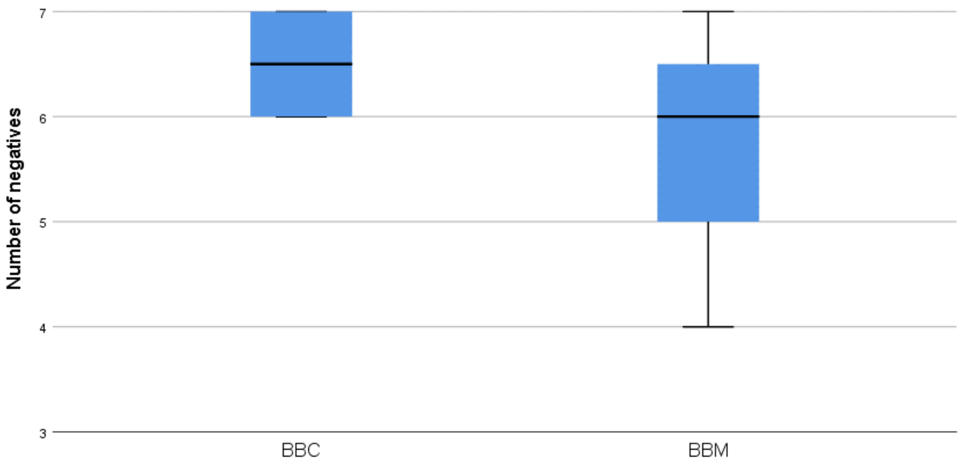


Figure 6.21. Boxplot of the number of removals in first surface of bifacial cores.

Second surface

Cortex degree

In bifacial cores, the second surface show a presence of cortex in the 60% of the cases (N=3), a medium cortical degree in the 40% (N=2) and a high cortical degree in the 20% (N=1). All the BBC cores have a medium and high cortical degree and the BBM is dominated by cores without cortical cover, the 66.7% (N=2), plus one core with a medium cortex degree (Table 52).

Table 52. Percentage of cortex degree in second surface of bifacial cores.

		0CTX2	2CTX2	3CTX2
BBC	**N**	-	1	1
	% By type	-	50%	50%
	% In total	-	20%	20%
BBM	**N**	2	1	-
	% By type	66.7%	33.3%	-
	% In total	40%	20%	-

Angle

Two types of flaking angle are predominating in the second surface, semi-abrupt with the 60% (N=3), and abrupt with the 40% (N=2). All the BBC cores are characterized by semi-abrupt flaking angle, while the BBM cores are dominated by abrupt angles in the 66.7% (N=2) of the cases plus one core with a semi-abrupt flaking angle (Table 53).

Table 53. Percentage of the second surface angle in bifacial cores.

		Angle	
		Abrupt	**Semi-Abrupt**
BBC	**N**	-	2
	% By type	-	100%
	% In total	-	40%
BBM	**N**	2	1
	% By type	66.7%	33.3%
	% In total	40%	20%

Extent of removals

Three types of removals extent have been identified, total and very marginal extent, with frequencies of the 40% (N=2) each, and marginal extent, 20% (N=1). The BBC shows marginal and very marginal represented in the 50% (N=1) of the cases each. For the BBM, the total extent dominates with the 66.7% (N=2) followed by one core with very marginal extent (Table 54).

Table 54. Extent of the removals in second surface of bifacial cores.

		m	mp	t
BBC	**N**	1	1	-
	% By type	50%	50%	-
	% In total	20%	20%	-
BBM	**N**	-	1	2
	% By type	-	33.3%	66.7%
	% In total	-	20%	40%

Removals organization

Three types of removals organization have been identified in the second surface of bifacial cores (Table 55), dominated by centripetal 60% (N=3) and followed by longitudinal and orthogonal types with 20% (N=1) each. Grouping by polarity, the BBM show an equal representation of each type, with the 33.3% (N=1).

Table 55. Percentage of removals organization in second surface of bifacial cores.

		Orthogonal	Centripetal	Longitudinal
BBC	N	-	2	-
	% By type	-	100%	-
	% In total	-	40%	-
BBM	N	1	1	1
	% By type	33.3%	33.3%	33.3%
	% In total	20%	20%	20%

Number of negatives

The mean number of negatives in the second surface is high in centripetal cores (N=8), followed by multipolar cores (N=3) (Fig. 6.22). According to polarity, there is differential pattern in each type. The two BBC cores are characterized by one with a high number of negatives (13) and a second with a low number (3) of removals. For the BBM cores, the two cases show a low number, with 1 and 3 removals and other case with 6 removals (Table 56).

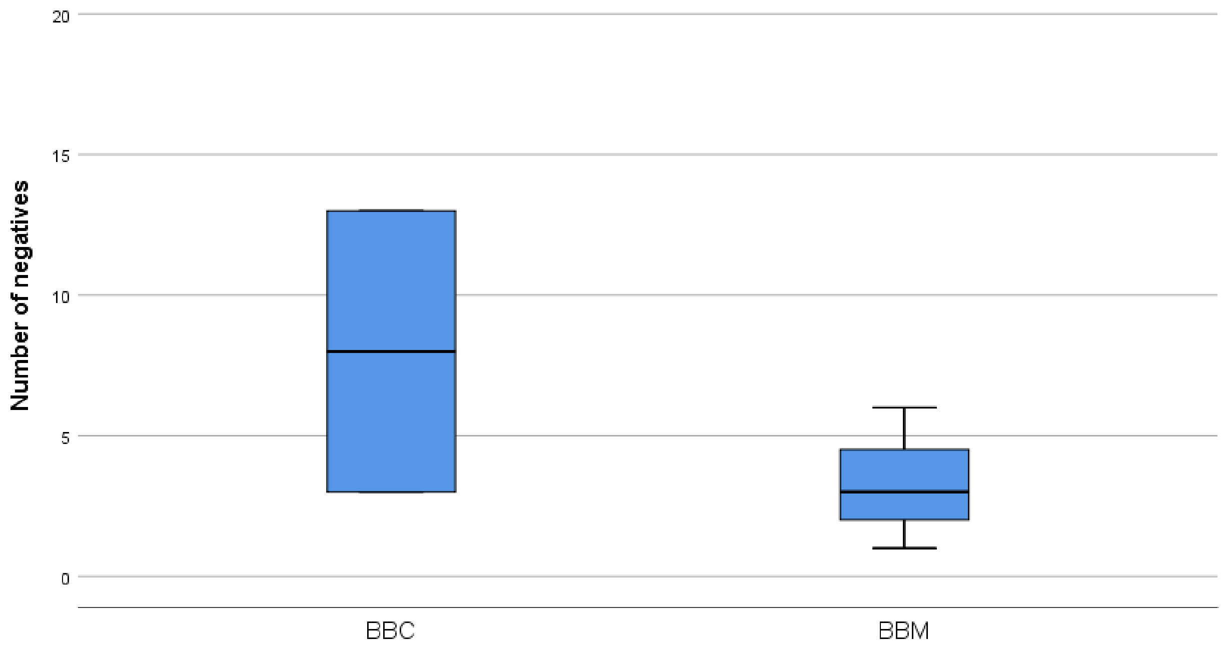


Figure 6.22. Boxplot of negatives number in second surface of bifacial cores.

Table 56. Distribution of negatives number is second surface of bifacial cores.

		BBC		BBM	
		N	%	N	%
Number of negatives	**1**	-	-	1	20%
	3	1	20%	1	20%
	6	-	-	1	20%
	13	1	20%	-	-

Hierarchization and symmetry

The symmetry in bifacial cores is low, with only one case of a symmetrical core. All the BBM cores show no symmetry the two knapped surfaces, while only one BBC core have a symmetrical shape. For the hierarchization, the 40% (N=2) are hierarchized, and according to polarity one is BBC and the other BBM (Table 57).

Table 57. Percentage of symmetry and hierarchical bifacial cores.

	Hierarchization			**Symmetry**		
	Yes			**Yes**		
	N	**% By type**	**% In total**	**N**	**% By type**	**% In total**
BBC	1	50%	20%	1	50%	20%
BBM	1	33.3%	20%	-	-	-

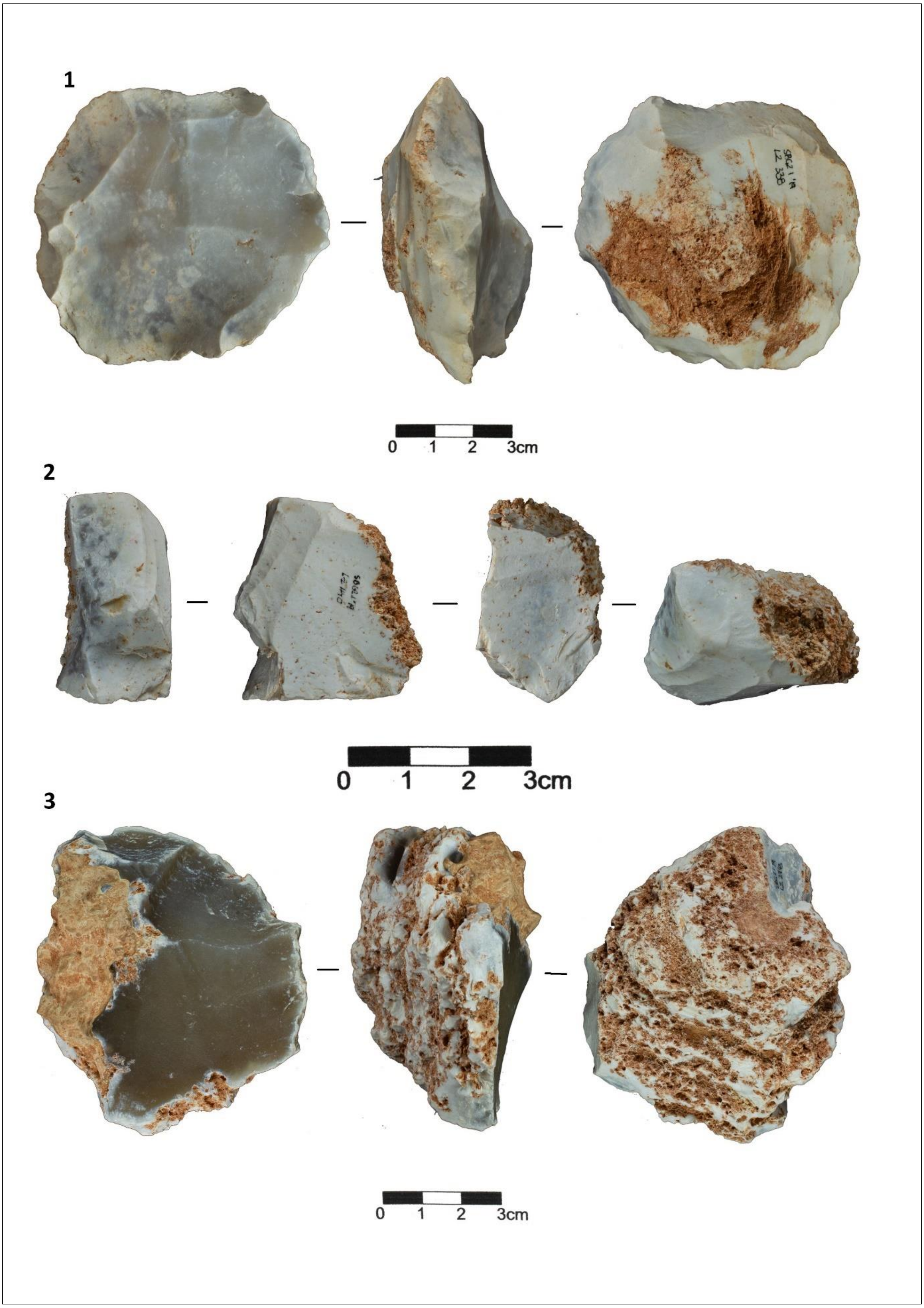


Figure 6.23. Examples of SBG2.L2 cores studied, 1-3 Levallois recurrent centripetal, 2 laminar cores.

6.3.3 Level 3 (SBG2.L3)

Core size

The metric measurements of SBG2.L3 has been studied according to core types (cores 75% (N=9), core-on-flake 16.7% (N=2) and core fragments 8.3% (N=1). The length mean differs between 63 and 44mm. The standard deviation for cores is the highest with a value of 20, while the cores-on-flake is 4. The width mean differs between 49 and 38mm. The thickness mean shows a high value in cores-on-flake type with the values ranging between 32 and 16mm. The standard deviation is 9 in cores (Fig. 6.24).

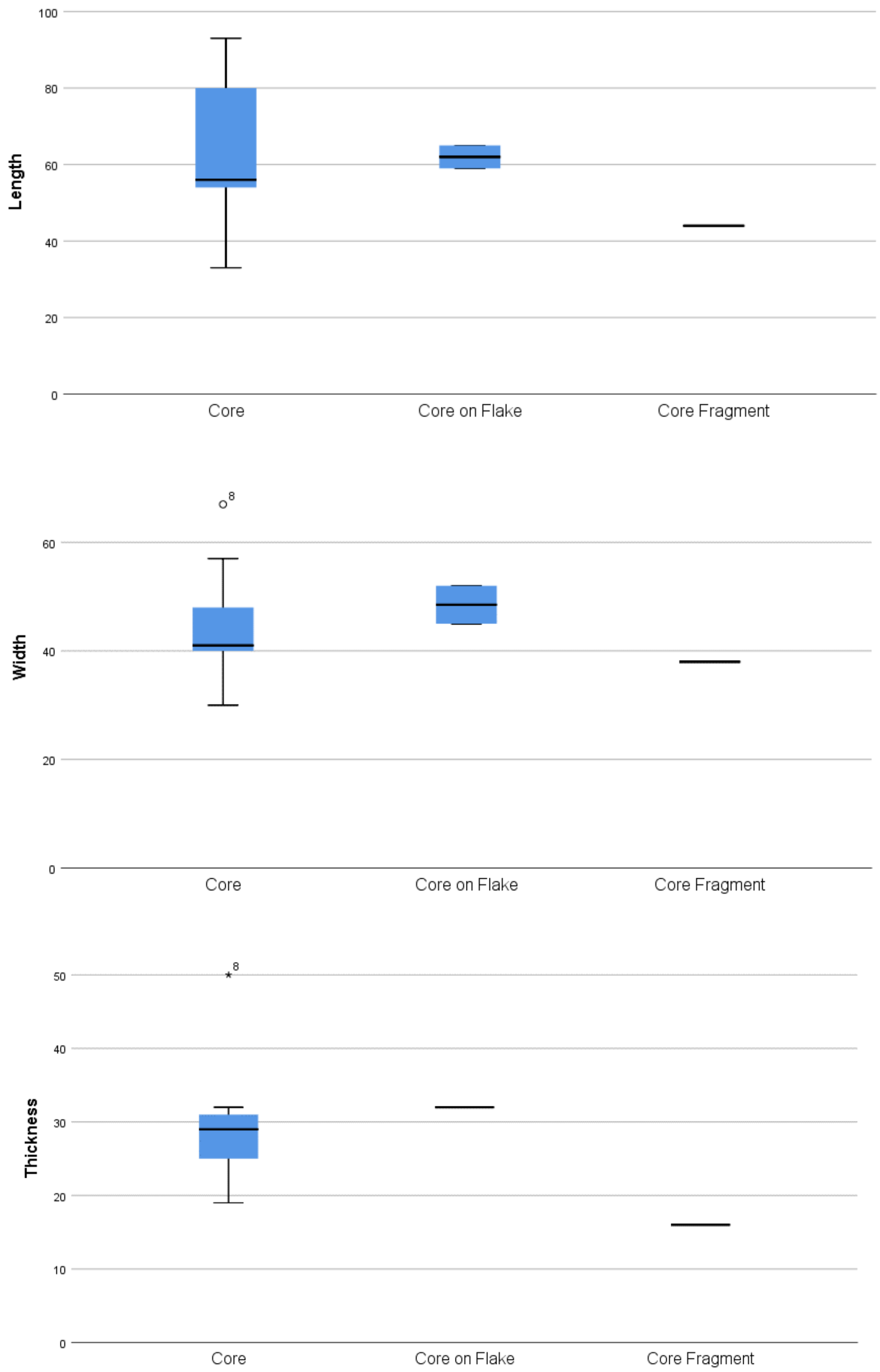


Figure 6.24. Boxplots of length, width, thickness in SBG2.L3 according to categories.

6.3.3.1 Taphonomical attributes

The dominating alterations in SBG2.L3 assemblage is concretion, present in the 100% (N=12) of the cores. The concretion varies from a thin to a thick layer of carbonate precipitation. The 66.7% (N=6) of the cores have been cleaned with a second round by HCL solution. The second type of alteration is patina, most cores show a high degree of patination, 83.3% (N=10), while the 16.7% (N=2) show a medial degree. In the same line the double patina is present in the 83.3% (N=10) of the assemblage. Slight rounding has been identified in the 50% (N=6) of the cores. And the last type of alteration is fractures, present in three cores, the 25% (Table 58).

Table 58. Taphonomical cores attributes in SBG2.L3.

		Level 3	
		N	%
Patina degree	**High**	10	83.3%
	Medial	2	16.7%
Double patina	**No**	2	16.7%
	Yes	10	83.3%
Rounding degree	**Fresh**	6	50%
	Slightly	6	50%
Ice fracture	**No**	9	75%
	Yes	3	25%
Concretion	**Yes**	12	100%

6.3.3.2 Technological attributes

Core cortex

Most cores in SG2.L3 show a presence of cortical cover, the 91.7% (N=10) (Fig. 6.25). The cortex varies within the assemblage and is dominated by medium (25-50%) and low (less than 25%) degree with the same value 41.7% (N=5) each, only one core show a high degree (50%-75%) and another one without cortex (N=1).

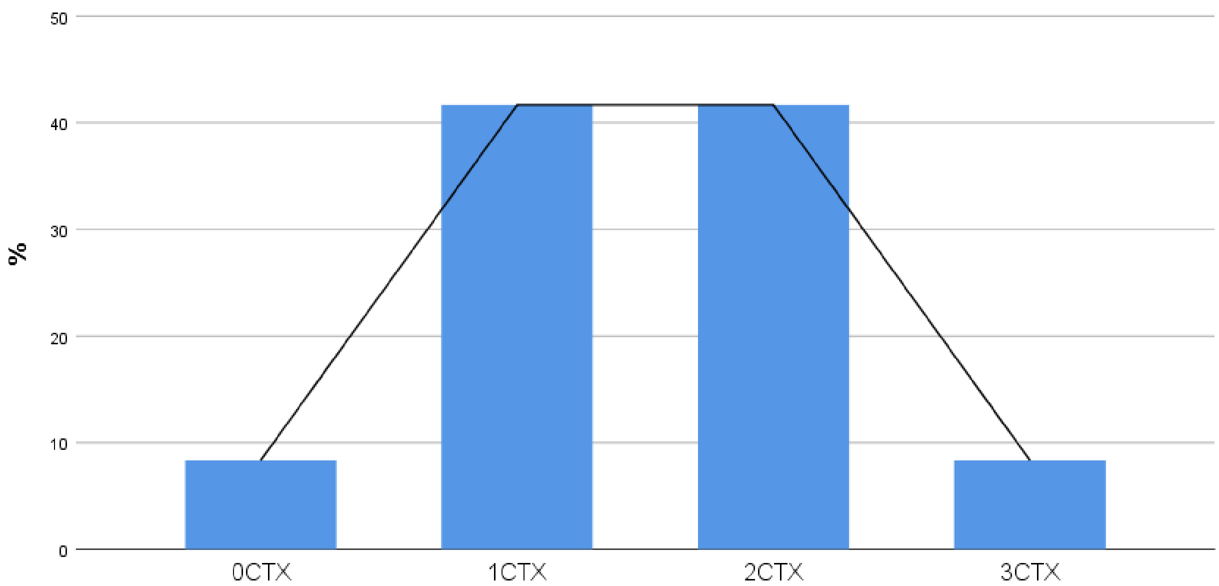


Figure 6.25. Bar-chart of cortex degree in SBG2.L3

Faciality and general polarity
SBG2.L3 (Fig. 6.26) is dominated by bifacial cores, with the 91.1% (N=11), mainly bipolar bifacial centripetal, the 41.7% (N=5), bipolar bifacial multipolar, the 41.7% (N=5), and bipolar bifacial orthogonal, the 8.3% (N=1).

The unifacial cores have a very low presence 8.35% (N=1) and are represented by a unifacial unipolar centripetal.

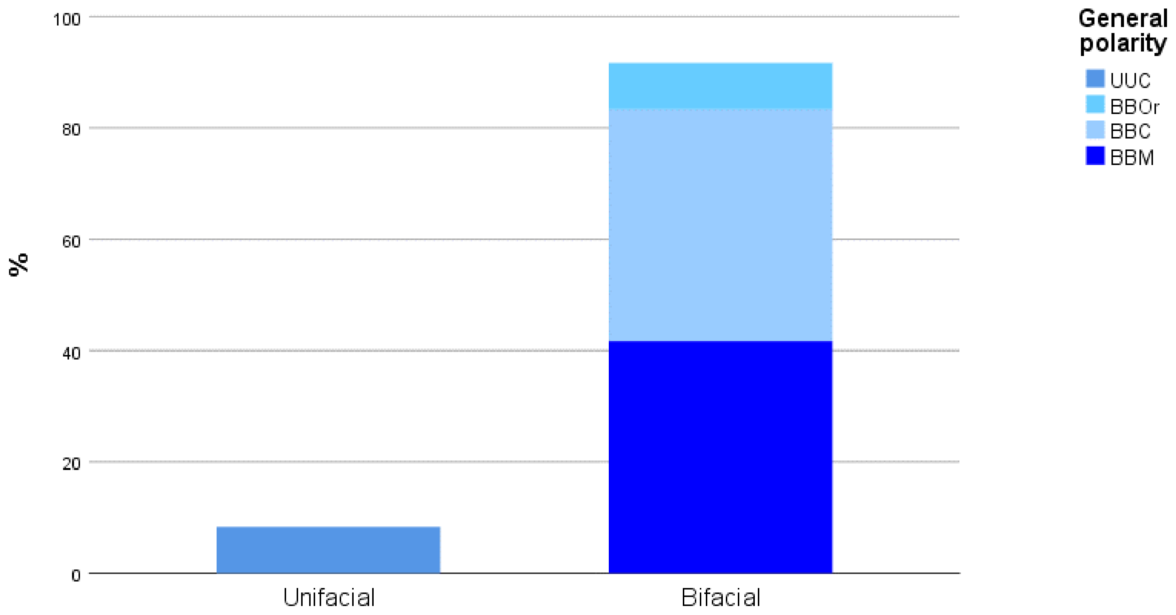


Figure 6.26. staked bar of faciality by general polarity in SBG2.L3.

Morphology
In the same pattern of other levels from SBG2, there is no predominant morphology in the assemblage from Level 3 (Fig. 6.27). First, within the horizontal view, five types have been identified, dominated by pentagonal morphology with the 33.3% (N=4), followed by ovoid, representing the 25% (N=3), circular and trapezoid with the same value 16.7% (N=2) each, and triangular type presenting in one core 8.3% (N=1).
The transversal view is dominated mainly by triangular morphologies, representing the 41.7% (N=5), followed by trapezoid types with the 33.3% (N=4) and rhomboid, 25% (N=3).
The sagittal view show four types, dominated by trapezoid 44.7% (N=5), followed by rectangular and triangular with the same value 25% (N=3) each, and pentagonal morphology present in one.

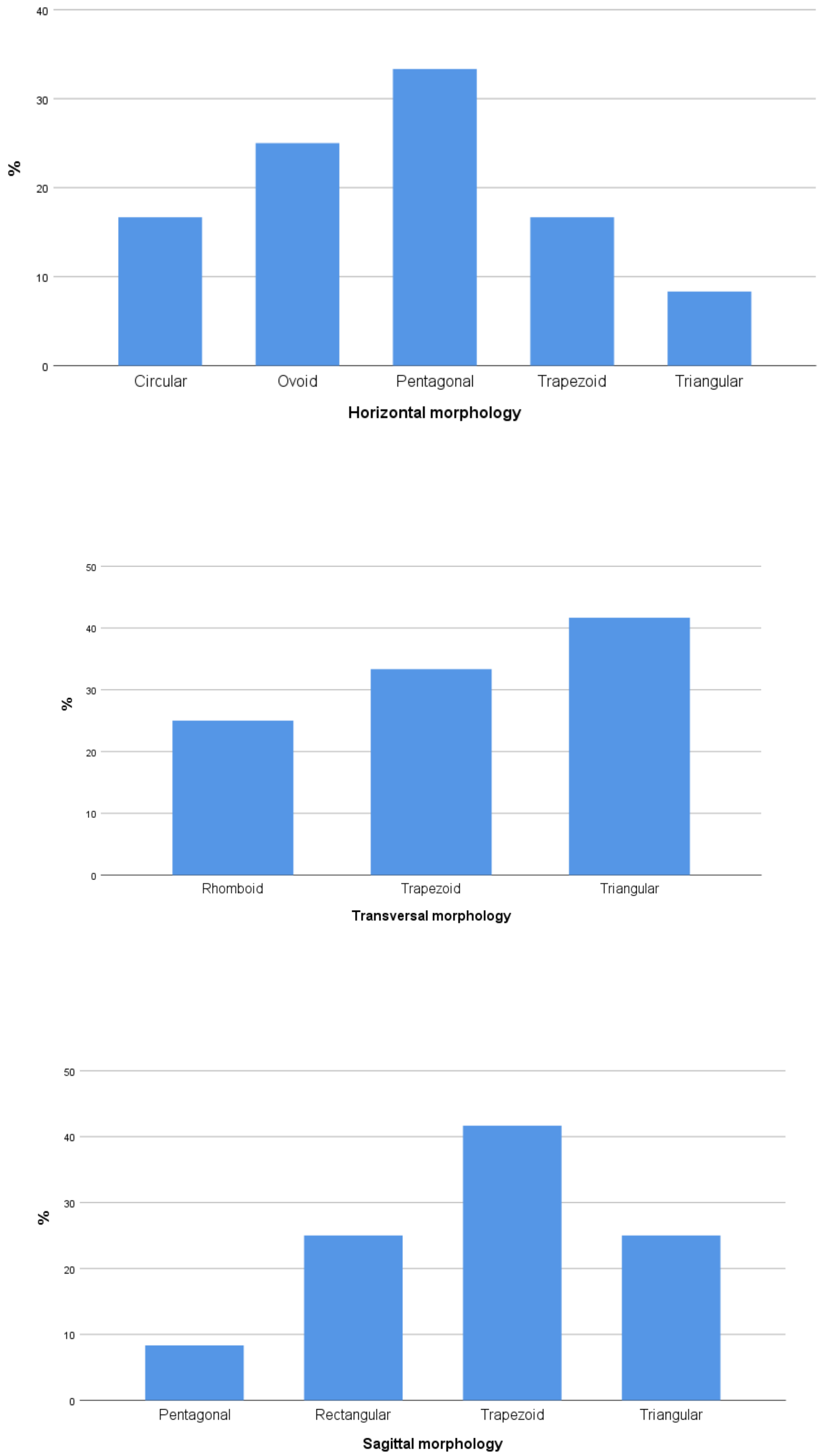


Figure 6.27. Bar-chart of horizontal, transversal and sagittal morphology of SBG2.L3 cores.

Unifacial cores

One unifacial core on flake have been identified, performed on a large flake. The dimensions are 65x45x32mm and is highly patinated and concreted (concretion have been cleaned two times with HCL solution). For the technological characteristics, the flaking angle is abrupt without cortical cover, the removal extent is total and presents 6 removals organized centripetally.

Bifacial cores

First surface

Facial cortex

The majority of the first surfaces, the 81.8% (N=9), do not show cortical cover. Low cortical cover is present in the 18.2% (N=2) of the cores. Grouping by polarity, the BBOr is represented by one core showing no cortical cover (Table 59). The BBC and BBM cores show the same value, with the 80% (N=4) showing no traces of cortex, while one core presents a low cortical degree.

Table 59. Percentage of cortex degree in first surface of bifacial cores.

		0CTX1	1CTX1
BBC	**N**	4	1
	%By type	80%	20%
	% In total	36.4%	9.1%
BBM	**N**	4	1
	%By type	80%	20%
	% In total	36.4%	9.1%
BBOr	**N**	1	-
	%By type	100%	-
	% In total	9.1%	-

The angle

The flaking angle is semi-abrupt in the 54.5% (N=6) of the cases, simple in the 27.3% (N=3) and plane in the 18.2% (N=2). Grouping by the polarity, the BBOr core presents a simple angle. The BBC are characterized by semi-abrupt angles, with the 80% (N=4), followed by the simple angle. For the BBM there is a higher variability, the plane and semi-abrupt flaking angles are present in the 40.5% (N=2) each, plus one core with simple type 20% (N=1) (Table 60).

Table 60. Percentage of first surface angle types in bifacial cores.

		Plane	Semi-Abrupt	Simple
BBC	**N**	-	4	1
	% By type	-	80%	20%
	% In total	-	36.4%	9.1%
BBM	**N**	2	2	1
	% By type	40%	40%	20%
	% In total	18.2%	18.2%	9.1%
BBOr	**N**	-	-	1
	% By type	-	-	100%
	% In total	-	-	9.1%

Extent of removals

The extent of the removals in bifacial cores is total in the 90.9% (N=10) of the cases, and very extensive in 9.1% (N=1). The only BBOr core have a total extent of the removals While the BBC and BBM cores shows the same value, dominated by total extent, 80% (N=4), followed by very extensive type in 20% (N=1) each (Table 61).

Table 61. Percentage of the extent of removals in bifacial core first surface.

		mp	t
BBC	**N**	1	4
	% By type	20%	80%
	% In total	9.1%	36.4%
BBM	**N**	1	4
	% By type	20%	80%
	% In total	9.1%	36.4%
BBOr	**N**	-	1
	% By type	-	100%
	% In total	-	9.1%

Removals organization

Five types of removals directions have been identified (Table 62), the most abundant is the centripetal direction in the 45.5% (N=5), followed by orthogonal and cordal directions with the same value 18.2% (N=2), and opposed and longitudinal in 9.1% (N=1). Grouping by polarity, four organizations have been identified in the BBM cores, the cordal organization is present in two cores 40% (N=2), while the opposed, orthogonal, and longitudinal direction are present in one core each.

Table 62. Percentage of directional removal in first surface of bifacial cores.

		Opposed	Orthogonal	Centripetal	Cordial	Longitudinal
BBC	**N**	-	-	5	-	-
	% By type	-	-	100%	-	-
	% In total	-	-	45.5%	-	-
BBM	**N**	1	1	-	2	1
	% By type	20%	20%	-	40%	20%
	% In total	9.1%	9.1%	-	18.2%	9.1%
BBOr	**N**	-	1	-	-	-
	% By type	-	100%	-	-	-
	% In total	-	9.1%	-	-	-

Number of negatives

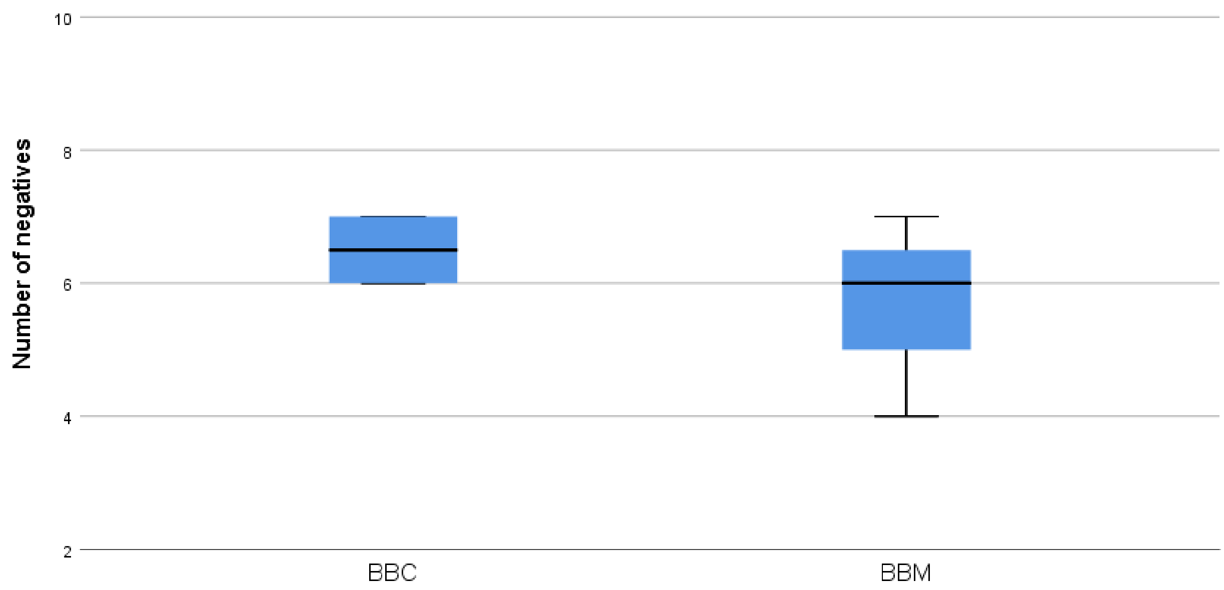


Figure 6.28. Boxplot of removals number in first surface of bifacial cores.

The mean number of negatives is high in the first surface of centripetal and multipolar cores, with 6 negatives each, and medium in orthogonal cores, with 4 negatives. For the distribution of the number of negatives according to core types, BBC cores show the highest number of removals with 10 and 7 each, plus three cores with a medium number between 4 and 6 removals. The BBM cores show a low number between 2 and 4 removals in three cores each, and one presents 11 removals. The BBOr core show 4 removals in the first surface (Fig. 6.28, Table 63)

Table 63. Distribution of the first surface negative's number in bifacial cores.

		BBC		BBM		BBOr	
		N	**%**	**N**	**%**	**N**	**%**
Number Of negatives	**2**	-	-	1	9.1%	-	-
	3	-	-	1	9.1%	-	-
	4	1	9.1%	1	9.1%	1	9.10%
	5	1	9.1%	-	-	-	-
	6	1	9.1%	-	-	-	-
	7	1	9.1%	-	-	-	-
	10	1	9.1%	-	-	-	-
	11	-	-	1	9.1%	-	-
	12	-	-	1	9.1%	-	-

Second surface

Facial cortex

In the bifacial cores, the second surface is dominated by the presence of cortex in the 72.8% (N=8) of the cases. The frequencies of cortex are devised as follow, 36.4% (N=4) have a 50-75% cortex, 18.2% (N=2) with less than 25% and 25-50% cortex each. Plus 27.3% (N=3) shows no cortical cover (Table 64).

The only BBOr core show no cortical cover in the second surface, while the BBM and BBC cores are dominated by a high degree of cortex (50%-75%) in the 40% (N=2) of the cases each, followed by medium (25%-50%) and low (less than 25%) degree in the 20% (N=1), plus one case without cortex cover, 20% (N=1).

Table 64. Percentage of cortex degree in second surface of bifacial cores.

		0CTX2	**1CTX2**	**2CTX2**	**3CTX2**
BBC	**N**	1	1	1	2
	% By type	20%	20%	20%	40%
	% In total	9.1%	9.1%	9.1%	18.2%
BBM	**N**	1	1	1	2
	% By type	20%	20%	20%	40%
	% In total	9.1%	9.1%	9.1%	18.2%
BBOr	**N**	1	-	-	-
	% By type	100%	-	-	-
	% In total	9.1%	-	-	-

Angle

The abrupt and semi-abrupt flaking angle is the most abundant, with the 36.4% (N=4) each, followed by the simple angle present in the 18.2% (N=2) and plane angle in the 9.1% (N=1) (Table 65).

The BBC and BBM cores show the same pattern of abrupt and semi-abrupt flaking angle in the second surface with a percentage of 40% (N=2) each, plus one case characterized by a simple angle. The only case of BBOr is characterized by a plane angle.

Table 65. Percentage of the second surface angle types in bifacial cores.

		Abrupt	Plane	Semi-Abrupt	Simple
BBC	**N**	2	-	2	1
	% By type	40%	-	40%	20%
	% In total	18.2%	-	18.2%	9.1%
BBM	**N**	2	-	2	1
	% By type	40%	-	40%	20%
	% In total	18.2%	-	18.2%	9.1%
BBOr	**N**	-	1	-	-
	% By type	-	100%	-	-
	% In total	-	9.1%	-	-

Extent of removals

Three types of removal's extent have been identified, very extensive in the 45.5% (N=5), total in the 27.3% (N=3) and marginal in the 27.3% (N=3) (Table 66).

The BBC cores are characterized by marginal and very extensive removals with the 40% (N=2) plus one case with a total extent. The BBM cores are dominated by very extensive removals in the 60% (N=3), plus one case with marginal and total extent each. Finally, the only case of BBOr have a total extent in the second surface.

Table 66. Extent removals of second surface in bifacial cores.

		m	mp	t
BBC	**N**	2	2	1
	% By type	40%	40%	20%
	% In total	18.2%	18.2%	9.1%
BBM	**N**	1	3	1
	% By type	20%	60%	20%
	% In total	9.1%	27.3%	9.1%
BBOr	**N**	-	-	1
	% By type	-	-	100%
	% In total	-	-	9.1%

Removals organization

Four different removals organizations have been observed in the second surface (Table 67), dominated by centripetal in the 72.7% (N=8), and followed by opposed, orthogonal and longitudinal with one case each. For the BBM cores, the second surface is characterized by a centripetal direction in the 60% (N=3), plus one case with opposed and longitudinal directions.

Table 67. Percentage of removals organization in second surface of bifacial cores.

		Opposed	Orthogonal	Centripetal	Longitudinal
BBC	N	-	-	5	-
	% By type	-	-	100%	-
	% In total	-	-	45.5%	-
BBM	N	1	-	3	1
	% By type	20%	-	60%	20%
	% In total	9.1%	-	27.3%	9.1%
BBOr	N	-	1	-	-
	% By type	-	100%	-	-
	% In total	-	9.1%	-	-

Negatives numbers

The mean number of negatives in the second surface is high in centripetal cores (8), followed by multipolar (5) and orthogonal ones (2) (Fig. 6.29). The centripetal cores show between 6 and 7 negatives in three cases, followed by two cases with 10 and 12 (Table 68). The multipolar cores have between 4 and 7 negatives in 5 cases. While the orthogonal core displays 2 removals in the second surface.

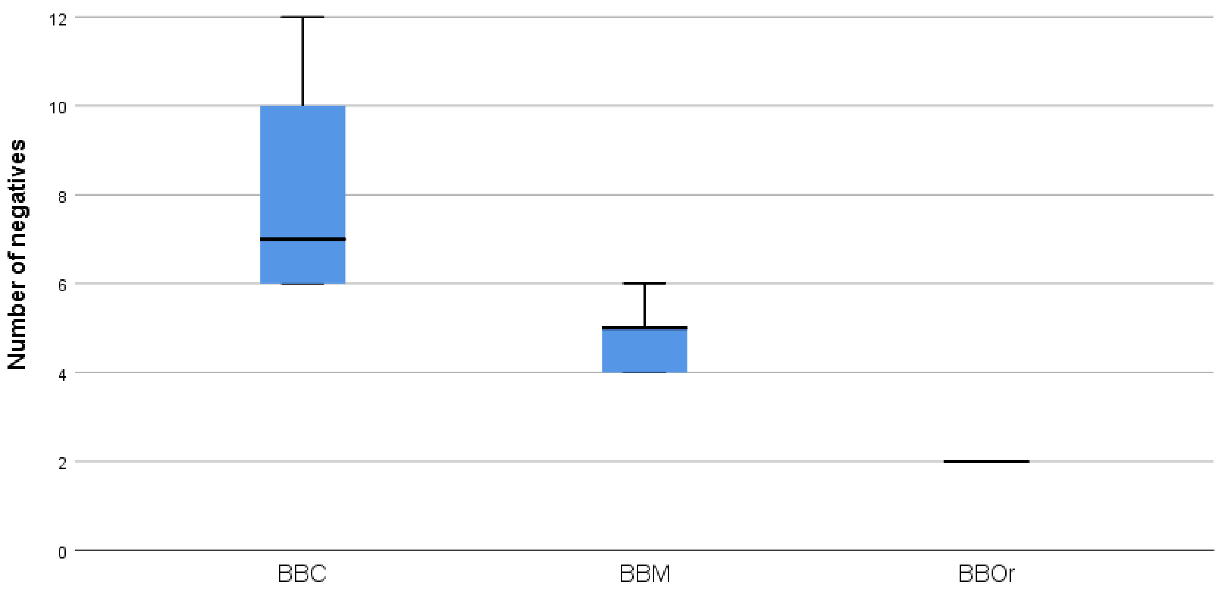


Figure 6.29. Boxplot of negative number in the second surface of bifacial cores.

Table 68. Distribution of negative number in second surface of bifacial cores.

		BBC		BBM		BBOr	
		N	% By type	N	% By type	N	% By type
N. negatives	**2**	-	-	-	-	1	9.1%
	4	-	-	2	18.20%	-	-
	5	-	-	2	18.20%	-	-
	6	2	18.2%	1	9.10%	-	-
	7	1	9.1%	-	-	-	-
	10	1	9.1%	-	-	-	-
	12	1	9.1%	-	-	-	-

Symmetry & hierarchization

The symmetry in bifacial cores is low, with the 20% (N=3) of the cores presenting symmetry between their faces. The BBC cores display the highest values with two cases, while in BBM one case have been identified. The hierarchized cores in SBG2.L3 represent the 33.4% (N=4), the BBM and BBC types show the same frequency with the 16.7% (N=2) each (Table 69).

Table 69. Percentage of symmetry and hierarchical in bifacial cores.

	Symmetry		**Hierarchization**	
	Yes		**Yes**	
	N	**%**	**N**	**%**
BBC	2	16.7%	2	16.7%
BBM	1	8.3%	2	16.7%

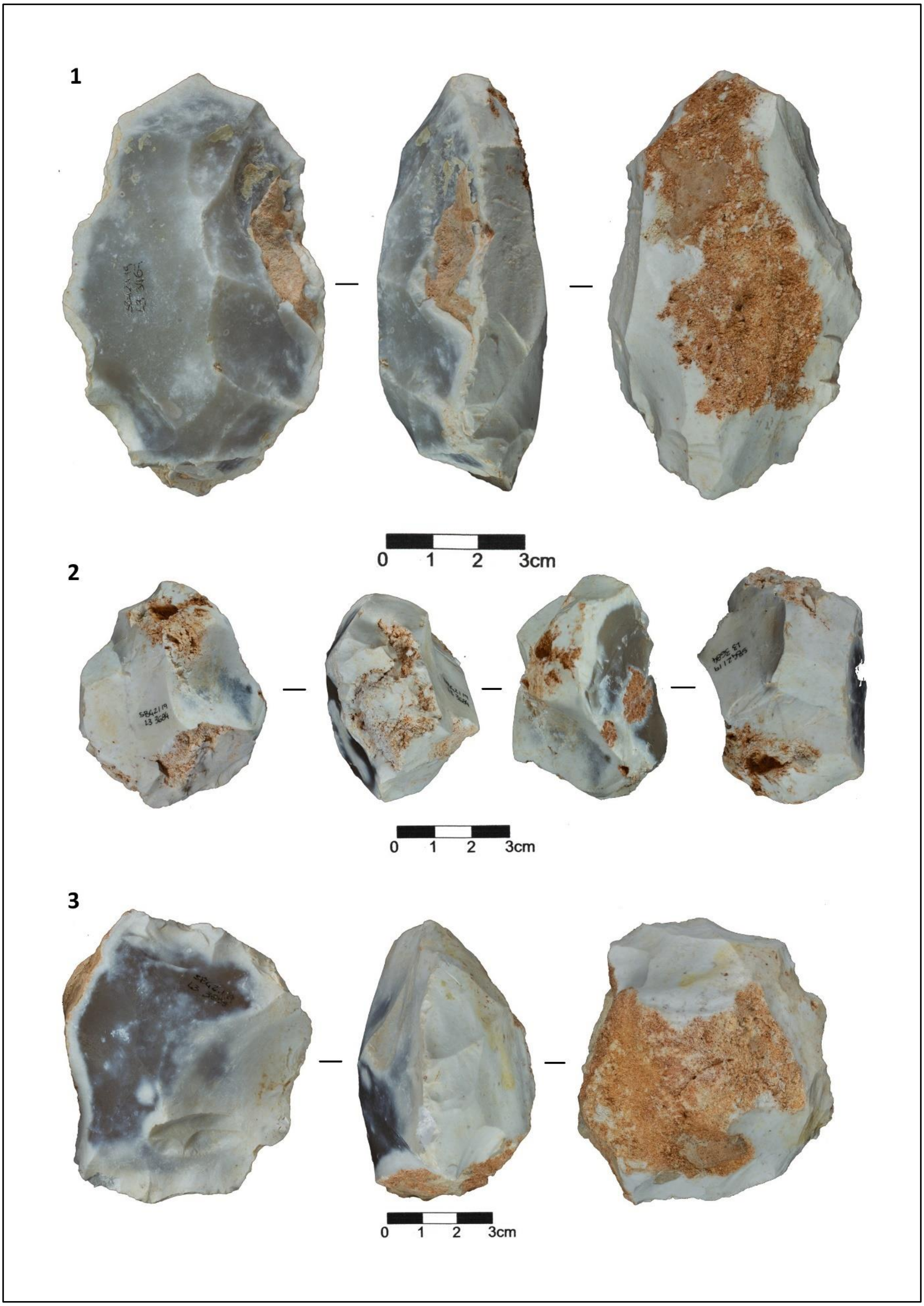


Figure 6.30. Examples of SBG2.L3 cores studied, 1-3 Levallois recurrent centripetal, 2 Bipolar multidirectional

7. DISCUSSION

This Master Thesis is focused on the MSA in North Africa through the study of the core assemblages from the newly discovered site of Sahb El Ghar 1 & 2 in Eastern Morocco. Sahb El Ghar sites are significant and key sites to understand the human evolution during that period because its strategical position as an open-air site with a stratified archaeological sequence of repeated human occupations. Furthermore it is situated in an raw material-rich area where high quality cherts are abundant (Chacón et al., 2018, 2019a, 2019b; Oujaa et al., 2018; Sala Ramos et al., 2017)

The SBG1 & SBG2 cores assemblage studied in this master thesis has provided a large detail about the taphonomical and technological characteristics present at the SBG1 & SBG2 sites. The technical attributes of the lithics assemblages allow to associate these sites to the Middle Stone Age period, plus the presence of levels in stratigraphic position provide insights about the human adaptive behaviors during the MSA period in the region. This research presents the first technological work based in the study of core-reduction strategies of the 101 cores identified in both SBG1 and SBG2 sites. The first part of the discussion will be focused on the taphonomical attributes that provide information about post-depositional features affecting the cores and site formation processes. The second part will deal with the detailed technological analysis, and the third one with the contextualization of our results in a broader perspective.

7.1 Post-dispositional features

All the cores studied in both sites shows some post-depositional alterations, the patina is always present with some variability between levels. The patination is homogenous and affected cores' surface, however in SBG2.L2 & L3 there is a clear differentiation of patina between core surfaces related with the core deposition. The concretion is present in high degree in SBG2.L2 and L3, in some cases even with HCL treatments the concretions was hard remove (Table 58). While the cores edges are mostly slightly rounded in SBG2 (all the levels), in SBG1.L1 there is a medium rounding degree (Table 8). Even that the sites are currently located in a semi-arid environment it appears that there is two main different environmental process influence the sites. The SBG1.L1 and SBG2.L1 cores assemblage have been affected with the same abrasion and chemical alteration with a little differentiation regarding the rounded degree that may related with position in the lower segment of the slope and the high number of lithic assemblage in the occupation wish make it easy to damage the cores edges (Burroni et al., 2002; Hurst and Kelly, 1961; Tringham et al., 1974). SBG2.L1 and L3 assemblages are affected mainly by chemical alterations related with water flowing, the presence of SBG2.L3 assemblage in a laminar calcrete layer confirm the existence of a low water stream and the rapid carbonate precipitation which conserve the cores in their initial position without transport.

We should take a point on another factor that have been observed in the assemblage, the fractures due to the seasonal change of temperature between warm and cold weather or crioclastic processes. In our case the fractures are abundant in SBG1.L1 and SBG2.L1 which indicate long time exhibition of lithic assemblages in the surface. This is also confirmed by the double patination, related with recycling behaviors in the same assemblage(Amick, 2015). The 16.7% and 21.7% of the cores show a double patina due to re-use processes in SBG1.L1 and SBG2.L1 assemblages. In SBG2.L2 and SBG2.L3 we couldn’t identify any core with a double patina related with re-use behaviors.

7.2 Raw material Procurement

The sites are located in a quarry area rich in evaporitic nodular cherts in a range of 30 km2 (Figure 4.13). This area has been well known even before of the excavation of SBG 1 & 2, and most of the archeological sites previously identified belonged to the ESA. However, the tendency to use materials from Swiwina increases during the MSA period (Soto et al. 2021). Regarding the SBG sites, all the raw material used come from the local environment (immediate procurement) with only one core show a different source in Aïn Beni Mathar-Guefaït area (rhyolite) (Figure 4.14). Because of the abundance of high-quality material to knap, the reduction sequences are attended to be more opportunistic. The objective of knapping is to get as much as possible flakes and it is supported by the percentage of cores in the sites, especially in SBG1.L1 and SBG2.L1 & L3, plus the selection of weathering fragments (crioclasts) in more than 40% as a support show this behavior.

7.3 Reduction sequences

In a general point of view, the core assemblages clearly show technical attributes associated to the Middle Stone Age. The cores structures are characterized by the dominance of bifacial knapping in all the levels (Figure 6.5Figure 6.12Figure 6.19Figure 6.26), while the unifacial and trifacial types have been observed in SBG1.L1 and SBG2.L1 only with a limited number. The analyzed results show the presence of complex reduction strategies such as Levallois, discoidal and laminar, but also a high percentage of opportunistic strategies (Figure 7.1). Some refits have been documented in SBG1.L1 which indicate the in situ knapping activities.

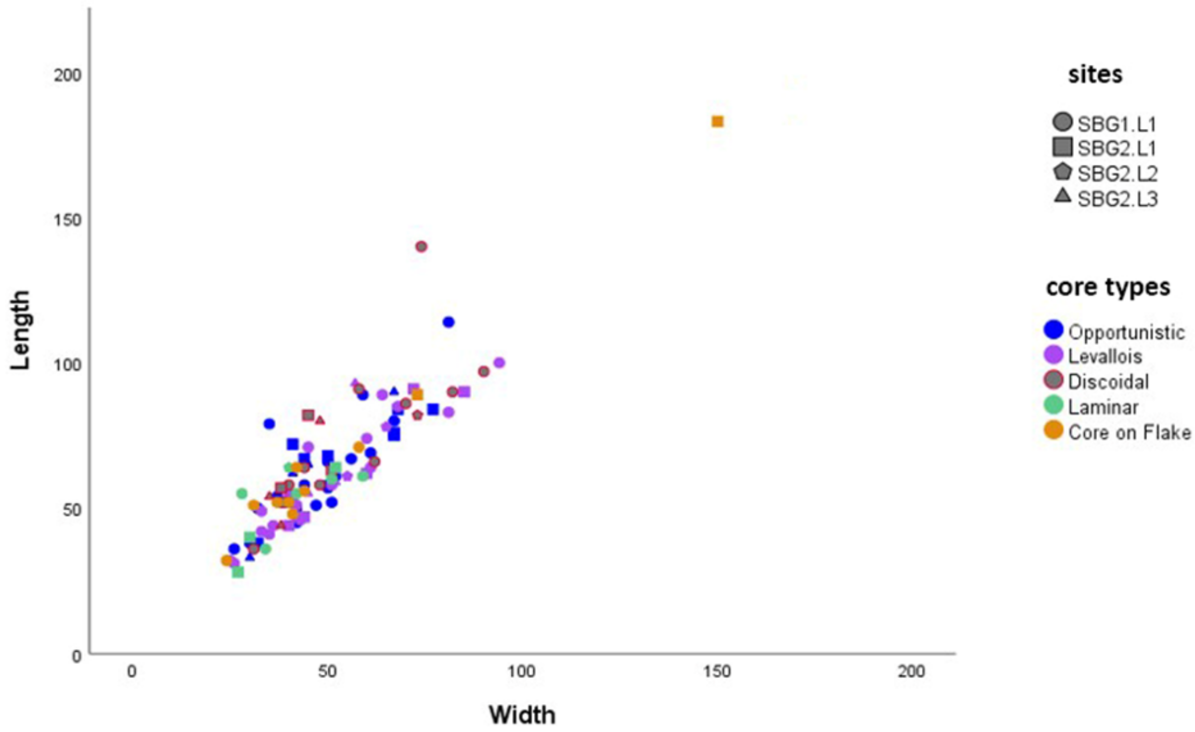


Figure 7.1 Distribution of core types according to size on each level.

Opportunistic cores

The opportunistic cores show a high percentage in the SBG assemblage. The method is based on the informal exploitation of raw materials, without any standardized morphology and size. The cores attend to have different negative directions and series of removals depending on the adaptation to the raw material features. This type is observed in SBG1.L1 and SBG1.L1 & L3 with a high percentage between 31% to 35%, and they are mostly in both initial and advanced reduction stages. This system is very clear in re-used core types, where the systematic exploitation is interrupted by short series of removals.

Levallois Cores

For the complex reduction strategies, the Levallois conception of flaking is the most abundant in the core assemblage. It consists of the preparation of cores with hierarchized surfaces and convex striking platforms where the flakes are removed parallel to the intersection plan. In the sites the number of Levallois cores is very high (in term of percentage) specially in SBG2.L2 & L3 where Levallois type consist between 40% and 50%. While in SBG1.L1 and SBG2.L1 they present the higher percentage compared with other complex reduction strategies 34% and 30% respectively. The main modalities applied in the sites are the preferential and recurrent centripetal. The centripetal modality is the most abundant in all the levels, especially in SBG1.L1 and SBG2.L1, and is characterized by the production of numerous flakes from the same flaking surface. The removals organization is even centripetal or multidirectional, the preparation surface has a medium to high cortical cover. The second type, preferential modality is used to produce unidirectional or opposed flakes that are slightly elongated, this type is present in all the levels but with low frequencies, some cores show no platform preparation, but the hierarchical structure is present. The cortical cover in the preparation surface is high. Both modalities present an advance or exhausted stage of removals where in some cases the cores are less than 40x40mm in size.

Discoidal cores

The discoidal strategy is less represented in the sites. The highest representation is observed in SBG2.L3, with the 25%, while in the other levels it differs between the 16% and 17%. This type of strategy has been applied to get small flakes and the number of removals is higher than in other types. There is no preferential morphology or size, and the flaking angles are even abrupt or semi-abrupt which make it very hard to extract any further flakes. The removals attend to be centripetal or multidirectional (related with the relationship between the two surfaces). The cortical cover is scarce or absent in both surfaces. Most of the cores show an advanced stage of reduction, and some of them are exhausted.

Laminar cores

The laminar strategy is considered one of the main indicators of the Aterian technocomplex. These cores are characterized by a single striking platform arranged to flake longitudinal blades. Laminar cores have been observed in SBG1.L1 (N=5), SBG2.L1 (N=3) and SBG2.L2 (n=1) while in SBG2.L3 this type of strategy is absent. They are characterized by a small size compared with Levallois and discoidal types. The number of removals differ between cores and is not related with the core size, but with the potential to extract more laminar flakes. The cores always preserve some cortical cover and show advanced reduction stages.

Core on flakes

Core-on-flakes are only present in SBG1.L1 and SBG2.L1. This type of reduction is not related with Kombewa strategy. The core-on-flakes are exploited depending on the convexity present naturally in the ventral face to extract some flakes. The size of the cores-on-flake varies from 180mm to 40 mm in length. The series of removals are short, between 1 and 4, only one core show 7 removals in SBG2.L1. The removal organization is dominated by the longitudinal type, followed by centripetal ones.

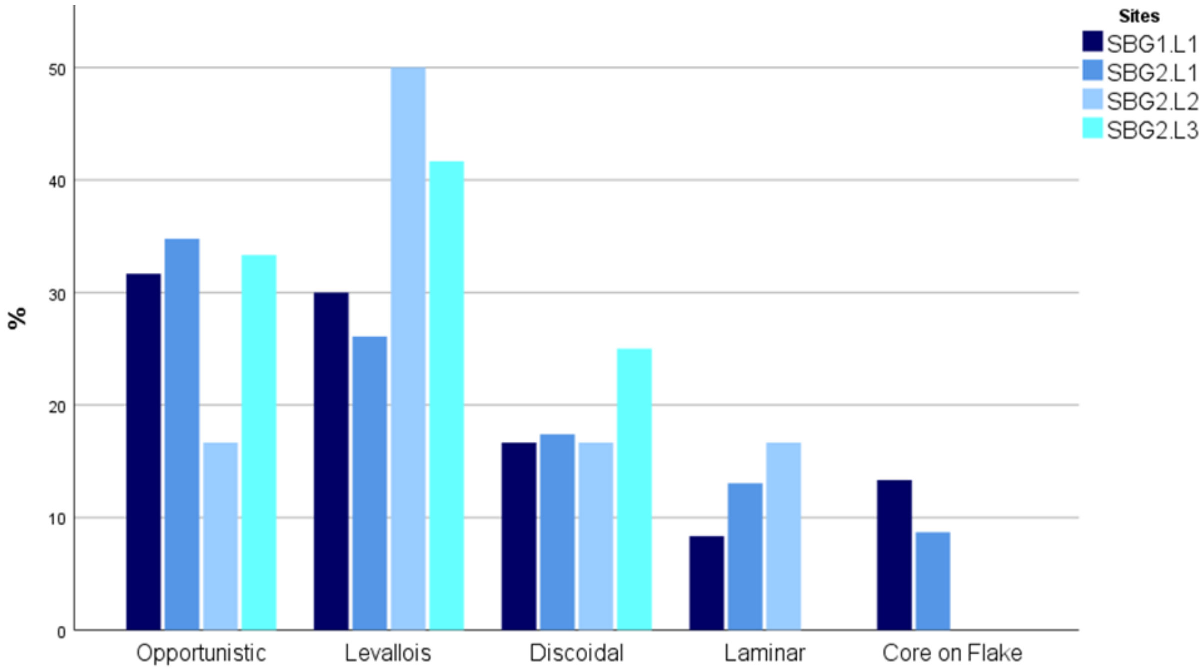


Figure 7.2. Percentage of core types in SBG1 and SBG2.

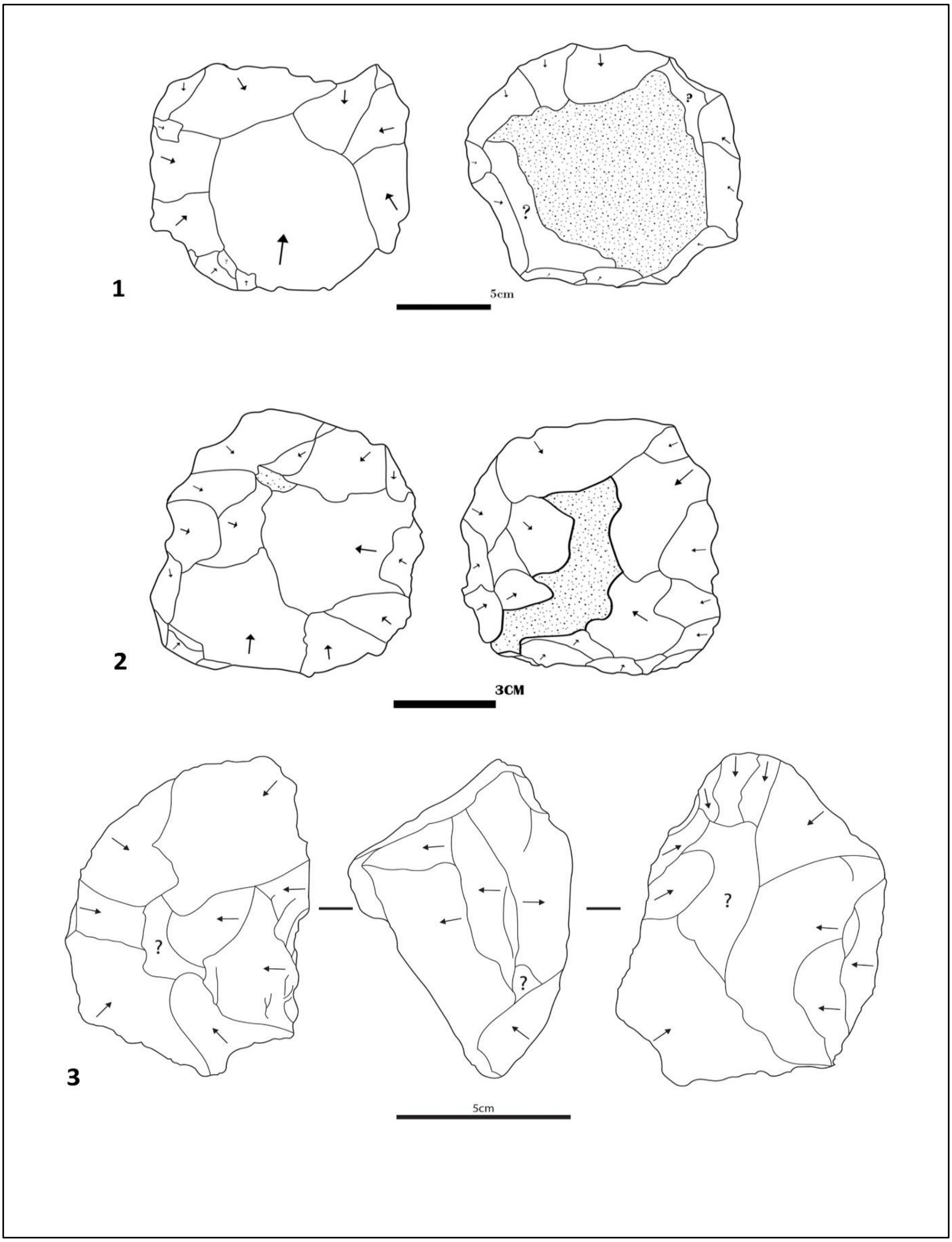


Figure 7.3. SBG1 cores. 1-2 Levallois (1-preferential. 2-Centripetal), 3 discoidal

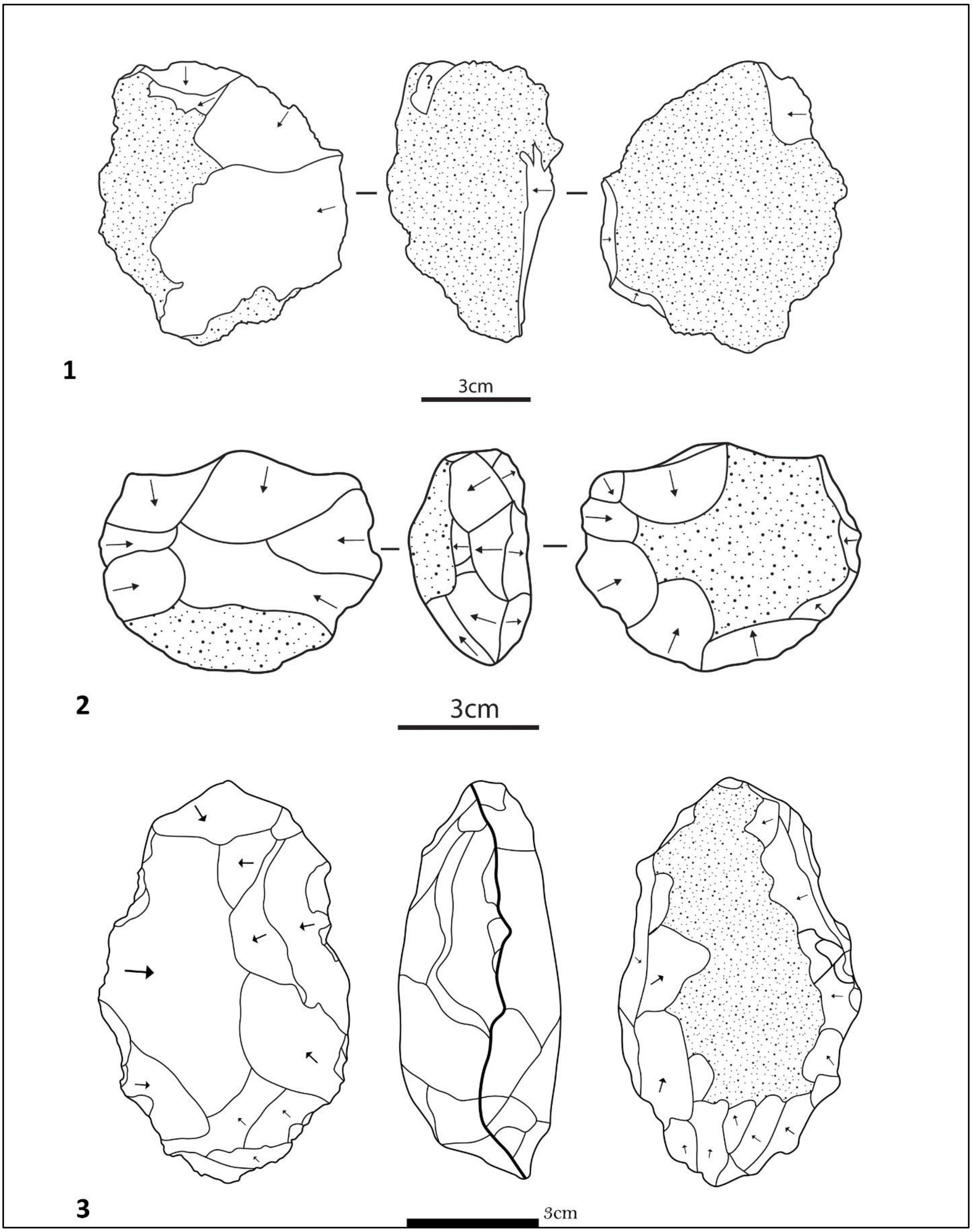


Figure 7.4. SBG2 Bipolar centripetal Cores. 1-SBG2.L1, 2-SBG2.L2, 3-SBG2.L3

7.4 Regional contextualization of SBG cores assemblage

The Sahb El Ghar 1 and 2 sites have provided the first technological results through the analysis carried out in the core assemblages. The sites present stratified occupation levels in an open-air quarry area with a surface of 8 km2. From the core assemblage analysis, the site is associated to the typical Middle Stone Age period of north Africa. More specifically, the sites provide evidence of the two technocomplex, Aterian and Mousterian, showing a similarity with other caves and rockshelters in the region.

Starting with the Mousterian, the technocomplex is characterized by a Levallois and discoidal technology, plus the presence of low number of retouched pieces, denticulates and notches. The SBG2.L3 is characterized by the abundance of the Levallois strategy with two modalities, the recurrent centripetal and the preferential, followed by the opportunistic cores and discoidal, while there is a total absence of laminar reduction type. Additionally, the knapping products shows a homogeneous flake assemblage including almost all the stage of the reduction sequences where cortical, ordinary, predetermined, and predetermining Levallois flakes have been identified associated with a very low number of retouched pieces such as denticulates and scrapers (Chacón et al. 2021, Farkouch et al. 2021). The technological similarities have been identified in contemporary sites such as layer 3 in Rhafas (Doerschner et al., 2016; Wengler et al., 2001), layer h in Taforalt (Roche, 1967, 1969), layer 35-42 and 55-63 in Ifri-N'ammar (Nami, 2010) or Station meteo (Wengler, 1993). In other open-air sites in the south Saharan Tafilalt region such as Imlil, Aferdou, Ighiramagaruh 1, 2, Jbel Kifroun (Arzarello et al., 2013) and Amane Oukidar (Arzarello et al., 2012). In the Atlantic coast, layer 5-6 in Contrebandiers cave (Dibble et al., 2013), El Mnasra, El Harhoura and Dar es Soltan (Ben Arous et al., 2020; Scerri and Spinapolice, 2019)

The Aterian is described as a Mousterian with tanged tools because of the similarity in complex reduction strategies applied such as Levallois, discoidal, but with specific features, the presence of laminar reduction associated with tanged tools and bifacial foliates. These characteristics are present in SBG1.L1, SBG2.L1 and in a lower degree in SBG2.L2. We identified the presence of laminar cores in all the three levels (SBG1.L1= 8.3% (n=5), SBG2.L1=13% (N=6) and SBG2.L2= 50% (n=1)), additionally tanged tools andretouched blades have been documented in level 1 of both localities, while there is an absence in SBG2.L2 in which the retouched pieces are very low (0.76%) and they are mainly denticulates and scrapers. The technological similarities, specially comparing with SBG1.L1 and SBG2.L1 have been documented in the majority of the regional sites in Eastern Morocco such as Layer 2 in Rhafas (Wengler, 1997;Hublin and McPherron, 2012), layer D of Taforalt (Roche 1967, 1969; Barton et al., 2016), layers 26-34 and 50-54 of Ifri N'ammar (Nami and Moser, 2010). In South sahara specially in Lhmar lakhdad, Aferdou bega (Arzarello et al., 2013). Also in the Atlantic coast region, such as sector 4 and 5 of Contrebandiers cave and el Harhoura site (Ben Arous et al., 2020; Dibble et al., 2013; Scerri and Spinapolice, 2019).

8. CONCLUSION

Sahb El Ghar 1 & 2 are key sites to understand the human evolution during the MSA in Eastern Morocco, specifically with the geographical position in chert quarry area and the stratified levels present in an open-air site type providing a new data and information of the MSA in Maghreb. After the preliminary data of the core knapping strategies , we can conclude that:

- Chert used in both sites come from the local environment with a preference in selection of weathering fragments (Crioclasts) as a primary material for knapping.

- In SBG1, there is a high variability in the core reduction strategies, but with a predominance of bifacial cores with a mixture of opportunistics characterize by short reduction sequences that may related with raw material availability, and more complex such as the Levallois cores (recurrent centripetal and preferential modalities), discoidal and laminar cores attributed the site to the typical MSA of North Africa.

- In SBG2, there is a predominance of bifacial and unifacial cores in all the levels with the presence of opportunistic characterize by a short reduction sequence, Levallois and discoidal strategies. However, SBG2.L1 and SBG2.L2 show a singular feature of laminar cores, including trifacial ones in SBG2.L1 only.

Therefore, the technological attributes described in this work could allow us to associate SBG1.L1, SBG2.L1 and SBG2.L2 to the Aterian technocomplex, while SBG2.L3 to the Mousterian technocomplex. Additionally, these technological features have been observed in numerous contemporary sites in different regions of Morocco: Eastern Morocco, Rif, South Sahara or the Atlantic coast.

9. PERSPECTIVES

There are different future perspectives that we planned:

- To extend the analysis to the entire lithic assemblages of SBG1 &2 including the rest of the technical categories (knapping products and retouched pieces) to reconstruct completely the technological behaviors and to understand the sites function and the human behavior during MSA period in this area.

- To realize the refit and the spatial distribution analysis of the flaking products and the natural ones to reconstruct and to have a better understanding of the post-dispositional process and the formation of the archaeological remains.

- Compare the lithic technology with other sites in the Swiwina area attempt to understand the different types of human occupation patterns in the territory during the MSA.

- To review the lithic collections from similar chronological sites (e.g., Station Météo, Rhafas, Ifri N'Ammar and Taforalt to understand MSA settlement patterns dynamics and the adaptive behaviors between caves, rock shelters and open-air sites.

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