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**Dissertação final:**

# The Lower Paleolithic and the Lithic Materials of the Dauqara Formation, Jordan


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# Abstract

The lower Paleolithic of the Levant is known through sites like Ubeidiya in Israel, El Kowm in Syria and Bordj Kinnarit in Lebanon. Lithic assemblages from Mode 1 and Mode 2 industries are found in these sites but in Jordan the works about the lower Paleolithic are scarce and the archaeological record for these industries is poorly understood.

The aim of this thesis is to verify the spatial distribution of archaeological materials of sites 330, 334 Inferior and 334 Superior in Sukhne, Jordan, through the use of GIS software and statistical methods as well as through analysis of variance and qualitative methods to compare the lithic assemblages of these sites to confirm their typology and in search for patterns that might indicate fluvial interference in the site's artifacts. Before that, the geology of the area is visited as well as the hypothesis for the paleoenvironment of Jordan during the lower Paleolithic, the tectonic movements that are active in the area and the site's stratigraphy.

The results of this study show that spatial distribution in the worked sites is not random, contrary that would be expected from heavy interference from water, that the qualitative features of the lithic assemblages are also not random nor show specific patterns attributed to water flow and that the lithic industry is compatible with Mode 2 industries in the middle stage of reduction.



**Keywords:** Lower Paleolithic, Jordan, Lithics, Acheulean, Spatial Distribution, Analysis of Variance



# Resumo

O Paleolítico inferior do Levante é conhecido através de sítios como Ubeidiya em Israel, El Kowm na Síria e Bordj Kinnarit no Líbano. Coleções líticas do Modo 1 e Modo 2 são encontrados nesses sites, mas na Jordânia os trabalhos sobre o Paleolítico inferior são escassos e o registro arqueológico para estas indústrias é pouco compreendido.

O objetivo deste trabalho é verificar a distribuição espacial dos materiais arqueológicos de sítios 330, 334 Inferior e 334 Superior em Sukhne, Jordânia, através da utilização de software GIS e métodos estatísticos, bem como através de análise de variância e métodos qualitativos para comparar as coleções líticas destes sítios para confirmar a sua tipologia e na busca de padrões que podem indicar interferência fluvial em artefatos do sítio. Antes disso, a geologia da área é visitada, bem como as hipóteses para o paleoambiente da Jordânia durante o Paleolítico inferior, os movimentos tectônicos que estão ativos na área e a estratigrafia do local.

Os resultados deste estudo mostram que a distribuição espacial nos sítios trabalhados não é aleatória, contrariamente do que seria esperados de grande interferência fluvial, que as características qualitativas da coleção líticas também não são aleatórios nem mostram padrões específicos atribuídos ao fluxo de água e que a indústria lítica é compatível com a indústria lítica Modo 2 no estágio intermediário de redução.



**Palavras-Chave:** Paleolítico Inferior, Jordânia, Líticos, Acheulense, Distribuição Espacial, Análise de variância

*To Aline, for always being there for me.*

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# Introduction

The Out of Africa theory postulates that hominins developed in Africa, possibly in the territory that is currently Ethiopia or Tanzania and eventually spread out of Africa to all the continents. This theory is largely supported by fossil remains of early hominins but also by lithic assemblages, Oldowan and Acheulean, and their chronology and spread through time to other parts of the world, from 2.6 or 2 million years ago for Oldowan and 1.7 million years ago for Acheulean. Despite the multiple paths theorized for the Out of Africa dispersion, the path with the oldest evidence is through the Levant, crossing the Sinai Peninsula and upwards towards the Caucasus and eastwards to Asia. While the climate during the lower Paleolithic in the region was radically different from the deserts and xeric shrublands that dominate northern Africa, Sinai and much of the east bank of the Jordan and the Levant in modern times (Copeland, 1998), aridity had already begun to crept in these regions and the most abundant and fertile valleys would be in the wadis of Jordan, on the western parts of the current country and in the territory of Israel (Al-Nahar & Clark, 2009) while in the east, where the Arabian Desert and East Saharo-Arabian xeric shrublands now are, steppes dominated the landscape, albeit less fertile than the water rich ecosystem of the west.

The Levant was then the natural land bridge outside of Africa and a gateway for Europe and Asia during the Lower Paleolithic, a corridor of water rich and fertile valleys that was narrowing as climate changed. As with the Oldowan and Acheulean evidence for the Out of Africa hypothesis, there is archaeological evidence found in sites in the Levant to sustain the Out of Africa hypothesis. Sites that have Oldowan or Early Acheulean (or sometimes as the authors prefer to refer to them, Mode 1 and Mode 2) lithic assemblages were systematically studied for years now (Bar-Yosef & Goren-Inbar, 1993; Le Tensorer, von Falkenstein, Le Tensorer, Schmid, & Muhesen, 2011; Jagher & Le Tensorer, 2011).

These sites have a well-defined and studied stratigraphic context and in some cases even hominin fossils, but the same can't be said of Jordan, a country that is situated in the Levantine "corridor". Jordan, be it by lack of investment or interest, has long been kept under the radar of pre-historic archaeologists and its territory is an incognita in the dispersal conundrum that is hominins out of Africa, with a few exceptions (Besançon, Copeland, Hours, Macaire, & Sanlaville, 1984; Parenti, et al., 1997; Copeland, 1998;

Adams, 2008; Al-Nahar & Clark, 2009). Under Besançon and Baubron, the first systematic studies of the lower Paleolithic of the area were undertaken in the nineteen-eighties. Even though the main objectives were geological studies, formations with visible lithic materials were recorded and reported. Nevertheless, the Early Paleolithic of Jordan, situated in one of the theorized first migratory roads out of Africa remains largely unknown.

Following the discovery of the studied sites in the Dauqara formation and the characterization of the later, in the nineteen-eighties, by the expeditions headed by Besançon and Baubron, in the nineteen-nineties a group of Italo-Jordanian expeditions set out to clear some of the shroud that clouded this specific point and place of the archaeological record by identifying, assessing, recording and analyzing prehistoric sites in Jordan. From 1994 to 2001 these expeditions were headed by Gaetano Palumbo and Zeidan Kafafi but from 1996 onwards they were headed by Fábio Parenti. These expeditions found that the Dauqara formation, north of Sukhne, potentially had material dating back to the Acheulean and the discovery of animal fossils in one of the sections brought the possibility of relative dating to the sites. The Dauqara formation is, however, a sedimentary polygenic and polycyclic formation. There are clear signs of water presence in the stratigraphic layers and of riverbeds, but the extent to which it interfered in the archaeological material is unknown. Thus a conundrum about the contemporaneity of the artifacts and the fossil remains found within became evident.

The topography of the studied area is markedly rugged, with the Zarqa River and ancient wadis carving valleys in the limestone hills. Modern precipitation is low and the climate is arid, but during the Pleistocene the conditions were more humid and the ancient and now dried wadis ran with fresh water. The Dauqara formation and the sites lie in a hilly plain where the Zarqa River meets one of its tributaries, the Dhulail. The elevation is lower compared to neighboring hills, but the terrain is still rugged enough to form naturally occurring sections and hills, but eroded enough to allow small plains to exist.

Through the search of distributional patterns and comparing it with the literature available for the possible processes affecting the site, as well as literature about the area, this work is an attempt to solve this question through statistical, qualitative and spatial analysis. Analysis of variance between key assemblage characteristics can tell the stages of production of each one (Magne & Pokotylo, 1981) and consequently if random patterns can be found in the distribution of lithic characteristics, qualitatively or spatially. At first the situation of each site and their history will be reviewed as well as their geological characteristics. Macro stratigraphic layers and features were assessed in this work and qualitative elements of the collection established and then the GIS work is done in order to better visualize spatial distribution. Coupled with spatial analysis and analysis of variance, a picture of the site's distribution patterns and its lithic assemblage is drawn. But before this study can get to the spatial and statistical analyses, it is necessary to understand the geology and the geological processes behind the formation of the landscape during early Pleistocene in Jordan.

# Jordan in the Early Pleistocene

## Geology and Topography

Covering an area of 96,500 km², the Hashemite Kingdom of Jordan is located in the north-western part of the Arabian Plate (Figure 1) and is separated from the African Plate by the Jordan Rift Valley, a rift system that goes from Aqaba, in the south of Jordan, up to the Dead Sea and follows the Jordan Valley to the north. Theorized to be a part of the Great Rift Valley, it would follow through the Red Sea all the way south to Ethiopia and Tanzania, eventually ending in Mozambique. The tectonics of both plates point to the African plate going north while the Red Sea widens, meaning the Jordan Valley and the rift are also getting wider, deeper and are more so now than they were two million years ago (Burdon, 1959).

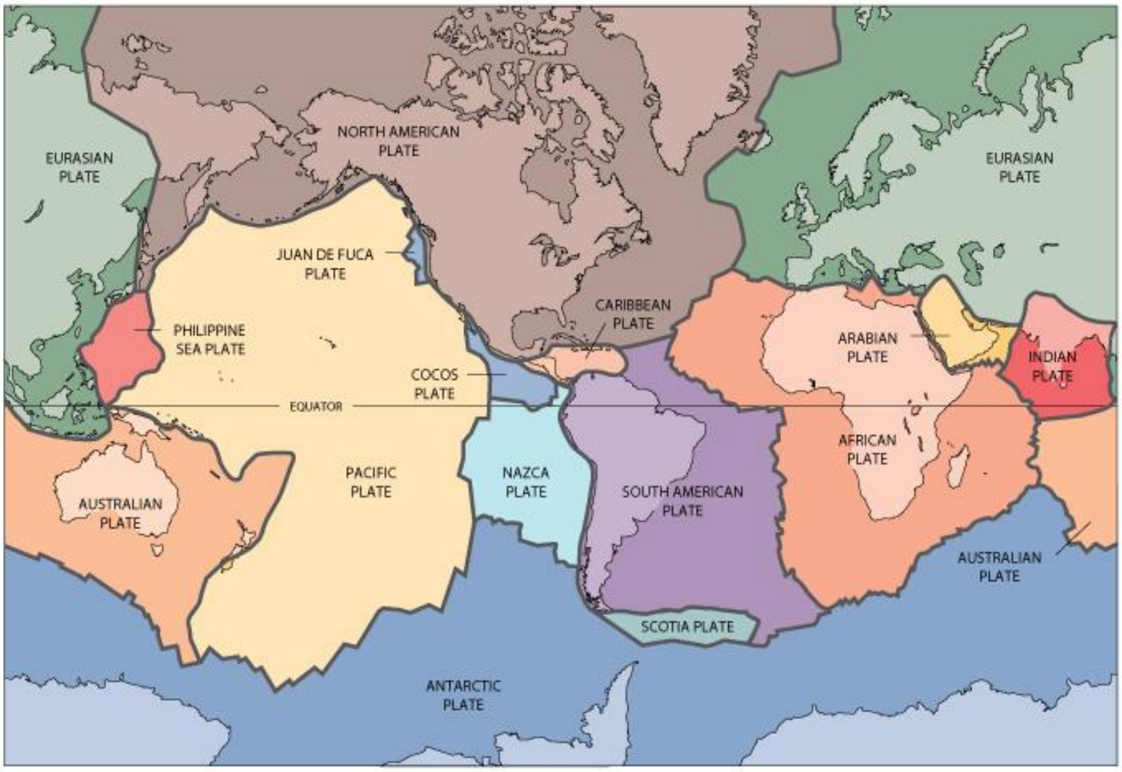


**Figure 1 - World Plates (Source: Watson J., 2011)**

By virtue of its nature as a rim zone, Jordan lies in the northern end of the African-Arabian Pre Cambrian granitic shield. Variations in the epeirogenic movements allowed erosion phases or sea ingression in the area (Burdon, 1959). Its recent geological history that is relevant for this work starts in the Miocene and Pliocene, when during a time the

Mediterranean Sea might have been linked with the Red Sea through the Gulf of Aqaba, the Wadi Araba and the Beisan Depression (Ababsa, 2013). More recently, during the Quaternary, starting 2.588 million years ago, the Rift Valley and its extensions, the Azraq – Wadi Sirhan and al-Jafr depressions, had sediments and other detritus already being transported into these regions (Ababsa, 2013).

Rifting in the Jordan Rift Valley began around 25 to 30 million years ago, during the transition of the Oligocene to the Miocene periods (Adams, 2008). Subsidence in the basin of the Dead Sea began in the Pliocene and came with deposits of evaporates and marine sequences (Ginzber & Kashai, 1981), a process that is still in course to this day. The rifting dynamics in Jordan play a crucial role in the lacustrine and fluvial systems, past and present, and in the process of sediment deposition of the Rift Valley in Jordan. This sedimentary deposition in the Rift Valley accelerated during the Pleistocene as continental fluvial and lacustrine influence moved large quantities of sediments by eroding the steep valley flanks that surrounds the depression (Adams, 2008).

During the Pleistocene the depressions created by the rifts were covered by fresh and briny water lakes, with isochronous fluviatile conglomerates spreading along wide areas in the mountain ridges and eastern slopes of the east side of the Wadi Araba – Jordan Rift system (Jreisat, 1995). Wadis such as Hisma and Wadi Hasa, associated with major lateral faults, as well as Lake Tiberias, in Ubeidiya, foster the most important hominid occupations in the region. In the north, in the Tabaq Fahl region, the landscape was heavily influenced by tectonic activity, with phases of uplift movements from the Rift Valley leading to incisions in the landscape and the development of ancient wadis. These wadis underwent extensive alluviation during the filling of Lake Lisan in the Late Pleistocene (Adams, 2008).

Extensive volcanic activity is associated with rifting, beginning in the early Miocene and continuing to recent times, with phases of activity dating to 10 million years ago and visible in the outcrops of basalt and basaltic formations, like the Dauqara formation in the Western Highlands / Upper Zarqa region as well as extruded outcrops along major faults like the ones in Dhra and Wadi Hisma (Adams, 2008).

With the development of the Rift Valley in Jordan, the groundwater systems that ran eastwards to the Mediterranean and westwards to the depressions of the Central Plateau were trapped, resulting in the inland water flowing to the Valley and emerging as springs (Salameh, 1985). These springs are of critical importance, acting as conduits for the released groundwater, sustaining a more stable water source. Its catch system is more shielded from seasonality and aridity in a region where periods of aridity affected the region ever since the Early Pleistocene. The final result is that since the Calabrian period the abundance of water in the Jordan Valley, and to some extent in the neighboring faults, made it a corridor for migration from Africa to Asia and Europe (Adams, 2008), making it one of the prime land routes for hominins migrating from Africa.

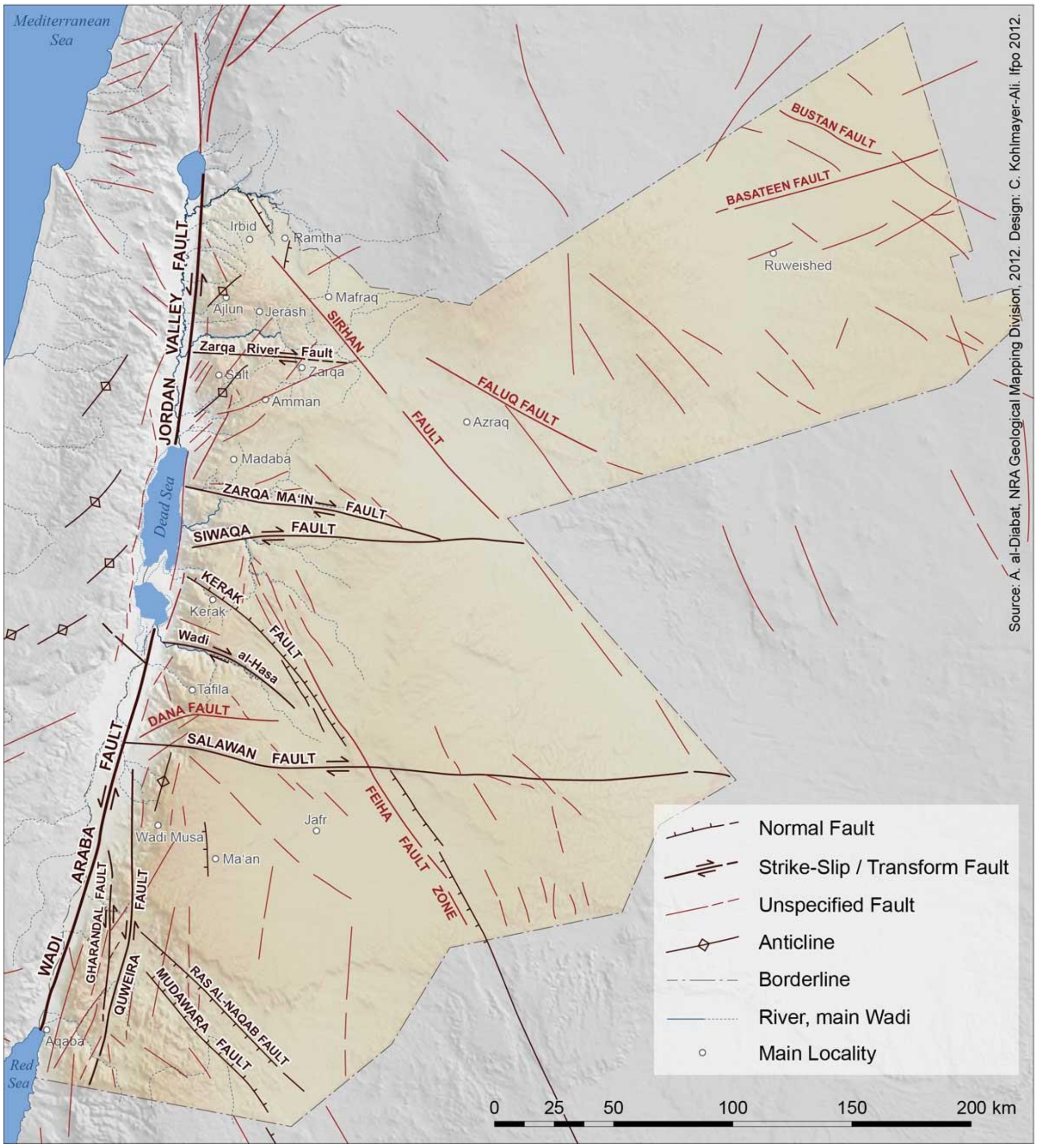


**Figure 2 – Major Structural Features of Jordan (Source: Al-Diabat, 2012)**

During the Early Pleistocene, the territory of what is now Jordan was radically different than the encroaching arid that dominates the east bank of the Jordan River. Using the proposed model for the physiographic regions of Jordan (Figure 3) of Bender (1975) as a basis for understanding the region, some authors established that the area was dominated in the western highlands by swamps and lakes for the most of the Pleistocene, with most sites during that age appearing associated with lakeshore environments while to the east, in the Central Plateau, steppe and grassland savannahs dominated the landscape (Adams, 2008; Al-Nahar & Clark, 2009).

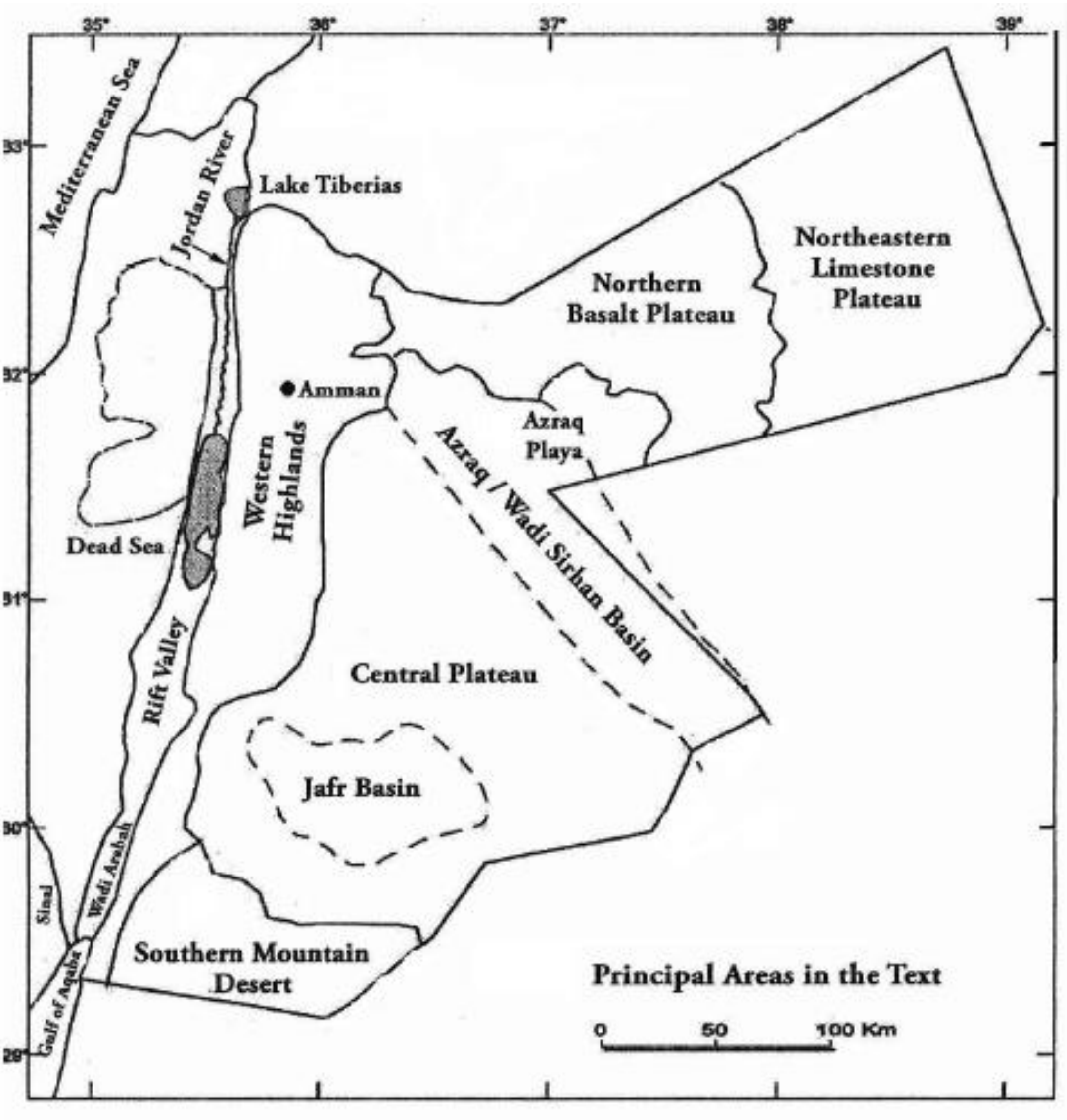


**Figure 3 - Five physiographic provinces of Jordan. (Source: Al-Nahar & Clark, 2009; Adams, 2008; both based on Bender, 1975)**

In arid and semiarid conditions, human occupation is synonymous with the presence of water. Ground water and rain occurrence happens at the mercy of seasons, but it is those ground waters sites that warded off the aridity that now dominates the landscape. The continuing presence of animals over time is associated with the availability of water and this is the case of the Azraq Basin and several other sites (Adams, 2008). Currently, the original steppe vegetation of fifty years ago vanished and the country remains mostly arid. To the east of the Western Highlands, in the Central Plateau, lie the Southern Mountain Desert, the Azraq Basin and the harsh Arabian Desert.

The Western Highlands province, where the studied sites are located, has a maximum extension of about 370 kilometers from the north, from Lake Tiberias and ends to the south, in the Gulf of Aqaba. The north of this province is largely composed of early Tertiary and Cretaceous limestone, as well as shale and sandstone sequences deposited by the Tethys Ocean, a body of water that covered large areas of the northeast and eastern Jordan that existed during the Cenozoic and the Mesozoic. To the south of the Western Highlands the formations are mainly pre-Cambrian crystalline rocks which form the base of the Arabian shield, being an important source of the Cambrian and Ordovician sediment that created the sandstone landscape of Southern Jordan (Adams, 2008). Uplifting in the western mountains has different characteristics in the North and South of the province, with the south being characterized by faulting and the north being dominated by arching and tilting. Research in this area, specifically on Jabal Qalkha, Judayid Basin, Jabal Muaysi and Jabal Hamra points to occupations ranging from the Lower Paleolithic up to the Chalcolithic (Henri & Shen, 1995).

The Western Highlands are incised by wadis such as the Yarmuk and Zarqa wadis as well as the wadis Karak, Hasa and Mujib, consequence of rifting and lowered base levels. Many of the deeper wadis cross zones of saturated upper cretaceous limestone aquifers, receiving water and base flow sufficient to permit occasional flow and enough to provide water to small settlements, with an author even estimating a base and spring flow in the Wadi Hasa of about 25 million $m^3$/year in a high permeability zone (Parker, 1970). The wadis are usually terraced, reflecting periods of erosion by water and incisions as well as changes on the base level resulting from rifting and tectonic activity. Erosion can happen not only by streams and rain, but sometimes by lake level changes in the adjacent Rift Valley or even by localized blocking of major wadis, the result of tectonic activity, creating temporary lake systems until further erosion reestablishes the previous fluvial landscape (Adams, 2008).

Besançon and a team of French geologists carried one of the most important geological works in the area of the upper Wadi Zarqa, north of Amman, thus laying the basis of the knowledge of this region geological features and the Paleolithic sites found therein. The Wadi Zarqa terrace sequence is one of the best known terrace sequences in Jordan, with a stratigraphic framework established and related to middle Pleistocene archaeological content (Adams, 2008) through the comparison with terrace sequences from Syria (Besançon, Copeland, Hours, Macaire, & Sanlaville, 1984). This interpretation, however, assumes a uniform geological evolution of the landscape that has yet to be based on more evidence as the model assumes a similar development in erosion patterns, orography and tectonics between the compared terraces.

Tectonics in the Wadi Zarqa system has been spotty, that is, active and inactive times vary wildly, with it being theorized to be responsible for the variations in the terrace systems in Hashimiya (Adams, 2008). Nevertheless, the region was strongly influenced by basalt flows, such as the ones that lay in the basis of the Dauqara Formation, preceding it. The Dauqara formation now caps some of the surrounding hills of the Wadi Zarqa region and its basaltic base is dated from *circa* 7 to 4 million years before present (BP) (Baubron, et al., 1985), with an incision in the valley followed by a second phase of basalt flow dated to 2.92-3.35 million years BP (Adams, 2008) and at least four colluvial or alluvial terraces recognized. These terraces, sometimes with a fifth recognized, have the oldest ones overlying the younger basalts and were named by Baubron *et al*. (1985) as Qf3 - Dauqara Formation, Qf2 – Bire Formation, Qf2-1 – Bire-Samra, Qf1 - Khirbat Samra Formation (last Glacial/Pluvial) and Qf0 – Sukhna Formation (Besançon, Copeland, Hours, Macaire, & Sanlaville, 1984). The Dauqara formation overtops and fills a trench carved into the basalt and it occurs 70-80 meters above the Zarqa Valley floor, being composed largely of cemented conglomerates containing traces of hominid occupation in the form of rolled late and middle Acheulean bifaces, cores and flakes, estimated by Besançon to be 200.000 BP (Adams, 2008; Besançon, Copeland, Hours, Macaire, & Sanlaville, 1984).

The Qf1 terrace – the third terrace, Khirbat Samra formation and the Bimre-Samra unit – consist mostly of colluvium, more than alluvium, and it includes material of

Aeolian origin. This low terrace is rich in Middle Paleolithic Levallois flakes and cores, with a suggested age in the last glacial or the early Wurm (Besançon, Copeland, Hours, Macaire, & Sanlaville, 1984). From the final Wurm to the Holocene, a further phase of incision of the terraces occurred and the Qf0 – Sukhna Formation was deposited, containing material from the Epipalaeolithic to the Bronze Age.

The earliest documented incisions along the Wadi Zarqa occurred prior to the basalt flow dated 3.35 million years BP, with one before and one after the flow and the latter preceding the deposition of the Qf3 sequence. A number of phases of backfilling and downcutting are represented in the terrace system, reflections of major base level changes of the Wadi Zarqa system, that starting in the Middle Pleistocene have been interpreted as due to climatic changes, with colder or drier phrases linked to aggradation (Besançon, Copeland, Hours, Macaire, & Sanlaville, 1984). Thus, the Dauqara formation is theorized to be polygenic and polycyclic, consisting of sediment from more than one climato-sedimentary episode (Baubron, et al., 1985; Copeland, 1998).

# The Studied Sites

## Literature Review

The first systematic study of the area of Sukhne was conducted by a team of the CNRS (Centre National de la Recherche Scientifique – the French National Center for Scientific Research) led by Besançon[1] in 1982 and 1983. It had an eminently geological character, as the author exposes in the first report that "Using a combination of prehistoric and geomorphological studies of these terraces, we hoped to reconstruct the evolution of the Middle and Late Pleistocene in this part of northern Jordan" (Besançon, Copeland, Hours, Macaire, & Sanlaville, 1984, p. 91). The expedition surveyed three areas: the valley of Wadi Dhulail, a non-perennial tributary of the Zarqa river, upstream from its confluence with the Zarqa up to 15 kilometers, an area consisting of "low plateaux and shallow steam valleys" (Besançon, Copeland, Hours, Macaire, & Sanlaville, 1984, p. 92). The second area is the region where the Dhulail meets the Zarqa, the Dauqara plateau, which is described as having a marked relief and basalt-capped mesas. Finally, the third and last zone is the Zarqa Valley, where the river Zarqa runs and downstream 5 kilometers from where it meets the Dhulail, up to the village of El-Bire and up for another 5 kilometers, the region being rich in gravel terraces. The zones were chosen for research in fluvial sequence and because of their easy access.

Jordan is traditionally divided into 3 main physiographic[2] areas, the Rift Valley, hilly-mountainous belt that follows parallels to the rift and the vast desert. This separation is important because the changes in elevation imply differences in temperature and rainfall patterns of the three areas (Henry, 1986). The Sukhne region presents certain specific traits such as sufficient rainfall, slightly above 250 mm / year, and it is located at 800 meters above sea level, over wide a region of basalt plateaus directly involved in the

[1] In the nineteen-eighties, Besaçon and his team (Besançon, Copeland, Hours, Macaire, & Sanlaville, 1984) worked with the alluvial/colluvial terraces sequences, relating them to the Syrian ones. His work was later criticized by Macumber (Macumber, 1998 *apud* Al-Nahar, 2009) because of the tectonics effects in the region and the great distance between the two regions.

[2] Other authors prefer to differentiate Jordan into 5 physiographic provinces: Jordan rift valley, central plateau, northern basalt and limestone plateau, southern mountain desert, western highlands (Al-Nahar & Clark, 2009) and that is the classification system used in this work.

hydrographic structure of Wadi Zarqa. The structure of the valleys and plateaus are essentially consequences of a substrate consisting of marine formations of the Upper Cretaceous featuring nodular limestone cuts, dolomites and flint (Baubron, et al., 1985).

The Neogene formations identified in the region are: basalts B1, Formation Jabal Bakiya, basalts B2, B3 basalts, Formation Dhuleil, basalts B4. While the quaternary formations in Jordan are Dauqara complex, Bire training, training Khirba Samra, the Sukhna training, training Jabal Qara. The Dauqara complex is a terrace of gross formation, made up mainly of limestone, which can have flint in some levels. It resembles chronologically distinct fluvial formations and much of this seems to be set after the B4. To Baubron, considering the location of the artifacts, it's possible to think that "*le membre supérieur du complexe Dauqara est contemporain du façonnement du glacis de haut niveau*" (Baubron, et al., 1985, p. 278), that is, "the top layer of the Dauqara complex is contemporary to the shaping of high-level glaciers". The Sukhna formation is present in the Zarqa banks, immediately upstream of the confluence with the Dhuleil. This formation is Sablo-limoneuse, but it is observable decimetric layers rich in coarse elements especially at the base.

It is necessary to understand the relationship between the territories of Jordan and Israel. Even being so close, a number of topographic characteristics differ between them and produced different ecological niches and distinct environments. Nevertheless, the atmosphere of the area would have become attractive for plants and animals to develop, creating a land bridge across which early man could have left the Africa and gone to the rest of the Levant and Eurasia (Copeland[3], 1998). While in Jordan no hominins remains where yet found, the first occupations of Homo *erectus* in the Levant are considered to be in Israel and Syria between 1.8 and 1.4 million years ago. These occupations have no absolute dating, and the occupations of the Jordanian Lower Paleolithic often has its age

[3] There is a critic of the author that until the 90's it was still used European or African terms for the archaeological material, comparing the tool kits found with the Europeans. It would have been settled that all lower Paleolithic artifacts in the Levant are part of the Acheulean complex (Bar-Yosef 1994 *apud* Copeland, 1998). Another critic in the text refers to the fact that Acheulean are divided into early, middle and late chronological phases, claiming that definitions are based on unsupported typological judgments. Thus it refers to the terms of geochronological form, i.e. Early Acheulean corresponds to early Pleistocene and the same for middle and late.

inferred by collections of chipped stone tools and fossilized bones. The sites associated with that period are usually found in the open and with confusing contexts. Using as a reference one of the most ancient sites and one of the better contextualized, Ubeidiya, located in the Jordan valley, south of the Sea of Galilee, Copeland (1998) draws a chronostratigraphic start line which starts around 1.4 – 1 million years ago (date of the site Ubeidiya). This is the oldest known hominid occupation site in the Near East and the deposits were laid down during the Matuyama geomagnetic reversal period. Its end is not so clear, but it coincides with the disappearance of handaxe tools around the last interglacial *circa* 200 Ka to 150 Ka. No old site with such a context for sedimentation structures and faunal remains were found in Jordan as of yet. Its artifacts consist primarily of partially-worked pebbles, with some features that even resemble Oldowan more than Acheulean. In Jordan, in the Abu Habil Formation, near Amman, there are descriptions of pebble tools of Oldowan type (Bender, 1974 *apud* Copeland, 1998). This statement is, however, criticized based on the fact that the materials were not available for studies and that the drawings "leave much to be desired" (Macumber 1992 *apud* Copeland, 1998).

During the Lower Paleolithic, other occupations have already been identified throughout the country but few were systematically studied. Some were attributed to the Early, Middle and Late Acheulean. Some places like Abu el-Khas present bifaces and choppers suggesting Lower Paleolithic occupation, but thanks to its complicated context, low density of artifacts and various components from different Paleolithic periods it turned into a hard task to make any conclusive statements about it. The situation repeats itself in other places, according to Henry (1986), the lower Paleolithic in Jordan has a lack of artifacts recovered in primary context. Therefore, analytical methods for identification and timing parameters are based on qualitative geographic differences, context, size, and integrity of the samples. In a country that presents occupations from the Lower Paleolithic, passing middle, upper, Epipalaeolithic, Neolithic, "For the Lower Paleolithic Period, only the Acheulean Interval is firmly represented in Jordan but within this interval, only Middle and Late Acheulean assemblages are represented" (Henry, 1986, p. 22). For al-Nahar (2009) the areas in Jordan with Lower Paleolithic sites are located in three widely separated areas: the Jordan Rift Valley at north of the Dead Sea, in north and central Jordan in the Azraq Basin, and in the Jafr Depression.

There is a big problem that involves the classification of these sites, as has been said before, that often present confusing or little contextualized information. A case that

Copeland (1998) cites as something that still raises doubts is an area based on the Dauqara formation that during the nineteen-eighties some very poorly-made flint flakes were found. The same area was reworked by Parenti's team in 1996 and new discoveries such as teeth from *M. meridionalis* and the *Equidae* families were found in apparent association with flint flakes (Parenti, et al., 1997). The author explains that the context was problematic because, firstly, it consists of "erosional debris from more than one climato-sedimentary cycle" (Parenti, et al., 1997, p. 9) and secondly because due to the great handling and transportation by water for long distances, it is necessary to think that the fauna and flakes are not necessarily contemporary and thirdly because having few cores and few choppers, raises the question if it should be included in the Acheulean industrial complex. Lastly, the fauna that was found has links (as in, similar species) to similar specimens found in Ubeidiya and Latamne, where they range from early to middle Acheulean.

To understand why there is a need to invest in research in the region, authors justify that the Rift Valley is a good candidate for a migration route used by early hominins as they dispersed thought Eurasia, since the Jordanian valley is the passage from the Mediterranean to the desert, the region is one of the most important places of study for Asian and European occupations, as well as for the spread of *Homo erectus* in semi-arid regions (Bar-Yosef, 1994 *apud* Palumbo, *et al.*, 2002; Al-Nahar & Clark, 2009).

Although the Dead Sea depression is an "ultimate base level", other more ephemeral lakes were located at different elevations. The depression of the Dead Sea is in the Great Rift Valley fault system that extends from East Africa to Lebanon, and it was raised millions of year ago by tectonic activity. The rift became a canyon with the deepening process. Many lakes were present in the region from 3 to 7 million years ago. Even in this period, there is no indication that hominins extended their range for environments like that in the Middle East, even though they were similar to the ones in Africa during that period. Meanwhile Lake Shagour, at north the Dead Sea, formed two million years ago, survived for a long time and it coincides with the first dates of human presence in the region. This period compromises the period of unquestioned appearance of stone artifacts in the Pliocene. During this period three major typological groups can be recognized, the Oldowan, the Acheulean, and the chopper-chopping tool tradition of East Asia (Al-Nahar & Clark, 2009).

The Oldowan artifacts tend to be more crude and informal, have striking platform, bulbs of percussion, striae, eraillure scars, among other characteristics. The Oldowan complex found in Ubeidiya is the earliest evidence of human presence and occurs in the complex of silts, re-deposited soil, sand and clay, being in total 22 to 30 meters thick. The sediments record the fluvio-litoral deposits in the delta. The fauna reflects the transitional nature of the coastal environment, with specimens of invertebrates and vertebrates. Fossils of hominins attributed to *Homo ergaster* and *Homo erectus* were also found in this unit as well as two Oldowan and one Acheulean assemblages (Al-Nahar & Clark, 2009). This early strata have been compared with archaeological materials from middle and upper Acheulean, the result was the identification of a phase of transition between Oldowan and upper middle Acheulean. The Acheulean is constituted by large, bifacially-flaked handaxes and cleavers that define the tool kit. Acheulean sites are much more common in Jordan, mostly attributed to the middle to upper phases of the Acheulean. It is worth noting that an interpretation from an apparent progression of crude and asymmetric to refined and symmetric may be a problem, because the quality of the lithic material, such as the amount of raw material, amount of bifaces reworked or reused as another type of part, can effectively influence what is found in the archaeological record, but can't lead to interpretations about behavior or culture. (Clark, 2002 *apud* Al-Nahar & Clark, 2009).

An archaeological project has been developed in the region of Zarqa under the coordination of Gaetano Palumbo of the Università di Roma La Sapienza, and had fieldwork seasons between 1993 and 1995 in the first phase. A second phase from 1996 to 1999, in collaboration with Yarmouk University, Irbid, and with the coordination of Zeidan Kafafi, Paolo Matthiae and Gaetano Palumbo, was carried out and directed on the field by Fábio Parenti. A third phase between 2000 and 2002 with participation of Massimiliano Munzi and Gaetano Palumbo (Kafafi, et al., 1997; Kafafi, et al., 2000; Caneva, et al., 2001; Palumbo, et al., 2002). The search area was focused in Wadi az-Zarqa, an area of 144km² concentrated between the coordinates 243.00 and 255.000 east and 164.000 and 176.000 northern Palestine Grid. The seven years of researched yielded a total of 450 sites identified in the area (Kafafi, et al., 1997; Kafafi, et al., 2000; Caneva, et al., 2001).

The project had as one of its aims understanding the extent of human occupation in the area and tried to assess what was possible beyond man's relationship with the environment. Some main points were established as objectives, such as making a survey of the region collecting information about the sites and their periods of occupation, create a database and understand the evolution of settlements from prehistory to the Iron Age, including the studies of the remains from the Roman, Byzantine and Islamic periods.

Until the nineteen-eighties, the sites of Early and Middle lower Paleolithic in the region were recognized as surface findings with uncertain or not very clear stratigraphic context. One of the starting points that this project undertook was to confirm the chrono-stratigraphical reconstruction made by the previous French mission led by Besançon. In 1996 the project was divided into two parts, one with a chronological focus and stratigraphic of the Pleistocene terraces, another a study of "Dauqara formation, the most ancient unit conserving traces of human presence, through the investigation of its sedimentary evolution and the study of rich chipped stone industries and faunal remain contained in it" (Palumbo, et al., 2002, p. 135).

The 1993 campaign resulted in the recognition and confirmation of the geomorphological units identified by the French mission and the identification of 30 archaeological sites. These had characteristics from Acheulean to Upper Paleolithic. In 1996, the project had focused on pre-Holocene sites in the Jordan Valley, with a total of 85 local lithic industries recorded. The main finding was a fossiliferous site dubbed site 330, located one kilometer north of Sukhne, placed on the top of the Dauqara formation. After the initial dating of the Dauqara Formation to around one million years ago, the activities were concentrated to the most promising sites, resulting in 1300 artifacts and 30 animal bones taken from 15 sections in the Dauqara formation, especially the sites 330, 331, 332, 342, 343 and 415. There was also an intensive dedication of working the paleontological and stratigraphic aspects of Site 330 (Kafafi, et al., 2000; Palumbo, et al., 2002). In 1999, still at site 330, an area 150 meters long and 2 meters deep was opened with machinery. The site showed high density of artifacts, with an average above 100 stone tools per cubic meter. Most of the findings were in riverbeds, covered by deposits of the Zarqa River in the Lower Pleistocene

The region studied and reported by the Italo-Jordanian expeditions is comprised of three main litho-stratigraphic units: Mesozoic limestone's with a height up to 800 meters above sea level; basalt flows, where there was volcanism in the Pliocene and colluvial-alluvial terraces of Plio-Pleistocene age. The sedimentary composition of the terraces is polycyclical with lava floors dating from 7 to 2.3 million years ago (Kafafi, et al., 1997; Kafafi, et al., 2000). The chronostratigraphic proposal begins with four Pliocene basalt floors ranging from 7 to 2.2 million years ago. The oldest unit, the Dauqara formation is located 75-60 meters above the river bed, and consists of alluvial and colluvial sediment. In the second, there are at least two alluvial formations of the middle Pleistocene, containing upper Acheulean and lithics from the Mousterian. The third one, the Birah and Khirbat Samra Formation, between 40 and 15 meters above the river bed, and the fourth one, a lower terrace in the Sukhne Formation between 15 and 5 meters above the river bed with Epipalaeolithic and Neolithic remains. (Kafafi, et al., 1997; Kafafi, et al., 2000). Of all of the above, the Dauqara Formation proved to be the most abundant source of artifacts, especially with a large presence of flakes, cores, and an absence of hand-axes, confirming the classification of these artifacts as pre-Acheulean from the Lower Paleolithic, though the artifacts in this formation are reported to be more abraded and rolled than in the other formations. "Judging from the actually available data, possible chronostratigraphic attributes for the ad-Dawqara formation span between the final lower Ubeyidiye formation in Israel and Middle Pleistocene (*Latamné* formation or terrace III in Syria)" (Guérin *et al*, 1993 *apud* Kafafi, et al, 1997, p. 13). In this regard, preliminary analysis would allow to make inferences of proximity with the lower layers of Ubeidiya that present characteristics of evolved Oldowan or lower Acheulean (Kafafi, et al., 1997; Parenti, et al., 1997):

> "The comparison with the published lithic complexes of Lower and Middle Pleistocene in the near east, points to a closer proximity with the lowest layers of Ubeidiya (Israel) and Bordj Kinnarit (Lebanon). We can not yet state if the lack of handaxes has a chronological or simply the geographical significance. In any case, it seems to us that the richness and the density of the industry could not represent the very first appearance of humans in the region" (Kafafi, et al., 2000, p. 701).

Considering that only a small portion of the registered sites could be dated between Paleolithic and Bronze Age, because most of them were surface sites, Site 330 has been more systematically studied to add certainty to the conclusions involving it. Its stratigraphy was done by Caneva (Caneva, et al., 2001) and divided in seven units, exposed in the stratigraphy section of this work. Units 5 and 6 of her model are also present at section 415 and 414, sections that are very close to section 330. Parenti (Parenti, et al., 1997) describes the stratigraphy of three main groups from the top as a first layer of colluvium, second limestone crust, third as channel bed structures.

During the 1996, 1997 and 1999 campaigns, it was removed from the site 330: 26 choppers (2.1%), 74 cores (6.0%), 900 debitage (73.3%), 207 retouched (16.9%), 20 chunks (1.6%), a total of 1227 parts, forming a large collection of the Dauqara formation. These sites, as well as others, have frequently appeared in various authors (Kafafi, et al., 1997; Copeland, 1998; Caneva, et al., 2001) with abrasion of the lithic materials as a serious problem in the lithic assemblages. Therefore, they claim that there is still no irrefutable evidence of sites with original deposition, or a primary site, given that the plateau formation process of as-Sukhna involved several alluvial events, constantly eroding and over flooding. Nevertheless, the Italo-Jordanian project gave a better understanding of the presence of hominin groups in Jordan half a million years earlier than previously thought (Copeland, 1998), as well as an environmental reconstruction with more detailed information and stratigraphy on the Lower Pleistocene.

Although the sites are believed to date back to the Early Acheulean (Parenti, et al., 1997), it is necessary to consider the hypothesis of an earlier or older age for it, as the contextual dates of the site were acquired through the fossil remains of an animal that lived in the area from 2 to 0.9 million years ago (Parenti, et al., 1997) and the possibility of sites older than 'Ubeidiya in the Levant was raised by other authors (Bar-Yosef & Belfer-Cohen, 2013). With the discovery of Oldowan stone tools in Dmanisi, Georgia, (de Lumley, et al., 2005; Toth & Schick, 2006; Hovers & Braun, 2009), in Bizat Ruhama, Israel, (Zaidner , 2013) as well as 'Ubeidiya (Jagher & Le Tensorer, 2011), Israel and El Kowm, Syria, (Toth & Schick, 2006; Jagher & Le Tensorer, 2011; Le Tensorer, von Falkenstein, Le Tensorer, Schmid, & Muhesen, 2011) it becomes necessary to ponder the hypothesis of the presence of Oldowan, or as some authors prefer to call the out-of-Africa early industries, “Mode I industries: chopper-tools and flakes” (Toth & Schick, 2006) in the lithics assemblage. Without going in the merits of the debate over Pre-Oldowan and Developed Oldowan, Grahame Clark classification system of Mode 1 to 5 is the one preferred in this work, though since previous literature on the area use early and middle Acheulean, comparisons and the use of this terminology will be inevitable.

The “Oldowan” term was coined by Louis Leakey in 1936, a reference to the artifacts of the Olduvai Gorge that predated Acheulean industries. Previously, Leakey had used the term “pre-Chellean” to refer to these artifacts (Phillipson, 2005; Toth & Schick, 2006). These earliest hominid-made artifacts, conclusively starting from 2 million years ago (Phillipson, 2005) had their classification consolidated by Mary Leakey’s work *Olduvai Gorge Volume 3: Excavations in Beds I and II, 1960-1963* (1971) that subdivide Oldowan in several categories. Without entering in the merit of Mary Leakey divisions of the Oldowan, the assessment if the lithics assemblage of this work is compatible with Oldowan-like or Mode 1 industry will be made.

From the point of view of spatial analysis, in *Spatial Technology and Archaeology*, Wheatley and Gillings (2002) present and discuss the different ways spatial technologies can be applied, such as Geographic Information Systems. One function of these technologies goes beyond the illustration and graphic representation of the site and its artifacts, that is, the spatial analysis, which corresponds to a set of techniques where the results will depend on the distribution of the objects to be analyzed (Goodchild, 1996 *apud* Wheatley & Gillings, 2002). From techniques like this it is possible to seek answers to questions such as if there is some structure to be seen through artifact distribution, if a set of points exhibit any spatial patterning or what is the chances that a distribution pattern is random or not. Whereas archaeological sites are produced by human action and not just environmental action, its structure and distribution will never be completely random, but attention must be paid to disturbances so to evaluate the possibilities of taphonomic effects or if assess the presence of an intentional organization.

Ian Hodder and Clive Orton in their book *Spatial Analysis in Archaeology* (Hodder & Orton, 1976) discuss the emergence and importance of systematic methods for examining archaeological maps. Its biggest differential is the assessment that dealing with artifact distribution subjectively is an unsafe and unreliable method, and that the ideal method is to work the artifacts distribution in space through the application of site analysis, applying concepts of randomness and regular spacing. In the distribution of artifacts, the areas without any date are the hardest to analyze, as they may mean that nothing was there, that the area was not excavated or simply that artifacts were not found or were lost by a series of taphonomic causes. It is also necessary to highlight that it is very unlikely that standards involving human subjects and decisions are completely random, it is expected that most maps show some sort of pattern or order.

Washburn (Washburn, 1974 *apud* Hodder & Orton, 1976) suggested that the comparison of the mean distance found with the expected value is an efficient method for non-randomness in the direction of uniform spacing. It also determines the standards within the region, but not a pattern throughout the region. One of the concepts used in this work is the random pattern (Skellam, 1952 *apud* Hodder & Orton, 1976), if an individual sample is randomly eliminated in a random distribution, the random pattern will continue. However, if it is done in a non-random sample, a random distribution may possibly be produced if the density is affected.

An alternative method to deal with the randomness would be the simulation of artifacts dispersion, such as the process based in the random-walk process. It consists in a series of simulations that are used to observe different spatial processes which can produce this specific fall-off curve, allowing interpreting the process behind the pattern (Hodder & Orton, 1976).

## Location and Materials

The region of the studied sites is around the village of Sukhne (also known as Sukhna, Es Sukhna or El Sukhne), lying ten kilometers north of the city of Az-Zarqā (also known as Zarqa), in the Zarqa valley. Sukhne lies in a plateau that ranges from 700 to


**Figure 4 - Location of Sukhne in Jordan**

800 meters of altitude made up by limestone of marine formation from the Upper Cretaceous (Baubron, et al., 1985; Parenti, et al., 1997) forming hills heavily carved by hydrologic activity from springs that dried long ago and from the Dhuleil river and Zarqa river, the latter an eastern tributary of the Jordan river that cuts the calcareous marl and flint from the Turonian and Senonian (Baubron, et al., 1985). Both rivers are located in the Zarqa transform fault (Figure 2). The sites are divided as sites 330, 334 Superior and 334 Inferior and are part of the Dauqara formation, which has a base constituted of various flows of basalt, with the most recent flow dated by Baubron *et al* (1985) through Potassium-Argon to $4.62^{10}$±0.27 years ago. Large cemented pebbles form the conglomerate that comprises most of the Dauqara formation, with a pink-colored matrix, covered by crust and with most of these being limestone pebble conglomerates (Besançon, Copeland, Hours, Macaire, & Sanlaville, 1984).

The 334 sites are part of the same hill that is divided by man-made terraces and that are currently used for agriculture. The earth is constituted of coarse whitish sand, sometimes acquiring reddish or pink characteristics, rich in archaeological materials both in the agricultural terrace and the wall that marks the end of the terrace. The wall or section that marks the end of the first terrace and consequently the beginning of the 334 Superior terrace is filled with rocks from all sizes, from small pebbles to boulders.


**Figure 5 - Location of the studied sites**

The studied sites proper are not the agricultural terraces but the sections that divide the terraces. The man-made terraces were, by their own nature, shuffled by humans and therefore carry no stratigraphic or chronological relation that can be established, rendering them nearly useless for the archaeological study. The studied material was collected from the section in an area covering 150 meters horizontally and 5 meters vertically in the 334 Inferior site and an area of 240 meters horizontally and 4 meters vertically in 334 Superior. Furthermore, material was gathered from a the wall of the terrace above 334 Superior dubbed 334 Top, but the material wasn't plotted with a total station so they don't carry a good spatial relation with the other materials, only a typological and elevation one, and therefore weren't included in this study. The hill where the 334 sites lay is divided in two by a man-made dirt road that cuts it and exposes the


**Figure 6 - Detail of the location of sites 334**

basalt of the Dauqara formation, but only one side, the eastern one, was studied. There are a total of three man-made terraces in the hill, with the flat top of the hill being used for agriculture and extending a few kilometers to the south-east. These terraces can be observed in figure 6. To the north, 174 meters from the 334 Inferior section, touching the hill which the sites lays in, the Zarqa river is located, cutting the landscape in two, with hills that go up to 700 meters of altitude and made primarily of cretaceous limestone to the north. The Zarqa River is "hold" by the basalts outcrops of the Dauqara formation that lay exposed in the river margins, and it meets the Dhuleil River one kilometer to the west of the site, where the latter joins the Zarqa.

To the south east, 781 meters from the 334 sites lies site 330. Part of the same Dauqara formation but at a higher elevation (roughly 500 meters above the sea level, while 334 Inferior lies 485 meters above the sea level and 334 Superior lies 491 meters above the sea level), it is constituted of a wall that marks the end of a short boulder-filled plain, potentially a hill top that was leveled to be made in an agricultural terrace. The section contains pebbles and boulders of all sizes, sometimes forming gravel and lenses which indicates some fluvial activity. The top of the wall is enclosed by a layer of hardened calcite ($CaCO_3$), forming conglomerate rocks where the calcite penetrated the sediment and a capsule that seals parts of the site and that presumably sealed the site in the past, which allowed for conservation of the material and sediments. The outcrop itself has little more than 65 meters horizontally and 4 meters vertically and the plain above it has houses no more than 36 meter far from it.


**Figure 7 - Detail of the location of sites 330**

While the most recent outflow of basalt was dated by Baubron's team, it constitutes only the base of the Dauqara formation. The only other date related to the sites was made by Claude Guérin with material from a 1996 Italian expedition. Dr. Guérin analyzed fossilized teeth that were found in the 330 site. One of the teeth was identified as *Equidae*, belonging specifically to *Equus sp.* and it was compared to one specimen found in 'Ubeidiya, Israel, and it was identified as belonging to *Equus tabeti*. The other tooth, an upper molar, was identified as "almost within range of the Aurochs (*Bos primigenius*)" (Parenti, et al., 1997, p. 14). Another tooth was also identified as the same species of elephant found in 'Ubeidiya, close to the subspecies *tamanensis*, however Guérin argues that the species should be more recent because of the characteristics of the tooth, putting it as *M. meridionalis* that spans in 'Ubeidiya from 2 to 0.9 million years. Thus, the site cannot be older than the dated basalt of the Dauqara formation and it is contextualized to, at least in the fossil tooth level and assuming no major shifting of the stratigraphy happened, to be in a range from 2 to 0.9 million years old (Parenti, et al., 1997) Simply put, the bio-chronological date for the site is estimated to be around one million years ago.

The fieldwork for the materials that are studied in this work occurred in November 2014 and the main types of artifacts found in all three sites were lithic artifacts, overwhelmingly flakes, totaling 370 artifacts. Four animal teeth were found in site 330 while a small fragment of what seems to be an animal bone was found in site 334 inferior.

## Site Stratigraphy

Scientists have developed different soil classification systems through time, but for the purpose of this study the soils will be identified and classified according to the USDA soil taxonomy developed in the 1950's (Soil Survey Staff, 1999). The purpose of

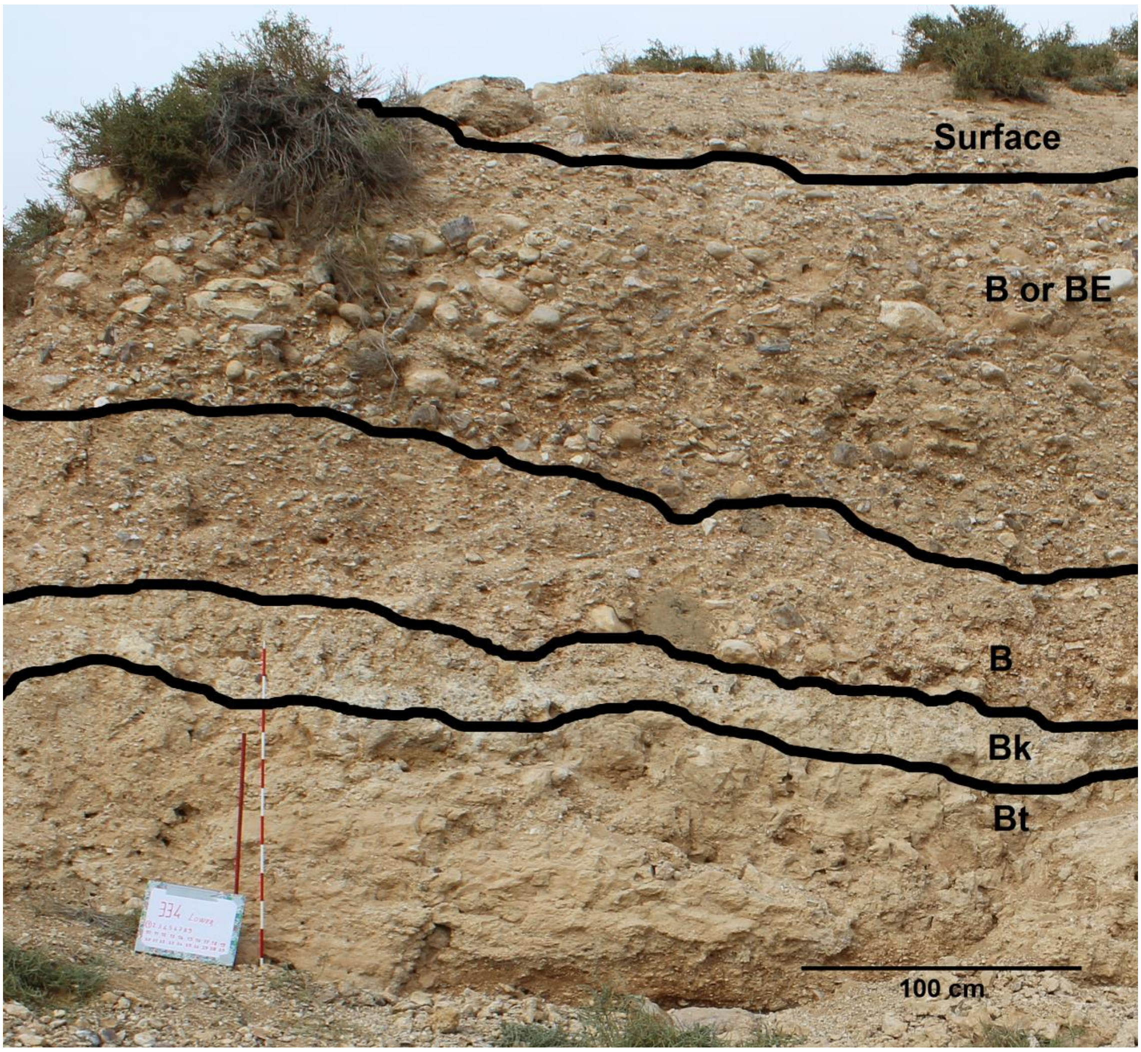


**Figure 8 - Site 334 Inferior Horizons**

trying to identify these soils and to assess the soil layers is to help the identification of soil horizons, establishing a simple stratigraphic scheme, and to verify if any of the layers in sites 330 and site 334 could be isochronous, that is, if they are of equivalent age and of common origin.

Covering 60% of Jordan's surface (Al Qudah, 2001), aridisols are the main component of the site's section. These are dry soils with calcite accumulations, calcic horizons and sometimes cemented calcic horizons that are usually found in deserts and xeric shrublands. The soil has a sandy-skeletal and calcareous characteristic, in both sites, and in both sites the horizons are mainly gravel terraces. A testament of wetter climates, site 334 inferior has a Bt horizon (figure 8) at the visible bottom, which is an argilic horizon, superseded by a Bk horizon, an argilic horizon with a heavy presence of salts or most probable, lime or calcium, giving it a white color. It lacks a clear O, A or E horizon since there's a lack of significant presence of organic matter. The B horizon has characteristics of inceptisols, especially given the sedimentary nature of the soil as proposed by previous studies in the area (Besançon, Copeland, Hours, Macaire, & Sanlaville, 1984; Baubron, et al., 1985).


**Figure 9 - Site 334 Superior horizons and exploratory trench**

Above the Bk horizon, there are two horizons that eventually fuse with each other but that are both B. In Figure 8, however, at the start of site 334 Inferior section they are distinct because of the size of the pebbles. They are white superficially but when scrapped they acquire a reddish color.

In the site 334 Superior (Figure 9) the horizons are less clear. An apparent E horizon rich in clay and calcite is present at the top with a Bw horizon, that is, a redder horizon with oxides is present right below it. It contains thin lenses of black soil, possible magnesium or other oxides, that stretch all over this horizon in the section. A B horizon rich in clay (Bt), a little lighter in color, occasionally surfaces in the lower edge of horizon Bw. Finally, in the lower part, heavy accumulation of clay and calcite makes up horizon Bk, which mingles with horizon Bt. Large pebbles are present especially in horizon Bk but they are also present all over the section in all horizons.

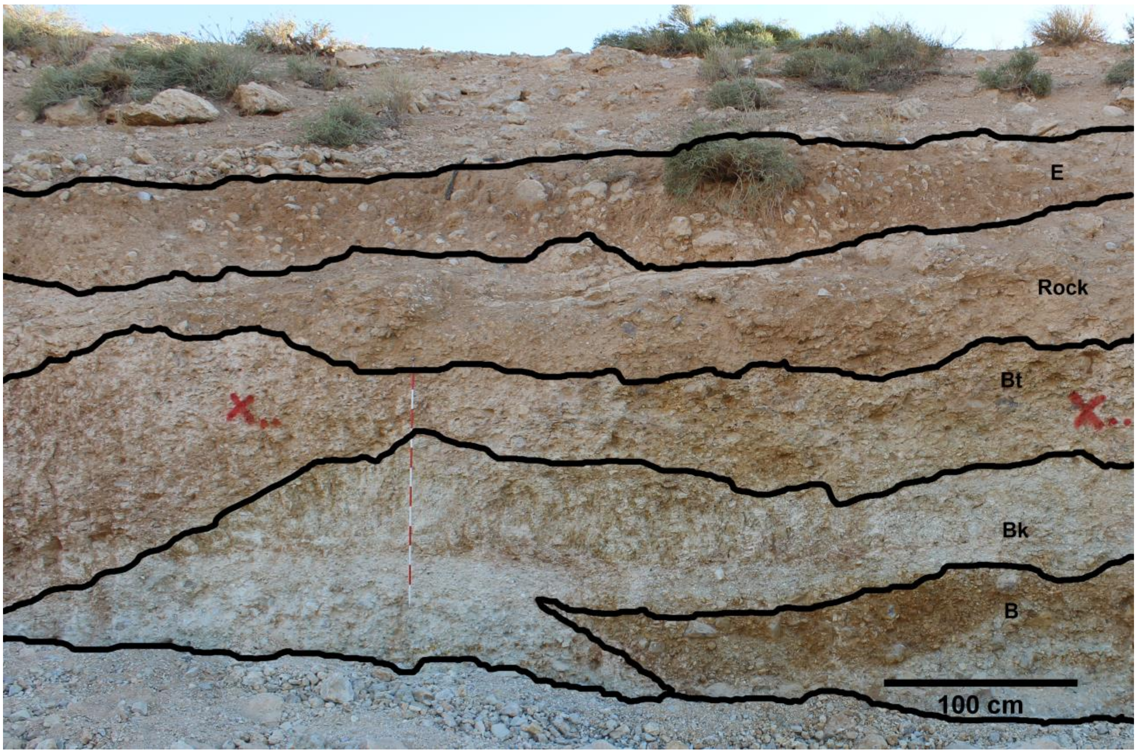


**Figure 10 - Site 330 horizons**

Site 330, roughly 9 meters above site 334 superior, represents the topmost layer of the Dauqara formation. As with site 330, the polygenetic and polycyclic of the site makes the interpretation of the layers a complicated matter. At the top, the E layer, the most recent layer is sterile of any archaeological material. Right below it the soil was illuviated with calcite and already underwent lithification or is currently undergoing lithification. There are no clearly defined boundaries between the rock and the harder soil drenched in calcite, but the topmost part is already fully rock while the lower part in contact with the Bt horizon is partially calcified. Consequentially, it was not possible with hand-tools to excavate the rock part of the section. The Bt horizon right below it is a transition area between the soil and the calcite intrusion. It is harder the closer to the rock layer and softer the closer to the Bk layer and it has accumulation of clay, being also fairly

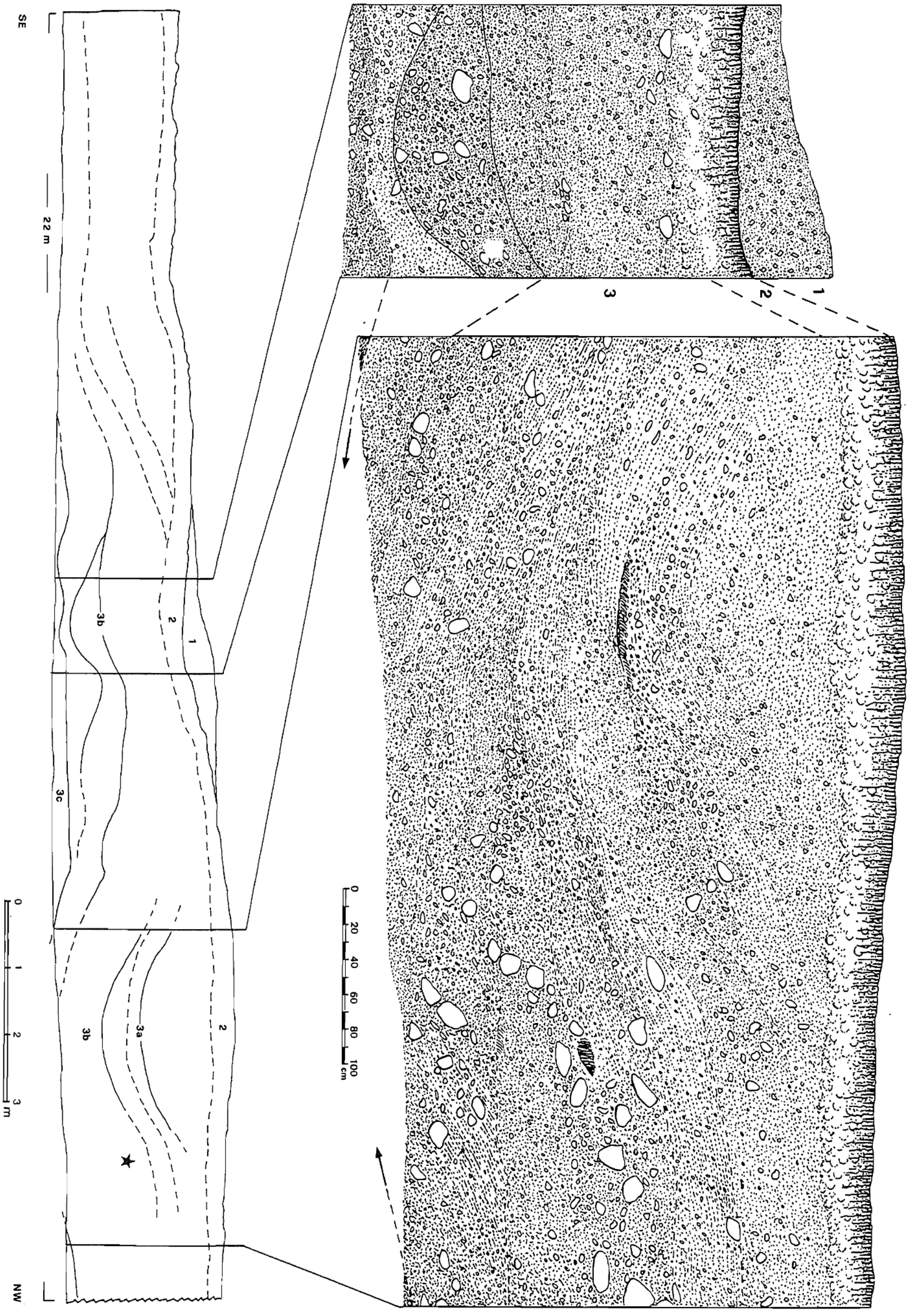


**Figure 11 – Site 330 Section (Source: Field Drawing by M. Wilson in Parenti *et al.*, 1997)**

heterogeneous with a usually brown or brownish color and varying size. Archaeological materials start appearing in this layer, albeit sparsely. Below it, layer Bk has a considerable accumulation of clay and carbonate, acquiring a whitish color through its length. Lastly the B layer usually has sandy sediment and it is characterized by the absence of clay, black soil lenses, most likely magnesium or other metals oxides. It has a brown color and a great presence of small pebbles, while the two layers on top of it usually have bigger pebbles, though it is not exclusive of them. The 330 section is concave while the sections of site 334 are straight with a slight slope on the top.

The soil horizons for the sites were done as macro groups to better understand the site’s structure but they can be subdivided in smaller stratigraphic units. One of such observations was done by Parenti, (Caneva, et al., 2001) for site 330, which he divided in seven units: the first consisting of modern back dirt currently being farming terrace; second, hard crust formed by limestone, with scattered flakes; third, non-cemented, with rare cultural remains; fourth, river sedimentation, discontinuity side; fifth, sandy matrix, locally reddened on the bottom of paleo channel beds. Rich in paleontological and archaeological remains and considered paleo-soil; sixth, greyish layer gritty, sandy matrix, rich coble and flake industry; seventh, sub angular brownish sand grit in the matrix, being the oldest archeological phase in sequence.

For each site, the artifacts are usually found in one or two horizons. In the case of site 330, the artifacts are found mainly in the horizons B and Bk, while fossils were found only on horizon B. In site 334 inferior, the artifacts are heavily concentrated in between 20 to 50 meters of the section start, on the B (and BE) horizons that make up the “middle” of the visible section. These distribution patterns in horizons, both in 330 and 334, are by no means exclusive and artifacts were found in other layers, albeit in a smaller quantity.

This characterization is by no mean extensive, it is missing laboratorial tests and granulometry that are absolutely necessary for a better classification system, but it is necessary to characterize the section of the site even if only through the macro characteristics. The sections are also large, and the photos represent only a small part of it, but the horizons are present and identifiable through the entire section.

# Methods

## Data Gathering

The artifacts were collected during a fieldwork season in Jordan that occurred from 20/10/2014 to 07/11/2014. The fieldwork was organized and headed by Professors Fábio Parenti, President of the Italian Institute of Human Paleontology (Istituto Italiano Di Paleontologia Umana), Professor of Human Evolution and Physical Anthropology Walter Alves Neves, of the Biology Institute of the University of São Paulo, Professor of Archaeology and Geoarchaeology Astolfo Gomes de Mello Araújo, of the Museum of Archeology and Ethnology of the University of São Paulo, Professor of Geology Giancarlo Scardia from the University of the State of São Paulo and Professor of Human Evolution Maria Mercedes Martinez Okumura of the Federal University of Rio de Janeiro. This equip was complemented by the author of this study as a student, by Assistant Professor Mark Hubbe of the Ohio State University, André Strauss, PhD student of the Max Planck Institute for Evolutionary Anthropology and Leipzig University, volunteers Ana Cristina Hochreiter, Gabriela Sartori Mingatos and Dr. Rodrigo Elias de Oliveira, all participated in the fieldwork for a period of time. Besides these researchers, a team of four local Chechens from the village of Sukhne helped to organize, communicate and helped during the excavations.

**Figure 12 - Site 334 inferior section**

Before the collection of the material, a total station was set up and triangulated with three defined points. The section was divided by iron stakes every 5 meters for a profile to be set up, each stake point was recorded in the total station. In the case of 334 Inferior (Figure 11), 30 stakes were used (150 meters), for 334 Superior 48 stakes were used, totaling 240 meters and for the 330 section 13 states were used or 65 meters. Each of the stakes or points was photographed (Figure 12). Every point recorded with the total station was not only saved in the machine but written down in a spreadsheet and a separate notebook.

To collect the materials, each section was scraped using handpicks, mostly by scrapping the soil and breaking the conglomerate when it was needed. The section was systematically scraped from the beginning to the end, up to twenty centimeters inside and the artifacts found *in situ* were marked using the total station. After marked, the artifacts were collected in a plastic bag, given a tag with the point number they were attributed in the total station and stored.

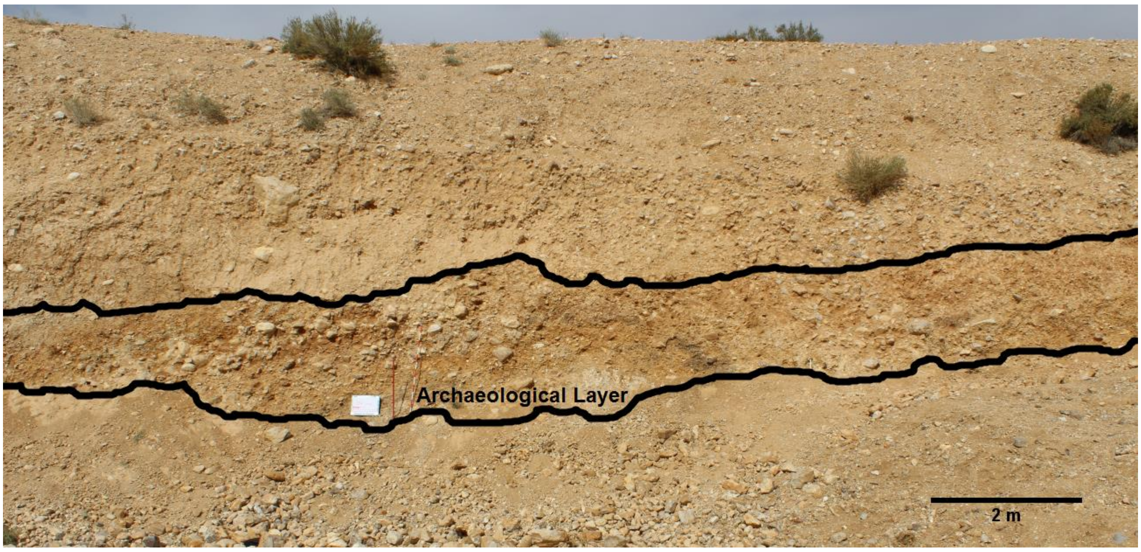


**Figure 13 - Detail of the section and of stake 5 of site 334 inferior**

The fieldwork occurred during the morning and afternoon. In the evening and weekends, the artifacts were washed while the ones that were washed previously and that were already dry were numbered and separated for analysis. The artifacts were numbered according to the number they are attributed in the total station when their coordinates were taken. The analysis started with the random distribution of the numbered artifacts in a table. Each one of them was then measured and the physical attributes of the artifacts were measured. The weight was recorded, the artifact was classified, its integrity was assessed, the cortex amount was determined, the type, according to pre-determined types, was determined, the maximum length, the striking platform width, the length in the flaking axis, the maximum width and the thickness of the artifact. Finally, the number of scars in the dorsal surface, the flaking angle, the state of the surface and the material of the artifact is determined, along with any other notes. A database was created in Microsoft Excel with all the recorded measurements along with the artifact number and its X, Y and Z coordinates given by the total station and the processed materials were put in a new bag with a new paper tag and stored.

The flakes were weighted in a scale that could measure up to five kilograms with a readability of one gram. Width, length and thickness of the materials were recorded using a Draper caliper model 46610 with a readability of 0.01 millimeters. To avoid a common problem in lithic studies, that is, the lack of consistent terminology (Sullivan III & Rozen, 1985; Andrefsky Jr., 2005) when dealing with artifacts, this work will explain how each of the measurements was recorded.

To measure the flake length along the flaking (or striking) axis, firstly the flake was positioned with its ventral surface lying down in the table while the dorsal surface faces the researcher, with the striking platform turned towards the researcher. Then the distance of a straight line perpendicular to the axis of the striking platform up to the farthest point of the line is measured with a caliper, though this line might intersect the edge of the flake, ending before the reaching the distal end of the flake, thus the recorded length could be smaller than the maximum length of the flake, which is why the maximum length of the flake is another attribute recorded.

Using the same position described before for the measurement of flake length along the flaking axis, the maximum length of the flake is measured as a line perpendicular to the flake length line up to the farthest point on the distal end, basically the maximum length a flake can have. This method of measurement is called by Andrefsky Jr. (2005) as “maximum flake length” and, along with the measurement of the flake length along the striking axis, it is part of the methodology described by the author for the measurement of flake length, though the “maximum flake length” method is the one clearly favored and argued as the superior method by him (Andrefsky Jr., 2005), the measurement of the length along the striking axis was used to separate “curved” flakes better.

To measure the flake width the same positions that was used for the length measurements is kept: ventral surface down, striking platform facing the researcher. The flake width is a measurement of a straight line perpendicular to the flake length line. When this line intersects the flake widest point, that's where the measurement is taken, therefore giving the maximum width of the flake. Flake thickness is measured essentially as flake width: the biggest distance between the dorsal and ventral side in a straight line perpendicular to the flake length line. For this measurement, the flake needs to be lifted from its position used in the other measurements and a bigger caliper needs to be used.

For the striking platform width measurements, first the strike platform is located. In case of cortical striking platforms it usually means there's no clear striking platform and no measurement was taken. Usually, the strike platform is in contact with the dorsal and ventral surfaces and the lateral margins of a flake. The striking platform is then measured as the distance from one lateral margin to the other lateral margin, the biggest distance between the two edges of the striking platform. Striking platform width can be especially useful in determining the stage of reduction (Pokotylo, 1978), correlated with the size of debitage varying across the reduction stage (Magne & Pokotylo, 1981), or it can be correlated with product width (Van Peer, Vermeersch, & Paulissen, 2010) and can also be used as a discriminator of reduction trajectories when combined with strike platform thickness (Odell, 1985 *apud* Andrefsky Jr., 2005). If put in a three dimensional Cartesian coordinate system the maximum length of the flake would be the Y, the maximum width of the flake would be the X and the thickness would be the Z.

The described measurements so far are the "absolute" ones – the ones that can be replicated with a caliper. However, they don't contain all the necessary information, so other characteristics – the ones that cannot be measured with a ruler, a caliper or a scale – need to be recorded. One of those is the striking platform type. While striking platforms can have infinite variability (Andrefsky Jr., 2005), a common typology is necessary to standardize a few common types so classification can be done.

For this study, the striking platforms are divided in nine categories: cortical striking platform, flat striking platform, dihedral striking platform, multifaceted striking platform, linear striking platform, punctiform striking platform, crushed striking platform and finally, absent striking platform and unrecognizable striking platform. Assuming that a common definition exists for every type or typology is one of the common pitfalls mentioned earlier and, as with the measure recoding process, an explanation of each type of striking platform is thoroughly needed if one of the fundamental principles of science – replicability – is to be achieved.

Starting with the two last types, the simpler types, unrecognizable striking platforms are platforms that, through age, abrasion, chemical processes or other factors have been deformed, and while it can be seen in the flake, it is not possible to classify or assert with confidence the type of the striking platform. Absent striking platforms only happen in the case of broken flakes, where the striking platform was part of the lost piece of the flake.

A cortical striking platform is simply the unmodified cortical surface of the piece that was used to detach a flake. This kind of striking platform may or may not have a dorsal cortex present. Meanwhile, flat striking platforms are smooth flat surfaces, not thin enough to be considered a linear striking platform, which are the result of a detachment from a piece. Commonly, flat striking platforms happen as the result of detaching pieces of nonbifacial tools, flakes with flat striking platforms usually being the result of reduction of unidirectional cores (Andrefsky Jr., 2005). Usually, this kind of striking platform articulates with the dorsal surface of the detached piece as to form an angle that can approach 75º to 90º.

Dihedral striking platforms are characterized by a dihedral angle, that is, when two intersecting planes (or facets) form the platform. It is formed by two negatives from previous flaking. Multifaceted platforms are characterized by three or more facets – something that happens more frequently on biface production, with the more facets a striking platform has indicating later stages of the biface production, generally speaking (Andrefsky Jr., 2005). Linear or straight striking platforms are characterized by a flat but thin striking platform, almost forming a cutting edge. Lastly, punctiform striking platforms are composed solely of the point of impact, just a small platform where the hammer hit the rock.

The number of scars greater than ten millimeters in the dorsal surface is then assessed, a criteria that is, admittedly, harder to measure consistently with accuracy when given to different researchers. For that reason, the main guiding signs for the counting were negative bulbs and guiding edges, that is, where two flaking surfaces touch each other. The angle was recorded by using a goniometer and by positioning the flaking surface it, giving the flaking detachment angle.

Lastly, general surface characteristics and conditions were recorded in a few categories. The first one, generically called “Type”, is further divided in six sub-categories: Completely cortical flakes with a cortical striking platform are flakes with a dorsal surface completely cortical and a cortical striking platform. Non cortical and cortical striking platform are flakes without any cortex in the dorsal area but that have a cortical striking platform. Completely cortical and non-cortical striking platforms are flakes that have a dorsal surface that’s completely cortical but have a non-cortical striking platform. Partially cortical and non-cortical striking platform are flakes with a little cortex in the dorsal surface and a flat striking platform and finally, the last category is a flake with no cortex and no cortex in the striking platform. This flake type classification system was developed by Nicholas Toth in 1985 (Toth, 1985).

The integrity of the flake is then assessed: if it is complete, that is, it contains all the characteristics of normal a flake (bulb, striking platform, distal and proximal ends) and its whole, if it is incomplete, that is, if it is missing any of the previously characteristics, if it is fragmented, which means the flake is broken but its remaining parts where found and fit together and finally if it is a Siret fracture, which is a kind of fracture that happens when a flake breaks in two pieces along the axis of impact.

The cortex coverage of the dorsal area of the flake is another criteria used to classify. Differently from the previous parameters, the striking platform is not taken into account. The subcategories are completely cortical, more than half cortical, less than half cortical and finally no cortex. Lastly, the surface conditions of the flake are assessed and more than one subcategory can be noted in regards to any conditions in the surface. The sub-conditions were divided in: recent debitage removal, crioclasts, post-depositional crioclasts, thermoclasts, surface oxidation, lichen presence, differential erosion, marginal retouch, chemical weathering, incisions and lastly carbonate incrustation. These categories are mostly self-explanatory. Crioclasts is a process of physical weathering caused by the cooling of the artifact. Thermoclasts is the process of physical weathering caused by the heating of the artifact. Lastly, the material of the artifact is noted down and observations are made about the freshness of the piece – how rolled or abraded it is – and the presence of any other characteristics: if it is retouched or if there is the presence of patina on the surface, for example.

Until now, the categories used for classification were only for small artifacts, namely flakes, scrapers and denticulates. The other major category, core tools, involves big artifacts and also cores. The absolute measurements recorded are the same as the ones in the previous category: weight, maximum length, width and thickness. The different is an additional category – length in the morphological axis. The latter is measured as a line from the earliest negative, the first flake that was taken from the piece, to its distal end in a straight line. Finally, there's also the maximum linear dimension (MLD), described as the weight multiplied by the biggest measurement of the core tool (Andrefsky Jr., 2005), which was done post fieldwork. All measurements were taken by identifying the earliest negative of a flake and turning it down, facing the table, while the direction of the force of impact of the earliest flake negative goes outwards from the researcher in such a manner that what was the striking platform of the detached flake is facing the researcher.

After the absolute measurements are taken, the cortical surface of the artifact is assessed using the same categories described before: completely cortical, more than half cortical, less than half cortical and completely non cortical. Afterwards the number of negative bulbs in the artifact is counted and recorded.

The type of the core tool artifact is then recorded, being divided in the following categories: chopper, unipolar core, orthogonal core, bidirectional core, polyhedral core, globular core, parallel and opposite core, convergent core, centripetal core, undetermined and core fragment. As with the measurements, even if the core classification might seem self-explanatory, the lack of standardized terminology makes necessary for a quick explanation of the criteria used for classification.

Choppers or chopping tools were defined as stone tools with a working edge formed through lithic reduction. They are usually largely unmodified and crude in appearance. A unipolar core was defined as a core with only one striking platform, a bidirectional or bipolar core is a core with two opposed striking platforms. Meanwhile, an orthogonal core is one with striking platforms perpendicular to each other. A polyhedral core is a core with several different striking planes. A globular core is a spherical core, usually reduced to that shape, but not necessarily exploited over the whole circumference. A core defined as "parallel and opposite" is one core with reductions or striking platforms parallel but in opposite directions to each other. Convergent cores are the ones defined unidirectional convergent flaking and finally, centripetal cores are the ones achieved by centripetal reduction technique, where the main reduction surface is formed such that the morphology of the product is a function of the lateral and distal convexities serving to guide the shockwave of each flake. Core fragments are incomplete cores which lost recently or not a part, without signs of intentional flaking. Undetermined are cores too rolled and that conserve just a few characteristics, insufficient to classify it.

The material of the artifact is assessed and if it is classified as a chopper, it is also attributed a type according to the *fiche de typologie africaine* (FTA). FTA types are based on "Fiches typologiques de Préhistoire et Protohistoire africaines", that is, Typological Sheets of African Prehistory and Protohistory. This standard model developed by Lionel Balout in 1967 divides choppers in types according to shape and number of removed flakes and its use is an attempt to, as with the measurements, adopt universal and reproducible standards for lithic analysis. The last parameters are observations about the surface of the artifact, if it is rolled, fresh, if it is retouched, if it has patina or calcite incrustations.

After the material was measured and classified, eighteen of the cores and choppers were selected by the author for preparation for 3D digitalization during the night and after the main work was done. Time constraints limited this work to eighteen artifacts, with no criterion utilized but the shape and size, as the photogrammetry is highly dependent on these parameters to be successful. These were reconstructed in 3D using a method known as photogrammetry. In this method the object is photographed from a series of different directions and angles and the photos are then translated in a point cloud using a series of algorithms and routines, like feature matching across the photos, dense surface reconstruction, texture matching and scale-invariant feature transform (SIFT).

The photos were then processed in Photoscan – a software designed for the creation of 3D models out of photographs – which creates a point cloud that forms the base of the object. This point cloud is a set of points in a data system that provides information for the X, Y and Z of each point and grouped together they form the skeleton of the 3D structure. These points are then manually cleaned to remove background noise, and automatically linked through vertices and faces, resulting in a rough mesh model containing, in average, twenty five thousand vertices and fifty thousand faces from the forty thousand points from the point cloud. The model is then finished with the application of the photos themselves as a texture.

The artifact is then measured in a recognizable position or feature and the distance is noted down to be later used. In the created 3D model, the same points are marked and referenced by using the distance of the previously set point A and point B - the ones measured in the artifact - and the distance is inserted in the model. The result is the creation of scale in the virtualized artifact, resulting in a 3D model that can reach up to 0.2 millimeters of precision. The conditions for the accuracy of the precision and success of each model vary with a group of factors, for example, with the number of the photos taken, the overlap of the photos, the light conditions, angles of the artifact and light reflection on the object surface, with the more photos being taken resulting in more precision and better quality but also requiring exponentially more processing power out of the computer generating the digital model.

Three dimensional reconstruction methods can be used in a wide range of fields. Besides providing the basic framework for curatorial work, as well as providing the researcher with a good model to work without the need to take the original piece from its original country and aiding typological work (Grosman, Smikt, & Smilansky, 2008; Kuzminsky & Gardiner, 2012), 3D models are pure mathematical data. As such, they are well fitted for use in scientific work and are usually used in archaeology in the fields of morphometrics. Recent studies of lithic assemblages have been carried out by Muller and Bretzke and Conard (2012) Clarkson (2013), Clarkson and Muller (2014) Lin et al. (2010) on the application of reconstruction and quantification of lithic stone tools. As 3D laser scans become cheaper and the morphometric analysis of 3D models become more widespread, these models and techniques are bound to become more common in the field of archaeology, especially in international missions, as it gives the researcher on the spot data accurate data about lithics no matter where he is. The use of photogrammetry was used in this work to allow access to artifacts that are physically away.

For treatment of images, addition of scale bars or pointers, Adobe Photoshop ™ CS6 and ImageJ were used and for the site maps, Google Earth™ was used.

# Data Analysis

## The Process of Spatial Analysis

After World War II, computing and the use of new mapping technologies began to receive more attention, especially after the sixties when computers started to be more systematically used in data analysis (Allen, Green, & Zubrow, 1990). In 1970 there was one of the first conferences on technology, computing and archaeology, called "The annual Computer Applications in archaeology conference" and that was later renamed to "Computer Applications and Quantitative Methods in Archaeology". This meeting resulted in the dissemination of knowledge and recommendations about the development of software, hardware, archiving, data transfer, database structure and mapping (Reilly & Rahtz, 1992). In the same decade the number of studies involving spatial distribution analysis with spatial standards tests increased. The biggest development of the software industry related to Geographic Information Systems took place in the eighties in the US. These early applications are the result of developments in the fields of computer graphics and the use of statistics, trend-surface analysis, artifacts distribution studies and management of multiple spatial variables (Lock & Stančič, 1995).

Throughout the development of this field of study, many works have suffered from a lack of structure, expensive software or sparse specialized workforce, making room for large error margins (Lock & Stančič, 1995). Since then the software industry opened up to suggestions and collaborations from professionals that use its products, new releases and databases were developed, fed and updated. According to Reilly and Rahtz (1992) one of the major limitations in the beginning was the impossibility of adding qualitative information to the data, being necessary to quantify all available information, however, these days versions of various products, such as the one used in this work, let you work both qualitative and quantitative data on the pieces and the space. An example given by the authors is that when comparing two different sites, using information such as topography, hydrology, soil type and vegetation cover, these factors should be highlighted as potentially affecting the distribution of artifacts, being more difficult to incorporate in the analysis. However today it is possible to use tests that establish relations between contextual information and the distribution of points. Thus, information about the site formation process become important for style or culture differentiation, considering that a given spatial structure can mean variability not only by different ethnic groups, but also as a functional change in front of the environment and external interactions (Wheatley & Gillings, 2002).

In archaeology the main objective is the study of material culture, beyond it as a single isolated object, but as an object that has a context and that belongs to a space. While there are many methods of studying it, one of the most common and necessary approaches is creating maps and using it as a tool to associate information in different scales and coordinates. Archaeology goes through the process of understanding where things are and how they are related to each other, working with themes of spatial organization, areas of human activity, and the use of the landscape, starting from the initial assumption that man uses space and appropriates it in various ways to carry out their activities. According to Lock Reilly and Harris Rahtz (Reilly & Rahtz, 1992) spatial information that is collected for archaeological studies can be acquired from one or more points in space and if this phenomenon is observed under the Earth's surface it is called geographic data, which can be translated through a graphical representation. In *Interpreting space: GIS and archaeology* (Allen, Green, & Zubrow, 1990) this topic is approached from landscape theories by considering the use of space as an integrative relationship between culture and the environment. This highlights the importance of maps and their ways of representing things (Sharon, Dagan, & Tzionit, 2004) and as an archaeological tool which allows a reduction of reality to a more manageable analogue space.

A similar argument is made by other authors (Peterman, 1992; Lock & Stančič, 1995), who argue that it must be clear that factors directly influencing human beings are not simply demonstrated in Cartesian planes, not all confined to space and the proximity of resources but also involve social and cultural issues that are reproduced by the group. It is a mistake to believe that to analyze is necessary to separate the social from the natural, it is necessary to keep in mind the fact that archaeology works with some of these characteristics that are hard to be aggregated because they are in the field of the immaterial. In Lock and Stančič’s book, D. Arroyo-Bishop and M. T. Lantada Zarzosa define in the second chapter some analytical frameworks that can be observed in order to understand more the context under consideration, which are the archaeological and architectural unit, the spatial entity, the temporal entity and the interpretive group. The archaeological and architectural units are the basic components used to identify elementary archaeological demonstrations, as well as the combination of all of them for the formation of a further interpretation, for example, bricks and walls are identified as elemental units, and together allow inferences about buildings. The spatial units, usually X, Y, Z, but may also be the natural or modified by human action environment as well as the spaces in and around sites of human activity. The temporal entity is archaeology in the relationship between object-space-time and the interpretive group, in turn, allows or momentarily selects data that is homogeneous and heterogeneous. The analysis of all these units would result in transcription of the observed results in archaeologically analyzable data, such as descriptive systems, variables, objects, mapping, and it can be made based on observations of archaeologists or with the help of tools such as Geographic Information Systems software.

It should be noted the difference between software developed to handle information related to space, such as CAD, GIS and DBMS. The main difference is that GIS has the possibility of establishing a link between the display program and a management database system while it is still possible to illustrate the interrelated data, the different variables and different moments in time among other things. Currently GIS software allows to entry and record raw data, building up and storing databases, the manipulation and analysis of data beyond the visualization in various forms, such as representations in maps and text. (Peterman, 1992; Lock & Stančič, 1995; Sharon, Dagan, & Tzionit, 2004).

With techniques learned from geography and plant ecology, the methods applied to GIS software sets to quantify the relationships between points and their distributions. More recent studies also tend to include background information trying to avoid reductionist analysis. All this so that the spatial analyses that are based on maps or statistically oriented could be able to analyze and interpret the anthropological record (Reilly & Rahtz, 1992). One factor that impacts the analysis of material culture is the scale that is used (Wescott & Brandon, 2000) whether global, regional or local. Although GIS can be used in all these scales, how to interpret the relationships and dispersions will depend on the observed levels and the relationships between the sites, as well as certain specific environmental variables of the studied area, like the polygenic and polycyclic nature of the studied sites.

The techniques of geographic information systems stand out then to help establish new methods as well as apply more traditional ones (Wilkins & Anderson, 2009). One of the possible techniques to use that has a large number of adepts in rescue programs and rescue sites is predictive modeling, a method consisting in "drawing" known occupation patterns in a space where there would be the possibility to predict were sites are located (Wescott & Brandon, 2000). This method relies on two assumptions: That the settlement choices are influenced by environmental issues and that the factors that influenced those choices in the past are still observable even indirectly and can be identified on modern landscapes. This allows the method to be applied in large areas that weren't surveyed previously, to implement faster actions of protection and management of cultural resources. Other possibilities are the elevation model (DEM) and the viewshed analyses, which through elevation values allows to calculate the location and visibility of the sites, this being an important factor for settlement options (Wheatley & Gillings, 2002).

GIS, as was described above, leverage results from your layout, thus, some authors such as Gary Lock and Zoran Stančič (1995) suggests that the software must be combined with statistical tests, because it allows understanding the site as occupation floors, understanding structure, occupational history and interrelationships between stratigraphic units.

An important concept when analyzing distribution in space is distance, because from it is possible to make inferences and interpretations according to the locations and with direct influence on archaeological issues such as the relations of proximity and distance. For this purpose a series of tests exist that helps this kind of analysis, as they are described below. One of them is the quadratic method (Wheatley & Gillings, 2002), where a grid is placed on the map and it is considered how many points are observed in each grid cell. In a random population, the distribution should theoretically be close to the Poisson distribution, that is, a function used for identifying events with low probabilities of occurrence within some definite time or space. Hodder and Orton (1976) explained that the analysis of Point Pattern was developed in the field of study of plant ecology and geography, where the study started assuming the randomness of distribution. The map has to be divided into square cells, and points are allocated in a random order within the cell, then all quadrats have an independent and equal chance of receiving a point, and every point in turn has an equal and independent chance of occurring in any square. In terms of patterns in maps, *pure chance* means that each location in the map has an equal probability of receiving a point (Dacey, 1964 *apud* Hodder & Orton 1976). The quadratic test calculates the ratio between the variance and the mean, which are directly influenced by the size of the quadrats used and its form, i.e. whether it is square, rectangular, etc. Observing the problem of size and shape of squares, this test may ultimately not be effective according to the densities and chosen scales.

### *Working with Layers*

Working with GIS software allows work with a variety of different technologies, adding a number of different tools from different fields of knowledge but its differential comes with the possibility of manipulation and its analyses tools. With a single database software you can work the whole information package, setting tables with data beyond the spatial distribution of references, being possible to associate attributes and different characteristics to the same database.

Some authors (Allen, Green, & Zubrow, 1990; Wheatley & Gillings, 2002) discuss the concept of thematic mapping, an approach to GIS software in which it is possible to work not only a single map, but one set of structured layers that shows different characteristics which were recorded in the database. It is possible to generate a feature for each layer or theme, maintaining a link to the database system, so it is possible to work the layers individually or together. Working with GIS layers in a structure ensures a variety of displays and allows going beyond the visual, combining action and operational analysis. Constructing a georeferenced map doesn’t serve just a purely visual function but allows combinations of features and analysis to be worked together with theoretical or statistical significant approaches.

### *Recording GIS Data*

A major concern among several authors (Wescott & Brandon, 2000; Wheatley & Gillings, 2002; Howard, 2006) is the accuracy and care during data collection in order to minimize damage to research later. It’s necessary to be sure about the data and its quality only can be guaranteed with the control of how many points were recorded, which ones were recorded, the accuracy with which the measures were made and the skill and knowledge of the one taking the measurements. In *Archaeological Surveying and Mapping: Recording and Depicting the Landscape*, Phil Howard dedicated the fifth chapters to reinforce the importance of using devices such as the total station and the level properly while collecting spatial information. The total station “is, in essence, a digital theodolite with an in-built electronic distance measurer (EDM), a calculator (or simple computer) and usually an internal or external data logger” (Wheatley & Gillings, 2002, p. 64). In archaeology it is used to generate location data in a three dimensional coordinate system, and when its exact location is known, the station assigns a real value of coordinates from a mapping system. When it is not known another value of reference is assigned (A), a second point in space then is referenced (point B), and all that needs to be generated from there (point C) are given as a result of a triangulation between points (the total station - point A, the second point in space - point B, and the point to be registered - point C).

### *Quantum GIS*

The software used for the GIS study was Quantum GIS, created in June 2002 by Gary Sherman, also known as QGIS. The version used was 2.8.2-Wien, updated in 2015. The software is a free and open source cross-platform program, which currently has the contribution of several professionals for constant updates and bug fixes and has been translated into several languages. The software lets you create, edit, preview and publish geospatial information for Windows, Mac, Linux, BSD and Android.

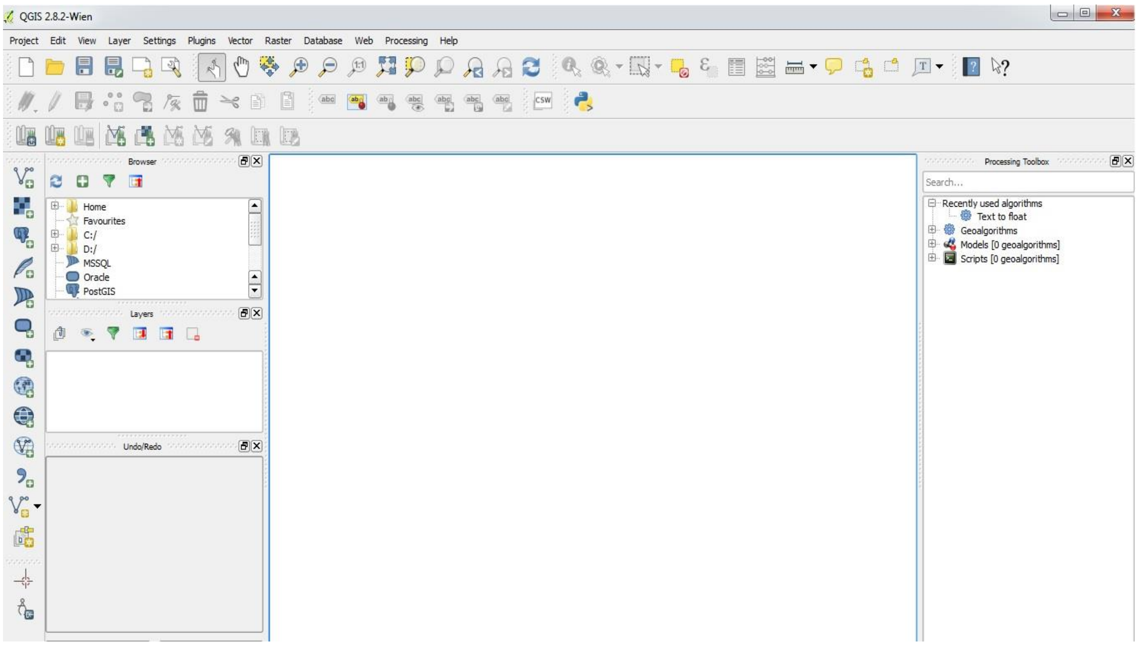


**Figure 14 - QGIS Main Screen**

QGIS allows maps to be composed in raster or vector layers. Typical for this kind of software, the vector data is stored as point, line, or polygon-feature. Different kinds of raster images are supported and the software can perform georeferencing of these images. All the management and analysis are possible to be done from simple tables created in Excel and saved with the CSV extension.

In this work it was chosen to use the vector data using the geometric shape of dots to represent the pieces and stakes. The map was created considering the first stake from left to right in each site as zero point (0,0) reference for each of the following points are stakes or parts, thus creating an artificial space where distances are relative and they were obtained from the triangulation points of the total station.

An alternative considered sensitive (Clark & Evans, 1954 *apud* Hodder & Orton, 1976) that was applied at this work to analyze the presence or not of patterns is the Nearest-neighbor Distance. This test (Tung, 1962 *apud* Hodder & Orton, 1976) consists in measuring the distances from the nearest point and also depends on the density of points. The ratio between the observed distance (if random) and the expected has to be calculated. The closer to 1, more random the distribution is. Lastly, a nearest neighbor analysis was made to assess the randomness or not of the distribution of artifacts in the horizontal view, floor plan. The formula for the analysis is:

$$R_n = 2\bar{d}\sqrt{\frac{n}{a}}$$

Where $R_n$ is the nearest neighbor statistic; $\bar{d}$ means the observed nearest neighbor distance; $n$ is the total number of points and $a$ is the total area. The scale for the results go from 0 (Clustered) to 1 (Random) and lastly 2.15 (Regular).

## The Process of Statistical Analyses

In this work the first kind of observation was qualitative, considering the analysis of the landscape and the general location of the site, as the parts with typological considerations, attributing qualities to the artifacts, classifying them according to type, class, integrity, type of core, raw material and FTA. For these analyses it was chosen to focus on observations of the frequencies of distributions presenting them with bar graphs and histograms. Subsequently, quantitative observations were made such as location or dimensions, quantification of attributes, among others. To understand their relationships into the site two aspects of the sites were observed, their horizontal and vertical distribution. This is done in order to consider their pattern at space and time, due to the importance of knowing in an archaeological context if the spatial distribution obeys some structure, even if these are not immediately apparent. The association patterns can be done for both within-site and between-sites relationships if it provides some degree of objectivity to the analysis. It was separated aspects to understand the structure of the site, such as prevalence of pieces, like, among others, always considering the survival of artifacts through time. Noticing that different processes can result at the same structure and knowing all the consequences of interpreting process through this simplest way, it was chosen to apply an integrated statistical and computational analysis to enrich the work and provide more information with great potential for understanding these processes and patterns.

### *Analysis of Variance and Significance Testing*

One of the objectives of this work is to make comparisons on different samples using also measurable variables. One of the tests used was Analysis of Variance (ANOVA). This type of analysis enables you to compare different populations, in the case of this work, the samples of the three sites. The comparison of averages of different populations is to check if their mean is equal or not and is used to determine whether differences in the observed sample is real, it also replaces a lot of T-tests to be applied. In this work it was analyzed the weight of the artifacts, number of scars in the dorsal surface, maximum length and striking platform width. The experiment needs to be random, independent and have normal distribution. The null hypothesis tested was that the means are equal, which means they are homogeneous and the alternative hypothesis is that they are different:

$$H_o: \mu_1 = \mu_2 = \mu_3 = \cdots = \mu_\alpha$$

$$H_A: \mu_1 \neq \mu_2 \neq \mu_3 \neq \cdots \neq \mu_\alpha$$

Where, $\mu$ is the group mean and $\alpha$ is the number of groups.

To calculate one-way ANOVA a few steps must be followed. First, it is needed to calculate the mean within each group, then the overall mean with the following formula:

$$\bar{Y} = \frac{\Sigma_i \bar{Y_\iota}}{a}$$

Then it is necessary to calculate the between-group sum of squares:

$$S_B = n\,(\bar{Y}_1 - \bar{Y})^2 + n(\bar{Y}_2 - \bar{Y})^2 + n(\bar{Y}_3 - \bar{Y})^2$$

The between-group degrees of freedom is another necessary value, which is calculated by:

$$F_B = \alpha(n-1)$$

So the between-group mean square value is:

$$M = S_B/F_B$$

The within-group sum of squares is the sum of squares of all values in the table while the within-group degrees of freedom is represented through:

$$f_w = a(n-1)$$

At last, the within-group mean square value:

$$MS_W = S_W/f_w$$

And the F-ratio:

$$F = \frac{MS_B}{MS_W}$$

The Analysis of Variance test doesn't tell which samples are different from each other in experiments involving multiple factors as is the case of this work, so a post-hoc test, that is, a test for the significance of factors individually as well as the interactions caused by one or more factors interacting with each other must be made. In this work the post hoc tests used were decided on a case-by-case basis, but the most commonly used test was the Tukey's honestly significant difference (HSD), represented by the equation:

$$q_s = \frac{Y_A - Y_B}{SE}$$

Where $Y_A$ is the biggest number between the two compared, and $Y_B$ is the smallest one. SE is the standard error of the data being compared. The other test used was Games-Howell, an extension of Tukey-Kramer test for unequal variances, where the error term is represented by:

$$\sqrt{\frac{\frac{s_i^2}{n_i} + \frac{s_j^2}{n_j}}{2}}$$

And the degrees of freedom:

$$df' = \frac{\left(\frac{s_i^2}{n_i} + \frac{s_j^2}{n_j}\right)^2}{\frac{\left(\frac{S_i^2}{n_i}\right)^2}{n_i - 1} + \frac{\left(\frac{s_j^2}{n_j}\right)^2}{n_j - 1}}$$

The qualitative information of parts per site was analyzed with frequencies and simple proportions described in tables and illustrated in comparative charts. Quantitative information was also analyzed by their frequencies and proportions, being applied for categories such as weight, but it was chosen to complement it using other quantitative statistical analysis. The programs used to execute the analysis were Microsoft Excel and IBM SPSS Statistics 22.

## The Process of Qualitative Analysis

### *Mode 1 Industries*

The characteristics of the Oldowan Industrial Complex (or Mode 1) are "simple core forms, usually made on cobbles or chunks, the resultant debitage (flakes, broken flakes, and other fragments) struck from these cores, and the battered percussors (hammerstones or spheroids) used to produce the flaking blows" (Toth & Schick, 2006, p. 4), but it can also have retouched pieces, usually flakes chipped along one or more edges (Toth & Schick, 2006), being a system or industry based on the least effort required to obtain a cutting edge or to adapt the rock for its intended purpose.

Since there is no standardized system for the classification of Oldowan or Mode 1 lithic assemblages as of yet (Toth & Schick, 2006), for the purposes of this work and for the sake of a more standardized and repeatable system, de Lumley classification system for Mode 1, used in Eurasian sites such as Dmanisi was partially be used to assess the presence of Oldowan tools in the assemblage. De Lumley's classification is divided in pebble tools and debitage (which can include cores and flakes).

De Lumley's classification for flakes was already exposed in the data gathering section – a classification system based on 4 categories for flakes (1C – Completely Cortical, 2C – Mostly Cortical or more than half, 3C – Flake with Residual Cortex or less than half cortical and 4C – Flakes with no cortex) with eight subdivisions for platforms (Cortical, *Lissé* or flat, dihedral, faceted, punctiform, linear, removed, absent), as well as a class for small flakes and debris. For cores, they are divided in Unifacial (Unidirectional, Bidirectional and Multidirectional), Bifacial (Unidirectional, Bidirectional and Multidirectional), globular, prismatic, atypical, casual cores and core fragments (de Lumley, et al., 2005; Toth & Schick, 2006)

It's necessary to note that flakes were classified in two systems, both De Lumley's (2005) and Toth's (1985). While a universal method for classification if preferred for the sake of standardization, De Lumley's classification is more nuanced in its identification of cortical coverage and striking platform type and it is necessary for the application of Platform Remnant Bearing identification methods (Magne & Pokotylo, 1981), which will be explained below.

### *Mode 2 Industries*

Mode 2 industries, usually identified as the Acheulean lithic industry, are more complex than Mode 1. The main characteristic of these industries, however, is the so called Large Cutting Tools (LCT) (Vallverdú, et al., 2014), a denomination for bifaces and unifacial tools, Acheulean type. While some scholars might prefer the use of the term bifaces to avoid any implicit use of the artifact, LCT is still largely used as sometimes bifaces are used synonymously with handaxes (Sharon G. , 2006).

The earliest handaxes were found associated with *Homo erectus* in Bed II of Olduvai Gorge. These were bifaces crudely made were the chips were removed from the sides of the core by rapping it against an anvil, forming cutting an edge. The anvil was eventually replaced by a hammer and the cores were being flaked in an oval manner. Besides the handaxes the Acheulean and consequently, Mode 2 Industry, has cleavers, choppers and also the use of flakes as tools, sometimes as knives and sometimes retouched to be served as knives. Eventually, the Mode 2 was replaced by Levalloisian made artifacts and the Mousterian industry.

The classification used in this study, already exposed above, has its basis on the classification of the lithic industry of 'Ubeidiya (Bar-Yosef & Goren-Inbar, 1993), though a little modified. The number of negative bulbs is a good indicator of complexity of the technology as well as striking platform width in the case of flakes (Andrefsky Jr., 2005) and although no bifaces were found, flakes product of biface reduction were found.

Certain key characteristics were analyzed to try and find the reduction stage of the artifacts. Using the methodology established by Magne (Magne & Pokotylo, 1981), some flakes were divided in certain criteria, namely four categories, being: Early Platform Remnant Bearing (PRB), that is, flakes with less than 10 grams of weight, 0-3 negatives at the dorsal surface and with cortex coverage more than half or completely cortical (1C or 2C). Middle PRB, flakes between 2-10 grams with 0-4 negatives in the dorsal surface and being less than half covered by cortex or without any cortex (3C or 4C). Late Shatter, flakes with less than 1 gram and having 3C or 4C and Late PRB, flake with less than 2 grams with 3 or more dorsal negatives and 3C or 4C for cortex.

# Results

## Spatial Analyses

For site 334 Inferior there's a total of 121 artifacts that were found during the 2014 expedition. One of the main concerns in spatial analysis is to evaluate whether the artifacts of different types and in different depths are randomly distributed or are agglutinated (Hietala, 1984). For that, two main categories were used: flakes (including denticulates, scrapers and other "small" artifacts) and core tools (including choppers and cores, "bigger" artifacts). It's important to note that all maps are presented through a vertical viewpoint, that is, the observer is facing the section.

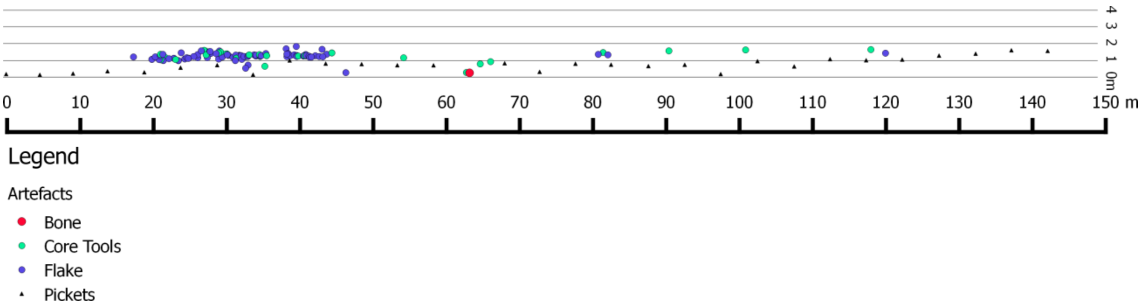


**Figure 15 – Vertical distribution of artifacts by three major categories – Site 334 Inferior**

The section shows a clear cluster of artifacts between the meters 20 and 50, so due to the sedimentary nature of the site, a close up of the area with a more absolute unit of measurement is necessary to assess if, due to the sedimentary and polygenic nature of the site, the cluster could represent a natural (colluvium, alluvium) process.

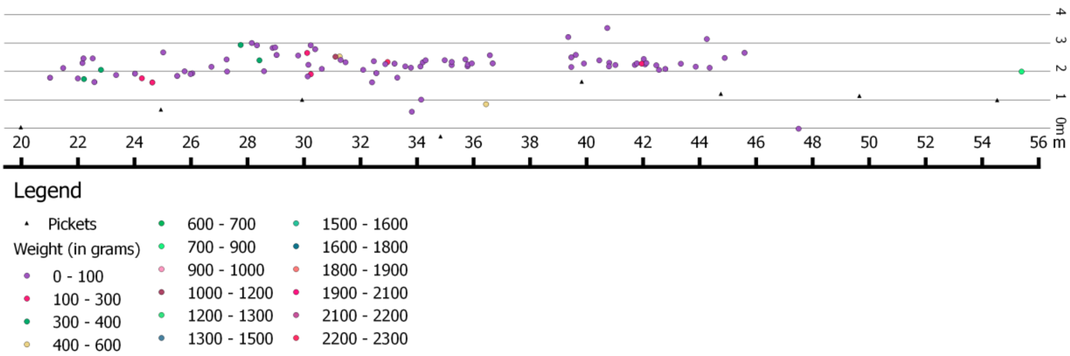


**Figure 16 – Vertical distribution of artifacts in high density zone by weight - Site 334 Inferior**

Light flakes make up most of the of the high density zone of the 334 inferior. They are roughly on the same height level and heaviest artifact is between meter 32 and 34, in the range of 1.9 to 2.1 kilograms. There are heavy artifacts inside the cluster, which rules out a low energy single alluvial event, but it doesn't rule out colluvium forces. The fragment of animal bone was found outside this cluster, in a lower height, making it probable that it isn't related to the lithic artifacts

Site 334 Superior has a low density of artifacts, with only 12 pieces in the whole section for 2014. Due to the proximity (some of them being in the same spot), only 9 are visible in the section.

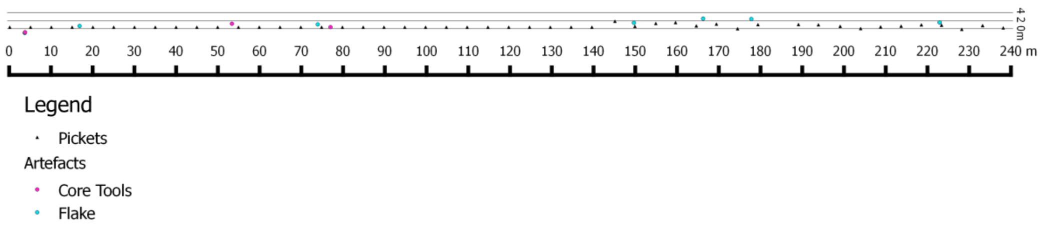


**Figure 17 – Vertical distribution of artifacts by three major categories – Site 334 Superior**

The lack of artifacts turns the process of identification of layers of artifacts difficult and small sample interferes with the process of spatial analysis, but it still can bring much information about the site and its genesis.

Lastly, site 330 has 239 artifacts found in 2014, the biggest collection of the three.

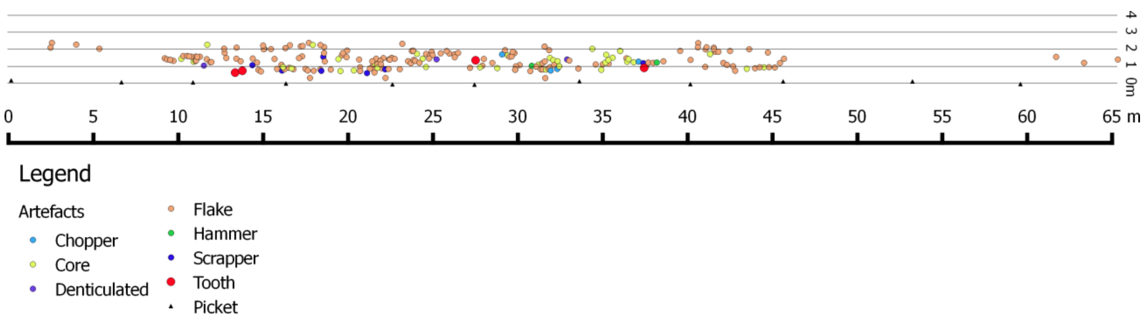


**Figure 18 - Vertical distribution of artifacts by three major categories – Site 330**

Artifact distribution, as with site 334 Inferior, is concentrated in a horizontal manner and around the same elevation, which represents the bottom of the site. The fossil teeth found are all part of the same layer, being less than a meter away from each other in the Y axis.

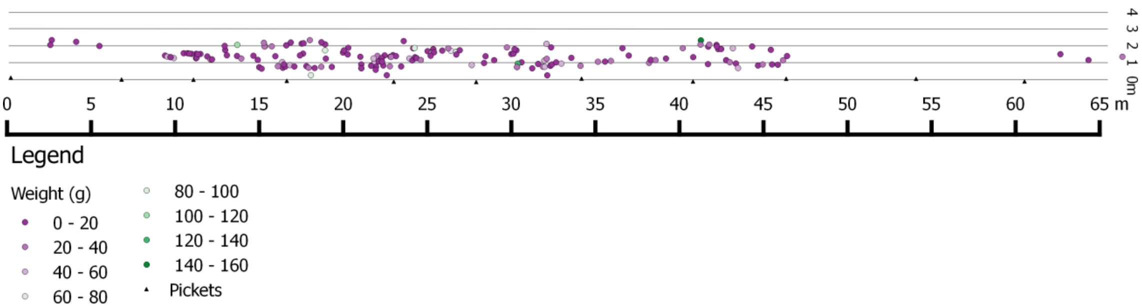


**Figure 19 - Vertical distribution of flakes by weight – Site 330**

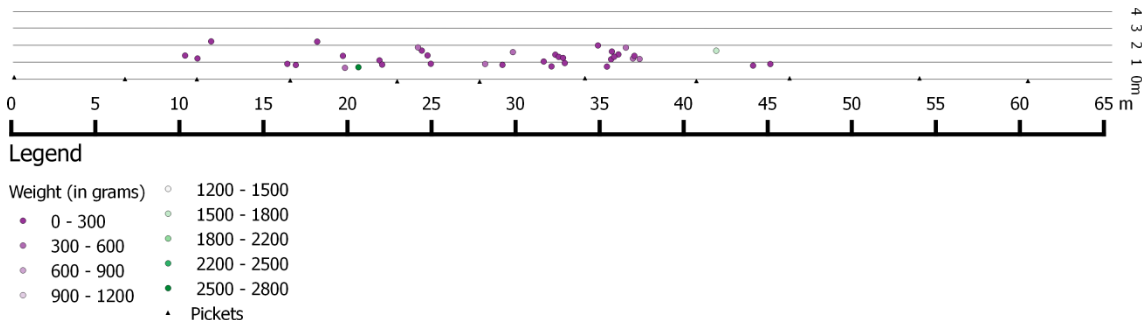


**Figure 20 - Vertical distribution of core tools by weight – Site 330**

The weight distribution doesn't show a clear concentration of light artifacts or heavy artifacts in one side or the other.

With use of QGIS it was possible to perform the Nearest-neighbor Distance analysis for the three sites, considering the horizontal dispersion of artifacts.

| **Site 330** | |
|---|---|
| **Mean Observed Distance** | 0.161682219059 |
| **Mean Expected Distance** | 0.734874187483 |
| **Nearest Neighbor Index** | 0.220013468718 |
| **Number of Observed Artifacts** | 238 |
| **Conclusion** | **Not Random** |

| Site 334 Inferior | |
|---|---|
| **Mean Observed Distance** | 0.484190904659 |
| **Mean Expected Distance** | 1.68865856525 |
| **Nearest Neighbor Index** | 0.286731086214 |
| **Number of Observed Artifacts** | 119 |
| **Conclusion** | **Not Random** |

| Site 334 Superior | |
|---|---|
| **Mean Observed Distance** | 6.7151998138 |
| **Mean Expected Distance** | 7.26845110735 |
| **Nearest Neighbor Index** | 0.923883192528 |
| **Number of Observed Artifacts** | 12 |
| **Conclusion** | **Random** |

**Table 1 – Randomness of artifact distribution in the analyzed sites**

The low density of observed artifacts should be considered as a factor for the randomness of Site 334 Superior. The smaller the sample in a statistical analysis the more the result can end skewed. Ideally, the construction of erosion maps, destruction and excavation of sites could be compared with the maps of distribution of artifacts.

## Quantitative Analyses

### Site 330

The presented results are the analysis of all artifacts found in 2014 for site 330 according to a group of characteristics that were observed. It's noteworthy that all artifacts are made of flint. The first table and graph shows the distribution and proportion of artifacts through class categories.

| Class | Occurrence | Percentage |
|---|---|---|
| Choppers | 5 | 2,1% |
| Cores | 37 | 15,54% |
| Denticulates | 3 | 1,26% |
| Flakes | 184 | 77,31% |
| Hammers | 2 | 0,84% |
| Scrappers | 7 | 2,94% |
| Total | 238 | 100% |

**Table 2 - Frequencies of artifacts by class categories – Site 330**

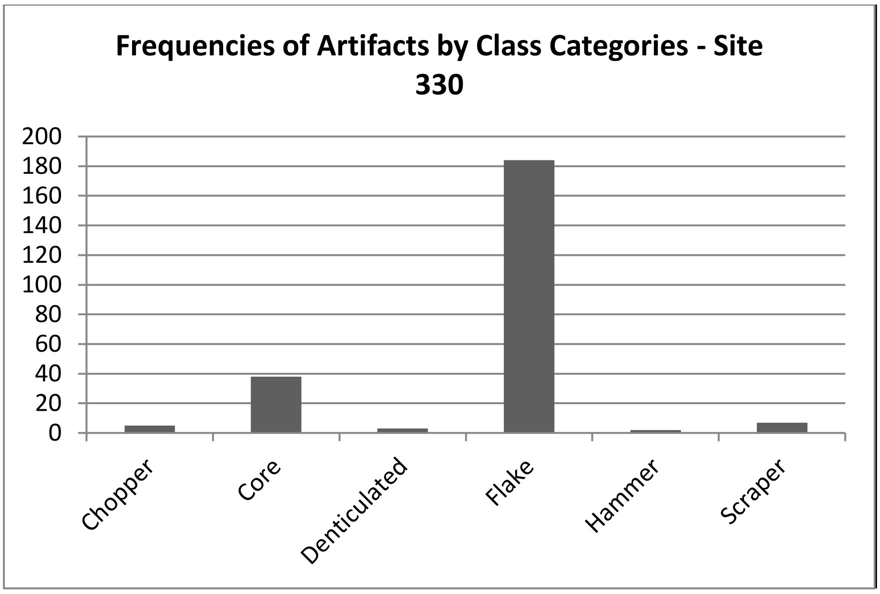


**Figure 21 - Frequencies of artifacts by Class Categories in absolute numbers – Site 330**

As seen in the table and the graph above for the 330 site, the number of flakes is much bigger being followed by cores. Choppers, denticulates, hammers and scrapers are also present in this sample, making it the most diverse of the three sites.

| Type | Occurrence | Percentage | Legend |
|---|---|---|---|
| S1 | 2 | 1,02% | S1 – Completely Cortical with Cortical Striking Platform |
| S2 | 30 | 15,31% | S2 – Partial Cortex and Cortical Striking Platform |
| S3 | 22 | 11,22% | S3 – No Cortex and Cortical Striking Platform |
| S5 | 86 | 43,87% | S5 – Partial Cortex and Flat Striking Platform |
| S6 | 56 | 28,57% | S6 – No Cortex and Flat Striking Platform |
| Total | 196 | 100% | |

**Table 3 - Frequencies of flakes by type categories – Site 330**

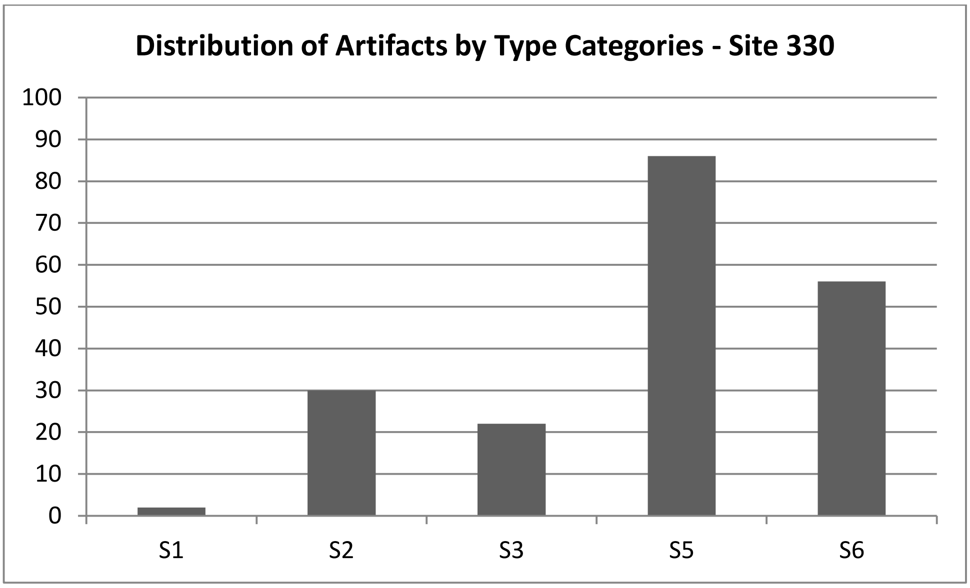


**Figure 22 – Distribution of flakes by Type in absolute numbers – Site 330**

As seen in the table and graph there is a much more representative quantity of material that is S5 type, which means with Partial Cortex and Flat Striking Platform, followed by S6 or No Cortex and Flat Striking Platform pieces.

It's noteworthy that almost all pieces have a weight under 300 grams and it's necessary to point out that almost all pieces over it are cores.

| | |
|---|---|
| Mean | 354,54 g |
| Standard Deviation | 502,79 |
| Sum | 15600,0 |
| Minimum | 20g |
| Maximum | 2763g |
| Coefficient of Variation | 1,418 |
| Range | 2743g |
| Median | 250,5g |

**Table 4 - Descriptive analysis of the weight of Core Tools – Site 330**

The distribution of the core tools weight shows that there is a wide range, 2.7 kilograms, and also shows that this sample has from lighter to heavier cores.

| Weight (g) of Core Tools | Occurrence | Percentage |
|---|---|---|
| <100 | 9 | 20,45% |
| 100-200 | 11 | 25% |
| 200-300 | 10 | 22,72% |
| 300-400 | 5 | 11,36% |
| 400-500 | 3 | 6,81% |
| 500-600 | 3 | 6,81% |
| 1700-1800 | 2 | 4,54% |
| 2700-2800 | 1 | 2,27% |
| Total | 44 | 100% |

**Table 5 - Frequencies of core tools by weight (g) – Site 330**

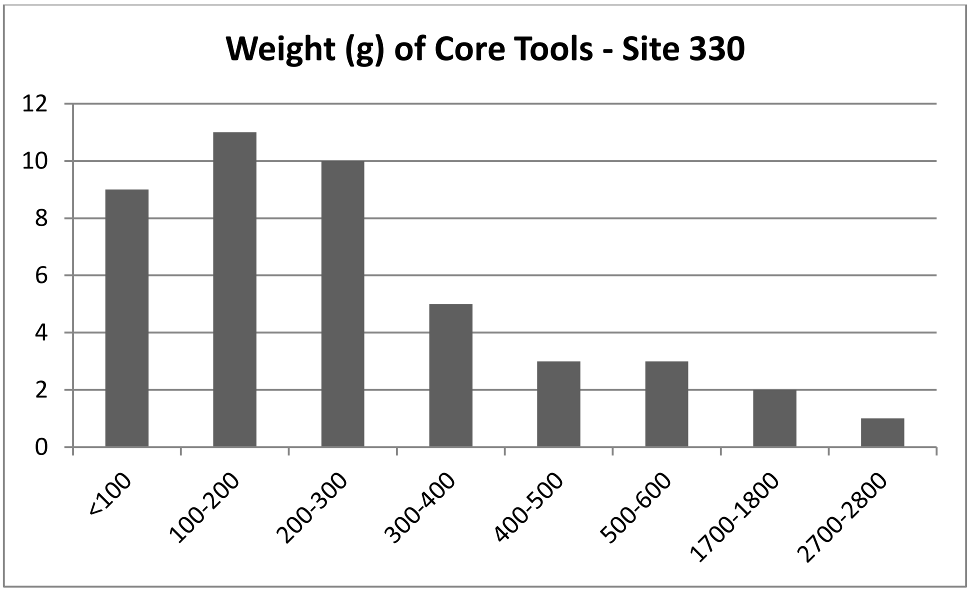


**Figure 23 - Frequencies of core tools by weight (g) in absolute numbers – Site 330**

It is possible to see that most part of artifacts are concentrated between less than a 100 and 300 grams. However, there are 3 artifacts heavier than 1 kilogram, representing the chopper category.

| | |
|---|---|
| Mean | 21,84g |
| Standard Deviation | 23,67 |
| Sum | 4238,2g |
| Minimum | 0,3g |
| Maximum | 160g |
| Coefficient of Variation | 1,08 |
| Range | 159,7g |
| Median | 14g |

**Table 6 - Descriptive analysis of weight of flakes – Site 330**

For the flakes of this sample, the range is not so wide, and the most part of them are concentrated below the 50 grams line.

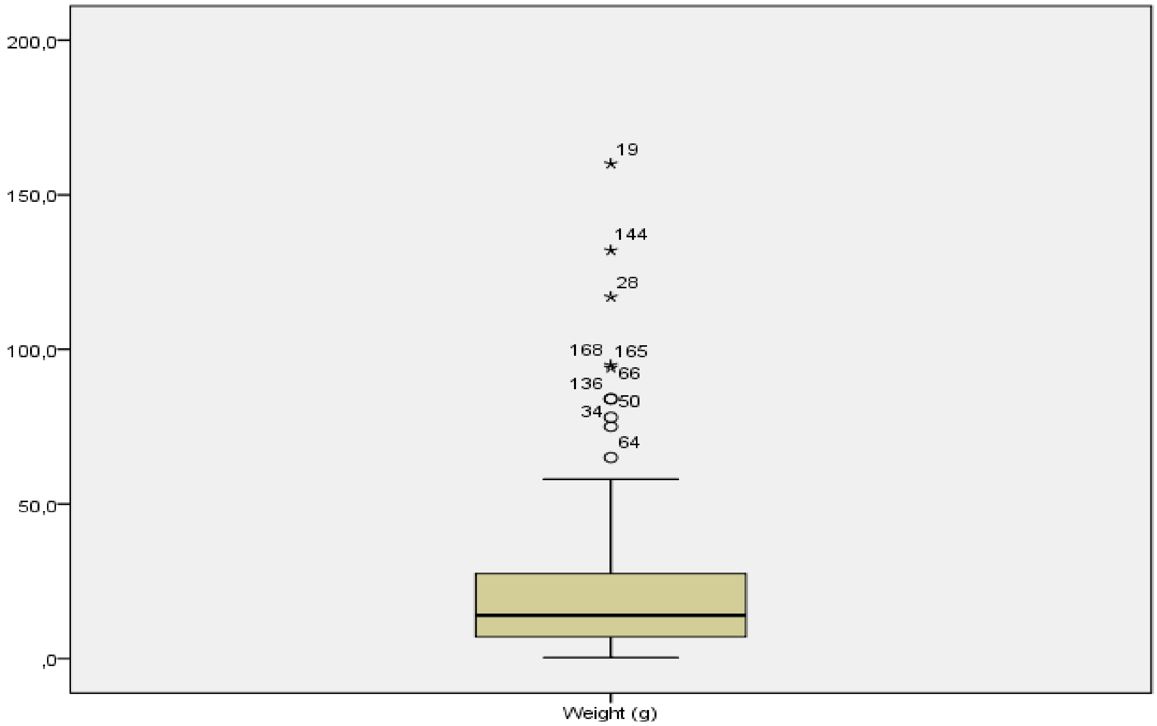


**Figure 24 - Boxplot graph of weight (g) of flakes – Site 330**

| Weight(g) of Flakes | Occurrence | Percentage |
|---|---|---|
| <10 | 75 | 38,65% |
| 10-20 | 54 | 27,83% |
| 20-30 | 21 | 10,82% |
| 30-40 | 13 | 6,70% |
| 40-50 | 11 | 5,60% |
| 50-60 | 10 | 5,15% |
| 60-70 | 1 | 0,51% |
| 70-80 | 2 | 1,03% |
| 80-90 | 2 | 1,03% |
| 90-100 | 2 | 1,03% |
| 100-110 | 0 | 0% |
| 110-120 | 1 | 0,51% |
| 120-130 | 0 | 0% |
| 130-140 | 1 | 0,51% |
| 140-150 | 0 | 0% |
| 150-160 | 1 | 0,51% |
| Total | 194 | 100% |

**Table 7 - Frequencies of flakes by weight (g) – Site 330**

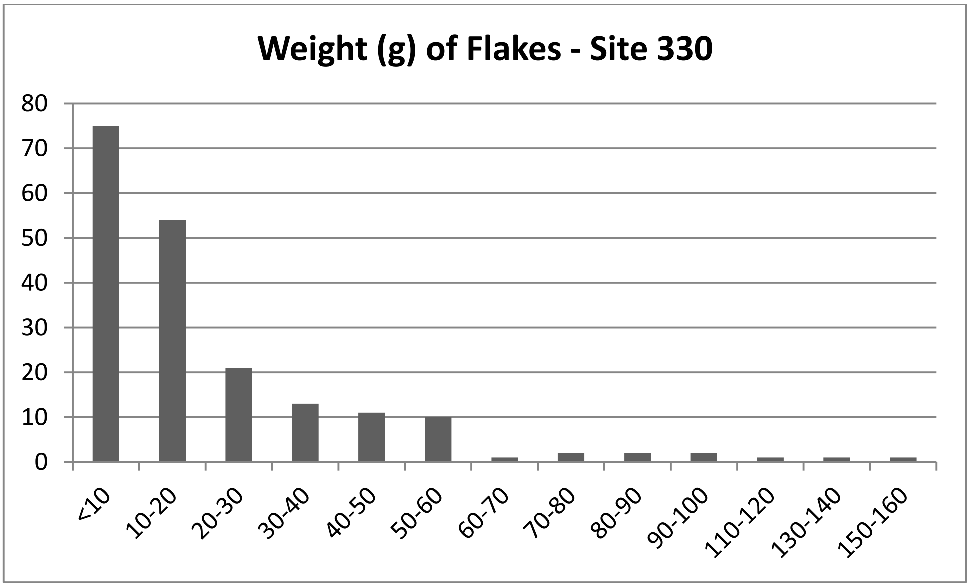


**Figure 25 - Frequencies of flakes by weight (g) in absolute numbers – Site 330**

Most part of the flake have weight under 30 grams, with its peak under 10 grams. When core and flakes are putted together, it's possible to see that there is no specific cluster of artifacts by depth. The chart below shows that there is an equal distribution of pieces through the Z values.

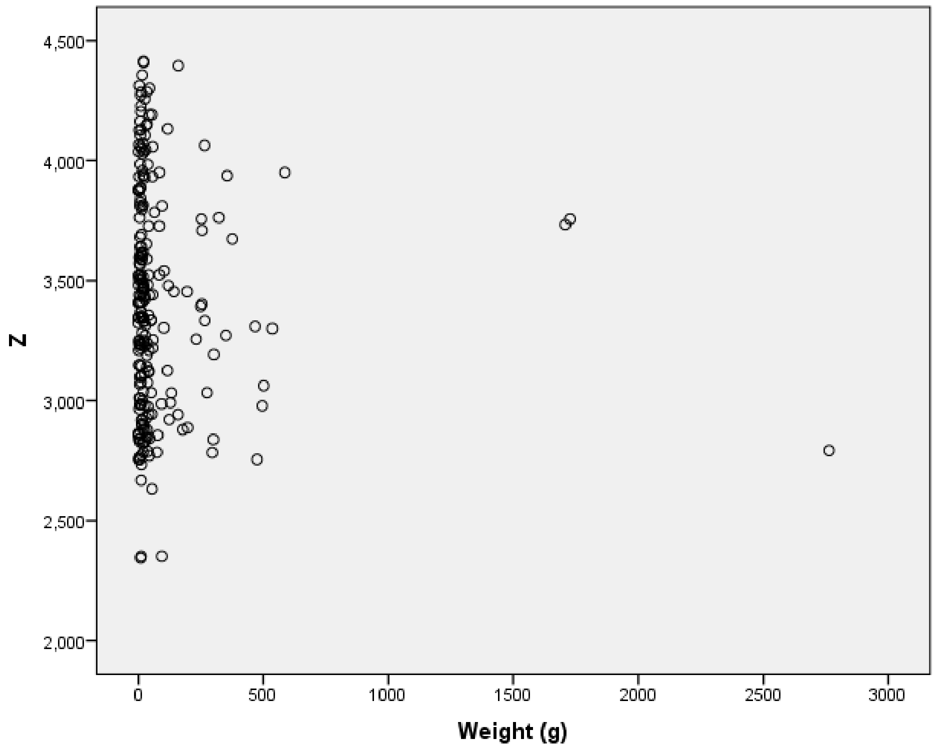


**Figure 26 - Boxplot graph of the weight of flakes parameter correlated with depth – Site 330**

| Number of Scars in the Dorsal Surface | Occurrence | Percentage |
|---|---|---|
| No Scars | 12 | 6,60% |
| 1 | 40 | 21,98% |
| 2 | 49 | 26,92% |
| 3 | 35 | 19,23% |
| 4 | 22 | 12,09% |
| 5 | 9 | 4,94% |
| 6 | 13 | 7,14% |
| 7 | 2 | 1,10% |
| Total | 182 | 100% |

**Table 8 - Number of scars in the dorsal surface of flakes – Site 330**

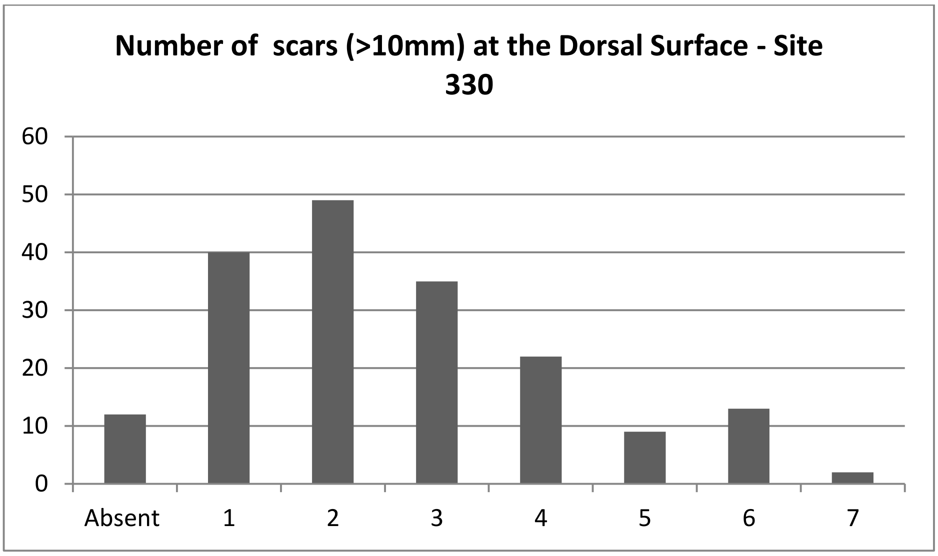


**Figure 27 - Number of scars in the dorsal surface of flakes in absolute numbers – Site 330**

The predominant number of scars in the dorsal surface is 2 negatives. More than 50% of pieces have between 1 and 3 negatives.

| Number of Negative Bulbs | Occurrence | Percentage |
|---|---|---|
| 1 | 5 | 11,36% |
| 2 | 6 | 13,64% |
| 3 | 7 | 15,90% |
| 4 | 7 | 15,90% |
| 5 | 1 | 2,27% |
| 6 | 4 | 9,09% |
| 7 | 2 | 4,54% |
| 8 | 6 | 13,64% |
| 9 | 2 | 4,54% |
| 10 | 2 | 4,54% |
| 11 | 2 | 4,54% |
| Total | 44 | 100% |

**Table 9 - Frequency of core tools by number of negative bulbs – Site 330**

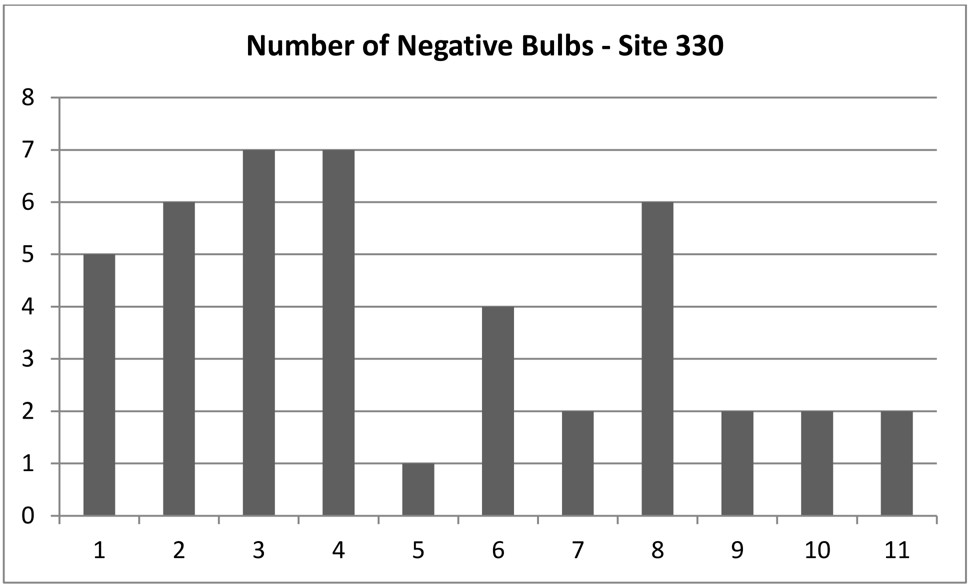


**Figure 28 – Core tools by number of negative bulbs in absolute numbers – Site 330**

The table and graph shows that is a progressive growth for core tools to 4 negative bulbs, reaching another peak with the same quantity of pieces (about 6) at 8 negative bulbs.

| Integrity | Occurrence | Percentage |
|---|---|---|
| Complete | 168 | 85,71% |
| Incomplete | 27 | 13,77% |
| Fragmented | 1 | 0,51% |
| Total | 196 | 100% |

**Table 10 - Integrity classification of flakes – Site 330**

The table and graph shows that almost all artifacts were complete, but with a representative percentage of incomplete artifacts, and just one artifact was found fragmented, that is, with a piece that refits somewhere else in the profile.

| Fiche Typologie Africaine | Occurrence | Percentage |
|---|---|---|
| I-1 | 2 | 40% |
| II-4 | 1 | 20% |
| III-1 | 1 | 20% |
| II-8 | 1 | 20% |
| Total | 5 | 100% |

**Table 11 - Frequency of Choppers by Fiche Typologie Africaine – Site 330**

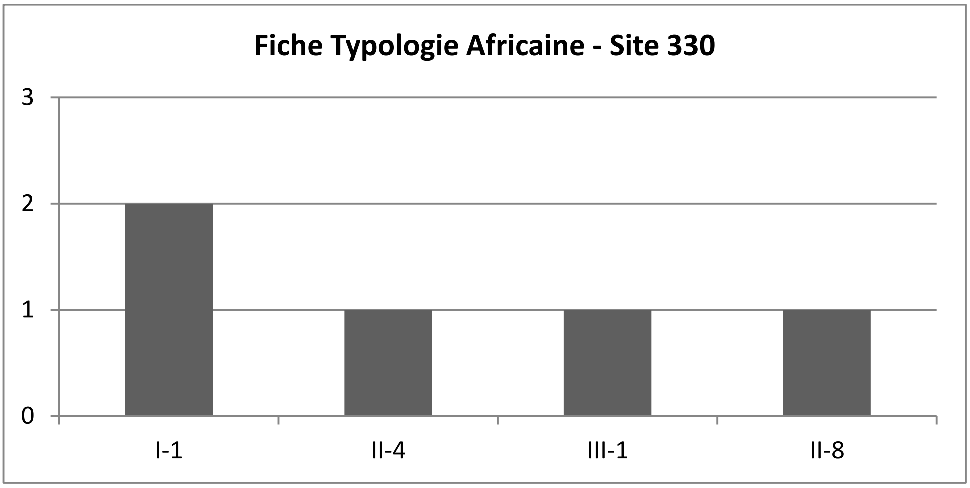


**Figure 29 - Choppers by Fiche Typologie Africaine in absolute numbers – Site 330**

As shown by the table only five chopping tools were classified within these categories. The sample for this category is too small for any clear predominance or pattern.

| Detachment Angle of Flakes | Occurrence | Percentage |
|---|---|---|
| 90°- 100° | 21 | 11,47% |
| 100°- 110° | 62 | 33,88% |
| 110° - 120° | 68 | 37,16% |
| 120° - 130° | 29 | 15,85% |
| 130°- 140° | 1 | 0,55% |
| 140°- 150° | 1 | 0,55% |
| Opposed | 1 | 0,55% |
| Total | 183 | 100% |

**Table 12 - Detachment angle of flakes – Site 330**

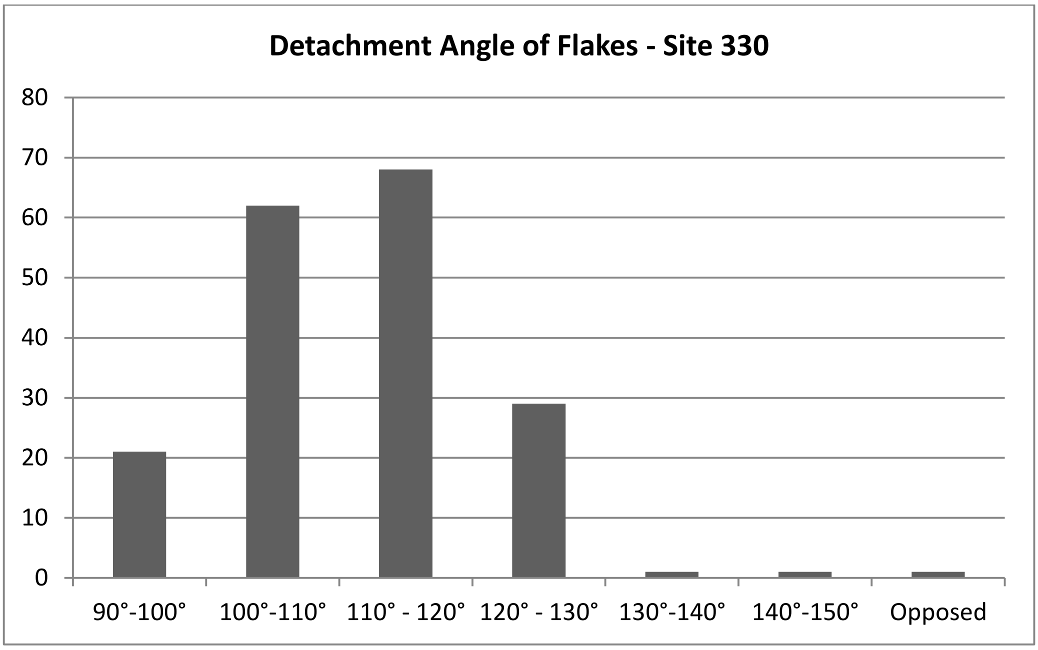


**Figure 30 - Flakes by detachment angle in absolute numbers – Site 330**

The table and graph shows that more than half of the artifacts have detachment angles that lies between 100º and 120º, and it is necessary to point out that all artifacts have obtuse angles (>90º).

| Striking Platform Type | Occurrence | Percentage | Legend |
|---|---|---|---|
| 1T | 54 | 27,55% | 1T – Cortical Striking Platform |
| 2T | 102 | 52,04% | 2T – Flat Strike Platform |
| 3T | 7 | 3,57% | 3T – Dihedral Striking Platform |
| 4T | 4 | 2,04% | 4T – Faceted Striking Platform |
| 5T | 7 | 3,57% | 5T – Linear Striking Platform |
| 6T | 3 | 1,53% | 6T - Punctiform Striking Platform |
| 7T | 19 | 9,69% | 7T – Absent Striking Platform |
| Total | 196 | 100% | |

**Table 13 - Frequency of flakes by type of striking platforms – Site 330**

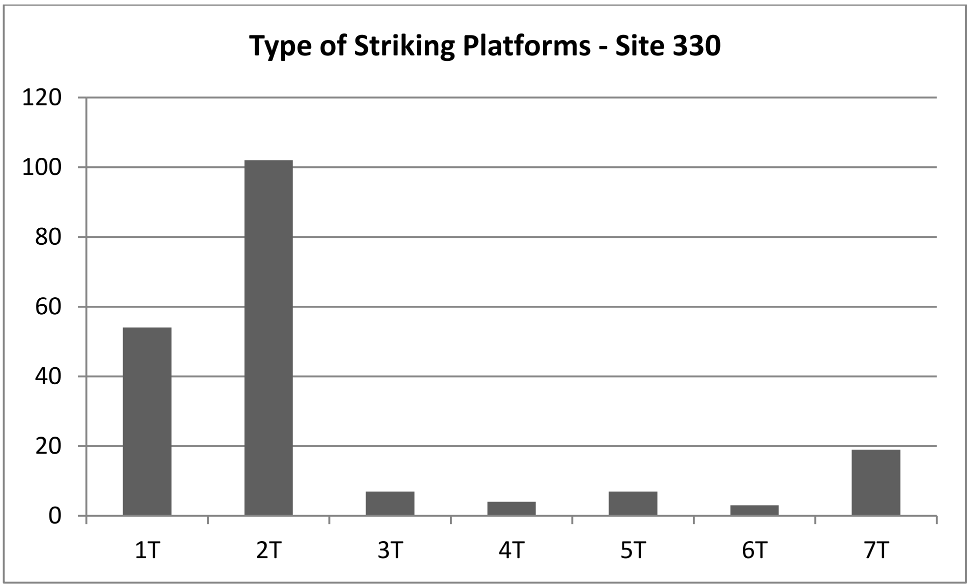


**Figure 31 - Flakes by type of striking platforms in absolute numbers – Site 330**

It is possible to observe that almost one third of the samples (54 artifacts) are type 1 platform (cortical striking platform) and almost its double (102) is 2T (flat striking platform).

| Cortical Coverage of Flakes | Occurrence | Percentage | Cortex |
|---|---|---|---|
| 1C | 2 | 1% | 1C – Completely Cortical Flake |
| 2C | 18 | 9,8% | 2C – Covered in more than half |
| 3C | 111 | 60,3% | 3C – Covered in less than half |
| 4C | 53 | 28,8% | 4C – No Cortex |
| Total | 184 | 100% | |

**Table 14 - Frequencies of flakes by cortical coverage – Site 330**

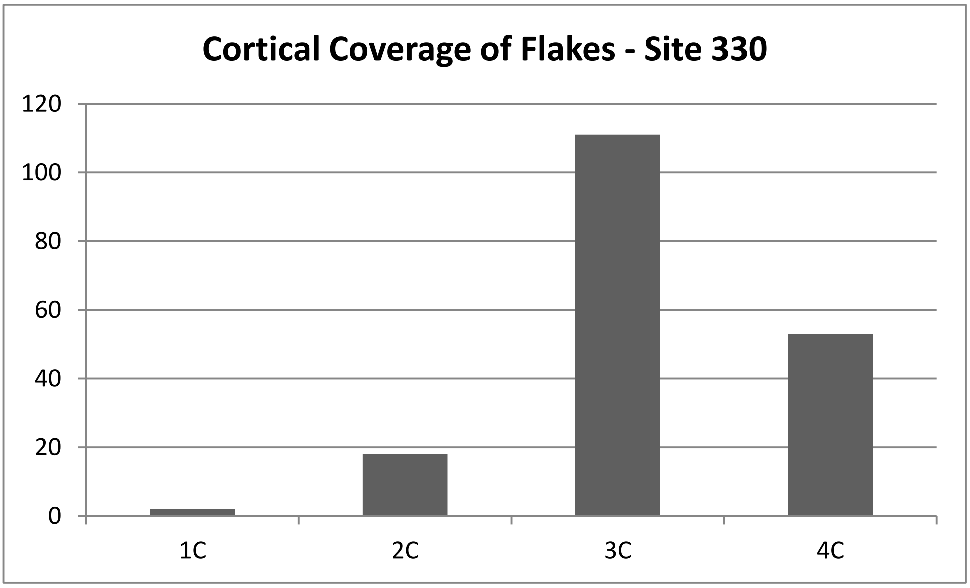


**Figure 32 - Frequencies of flakes by cortical coverage in absolute numbers– Site 330**

It is possible to see that flakes overwhelmingly lake cortical coverage or have less than half of cortical coverage.

| Cortical Coverage of Core Tools | Occurrence | Percentage | Legend |
|---|---|---|---|
| 2C | 21 | 56,8% | 2C – Covered in more than half |
| 3C | 15 | 40,5% | 3C – Covered in less than half |
| 4C | 1 | 2,7% | 4C – No Cortex |
| Total | 37 | 100% | |

**Table 15 - Frequencies of Core tools by cortical coverage – Site 330**

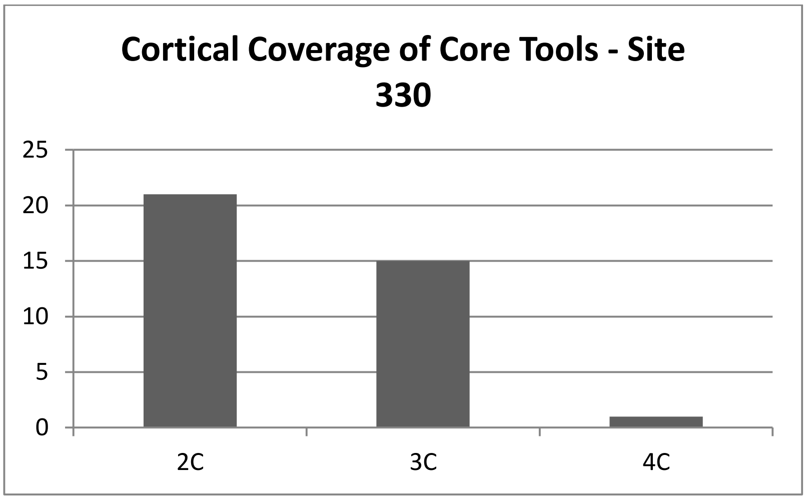


**Figure 33 - Frequencies of core tools by cortical coverage in absolute numbers – Site 330**

When looking just at core tools, there is still a significant part of 3C, but the majority is composed by 2C, which means they are covered in more than half.

| | |
|---|---|
| Mean | 78,36mm |
| Standard Deviation | 35,14 |
| Sum | 3448,0mm |
| Minimum | 27,0mm |
| Maximum | 200,0mm |
| Coefficient of Variation | 0,448 |
| Range | 173,0mm |
| Median | 71,5 |

**Table 16 - Descriptive analysis of core tools by maximum length – Site 330**

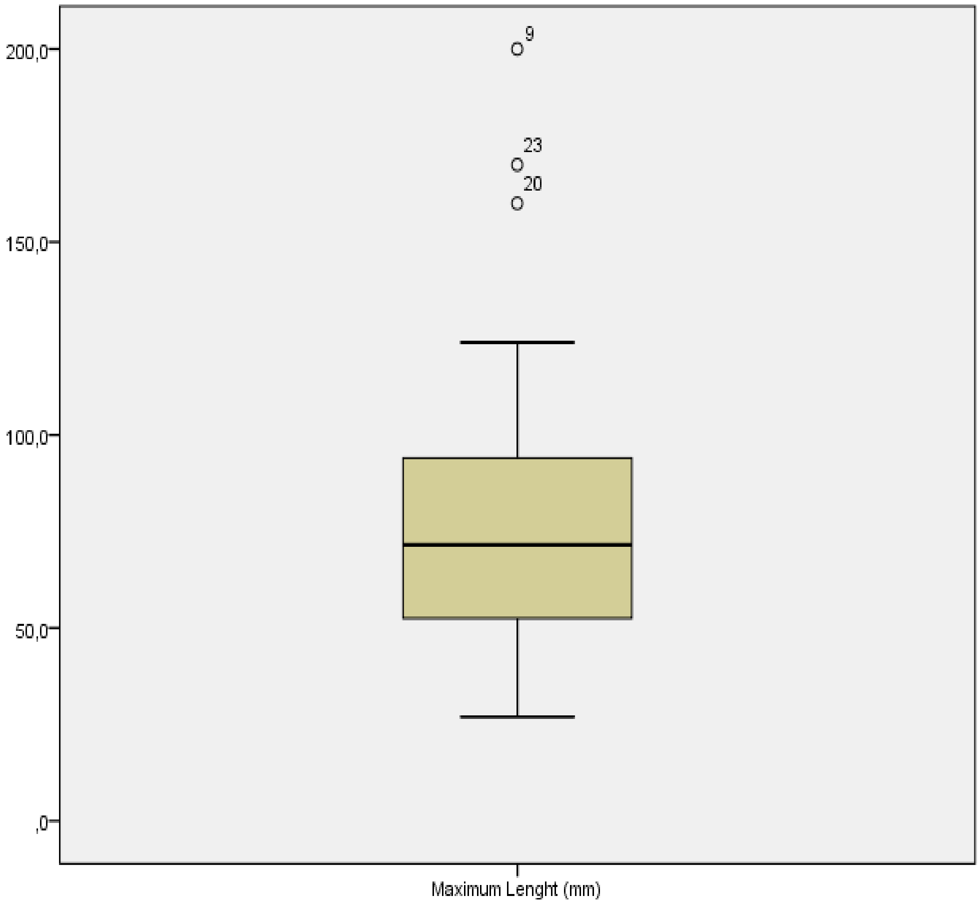


**Figure 34 - Boxplot graph of core tools maximum length (mm) – Site 330**

| **Maximum Length of Core Tools** | Occurrence | Percentage |
|---|---|---|
| <10mm | 0 | 0% |
| 10-30mm | 0 | 0% |
| 30-50mm | 9 | 20,45% |
| 50-70mm | 12 | 27,27% |
| 70-90mm | 11 | 25% |
| 90-110mm | 7 | 15,90% |
| 110-130mm | 2 | 4,54% |
| 130-150mm | 0 | 0% |
| 150-170mm | 2 | 4,54% |
| 190-200mm | 1 | 2,27% |
| Total | 44 | 100% |

**Table 17 - Frequencies of core tools by maximum length (mm) – Site 330**

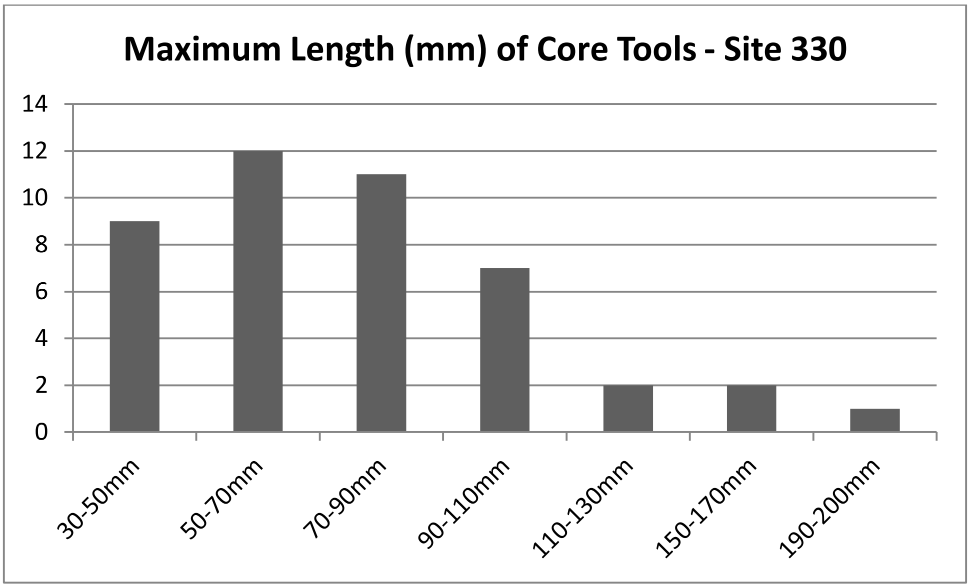


**Figure 35 - Frequencies of core tools by maximum length in absolute numbers – Site 330**

Most part of the core tools present maximum length between 50 and 70 mm while most part of the flakes have their peak around 30 to 50 mm.

| | |
|---|---|
| Mean | 44,21mm |
| Standard Deviation | 15,11 |
| Sum | 8577,0mm |
| Minimum | 11,0mm |
| Maximum | 93,0mm |
| Coefficient of Variation | 0,34 |
| Range | 82,0mm |
| Median | 42,0 |

**Table 18 - Descriptive analysis of maximum length of flakes – Site 330**

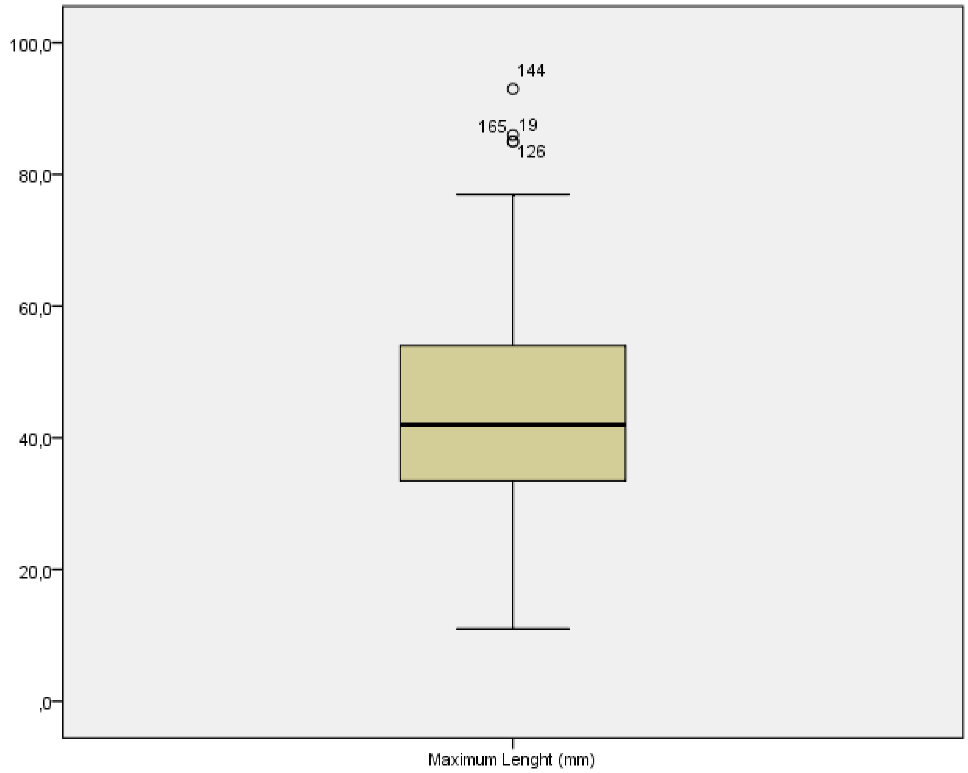


**Figure 36 - Boxplot graph of flakes distribution by maximum length – Site 330**

Maximum flake length for site 330 shows a peak at 3 to 5 centimeters, while still having a significant of flakes in the 1 to 3 centimeters and 5 to 7 centimeters horizons.

| Maximum Length of Flakes | Occurrence | Percentage |
|---|---|---|
| <10mm | 0 | 0% |
| 10-30mm | 36 | 18,55% |
| 30-50mm | 97 | 52,71% |
| 50-70mm | 49 | 25,25% |
| 70-90mm | 11 | 5,70% |
| 90-110mm | 1 | 0,50% |
| Total | 194 | 100% |

**Table 19 - Frequencies of flakes by maximum length – Site 330**

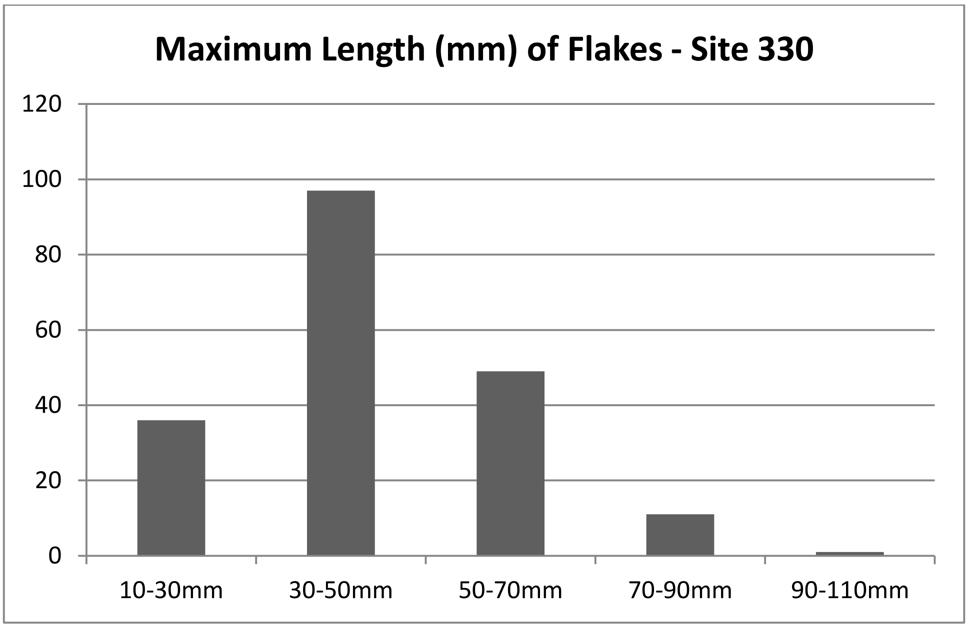


**Figure 37 - Frequencies of flakes by maximum length in absolute numbers – Site 330**

The core tools have a majority of orthogonal type of core, but the three more representative categories are orthogonal, unipolar and bipolar and orthogonal.

| Type of Core | Occurrence | Percentage |
|---|---|---|
| Orthogonal | 14 | 38,9% |
| Unipolar | 7 | 19,4% |
| Bipolar | 3 | 8,3% |
| Bipolar e Orthogonal | 6 | 16,6% |
| Centripetal | 1 | 2,7% |
| Convergent | 2 | 5,5% |
| Opposite Flaking | 3 | 8,3% |
| Total | 36 | 100% |

**Table 20 - Frequencies of core tools by Type categories – Site 330**

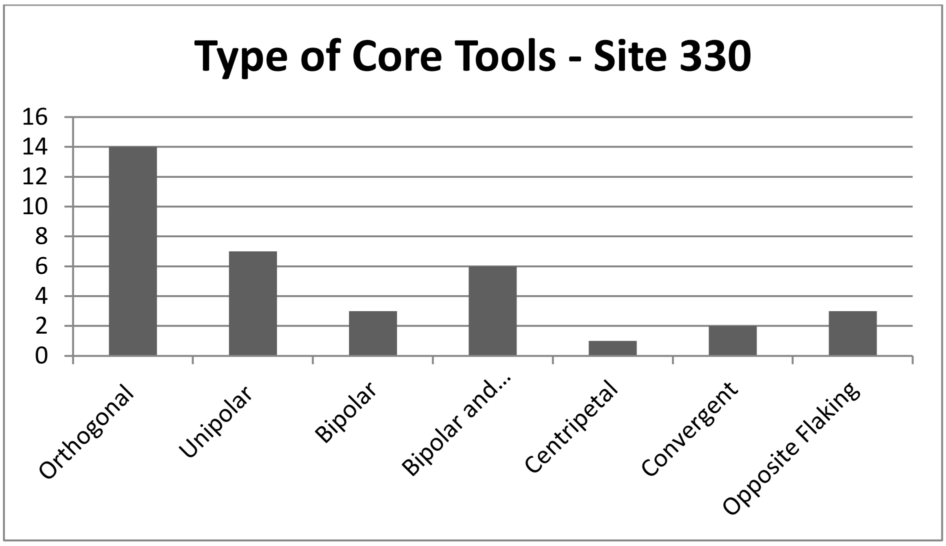


**Figure 38 - Frequencies of core tools by Type categories in absolute numbers – Site 330**

Core tools (cores and choppers) are predominantly simple – more than half have only 4 removal, though a peak at 8 removals can represent the more sophisticated cores. Flakes are predominantly non cortical and make up most of the material.

## Site 334 Inferior

Site 334 Inferior has fewer artifacts than site 330, even though its area is significantly larger (60 meters in 330 to 150 meters in 334). Their composition is also less diverse in regards to artifact types and there are more choppers and less cores in comparison to site 330.

| Class | Occurrence | Percentage |
|---|---|---|
| Core | 32 | 26,66% |
| Flake | 88 | 73,33% |
| Total | 120 | 100% |

**Table 21 - Frequencies of artifacts by class category – Site 334 Inferior**

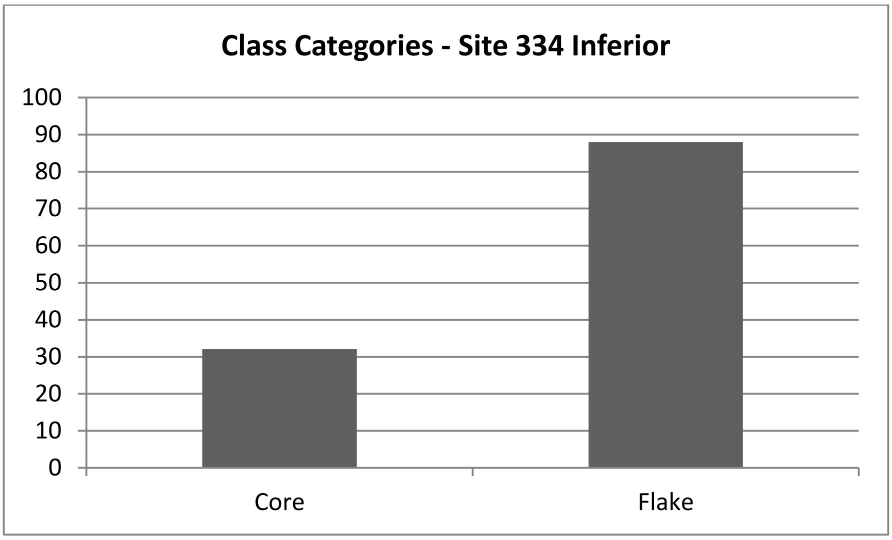


**Figure 39 - Frequencies of artifacts by class categories in absolute numbers – Site 334 Inferior**

As seen in site 330 the majority of artifacts are flake artifacts, with three-quarters of flakes, and one-quarter of cores tools.

| Type | Occurrence | Percentage | Legend |
|---|---|---|---|
| S1 | 2 | 2,32% | S1 – Completely Cortical with Cortical Striking Platform |
| S2 | 8 | 9,30% | S2 – Partial Cortex and Cortical Striking Platform |
| S3 | 4 | 4,65% | S3 – No Cortex and Cortical Striking Platform |
| S4 | 2 | 2,32% | S4 – Completely Cortical and Flat Striking Platform |
| S5 | 45 | 52,32% | S5 – Partial Cortex and Flat Striking Platform |
| S6 | 25 | 29,07% | S6 – No Cortex and Flat Striking Platform |
| Total | 86 | 100% | |

**Table 22 - Frequencies of flakes by type categories – Site 334 Inferior**

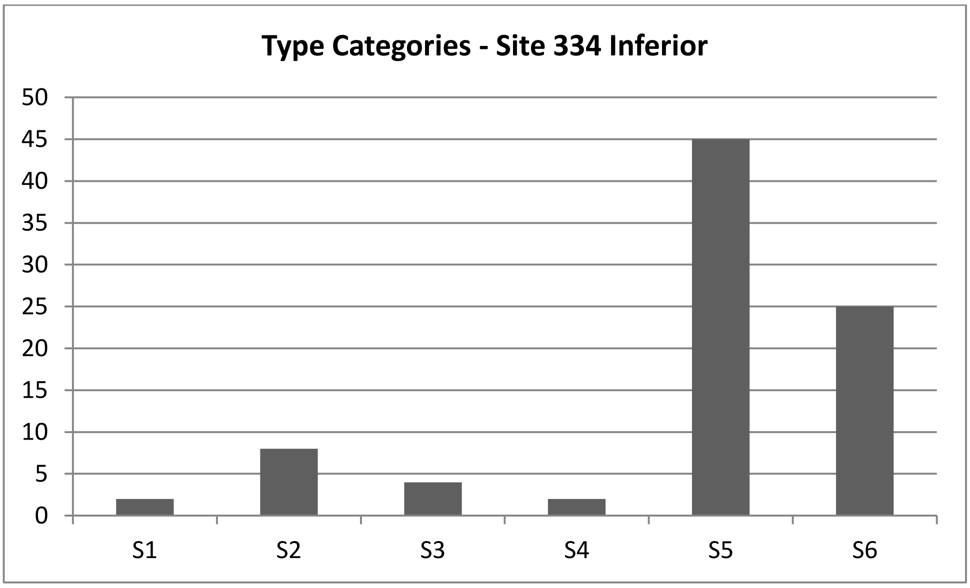


**Figure 40 - Frequencies of flakes by type categories in absolute numbers – Site 334 Inferior**

As seen in the table half of the sample is a S5 category, which means they have a Partial Cortex and Flat Striking Platform and it's closely followed by S6 type, No Cortex and Flat Striking Platform. Together they represent 80% of the sample.

| Weight (g) of Core Tools | Occurrence | Percentage |
|---|---|---|
| <100 | 8 | 25% |
| 100-200 | 6 | 18,75% |
| 200-300 | 6 | 18,75% |
| 300-400 | 3 | 9,37% |
| 400-500 | 2 | 6,25% |
| 500-600 | 0 | 0% |
| 800-900 | 1 | 3,12% |
| 1000-1100 | 3 | 9,31% |
| 1100-1200 | 1 | 3,12% |
| 1300-1400 | 1 | 3,12% |
| 2300-2400 | 1 | 3,12% |
| Total | 32 | 100% |

**Table 23 - Frequencies of core tools by weight – Site 334 Inferior**

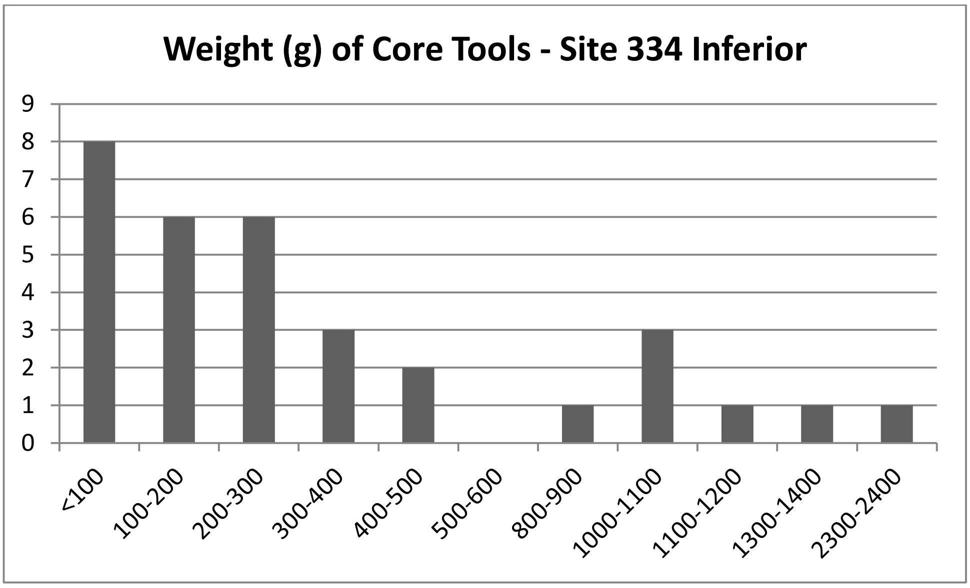


**Figure 41 - Frequencies of core tools by weight - absolute numbers – Site 334 Inferior**

| | |
|---|---|
| Mean | 418.46g |
| Standard Deviation | 505.17 |
| Sum | 13391.0g |
| Minimum | 37.0g |
| Maximum | 2343.0g |
| Range | 2306.0 |
| Coefficient of Variation | 1.207 |
| Median | 223.5 |

**Table 25 - Descriptive analysis of core tools weight– Site 334 Inferior**

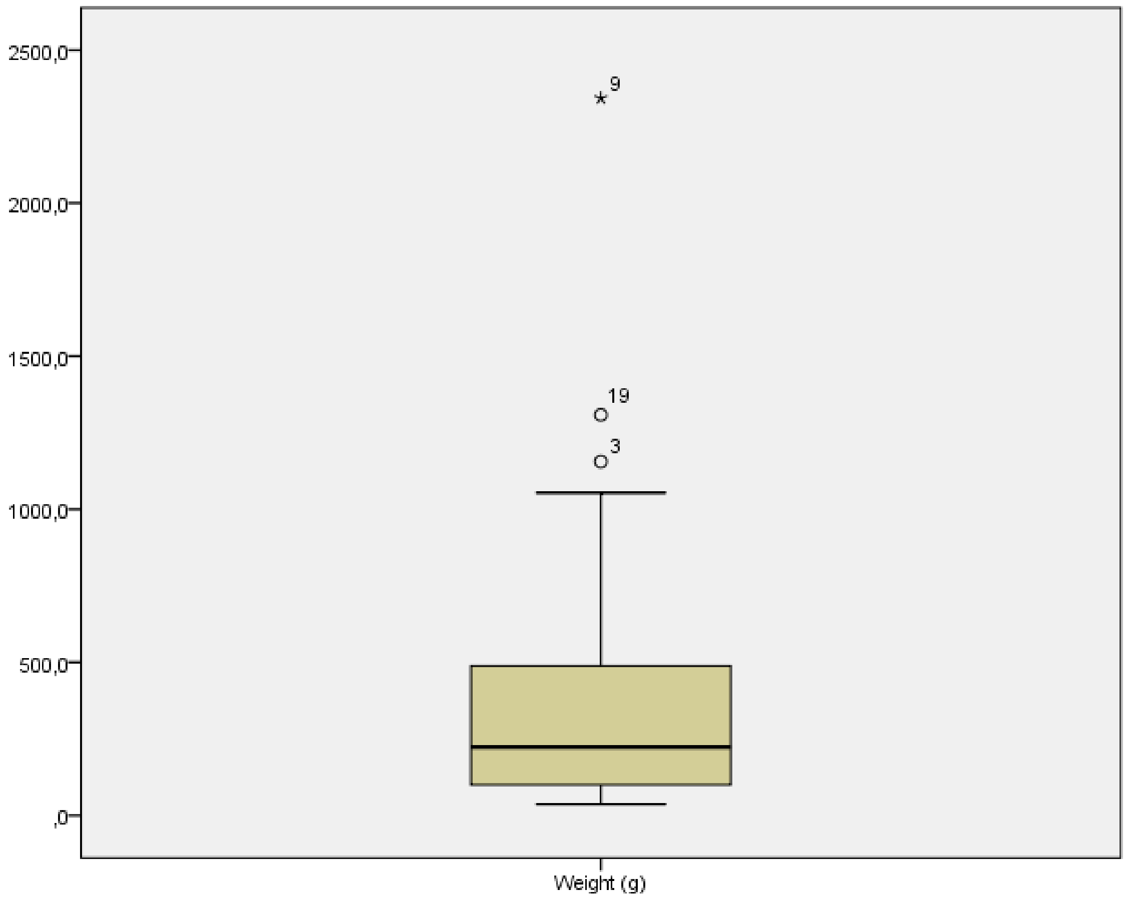


**Figure 42 – Boxplot representation of descriptive analysis of core tools by weight – Site 334 Inferior**

Most core tools are light, ranging from less than 100 to 400 grams, possibly due to the exhaustion of cores or simply by the smaller size of the rocks used for lithic tools.

| Weight (g) of Flakes | Occurrence | Percentage |
|---|---|---|
| <10 | 16 | 18,18% |
| 10-20 | 19 | 21,60% |
| 20-30 | 12 | 13,63% |
| 30-40 | 10 | 11,36% |
| 40-50 | 7 | 7,90% |
| 50-60 | 7 | 7,90% |
| 60-70 | 1 | 1,13% |
| 70-80 | 4 | 4,54% |
| 80-90 | 0 | 0% |
| 90-100 | 3 | 3,40% |
| 100-110 | 2 | 2,27% |
| 110-120 | 2 | 2,27% |
| 120-130 | 2 | 2,27% |
| 130-140 | 0 | 0% |
| 140-150 | 1 | 1,13% |
| 210-220 | 1 | 1,13% |
| 310-320 | 1 | 1,13% |
| Total | 88 | 100% |

**Table 24 - Descriptive analysis of flakes by weight– Site 334 Inferior**

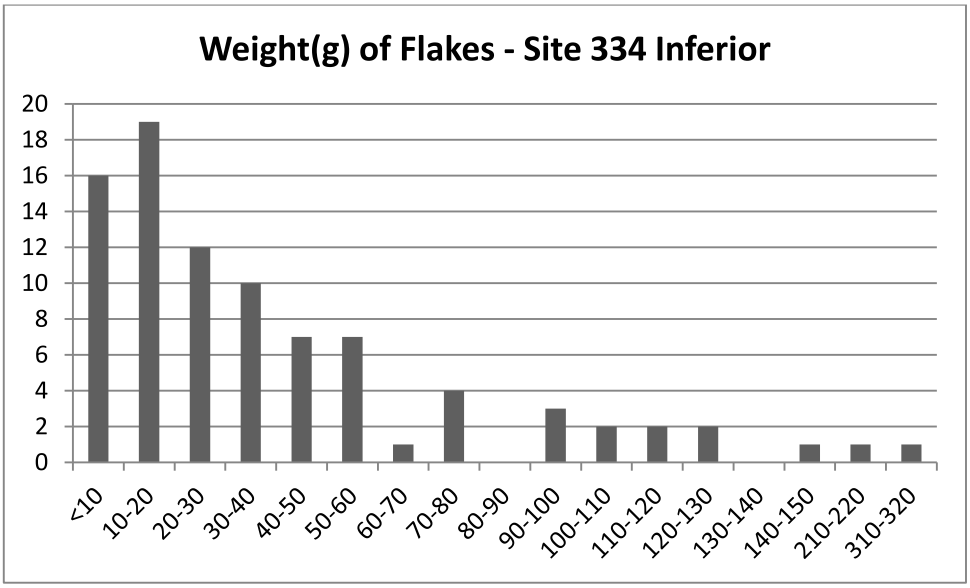


**Figure 43 - Distribution of flakes by weight in absolute numbers– Site 334 Inferior**

| | |
|---|---|
| Mean | 43.11g |
| Standard Deviation | 47.26 |
| Sum | 3751.0g |
| Minimum | 3.0g |
| Maximum | 311.0g |
| Coefficient of Variation | 1.09 |
| Range | 308.0g |
| Median | 27.0g |

**Table 25 - Descriptive analysis of flakes by weight– Site 334 Inferior**

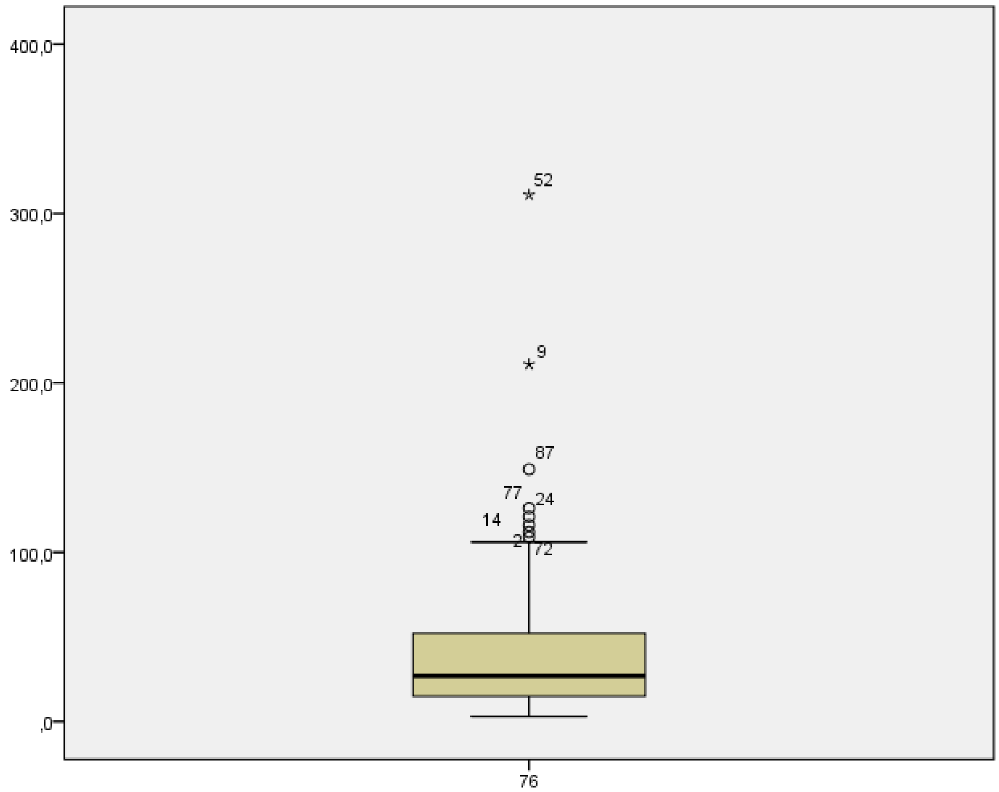


**Figure 44 - Boxplot of distribution of flakes weight– Site 334 Inferior**

Flakes weight in site 334 inferior concentrated in lower values, usually less than 100 grams, possible for the same reasons cores also have relatively low weights.

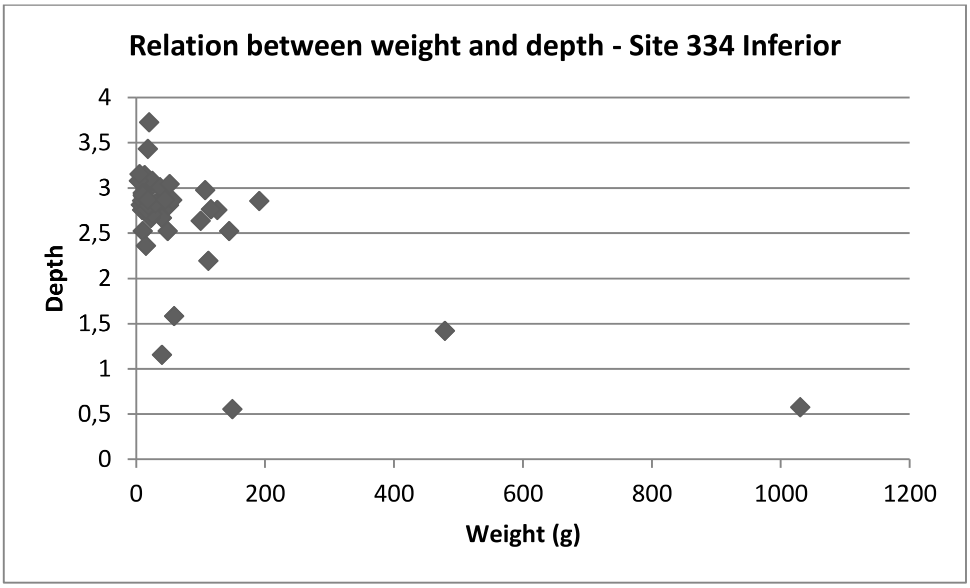


**Figure 45 - Relation between weight and depth – Site 334 Inferior**

At this site there is a bigger concentration around 3 meters, but at first there isn't a direct relation between weight and depth. There are rare exceptions of heavier pieces but they are in shallower areas.

| Integrity | Occurrence | Percentage |
|---|---|---|
| **Complete** | 65 | 73,03% |
| **Incomplete** | 23 | 25,84% |
| **Siret** | 1 | 1,12% |
| **Total** | 89 | 100% |

**Table 26 - Table of flakes by integrity classification – Site 334 Inferior**

Three-quarters of the flakes were found to be complete and one-quarter incomplete. There was just one piece classified as siret, that is, a false burin flake.

| Number of Scars at Dorsal Face | Occurrence | Percentage |
|---|---|---|
| Absent | 7 | 8,14% |
| 1 | 22 | 25,58% |
| 2 | 30 | 34,88% |
| 3 | 13 | 15,12% |
| 4 | 8 | 9,30% |
| 5 | 3 | 3,49% |
| 6 | 2 | 2,32% |
| 7 Negatives | 1 | 1,16% |
| Total | 86 | 100% |

**Table 27 - Number of scars at the dorsal surface of flakes – Site 334 Inferior**

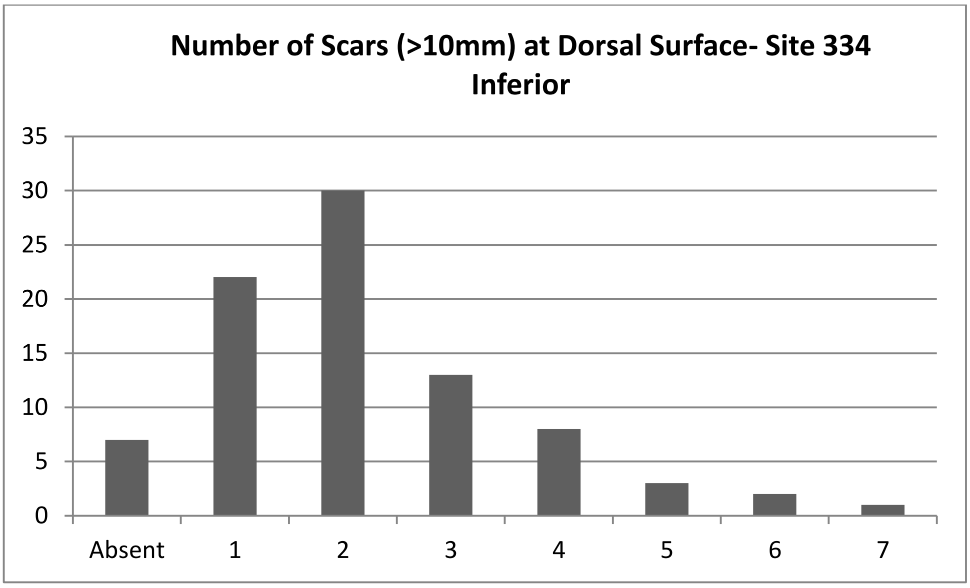


**Figure 46 - Number of scars at the dorsal surface of flakes – Site 334 Inferior**

More than a half of the artifacts present between 1 and 3 detachments at dorsal surface.

| Number of Negative Bulbs | Occurrence | Percentage |
|---|---|---|
| 1 | 4 | 13,78% |
| 2 | 5 | 17,24% |
| 3 | 4 | 13,78% |
| 4 | 4 | 13,78% |
| 5 | 5 | 17,24% |
| 6 | 5 | 17,24% |
| 7 | 1 | 3,45% |
| 8 | 1 | 3,45% |
| 9 | 0 | 0% |
| 10 | 0 | 0% |
| 11 | 0 | 0% |
| Total | 29 | 100% |

**Table 28 - Frequencies of core tools by number of negative bulbs – Site 334 Inferior**

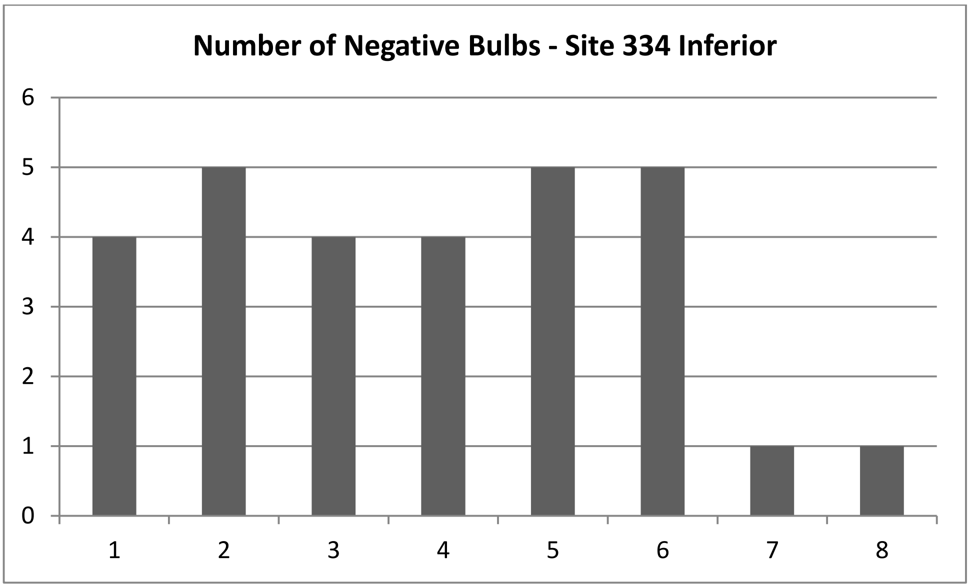


**Figure 47 - Frequencies of core tools by number of negative bulbs in absolute number – Site 334 Inferior**

There is an almost equal distribution between 1 and 6 negative bulbs in the artifacts of site 334 Inferior. More samples are needed to detect any more significant variations in detachments.

| Fiche Typologie Africaine | Occurrence | Percentage |
|---|---|---|
| I-1 | 1 | 20% |
| I -3 | 1 | 20% |
| I-4 | 1 | 20% |
| II – 11 | 1 | 20% |
| III-8 | 1 | 20% |
| III-1 | 0 | 0% |
| II-8 | 0 | 0% |
| II-4 | 0 | 0% |
| Total | 5 | 100% |

**Table 29 - Fiche Typologie Africaine – Site 334 Inferior**

It is important to highlight that only 5 artifacts were classified within this class and each one of them was from one category.

| Cortical Coverage of Core Tools | Occurrence | Percentage | Cortex |
|---|---|---|---|
| 2C | 19 | 61,3% | 2C – Covered in more than half |
| 3C | 12 | 38,7% | 3C – Covered in less than half |
| Total | 31 | 100% | |

**Table 30 - Frequency of core tools by cortical coverage - Site 334 Inferior**

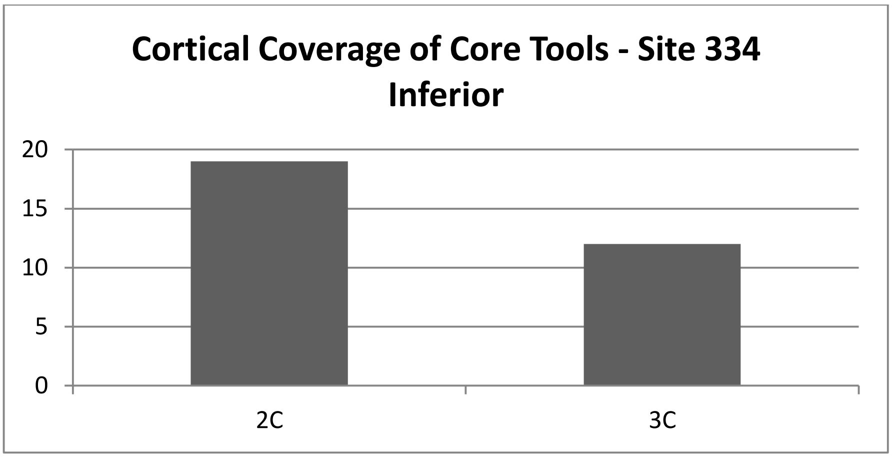


**Figure 48 - Frequency of core tools by cortical coverage in absolute numbers– Site 334 Inferior**

When looking at Core Tools it is possible to see that more than a half is 2C, but when looking at the flakes, the most part is constituted by 3C.

| Cortical Coverage of Flakes | Occurrence | Percentage | Cortex |
|---|---|---|---|
| 1C | 4 | 4,5% | 1C – Completely Cortical Flake |
| 2C | 8 | 8,9% | 2C – Covered in more than half |
| 3C | 52 | 58,4% | 3C – Covered in less than half |
| 4C | 25 | 28% | 4C – No Cortex |
| Total | 89 | 100% | |

**Table 31 - Frequency of flakes by cortical coverage– Site 334 Inferior**

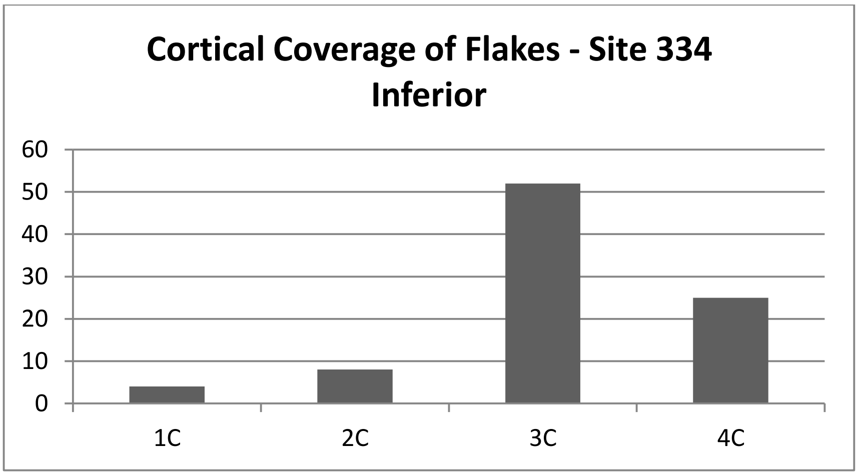


**Figure 49 - Frequency of flakes by cortical coverage in absolute numbers - Site 334 Inferior**

| Material | Occurrence | Percentage |
|---|---|---|
| Limestone | 3 | 2,50% |
| S. Limestone | 1 | 0,83% |
| Flint | 116 | 96,70% |
| Total | 120 | 100% |

**Table 32 - Frequency of raw materials – Site 334 Inferior**

The artifacts of the 334 Inferior have a greater diversity of material, a diversity that is not seen at Site 330.

| Striking Platform | Occurrence | Percentage | Legend |
|---|---|---|---|
| 1T | 13 | 14,44% | 1T – Cortical Striking Platform |
| 2T | 59 | 65,55% | 2T – Flat Strike Platform |
| 3T | 2 | 2,22% | 3T – Dihedral Striking Platform |
| 4T | 3 | 3,33% | 4T – Faceted Striking Platform |
| 5T | 0 | 0% | 5T – Linear Striking Platform |
| 6T | 0 | 0% | 6T - Punctiform Striking Platform |
| 7T | 13 | 14,44% | 7T – Absent Striking Platform |
| Total | 90 | 100% | |

**Table 33 - Distribution of flakes by type of striking platform – Site 334 Inferior**

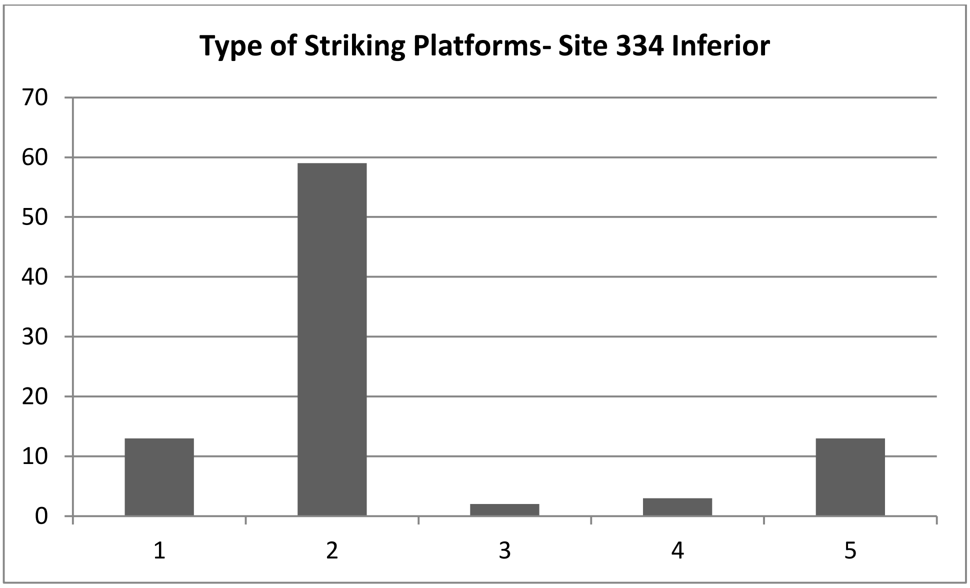


**Figure 50 - Distribution of flakes by type of striking platform in absolute number – Site 334 Inferior**

Most artifacts show flat striking platforms, usually characteristic of earlier stage of reductions or simple lithic industries.

| Detachment Angle of Flakes | Occurrence | Percentage |
|---|---|---|
| 90° - 100° | 19 | 21,35% |
| 100° - 110° | 30 | 33,70% |
| 110° - 120° | 31 | 34,83% |
| 120° - 130° | 9 | 10,11% |
| 130° - 140° | 0 | 0% |
| 140 °- 150° | 0 | 0% |
| Opposed | 0 | 0% |
| Total | 89 | 100% |

**Table 34 - Detachment angles of flakes – Site 334 Inferior**

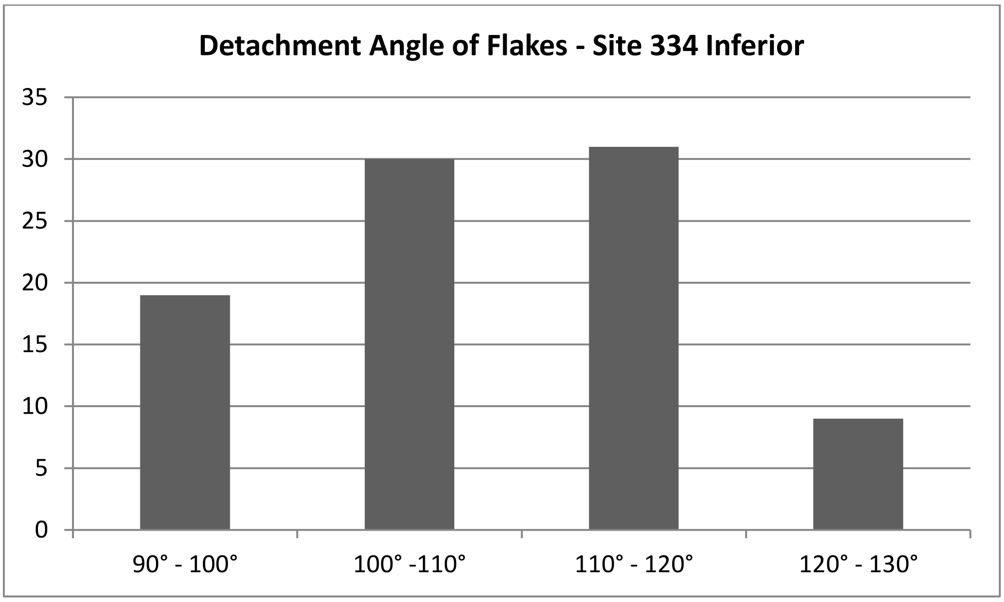


**Figure 51 - Distribution of artifacts by number of detachment angle in absolute number – Site 334 Inferior**

The artifacts have obtuse angles (>90º), and 80% are between 90º and 120º.

| | |
|---|---|
| Mean | 56,35 |
| Standard Deviation | 19,05107 |
| Sum | 4959mm |
| Minimum | 24mm |
| Maximum | 110mm |
| Range | 86mm |
| Median | 52,5mm |

**Table 35 - Descriptive analysis of maximum length of flakes – Site 334 Inferior**

The table show the median maximum length for flakes at around 56.35 millimeters, with a standard deviation of 19 millimeters and a range of 86 millimeters for flakes, showing a relatively small flake industry.

| | |
|---|---|
| Sum | 3005mm |
| Mean | 93,90625 |
| Min | 38mm |
| Max | 190mm |
| Range | 152mm |
| Standard Deviation | 41,81245 |
| Median | 82mm |

**Table 36 - Descriptive analysis of maximum length of core tools– Site 334 Inferior**

Core tools have a median maximum length at around 82 millimeters, with a standard deviation of 41 millimeters and a range of 152 millimeters, considerably larger than the flakes.

| Maximum Length of Flakes | Occurrence | Percentage |
|---|---|---|
| <10mm | 0 | 0 |
| 10-30mm | 5 | 5,6 |
| 30-50mm | 31 | 34,8 |
| 50-70mm | 29 | 32,6 |
| 70-90mm | 17 | 19,1 |
| 90-110mm | 6 | 6,7 |
| 110-130mm | 0 | 0 |
| 130-150mm | 0 | 0 |
| 150-170mm | 0 | 0 |
| 170-190mm | 1 | 1,1 |
| Total | 89 | 100% |

**Table 37 - Frequency of core tools by maximum length– Site 334 Inferior**

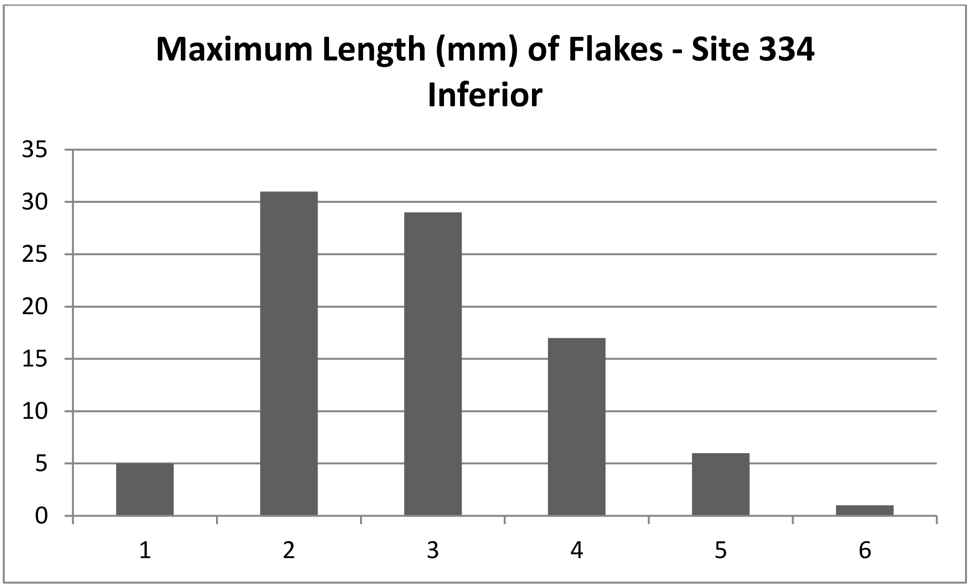


**Figure 52 - Frequency of flakes by maximum length in absolute numbers– Site 334 Inferior**

As shown, most flakes are under the 3 to 7 centimeters line with a few bigger ones. It's worth noting that the sediment in the Dauqara formation is coarse and usually filled with pebbles, which would make the process of identification of smaller flakes somewhat less likely.

| Maximum Length of Core Tools | Occurrence | Percentage |
|---|---|---|
| <10mm | 0 | 0 |
| 10-30mm | 0 | 0 |
| 30-50mm | 3 | 9,7 |
| 50-70mm | 9 | 29 |
| 70-90mm | 9 | 29 |
| 90-110mm | 2 | 6,4 |
| 110-130mm | 2 | 6,4 |
| 130-150mm | 1 | 3,2 |
| 150-170mm | 4 | 12,9 |
| 170-190mm | 1 | 3,2 |
| Total | 31 | 100% |

**Table 38 - Frequency of core tools by maximum length– Site 334 Inferior**

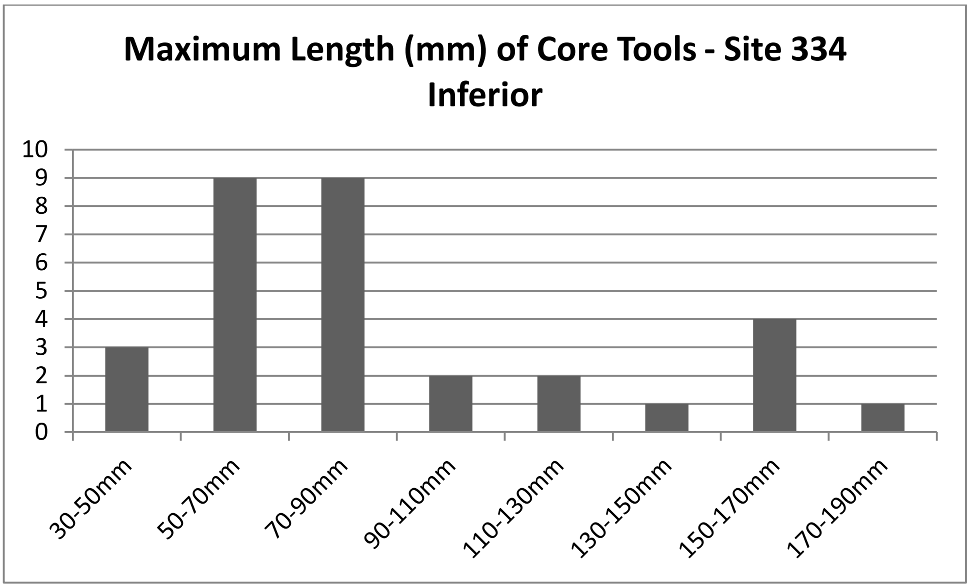


**Figure 53 - Frequency of core tools by maximum length in absolute numbers– Site 334 Inferior**

Core tools, the artifacts with negatives and no striking platform, are in average of a small size, only slightly bigger than the flakes. The range of 5 to 9 centimeters makes up most of the cores while the 15 to 17 centimeters range encompasses most of the choppers.

| Type of Core Tools | Occurrence | Percentage |
|---|---|---|
| Bipolar | 2 | 6,7 |
| Unipolar | 8 | 26,7 |
| Bidirectional | 1 | 3,3 |
| Orthogonal | 7 | 23,3 |
| Centripetal | 1 | 3,3 |
| Chopper | 6 | 20 |
| Globular | 1 | 3,3 |
| Core Fragment | 1 | 3,3 |
| Opposites and Parallels | 1 | 3,3 |
| Polyhedral | 1 | 3,3 |
| Undetermined | 1 | 3,3 |
| Total | 30 | 100% |

**Table 39 - Frequencies of core tools by Type categories – Site 330**

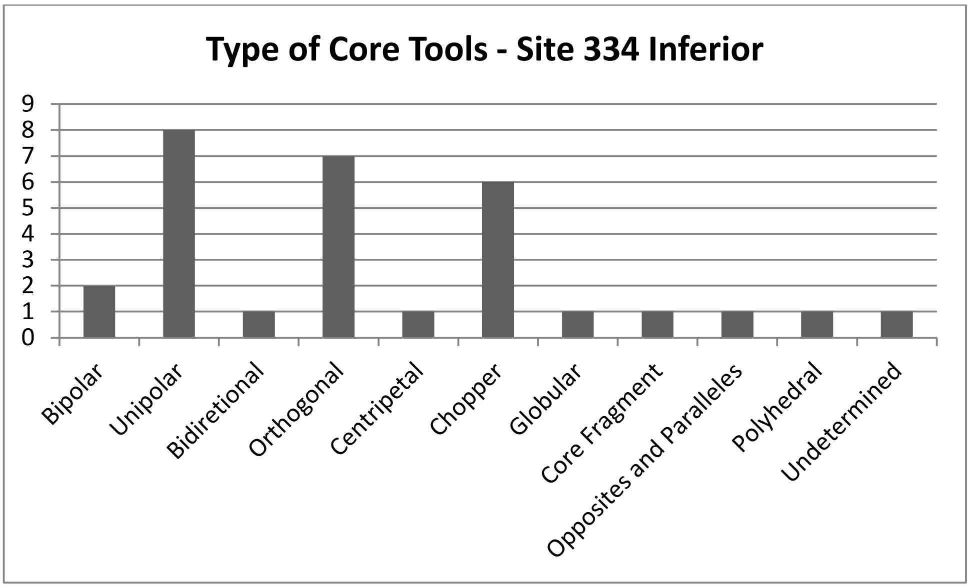


**Figure 54 – Frequencies of core tools by Type categories in absolute numbers– Site 330**

At Site 334 Inferior, there is a predominance of unipolar cores, choppers and orthogonal cores, with others kinds of cores, but in lower quantity.

## Site 334 Superior

Site 334 superior has considerably less materials. The section is a few meters above 334 inferior but despite that it can relate to a radically different time frame than site 334 inferior. Unfortunately, the lack of artifacts makes the process of statistically analyzing this site harder.

| Class | Occurrence | Percentage |
|---|---|---|
| Core | 3 | 40% |
| Flakes | 9 | 60% |
| Total | 12 | 100% |

**Table 40 - Frequencies of artifacts by class categories – Site 334 Superior**

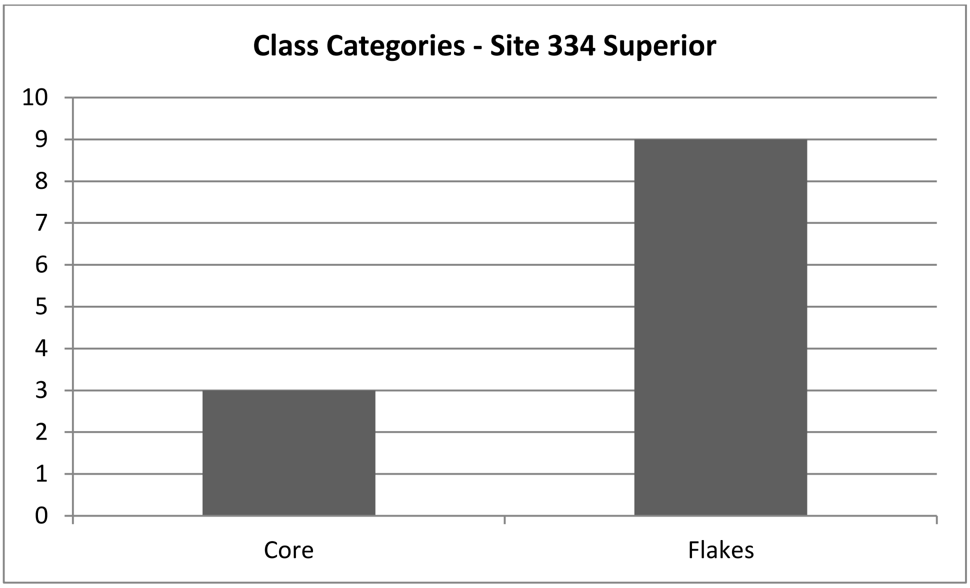


**Figure 55 - Distribution of artifacts by class categories in absolute number – Site 334 Superior**

Even if the sample for 334 Superior is significantly smaller than the other sections, flakes are still the overwhelming majority.

| **Type** | **Occurrence** | **Percentage** | **Legend** |
|---|---|---|---|
| S1 | 0 | 0% | S1 – Completely Cortical with Cortical Striking Platform |
| S2 | 3 | 33,33% | S2 – Partial Cortex and Cortical Striking Platform |
| S3 | 1 | 11,11% | S3 – No Cortex and Cortical Striking Platform |
| S4 | 0 | 0% | S4 – Completely Cortical and Flat Striking Platform |
| S5 | 3 | 33,33% | S5 – Partial Cortex and Flat Striking Platform |
| S6 | 2 | 22,22% | S6 – No Cortex and Flat Striking Platform |
| Total | 9 | 100% | |

**Table 41 - Frequencies of flakes by type – Site 334 Superior**

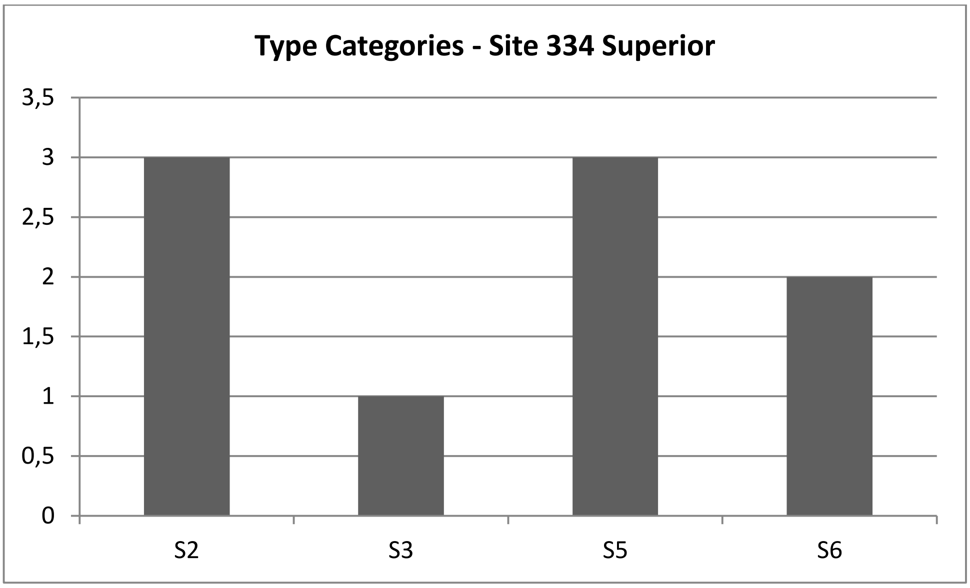


**Figure 56 - Distribution of flakes by type categories in absolute numbers – Site 334 Superior**

One-third is S2 Partial Cortex and Cortical Striking Platform and one-third is S5, which means that have Partial Cortex and Flat Striking Platform.

| Integrity | Occurrence | Percentage |
|---|---|---|
| Complete | 7 | 77,77% |
| Incomplete | 2 | 22,22% |
| Total | 9 | 100% |

**Table 42 - Frequencies of integrity categories – Site 334 Superior**

Almost 80% of pieces were complete, but unfortunately this doesn't say much about the site *per se* considering the low number of artifacts.

| Number of Scars at the Dorsal Surface | Occurrence | Percentage |
|---|---|---|
| No Dorsal Surface | 1 | 11,11% |
| 1 | 3 | 33,33% |
| 2 | 3 | 33,33% |
| 3 | 1 | 11,11% |
| 4 | 0 | 0% |
| 5 | 1 | 11,11% |
| 6 | 0 | 0% |
| 7 | 0 | 0% |
| Total | 9 | 100% |

**Table 43 – Frequencies of flakes by number of scars in the dorsal surface – Site 334 Superior**

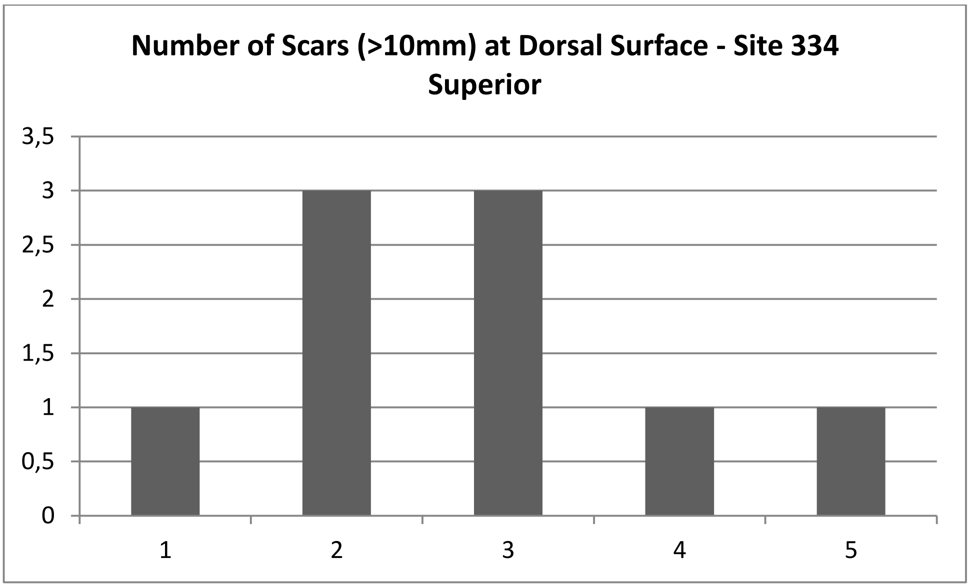


**Figure 57 - Distribution of flakes by number of scars in the dorsal surface in absolute numbers – Site 334 Superior**

The majority is between 1 and 2 detachments, but there is a significant quantity with none, 3 or 5 detachments.

| Number of Negative Bulbs | Occurrence | Percentage |
|---|---|---|
| 1 | 2 | 66,66% |
| 2 | 0 | 0% |
| 3 | 1 | 33,33% |
| 4 | 0 | 0% |
| Total | 3 | 100% |

**Table 44 – Frequencies of Core Tools by number of negative bulbs – Site 334 Superior**

Giving the size of the sample, only 3 artifacts were categorized within the number of negative bulbs.  There were 2 pieces with 1 negative bulb and 1 piece with 3 negative bulbs.

| Weight(g) | Occurrence | Percentage |
|---|---|---|
| <10 | 0 | 0% |
| 10 - 20 | 4 | 44,44% |
| 20-30 | 1 | 2,27% |
| 50-60 | 1 | 2,27% |
| 110-120 | 1 | 2,27% |
| 170-180 | 1 | 2,27% |
| 200-210 | 1 | 2,27% |
| Total | 9 | 100% |

**Table 45 - Frequencies of flakes by weight – Site 334 Superior**

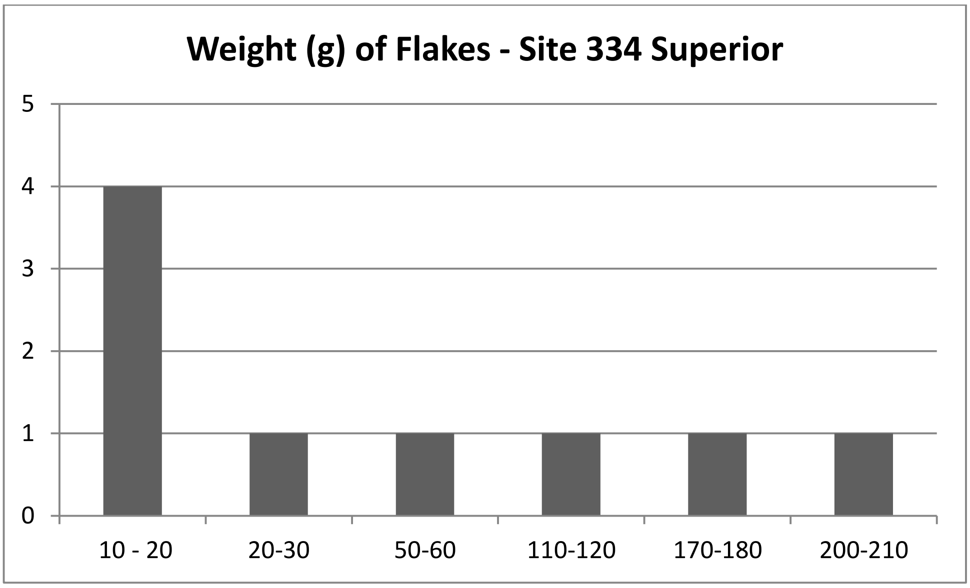


**Figure 58 - Distribution of flakes by weight in absolute numbers – Site 334 Superior**

| | |
|---|---|
| Mean | 71 grams |
| Standard Deviation | 72,53 grams |
| Sum | 639g |
| Minimum | 11 grams |
| Maximum | 210 grams |
| Coefficient of Variation | 1.021 |
| Range | 199 grams |
| Median | 22 grams |

**Table 46 - Descriptive analysis of the weight of flakes – Site 334 Superior**


**Figure 59 - Boxplot graph of weight of flakes– Site 334 Superior**

The Site 334 Superior has most part of the artifacts under 300 grams. Its mean is 135 grams, with a standard deviation of 134 grams. But about its distribution according to its depth, it's dispersed without a visual pattern.

| Fiche Typologie Africaine | Occurrence |
|---|---|
| I-1 | 0 |
| II-4 | 0 |
| III-1 | 0 |
| II-8 | 0 |
| I -3 | 0 |
| I-4 | 1 |
| II - 11 | 0 |
| III-8 | 0 |
| Total | 1 |

**Table 47 - Frequency of artifacts by FTA – Site 334 Superior**

| Cortical Coverage of Flakes | Occurrence | Percentage | Cortex |
|---|---|---|---|
| 3C | 6 | 66,7 | 1C – Completely Cortical Flake |
| 4C | 3 | 33,3 | 2C – Covered in more than half |
| Total | 9 | 100% | 3C – Covered in less than half |

**Table 48 - Frequency of flakes by cortical coverage - Site 334 Superior**

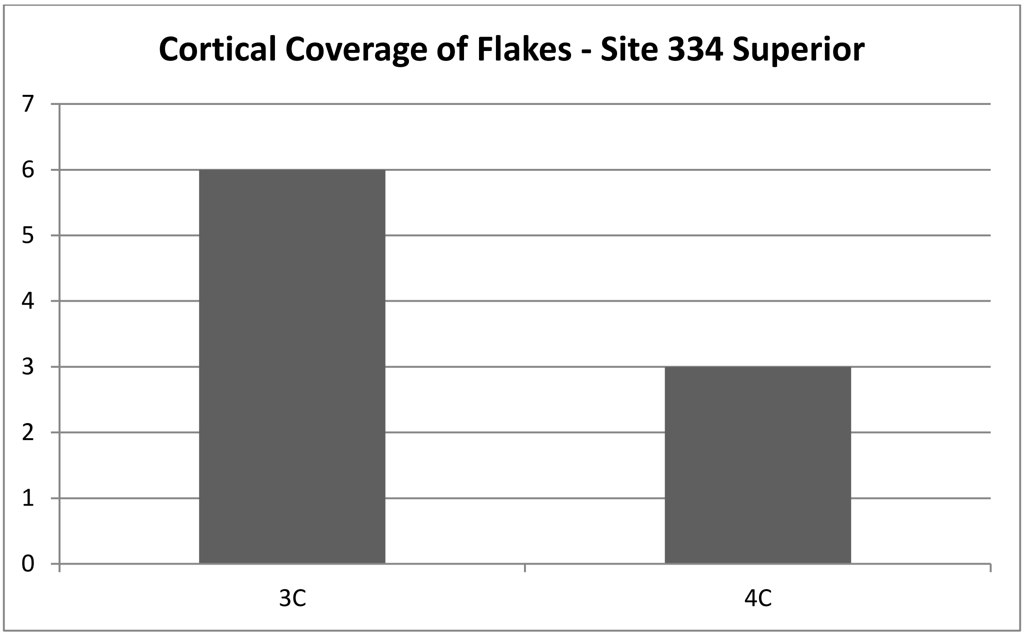


**Figure 60 – Frequency of flakes by cortical coverage - Site 334 Superior**

The few flakes observed are not completely cortical, having less than 50% of cortex.

| Cortical Coverage of Core Tools | Occurrence | Percentage | Legend |
|---|---|---|---|
| 2C | 3 | 100% | 2C – Covered in more than half |

**Table 49 - Frequency of core tools by cortical coverage - Site 334 Superior**

The core tools are exclusively more than 50% covered on cortex.

| Striking Platform | Occurrence | Percentage | Legend |
|---|---|---|---|
| 1T | 4 | 44,44% | 1T – Cortical Striking Platform |
| 2T | 4 | 44,44% | 2T – Flat Strike Platform |
| 3T | 0 | 0% | 3T – Dihedral Striking Platform |
| 4T | 0 | 0% | 4T – Faceted Striking Platform |
| 5T | 0 | 0% | 5T – Linear Striking Platform |
| 6T | 0 | 0% | 6T - Punctiform Striking Platform |
| 7T | 1 | 11,11% | 7T – Absent Striking Platform |
| Total | 9 | 100% | |

**Table 50 - Frequency of flakes by number of striking platform – Site 334 Superior**

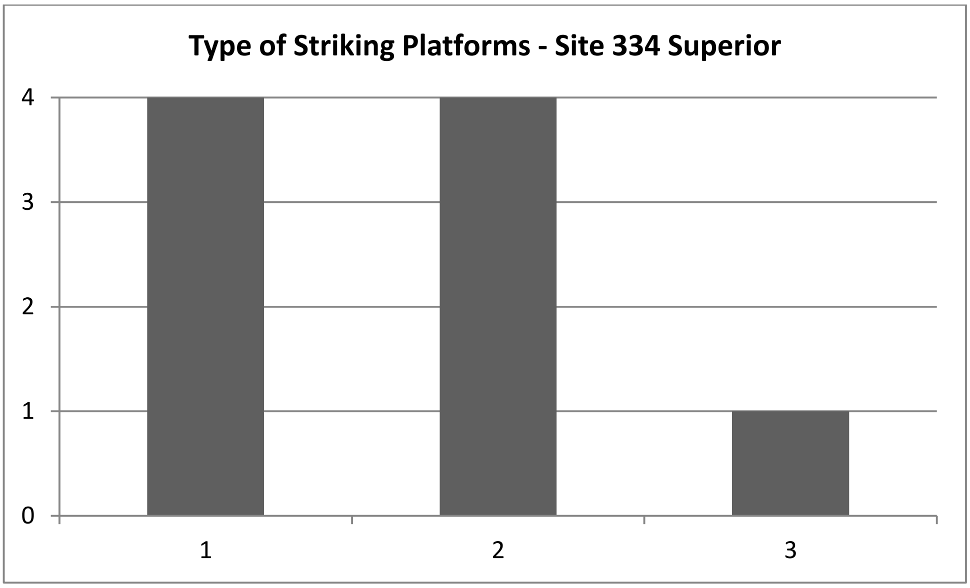


**Figure 61 - Distribution of flakes by number of striking platforms in absolute number platform – Site 334 Superior**

There are 4 pieces with cortical striking platform, and 4 pieces with flat striking platform that together make more than 80% of the sample, hinting to crude lithic tools or an early reduction stage.

| Detachment Angle | Occurrence | Percentage |
|---|---|---|
| 90° - 100° | 1 | 14,28% |
| 100° - 110° | 4 | 57,14% |
| 110° - 120° | 2 | 28,57% |
| 120° - 130° | 0 | 0% |
| 130°- 140° | 0 | 0% |
| 140° - 150° | 0 | 0% |
| Opposed | 0 | 0% |
| Total | 7 | 100% |

**Table 51 - Frequency of artifacts by detachment angle – Site 334 Superior**

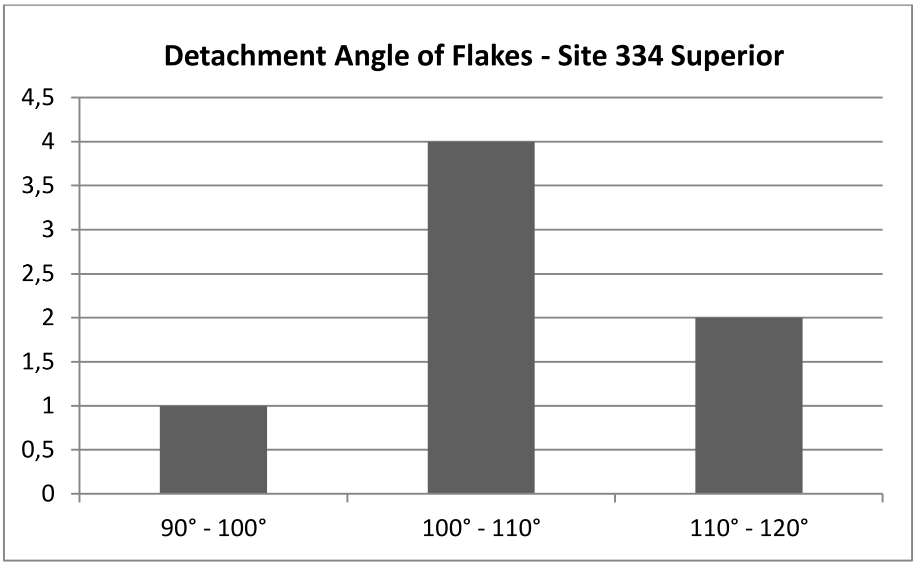


**Figure 62 - Distribution of artifacts by detachment angle in absolute number – Site 334 Superior**

All pieces have obtuse angles (>90º), with its majority between 100º and 110º.

| | |
|---|---|
| Mean | 59.95mm |
| Standard Deviation | 19.57 mm |
| Minimum | 40 mm |
| Maximum | 87.83 mm |
| Coefficient of Variation | 0.3264 |
| Range | 47.83 mm |
| Sum | 539.58mm |
| Median | 49 mm |

**Table 52 - Descriptive analysis of maximum length of flakes – Site 334 Superior**

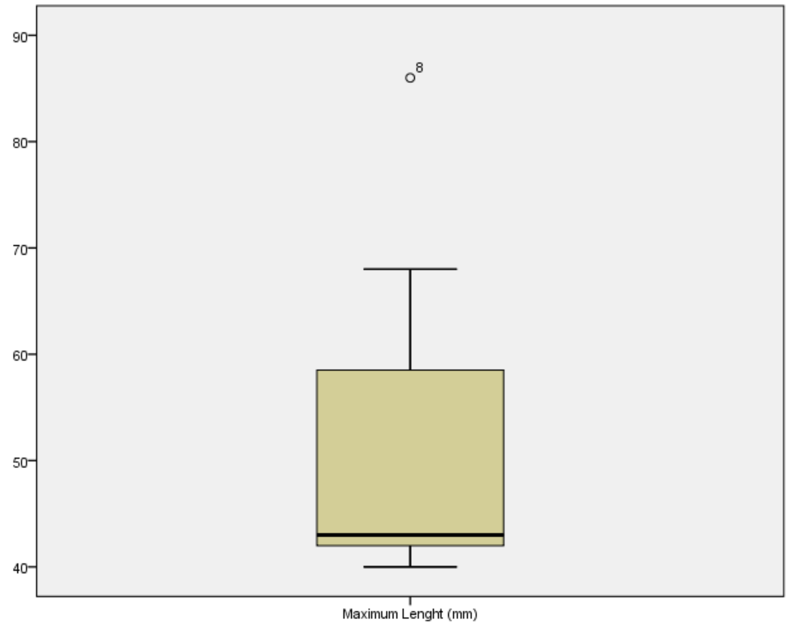


**Figure 63 - Boxplot graph of flakes maximum length of flakes – Site 334 Superior**

The boxplot and descriptive analysis show that the maximum length of the flakes from Site 334 Superior have a mean of 59.9 millimeters, with a standard deviation of 19.57 millimeters and a range of 47.83 millimeters.

| Maximum Length of Flakes | Occurrence | Percentage |
|---|---|---|
| <10mm | 0 | 0% |
| 10-30mm | 0 | 0% |
| 30-50mm | 5 | 55,5% |
| 50-70mm | 1 | 11,1% |
| 70-90mm | 3 | 33,3% |
| 90-110mm | 0 | 0% |
| 110-130mm | 0 | 0% |
| 130-150mm | 0 | 0% |
| 150-170mm | 0 | 0% |
| 170-190mm | 0 | 0% |
| Total | 9 | 100% |

**Table 53 - Frequencies of flakes by maximum length – Site 334 Superior**

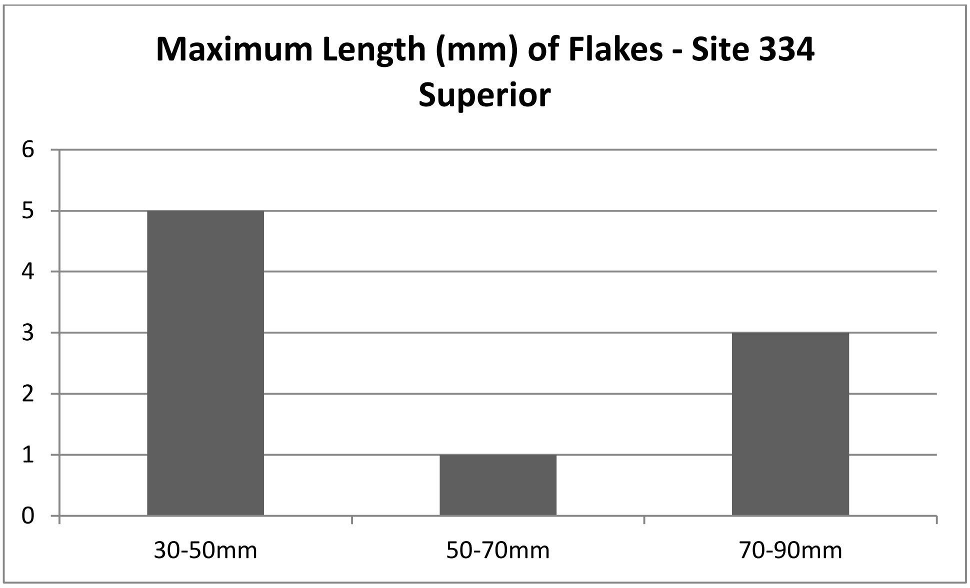


**Figure 64 - Maximum length of flakes by absolute numbers – Site 334 Superior**

Flakes are predominantly in the range of 3 to 5 centimeters in maximum length, though a few are also on the 7 to 9 centimeters range.

| Maximum length of core tools | Occurrence | Percentage |
|---|---|---|
| <10mm | 0 | 0% |
| 10-30mm | 0 | 0% |
| 30-50mm | 0 | 0% |
| 50-70mm | 0 | 0% |
| 70-90mm | 1 | 33,3% |
| 90-110mm | 0 | 0% |
| 110-130mm | 2 | 66,7% |
| 130-150mm | 0 | 0% |
| 150-170mm | 0 | 0% |
| 170-190mm | 0 | 0% |
| Total | 3 | 100% |

**Table 54 - Maximum length of core tools – Site 334 Superior**

Core tools are on the range of 11 to 13 centimeters in maximum length, possibly because of the predominance of big choppers, which make up 66.7% of the findings in the section of 334 Superior.

| Type of Core | Occurrence | Percentage |
|---|---|---|
| Chopper | 2 | 66,7% |
| Unipolar | 1 | 33,3% |
| Total | 3 | 100% |

**Table 55 – Core tools by type – Site 334 Superior**

## Site Comparisons

It was made a simple frequency comparison between the sites with focus at the characteristics that were described below. It is necessary to keep in mind that site 334 superior sample is smaller and therefore, the results might not be ideal for a comparison with site 330 but can tell something about site 334 Inferior due to their fairly close proximity.

| Class | 330 | 334 Inferior | 334 Superior |
|---|---|---|---|
| Chopper | 2,09% | 0% | 0% |
| Core | 15,90% | 26,66% | 40% |
| Denticulate | 1,25% | 0% | 0% |
| Flake | 76,99% | 73,33% | 60% |
| Hammer | 0,84% | 0% | 0% |
| Scraper | 2,92% | 0% | 0% |
| Total | 100% | 100% | 100% |

**Table 56 - Comparison between the sites about class categories**

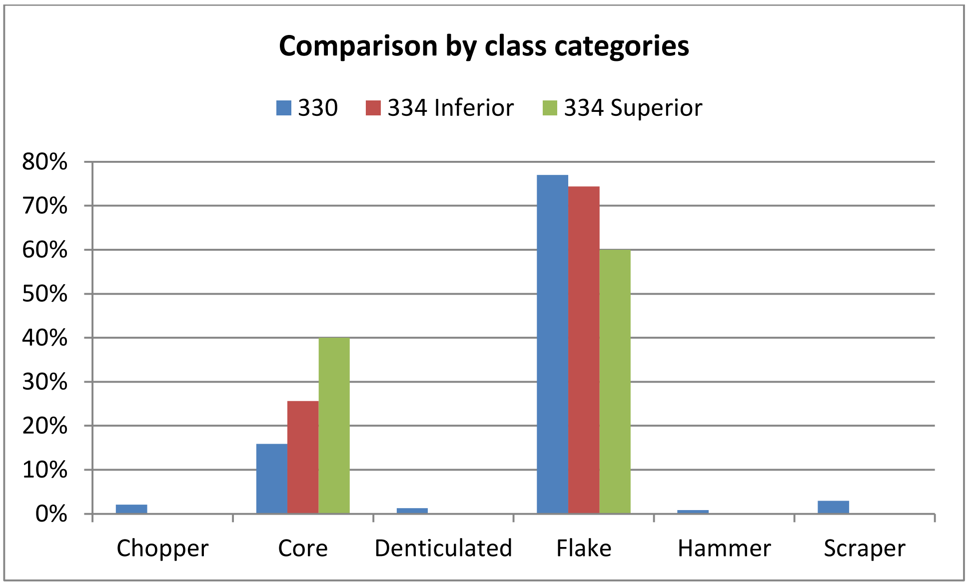


**Figure 65 - Comparison between the three sites by class categories**

As seen at the table and graph, the 330 site presents classes of artifacts that the others don't, such as choppers, denticulate, hammers and scrapers. It is also shown that proportionally, the 330 site has more flakes than the others, while at 334 Superior the difference between cores and flakes is smaller, likely due to the smaller sample size.

| Type | Site 330 | Site 334 Inferior | Site 334 Superior | Legend |
|---|---|---|---|---|
| S1 | 1,02% | 2,32% | 0% | S1 – Completely Cortical with Cortical Striking Platform |
| S2 | 15,31% | 9,30% | 33,33% | S2 – Partial Cortex and Cortical Striking Platform |
| S3 | 11,22% | 4,65% | 11,11% | S3 – No Cortex and Cortical Striking Platform |
| S4 | 0% | 2,32% | 0% | S4 – Completely Cortical and Flat Striking Platform |
| S5 | 43,87% | 52,32% | 33,33% | S5 – Partial Cortex and Flat Striking Platform |
| S6 | 28,57% | 29,07% | 22,22% | S6 – No Cortex and Flat Striking Platform |
| Total | 100% | 100% | 100% | |

**Table 57 - Comparison between the three sites by flake type categories**

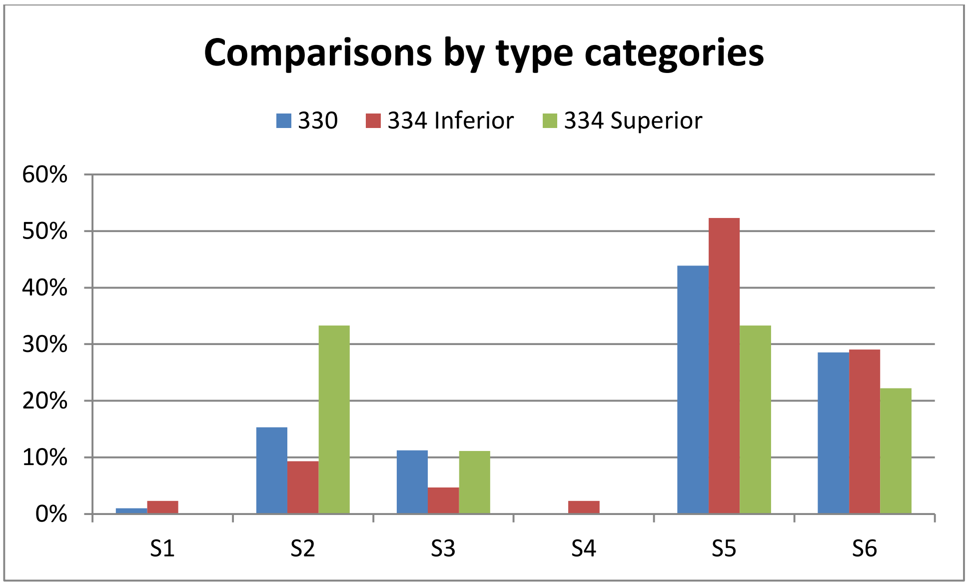


**Figure 66 - Comparison between three sites by type categories**

It is possible to see that the Site 334 Inferior has a more equal distribution between S2, S5 and S6, while the sites 330 and 334 Inferior have more of S5 and S6 artifacts, which means that they have more of Partial or No Cortex and Flat Striking Platform.

| Early PRB | | | | | |
|---|---|---|---|---|---|
| **Site 330** | | **334 Inferior** | | **334 Superior** | |
| Occurrence | % | Occurrence | % | Occurrence | % |
| 10 | 5,40% | 7 | 7,90% | 0 | 0% |
| **Middle PRB** | | | | | |
| **Site 330** | | **334 Inferior** | | **334 Superior** | |
| Occurrence | % | Occurrence | % | Occurrence | % |
| 49 | 26,63% | 15 | 17,04% | 0 | 0% |
| **Late Shatter** | | | | | |
| **Site 330** | | **334 Inferior** | | **334 Superior** | |
| Occurrence | % | Occurrence | % | Occurrence | % |
| 2 | 1,10% | 0 | 0% | 0 | 0% |
| **Late PRB** | | | | | |
| **Site 330** | | **334 Inferior** | | **334 Superior** | |
| Occurrence | % | Occurrence | % | Occurrence | % |
| 3 | 1,63% | 0 | 0% | 0 | 0% |

**Table 58 - Flake distribution by stage of biface reduction**

Using the criterion exposed on the "The Process of Qualitative Analysis" section and developed by Magne (Magne & Pokotylo, 1981), it was possible to establish the percentage of the flakes of all sites that are represent early, middle or late stages of reduction and possible also shatter debitage. It is possible to see that the proportions in

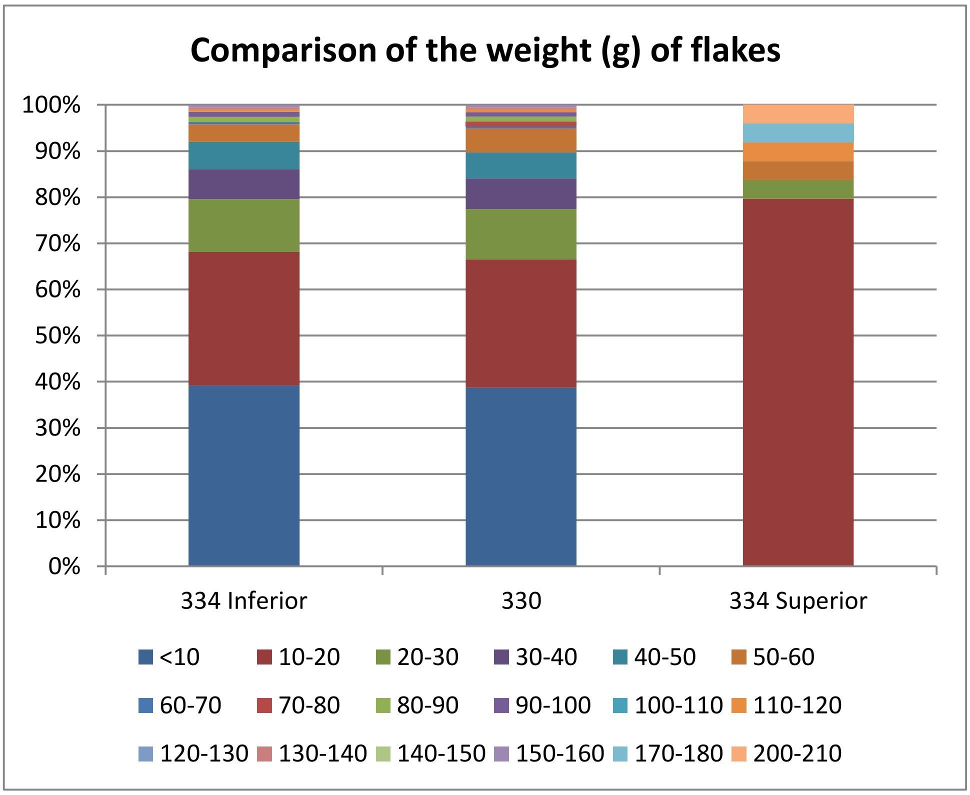


**Figure 67 - Comparison of flakes by weight in the three sites**

site 330 of middle stage debitage are bigger than site 334 inferior and that the later has a bigger proportion of early stage flakes than the former.

| Weight (g) | Site 334 Inferior | Site 330 | Site 334 Superior |
|---|---|---|---|
| <10 | 39,1% | 38,65% | 0% |
| 10-20 | 28,8% | 27,83% | 44,44% |
| 20-30 | 11,4% | 10,82% | 2,27% |
| 30-40 | 6,5% | 6,70% | 0% |
| 40-50 | 5,9% | 5,60% | 0% |
| 50-60 | 3,8% | 5,15% | 2,27% |
| 60-70 | 0,5% | 0,51% | 0% |
| 70-80 | 0% | 1,03% | 0% |
| 80-90 | 1,1% | 1,03% | 0% |
| 90-100 | 1,1% | 1,03% | 0% |
| 100-110 | 0% | 0% | 0% |
| 110-120 | 0,5% | 0,51% | 2,27% |
| 120-130 | 0% | 0% | 0% |
| 130-140 | 0,5% | 0,51% | 0% |
| 140-150 | 0% | 0% | 0% |
| 150-160 | 0,5 | 0,51% | 0% |
| 170-180 | 0% | 0% | 2,27% |
| 200-210 | 0% | 0% | 2,27% |
| Total | 100% | 100% | 100% |

**Table 59 - Comparison of flakes weight in the three sites**

Comparing the three sites, it is possible to see that most part of the flakes have their weight under 30 grams, especially under 10 grams, with the exception of 334 Superior.

The three sites have its majority of materials at under 10 grams. It’s possible to see that there are some artifacts over it but they are few and but none of them have flakes heavier than 210 grams.

| Weight (g) | Site 334 Inferior | Site 330 | Site 334 Superior |
|---|---|---|---|
| <100 | 24,30% | 20,45% | 0% |
| 100-200 | 27% | 25% | 0% |
| 200-300 | 18,90% | 22,72% | 33,33% |
| 300-400 | 13,50% | 11,36% | 33,33% |
| 400-500 | 5,40% | 6,81% | 33,33% |
| 500-600 | 5,40% | 6,81% | 0% |
| 1700-1800 | 2,90% | 4,54% | 0% |
| 2700-2800 | 2,90% | 2,27% | 0% |
| Total | 100% | 100% | 100% |

**Table 60 - Comparison of weight of core tools in the three sites**

The frequency of core tools under 200 grams is bigger at Site 330 and Site 334 Inferior. The Site 334 Superior has an equal distribution of one artefact by category between 200 and 500 grams.

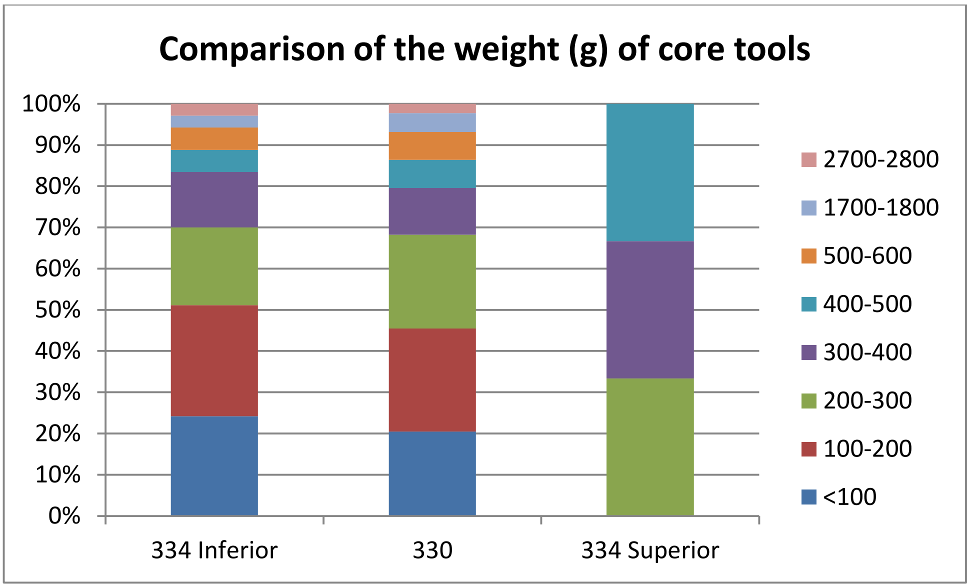


**Figure 68 - Comparison by weight of core tools**

The first 400 grams make the grand majority of the weight distribution in the 3 sites with pieces heavier than half a kilogram being the overwhelming minority.

| Number of Scars at the Dorsal Surface | Site 330 | Site 334 Inferior | Site 334 Superior |
|---|---|---|---|
| No Dorsal Surface | 6,60% | 8,14% | 11,11% |
| 1 | 21,98% | 25,58% | 33,33% |
| 2 | 26,92% | 34,88% | 33,33% |
| 3 | 19,23% | 15,12% | 11,11% |
| 4 | 12,09% | 9,30% | 0% |
| 5 | 4,94% | 3,49% | 11,11% |
| 6 | 7,14% | 2,32% | 0% |
| 7 | 1,10% | 1,16% | 0% |
| Total | 100% | 100% | 100% |

**Table 61 - Comparison by number of scars in the dorsal surface**

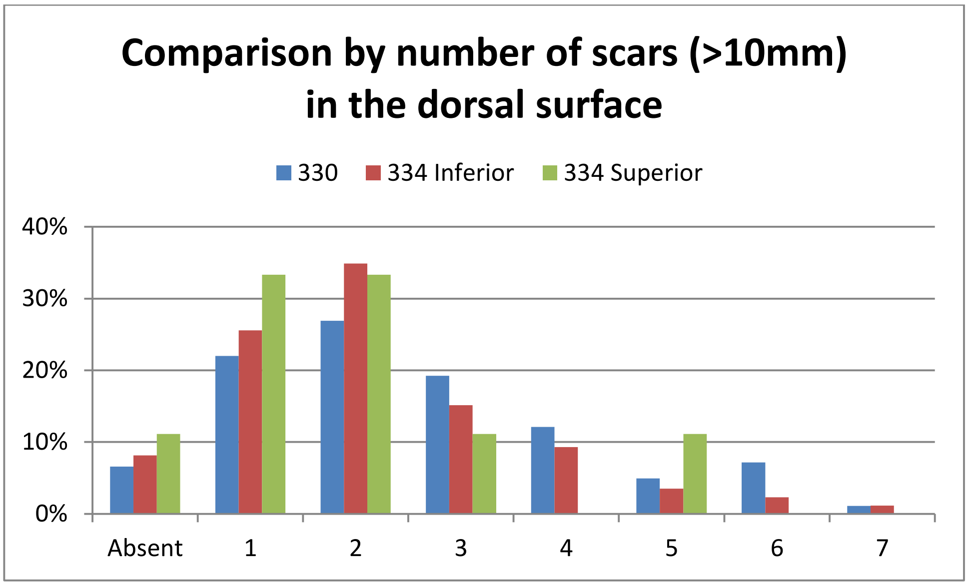


**Figure 69 - Comparison by number of scars in the dorsal surface**

The three sites have a progressive grow, reaching a peak at 2 negatives, but with its most part of artifacts presenting between one and three negatives. The three samples have a percentage between 5% and 10% of artifacts without negatives.

| Number of Negative Bulbs | Site 330 | Site 334 Inferior | Site 334 Superior |
|---|---|---|---|
| 1 | 11,36% | 13,78% | 66,66% |
| 2 | 13,64% | 17,24% | 0% |
| 3 | 15,90% | 13,78% | 33,33% |
| 4 | 15,90% | 13,78% | 0% |
| 5 | 2,27% | 17,24% | 0% |
| 6 | 9,09% | 17,24% | 0% |
| 7 | 4,54% | 3,45% | 0% |
| 8 | 13,64% | 3,45% | 0% |
| 9 | 4,54% | 0% | 0% |
| 10 | 4,54% | 0% | 0% |
| 11 | 4,54% | 0% | 0% |
| Total | 100% | 100% | 100% |

**Table 62 - Comparison by number of negative bulbs**

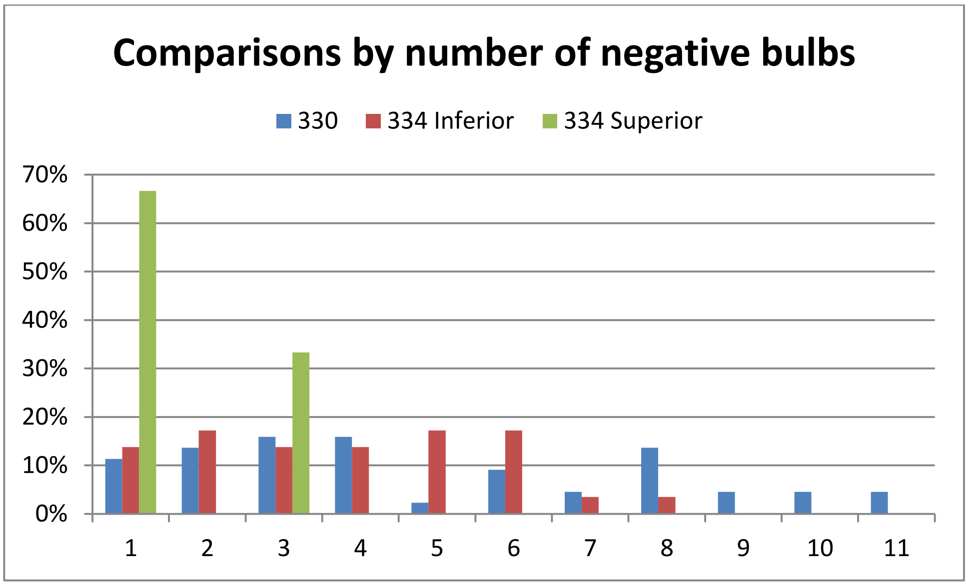


**Figure 70 - Comparison between three sites by number of negative bulbs**

At this chart is necessary to point out that the Site 334 Superior seems to have much more pieces with one negative bulb, but just proportionally, because of its small size of sample, only three artifacts were analyzed within this category. Site 330 and 334 Inferior have a frequency of almost 10% at all other categories.

| **Integrity** | **Site 330** | **Site 334 Inferior** | **Site 334 Superior** |
|---|---|---|---|
| Complete | 85,71% | 73,03% | 77,77% |
| Incomplete | 13,77% | 25,84% | 22,22% |
| Fragmented | 0,51% | 0% | 0% |
| Siret | 0% | 1,12% | 0% |
| Total | 100% | 100% | 100% |

**Table 63 - Comparison by integrity categories**

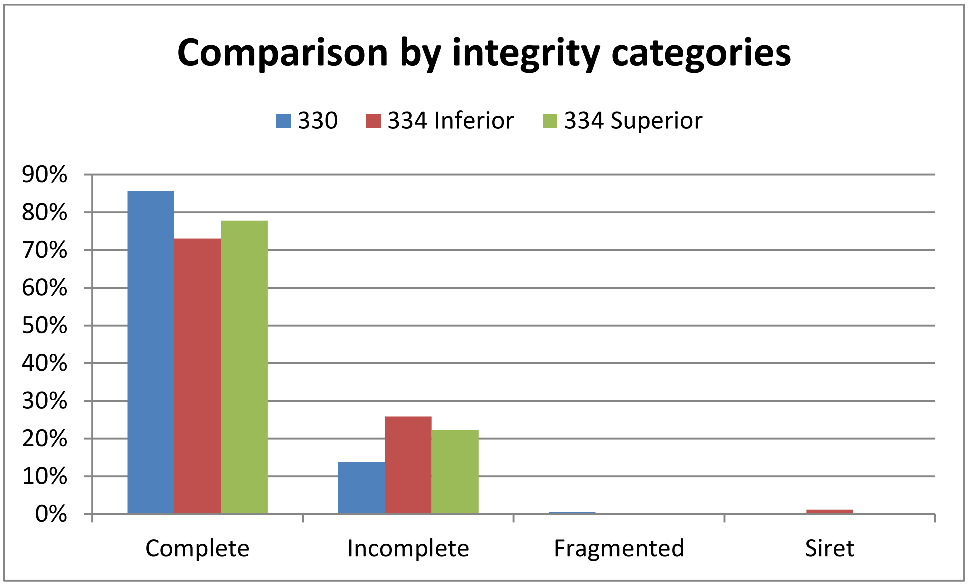


**Figure 71 - Comparison between three sites by integrity categories**

At the three sites different categories of integrity were used, because only the 330 Site had a fragmented piece, and the 334 Inferior had a siret one. Most part of the artifacts was complete, showing a good conservation, besides all taphonomic events they went through, as erosion.

| Fiche Typologie Africaine | Site 330 | Site 334 Inferior | Site 334 Superior |
|---|---|---|---|
| I-1 | 40% | 0% | 0% |
| II-4 | 20% | 0% | 0% |
| III-1 | 20% | 0% | 0% |
| II-8 | 20% | 0% | 0% |
| I -3 | 0% | 20% | 0% |
| I-4 | 0% | 20% | 100% |
| II – 11 | 0% | 20% | 0% |
| III-8 | 0% | 20% | 0% |
| Total | 100% | 100% | 100% |

**Table 64 - Comparison between three sites by Fiche Typologie Africaine**

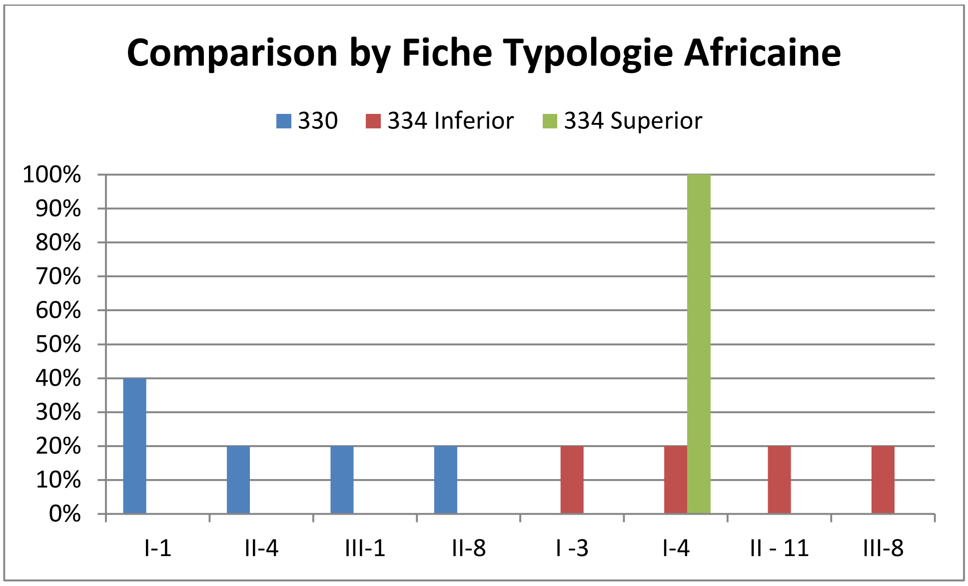


**Figure 72 - Comparison between three sites by Fiche Typologie Africaine**

At this characteristic is important to notice that for all the three sites just a small part of all samples was analyzed, since the presence of choppers, the only type this category applies to was very small. For Site 334 Superior, for example, there was just one artifact. For all sites a gamma of different categories appeared, and the categories don't repeat, with exception of I-4, for site 334 inferior and 334 superior.

| Striking Platform | Site 330 | Site 334 Inferior | Site 334 Superior |
|---|---|---|---|
| 1T | 27,55% | 14,44% | 44,44% |
| 2T | 52,04% | 65,55% | 44,44% |
| 3T | 3,57% | 2,22% | 0% |
| 4T | 2,04% | 3,33% | 0% |
| 5T | 3,57% | 0% | 0% |
| 6T | 1,53% | 0% | 0% |
| 7T | 9,69% | 14,44% | 11,11% |
| Total | 100% | 100% | 100% |

**Table 65 - Comparison by Striking Platform**

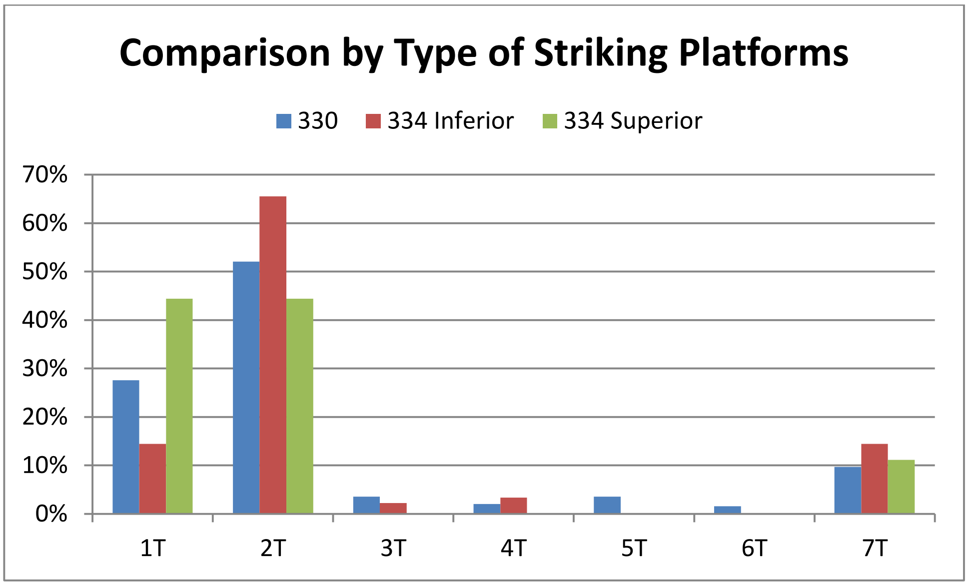


**Figure 73 - Comparison between three sites by number of striking platforms**

For all three sites it is possible to see a similar distribution, with a peak of flat striking platforms, a small but significant presence of missing striking platform around 10% for all three samples, with the biggest difference at the proportion of 1 cortical striking platform. The three sites have a significative 10% of artifacts with 7T.

| Detachment Angle | Site 330 | Site 334 Inferior | Site 334 Superior |
|---|---|---|---|
| 90° - 100° | 11,47% | 21,35% | 14,28% |
| 100° - 110° | 33,88% | 33,70% | 57,14% |
| 110° - 120° | 37,16% | 34,83% | 28,57% |
| 120° - 130° | 15,85% | 10,11% | 0% |
| 130° - 140° | 0,55% | 0% | 0% |
| 140° - 150° | 0,55% | 0% | 0% |
| Opposed | 0,55% | 0% | 0% |
| Total | 100% | 100% | 100% |

**Table 66 - Comparison by Detachment Angle**

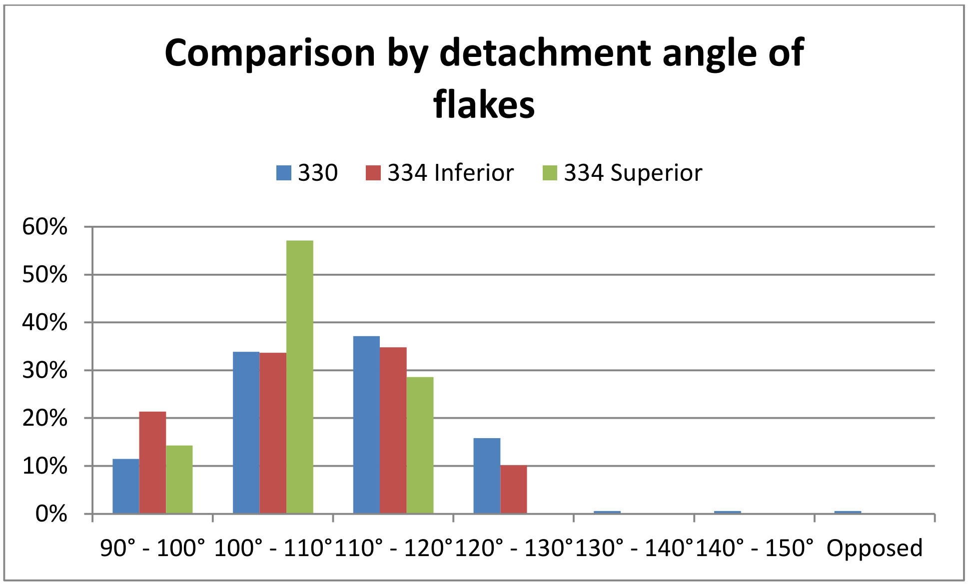


**Figure 74 – Flake comparison of the three sites by detachment angle**

As said before, all artifacts have obtuse angles which mean they are over 90º. Most of them are between 100º and 120º.

The three sites have most part of the artifacts with 2C, which means more than half covered. There is almost none without coverage. The table and graph below shows the frequency by flakes and cores.

| Cortical Coverage of Core Tools | Site 330 | Site 334 Inferior | Site 334 Superior |
|---|---|---|---|
| 2C | 56,8% | 61,3% | 100% |
| 3C | 40,5% | 38,7% | 0% |
| 4C | 2,7% | 0% | 0% |
| Total | 100% | 100% | 100% |

**Table 67 - Comparison of cortical coverage of core tools in the three sites**

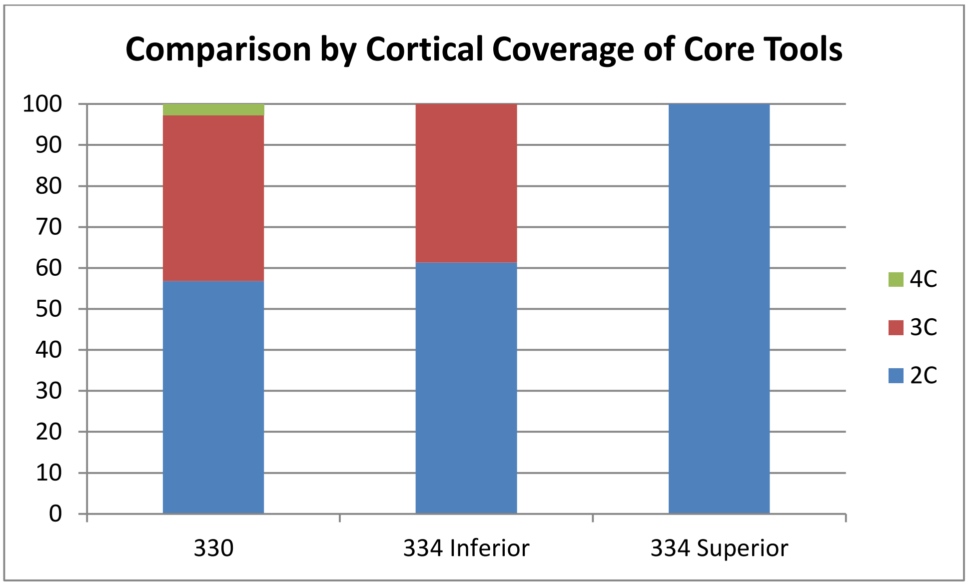


**Figure 75 – Comparison by cortical coverage of core tools**

| Cortical Coverage of Flakes | Site 330 | Site 334 Inferior | Site 334 Superior | Legend |
|---|---|---|---|---|
| 1C | 1% | 4,5% | 0% | 1C – Completely Cortical Flake |
| 2C | 9,8% | 8,9% | 0% | 2C – Covered in more than half |
| 3C | 60,3% | 58,4% | 66,7% | 3C – Covered in less than half |
| 4C | 28,8% | 28% | 33,3% | 4C – No Cortex |
| Total | 100% | 100% | 100% | |

**Table 68 - Comparison of cortical coverage of flakes in the three sites**

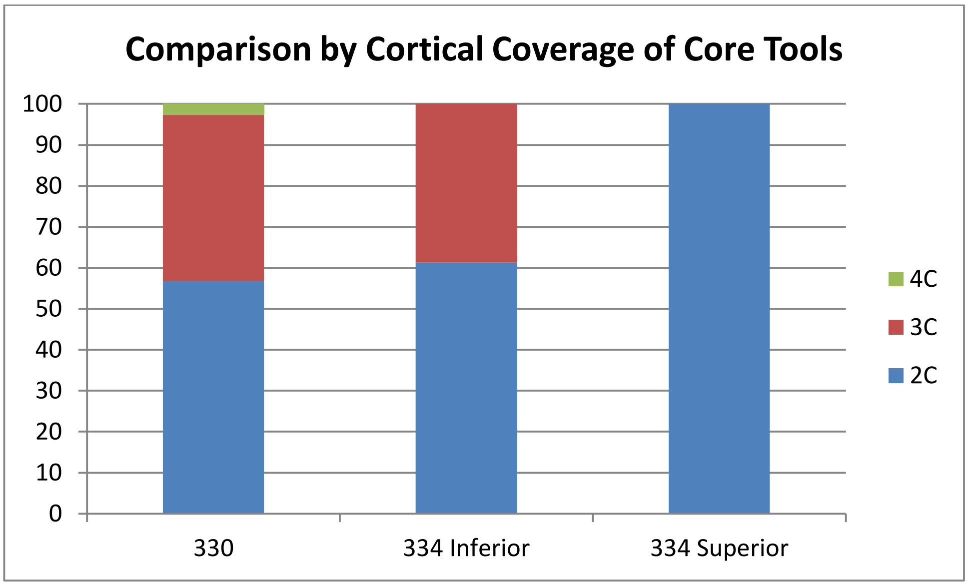


**Figure 76 - Comparison between the three sites by cortical coverage of flakes**

At the flakes sample what is seen is different of the core tools distribution. The comparison shows that the majority type of cortical coverage is 3C, which means covered in less than half. At the three sites most of flakes has half or none of the surface covered, while cores have more than a half covered.

| Type of Core Tools | Site 330 | Site 334 Inferior | Site 334 Superior |
|---|---|---|---|
| Bipolar | 8,3% | 6,7% | 0% |
| Unipolar | 19,4% | 26,7% | 33,3% |
| Bidirectional | 0% | 3,3% | 0% |
| Orthogonal | 38,9% | 23,3% | 0% |
| Centripetal | 2,7% | 3,3% | 0% |
| Chopper | 0% | 20% | 66,7% |
| Globular | 0% | 3,3% | 0% |
| Core Fragment | 0% | 3,3% | 0% |
| Opposites and Parallels | 0% | 3,3% | 0% |
| Polyhedral | 0% | 3,3% | 0% |
| Undetermined | 0% | 3,3% | 0% |
| Convergent | 5,5% | 0% | 0% |
| Opposite Flaking | 8,3% | 0% | 0% |
| Bipolar and Orthogonal | 16,6% | 0% | 0% |
| Total | 100% | 100% | 100% |

**Table 69 - Comparison of frequencies of core tools by type of core**

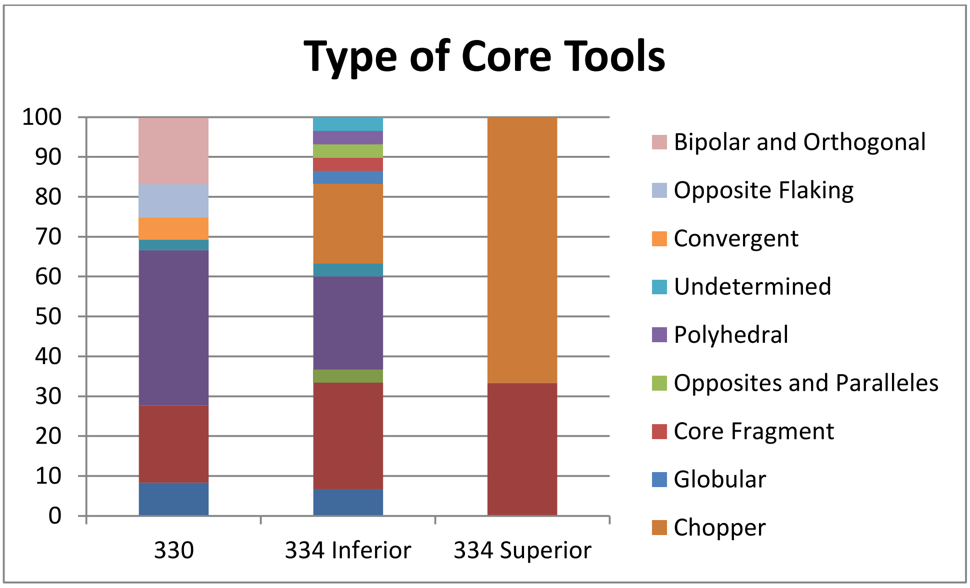


**Figure 77 - Comparison of types of core tools at the three sites**

The comparison between the three sites shows that the unipolar type is the one with greater representation in the three samples. Considering just Site 330 and Site 334

Inferior, with more robust samples, unipolar and orthogonal cores represent more than half of the cores.

| Maximum Length of Core tools | Site 330 | Site 334 Inferior | Site 334 Superior |
|---|---|---|---|
| <10mm | 0% | 0% | 0% |
| 10-30mm | 0% | 0% | 0% |
| 30-50mm | 20,6% | 9,7% | 0% |
| 50-70mm | 32,3% | 29% | 0% |
| 70-90mm | 26,5% | 29% | 33,3% |
| 90-110mm | 8,5% | 6,4% | 0% |
| 110-130mm | 5,8% | 6,4% | 66,7% |
| 130-150mm | 0% | 3,2% | 0% |
| 150-170mm | 5,8% | 12,9% | 0% |
| 170-190mm | 0% | 3,2% | 0% |
| Total | 100% | 100% | 100% |

**Table 70 - Comparison of frequencies of core tools by maximum length**

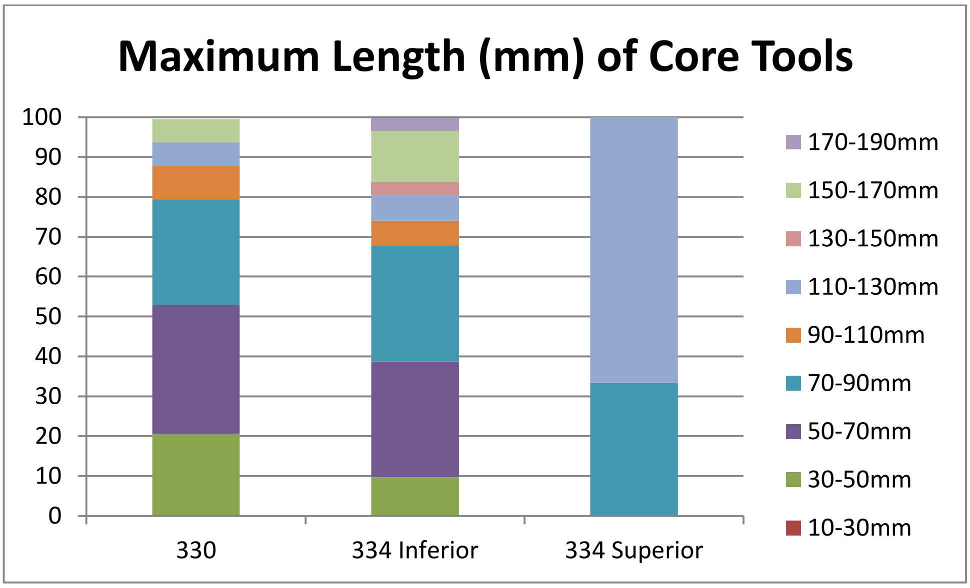


**Figure 78 - Comparison of frequencies of core tools by maximum length**

Looking at the cores separately, it is possible to see that most part of the samples are constituted by core tools with 70-90 millimeters length, and some cores with 50-70 millimeters. Site 334 Superior only has 3 core tools and two of them are in the 110-130 millimeters range. So core tools are overwhelmingly in the 9 to 5 centimeters range.

| Maximum Length of Flakes | Site 330 | Site 334 Inferior | Site 334 Superior |
|---|---|---|---|
| <10mm | 0% | 0% | 0% |
| 10-30mm | 19,6% | 5,6% | 0% |
| 30-50mm | 50,5% | 34,8% | 55,5% |
| 50-70mm | 23,4% | 32,6% | 11,1% |
| 70-90mm | 5,9% | 19,1% | 33,3% |
| 90-110mm | 0,5% | 6,7% | 0% |
| 110-130mm | 0% | 0% | 0% |
| 130-150mm | 0% | 0% | 0% |
| 150-170mm | 0% | 0% | 0% |
| 170-190mm | 0% | 1,1% | 0% |
| Total | 100% | 100% | 100% |

**Table 71 - Comparison of Frequencies of flakes by maximum length**

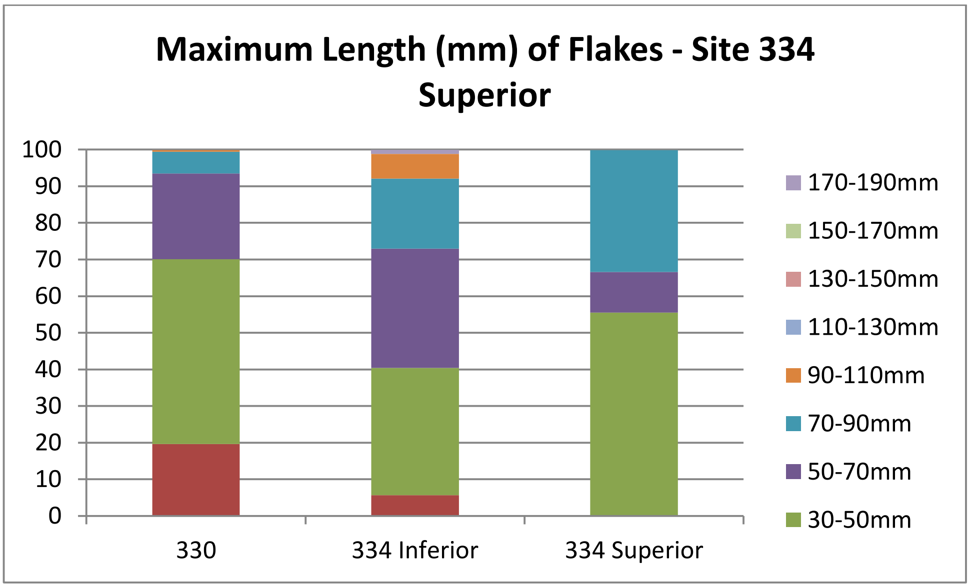


**Figure 79 - Comparison between the three sites by maximum length of flakes**

It is possible to see that the maximum lengths of flakes of most artifacts from the three sites are between 30 and 50 millimeters. The quantity of flakes with 50-70 millimeters and 70-90 millimeters are the ones that fluctuates the most.

| Raw Material | Site 330 | Site 334 Inferior | Site 334 Superior |
|---|---|---|---|
| Flint | 100% | 96,70% | 100% |
| Limestone | 0% | 2,50% | 0% |
| S. Limestone | 0% | 0,83% | 0% |
| Total | 100% | 100% | 100% |

**Table 72 - Comparison by material composition**

The predominant raw material found in of most sites is flint, but a few materials made out of silicified limestone were found. There's also the presence of a few limestone flakes, which are unusual for the relative abundance of flint in the area.

## Analysis of Variance

The first case to be described refers to variance analysis according to the weight of the flakes in the sample of each site. Subsequently it will be presented the same test with the weight of the cores of the three sites. At the table, sig means the significance of F-ratio.

| | Sum of Squares | df | Mean Square | Z | Sig. |
|---|---|---|---|---|---|
| **Between Groups** | 46282,046 | 2 | 23141,023 | 18,884 | ,000 |
| **Within Groups** | 340666,131 | 278 | 1225,418 | | |
| **Total** | 386948,178 | 280 | | | |

**Table 73 – ANOVA table for weight of flakes**

The F ratio tells us how the mean of these three groups are or are not equal.

$$F\ (2{,}278) = 18{,}884\ p = 0{,}000$$

The p-value was <0.05 so the data did not meet the homogeneity of variances assumption. After that, it was made the Games-Howell post hoc test.

| (I) site | | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval Lower bound | Upper bound |
|---|---|---|---|---|---|---|
| 330 | 334 Inf. | -22,5745* | 5,3320 | ,000 | -35,247 | -9,902 |
| | 334Sup. | -50,0859 | 25,7016 | ,187 | -123,392 | 23,220 |
| 334Inf | 330 | 22,5745* | 5,3320 | ,000 | 9,902 | 35,247 |
| | 334Sup. | -27,5114 | 26,1379 | ,566 | -101,065 | 46,043 |
| 334Sup | 330 | 50,0859 | 25,7016 | ,187 | -23,220 | 123,392 |
| | 334Inf | 27,5114 | 26,1379 | ,566 | -46,043 | 101,065 |

**Table 74 – Games-Howell post hoc test for weight of flakes**

There was a statistically significant difference between groups as determined by the one-way ANOVA (p= 0.000) test. When looking at then by pairs, it's possible to see that the difference occurs especially between site 330 and 334 Inferior (p <0.05), but not with such a significance.

A different result is given for the cores. The following table shows the result of ANOVA for weight of core tools.

| | Sum of Squares | df | Mean Square | Z | Sig. |
|---|---|---|---|---|---|
| Between Groups | 159040,223 | 2 | 79520,111 | ,316 | ,730 |
| Within groups | 17345391,554 | 69 | 251382,486 | | |
| Total | 17504431,777 | 71 | | | |

**Table 75 - ANOVA table for weight of core tools**

The F ratio tells us how the mean of these three groups are or are not equal.

$$F\ (2{,}69) = \ ,316\ p = 0{,}730$$

It allows us to consider that the variances of the underlying populations of the three analyzed groups are not different, given that homogeneity is achieved with values above p=0.05. After these results, post hoc tests are needed to evaluate whether there are differences among peers in groups. In this work's ANOVA test, the result achieved was that it was homogeneous, so the post hoc test used was Tukey's honestly significant difference (HSD).

| (I) Site | | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 330 | 334Inf. | -95,0633 | 121,0365 | ,713 | -384,983 | 194,857 |
| | 334Sup. | -6,9279 | 300,9789 | 1,000 | -727,866 | 714,010 |
| 334Inf. | 330 | 95,0633 | 121,0365 | ,713 | -194,857 | 384,983 |
| | 334Sup. | 88,1354 | 302,7373 | ,954 | -637,015 | 813,286 |
| 334Sup. | 330 | 6,9279 | 300,9789 | 1,000 | -714,010 | 727,866 |
| | 334Inf. | -88,1354 | 302,7373 | ,954 | -813,286 | 637,015 |

**Table 76 - Tukey's Honest Significant Difference test for weight of core tools**

The Tukey's Honestly Significant Difference showed that within the sites 334 Inferior and Superior the homogeneity is statistically more significant with the similarity being more real between them[4]. The value for Site 330 and 334 Inferior and Superior are also very significant.

An Analysis of Variance of the number of scars at the dorsal surface was made, comparing the three sites.

| | Sum of Squares | df | Mean Square | Z | Sig. |
|---|---|---|---|---|---|
| Between Groups | 5,266 | 2 | 2,633 | 1,048 | ,352 |
| Within Groups | 627,983 | 250 | 2,512 | | |
| Total | 633,249 | 252 | | | |

**Table 77 - ANOVA table for number of scars at dorsal face**

The F ratio tells us how the mean of these three groups are or are not equal.

$$F\ (2{,}250)\ =\ 1.048, p\ =\ 0.352$$

[4] The $p$ value says how much the difference is real, and not the size of the difference, so when a number is bigger it doesn't mean that it is more homogeneous, it means that the chance of the homogeneity is more real.

It allows us to consider that the homogeneity is achieved with values above p=0.05. After these results, the post hoc tests used was Tukey's honestly significant difference (HSD).

| (I) Site | (J) Site | Mean Difference(I-J) | Std. Error | Sig. | 95% Confidence Interval Lower Bound | Upper Bound |
|---|---|---|---|---|---|---|
| 330 | 334Inf. | ,2297 | ,2207 | ,552 | -,291 | ,750 |
| | 334Sup. | ,6111 | ,5421 | ,498 | -,667 | 1,889 |
| 334Inf. | 330 | -,2297 | ,2207 | ,552 | -,750 | ,291 |
| | 334Sup. | ,3814 | ,5595 | ,774 | -,938 | 1,701 |
| 334Sup. | 330 | -,6111 | ,5421 | ,498 | -1,889 | ,667 |
| | 334Inf. | -,3814 | ,5595 | ,774 | -1,701 | ,938 |

**Table 78 - Tukey's post hoc test for number of scars at dorsal face**

The ANOVA test showed that there is a statistically significant homogeneity between all groups, while Turkey's test allows to see that the site 334 Inferior is more similar to 334 Superior, than 334 Inferior with 330, than 330 with 334 Superior.

For the ANOVA test used to compare width of striking platform, the results achieved were:

| | Sum of Squares | df | Mean Square | Z | Sig. |
|---|---|---|---|---|---|
| Between Groups | 2896,246 | 2 | 1448,123 | 15,251 | ,000 |
| Within Groups | 23263,542 | 245 | 94,953 | | |
| Total | 26159,788 | 247 | | | |

**Table 79 - ANOVA table for striking platform**

Where the F-ratio is:

$$F\ (2{,}245)\ =\ 15.251, p\ =\ 0.000$$

The ANOVA resulted in p = 0.000, which means that the precision of the sig. is < 0.001. In this case, there is no homogeneity between the samples, but it was chosen to run Tukey's test for more robust and accurate results to identify where the differences are between the groups by pairs.

| (I) Site | (J) Site | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval Lower Bound | Upper Bound |
|---|---|---|---|---|---|---|
| 330,0 | 334Inf. | -7,16272* | 1,40104 | ,000 | -10,4664 | -3,8590 |
| | 334Sup. | -9,79703* | 3,75639 | ,026 | -18,6548 | -,9393 |
| 334Inf. | 330 | 7,16272* | 1,40104 | ,000 | 3,8590 | 10,4664 |
| | 334Sup. | -2,63431 | 3,87065 | ,775 | -11,7615 | 6,4929 |
| 334Sup. | 330 | 9,79703* | 3,75639 | ,026 | ,9393 | 18,6548 |
| | 334Inf. | 2,63431 | 3,87065 | ,775 | -6,4929 | 11,7615 |

**Table 80 - Tukey's test for striking platform**

Considering that the mean difference is significant under 0.05, Site 334 Inferior and Site 334 Superior shows similarities, while Site 330 doesn't show similarities with none of the sites, considering the width of the striking platform.

The ANOVA test was then used to compare the three sites about their maximum length of flakes and cores with the following table showing the significance for flakes.

| | Sum of Squares | Df | Mean Square | Z | Sig. |
|---|---|---|---|---|---|
| Between Groups | 10734,186 | 2 | 148653,811 | 19,475 | ,000 |
| Within Groups | 76614,048 | 278 | 23190,979 | | |
| Total | 87348,234 | 280 | | | |

**Table 81 - ANOVA table for maximum length of flakes**

The F-ratio $F(2,278) = 19.475$, $p = 0.000$ means that there is no homogeneity between the means of the three sites considering the maximum length of the flakes.

The Games-Howell post hoc shows homogeneity between Site 330 and Site 334 Superior and between 334 Inferior and 334 Superior, but an adjacent significance between Site 330 and Site 334 Inferior (just a little below 0.05).

| (I) Site | | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 330 | 334Inf. | -12,6240* | 2,3156 | ,000 | -18,109 | -7,139 |
| | 334Sup. | -16,0495 | 6,9309 | ,108 | -35,645 | 3,546 |
| 334Inf. | 330 | 12,6240* | 2,3156 | ,000 | 7,139 | 18,109 |
| | 334Sup. | -3,4255 | 7,1361 | ,882 | -23,170 | 16,319 |
| 334Sup. | 330 | 16,0495 | 6,9309 | ,108 | -3,546 | 35,645 |
| | 334Inf. | 3,4255 | 7,1361 | ,882 | -16,319 | 23,170 |

**Table 82 - Games-Howell test for maximum length of flakes**

A different process is seen for the maximum length of core tools.

| | Sum of Squares | df | Mean Square | Z | Sig. |
|---|---|---|---|---|---|
| Between Groups | 6029,213 | 2 | 2013,599 | 2,334 | ,105 |
| Within groups | 89126,286 | 69 | 1332,760 | | |
| Total | 95155,5 | 71 | | | |

**Table 83 - ANOVA table for maximum length of core tools**

$$F\ (2,69)\ =\ 2.334, p\ =\ 0.105$$

The F-ratio means that there is a statistically significance and that homogeneity of maximum length in core tools is achieved with this value above p=0.05. The Tukey HSD post hoc test confirms, with more significance for Site 334 Inferior and Superior and a smaller, but still very significant value for 330 and 334 Inferior and Superior.

| (I) Site | | Mean Difference (I-J) | Std. Error. | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 330 | 334Inf. | -17,0144 | 8,6762 | ,130 | -37,796 | 3,768 |
| | 334Sup. | -27,1081 | 21,5748 | ,425 | -78,786 | 24,570 |
| 334Inf. | 330 | 17,0144 | 8,6762 | ,130 | -3,768 | 37,796 |
| | 334Sup. | -10,0938 | 21,7009 | ,888 | -62,074 | 41,887 |
| 334Sup. | 330 | 27,1081 | 21,5748 | ,425 | -24,570 | 78,786 |
| | 334Inf. | 10,0938 | 21,7009 | ,888 | -41,887 | 62,074 |

**Table 84 - Tukey's test for maximum length of core tools**

Considering the linear dimension for core tools, obtained with the values of weight and the maximum measurement value, be it weight, thickness or length (Andrefsky Jr., 2005), the analysis of variance reached a significant value of homogeneity.

| | Sum of Squares | df | Mean Square | Z | Sig. |
|---|---|---|---|---|---|
| Between Groups | 5,266 | 2 | 2,633 | 1,048 | ,352 |
| Within groups | 627,983 | 250 | 2,512 | | |
| Total | 633,249 | 252 | | | |

**Table 85 - ANOVA table for maximum linear dimension**

$$F\ (2{,}250)\ =\ 1.048, p\ =\ 0.352$$

The Tukey post hoc test confirms the homogeneity between the three sites, with a more significant value for 334 Superior and Inferior. But with also significant values for Site 330 and Site 334 Inferior and Superior.

| (I) Site | (J) Site | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 330 | 334Inf. | ,2297 | ,2207 | ,552 | -,291 | ,750 |
| | 334Sup. | ,6111 | ,5421 | ,498 | -,667 | 1,889 |
| 334Inf. | 330 | -,2297 | ,2207 | ,552 | -,750 | ,291 |
| | 334Sup. | ,3814 | ,5595 | ,774 | -,938 | 1,701 |
| 334Sup. | 330 | -,6111 | ,5421 | ,498 | -1,889 | ,667 |
| | 334Inf. | -,3814 | ,5595 | ,774 | -1,701 | ,938 |

**Table 86 - Tukey's test for maximum linear dimension**

## Typology or Qualitative Analyses

### The 334 Inferior Collection

The artifacts for the qualitative analysis were semi-randomly chosen to demonstrate the wide array of characteristics that it's present at the sites. Preference was given to the digitalized artifacts for their easy-of-use and for artifacts more clearly preserved.

Starting with the artifacts of site 334 Inferior, we have artifact 9, a core tool weighting 378 grams, measuring 9.3 centimeters in the Y axis (height), 7.8 centimeters in the X axis (width) and being 4.5 centimeters thick. It has 8 negatives, its raw material is flint and it has a post-depositional calcite crust covering one of its sides.

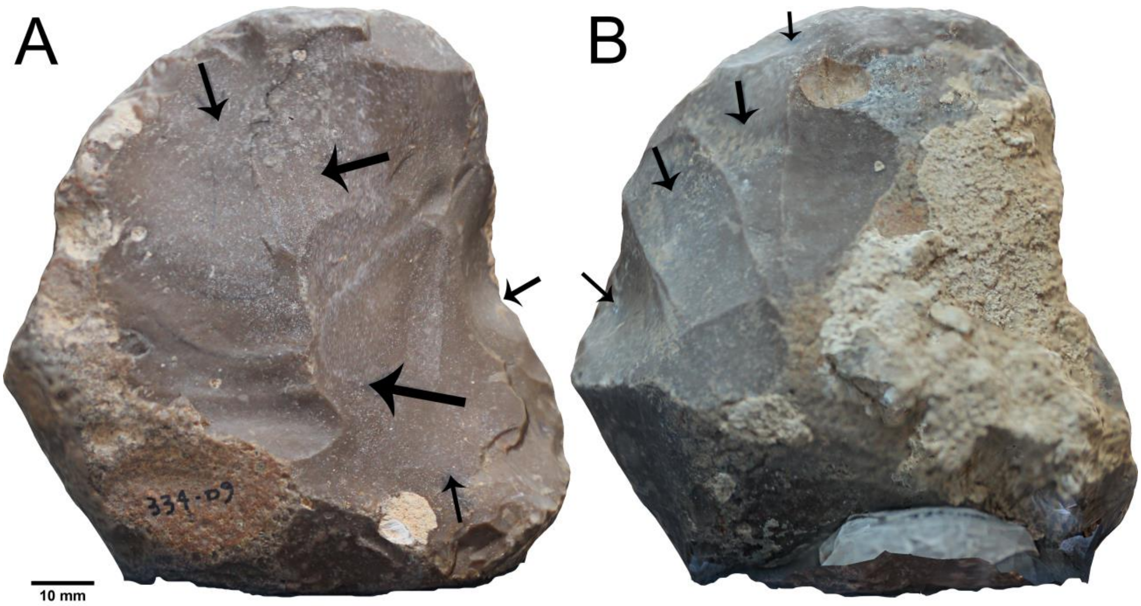


**Figure 80 – Negatives of artifact 09 of Site 334 Inferior**

Artifact 86, weighting 320 grams, it's an orthogonal core measuring 8.3 centimeters high, 6.5 centimeters wide and 6.6 thick, a flint core in a fresh state. Only one site was worked on, with 7 negatives on the same side and an entirely cortical side.

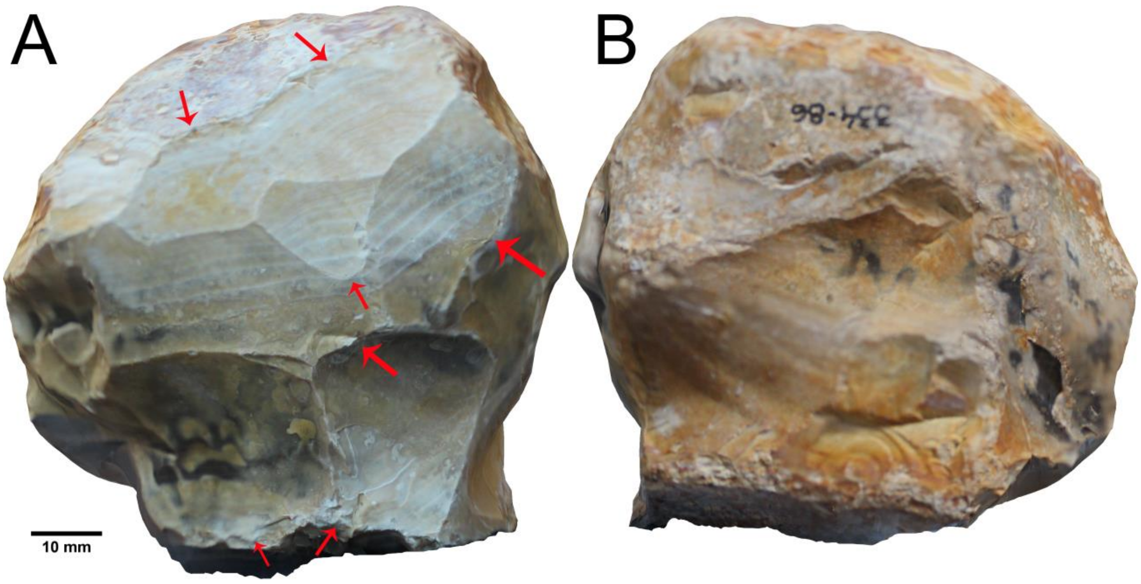


**Figure 81 - Negatives of artifact 86 of Site 334 Inferior**

Piece 108 is a rather crude core tool with a chopper-like appearance, with 3 heavily abraded negatives on the top, forming an edge. It weighs 1.308 kilograms, it is 15.4 centimeters high and 12.4 centimeters wide, with a thickness of 5.5 centimeters. The situation of conservation is precarious as the chopper is rolled. Flaking happened only in one face of the artifact.

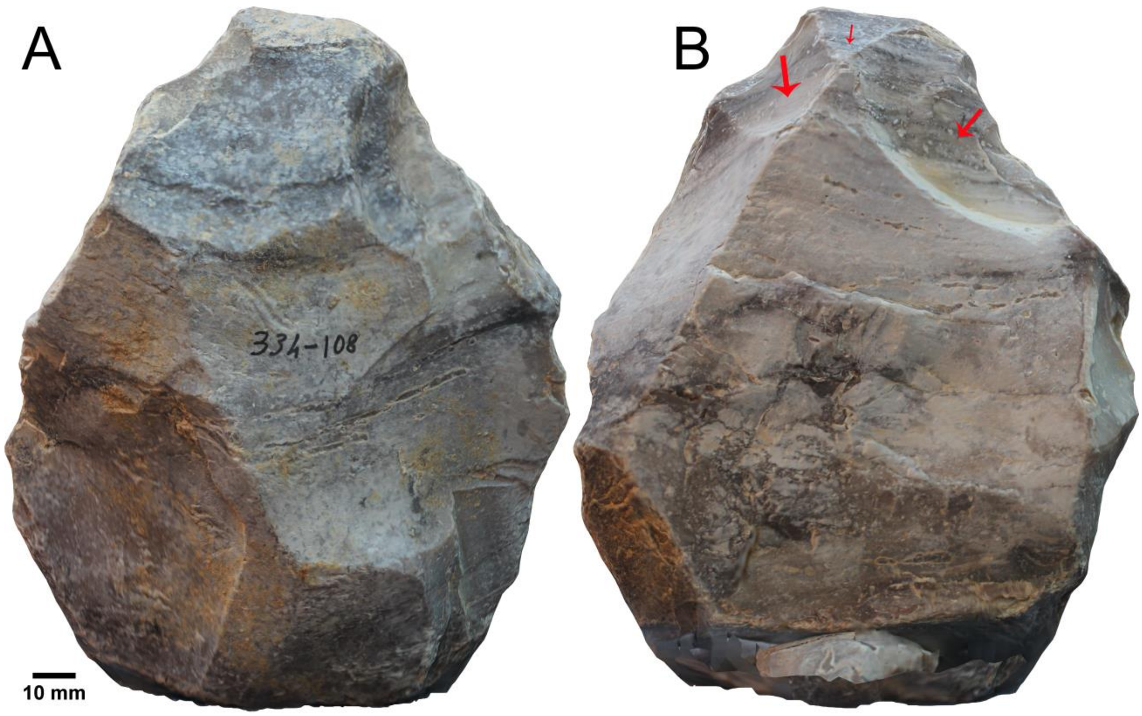


**Figure 82 - Negatives of artifact 108 of Site 334 Inferior**

Lastly on the core tools category, artifact number 8, which contains only 2 reductions. It weighs 894 grams, has a height of 12.6 centimeters, a width of 12.6 centimeters and 5.7 centimeters of thickness. There doesn't seem to be any logic for the reduction in this core tool and its state of preservation is bad, as it has been seriously abraded.

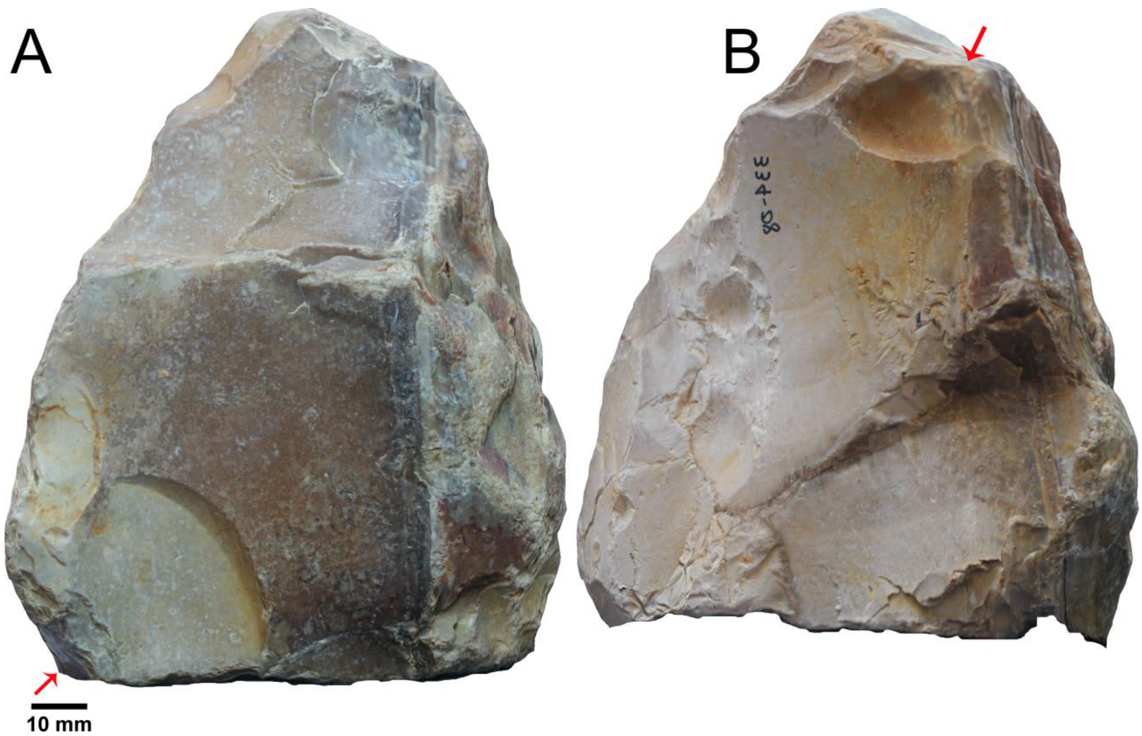


**Figure 83 - Reduction sequence of artifact 08 of Site 334 Inferior**

One of the better preserved artifacts of site 334, a flint "flake" weighing 311 grams, 11 centimeters tall, 10.8 centimeters wide and 3.6 centimeters thick and with two clear negatives in its dorsal surface and a flat striking platform, the artifact is largely covered on the ventral side by calcite. While the calcite covering doesn't allow a good analysis of the ventral surface, the dorsal cortex hints at an early stage in the reduction sequence.

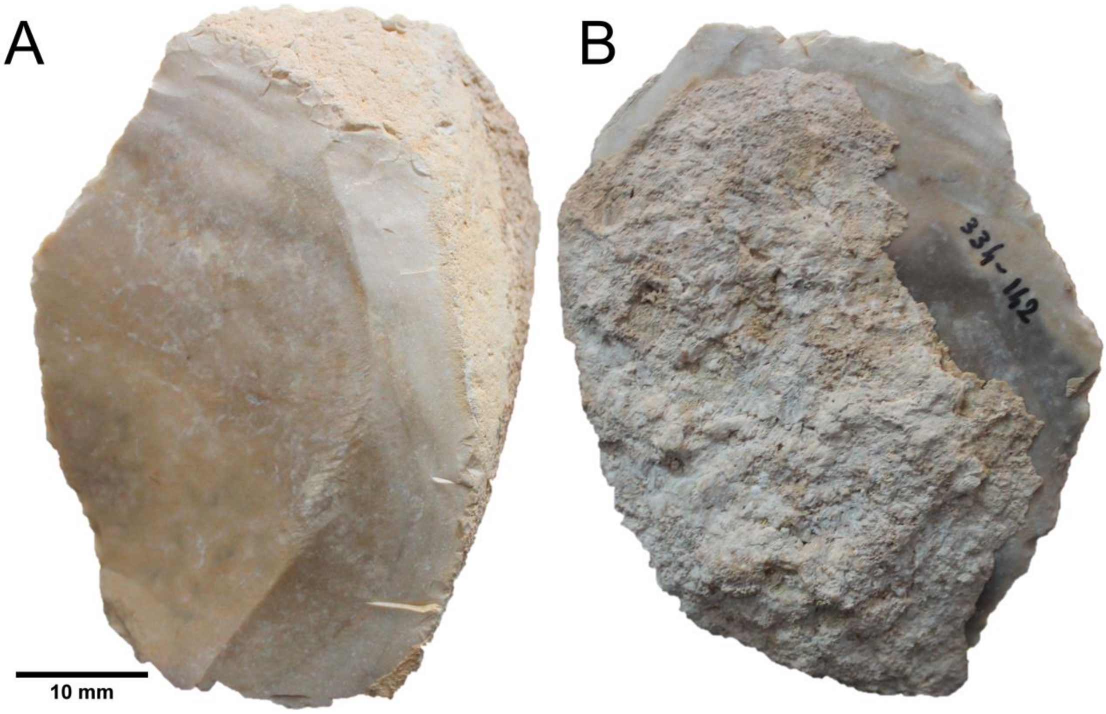


**Figure 84 – Flake 142 of Site 334 Inferior**

The overall makeup of the flake industry shows a pattern of overwhelmingly flint


**Figure 85 – Eighteen flakes of Site 334 Inferior**

predominance and usually lightweight artifacts. Only 3 (3.33% of the 334 inferior sample) flakes have a faceted striking platform, which is commonly associated with biface production (Magne & Pokotylo, 1981) and the weight and average cortical coverage (58.4% for less than half covered by cortex and 28% no cortex) of the flakes that can be classified as the product of biface reduction indicates and industry not in its early phases of reduction, but in the middle of the reduction process (Magne & Pokotylo, 1981). Still, it is likely that there is more than just one industry and the Acheulean is divided in several subcategories, which could skew the results towards one direction. The lack of bifaces and typical biface flakes can indicate an Oldowan industry, or a specific Acheulean culture for the region.

## The 330 Collection

With a weight of 741 grams, a length of 10.5 centimeters, a width of 11.1 centimeters and a thickness of 4.9 centimeters, piece 962 is a flint core tool with at least five removals. Its crude characteristics resemble choppers of the Mode 1 industry.

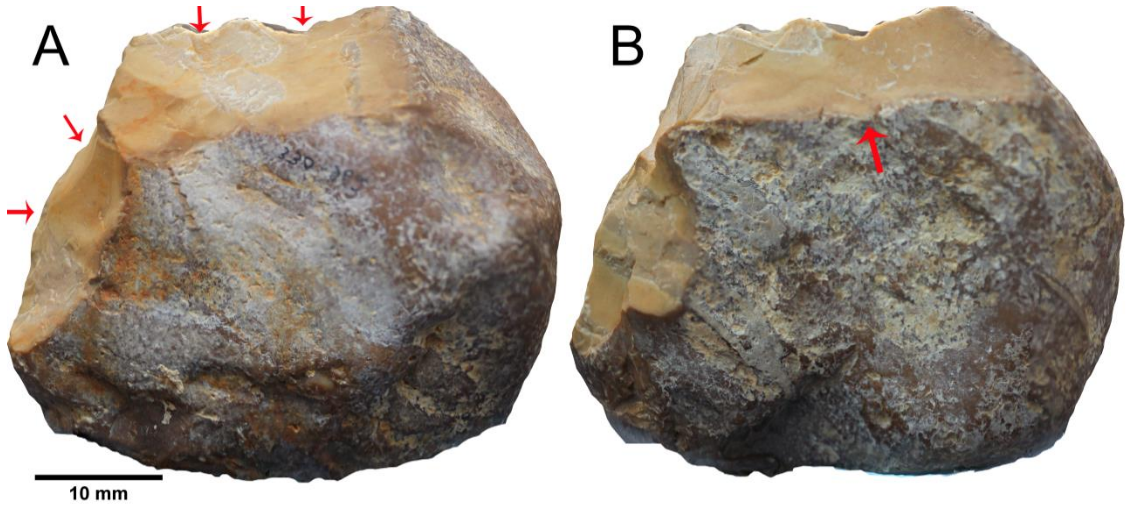


**Figure 86 - Chopper artifact 962 of Site 330**

The core 984, defined as a core with opposite striking planes, weighs 302 grams and has a height of 3.2 centimeters, 7.2 centimeters of width and 4.5 centimeters of thickness. It’s mostly cortical, has 4 negatives and it’s made out of flint, as well as being heavily abraded.

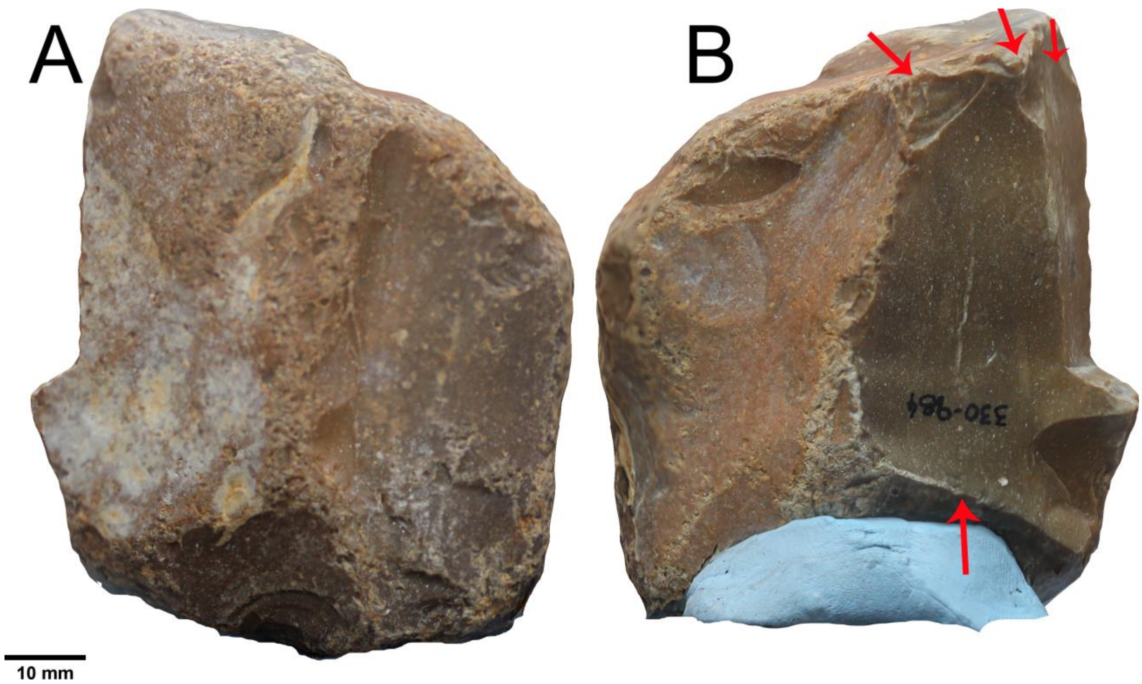


**Figure 87 - Artifact 984, a core, and striking directions - Site 330**

Artifact 1190 is a core tool with 2 main negatives, forming an edge in one side only, like a chopper. It weighs 296 grams, it is 8.2 centimeters long, 7.5 centimeters wide and 4.6 centimeters thick. Its raw material is flint and it's almost completely cortical, with the exception of the side that was flaked. In this side a part of the chopper is covered in soot, as the part of the section where the artifact was found is covered in soot from modern fires that were done in that specific part of the section.


**Figure 88 – Artifact 1190 of Site 330, a chopper with the tip covered in soot**

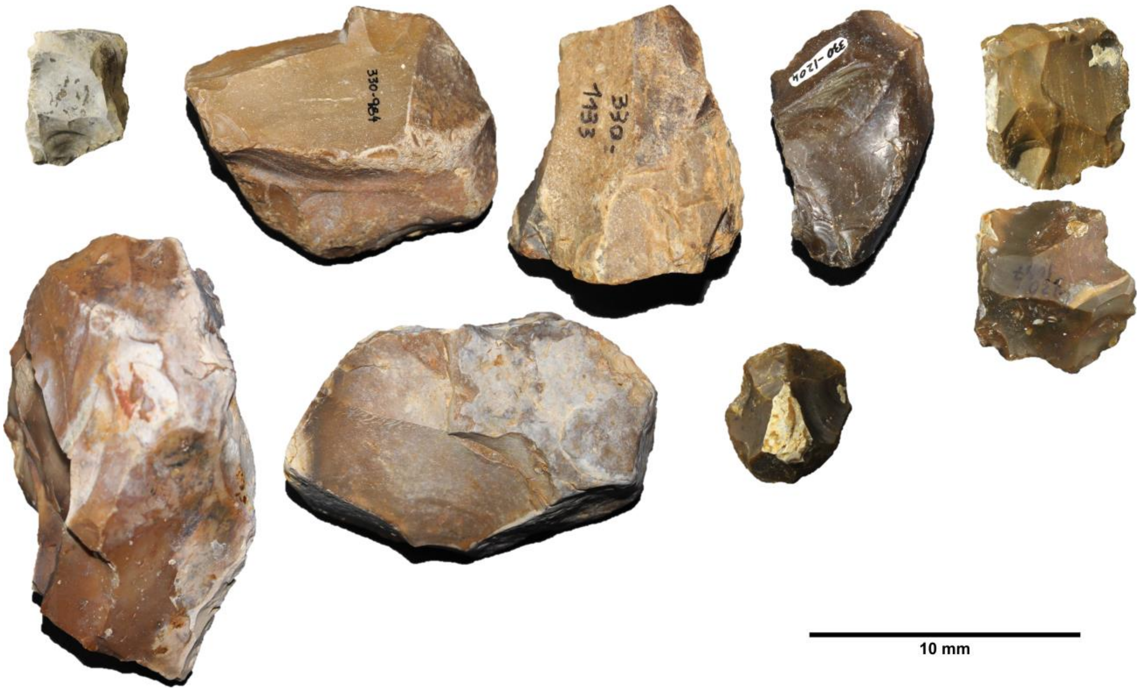


**Figure 89 - Nine cores of Site 330**

Lastly, an example of 9 smaller cores presumably exhausted. The material, as with the rest of the assemblage, is mostly flint. The cores are usually rolled but they still show clearly typical signs such as bulb negatives or the removal scars.

## Discussion

It was found that in the sites 330 and 334 Inferior distribution of artifacts in space is not statistically random, however it should be noted that the identification of a pattern does not mean that something has been explained, it is only one step for the interpretation and explanation of the site distribution (Stanislawski, 1973 *apud* Hodder & Orton, 1976).

The identification of random distribution or clustering patterns can be used to define differences between locations, such as locations for activities of disposal, site reorganization, different types of erosion, transportation of pieces by different actions. A number of factors influence the location and establishment of a site, such as distance from water sources, techniques of defense, soil type, passageways, type or value of artifacts, and vegetation, but all this in large scale, considering the sites location. When working with the artifacts separately it should be noted that other factors may appear such as disposal areas, topography and the possibility of reallocated artifacts. So the case of Site 334 Superior should be carefully considered by archaeologists because hominin and human settlement and disposal areas are not chosen randomly, so it’s better to recognize that there was no discernible pattern and that is caused probably by its low density[5].

However, it is noteworthy that there is no random distribution of artifacts and that high energy natural features that could move some of the heavier pieces, like rivers, would result in more random patterns (Petraglia & Richard, 1994). There are, of course, signs of water flow and clear riverbeds in the three profiles (Parenti, et al., 1997; Caneva, et al., 2001), but archaeological sites occur in these settings. Coarse grain sediments and pebbles are good indicators of high energy contexts, and these are present in the three sites, but they also make it more likely that the position of archaeological assemblages will be altered (Petraglia & Richard, 1994). Water in slopes lead to a spread of the artifacts and in more deep materials, (Schumm, 1967; Rick, 1976; Butzer, 1982; Frostick and Reid, 1983; Schuldenrein, 1986; Petraglia, 1987; Petraglia and Nash 1987 *apud* Petraglia & Richard, 1994) something that can’t be observed in site 330 or site 334 as the material in both sites are spread over 20 meters, despite the fact that the scale of the section in site 334 creates the impression of accumulation. Water flow can create gaps in the spatial distribution between the original point of the artifacts and the resting place of the material

[5] A frequent problem in small samples is that they allow you to see the variation of what is present and what is not, but they distort percentages and proportions.

while high increases in velocity of the flow may move all artifacts together to one side. None of the sites seem to present shadow effects, that is, when large objects protect smaller ones from the flow, creating an accumulation of smaller objects in a specific place (Petraglia & Richard, 1994). Even a better indicator, piece 1091 and piece 969 refit perfectly, and that's unlike to happen in the case of a situation of a water flow, though not necessarily impossible. The lack of very small flakes is a factor that can speak in favor of a water flow through the sites, but it can also be the result of noise, since the sediment is already filled with pebbles, or simply a matter of chance.

While it wasn't possible to find any marker horizons, that is, beds or stratigraphic units that share a composition distinct enough that it's highly likely they are isochronous, the lithic assemblages can tell a lot about the sites. According to methods established by Magne (1981), 26.63% of the debitage found in Site 330 and 17.04% in Site 334 Inferior is classified as a mid-stage reduction product while 5.40% in Site 330 and 7.90% in Site 334 Inferior is classified as early stage reduction. It has been established that the industry in Site 330 is Early Acheulean (Parenti, et al., 1997) or at least Middle Acheulean, (Copeland, 1998), it contains crude tools like choppers, which while not unheard in the Acheulean industry, it indicates a more early than Middle Acheulean nature for the site.

The relatively high concentration of flakes usually associated with mid-stage reduction of bifaces, taking into consideration no bifaces were found, compared to Site 334 Inferior coupled with the number of flat striking platform (52.04%) and the smaller percentage of cortical coverage (60.3% less than half and 28.8% no cortex at all) indicates the prevalence of an industry in its mid stage of reduction, but the low percentage of negatives on the dorsal surface (68.13% having up to 3 negatives on the dorsal surface) shows an industry simple enough to fit in the Mode 1 category. The cores, overwhelmingly orthogonal (38.9%) and in a smaller scale, unipolar (19.4%) and bipolar and orthogonal (16.6%) as well as the number of negative bulbs (56.8% have up to 4 negative bulbs) can help that proposition.

The greater diversity in artifacts (denticulates, choppers, scrapers), as well as the previous parameters can indicate a more sophisticated lithic industry in Site 330 than in site 334 Inferior, which shows less flakes in middle stages of reduction (17.04%) and more in the early stages of reduction (7.90%) in comparison to site 330, but the high concentration of flakes without striking platform (14.44%) and of incomplete flakes

(25.84%) in comparison to site 330 (13.77%) could indicate fluvial action of a sufficient energy to transport and damage the artifacts, but it's not necessarily a final diagnostic. Despite that, site 334 shows similar characteristics in regards to cortical coverage of flakes (58.4% less than half cortical and 28% without any cortex), though flat striking platform (65.55%) are more represented, so are cortical striking platforms (14.44%). Removals in the dorsal surface from zero to two represent a significant (68.6%) part of the material and coupled together with the previously mentioned data makes up a scenario of a lithic assemblage in its early stages of reduction. Finally, core tools are overwhelmingly orthogonal (23.3%), unipolar cores (26.7%) and choppers (20%) again indicate a cruder industry, though the number of negative bulbs in the cores remains more or less equal up ta numbo 6 negative bulbs. Unfortunately, for Site 334 superior there aren't enough artifacts for a statistically significant analysis to be made.

The ANOVA test allowed the assessment of which ones of the lithic characteristics could be similar. The test was applied for weight of flakes and cores, number of scars at dorsal face, width of striking platform, maximum length of flakes and cores and for linear dimension.

The weight of flakes parameters resulted as not having homogeneity; the only significant value occurred between Site 334 Inferior and Superior, but here it's necessary to be aware that the 334 Superior samples are too small and may not be representative.

The weight of cores showed homogeneity with significant values for all sites comparison. Number of scars at dorsal face also showed significant homogeneity between all sites. The maximum length of cores was homogeneous, with more significance between Site 334 Superior and Inferior, than with Site 330. They are still homogeneous, but it's an important difference since Site 330 and Site 334 Inferior have bigger samples to be compared. The maximum length of flakes didn't appear as homogeneous, especially between Site 330 and Site 334 Inferior and the same result was obtained when comparing width of striking platform values, that didn't appear as homogeneous. At last, the maximum linear dimensions (MLD) values showed a result of significant homogeneity between all three sites. With that said, it's possible to see that the results showed that cores are more homogeneous between Site 330, Site 334 Inferior and Site 334 Superior, than flakes are. This of course might be explained through the ever shifting nature of flakes, which come in a variety of sizes and shapes according to the knapper’s intention, but it also might indicate different reduction activities carried out on both sites.

# Conclusion

The results presented cast a light in the conundrum around the formation of the three sites in the Dauqara formation. While the signs of water presence are abundantly clear in the stratigraphy, the extent of its effects on the artifacts and consequentially, if they are *in situ* or were transported from another place remained unclear. The result of the Nearest Neighbor Search analysis shows that the distribution in the sites with a statistically significant population is not random. While natural processes can lead to non-random patterns (Petraglia & Richard, 1994), they tend to leave specific, repeatable patterns or random patterns.

Moreover, the distinct composition of each site and the abundance of certain characteristics make it unlikely that they were sorted out by natural processes, as erosional forces don't selectively pick lithic artifacts by their features. The homogeneity in the core features also can hint to a common genesis and a similar lithic assemblage, something likely to be erased especially in the smaller cores in case of fluvial action.

Nevertheless, the hypothesis of water at least interfering with the site can't be discarded so readily. Hydrologic activity could have washed away the flakes and kept the cores, potentially keeping the homogeny in one while removing it from other. However the development of dorsal negatives in flakes show a significant homogeneity, meaning that unless a hypothetical water flow washed away flakes in similar reduction stages or that both sites were in similar reduction stages but water didn't alter them significantly.

In sum, the two sites, despite showing signs of ancient hydrological activity, lack expected attributes and patterns that would come with medium or high energy water flow (Petraglia & Richard, 1994). The two collections appear to be Mode 1 or an early Mode 2 industry, with a small part of the flakes hinting for a bifacial industry in the middle stages of the reduction process, but the absence of bifaces make it categorizing it as Mode 2 a difficult task. Lastly, the cores from both sides show homogeneity in some characteristics, suggesting a common stage of production from the point where reduction stopped.

Whereas there's a clear lack of handaxes and bifaces in both sites, characteristic of the Acheulean industry, there's also a clear predominance of flakes with a flat striking platform, which happen as the result of detaching pieces of nonbifacial tools and also as the result of reduction of unidirectional cores (Andrefsky Jr., 2005), coupled with only a very small number of multifaceted platforms, something that happens more frequently in biface production, it paints a scenario of few to non-existent bifaces in the sites. With the proportion of striking platforms in Site 334 Inferior being 65.55% flat while for site 330 the percentage of the flakes with flat striking platform is at 52.04%, and the other predominant striking platform being cortical (14.44% and 27.5% for each site respectively), there clearly is a lack of evidence for biface production. They are also compatible with the proportion of unipolar cores in the assemblage (19.4% for site 330 and 26.7% for site 334 Inferior).

The proportion of multifaceted (3.33% and 2.04% respectively for sites 334 Inferior and site 330) striking platform flakes, something that happens more frequently on biface production, is also a good indicator to support the hypothesis of a non-bifacial industry, something that can't be taken for granted even if there's a complete absence of bifaces.

The Acheulean is typically characterized by the presence of bifaces, cleavers and handaxes, but despite the Acheulean classification cautiously given in a first time (Parenti, et al., 1997) to the assemblages by the discussed authors of this study, the lithic materials found lack key characteristics to fit in this classification. The non-random nature of the spatial distribution of the artifacts, the non-random nature of the distribution of the qualitative characteristics of the artifacts and the coherence of the flakes with the found cores indicates that sites 334 are two distinct, primary sites that can be classified as Mode 1, or at best a Mode 2 industry with a very small production of bifaces.

Further confirmation in the form of other experiments such as microartifact tests, experiments to determine influence of water in the dispersal through time and space correlated with weight and shape of artifacts and bigger sample size and information about its spatial distribution, as well as direct, absolute dates, are needed so a better picture of one of the locales standing on the crossroads of the first hominins out of Africa can be drawn and the understanding of their migration routes and the new environment they faced right outside of Africa can be better understood.

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