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# Preliminary Study of Grinding and Milling Tools of Prehistoric Site of Ifri Ouzabour (Eastern Rif, Morocco)

Fadoua Nekkal and Hassan Aouraghe
Laboratory of Geosciences (Applied Geology and Archaeology), Department of Geology,
Faculty of Sciences, University of Mohamed I, Oujda, Morocco

**Abstract:** Archaeological research conducted during the past two decades in the Eastern Rif region have allowed the discovery of several sites of prehistoric settlements whose occupations date back mainly to the different phases of the Holocene. The excavations carried out in some of them have yielded new data on the economy of the first agro-pastoral societies of Morocco and to identify their different cultural aspects. This study presents, the results of the preliminary study of milling and grinding tools discovered in the site of Ifri Ouzabour whose main occupation levels date back to the Early and Late Neolithic. The site is marked by a considerable amount of this kind of objects in comparison with the surrounding sites. The set of available tools is taken into account and actual selection could be highlighted in the selection of materials and shapes according to the use of the objects.

**Key words:** Prehistory, Eastern Rif, Ifri Ouzabour, Neolithic, grinding and milling tools, Morocco

## INTRODUCTION

This study reports the results of preliminary study of grinding and milling tools discovered in the Neolithic site of Ifri Ouzabour. Although, other tools have been unearthed in other sites dating back to the same cultural period, they are rarely reported in the literature. A global approach as possible was attempted in this research, taking into account the raw materials, morphological and technological aspects and the eventual function in order to define this tools whose growth seems particularly associated to the context of the first agro-pastoral societies. The grinding and milling tools constitute as well as ceramic and lithic an integral part of the Neolithic study.

Archaeological excavations in the site were conducted as part of the research program "Pre and Protohistory of the Eastern Rif" which united the Institut National des Sciences de l'Archeologie et du Patrimoine of Morocco (INSAP) and the Kommission fur die Archaologie Außereuropaischer Kulturen des Deutschen Archaologischen Instituts (KAAK). The site of Ifri Ouzabour was discovered in 2004 during surveys campaigns along of the Mediterranean bypass. This cave constitutes in the present state of knowledge, the extreme coastal extension of Cardial Culture on East of Morocco and across North Africa. Researches in the site have yielded a considerable number of grinding and milling tools arousing special attention due to their richness and diversity.

## MATERIALS AND METHODS

Two excavations campaigns were conducted in the site of Ifri Ouzabour in 2006 and 2007 in two soundings areas measuring 6 $m^2$. The excavations were carried out first on the slope in order to evaluating the stratigraphic sequence and then they were prosecuted inside the cave. The trenches were excavated by horizontal levels of 5 cm. The dip of the structures, consistency and homogeneity of the morpho-sedimentary characters of each layer are respected.

Inside the cave, archaeological deposits were covered by a layer of manure accumulated following the use of the cave as livestock enclosures. Texture, color and structural diversity allows to divide the archeological deposits into 4 stratigraphic units reposing on the bedrock. The sequence is up to 2 m thick and date back to two human occupation phases which are Late and Early Neolithic. Most of the archaeological remains comes from the lower occupancy. A large pit greatly affects the upper layers including layer 3 which was preserved only in some places. Bio-perturbations are also identified *in situ* nevertheless the external survey is favored by preserving intact archaeological units.

**Corresponding Author:** Fadoua Nekkal, Laboratory of Geosciences (Applied Geology and Archaeology), Department of Geology, Faculty of Sciences, University of Mohamed I, Oujda, Morocco

Samples for dating were systematic throughout the investigation's depth. To sum up, 10 samples of charcoal, charred shells and a carbonized seeds have been dated by radiocarbon by the Laboratory of AMS of the University of Cologne (Germany) and the Laboratory of Researches and Technical and Scientific Analyzes of Rabat (Morocco). $^{14}C$ ages attest a Neolithic occupation between 7.3 and 4.6 ka cal BP.

All blocks and pebbles, collected systematically during the excavations were examined later to define the artifacts and the geofacts which seem to be imported intentionally in the cave. The descriptive study is essentially focused on material row and the metric, morphological, technological and functional characters.

Macroremains analyzes were also performed on sediment samples coming from combustion structures. The salvaged samples were treated according to standard procedure including flotation, sorting and identification. The limited quantity of recovered macroremains shows a restricted human activity. However, it should be noted that the selective and non-systematic selection of samples can affect negatively the amount of collected remains.

## RESULTS

**Stratigraphic and archaeological context:** The site of Ifri Ouzabour is located in a coastal cliff a few kilometers West of the mouth of Oued Kert and dominates Mediterranean coast (Fig. 1). It is a small cavity formed by marine abrasion during a period of higher sea level and is some 2 m high, 2 m wide and 7 m depth. Two field campaigns were carried out in the years of 2006 and 2007 during which time 12 $m^2$ were excavated outside and inside of the cave (Nekkal and Mikdad, 2014).

In 2006, the first survey was carried out down of the talus of the cave. This research allowed the discovery of a stratigraphic sequence of 1.95 m of depth, divided into 3 distinct layers. The excavations continued in 2007 on an area of 6 $m^2$ inside the cave have allowed the identification of 4 archeological deposits deep of 1.99 m. The ground inside the cave has a faint dip from the background to the outside. Anthropic (pits and fireplaces) and biological (burrows) alterations have contaminated to varying degrees all identified layers.

The lower occupation of the site is only identified in external sounding (layer 3). It dates back to the Epipaleolithic at around 8477±63 cal BP (7666±76 BP, Erl.9985) (Fig. 2). This layer is characterized by a brown color and a compact texture with a mixing of sandy sediment, marine shells and snails. The archaeological assemblage provides only lithic industry consisting unretouched and retouched flakes, unretouched and backed bladelets, cores and debris.

The second occupation dating back to the Early Neolithic, was identified in both soundings (layer 4 of the internal sounding, layer 2 of the external sounding). The layer consists of loamy sandy sediment with a dark grey brown color and a relatively compact texture. It contains

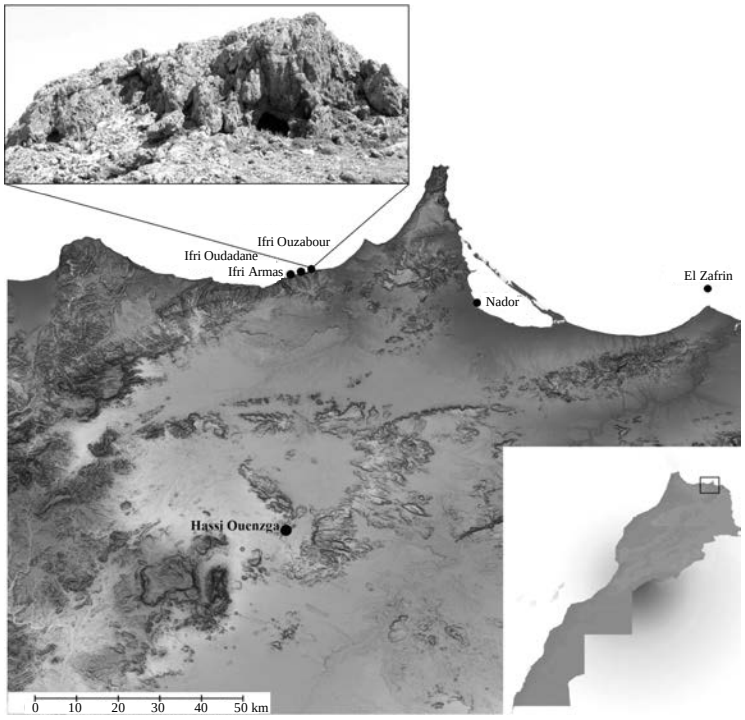


Fig. 1: Geographic location of principal Neolithic sites in Eastern Rif and general view of the site of Ifri Ouzabour

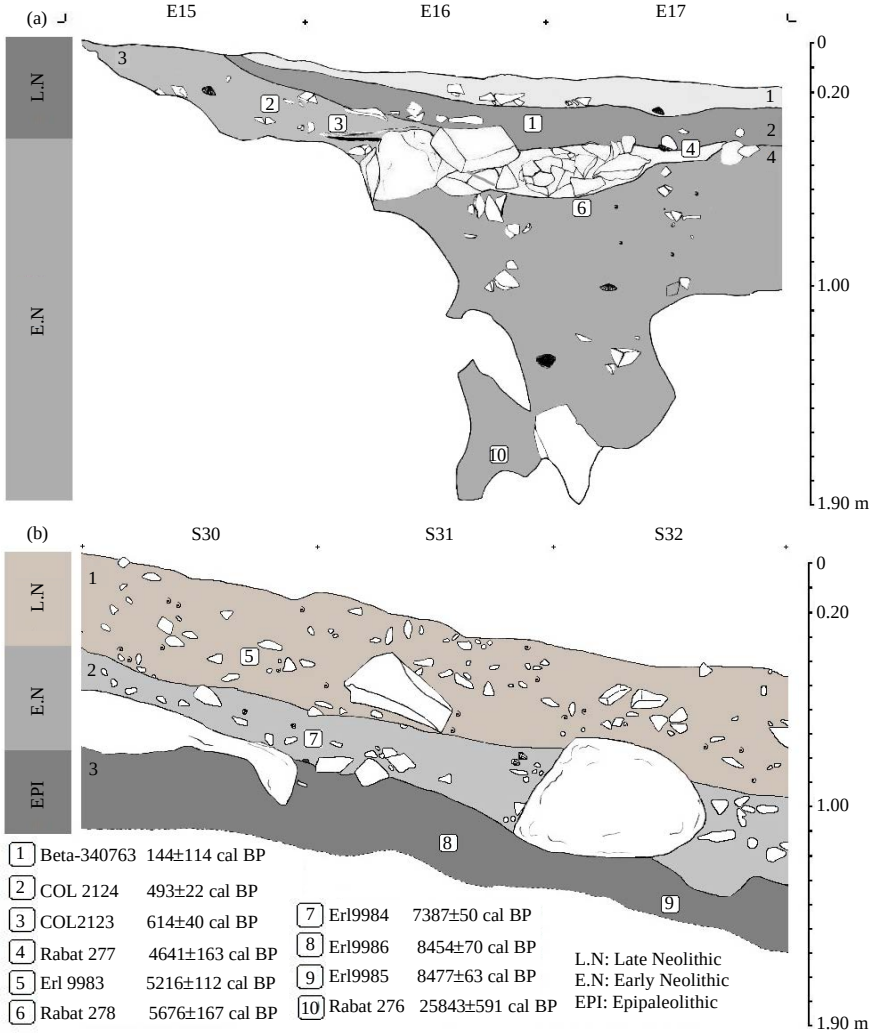


Fig. 2: Stratigraphy and radiocarbon dating from Ifri Ouzabour: a) internal sounding/North profile and b) external sounding/Northeast profile

marine shells and snails, some stones, pieces of charcoal and pockets ashy. In the interior of the cave, this layer is situated directly on bedrock. However, outside of the cave, the same layer rests without apparent sedimentary gap on the underlying layer attached to the Epipaleolithic.

The calibrated dating taken from a calcined snail shell coming from the layer 4 of internal sounding has proven an age of 5676±167 cal BP (4920±140 BP, Rabat 278). This result seems random compared to the morpho-typological and stylistic character of ceramic which testifies the occupation of this layer at Early Neolithic. This chronological and technical discrepancies identified can be explained by the intrusion of recent materiel following human and biological disturbance that affected to different degrees the stratigraphic units within the cave.

Despite this, it is possible, following the principle of stratigraphic continuity to extrapolate the dating of the external sounding confirming the lower occupation of the site in Early Neolithic at around 7387±50 cal BP (6481±53 BP, Erl. 9984).

The upper occupation is attached to Late Neolithic dated between 5676±167 cal BP (4920±140 BP, Rabat 278) and 4641±163 cal BP (4126±128 BP, Rabat 277). It is characterized by silty friable dark gray brown sediment, containing small stones and crushed snails and marine shells.

This occupation includes the layers 2 and 3 of internal sounding and the layer 1 of external sounding. The ceramic artefacts discovered include essentially modeled shards and some decorated fragments by comb

impressions. Inside the cave, stratigraphic units are completely disturbed because of strong anthropic and biological perturbations at the expense of Late Neolithic layers. Subactuels fireplaces and animal burrows have affected to different degrees the sequences. A superficial layer of manure, formed following the use of the site as cattle encloses, covers the upper Neolithic layer.

**Study of grinding and milling tools:** All of the studied material comes from inside the cave. Altogether 134 objects are counted, divided into 52 blocks and pebbles, 58 fragments of pebbles and 24 nodules. Among the pieces we distinguished 23 objects with morphological appearance allowing their integration among grinding and milling tools. Most of this materiel comes mainly from layers 2 and 3 attached to Late Neolithic (4641±163-5676±167 cal BP) with a remarkable increase of objects between levels 3 and 11 (Fig. 3). The lower levels attributed to Early Neolithic (7387±50 cal BP) have delivered only 7 specimens.

The identified material is distributed between millstones and handstones (Fig. 4). The typo-technological analysis of objects is based on the classic typology (shape, section, size, etc.) on the technological aspects as well as the choice of the raw material and prior preparation. All pieces are unshaped and few ones have been previously prepared to perform their function. All

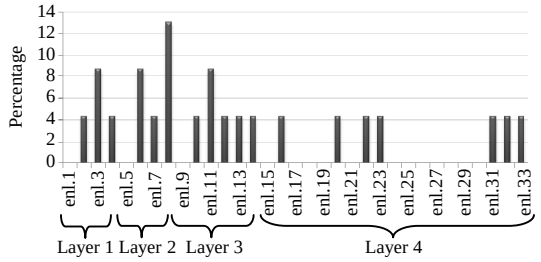


Fig. 3: Distribution of grinding and milling tools by levels

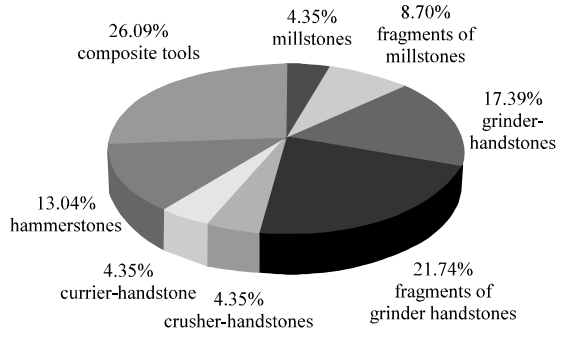


Fig. 4: Percentage of grinding and milling tools by functional class

the supports are obtained on sandstone and quartzite due to their features providing durability, hardness and roughness.

**Millstones:** Just one complete piece and 2 millstones fragments are identified among the tools (13%). The complete millstone conserved in the archaeological record is obtained on quartzite stone with a volume of 1056 $cm^3$ (Fig. 5). It presents a shape and a subrectangular section and provides a slightly concave active surface with some type of wear in the form of smooth, polished areas. It still retains traces of pecked areas, evidence of prior preparation or refection of smoothed surface rough again to allow continuing use. The other fragments are obtained on sandstone and provide rough active surface, flat or slightly concave with polished wear areas. All millstones have a regularized active face and a gross inactive side (back). They are used in a back and forth and are very often associated with handstones.

**Handstones:** The handstones are more abundant and varied. A group of 20 tools was found in the cave (86.95%) including the grinder-handstones, the crusher-handstones, the currier-handstones, the hammerstones and the composite tools. As millstones, handstones are obtained on the same raw materials and have restricted dimensions. The sizes of this smallers hand-held stones facilitate their use of "back and forth" or their direct impact against a support.

**Typological study**

**Grinder-handstones:** Among the tools, 9 grinder-handstones are discovered (39.13%). They are made of sandstone, quartzite or sandstone-quartzite. The 66.67% of grinder-handstones have an oval shape and 33.33% present a sub-rectangular shape with one grinding surfaces (Fig. 6). Their sections are plano-convex (43%), subrectangular (28%) or oval (29%). The sizes of tools

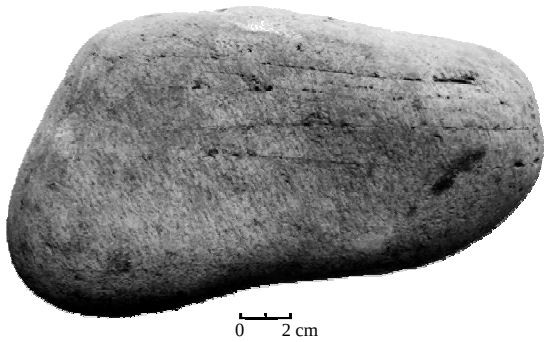


Fig. 5: Quartzite millstone


Fig. 6: Active surfaces of grinder-handstones

range between 7.4 and 15 cm for lengths, 5.9 and 12.1 cm for widths, 2.9 and 5.6 cm for thickness and between 152.81 and 1016.4 $cm^3$ for volumes. Some grinder-handstones were pecked to make their surfaces rougher before the use and the traces of preparation still preserved along the ends or margins. Sometimes, they are also used in the raw state when the natural surface provides sufficient roughness. The active surfaces, planers or slightly concaves, show smooth and polished areas evidencing a prolonged use.

**Crusher-handstones:** This type is represented by a single specimen. This artifact is made of hard heavy volcanic stone used in its natural state on both faces. The choice of this raw material is probably dictated by his resistance. The crusher-handstone has subrectangular shape and oval section. It measures 8.6 cm of length, 9.2 cm of width and 5.4 cm of thickness with a volume of 427.248 $cm^3$. Its two active faces show signs of wear in the form of centric or eccentric depressions resulting from the percussion action applied on hard materials.

**Currier-handstones:** One specimen of this type is identified among the handstones. It is in sandstone with shape and rectangular section. It makes 9.9 cm length, 8.4 cm width, 3.1 cm thickness and of 257.796 $cm^3$ volume. The artifact offers two active faces with intensive polishing traces which are resulting from repeated friction of the active surface against some material (animal leathers).

**Hammerstones:** Three hammerstones are identified among handstones's collection (13.04%). Two objects have provided shape and oval section while the third has a circular shape and subrectangular section. The dimensions of the objects vary between 5.7 and 11.1 cm in length, 5.6 and 8.6 cm in width, 2.9 and 4.1 cm thickness and between 92.568 and 391.386 $cm^3$ of volume. They are made of a fine grained sandstone and quartzite used in the raw state. The signs wear on the objects are located along the ends or margins which show roughening because of pecked cups and marks.


Fig. 7: Composite tool (Grinder-handstones/hammer stones) with smooth areas and percussion scars on its distal extremity

**Composite tools:** They have been used as grinder-handstones as well as hammerstones in these case, battered areas as well as smoothed areas are identified on the tools (Fig. 7). The 6 composite tools are found among the collection (26.09%). These tools are made mostly of sandstone, quartzite or sandstone-quartzite. In 66.67% of the cases this tools are used in its natural state. The rest show a slight transformation particulary by bush hammering technique. The tools have different shapes: sub-triangulaires, oval, circular, sub-circular and sub-rectangular. The sections are plano-convex for three tools, oval for two others and sub-triangular for a single object. The dimensions vary between 8.7 and 12.6 cm in length, 6.3 and 11.4 cm in width, 2.6 and 5.7 cm in thickness and between 675.108 and 147.42 $cm^3$ in volume.

**Comparative study of handestones**

**Raw material:** The use of the raw material is a real choice of functional order that focused on two main supports of stones. These artifacts are made on a fine grained hard stone to allow continuing use. The hammerstones were obtained for most on sandstone, dominating with a percentage of 50% and quartzite with a percentage around 35%. The sandstone-quartzite and a volcanic rock (trachyte) reach respective percentages of 10 and 5%. The row material seems to be imported from the immediate vicinity of the site including the Oued Kert valley located 3 km eastward of the site. The choice of these materials is dictated by their mechanical properties that determine their uses and functions including hardness, resistance and abrasion (Table 1). The sandstone is particularly preferred for grinder-handstones, currier-handstone and

Table 1: Raw materials serving for manufacture of handstones and hammerstones

| Raw materials | Grinder-handstones | Crusher-handstones | Currier-handstones | Hammerstones | Composite tools |
|---|---|---|---|---|---|
| Sandstone | 4 | - | 1 | 1 | 3 |
| Sandstone-quartzite | 1 | - | - | - | 1 |
| Quartzite | 4 | - | - | 2 | 2 |
| Volcanic raw | - | 1 | - | - | - |

Table 2: Metric data of handstones from Ifri Ouzabour

| | | | Measures | | |
|---|---|---|---|---|---|
| Materials | Number | Variables | Moyenne | Minimum | Maximum |
| Crusher-handstones | 1 | Length | - | 8.600 | - |
| | | Width | - | 9.200 | - |
| | | Thickness | - | 5.400 | - |
| | | Volume | - | 427.248 | - |
| Currier-handstone | 1 | Length | - | 9.900 | - |
| | | Width | - | 8.400 | - |
| | | Thickness | - | 3.100 | - |
| | | Volume | - | 257.796 | - |
| Grinder-handstones | 9 | Length | 10.22 | 4.700 | 15.000 |
| | | Width | 8.08 | 5.900 | 12.100 |
| | | Thickness | 3.90 | 2.900 | 5.600 |
| | | Volume | 382.70 | 152.810 | 1016.400 |
| Hammerstones | 3 | Length | 8.87 | 5.700 | 11.100 |
| | | Width | 7.40 | 5.600 | 8.600 |
| | | Thickness | 3.60 | 2.900 | 4.100 |
| | | Volume | 260.62 | 92.568 | 391.386 |
| Composite tools | 6 | Length | 10.78 | 8.700 | 12.600 |
| | | Width | 8.66 | 6.300 | 11.400 |
| | | Thickness | 4.04 | 2.600 | 5.700 |
| | | Volume | 403.14 | 147.420 | 675.108 |

composite tools because of its quality of abrasion. The hammerstones are obtained mostly on quartzite which is a harder than sandstone. The crusher-handstone is made on heavy, hard and dense volcanic raw material.

**Metrics data:** According to measurements taken on the tools (Table 2), we find that:

- The volume allows to distinguish in decreasing size crusher-handstones, composite tools, grinder-handstones, the hammerstones and currier-handstones
- The length can differentiate in order of decreasing composite tools, grinder-handstones, currier-handstone, hammerstones and finally crusher-handstone
- The width classifies in decreasing crusher-handstone, composite tools, currier-handstone, grinder-handstones and hammerstones
- The thicknesses are relatively homogeneous for the tools accepted the crusher-handstone which shows a significant thickness

The metric variations of tools depend on their function. For instance, the crusher-handstones are more voluminous to provide greater resistance and hardness. The width is more important for tools with active ends, especially for crusher-handstones and composite tools. The grinder-handstones and currier-handstone are particularly long for driving a sufficient quantity or surface of the worked material. All objects have restricted dimensions due to the interest of the gripping of the tools which have often a hand size.

**Surface conditions and functionality of grinding and milling tools**

**Preparation:** The handstones supports are used in raw state as they may undergo some slight transformations necessary to their use. Among 20 tools, 8 specimens still conserve traces of preliminary preparation by bush hammering whom four grinder-handstones, a currier-handstone and three composite tools. This technique provides to the tools a rougher surface and increases their abrasive quality.

**Signs wear:** Visual examination of the objects has allowed identifying:

- Traces of polishing identified on 15 tools (75%) including 9 grinder-handstones, the currier-handstone and 5 composite tools. This is a major feature of grinder-handstones and composite tools, resulting from repeated rubbing against a support via another material (Table 3)

Table 3: Summary of wear traces by type of grinding and milling tools

| | | Signs wear | | | |
|---|---|---|---|---|---|
| Tools | Bush hammering preparation | Polishing | Depressions | Lustring | Traces of calcination |
| Grinder-handstones | 4 | 9 | - | - | 1 |
| Crusher-handstone | - | - | 1 | - | - |
| Currier-handstone | 1 | 1 | - | 1 | - |
| Hammerstones | - | - | 3 | - | - |
| Composite tools | 3 | 5 | 6 | - | 1 |

- Traces of lustring which seems as a very glossy smooth surface on the active part of the object. These wear traces were identified only on currier-handstone (Table 3)
- Depressions resulting from the impact of the handstone and the support or another hard material. They are marked on the crusher-handstone, three hammerstones and six composite tools (Table 3)
- Traces of calcination which are a minority, identified on two objects including one grinder-handstone and one composite tool (Table 3)

**Functionality of grinding and milling tools:** There are no certainties to prove the functionality of grinding and milling tools discovered in the site of Ifri Ouzabour. However, some indications let suggest different uses of these tools. The use of grinder-handstones for milling seeds and transforming vegetable substances cannot be proved without traceological analyzes. Even so, the analysis of the collected macro-remains allows identifying a corpus of charred remains of seeds and fruits. The numbers are too low to realize an interpretation among different identified taxa. This result depends on several factors including the selective sample collection and preservation of macro-remains.

Macro-remains identified in Ifri Ouzabour correspond to angiosperms of *Pistacia* sp., *Olea europaea* and conifers of *Juniperus communis*. The remains of *Pistacia* sp. are attested in Late Neolithic levels (layers 2 and 3) but in decreasing values in comparison with Early Neolithic levels (layer 4). All the remains of *Olea europaea* and *Juniperus communis* are concentrated in Early Neolithic sequence. This preponderance particularly observed in the lower occupation is explained by their abundance in nature especially in this chronological phase (around 7.3 cal BP) corresponding to the Holocene climate optimum. At this time, climate may have been warm and humid as evidenced by the importance of riparian forest and the xerothermophilous macchia composed mainly by wild olive (*Olea europaea*) and mastic (*Pistacia* sp.) (Zapata *et al*., 2013). These data are already confirmed by the results of the anthracological analysis carried out in the Djamila profile in Lower Moulouya river (Linstadter and Zielhofer, 2010; Zielhofer *et al*., 2010) indicating the predominance of Olea and Pistacia between 7.4 cal BP and 6.6 cal BP (Zapata *et al*., 2013). The presence of botanical remains throughout the stratigraphic sequence of Ifri Ouzabour, testifies also the persistence of the collection during Neolithic. Although, the remains of plants identified are an important nutritional resource, it is difficult to demonstrate their consumption and transformation by grinding and milling tools but they constituted the principal vegetal subsistences harvested and fuels used.


Fig. 8: Charred seed of sorghum from Ifri Ouzabour

Carbonized sorghum seed is also identified among the marco-remains (Fig. 8). In contrast, the dates produced on the seed have proved more recent age 144±114 cal BP (160±30 BP, Beta-340763). This result confirms the disturbance of levels in the site by subactuels fireplaces and pits. However, this remain constitute, at the actual state of knowledge, the oldest attestation and direct date of a domesticated seed of Sorghum in Morocco.

The streaks resulting from the use, spotted over the entire active surface of some tools, cannot be produced by harvested plants. However, very different products could be crushed including minerals. The treatment of pigments is attested by the discovery in the site of the hematite fragments of Galena and a grinder-handstones with marks such ores (Fig. 9). The technological study focused on the ceramic shards unearthed in the site testifies the use of mineral additives to decrease the elasticity of the clay used to make the containers. These additives could be crushed and prepared by the grinders or crushers-handstones. Also, the presence in the site of debitage products such as flakes and cores in addition to


Fig. 9: Grinder-handestone with traces of red ocher (1), fragments of hematite (2-3 ) and galena

the high percentage of debris which is around 41% indicates the production of lithic artifacts *in situ*. This production is mostly diverted to produce of flake by direct percussion, attesting the use of hammerstones. These ones could also be used to split animal's bones in order to extract the marrow as evidenced by the identification of percussion cones on some faunal remains.

## DISCUSSION

Ifri Ouzabour's archaeological deposits whose occupation dates back to the Neolithic between 7.3 and 4.6 ka cal BP, fits chronologically and culturally in its regional context. Generally, the ceramic artifacts unearthed at the site have the same morpho-typological characteristics and style as the surrounding sites. The archaeological levels attached to the Early Neolithic in the sites of Ifri Armas (Lorenz, 2010) and Ifri Oudadane in West (Linstadter, 2010; Linstadter and Kehl, 2012), Hassi Ouenzga in South (Linstadter, 2004), Ifri n 'Etsedda (Linstadter and al in press) and the site of El Zafrin (Guerra *et al*., 2010) in East have yielded ceramic fragments decorated with Cardium similar to those discovered in Ifri Ouzabour. The radiocarbon dating trace the age of Cardial sequence in this region between 7.6 and 6.3 ka cal BP in the sites of Ifri Armas, Ifri Oudadane and Hassi Ouenzga and up to 6 ka cal BP in the site of El Zafrin. $^{14}$C dates from Ifri Ouzabour fit perfectly into this time slot with an age of 7.3 ka cal BP. The occupation of the site during the Late Neolithic at around 5.6 and 5.2 ka cal BP is also adjusted to regional chronology dated between 5.7 and 3.8 ka cal BP.

Marked by its ceramic furniture making this deposit the most eccentric point of confirming the presence of Cardial on the Southern shore of the Mediterranean coast, Ifri Ouzabour is also characterized by its grinding and milling tools unearthed in archaeological levels associated to Early and Late Neolithic. This collection has aroused particular interest given by its high number and typological richness. No regional comparison can be performed in the absence of specialized studies of milling instruments in the surrounding sites. Indeed, the discovery of this type of equipment is particularly rare in nearby Neolithic sites and is limited to one or two copies. The existence of some specimens is reported briefly and occasionally in the general counting of the archaeological material without description or morpho-typological study.

## CONCLUSION

This preliminary study is a first attempt to analyze, define descriptive standards and raise new issues and problems related to the study of grinding and milling tools. The assemblages recovered from Ifri Ouzabour demonstrate changes related to increasing use of this tools in Late Neolithic compared to Early Neolithic. The grinding material analysis helped determine the worked materials and the surface preparation processes to understand the choice of rocks and forms sought. Besides the morpho-typological study, functional diagnostics is attempted through macroscopic analysis of surface states, traces of wear and residue. Analytical methods were designed to identify the potential wear surfaces, distinguish the wear formed through use intentional and sort the tools by types. The dyes grinding is evidenced on the basis of the residues of pigments conserved on the surface of grinder-handstones while the work of other substances including plants and leathers to be proven by multidisciplinary analysis. At this stage of the research, it appears important to complete this work by various analyzes and studies including traceology in order to interpret objectively the use of these tools.

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