



Actes du XIVème Congrès UISPP, Université de Liège,  
Belgique, 2-8 septembre 2001

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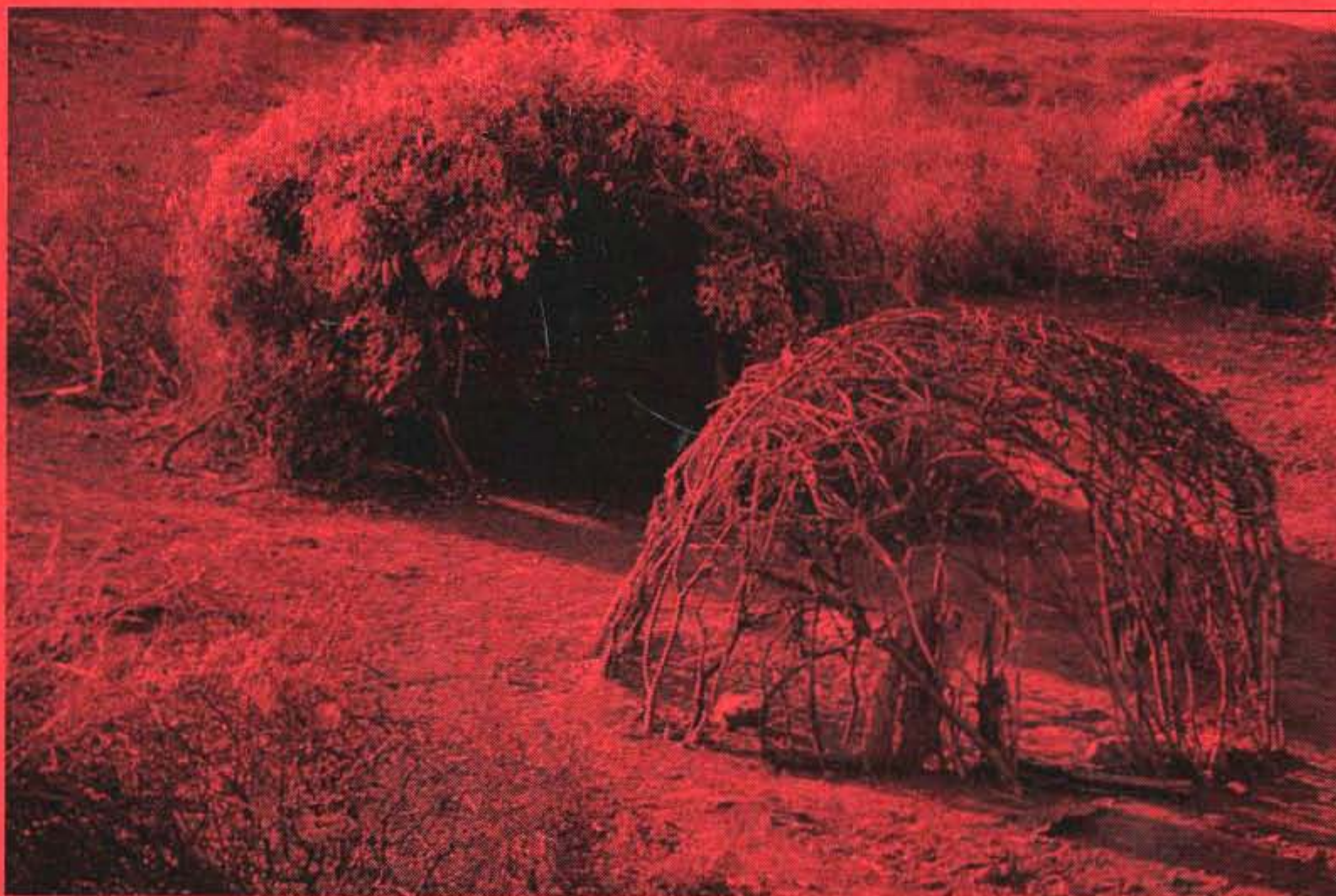
Colloque / Symposium 1.4

# L'outillage lithique en contextes ethnoarchéologiques

## Lithic Toolkits in Ethnoarchaeological Contexts

Édité par / Edited by

Xavier Terradas



BAR International Series 1370  
2005

# ANALYSIS OF AN ARCHAEOLOGICAL GRINDING TOOL: WHAT TO DO WITH ARCHAEOLOGICAL ARTEFACTS?

Débora ZURRO, Roberto RISCH & Ignacio CLEMENTE CONTE

**Abstract:** This paper aims to offer an alternative approach to conventional (and often even non-existent) studies of macrolithic or ground stone tools found in archaeological contexts. The analysis of a unique artefact, a “mano”, from an ethnographic context (Dogon country, Mali), is used to develop a methodological model for the daily archaeological research of this type of material. From the standpoint that labour processes (which are materialised in archaeology mainly as tools and finished products) are the key elements in the understanding of prehistoric societies, we propose a methodology which integrates use-wear analysis (addressing the participation of the tool in the productive cycle) and residue analysis (allowing an understanding of the processed good). The combination of both techniques should allow us to make evident a series of materials and working processes that have hardly been documented in the archaeological record until now, or even remain unknown.

**Résumé :** Cet article a l'objectif d'offrir une alternative aux études classiques concernant le macro-outillage provenant des contextes archéologiques. L'analyse d'un unique outil, dans ce cas une « mano » provenant d'un contexte ethnographique (pays Dogon, Mali) a été réalisé afin d'obtenir un modèle méthodologique à suivre dans notre recherche archéologique quotidienne. Partant de la prémisse que les processus de travail (lesquels sont habituellement matérialisés dans les gisements archéologiques sous forme d'instruments et de produits/biens) constituent l'aspect primordial qui va nous permettre arriver au connaissance des sociétés préhistoriques, nous considérons nécessaire la combinaison de l'analyse tracéologique (qui constate la participation de l'instrument dans le cycle productive) et l'analyse des résidus conservés sur des surfaces des outils (qui permet une approximation aux matériaux processés). La combinaison de ces deux techniques devrait nous permettre rendre en évidence dans le registre archéologique des processus de travail et des matériaux transformés qui n'ont pas été jusqu'à maintenant documentés.

## INTRODUCTION

Macrolithic or ground stone tools comprise a wretched category among prehistoric artefacts. Despite their good preservation and frequency in the archaeological record, these objects are only mentioned superficially, if at all, in most excavation reports, and are seldom seen to deserve a thorough petrographic and technological study. Systematic recording carried out on some exceptional excavations (e.g. Zimmermann 1988; Risch 1995; Böhner 1997; Stranini and Voytek 1997; Castro et al. 1999) encourages the suspicion that thousands of stone tools usually end on the spoilheap or, less likely, are stored in deposits of archaeological museums<sup>1</sup>. This “sampling strategy” contrasts, at least in the later Prehistoric sites of the Western Mediterranean, with the exhaustive documentation and study of pottery, bone, metal, wooden or flaked stone tools, materials which tend to appear in small quantities or are more likely to be affected by taphonomic processes (fragmentation, degradation, etc.), which limit their heuristic potential.

The marginal attention paid to macrolithic artefacts is also surprising in view of their importance as the technical means of many production processes in prehistoric, but also historical times. Grinding, pounding, polishing, burnishing, hammering, cutting or casting are some of the activities which can be carried out with stone tools.

Therefore, societies have developed a great variety of tool types which were used to process grain and other plants, meat or skin, in pottery production, metal working, mining, etc. Many activities can only be identified in the archaeological record by means of the stone artefacts employed. Given that the final products obtained are destined to and transformed in the consumption process, these tools are also an important means for quantifying the volume of production. Consequently, it must be argued, that any archaeological approach concerned with questions like “what”, “how” and “how much” was produced by a society, implies a definition of the technical means of production, where stone artefacts have played a significant role until historic times.

The claim for a more rigorous analysis of the ground stone assemblages has been made repeatedly in the last decades (e.g. Kraybill 1977; Wright 1992). Yet, although some methodological and empirical progress has been achieved, it still holds true that, in general, these archaeological materials are analysed and published in an insufficient way. Thus, aspects which are crucial in order to understand the development of the forces of production in different societies, such as the morpho-technological changes of tools and their spatial distribution during later Prehistory, remain unknown.

The reasons for such research deficiencies seem to be diverse: the weight of the stone assemblages causes transport and storage difficulties; many artefact types are considered uninteresting because of their rough aspect and, in Binford's terms, “expedient” character; for similar reasons they can hardly be used in chrono-typological studies, which still play an important role in European

<sup>1</sup> Just to give an approximate figure of the volume of stone tools which can be expected in prehistoric settlements of the western Mediterranean: in a systematically excavated multi-phase Bronze Age site like Gatas (Almería), where all sediment is sieved, 345 tools were recovered in only 60 m<sup>2</sup>.



Figure 1.

archaeology; their geological, morphometrical and functional variability requires a combination of different analytical approaches (geology, petrography, material behaviour, typology, functional analysis). Yet, in our view, the main difficulty lies in the insufficient development of a research methodology, which allows the understanding and explanation of these artifacts in relation to the productive processes and economic structures of which they formed part. Interpretative models are necessary that give meaning to the natural resources used, the observed morphometrical variables and the use-wear patterns (e.g. Hayden 1979, 1987; Adams 1989, 1993; Risch 1995, 2002).

One way to progress in our understanding of the natural, formal and technical parameters involved in the formation of a stone tool is through analysis of social and economic contexts where these materials are still used (e.g. Horsfall 1987; Baune 1989; Gronenborn 1994). Such approaches allow the testing and improvement of the methodology of ground stone studies, and the gathering of reference patterns for our archaeological observations. The present study applies a series of functional analyses of a grinding instrument collected by one of us in 2000 at the Bandiagara fault in Southeast Mali. This artefact was being used by Dogon women in order to produce millet flour in grinding areas placed on a large medium and coarse grained sedimentary rock (Fig. 1).

A quartzite river cobble was used as a grinding tool, which, apparently, required no specific shaping process.

Nearly all sides the natural surface were altered through working processes. Macroscopically, polished surfaces are visible on the obverse and reverse sides, while the top, left and right sides present a rough aspect (Fig. 2). The length, width and thickness of the tool are 10, 9, and 3.9 cm respectively. Compared with the type of tool recorded in American Indian contexts, these dimensions are rather small for a "mano" which was used with two hands during the grinding process.

In the numerous settlements of the Dogon country, which are distributed on the high plateau, as well as at the foot of the Bandiagara fault and in the plain which extends from here to Burkina Faso, one observes the use of different wooden mortars and grinding stones for the production flour (especially millet) and/or oils (peanut). The economy of these villages is based on agriculture and some husbandry. Millet is the main crop and plots of rice, onions and other agricultural products exist in the area of the fault, where small dams for irrigation have been build. The Dogon take great care in the construction of granaries in which grain and flour are stored. They are build on platforms, that isolate the products from the rain, roofed with straw and they present only a small opening, such as a window or door, which allows access to the stored products. Each family owns several of these constructions and female granaries can be distinguished from male buildings. While the first present four compartments in which different types of grain and spices are stored, the male granaries only store millet ears in a single room. The

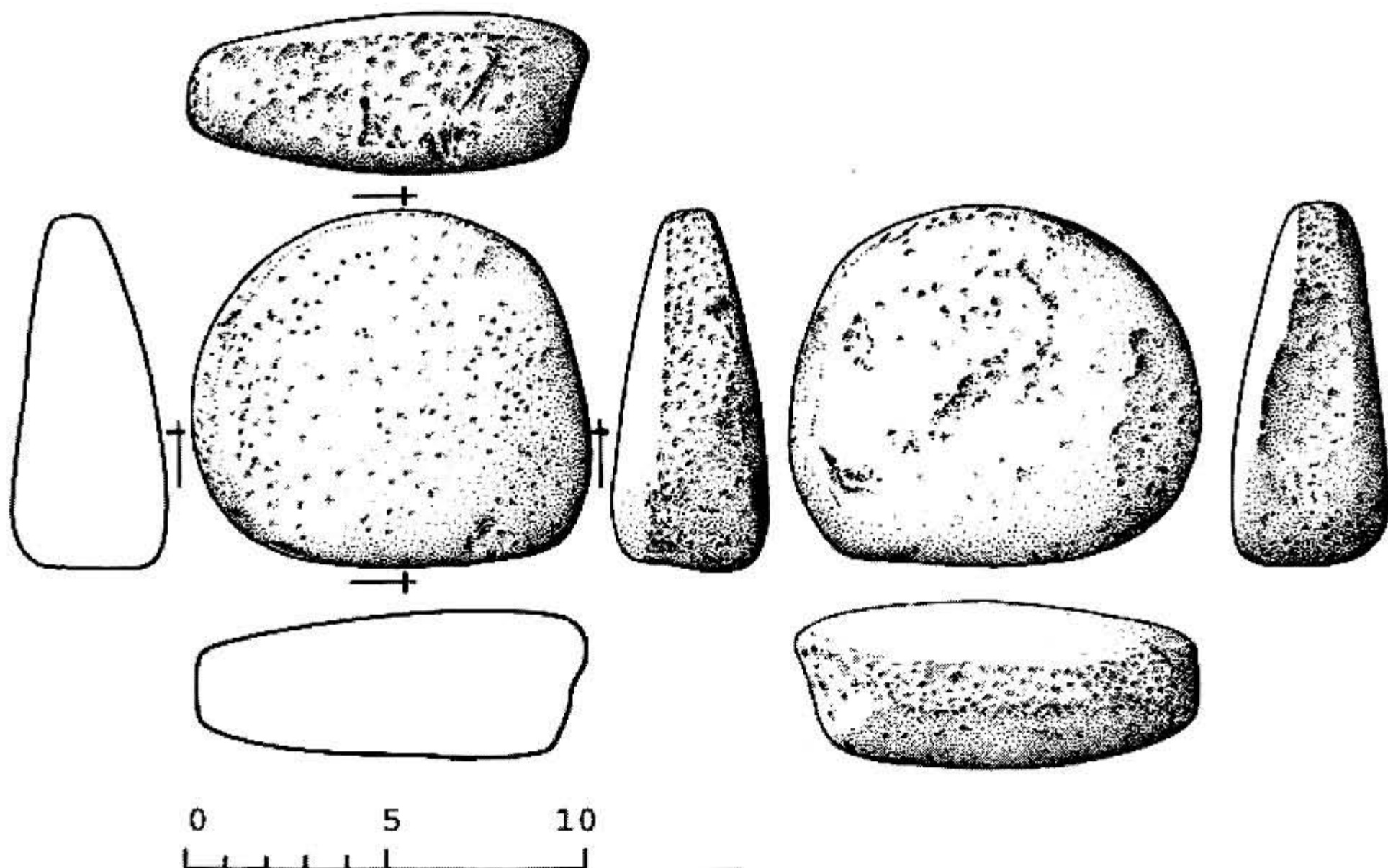


Figure 2.

wife provides the family with food over the whole year, and when her stock is exhausted, the husband continues grain distribution, underlining in this way his control over the basic subsistence product.

Apart from movable querns in domestic contexts, grinding areas also exist outside the villages. The area to which the “mano” studied belongs is located immediately above the Bandiagara fault, next to millet fields, and the distance to the nearest two villages is approximately 1 km. The “grinding platform” presented 4 grinding basins, and around them a series of “manos” were placed. In total 6 handstones could be recorded, but their association with the basins presented an irregular pattern (3, 2, 1 and 0 “manos” x basin). This millet processing complex was not used on a daily basis, but only occasionally, apparently when other activities were carried out in the area.

In order to analyse the plentiful residues present on the active surfaces of the collected “mano” a simple brushing was enough to obtain a minimal sample necessary for microscopic observation. In order to document the use-wear all residues had to be removed from the tool. Therefore the stone was subjected to an ultrasonic bath for 20 minutes, but numerous starch grains remained attached to the surface. A new bath took place, using this time a 10% HCl to allow an easier cleaning of the pores. A thin covering of white and black particles was still present at

some points, showing the resilience of this type of residue (Fig. 3).

### MESOSCOPIC FUNCTIONAL ANALYSIS

Semenov (1981) already considered the study of macrolithic tools, such as axes, mortars, polishers or so called arrow straighteners, when he introduced use-wear analysis to archaeology. Contrary to what has occurred since then with chipped stone industries, the development of functional analysis related to other stone artefacts is limited (see, mainly, Hayden 1979, 1987; Adams 1989, 1993; Risch 1995, 2002).

Semenov, as well as more recent studies, have applied a mesoscopic approach, analysing this type of artefact under 10-80X. One reason is that the field of observation is frequently more important than magnification in order to identify the type of alteration produced on the granular rock surfaces. Still, the potential of high power or ESM observations is a field which should be tested in the future (see below).

Based on our own experiences with functional analysis of experimental and archaeological tools, the following use-wear traits are considered relevant in a mesoscopic approach:

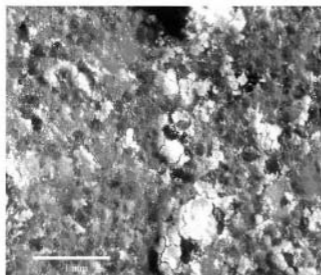


Figure 3.

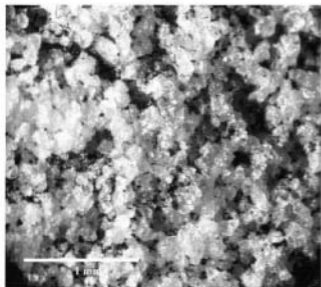


Figure 4.

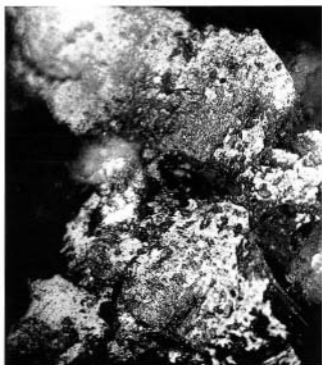


Figure 4.

An important aspect among abrasive artefacts is the description of the topography of the surfaces and the degree of invasiveness of the use-wear (Adams 1993). In qualitative terms, it is therefore useful to differentiate during microscopic observation between a high, middle and low microtopography.

One of the main factors that affects the appearance of wear traces is the mineralogical composition, grain size and grain organization (fabric) of the rock used as a tool. The same activity can produce different types of use patterns depending on the type of raw material. Therefore, it is important to undertake a detailed petrographic description and to describe the wear traces visible on each mineral/grain type present in the artefact.

The artefact collected at the Bandiagara fault is a fine-grained (c. 0.1-0.3 mm) quartzite cobble stone, with a very homogeneous grain structure. Previous analysis of experimental tools has shown that quartz and quartzite tools develop different abrasive wear traces, than basalt, diabase or gabbro. While under macro- and mesoscopic observation striations are a characteristic feature of the later, they appear less developed on quartz (Broadent 1979; Risch 1995).

Practically all sides of the clast present alterations of the natural surface. Only the bottom part does not seem to have been used actively (fig. 1). While a smooth surface can be observed on the obverse and reverse sides, the top, left and right faces present a rough aspect (Fig. 2, 3 and 4).

#### Obverse and reverse side

The dominant feature under mesoscopic observation (45X) is an intense leveling of the quartz grain (Fig. 3). Yet, the

1. linear traces (Semenov 1981), were striations (width < 0.5 mm) or scratches are differentiated (width > 0.5 mm);
2. polish or sheen (Semenov 1981);
3. plaque (Hayden 1987: 87-88);
4. edge-rounding (Hayden 1979: 18-19; Adams 1989);
5. leveling (Adams 1989);
6. grain aggregate or extraction (Hayden 1987: 86; Adams 1993);
7. frosted appearance (Hayden 1979; Adams 1989);
8. pitting (Hayden 1987: 86-87; Adams 1989; 1993);
9. checks (Hayden 1987: 85-86);
10. fractures, which can classified into conchoidal or stepped fractures (Hayden 1979: 19, 1987: 91);
11. crushing or shattering (Sussman 1988: 17; Hayden 1979: 19, 1987: 89-91).

surfaces are not completely smooth or flat, but show a slight asperity. This factor appears to limit the development of polish or sheen. The margins of the grain can present microfractures. The shallow interstices between the quartz grains seem to be slightly worn out, indicating adhesive wear (Adams 1993). Another important wear trace is grain extraction. No use-wear traits extend into the resulting pits, i.e. into a low topography. Fine, more or less parallel striations are hardly visible, while scratches occur occasionally.

These use-wear traits correspond to a large degree with the observations made on experimental and archaeological grain processing artefacts, made out of sandstone, vesicular basalt and psammitic shists. The patterns usually reported for stone against stone contact with vegetal intermediate material are leveling of the grain surfaces, fractures of the grain edges, pits caused removal of grains or grain aggregates, scratches and striations on the high topography, and superficial sheen, in case oily substances are ground. The leveled surfaces do not present a completely smooth aspect, as is the case, for example, after a stone against wood contact (Adams 1989, 1993; Risch 1995, 2002).

It is interesting to point out that the active surfaces of the artefact extend slightly from the obverse and reverse sides to the bottom part. Moreover, the active surface on both sides are divided into an upper and lower facet, separated through a slight ridge where abrasion is less intense. These features are the result of the way in which the artefact was worked during the grinding process, and confirm the model proposed by Adams (1999: 482; fig. 4), based on experimental grain processing tools. Two faceted use-surfaces on "manos" are indicative of working in basin (concave) grinding stones with a reciprocal, rocking stroke, which actually is the grinding technique observed in Southeast Mali. Here the pressure produced with the away-stroke is prolonged by slightly elevating the front part of the "mano", which allows the active use of the margins of the bottom side of the artefact, and produces the described downward enlargement of the lower use-facet.

The only differences between the obverse and reverse active surfaces are the intensity of the abrasive traces, and the adhered residues. Use-wear on the first presents a more developed or "fresher" appearance, and its surface was covered, before cleaning, with the white flour adherences described. The reverse side presents mainly dark residues, which are also very extended on the top, left and right sides. The aspect of both the white and black particles is practically the same, and despite the intense cleaning process, part of these residues continued to appear adhered as a film in the interstices of the stone surface (Fig.3). In both cases we seem to be dealing with flour remains, which were pressed onto the surface during the intense grinding process. The colour differences must be caused by a chemical alteration of the residues after some time of exposure of the tool in the open air. After each working session the quartzite "manos" were left on the bedrock, next to the grinding basins. While the white adherences had formed during the activities that had just taken place when the "mano" was collected, the black coloured

residues correspond to a previous session. Unfortunately the periodicity of these grain processing activities at the Bandiagara fault could not be confirmed, although a yearly cycle is probable.

It is interesting to point out that this type of thin adherence of black residues has also been observed occasionally in grain interstices on the surfaces of prehistoric grinding stones from Southeast Spain, which clearly were used for grain processing. Closer analyses have not been carried out so far. The high resistance of these remains to degradation processes might imply that here we have a further functional indicator for this type of activities.

### Top, left and right sides

All three sides show a continuous irregular, pitted surface (Fig. 4). Such intense material extraction is caused by impact loosening or pulverising of the grains. A second use-wear trait is the edge-rounding, produced by an abrasive processes which eliminates the sharp edges of the quartz grains at a high topography. Grains at a lower topography maintain their natural edges, indicating that the use-wear is not penetrating in the interstices, i.e. that we are dealing with percussive activities on hard materials, such as rocks. Large conchoidal fractures occur very occasionally at the margins of the pitted surfaces, invading the obverse and reverse sides (fig. 1). Given the hardness of quartzite and according to experimental models of use-wear development, all these features are considered to be characteristic of intense and/or prolonged percussion on stone surfaces (Risch 2002: 128-131).

Such use-wear patterns also closely resemble the blunted prehistoric celts from Guatemala described by Hayden (1987: 96-101), and which are still (re)used today for reworking grinding stones. Here the raw materials are mainly greenstones with a grain size ranging between 0.01-0.5 mm. The most distinctive use-wear observed on the blunted celt edges is an irregular topography, caused mainly by pronounced pitting. Also in this case macrofractures can occur in limited numbers (0-4) at the margins of the edges. Rounding of the grains is not reported in this case, possibly due to the low magnification used (generally 12X), but abrasive wear is visible on the microphotographs (Hayden 1987: 98).

All these pitted surfaces have a dark colour, produced by the presence of the same type of residues adhered in the grain interstices, as observed on the reverse side of the artefact (Fig. 4). Two conclusions can be drawn from these occurrences. First, the top, left and right sides also interacted with the processed cereal grain or flour. Second, these active surfaces were used, as the reverse side, in a previous working session and not recently, given the absence of white particles. In conclusion, it seems that this artefact had been used for working by percussion of a stone surface covered with flour. As we have no indication at the site that millet was processed through pounding, and given that such an activity is not expected to cause the observed use-wear patterns, the lateral sides of the stone tool must have served for re-roughening the grinding basins, when these became flat and their efficiency

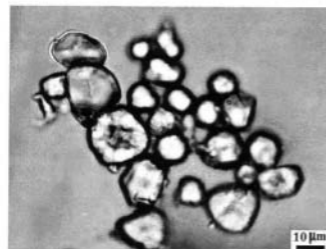


Figure 5.

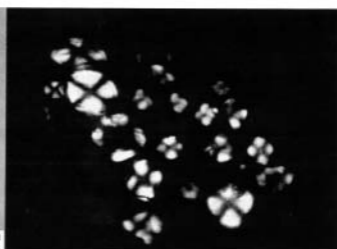


Figure 6.

declined. The fact that millet flour covers the whole activity area at Bandiagara and is not removed systematically (Fig. 1), explains the presence of flour adherences on the pecking surfaces. Re-sharpening is an occasional activity<sup>2</sup>, and was probably not carried out in all grinding basins during each grinding session.

### MICROSCOPIC FUNCTIONAL ANALYSIS

Microscopic use-wear traces are visible on the obverse and reverse sides of the artefact, although they appear more developed on one of them. The traces are distributed significantly over those areas which have received more contact and pressure with the grinding basin. At a macroscopic level, such surfaces present a specific sheen and allow the reconstruction of the cinematic of the instrument. Through a metallographic microscope one observes a micropolish with a compact development on the highest topography, which is bright and not massive and whose aspect is between smooth and rough<sup>3</sup> (Fig. 5). In general, this type of micropolish brings to mind experimentally produced traces through contact between two lithic materials (friction of stone against stone). Nevertheless, it seems to have more volume and a smoother aspect, possibly due to the contact with the processed grain.

### RESIDUE ANALYSIS

Most perishable products, and particularly materials of vegetable origin, only appear occasionally, under exceptional conditions of preservation in archaeological

sites or as vegetable residues such as phytoliths, silica skeletons or starch grains. These residues present a high durability and resistance to dissolution, as well as to percolation (Therin 1994).

Starch, as a reserve substance, is especially localised in certain parts of the plant (seeds, tubers, roots and fruits) and forms the basic component of vegetable flours. Therefore, it is especially important in the study of grinding stones, as it allows the confirmation of their function in ambiguous cases as well as a more specific determination of the processed species.

The analysis of starches began in the 19th century (Nägeli, Mayer), but it was not adopted as an archaeological technique until recently (Loy 1994, Piperno et al. 2000, Therin et al. 1999), being applied primarily in certain geographical areas (Mesoamerica and Australia).

In the case of the stone tool from Mali, after the extraction of the residues, these were washed in a centrifuge with distilled water at 2,000 r.p.m. for 3 minutes (three consecutive times). Finally they were disposed, in parallel, on slides with distilled water and with a synthetic resin (Eukitt) for observation under the microscope (Olympus BX-51 at 400x).

The identification of starch grains can be carried out with different methods (Loy 1994), although the most common and straightforward one is the verification of the presence of the extinction cross or *hilum*, which can be seen with the optical microscope under polarised light. The *hilum* results out from the molecular structure of the grains (Esau 1969) and produces birefringence and optical anisotropy. Its morphological variation can be used as a key to plant identification, by comparing archaeological samples with known present day materials from the reference collection. Usually employed *variables* are the form and composition of the grain (simple or composed), as well as the form of the extinction cross (Loy 1994). At its present stage of development, this research method does not allow us to achieve a very precise identification of the taxa. Apart

<sup>2</sup> Depending on factors such as rock type, use intensity, or tool shape, resharping frequencies can range from once every five days to once every year (Horsfall 1987: 341). The average reworking interval reported for metates from Mesoamerica made of vesicular basalt is 3 months (s.d. = 1.8) (Hayden 1987: 96).

<sup>3</sup> The description of the micropolish follows the definitions proposed by González e Ibáñez (1994) and Clemente (1997).

surfaces are not completely smooth or flat, but show a slight asperity. This factor appears to limit the development of polish or sheen. The margins of the grain can present microfractures. The shallow interstices between the quartz grains seem to be slightly worn out, indicating adhesive wear (Adams 1993). Another important wear trace is grain extraction. No use-wear traits extend into the resulting pits, i.e. into a low topography. Fine, more or less parallel striations are hardly visible, while scratches occur occasionally.

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