Taphonomic interpretation of the Developed Oldowan site of Garba IV (Melka Kunture, Ethiopia) through a GIS application

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A GIS intra-site application for the taphonomic interpretation of the Developed Oldowan site of Garba IV (Melka Kunture, Ethiopia) allowed the automatic data processing of more than 12,000 lithic artefacts and faunal remains lying on a 100-sq. m excavated palaeosurface dating to about 1,500,000 years ago.

Key-words: Melka Kunture, Oldowan, GIS, taphonomy

Introduction

Melka Kunture is a valley site formed mainly of fluvial sediments, extending for over 5 km along the banks of the Awash (FIGURE 1). Its deposits attain a maximum depth of 100 m, and are interspersed with tuff and cinerite providing important chronological markers. The site, discovered in 1963 by hydrogeologist Gérard Dekker, was explored systematically by a French–Ethiopian expedition directed by Jean Chavaillon from 1965 to 1982, and then again from 1993 to 1995. Since 1999, an Italian expedition directed by one of the authors (MP) has been collaborating with J. Chavaillon to create an open-air museum on the site and publish the abundant geological, archaeological and paleontological data gathered so far (Berthelet *et al.* 2001).

Of the over 70 archaeological levels identified so far, about 20 have been partially inves-

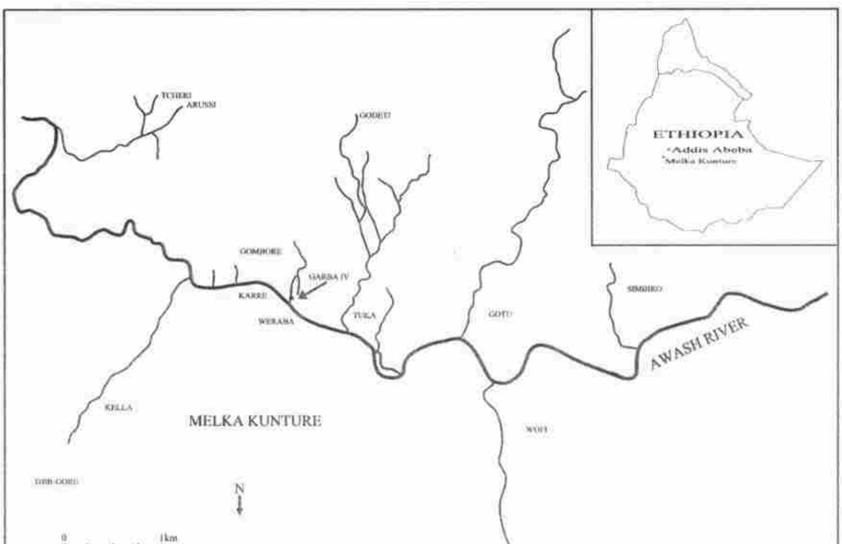

FIGURE 1. *Map of Melka Kunture showing the location of the main Palaeolithic sites in the area.*

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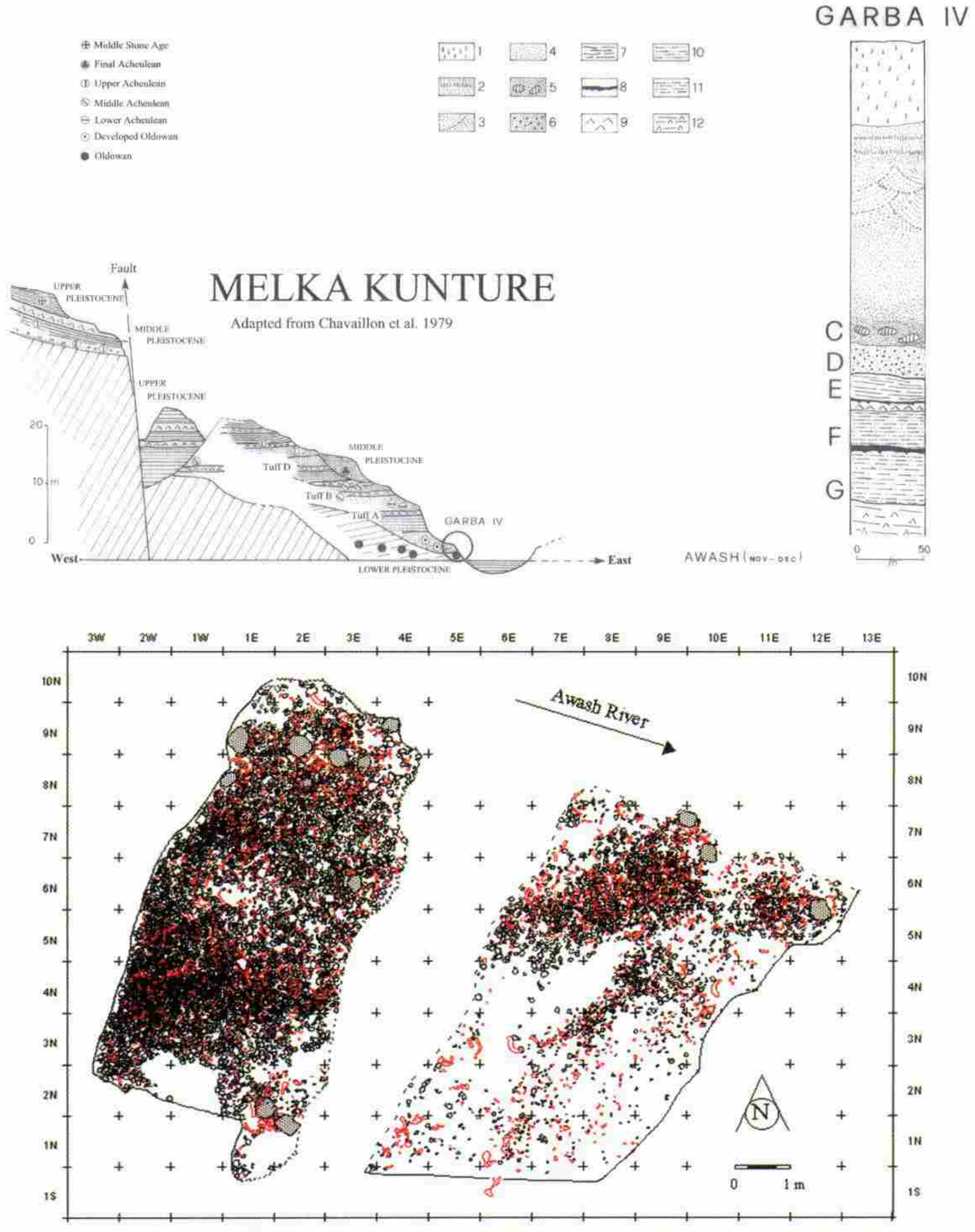
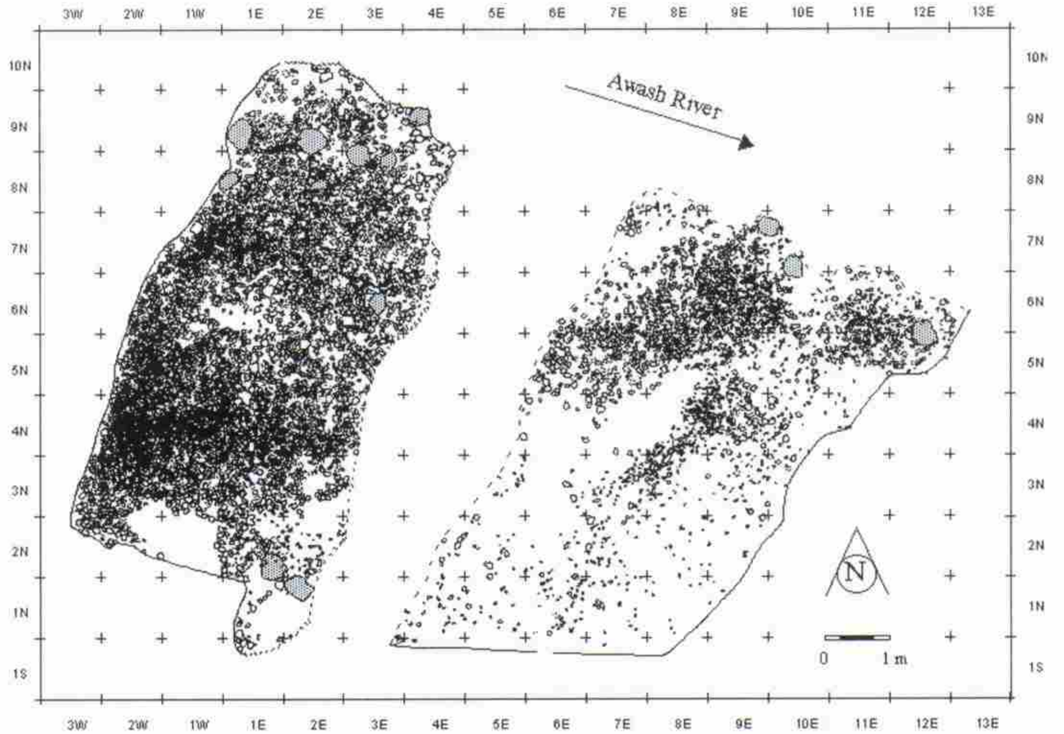


FIGURE 2. Top. *Simplified stratigraphy of Melka Kunture and schematic section of Garba IV.* 1 *black cotton soil;* 2 *sand with clay lenses;* 3 *cross-bedded sand;* 4 *fine sand;* 5 *sand with clay nodules;* 6 *sand with fine gravel;* 7 *clay;* 8 *ferruginous crust;* 9 *ash and tuff;* 10 *consolidated sandy clay;* 11 *sandy clay;* 12 *tuffaceous clay).* Bottom. *The excavation area. Red: fauna; black: lithic industry; dotted: large basalt blocks.*



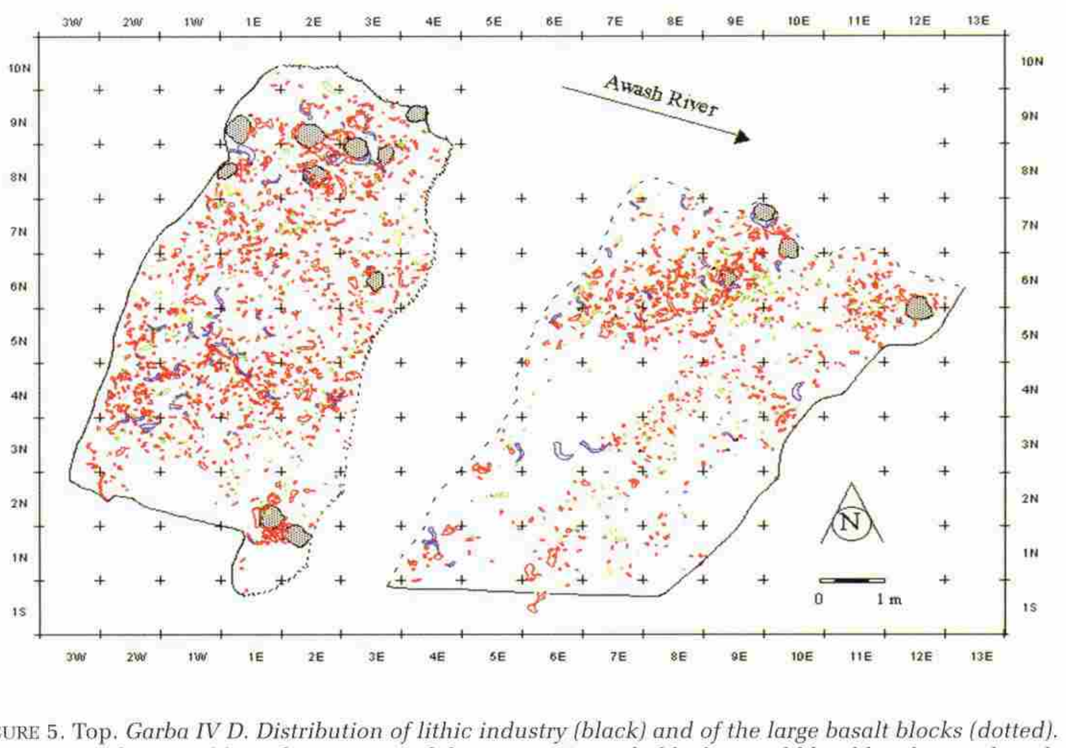


FIGURE 5. Top. *Garba IV D. Distribution of lithic industry (black) and of the large basalt blocks (dotted).* Bottom. *Distribution of faunal remains. Red: bones; green: teeth; black: mandibles; blue: horns; dotted: large basalt blocks.*

FIGURE 3. *Garba IV D. General view of the western sector of the excavation.*

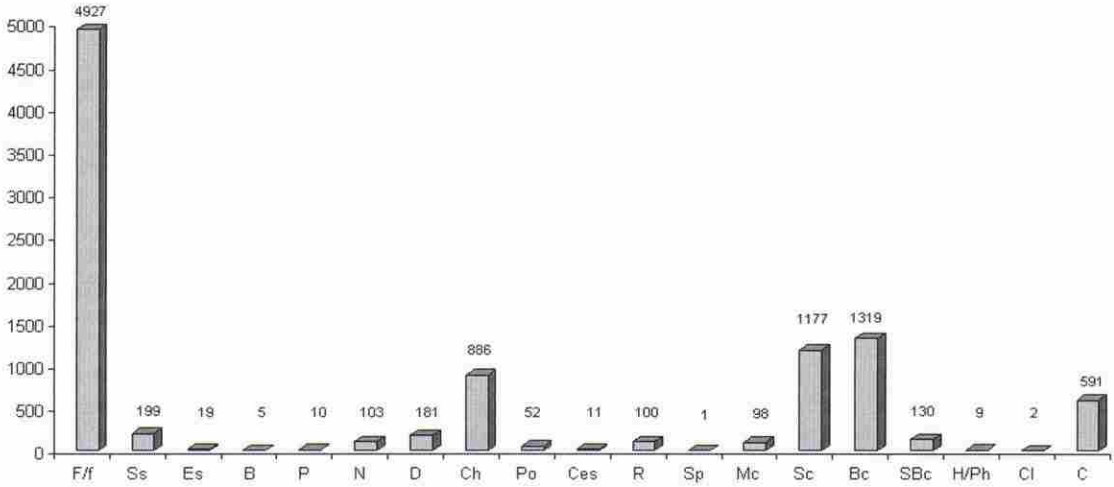


FIGURE 4. *Garba IV D. Typology of lithic industry.* F/f *flakes and fragments;* Ss *side-scrapers;* Es *end-scrapers;* B *burins;* P *perforators;* N *notches;* D *denticulates;* Ch *choppers;* Po *polyhedrons;* Ces *carinated end-scrapers;* R *rabots;* Sp *spheroids;* Mc *modified cobbles;* Sc *split cobbles;* Bc *battered cobbles;* SBc *split and battered cobbles;* H/Ph *handaxes and proto-handaxes;* Cl *cleavers;* C *cores.*

tigated, while 8 have been extensively excavated; the latter are referable to the Oldowan (Karre I and Gombore I), the Developed Oldowan (Garba IV, Gombore Iγ), several phases of the Acheulean (Garba XII J, Gombore II, Garba I) and the Middle Stone Age (Garba III), with ages ranging between 1,700,000 and 200,000 years old (Chavaillon *et al.* 1979).

The site of Garba IV is one of the most interesting, especially extensive and with abundant lithic and palaeontological finds spanning a broad chronological range (Piperno & Bulgarelli 1974–1975). The site, excavated from 1973 to 1982 (FIGURE 2), consists of five late Oldowan (about 1,500,000 years) archaeological layers (from the top down: C, D, E, F, G). A right hemimandible attributed to a 3–5-year-old *Homo erectus* child was found in level E. An area of about 100 sq. m at level D (FIGURE 3), explored systematically, yielded an extremely dense concentration of nearly 10,000 artefacts and over 2,700 faunal remains, mostly of bovids, equids, suids, hippopotamuses, elephants, giraffes and a primate resembling the present-day gelada (baboon) (Geraads 1979).

The lithic tools are made from volcanic rocks (obsidian, basalt, lava, trachyte, tuff). Most of the flake tools are made of obsidian, while the pebble tools are mainly of other volcanic rocks. This lithic assemblage is characterized by a high percentage of flakes and fragments, mono- and bidirectional choppers, heavy scrapers and polyhedrons. It also includes broken and battered pebbles, cores and core fragments, some retouched tools (side-scrapers, denticulates and notches), a few bifacial tools and two cleavers (FIGURE 4).

Computerized archaeological investigations

Intra-site spatial analysis makes a fundamental contribution to the interpretation of prehistoric deposits, especially in extensively investigated sites. Since the spatial distribution of archaeological evidence often reflects the functional organization of a site, statistical analyses aimed at the classification of finds and the highlighting of specific associations can be extremely useful. In a recent essay on the study of artefacts, Djindjian (2001) discusses once again the most commonly employed quantitative methods for the analysis of spatial data. He points out that intra-site analysis is still a relatively new method and hence open to considerable improvement, especially in the selection of data used in spatial distribution models.

In the interpretation of 'social structures', considered as functional areas into which a given archaeological surface is subdivided, special attention should be given to the position of artefacts and the distribution of faunal and paleobotanical remains. Spatial technology, and especially GIS, are particularly effective in correlating the spatial distribution of evidence with analytical studies of each individual find.

It should be stressed that, although many computer applications for the recording and processing of excavation data are generically called 'GIS', a true GIS is distinct from a cartography or mapping application, not only because it allows the integration of spatial and non-spatial data, but first and foremost because it processes, manipulates and visualizes information differently. In fact, one of the main functions of a GIS is to generate derived information based on the integration of thematic data. By interrogating spatial or alphanumerical variables contained in archives, it is possible to single out elementary spatial units which may correspond to functional areas. Within each unit, the various categories (faunal remains, artefacts, etc.) can be counted individually, or as part of a group of categories to speed up comparison between units and analysis of areas with different surfaces and characteristics.

Although these capabilities have led to an increase in the use of GIS in site analyses, there are several risks involved in the 'conversion' of spatial data to a digital format. The logical and physical structure of the application needs to be accurately planned to make up for the limitations imposed by 'electronic translation'. Special care should be given to planning the alphanumeric archives of the application and programming its vectorial graphics. However, since the description and organization of information levels include no explicit interpretation or explanation of the nature of associations between investigated objects, the point of departure for the deduction, reconstruction and explanation of spatial phenomena must be the structuring of spatial entities and the descriptive variables associated with them.

Our decision to use a GIS application to analyse the archaeological evidence of the Oldowan sites of Melka Kunture was prompted by the need to simplify the processing of data gathered during various excavations and generate single or derived computerized maps based on paper maps drawn in the field (D'Andrea *et al.* 2000). By applying specific modules to interrogate the archives, we were able to generate several tables showing the distribution of certain object classes. To compare the distributions of these classes over the whole investigated surface, we superimposed a grid on the excavation area. Then we employed topological overlay, a typical function of GIS, to run an automatic calculation of the number of occurrences of objects in each square of the grid. In this way we got density values — expressed in absolute terms or as percentages — for each class of objects within each square. We then proceeded to analyse frequency maps for specific classes to highlight what we felt were significant distributive patterns for specific classes.

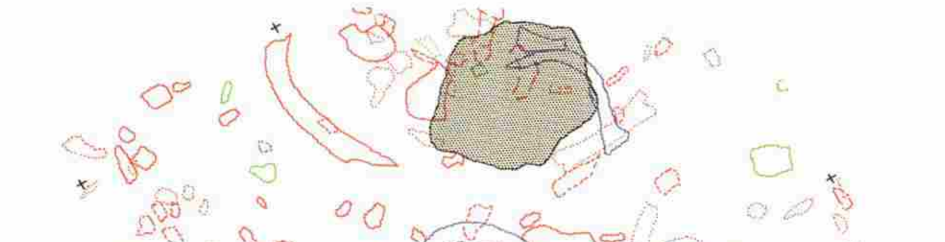


FIGURE 6. *Garba IV D.* Top. *Detail of the large basalt blocks surrounded by faunal remains in the northern area of the western sector.* Bottom. *General view of the large blocks and faunal remains in the same area. Red: bones; blue: horns; green: teeth; dotted: large basalt blocks.*

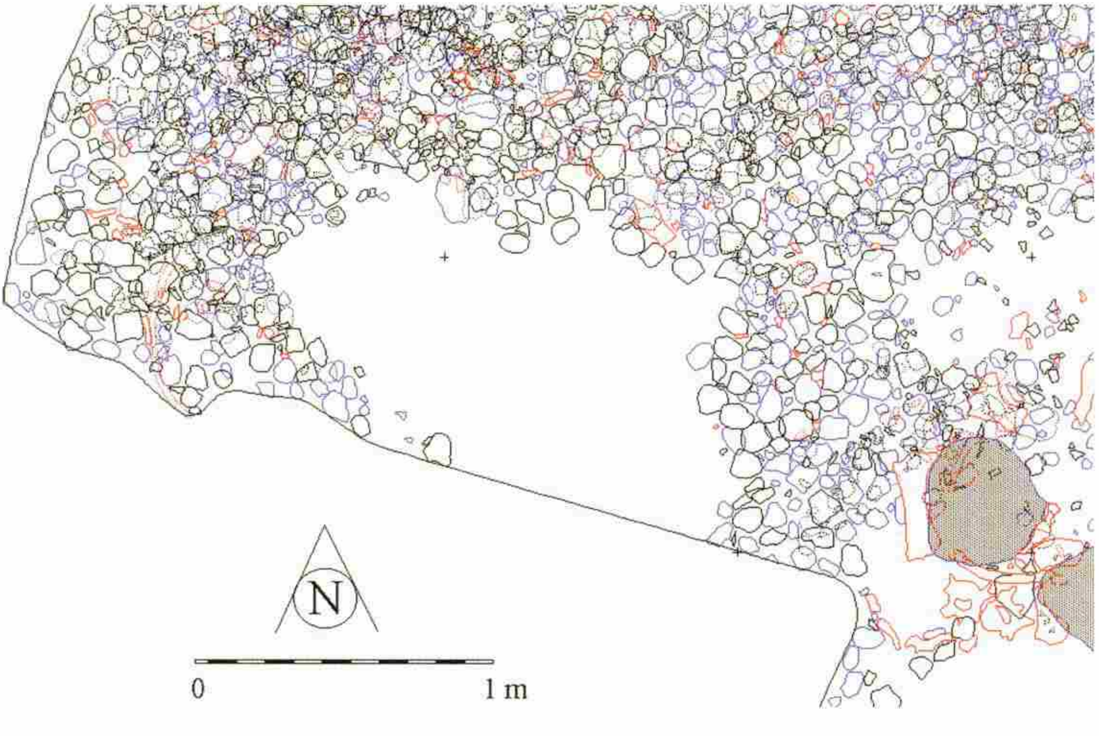


FIGURE 7. *Garba IV D.* Top. *Detail of the semicircular area without remains in the southern area of the western sector.* Bottom. *Plan of the same area. Red: bones; black: lithic industry; blue: unmodified pebbles; dotted: large basalt blocks.*

The flexibility of the GIS allowed interactive processing of information, as well as the verification of alternative hypotheses simply by adding or removing specific object classes from the derived maps, or modifying the size of the grid squares.

The results we have obtained so far have encouraged us to undertake further quantitative investigations in two new fields. On the one hand, we are applying statistical techniques based on square methods such as chi-test, spatial correlation coefficients and trend surface analysis (Hodder & Orton 1976) to establish whether the distribution of objects over the palaeosurface of level D is random or determined by human agency. On the other hand, we are developing methods based on the simple consideration that, while GIS allows the visualization of multiple spatial variables, the nature of depositional processes is such that one is rarely able clearly to distinguish certain associations. In particular, the application of multivariate statistic methods can play a decisive role in the filtering of data, and hence in bringing into view latent structures which post-depositional events have made invisible to traditional methods of observation.

The GIS application to Garba IV D

We chose to employ a GIS application to study the spatial distribution of the evidence of level D of Garba IV because of the difficulties we had experienced in analysing over 12,400 lithic and faunal remains gathered on the site's palaeosurface (D'Andrea *et al.* 2000).

We needed an application capable of performing the following operations:

- visualization of all finds as spatial variables;
- bi- and tridimensional spatial interrogations (topographical selections, removal of post-depositional noise) to reconstruct the anthropic or post-depositional processes which led to the formation of the deposit;
- statistical inference of spatial data (spatial correlation and autocorrelation, trend surface analysis) to highlight concentrations and significant associations, or relationships between different object categories.

The first step in our research was to convert the data to a format compatible with digital processing. The original paper archives were converted into a database allowing a wide range of single or multiple queries in order to sort and count the data, a fundamental function for statistical analysis.

The next step was to convert the plans of the excavation to a vectorial format. Each object was assigned an exclusive value (or primary key) consisting of its inventory number. This key provided the link for the importation of the database, allowing simultaneous interrogations of graphical objects and the database information connected with them, as well as the generation of different types of maps by visualizing finds on a palaeosurface either individually or in association with any other type of information.

We simplified the visualization of the density or dispersion of remains by using SQL (Standard Query Language) to create frequency maps grouping objects by value range. In these maps, archaeological remains are grouped and counted by grid square, using either the excavation grid square (1x1 m) or smaller squares (50x50 cm) to zoom in on especially significant areas.

Our GIS application proved especially useful for a taphonomic interpretation of specific classes of materials from Garba IV D. The distribution of finds on the surface of the site is not uniform (FIGURE 5).[1] Remains are denser in the western than in the eastern sector of the excavation. There are more or less high concentrations of materials in several points of the excavated area. Two of these concentrations are in the northern part of the eastern sector, one near the eastern bank of the dig, the other in a strip about 2·5 m long and 1 m wide, oriented southwest/northeast. In the western sector, the highest frequency occurs in the middle, especially along the western bank, where some squares contain up to 500 finds.

Furthermore, the whole palaeosurface is strewn with raw pebbles of basalt and other volcanic rocks, but not obsidian. Their distribution approximately matches that of the lithic and faunal remains.

An important feature of the site consists of several large blocks of basalt (FIGURE 6) each weighing scores of kilos, brought here by the hominids. Most of them lie in the northern part of the western sector, two in the southeastern part of the same sector, three more in the north-

1 Because of the economic restrictions of colour printing, FIGURE 5 will be found on p. 993.

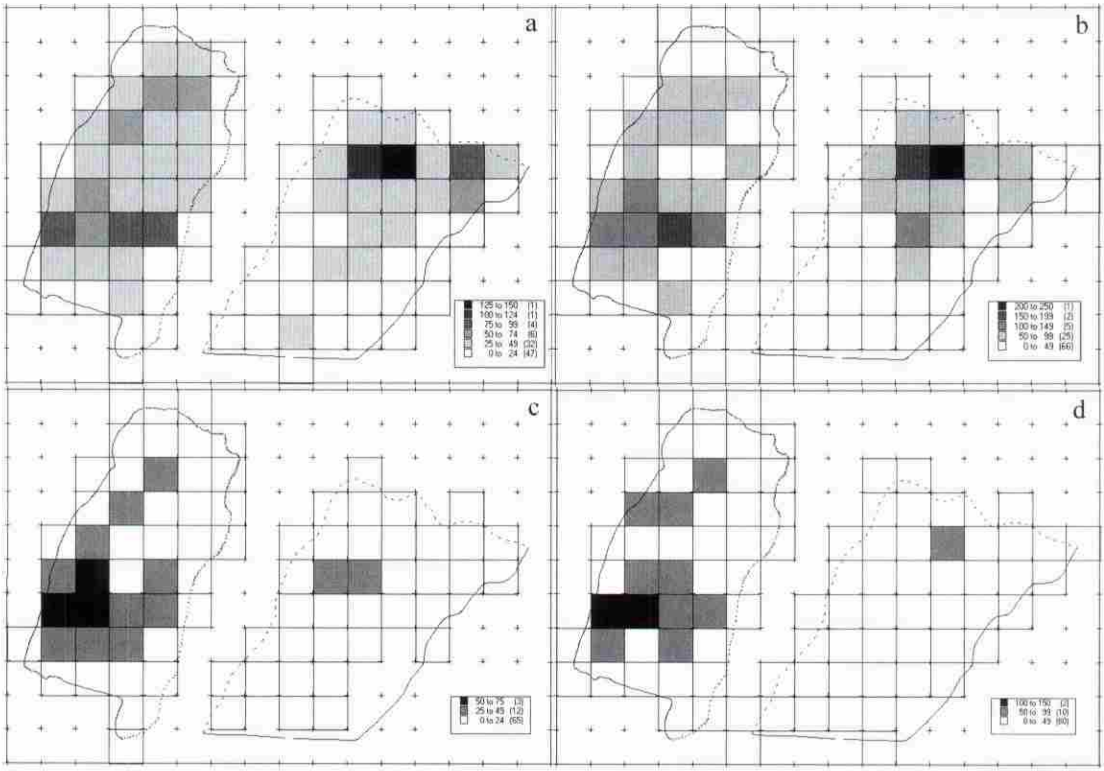


FIGURE 8. *Garba IV D.* a *Frequency of faunal remains.* b *Frequency of obsidian flakes, tools and cores.* c *Frequency of basalt pebble tools.* d *Frequency of basalt flakes and flake tools.*

ern part of the eastern sector. Each block is surrounded by large faunal remains (pelvises, mandibles, horns and ribs). The function of these areas is explainable only in terms of this recurrent association of the blocks with the fauna.

Some areas have yielded almost no evidence at all. The most significant from a taphonomic point of view is an approximately round area (FIGURE 7), *c.* 1·5 m in diameter, near the southern boundary of the western sector of the excavation. This area is almost completely surrounded by abundant lithic and faunal remains.

Another interesting aspect is the relatively high number of antelope horns (about 100) strewn all over the surface, but with a significant concentration in areas also showing the highest density of obsidian artefacts, near some of the large basalt blocks.

The distribution maps of raw materials, especially obsidian, also show some significant concentrations. The density of obsidian, for example, is higher in the eastern than in the western sector. Furthermore, there is an evident correlation between high concentrations of fauna (FIGURE 8a) and high concentrations of obsidian artifacts (FIGURE 8b), on the one hand, and between high concentrations of basalt pebble tools (FIGURE 8c) and high concentrations of basalt flakes (FIGURE 8d), on the other.

In the north-central part of the eastern sector, the density of obsidian chips, flakes and cores associated with numerous large faunal remains is much higher than on the rest of the palaeosurface, and also higher than that of non-obsidian flake and pebble industries in the same area. Significantly, these remains are concentrated around one of the above-mentioned large blocks of basalt (FIGURE 9).

Conclusion

Our intra-site GIS has proved to be a highly effective tool for performing analyses on the very high number of artefacts and faunal remains yielded by the palaeosurface of Garba IV D.

At a first glance, the finds appear to be distributed rather randomly over the whole

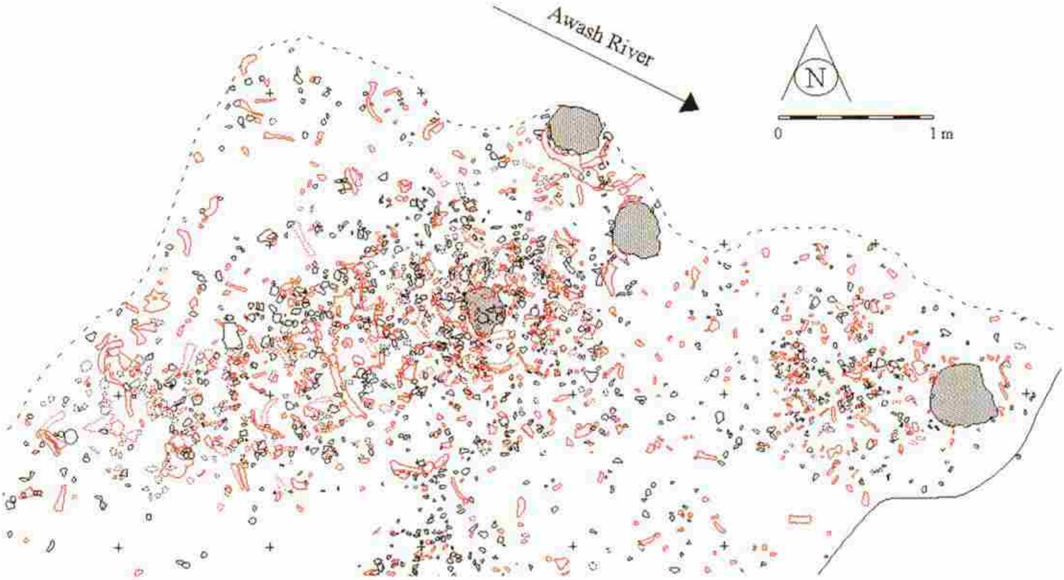


FIGURE 9. *Garba IV D. Distribution of obsidian (black), faunal remains (red) and large basalt blocks (dotted) in the northern part of the eastern sector.*

palaeosurface, with the exception of two sterile areas of uncertain significance, and concentrations of large animal bones near massive blocks of basalt brought to the site by hominids. It is evident that post-depositional phenomena have played a major role in the present distribution of lithic and palaeontological remains. Detailed analyses, however, have highlighted interesting and significant associations between the remains of large fauna, the basalt blocks and obsidian flake tools.

We were also able to project all the archaeological objects found on the palaeo-surface onto transversal (FIGURE 10) and longitudinal sections and thus analyse the vertical distribution of the finds. The GIS' topological functions have allowed us to estrapolate spatial coordinates for each find (*x* and *y*). By ranging the values of *x* or *y*, respectively, for the transversal and longitudinal sections, on the abscissa, and depth values on the ordinate, it was possible to visualize archaeological sections of any part of the excavated area (FIGURE 11).

The interpretation of these sections is still in an initial stage, but it is clear that topological analyses such as these will be extremely helpful in our future studies. They will enable us to reconstruct the modes and phases of the occupation of the site and its post-depositional vicissitudes, and highlight specific object associations or distributions by interfacing data from different thematic sections with the horizontal maps.

Translation by Federico Poole.

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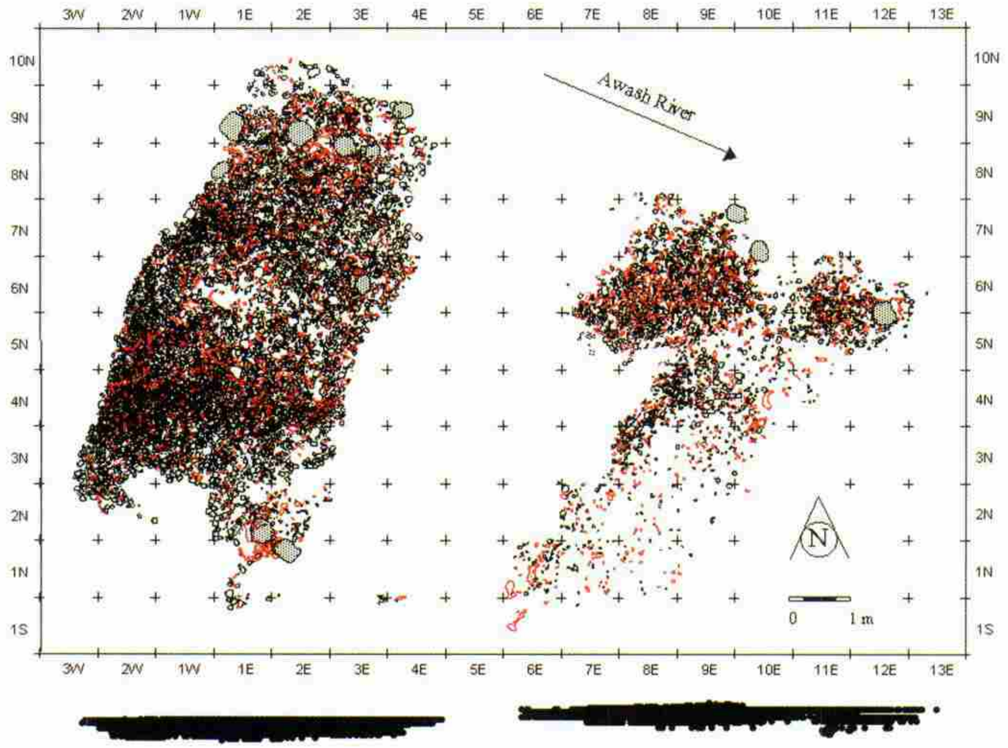

FIGURE 10. *Garba IV D. Cross section of the excavation obtained by projecting the altitudes of all the faunal and lithic remains.*

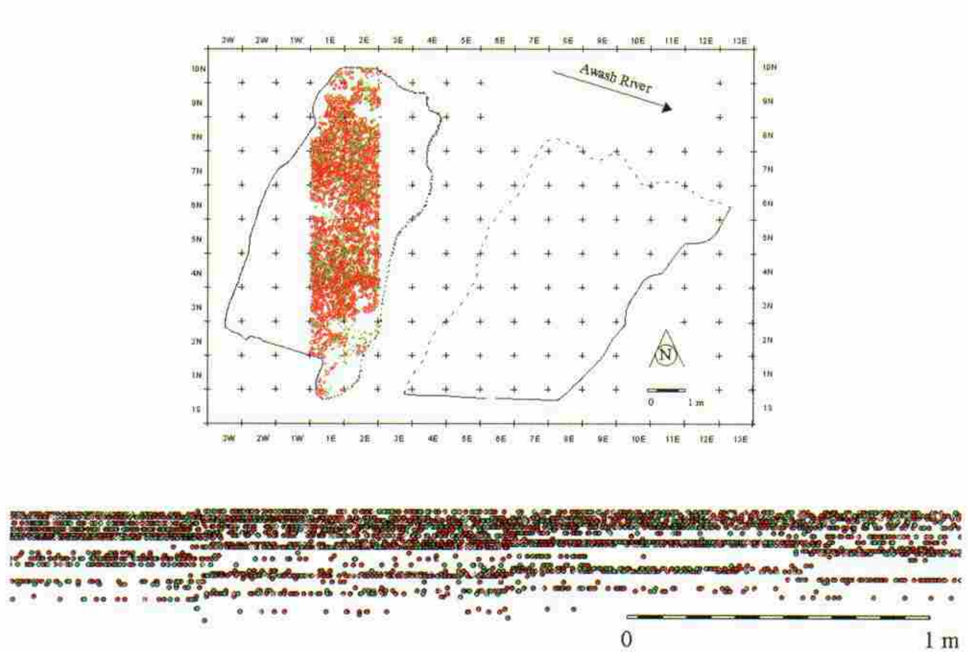

FIGURE 11. *Garba IV D. North/south section showing the lithic artefacts in the central area of the western sector. Green: obsidian; red: other volcanic rocks.*