The application of GIS to intra-site spatial analysis: preliminary results from Alpe Veglia (VB) and Mondeval de Sora (BL), two Mesolithic sites in the Italian Alps

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Introduction

The southern side of the Alps, and in particular its eastern sector, is crucial to the study of the early Holocene settlement in Italy.

The retrieval in the last thirty years of some hundred sites, mostly referrable to the Sauveterrian (i.e. to the cultural phase approximately corresponding to the Preboreal and Boreal, ca. 10000-7800 BP), has made it possible to establish a rather precise chrono-stratigraphic sequence along with a model of occupation of the territory (Bagolini, Broglio and Lunz 1983; Broglio 1980, 1992; Broglio and Lanzinger 1996; Angelucci 1996). According to the latter, early Mesolithic settlement in the Italian Alpine area showed a different pattern according to seasonality. The winter sites were located in the main valley bottoms, up to ca. 200 m, under rockshelters. The summer sites were situated in the mountains, generally in flat areas, in the proximity of water resources (small rivers or lakes) and near passes, either in the open air or under the overhang of large rock boulders, reaching altitudes as high as 2000 m.

As far as high altitude sites are concerned, these can be distinguished typologically into two categories, base camps and specialised hunting camps, on the basis of the caracteristics of both topography and lithic assemblages. With the exception of a rather limited area - Colbricon (Bagolini and Dalmeri 1987) - very little is known on the socio-economic organisation and function of these sites, due to the paucity of spatial analysis which has been performed so far at the intra-site level.

In this paper, a first attempt at the understanding of such fundamental aspects of early Mesolithic human behaviour in the Italian Alps is presented.

Intra-site spatial analysis was performed using GIS (Geographical Information Systems) methodologies on two pilot sites, representative respectively of two different typologies of base camps -an open-air site (Alpe Veglia) and a rock-shelter (Mondeval de Sora)- in order to detect and compare possibile patterns indicating activity areas or other forms of utilisation of dwelling space. Both sites were identified by field-walking and were excavated since the late '80s by teams of the University of Ferrara.

The choice of using GIS for the intra-site spatial analysis was dictated by several concurrent reasons: the necessity of handling at once a considerable amount of data and the possibility of producing single or combined maps according to different criteria and at different scales, of relating directly the artefacts distributions (possible "structures latents") with the "structures evidents" (Leroi-Gouran and Brézillon 1972) and of quickly updating the distribution maps on the basis of new data/results from other kinds of analyses. Last but not least, the utilisation of computer systems makes it possible to share and insert the research data within a wider multidisciplinairy and diachronic project - "Terre Alte" (Highlands) (http://dns.unife.it/terre_alte/index.html) - on the traces of ancient human settlement in the Italian Alpine area. The project, coordinated by the University of Ferrara, involves several Italian Universities and Institutions and it is funded by the National Research Centre (CNR).

A raster-based software (Idrisi 2 for Windows) was considered more appropriate for analytical purposes since in both cases the excavation data were spatially referred to grid cells instead of being singularly positioned (the application of such procedure was not been possible for Alpe Veglia given the invisibility of the lithic artefacts -rock crystal- during excavation and for Mondeval given the enormous quantity of material present on the site).

The sites

Alpe Veglia and Mondeval de Sora are located respectively on the Western and on the Eastern sides of the Italian Alps (fig. 1). Alpe Veglia lies in the Upper Val d'Ossola (Alpi Lepontine). The site is situated on an alluvial fan in the middle of a glacial valley at an altitude of 1750 m. It is the only Holocene site which has been excavated up to date in the Western Italian Alps (Gambari, Ghiretti, Guerreschi 1991; Guerreschi, Ghiretti, Gambari 1992; Fontana, Guerreschi and Vullo in press). An area of about 118 sqm has been so far uncovered (fig. 2). Because of soil acidity, organic remains have not been preserved. The archaeological record therefore consists exclusively of lithic artefacts, about 10 kg of which have been retrieved so far. These are almost entirely made of local rock crystal.

The lithics are scattered immediately underneath the meadow within a single podzolised layer approximately 25 cm thick (US 2); this lies directly on the top of the sterile level, the surface of which contains a great number of stones of probable crio-nival origin (Angelucci in press).

Mondeval lies on a terrace in the in the Upper Val Fiorentina, in the center of the Dolomite Region, at 2150 m of elevation. It is an exceptionally rich and well preserved site within the early Holocene deposits of the eastern sector of the Italian Alps (Alciati and others 1992; Fontana and Guerreschi 1998). Archaeological investigations have focused so far on

sector I, beneath and outside the large erratic dolomite boulder (fig.3). An area of approximately 60 sqm, about 50 cm thick, has been uncovered, revealing a complex stratigraphic sequence. This includes a series of levels relating to different chronological phases, spanning, with various lacunae, from the early Mesolithic to the sub-present age.

The early Mesolithic layers (fig. 4) contain a pavement made of tufa slabs (Layer 14), which is situated underneath the overhang of the boulder. To the northern side of the pavement, external to the boulder, lies an artificial arrangement of blocks of dolomite stones (Layer 33). Between these two layers, Layer 32 forms the basal part of a sub-circular structure, interpretable as a hearth and delimited by blocks of dolomite.

All these features were covered by two contemporaneous anthropogenic layers: layer 8 is a dark brown-black soil, very rich in charcoal and ecofacts, which was found mainly in the area protected by the boulder. It contains about 20000 lithic artefacts (mainly made of flint), almost half of which are totally altered by fire. Because of the great number of artefacts retrieved, the layer was excavated by means of two artificial décapages (figg. 5-6). Layer 31 is a light brown silty-sandy soil, containing abundant faunal remains and extending mostly in the area external to the erratic mass. Since the data from layer 31 are still in course of study, GIS spatial analysis has been performed only on the lithic assemblage from layer 8.

Methodology

As already mentioned, excavation methodology has been carried out for Alpe Veglia and Mondeval de Sora using grid-cells, which are in both cases sub-multiples of the main excavation grid, measuring 1 x 1 m. These grid-cells, to which the archaeological materials have been referred during the excavation, have been used as basis for the spatial distribution in the GIS.

The plans and excavation grids have been digitised in AutoCad 14 and imported in Idrisi as dxf files. The archaeological data were stored in Access, into a database containing information relating to the spatial location of the artefacts, to their techno-typological characteristics and to the nature and origin of the raw material (Medesi 1995-96; Fontana 1998). This database, after the necessary modifications, has been linked to the base maps in Idrisi by means of the newly implemented module Database Workshop.

For both sites, only a preliminary spatial analysis has been carried out so far. This analysis was based on the techno-typological structure of the lythic material only: in the case of Alpe Veglia the lithic material was the only one to be preserved and, due to its nature (rock-crystal), it was virtually impossible to undertake refitting or micro-wear analysis. As regards Mondeval, these kinds of analyses, along with the study on the faunal and palaeo-botanic remains, are still in course. Moreover, the data used were retrieved from layers whose extension is incomplete: in the case of Alpe Veglia because the excavation of US 2 is not finished, and in the case of Mondeval because the northern and western limits of US 8 have not been preserved, due to the effect of later anthropic activities and/or post-depositional agents.

As for the methodology used, this consisted in the elaboration of distribution maps of the different main techno-typological classes of materials (débitage, cores, tools, microlithic tools, microburins), assuming that they have a functional value, thus reflecting the nature of the activities carried out on a given site (Binford and Binford 1968). The model which is commonly accepted for the north-eastern sector of the Italian Alps is based on the contraposition of microlithic tools/tools and microlithic tools/microburins and considers microlithic tools as indicators of hunting activities and as obtained by means of the microburin technique (Broglio and Lanzinger 1990).

The techno-typological classes of materials were plotted singly or together, and according to boolean and/or quantitative criteria, using the routine options of mathematical manipulation provided by the software. Map interpretation was based on a combination of visual inspection and summary statistic information obtained for the images.

Map interpretation was based on descriptive statistics, since the results were strongly patterned (Shennan 1988).

Frequency values -per square- have been expressed in reclassified percentage density, in order to be able to compare classes of materials which were quantitatively different or which, as in the case of Alpe Veglia, had been recorded using different parameters (weight for flakes and number for all the other classes). The reclassification has been based on a number of standard intervals which reflect with a good approximation the actual distribution of the data values (cfr. Bailey and Gatrell 1996).

The application of GIS to the site of Alpe Veglia

For Alpe Veglia, the archaeological data have been referred to the 50 x 50 cm squares which were used as a basis for excavation. The first results achieved by means of the methodology described above are illustrated by a few maps.

Fig. 7 represents the addition of boolean maps of all retouched pieces plus microburins considered as a single class, cores and flakes. It shows clearly that within a background noise composed of flakes, there are two main concentration areas. It is significant that these coincide with the zones where the stones on the surface of the sterile level are more scattered and smaller in size. In contrast, the lower part of the excavation, with a higher conglomeration of stones, tends to be void of materials. Here, only a homogeneous, low density (less than 0.1%) distribution of flakes is found. The concentration along the left-hand side of the excavation has a rather well defined concentric pattern. All classes of materials are found in association with each other and with high densities (as inferrable by the quantitative distribution maps) in the centre. This central area is surrounded by retouched pieces plus microburins and flakes in association with each other. On the right-hand side of the excavation, the situation is rather different, due to the lack of cores at the centre of the concentration area.

Focusing on the distribution of retouched pieces and microburins (fig. 8), it can be seen that the different classes in the retouched pieces -microlithic tools, tools and fragmented backed pieces- are present together both in the western and eastern side of the excavation area, with similar patterns, although with different levels of dispersion. Tools are the most dispersed, with an average density of 1.62 per square, while the fragmented backed pieces are the most clustered, with an average density of 2.9 fragments.

In contrast to retouched pieces, microburins tend to cluster only along the left-hand limit of the excavation, as shown by a boolean distribution map (fig. 9) where this class of artefacts is reclassified according to density higher than 1%.

In general, the presence -within the Mesolithic site of Alpe Veglia- of rather well structured and repetitive patterns seems to suggest that the positioning of the lithic materials within the podzolised layer is not dissimilar, horizontally, from the original one (the post-depositional effects would be limited to a vertical shift of the artefacts). On the other hand, it is possible to postulate the presence of a series of zones with the function of areas of activity rather than of deposition or evacuation. In particular, a specialisation towards the flaking and the manufacturing of microliths seems to characterise the area on the left-hand side of the excavation, while the definition of the function of that on the right-hand side appears more difficult. Also, the ring-like pattern shown by the distribution of the lithic artefacts could possibly indicate the presence of a fire at the centre of the concentrations and could suggest a manufacturing activity in the open-air rather than under a tent (Stapert and Street 1997).
In the case of Alpe Veglia, it must be stressed here that the results of the GIS spatial analysis have also contributed to the planning of the excavation strategy. The use of the preliminary results of this study as guidance for the organisation of the 1997 excavation campaign has made it possible to target the archaeological investigation towards the definition of certain areas, characterised by "structures latents", such as in particular the concentration of materials which had already appeared along the western side of the archaeological area. Thus, in just one season, about ¼ of the total finds collected since the beginning of the research was retrieved.

The application of GIS to the site of Mondeval

In comparison with Alpe Veglia, where, with a homogeneous excavation grid measuring 50x50 cm, there were no difficulties in assigning a spatial attribution to the archaeological data for the GIS analysis, the situation for Mondeval was rather more complicated (fig. 10). Here, across the years, different kinds of square units had been adopted for the excavation. Initially, it was carried out by squares of 10x10 cm in order to have a good detail for spatial distribution; these were too time-consuming and were therefore progressively substituted by squares of 20x20 and of 33.33x33.33 cm. These different kinds of squares are all sub-multiples of the main excavation grid measuring 1 x 1 m, but not always multiples of each other. In the case of layer 8, such modification in excavation strategy led to the presence, not only horizontally, but also vertically (since the excavation was carried out by means of subsequent artificial décapages, as already mentioned), of different kinds of grids. Archaeological data were referred to these different types of modules during the excavation, but it is clear that, in order to perform a spatial analysis on the data, all needed to be referred to just one type of squares. This could only be the 33.33x33.33 cm, since they are the only ones which can contain the other two. The problem is that each 33.33x33.33 cm square contains an incomplete number of smaller squares: fig. 10 shows that when superimposing the larger grid on the smaller ones, some squares of 10x10 and 20x20 inevitably fall between two of the 33.33x33.33 squares.

A solution had to be found for the treatment of the archaeological data which had been recorded for such "split" squares. Attributing proportional values to the "split" areas, according to their size (as determined by superimposing the 33.33x33.33 grid) was thought to be the most suitable method. This was based on the assumption that artefacts were homogeneously distributed across the grid cells in which they were found.
The proportional values were calculated by pixel, as required by the Idrisi module Extract. For the rasterisation of the data from each of the three different grids, it was adopted a number of pixels (30x30) which would make it possible, for all of them, to be contained entirely within the main reference grid, represented by the square metres.

The sum of the proportional values, multiplied by the frequencies of the archaeological data per squares of 10x10 or 20x20 included within each 33x33 grid, gave the score to be assigned to the 33.33x33.33 squares for spatial analysis. The distribution maps based on a single grid of 33.33x33.33, were thus formed by the addition of the scores obtained respectively for the 10x10 and 20x20 squares as described above, plus the original scores recorded for the 33.33x33.33 grid.

Using a macro, it was possible to perform rapidly the whole procedure and to refer automatically the archaeological data recorded for the 10x10 and the 20x20 grids to the 33.33 x 33.33 grid.

However, not all the archaeological data stored in the database for Layer 8 could be included in the base distribution maps. This data was composed of those artefacts, retrieved during general excavation "cleaning" activities, and thus referred to a whole sqm rather than to a single square. In order to visualize such data on top of the distribution base maps, so that their interpretation could also take into account the missing materials, vector textual files were superimposed on raster maps. An example of such procedure is illustrated by the map in which the total frequency of tools missing from the final 33.33x33.33 cm distribution maps per sqm is shown (fig. 11).

Turning now to some general results obtained, by means of manipulation of the original distribution maps, these can be summarised by a few images.

The map of total distribution (fig. 12) indicates that the central part of the excavated area is characterised by the presence of a homogeneous density of artefacts ranging from 0.5 to 1% (and corresponding to a number of 50-100 artefacts per square). A lower density is found towards the

limits of layer 8, while a main concentration appears in the northern part of the latter.
The background noise shown by this map is due mainly, as one could expect, to the distribution of flakes.

A reclassification of the latter in two categories (percentage density lower and higher than 1%) is shown in fig. 13, along with the distribution of cores (these are not reclassified). The areas of high density of flakes coincide with those which appeared in the map that we have previously considered. These are only partially covered by the presence of cores. It can be noted that this type of artefact tends to cluster along two parallel alignments. The first corresponds to the drop-line of the shelter, while the second is found not far from the southern limit of the layer. The different distribution of flakes and cores may indicate the presence of a drop zone corresponding with a manufacturing area and a toss zone external to the shelter respectively (Binford 1978; Gamble 1986).

A different kind of pattern is indicated by the distribution of the single classes of retouched artefacts and microburins. This is summarised by a map (fig. 14) reclassified as boolean representing the overlay (addition) of areas of density higher than 1% for such categories. These areas present a U-like pattern. If analysed in relation to the pavement 14, it can be noted that they distribute uniformly along the limits of the latter, without occupying its surface, indicating a situation already noted by other scholars (Gamble 1986), but for the explanation of which no precise hypotheses can be formulated.

As far as Mondeval is concerned, it should be also noted that while the maps elaborated on the basis of techno-typological criteria revealed significant patterns, those illustrating other parameters (such as the type of material) showed no patterns at all.

Conclusions

In conclusion, having taken as case studies two seasonal high altitude base camps that present different typological characteristics, the GIS spatial analysis has highlighted the existence of different patterns within the two settlements (although keeping in mind that data for both sites are not complete).

Such differences can be summarised as follows. At Alpe Veglia, two main concentrations of archaeological material have been detected. These could relate to discrete areas of activity, but whether they existed contemporaneously it is not possible to assess on the basis of a spatial analysis based on lithics distribution only. Conversely at Mondeval, where the existence of an occupational palimpsest is certain, it has been nevertheless possible to identify relatively stable patterns, which occur repetitively for different classes of archaeological materials (of a certain significance is the case of all retouched tools and microburins). This situation could suggest that the site has been inhabited several times during the Mesolithic with the same kind of occupational behaviour (palimpsest of occupations: Taborin 1987; Bietti 1993). Moreover, its structure could be defined as a "complex polifunctional area", thus confirming the results of the functional analysis carried out on the lithics.

An understanding of the intra-site organisation and of the function of the Alpine High Altitude Sites by means of a preliminary spatial analysis on the archaeological data would not have been possible without the use of GIS tools. This is because of the quantity of data to handle and, in the case of Mondeval, of the excavation technique employed. The use of GIS tools has made it possible to develop a good method for dealing with such a kind of excavation. This could be usefully applied to other sites which may have the same problems as at Mondeval. Finally, as already mentioned, for Alpe Veglia, the utilisation of GIS has been extremely useful as a "predictive" tool for the planning of the excavation campaigns.

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