The Melos Obsidian Quarries; A Case Study in Lithic Technology.

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In recent years considerable progress has been made in the study of prehistoric obsidian networks in many areas of the world (e.g. WRIGHT 1969; GRIFFIN et al. 1969; HALLEM et al. 1976) because the particular nature of the typically small, homogeneous and localized outcrops has meant that the individual obsidian sources used in the past can easily be discriminated. In the Aegean area, for instance, Colin Renfrew and his colleagues (e.g. RENFREW et al. 1965; ASPINALL et al. 1972) have demonstrated conclusively that virtually all the obsidian found so commonly on prehistoric sites throughout the area is derived almost soley from two outcrops on the island of Melos; furthermore, he has been able to suggest that two types of exchange may have been responsible for this distribution: direct access and down-the-line exchange (RENFREW 1975: 42). Nevertheless, even in this well documented cases the important results generated by the compositional studies cannot by themselves determine the mechanisms for the spread of obsidian on prehistoric sites. Although RENFREW (1975) has described means of testing his hypotheses about Melian obsidian trade using the shape of the curve relating quantity of obsidian to distance from the source, the requisite data for testing these patterns is not yet available for the Aegean and it is therefore necessary to invoke other classes of material.

Fortunately in the Aegean there is one category of sites studied systematically where there are more than adequate quantities of obsidian. These are the obsidian quarries on Melos at Sta Nychia and Demenegaki. During the summers of 1974-1977 I carried out an extensive program of mapping and sampling at the quarries in conjuction with the island-wide archaeological study undertaken by the British School at Athens under the direction of Colin

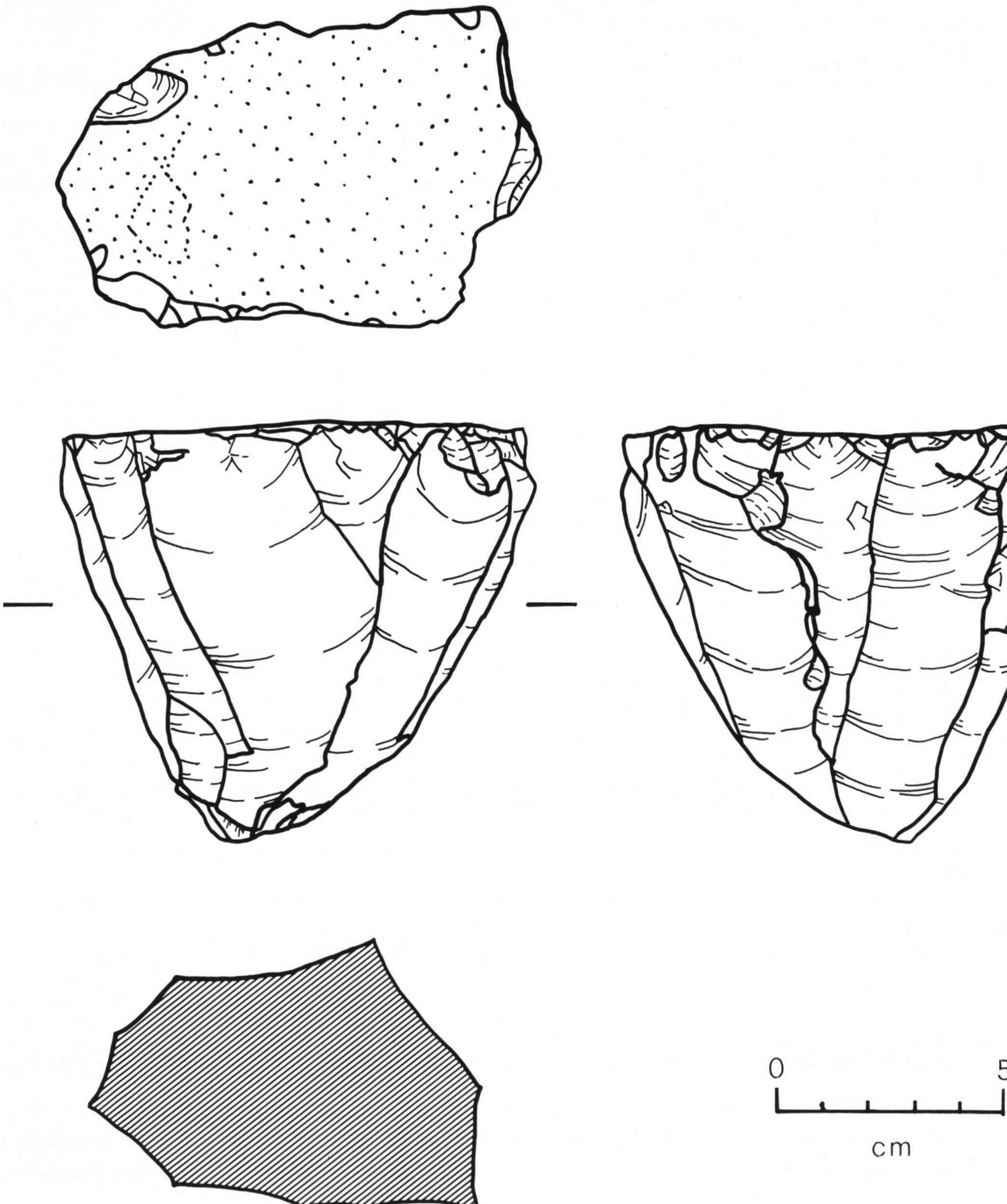

Fig. 1. A typical Macrocore from the Melos Obsidian Quarries.

Renfrew (RENFREW and WAGSTAFF in press). For understanding the mechanisms of prehistoric exchange, quarries offer a tremendous potential which has never been fully exploited by archaeologists. The way in which the stone was quarried and worked at the source will depend largely on the intended use of the material, e.g. direct consumption, exchange to kinsmen, foreigners, consumers or middlemen, or by sale in a market context, etc. This behaviour should leave traces in the nature and composition of the archaeological remains at the quarry; therefore it should be possible to determine the mechanisms by which the material was distributed in the past by studying the archaeological evidence at the quarries.

Despite the theoretically high potential value of quarries for studying distribution types, one might well ask how this can be accomplished by examining the literally tons of seemingly undiagnostic waste by-products which cover almost two square kilometers at the Melos obsidian sources and which are typical of many flint quarries. Although these analytical problems have not been completely solved on Melos, I would like to summarize briefly three methodological approaches which have produced results relevant to Aegean obsidian exchange in an attempt to demonstrate the potential value of quarry analysis (fuller discussion will appear in TORRENCE in press a; TORRENCE, 1979). These general techniques need not be limited to obsidian data but should be applicable to chipped stone quarries in all types of material throughout the world.

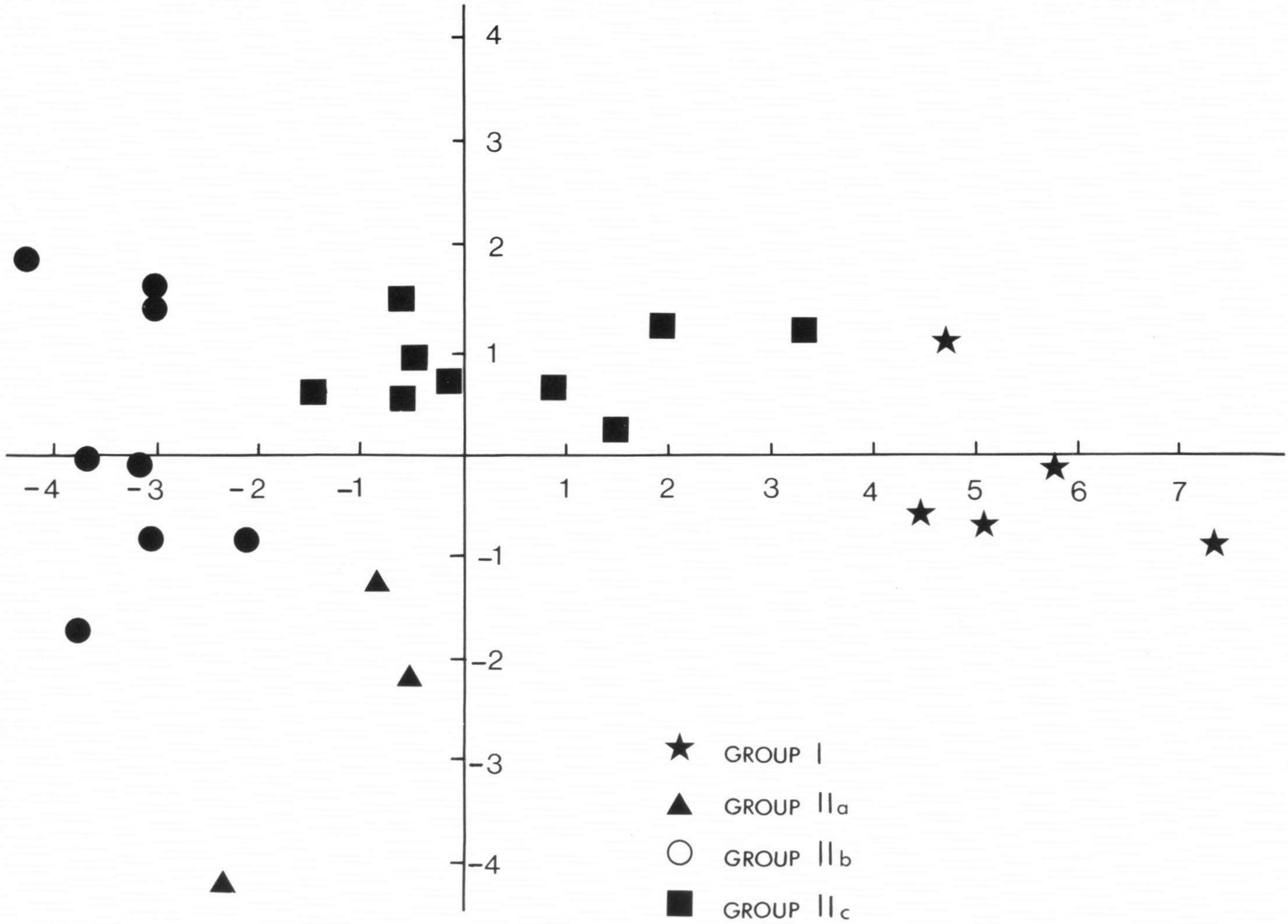

Fig. 2 Standardized discriminant scores plotted on the two significant discriminant functions.

The first stage of research at the quarries was to reconstruct the technology used in quarrying and reduction of the nodules. After the obsidian pieces were dug out of one of the variety of outcrops at the sites, they were converted into macrocores (fig. 1), the large cores which constitute the first stage in the fabrication of smaller, more regular cores from which prismatic blades were removed. They appear to have been the dominant product of stone working at the quarries, and the form in which much of the obsidian was transported from Melos. The analysis began with an attempt to reconstruct the steps involved in macrocore manufacture, so that it would be possible to evaluate the efficiency and standardization of production. By analyzing the types of waste present in the large scatters of debitage which cover both sites, it is possible to discern a series of related techniques which were used. The basic pattern is as follows:

1) a nodule of sufficient size was chosen;
2) a hard hammer percussion blow was struck to the side of the piece truncating the top of the nodule and thereby creating a relatively level platform which was approximately perpendicular to the sides of the core;
3) futher hard hammer blows were struck on the edges of the prepared platform removing flakes around the periphery of the core;
4) finally, an attempt was made to strike off long flakes or blades on the sides of the core leaving straight, narrow scars to be used subsequently to guide the force exerted by pressure in an attempt to produce regular, prismatic blades (TORRENCE, 1979).

In many cases an additional step was taken in core preparation. In order to create the desired long, narrow flake scars, a ridge was created between two adjacent sides of the core by striking parallel blows alternately between two adjacent sides of the core and perpendicular to the direction of blade removal. This 'crested' flake, when removed, would leave the necessary long scar for guiding future blade removals. Whenever possible, knappers began a core by removing a natural corner of a prismatic-shaped nodule. The variety of techniques utilized in the process of macrocore manufacture indicates that the knappers were skilled laborers but opportunistic in the approach to their work. They were not restricted in the type of nodules that could be worked, but also they did not regularly select particular shapes or sizes of nodules and the resulting macrocores are extremely unstandardized.

Secondly, I have studied spatial patterning of activities at the quarries. During the initial mapping phases of fieldwork, the rough outlines of activity areas containing large amounts of chipping debris could be discerned. The extensive major workshops comprising large quantities of every type of quarrying and macrocore debitage are located adjacent to the highest quality obsidian sources. In contrast, at more restricted areas located on hilltops distant from the obsidian sources, quarrying debris was absent although there was a high proportion of tertiary flakes and chips and small numbers of probable neolithic artifact types. In order to test for variability between areas in terms of their past use, two multivariate statistical methods, cluster analysis and stepwise discrimininant analysis, were applied to the data gathered from both systematic and grab samples. The analysis utilized the relative proportions of three flake types defined by the stage of manufacture in which they were produced: primary flakes are totally corticated, secondary flakes are partially decorticated, and tertiary flakes are completely decorticated.

A Ward's method CLUSTAN analysis using Euclidean distances (TRASI, 1975) produced tow major groups, one of which was comprised of three distinct sub-groups. The mean values for each of the flake types in the group suggested that they are to be distinguished in terms of reduction stages. For example, Group I's very high proportion of secondary flakes with few tertiary flakes implies that only te initial stages of core reduction took place in these activity areas, while the dominance of tertiary flakes in Group II clusters indicates that cores had been brought to these areas and finished there. As cluster analyses always produces groups, the extent to which they are archaeologically meaningful and statistically discrete must be evaluated by seeking convergent results from alternate, independent analysis. In order to determine the statistical significance of these clusters, an SPSS step-wise discriminant analysis (NIE et al. 1975) was performed. Two significant functions emerged, and when the standardized scores for each activity are plotted (fig. 2), it is apparent that there are indeed four discrete groups in terms of the relative proportions of flake types. If we examine the score of each variable on each discriminant function, we may summarize the major characteristics of each group of activity areas in two dimensional space:

Group I: large quantities of secondary flakes, moderate primary flakes;
Group IIa: highest proportions are tertiary and primary flakes;
Group IIb: very high amounts of tertiary flakes;
Group IIc: large quantities of both secondary and tertiary flakes.

Furthermore, these results can be interpreted as different stages in the core reduction strategy: Group I may represent areas where initial stages took place; while Group IIa are areas where all stages were carried out; IIb areas saw all stages, but the dominance of final tertiary flakes suggests that retouching of artifacts also took place; finally, IIc areas were only used in the final stages. This work suggests that most of the knapping activities at the quarries took place adjacent to the sources of absidian, but in a limited number of instance both raw nodules and partially worked cores were carried up to isolated hilltops for further knapping. A third facet of debitage analysis and one that is being increasingly utilized by lithic technologists is the estimation of artifact production totals (e.g. SINGER and ERICSON 1977). This excercise can be extremely useful in evaluating certain hypotheses about the organization of production at the quarries. For instance, if the estimates of the total output of each quarry are converted into numbers of man-days per year, it should be possible to determine to what extent full-time specialists might have been employed. The estimates for Melian macrocore production are based on two studies. The first involved mapping the density of surface cover of obsidian debitage at both sites. Next, by means of programm of systematic sampling in which the contents of 283 quarter meter squares were counted and weighed, it was possible to construct formulae for computing the number of any debitage category per square meter within any density range. Combining the number of square meters for each density category with these formulae, the total number of flakes on the surface of the sites could be determined: Sta Nychia c. 50,400,00; Demenegaki c. 31,750,000. the second study was a detailed analysis of 190 macrocores collected from both sites. Comparing the metrical attributes of the flake scars with the dimensions of flakes in the sample squares, the percentage of the total flakes that had been produced during preparation of the macrocore face could be determined. The total amount of this supposed macrocore waste was divided by 7, the average number of flakes removed from the studied macrocores. The final figure is a maximum estimate of the total output of macrocores for each quary: Sta Nychia c. 4,900,000; Demenegaki c. 3,100,000. To convert these macrocore totals into production rates in man-days per year, it was assumed that macrocores were made during a period of about 3,000 years (late neolithic to late bronze age) and that the number of pre-forms made per day by one man was 20. When the total number of cores is divided by both these figures, the final result is a total of 133 man-years per year as a maximum necesary to have generated the amount of macrocore debitage at both quarries.

It is difficult to evaluate these rates on their own, but they do restrict the type of models which could be proposed tot describe obsidian exploitation. At one extreme, it is possible that no exchange took place, and that on average 133 separate trips were made to the sources by consumers to procure their own obsidian; at the other, the most sophisticated industry could only have employed one specialist working for one-third of the year. Certainly, it is highly unlikely that specialist craftsmen were involved in the extraction of obsidian. In fact, the estimated 2,660 macrocores produced per year would hardly have satisfied the needs of the entire Aegean population and this work strongly suggests that the majority of obsidian nodules left Melos in an unmodified form.

Although it has only been possible for me to summarize just three of the analytical procedures used in the study of the Melos quarries (cf. TORRENCE in press a) and only very briefly, I hope that two points have become clear from this discussion. First, quarry sites hold a tremendous store of information about past human behavior that can be used to understand prehistoric economic systems. Secondly, the overwhelming quantities of lithic debitage characteristic of sites of this kind pose a real challenge to lithic technology and demand new and creative methods for exploiting these storehouses of data.

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