MODELLING STONE STOOL ASSEMBLAGES: A SIMULATION APPROACH TO THE ANALYSIS OF PREHISTORIC LITHIC TECHNOLOGY

Stone tools are a central source of data for the study of human behaviour in the deep past(1). For every hominin fossil, there must be tens of thousands of stone tools recorded. Much of what we know about human evolution thus comes from the recovery and analysis of lithic technology. There have been many recent advances in approaches to the study of lithics. Scientific techniques have enabled archaeologists to extract food residues from edges(2), to see and interpret edge damage in terms of use(3), and to source material to allow spatial patterns to be reconstructed(4). However, the analysis of the structure of lithic assemblages remains the primary source of information about past human behaviour. The aim of the project is to develop a new approach to strengthen inferences from lithic assemblage structure.

Stone tool assemblages

Archaeologists excavate and collect sets of lithics, which form analytical assemblages. These are categorised according to their traits and morphology (cores, flakes, broken or complete, type of platform, tool type, etc.), and metrics (mean lengths and breadths of flakes, etc). Assemblages are then assigned to either taxonomic units (Acheulean, Howieson’s Poort, etc.), or site functional units (quarry site, butchery site, encampment, etc.) or production stages. Differences lie in the number and nature of traits and the degree of quantification, with focuses on either technological production processes or typology, but nonetheless the fundamental approach is common to all analyses(5). Whatever approach is adopted, the principle is the same – use morphological attributes, and their frequencies and contexts, to infer assemblage structure, and in turn, infer elements of human behaviour, cognition or adaptation.

The problem: observed and expected

Hypothesis testing is concerned with comparing observations with expectations, but there is a substantial problem in lithics studies in having a set of expectations. The scale, nature and diversity of lithic production of prehistoric hominins no longer exists, and the processes involved in assemblage formation are numerous (from extraction to discard, to post-depositional winnowing and modification, to archaeological curation strategies). One way of producing expectations of assemblage structure is through replication knapping, but this is time-consuming and difficult to do on a large scale; it also requires highly expert knappers. The largest replication study of Levallois techniques produced 25 artefact sequences only(6). This approach is insufficient to develop quantifiable expectations that can be used across many assemblage contexts, and allow the application of model-based quantitative approaches.

Simulation

The proposed research will develop a simulation approach to contribute to a solution to the problem of having a robust set of expectations. Simulation techniques are widely used in the biological sciences to develop models in circumstances that are too complex for algebraic solutions. One example is in human evolutionary genetics. Genomic data can be used to reconstruct population histories – for example, the dispersals and divergences of human populations as they leave Africa(7). However, such inferences are probabilistic hypotheses based on enormously complex data. To determine whether the preferred pattern is significantly more likely than any number of alternative histories, bioinformaticians will simulate alternative histories thousands of times, under different conditions, and determine whether the preferred one is significantly different from other possible histories(8). This has proved to be an extremely powerful tool. This project will develop similar simulation approaches for lithic assemblages; the basic idea is to be able to create thousands of assemblages under different conditions, and so determine how actual observed assemblages match to these, and so understand the conditions under which they were produced.
Individual-based modelling

There are numerous approaches to simulation, but the one adopted here is individual-based modelling (IBM); this is structurally similar to agent-based modelling, extensively used in archaeology(9), but the latter is more applicable to agents who make decisions, which stone tools do not. The structure of the model will be as follows: a) each lithic will be an ‘individual’, which will have attributes (unmodified stone versus having been knapped, metric dimensions, whether broken or not, retouch patterns, etc.); b) when a lithic is knapped, it will produce ‘daughter’ lithics (flakes) which will then have attributes based on how it was knapped; c) this process can be re-iterated as many times as necessary (i.e. until the core is exhausted and subsequent flaking completed), with each fracturing event resulting in modifications to the traits of both the ‘parent’ and the ‘daughter’ lithic (daughter lithics will themselves become parent lithics); d) the model will capture the population level attributes from the sum of the individuals, and thus the model assemblage structure. This process can, in the model, be run under numerous conditions and numerous times, producing a vast pool of modelled assemblages with ‘known’ histories, either in parallel simple or more complex models.

In sum, the structure of the model will produce a very large number of virtual assemblages, with all traits recorded by individual lithic. The key to the utility of the model will be three central processes: a) ‘fracturing rules’ - with each ‘fracturing event’ the ‘parent lithic’ will be modified and the ‘daughter lithic’ will be created, and so the rules governing these ‘reproductive’ events will be important, as they will set the attributes of each. A central part of the research will be defining these rules; b) assemblage diversity processes – while each fracturing event will share the same basic processes, the diversity of the outputs will be dependent upon setting up alternative conditions – for example, reduction processes (blade versus flake production, use and discard behaviour; c) filtering processes – once the final set of lithics is produced, they can be subjected to a series of filters that represent post-depositional contexts, which would produce the final model assemblages.

The research is a proof of concept one. The work of the research assistant will be to develop the IBM, to test its feasibility, as a basis for future research and grant applications. Emphasis at this stage will be on the production elements of assemblage formation, rather than the filtering ones.