DID PALAEOLITHIC HUNTER-GATHERERS CROSS THE ICE? A BAYESIAN APPROACH TO THE ESTIMATION OF GLACIER MOVEMENT COSTS IN THE PYRENEES

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Abstract

Provenance studies of lithic raw materials, and particularly of chert, constitute one of the principal approaches employed in Palaeolithic research to investigate hunter-gatherer mobility (Féblot-Augustins, 1999). By establishing connections between archaeological assemblages and the geological formations from which these materials were likely acquired, such analyses provide valuable insights into patterns of resource exploitation and landscape use. Furthermore, evaluating the frequency of artefacts made from specific raw materials in relation to the distance or effort required to access their sources enables the identification of distinct procurement behaviours, traditionally classified as local, regional and extra-regional.

The application of spatial analyses, especially through cost-distance analyses and Least Cost Path (LCP) modelling, has significantly enhanced the study of prehistoric mobility by providing more realistic estimates of movement than simple straight-line distances (Herzog, 2013, 2020). Nevertheless, the construction of friction surfaces in most GIS-based studies continues to rely predominantly on slope-derived parameters. While terrain steepness undoubtedly represents a key factor affecting movement, particularly within mountainous regions, additional environmental or cultural constraints may also have played an important role in shaping mobility decisions. For Palaeolithic studies, glacial landscapes are among the most relevant of these factors. Thus, this study presents a methodological framework for integrating glacial conditions into friction-surface modelling, taking the Pyrenees as a case study to explore their potential impact on Palaeolithic mobility patterns.

A major limitation of Least Cost Path (LCP) modelling is that it generates a single optimal route between two locations (Herzog, 2013; Surface-Evans & White, 2012). This approach implicitly assumes perfect knowledge of the landscape and presupposes that individuals consistently selected the most efficient pathway available. Such assumptions may be problematic when investigating Palaeolithic hunter-gatherer mobility, as route choice was likely influenced by a wide range of environmental, social, and behavioural factors that are difficult to reconstruct archaeologically.

An alternative framework is provided by connectivity analyses based on Circuit Theory (CT) (Anantharaman et al., 2020). Originally developed and extensively applied in landscape ecology

(McRae et al., 2008), CT does not identify a unique route but instead models the relative likelihood of movement across a broader landscape. This approach highlights areas of higher connectivity and allows the identification of potential secondary or suboptimal routes. Consequently, it offers a useful means of incorporating uncertainty into reconstructions of past mobility patterns.

Like LCP modelling, CT requires the definition of a friction surface representing the costs associated with movement across the terrain. Incorporating the glaciers as a constraint area variable raises two key questions: (1) did Palaeolithic groups in the Pyrenees traverse glaciated areas or preferentially avoid them? and (2) how should the movement connectivity associated with glacier-covered terrain be quantified within a friction-surface model?

To answer these questions, rather than testing a range of arbitrary glacier-cost values and subsequently assessing which results appear most plausible, we adopt a different approach. We propose a Bayesian parameter-estimation framework to infer the resistance value assigned to glaciated areas directly from archaeological assemblages, assuming that the abundance of artefacts made from a given lithic raw material reflects, at least in part, the effort required to procure that resource. To evaluate the performance of the proposed methodology, we conducted a tactical simulation based on synthetic datasets representing lithic assemblages from multiple archaeological sites. We aim to assess the impact of different glacier-resistance values on the mobility patterns and to explore the applicability of the approach in real archaeological assemblages.

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