Paleogeographic reconstruction of the Tuscan coastal area nearby Grotta dei Santi (Monte Argentario, Italy) during the Neandertal occupation

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Abstract – The mobility of hunter-gatherer groups is crucial in understanding Palaeolithic settlement dynamics. The concept of mobility cannot be separated from the space in which it occurs, including landscape components, localization of critical resources and of other sites, and routes between them. Nevertheless, the landscape is not constant in time due to the geomorphological changes that occurred in the long timescale of Prehistory. Here we present a paleogeographic reconstruction of the coastal area around Grotta dei Santi during the Neandertal occupation. A GIS-based approach, combining geological, bathymetric, and sea-level fluctuations data, allows us to reconstruct the landscape around the cave at about 45 ky BP. The cave today opens onto a cliff facing the sea. The Neandertal occupation occurred with a sea-level 74 m lower than present-day. Consequently, the cave faced a vast coastal plain, playing a strategic role due to its position, allowing both proximity and control of essential resources.

Keywords: Palaeolithic mobility; Neandertal; Landscape archaeology; Paleogeography; GIS; Central Italy

I. INTRODUCTION

Each monocausal approach to the analysis of human societies is invariably destined to fail. Human societies are not a simple sum of abstract and independent elements. On the contrary, their structure is shaped by a complex entanglement of co-dependent components (e.g., social relations, demography, economy, exchanges, physical and biological environment, resources) [1]. Metric and relational properties can describe the reciprocal interactions of these components (e.g., density, connectivity, centrality, cohesion), highlighting their relative ranking and roles in a given context and at a given scale. Reading these dialectical relations in the frame of spatial analysis allows catching the dynamism behind the staticity of the archaeological record. Consequently, a contextual, multivariate and integrated approach is the fundamental prerequisite for a proper understanding of human society. This is particularly true for the Past due to the residuality of archaeological records [2]. From this perspective, Spatial Archaeology [3] plays a pivotal role, given its interdisciplinary, contextual and multi-scale approach [4]. The space is not only a passive box of “resources”, which can be reduced to mere geometric properties. It plays an active role in bounding, dividing, connecting and catalysing people, “resources” and their relationships [5].

The reconstruction of past mobility cannot be abstracted from the idea of moving from the geographical, informational and relational context in which it occurred. At the landscape scale (or macro-level sensu [3]), the reconstruction of mobility patterns significantly contributes to reveal the contextual framework of the economic sphere. This is particularly relevant for Palaeolithic hunter-gatherers, given the crucial role of mobility for the economy and social structures of nomad
groups [6], [7], [8], [9]. Recently, the developments of
gematiques applications to landscape and economic
archaeology returned exciting results, significantly
implementing our knowledge of Palaeolithic mobility
patterns [10], [11], [12], [13], [14], [15], [16], [17]. The
reconstruction of Palaeolithic mobility cannot be
adequately addressed without a paleogeographic framing.
The landscape, indeed, is not an invariable component. A
preliminary geomorphological assessment is fundamental
to recognize the changes in the long timescale of
Prehistory. Eustatic fluctuations of sea level, tectonics,
fluvial and glacial dynamics, and climate changes, along
with other geomorphological agents, determine a
difference in the aspect of past landscapes which gets
greater and greater as one goes back in time [18].

II. MATERIAL AND METHODS

This paper focuses on the paleogeographic
reconstruction of a 45km wide area around the Middle
Palaeolithic site of Grotta dei Santi (Monte Argentario,
Southern Tuscany, central Italy). This study area extends
along the coastline between Punta Ala (facing the Elba
island) to the north and the Lido di Tarquinia to the south
[19].

The scientific discovery of Grotta dei Santi dates back to
the middle of the last century [20]. Nevertheless, logistical
difficulties hindered further research until 2007, when the
systematic excavation campaigns started under the
direction of the Research Unit of Prehistory and
Anthropology – Department of Physical Science, Earth
and Environment of the University of Siena (Italy) [21],
[22], [23], [24], [25], [26]. The extraordinary importance
of this site to study Neandertal behaviour diversity with a
high-resolution perspective immediately arose with recent
interdisciplinary studies [19], [27], [28], [29], [30], [31].
Recent geological fieldwork, founded by the National
Geographic Society, allowed the collection of a large
amount of sedimentological data. This will contribute to a
high-resolution reconstruction of the archaeological
stratigraphy formation processes and cave environmental
changes.

Grotta dei Santi currently opens on a cliff facing the sea.
This was not the situation during the Neandertal
occupation. The combined contribution of eustasy and
tectonics produced a continuous process of large-scale
regression/transgression of the sea over time [32], [33],
[34], [35].

Consequently, the Digital Elevation Models of both the
Terrain (DTM) and Bathymetry (DBM) are required for an
accurate palaeogeographical reconstruction of the territory
around this key site during the Palaeolithic. This is a
challenging task, mainly due to the absence of high-
resolution models of the bathymetry. The most accurate
open-source DBM covering this area, indeed, is the
EMODNET, with a grid resolution of 1/16 * 1/16 arc
minutes (~ 115 * 115 meters) [36].
resolution (10m) and projection system [40], [41]. The interest area has been extracted with a mask by five frames (W47060, W47065, W47070, W46565, W46570).

Finally, the obtained models have been merged with a mosaic to a new raster procedure. The resulting elevation model includes the current continental and submerged relief, down to the depth of -148m. The slope map and the hillshade model have also been produced to improve the reading of this landscape in Prehistory. In order to enhance the realism of landscape reading, the value of eustatic sea-level at 47ky BP (73m) has been added to the obtained model, by the raster calculator tool.

III. RESULTS AND DISCUSSION

The High-Resolution model of landscape and seafloor returned by this study is a fundamental precondition for palaeogeographical reconstructions. Nevertheless, this is not the only condition. The proper rendering of the palaeolithic landscape stems from the intersection of multiple information.

Figure 2: Palaeogeographical reconstruction of the study area at 47ky BP.

Firstly, a chronological framing as accurate as possible is needed. Eustatic fluctuations of the sea level follow a characteristic pattern anchored in time. Radiocarbon dates from Grotta dei Santi allow for framing the Neandertal occupation of the cave between about 50-40 ky BP [29]. The new INTCAL20 calibration curve [42] on the only reliable radiometric dates allows constraining the occupation at about 47-45ky BP (straddling the end of Heinrich Event 5 and the Greenland Interstadial GI-12). According to the foraminifera isotopic records, the sea level in this interval was about -73m (± 13m) [32], [35].

Secondly, the analysis of local geomorphological proxies points to modest uplift rates, highlighting the relative tectonic stability of the area [33] [34]. In a radius of 25km from the cave, indeed, the vertical displacement computable from the last 47ky tends to be less than 1m (with values between -0.016 and 0.048 mm/yr). Only in the southern part of the study area (corresponding to the mouth of the Fiera River) are some higher uplift rates recognizable. Nevertheless, the estimated vertical displacement is around 8m (with values between 0.112 and 0.192 mm/yr). These tectonic displacements appear negligible considering that the sea-level estimate standard error is significantly higher [32], [35].

Finally, the recent contributions of fluvial transport and coastal dynamics have been taken into account to assess the reliability of each part of the reconstructed model. The Argentario promontory is characterized by a rocky coastline with a null sedimentary apport by fluvial distribution systems. As a result, this area is suitable for paleogeographic reconstructions. More problems affect both the northern and southern coastline sectors. In particular, the Holocene inputs from the Ombrone river significantly changed the assets of the coast, with high sedimentation rates. Sediments transported by the Albegna river in the last 10ky contributed to the formation of narrow dune belts, connecting the Argentario to the peninsular area (influencing the formation of the Orbetello lagoon). In the south, the area near the Fiera river is affected by the sedimentation rate of fluvial transport and the higher uplift rates.

The paleogeographic analysis, net of the delineation of the margins mentioned above of error, brings out a very different landscape outlook from the present one (figure 2).

The first evident difference is the large coastal plain extending in front of the cave and along the northern sector of the study area. In particular, the stretch of coastline facing the cave was expected to have an average slope of ~1% and a width of about 8.5km (directly connecting Grotta dei Santi with part of the coast in front of it). Given the morphology and acclivity (~4%) of the southwestern face of Punta Avoltore, bordering Grotta dei Santi, we infer that the sea was quite close to this stretch (~2.5km). In this frame, Mt Argentario was a prominent element of the landscape. Other minor but significant prominent elements on the plain were expected to be what are now the rocks of Isolotto, Argentarola and the Formica di Burano. These morphological features make the Grotta dei Santi an ideal hunter-gatherers’ camp, given its potential close access to diversified environments and resources. The cave’s position could potentially implement Neandertals’ control of the territory.

In summary, this work offers a helpful tool to frame
improve the accuracy of paleogeographic reconstructions.

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