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Geoarchaeology: A toolbox for revealing latent data in sedimentological and archaeological records

1. Introduction

Geoarchaeological applications stem from an optimistic application of geosciences and laboratory methods to understand stratigraphic issues in complex archaeological sites. These methods are particularly important in environments that suffer from major landscape evolutions related to geomorphological processes such as erosional crisis, overalluviation, and shifts in riverbeds or shorelines. In particular, the comprehension of site chronology might be challenging in the cases of very ancient remains, which are sometimes poorly preserved, and Pleistocene open-air sites or caves. In fact, the study of Palaeolithic sites initiated early collaborations between archaeologists and geologists in the 1830s, when interdisciplinary research was implicit. The need to locate artefacts in sedimentary sequences in order to establish a clear chronology of deposits encouraged such collaborations. Research initiated by Boucher de Crèvecoeur de Perthes in 1837 in the Somme valley (France) was one of the earliest illustrations of the interaction between geologists and prehistoric archaeologists; his observations included the stratigraphic context of the artefacts and extinct animals. Later on, the geologist Sir Charles Lyell, 'the father of geoarchaeology' (Rapp and Hill, 2006), summarised the work in the benchmark book *Geological evidence of the Antiquity of Man*, in which he addressed the role of geology in archaeological inquiries related to ancient periods. Since then, prehistoric archaeology and earth sciences have come together. A strong scientific solidarity unites them and gives rise to the school of thought known as 'quaternary science'.

The integration of stratigraphic studies and sediment analyses in archaeological sites that date back to protohistoric-historic periods arose during the second half of the twentieth century along with the development of 'Modern Archaeology'. The geoarchaeological approach to historic periods was first applied in the Mediterranean basin by Claudio Vita-Finzi and his team during the late 1960s (Vita-Finzi, 1969). It was followed by McDonald and Rapp's work titled 'The Minnesota Messenia Expedition: Reconstructing a Bronze Age regional environment' (McDonald and Rapp, 1972). The collaboration between geologists and prehistorians followed its course, and two years later the specific term 'geo-archaeology' was first mentioned in Karl W. Butzer's paper 'Geo-archaeological interpretation of Acheulian calc-pan sites at Doornlaagte and Rooidam (Kimberley, South Africa)', which was published in 1974 in the *Journal of Archaeological Science* (Butzer, 1974). After the 1970s, geoarchaeology gained ground through in-site and off-site analyses in the scientific field. Its status as a scientific discipline became concrete with the creation of the journal *Geoarchaeology* in 1986.

The expansion of geoarchaeology is thus linked to the growing awareness of the impact of climate and anthropogenic activities on the environment and, at some point, natural resources. Identifying factors that play a role in landscape mobility has helped to introduce geographers and geomorphologists into this field. It has also led to the development of palaeoenvironmental studies in conjunction with human-environment interactions in order to identify co-evolution patterns, which need to be analysed on several scales. Finally, it has also led to the progressive development of the following key subjects in geoarchaeology: occupation and territorial patterns; site exploitation and natural resource management; palaeoclimatic, palaeoenvironmental, and palaeogeographical changes and their impact on landscape and potential for occupation/exploitation; anthropogenic impacts and system responses; identification of anthropogenic influence in micro-remains; taphonomy and stratigraphic analyses, geomorphological dynamics, and predictive surveys; and hazards and site management.

Nowadays, several specialities, tools, and methods can employ geoarchaeological approach; these can include (in a non-exhaustive manner) geology, geography, sedimentology, petrography, micromorphology, geochemistry, geochronology, dating-methods (all of which have their own domain of application), botany, mineralogy, palynology, archaeozoology, malacology, and other related fields of research. As a result, the scope of geo-archaeology has swung between several definitions, of which the most inclusive is the one proposed by Fouache (2010): 'Geoarchaeology is the application of geosciences and geographical methods to prehistory, archaeology, and history'. He also proposed the consideration of geoarchaeology as a 'synthetic approach which could combine both in-site and off-site analyses, biotic as well as abiotic elements from a transversal, interdisciplinary perspective' (Fouache, 2013).

Considering the various potential methodologies, tools, and dating-methods that can help to create an understanding of an archaeological site, we can now propose a definition for geoarchaeologists as follows: 'a specialist in earth and life sciences who can evaluate the specificity and the problematic aspects of each archaeological site and its related area and propose a holistic streamlined approach to carry out these tasks'.

It implies that geoarchaeologists should continuously seek of innovations from and collaborations with new disciplines.

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2. Scope of this special issue

The multidisciplinary and multiscalar dimensions of geoarchaeology have encouraged the continuous development and innovation of new methods and approaches, which have opened up new possibilities for exploration in previously inaccessible geographical sectors (aerial, submarine, and underground) along with the development of large-scale data acquisitions and treatment (through spatial analysis and the use of Geographical Information systems or GIS) and precise microscopic scale analysis (micro fauna or vegetal remains, micromorphology). During the past thirty years, the development of such varied approaches has drastically implemented the scope of data that can be exploited to reconstruct ancient territories, complex sites and their evolution processes. As such, geoarchaeology enhanced the potential data that could be exploited to gain the best possible understanding of site formation processes. The scope of this issue "revealing latent data in sedimentological and archaeological records" aim to clearly highlights contributions of geoarchaeologist to the understanding of data invisible to the naked eye and that requiring a change in scale of analysis, that can range from the microscopic to the regional scale. The choice of the term "toolbox" refers to the diversity of possible tools and applications that can mobilise geo-archaeologists to extract latent data. The plurality of existing and future methods and tools in no way eclipses the necessary interpretation of the data in their spatial and temporal context (Fig. 1).

This special issue originates from the session T10D 'New contributions in Geoarchaeology', which was held at the end of August 2016 in Kyoto, Japan during the 8th World Archaeological Congress and was supported by the Working Group on Geoarchaeology of the International Association of Geomorphology (IAG). The aim of this session was to propose an overview of newly developed geoarchaeological advances and methodologies to an audience mainly consisted of archaeologists. The session focused on (1) new methods for data exploitation or acquisition; (2) methodologies that enable a better understanding of destroyed/perturbed sites; and (3) off-site methodology/regional approaches that allow the identification of human occupations/impacts. The implicit objectives of the session aimed to sum up helpful geoarchaeological approaches or methodologies for archaeological sites that deal with challenging archaeological contexts, extreme environments, climate constraints, important taphonomic biases, or a lack of 'visible' data.

The T10D session 'New contributions in geoarchaeology' was successful, with 10 oral presentations that reflected the wide range of possible applications that can be included within the scope of geoarchaeology. This volume of 14 papers presents original data, starting with the scale of regional studies, that aimed to identify off-site landscape mobility, human adaptation and anthropogenic impacts on environments, to microscopic scale with the objective to observe microscopic anthropogenic structures or extract information related to mineralogic or chemical composition. The classifications of the papers in accordance with spatial or physical scale are provided in the following subsections.

2.1. Regional scale

- **Snitker et al. (this volume)** deal with land-use dynamics based on a patch-based survey with field data and GIS analyses. This method allows researchers to ascertain whether a landscape characterised by intensive use had been occupied in earlier times.
- **Aucelli et al. (this volume)** study the evolution of the palaeolandscape of the Naples Bay dating to the 1st century BC. In the context of rapid subsidence related to the volcano-tectonic activity, the shoreline shifted considerably during the last two millennia and consequently led to landscape evolution and human adaptation. The authors deployed multi-technique approaches to gather and analyse underwater data, notably along the Posillipo hill. Three different stands of sea-level were identified for the last 5000 years along with anthropogenic terracing that can attest to a contemporaneous response to sea-level changes.
- **Russo-Ermolli et al. (this volume)** investigate the Holocene landscape development of a plain in Italy. The palynological analyses revealed deforestation activities dating to the Roman period and cultivation of olives from the Early Medieval period onwards.
- **Jotheri et al. (this volume)** apply a combination of geomorphological, historical, and archaeological approaches in order to reveal the impacts of freshwater fluvial processes on diachronic settlement patterns in lower Mesopotamia.
- **Peña-Monné et al. (this volume)** use different methods to study

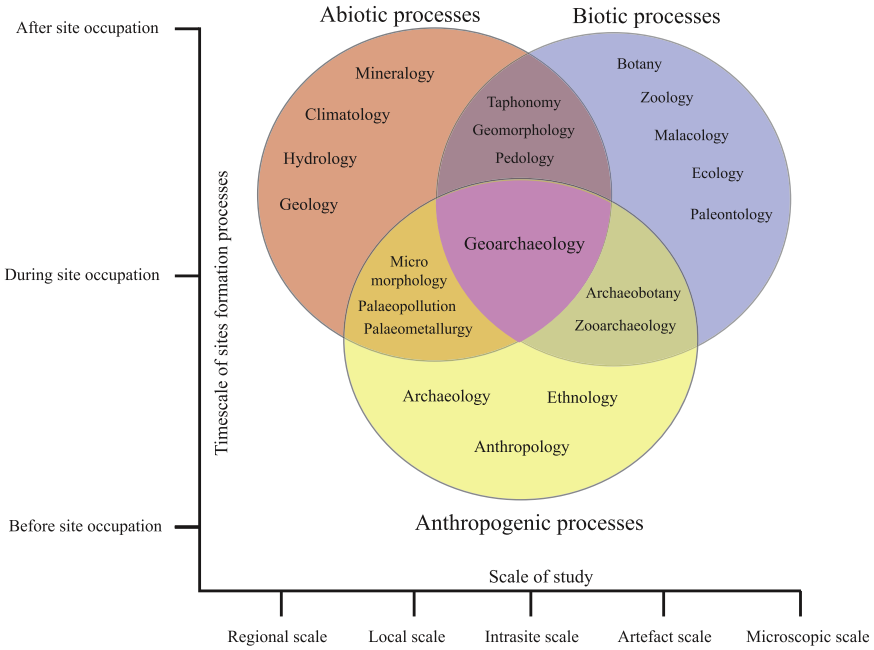

Fig. 1. Geoarchaeology : understanding ancient geosystem by using an interdisciplinary approach and multiples temporal and spatial scales. Schematic disciplinary interactions in Geoarchaeology (non-exhaustive) and spatio-temporal scales of study (scales are illustrative and not operational).