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Editorial

Geoarchaeology: A Review of Case Studies in the Mediterranean Sea

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The term "geoarchaeology" was established within the last 50 years, although earlier applications of this field can be found. For example, in 1830 AD, Lyell illustrated the cover page of his book *Principles of Geology* with the image of pillars of the temple at Pozzuoli (Southern Italy), in order to show how the former sea level differed from that of today. Geoarchaeology can be defined as the application of geological techniques to answer archaeological questions [1,2], but this is an insufficient definition because it depicts geoarchaeology as a set of tools and techniques with no independent approaches, no theory of its own, and no questions of its own to answer [3]. In fact, geoarchaeology today is developing into several disciplines with dedicated researchers: it is no longer geologists who help out archaeologists, nor archaeologists with an interest in geology. It is not something that lies between two disciplines, but it is a new discipline that bridges its main aspects and draws on the tools and techniques of both. In fact, geoarchaeology provides information to understand both the natural processes and the ways in which humans in the past interacted with them. Furthermore, archaeological recovery and analysis are already geoarchaeological approaches in the most fundamental sense because buried remains are contained within and removed from an essentially geological context.

Geoarchaeological research goes beyond this simple relationship and attempts to build collaborative links between specialists in archaeology and the Earth sciences to produce new knowledge about past human behavior. Starting from these tools, geoarchaeological investigations provide the key to recognizing landscape and environmental changes on the site, area, region, and world scales and reconstructing ancient landscapes and paleoclimate.

Other aims of the geoarchaeological investigations lie in understanding the relationships between humans and their environment: the determination of how cultures adjust to their ecosystem through time; what Earth science factors were related to the evolutionary emergence of humankind; and which methodological tools involving analysis of sediments and landforms, documentation and explanation of changes in buried materials, and measurement of time will allow access to new aspects of the past.

There are several reasons why the Mediterranean Sea is a particularly suitable area to study geoarchaeology. The Mediterranean Sea is a geographical area characterized by long-lasting settlements and archaeological sites extending back thousands of years. The main settlements are marked by stages of development, stability, recession, renewed growth, and in some cases abandonment and resettlement. The economic, political, and social dynamics that have driven these processes may be related to environmental factors (climate, earthquakes, volcanism, etc.), such that in Mediterranean contexts, the archaeological and geological records are deeply interconnected. Complex social and economic organizations developed as administrative centers, fortified citadels, temple complexes, and living communities became socially stratified, starting in prehistorical times, with development especially accelerating in the Bronze and Iron Ages. Some cities developed through a progressive coalescence of villages, such as Athens and Rome, whereas others were founded by means of formal planning, such as the Greek colonies in Southern Italy or the Roman colonies within the Empire. In the countryside, the natural landscape was modified by traces of human settlement, reclamation, and exploitation, attested to by the

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emergence of almost formal configurations of rural villages, canals, and agricultural tracts structured in specific patterns.

Coasts, rivers, lagoons, swamps, plains, and hillslopes have long attracted people and influenced the location, development, and growth potential of settlements. The intersection of land and water routes plays a particularly crucial role; for example, the emergence and expansion of Rome was linked to its role at a crossroads between one of the most important waterways of Central Italy, the Tiber River, and the routes joining the Tyrrhenian coast with the Latium, Etruscan, and Campania interior. Several important cities developed due to accelerating commercial traffic on waterways, especially those along the great navigable rivers, at the mouth of rivers, on the banks of wide coastal lagoons, or along the coasts. Settlement in coastal cities was highly interconnected with coastline changes, sediment supply of rivers, and relative sea-level movements. Others were tied to geological resources, such as springs, lithotypes, mineral deposits, or precious marbles. Another key factor explaining why the Mediterranean Sea is an ideal area for geoarchaeological approaches is the richness of the buried landscape that serves as a baseline for structuring chronologies, or archives, of integrated human and natural stratigraphies. Archives from these landscape features document significant environmental changes where evidence of interconnected natural and human processes are preserved within the same stratigraphic sequence. Together, the combined effects of climatic changes, cultural activities, and environmental dynamics have produced a complex pattern of Mediterranean landscapes, including its main settlements, through time.

The Special Issue of *Geosciences* on "Geoarchaeology: A Review of Case-Studies in the Mediterranean Sea" includes seven high-quality peer-reviewed papers outlining only a little part of the state of the art of research in the field of geoarchaeology in Mediterranean Sea environments.

The collection of papers spans a wide geographical range of the Mediterranean Sea but especially focuses on the Italian Peninsula, the area of the world where the best practices in geoarchaeology have been applied. In fact, the human environments include buried coastal sites, offshore and inundated sites, shell middens, fluvial and lacustrine environments (i.e., ephemeral or perennial streams), colluvial–alluvial–fluvial facies (i.e., places with hillslopes and valley fill sedimentation), landform sequences with paleosols (sediments affected by weathering and pedogenesis), and sites that yield significant paleobotanical and paleontological archives. The papers feature a variety of fieldwork approaches (mainly geomorphologic and stratigraphic), including a drilling and diving survey, and analytical techniques, such as geochemical and geochronological analyses and paleontological and pollen reconstructions, or geophysical investigation.

In detail, the Special Issue contains the following papers:

Pappone et al. [4] provide the results of a multidisciplinary study aimed to reconstruct the Roman coastal landscape in the area of the ancient Parthenope, the first settlement along the Naples coast. This coastal sector was surveyed by a team of specialized divers (archaeologists and geomorphologists), providing a high-resolution dataset of morpho-acoustic and optical measurements useful to obtain the geological, geomorphological, and archaeological interpretations. The data permitted the formulation of hypotheses on the functionality of the complex submerged archaeological structures as a vivarium related to a 1st century BC Roman villa. Finally, by measuring the submersion of several channels and a well-preserved crepido, the authors were able to deduce that the relative sea level during the period of use was -2.2 ± 0.2 m mean sea level (MSL).

De Donatis et al. [5] provide a data set on the coastal configuration of the Roman town Sena Gallica on the Adriatic coast in the 5th to 4th century BC. The authors outlined that the site choice was largely influenced by the geomorphological and physiographic conditions near the Misa river mouth. The interactions among climate variation, river dynamics, and relative sea-level rise determined the anthropic development. At the same time, the settlement strongly influenced the evolution of this sector in both medieval and recent times.

Sessa et al. [6] provide a data set on the micro-stratigraphical reconstruction of the scarcely known site of Tana di Badalucco cave, located in Imperia (Liguria, NW Italy), not far from the French border. Its stratigraphy ranges from Middle Paleolithic to Metal Ages, and thus it has registered important climate and environmental variations specific to the Upper Pleistocene and Holocene periods. The authors, using micromorphology techniques on undisturbed thin soil sections, demonstrated an alternating of cold and warmer conditions during the Quaternary and identified primitive signs of human and animal occupation.

Cozzolino et al. [7] provide a data set on the subsoil of the Temple of Athena, one of the main sacred areas of the Greek–Roman settlement of Poseidonia/Paestum (Southern Italy). A multidisciplinary study, including stratigraphic, geomorphological, archaeological, and sedimentological investigations; remote sensing; and electromagnetic and geoelectrical tests, was therefore carried out, shedding new light on the geomorphology and stratigraphy of the SW and W temple sectors. The geophysical data obtained revealed anomalies in the subsoil that correspond to ancient structures and the cutting of the travertine deposits around the temple, allowing the formulation of new hypotheses regarding the temple foundation.

Pascucci et al. [8] provide a data set on historical sea-level rise on NW Sardinia Island (Italy). Using the coastal quarries as sea-level indicators, the authors inferred that relative sea level from 1830 AD (and of the Little Ice Age) rose in about 200 years to the present level at the rate of about 1.4 mm/year. Considering that relative sea-level rise during the Medieval warm period was 0.6 mm/year over a period of about 400 years, the authors were able to deduce that human influence was strong enough to lead to a faster relative sea-level rise.

Gioia et al. [9] provide the results of a geoarchaeological study of a large segment of a Roman road (Via Herculia) that crossed the Lucanian segment of the southern Apennines (Italy). Based on the analysis of bibliographic, archival, literary, archaeological, and historical sources supported by detailed mapping of lithological and geomorphological features, the authors suggest that the choice of the road path was driven by the outcrop of typical lithotypes and the presence of specific geomorphological landforms.

Stubert et al. [10] elaborate a geographic information system (GIS)-based predictive modeling method for the development of models of Roman viticulture in the Laetanian Region (Hispania Citerior Tarraconensis). Using the location of several ancient wine-pressing facilities as response variables and topographical and socioeconomic cost distance datasets as predictor variables, the authors indicate that the accessibility of a location and its connectivity to trade routes and distribution centers, determined by terrain steepness, were decisive for the settlement of viticultural facilities.

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