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Review Article

Geomorphology, Geoarchaeology and their multiscalar approaches

Geomorfologia, Geoarqueologia e suas abordagens multiescalares

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Abstract: This paper discusses the importance of the multiscale approach in geoarchaeological investigations, highlighting the contribution of Geomorphology to this purpose. Although Geoarchaeology does not have a single definition, due to its inter and transdisciplinary nature, in most definitions it uses methods from Geosciences, and in particular from Geomorphology. It deals with everything from archaeological sites to the analysis of the landscape inhabited by human groups, although few studies integrate the various spatial and temporal scales which are essential to understand the complexity of the phenomena. The multiscale approach offers the potential to enrich geoarchaeological analysis by considering the physical elements of the landscape, such as rocks, terrain, soils, and sediments at different temporalities and levels of spatial organization. This broadens the understanding of human interaction with the environment. The widely disseminated model in Geomorphology, which considers forms, materials, and processes at different hierarchical levels of topographic compartmentalization, surface structure, and landscape physiology, coupled with long, medium, and short-term dynamics, represents a promising methodological approach for archaeological site studies. The multiscale approach, therefore, can complement all stages of analysis and has extensive applicability in Geoarchaeology.

Keywords: Archaeological site; Landscape; Local Scale; Regional Scale.

Resumo: Este artigo aborda a importância da abordagem multiescalar nas investigações geoarqueológicas destacando a contribuição da Geomorfologia para esse propósito. Embora a Geoarqueologia não tenha uma definição única, devido a sua própria natureza inter e transdisciplinar, na maioria das definições ela utiliza métodos das Geociências, e em especial da Geomorfologia. Ela se ocupa desde os sítios arqueológicos até a análise da paisagem habitada pelos grupos humanos, embora poucos estudos integrem as diversas escalas espaciais e temporais fundamentais para compreender a complexidade dos fenômenos. A abordagem multiescalar oferece o potencial de enriquecer a análise geoarqueológica ao considerar os elementos físicos da paisagem, como rochas, relevo, solos e sedimentos em diferentes temporalidades e níveis de organização espacial. Isto amplia a compreensão da interação humana com o ambiente. O modelo amplamente difundido na Geomorfologia, que considera formas, materiais e processos em distintos níveis hierárquicos de compartimentação topográfica, estrutura superficial e fisiologia da paisagem, aliado às dinâmicas de longo, médio e curto prazo, representa uma abordagem metodológica promissora para os estudos dos sítios arqueológicos. A abordagem multiescalar, portanto, pode complementar todas as etapas da análise e possui vasta aplicabilidade na Geoarqueologia.

Palavras-chave: Sítio arqueológico; Paisagem; Escala local; Escala regional.

1. Introduction

Geoarchaeological research is currently conducted as an integral component of archaeological investigations across much of the world (GOLDBERG; MACPHAIL, 2006; KLUIVING *et al*., 2015; MORLEY; GOLDBERG, 2017). Archaeological sites, whether in shelters or open-air locations, can present geoarchaeological challenges (RENFREW, 1976; ARAUJO, 1999), given that forms, processes, and materials on the planet's surface are part of the complex locus of human activities (SOUZA; RUBIN, 2020; BATISTA BARBOSA; COUTINHO; RUBIN, 2020; RUBIN *et al*., 2019; RUBIN; SOUZA, 2019; RUBIN *et al*., 2017; DUBOIS; RUBIN, 2017; RUBIN *et al*., 2016; RUBIN; DUBOIS; SILVA, 2015; RUBIN; SILVA, 2014; RUBIN; SILVA, 2013; RUBIN; CARBONERA, 2011; RUBIN; SILVA, 2008; RUBIN; SILVA, 2004; RUBIN; SILVA, 2003; RUBIN; SILVA; BARBERI, 2003; RUBIN; MELO, 1998; VIEIRA SOUZA; RODET, 2015). Thus, elements of archaeological heritage are more fully understood when integrated and interpreted within the landscape (CUNHA, 2006) and its physical components, particularly the relief.

Although Geoarchaeology has grown over recent decades, with increasing topics and areas of study, different approaches, revisited concepts, tools used, and publications in both Brazil and global literature, few studies have discussed the importance of a multiscalar approach in geoarchaeological analysis. A multiscalar approach involves transitioning between distinct and often successive spatial and temporal scales, with the premise that not only does the observer's interpretation of phenomena change with the scale adopted, but the way the phenomenon itself manifests also varies (CARDEPÓN, 2008). The significance of a multiscalar perspective in geoarchaeological research has been supported by authors such as Butzer (2008), Benedetti; Cordova; Beach (2011), and Shahack-Gross (2017), among others, who argue that the challenges arise precisely from the dialogue Geoarchaeology establishes with various fields within the Geosciences, notably Geomorphology.

To contribute to the discussion about the importance of a multiscalar approach in Geoarchaeology and the support Geomorphology can provide in this regard, this article presents an analysis of how physical components structuring landscapes, such as relief forms and associated materials (rocks, sediments, and soils), are relationated at different temporal and spatial scales and how this may enhance the understanding of the composition and significance of archaeological sites across varying scales.

2. Geoarchaeology or Geoarchaeologies?

Geoarchaeology origins date back to the 18th century, but its consolidation only occurred from the 1970s onward (GOLDBERG; MACPHAIL, 2006; BENEDETTI; CORDOVA; BEACH, 2011; HILL, 2017), associated with borrowing of concepts from the Geosciences by archaeologists in the context of the New Archaeology. There is not a unique definition of Geoarchaeology, given its inherently interdisciplinary and transdisciplinary nature (Table 1). Its scopes are diverse and vary depending on the nature of the research and/or the background of the researcher. The work of geoarchaeologists is often shaped by their professionals' paths, and moreover, researchers with very diverse specializations are drawn to this field of knowledge (ANGELUCCI, 2003).

Table 1. Main definitions and objectives of Geoarchaeology.

Author(s)	Definitions
Butzer (1982, p. 35).	Geoarchaeology involves conducting archaeological research using methods and concepts from Geosciences, distinguishing it from Geological Archaeology and not necessarily being related to Geology. A fundamental distinction must be made between technique and objective. Earth Science methodologies provide crucial empirical information and conceptual approaches to understanding prehistoric contexts. These contributions complement those offered by Archaeobotany, Zooarchaeology, Archaeometry, and Spatial Archaeology. The distinction between Geology and Earth Sciences is equally essential, as Geosciences also encompass Geography and Pedology, each providing essential data for the study of environmental systems. The complete matrix of these components includes a formidable list of subfields and approaches comprising Geophysics, Stratigraphy, Sedimentology, Geomorphology, Pedology, Hydrology, Climatology, and Spatial Analysis. All are relevant to Geoarchaeology to varying degrees. Inevitably, none of these individual components dominate in terms of useful techniques over the others.
Waters (1992, p. 2-7).	Geoarchaeology is the application of concepts and methods from Geosciences to archaeological research. More specifically, Geoarchaeology employs techniques and approaches from Geomorphology [...], Pedology [...], Stratigraphy [...], and Geochronology [...] to investigate and interpret sediments, soils, and landforms at archaeological sites. An alternative term, Archaeological Geology, has also been proposed for this discipline.
French (2003, p. 3).	Geoarchaeology is the combined study of archaeological and geomorphological records, focusing on recognizing how natural processes and those induced by human groups alter the landscape. The main objective of Geoarchaeology is to build integrated models of anthropogenic-natural systems and to investigate the nature, sequence, and causes of natural and anthropogenic impacts on the landscape.
Angelucci (2003, p. 36).	A scientific discipline that, using concepts and techniques from Earth Sciences, aims to solve archaeological problems. In its original sense, Geoarchaeology thus indicates an interdisciplinary and multidisciplinary science that employs various theoretical approaches, vocabularies, and methodological tools from both Earth Sciences and Archaeology, with the ultimate goal of understanding the interrelationships between past human groups and their surrounding environment.
Goldberg e Macphail (2006, p. 2).	There is no need to differentiate between Geoarchaeology, Geological Archaeology, or Archaeological Geology, as all fall under the same category: any question or topic that traverses the interface between Archaeology and Earth Sciences. Classifications—and in this case, distinctions—between Geoarchaeology and Geological Archaeology only hold value if they are ultimately useful.
Benedetti, Cordova e Beach (2011, p.84).	The objectives of modern geoarchaeological studies tend to focus on both the processes of archaeological record formation and broader reconstructions of the paleolandscape. Some of the methods employed in studies conducted at sites include magnetic susceptibility, micromorphology, and detailed sedimentology. Landscape studies consist of paleopedology and extensive geomorphological mapping and/or paleoecological reconstruction. Many integrate all of these and other approaches into multiproxy studies that demonstrate the complexity of changes on the planet's surface across multiple temporal and spatial scales.

Author(s)	Definitions
Wilson (2011, p. 2).	Geoarchaeology emerges from the interaction between Archaeology—focused on human groups, with its concern for culture and cultural evolution—and Geology, which is more empirical and centered on nature. Its central principle is the non-separation of human life from the natural world. This is not geographical determinism: it does not claim that human beings behave in specific ways due to their environment. However, it means that the factors influencing human behavior include natural and environmental aspects. In common with its parent discipline, Geology, geoarchaeologists tend to believe that these factors can be measured and understood, even though they are fluctuating and complex.
Kluiving *et al*., (2015, p.1,).	Geoarchaeology encompasses a field where natural and anthropogenic processes interact. Geoarchaeology is nothing more than Geology or Physical Geography associated with Archaeology, which provides the tool for dating. On the other hand, Archaeology is more than just a mere dating method. It is capable of providing insights into the reconstruction of landscapes, human behavior, and cultural processes that form the backdrop for landscape change. Geoarchaeology faces the ultimate challenge of combining information from Geology, Physical Geography, and Archaeology, varying according to the methodologies adopted in alignment with the spatial, chronological, and geographical focus of the examined problems.
Cordova, C., (2018, p.1).	Geoarchaeology as a field is an essential scientific approach to studying human-environmental relationships in the past and the present. From its original conception as a series of geoscience techniques applied to archaeological research, it has become more than a multidisciplinary approach bridging archaeology and the geosciences; geoarchaeology has evolved to tackle problems related to society and environment of interest not only to archaeology but also to other fields.

The definitions presented in Table 1, arranged chronologically, highlight common aspects regarding the authors' positions on Geoarchaeology, as well as singularities and differences. These are associated not only with each author's scientific stance but also with the development of Geoarchaeology over time.

It is widely agreed that Geoarchaeology incorporates the application of methods and techniques from the Geosciences in the interpretation of archaeological sites and associated artifacts. This is a primary conceptual essence of this field of knowledge, present in almost all the definitions provided. Over time, the complexity of integrated landscape analyses has also become part of Geoarchaeology, making it much more than just the application of techniques. In this sense, Modern Geoarchaeology does not merely study the material remains prospected and their involvement in site formation but also the landscape that ancient human groups occupied.

However, Geoarchaeology is distinct from Landscape Archaeology, a field that investigates the material remains of past human groups based on their interactions with the natural and social environments they inhabited in a broad and interdisciplinary manner (KLUIVING; GUTTMANN-BOND, 2012).

Geoarchaeological literature emphasizes studies that utilize detailed technical analyses at the local scale of sediment samples derived from archaeological sites, as well as observations at scales encompassing entire regions over long periods. Some archaeological studies focus on sites that are tens to hundreds of thousands of years old, while others cover sites from decades ago to the present. Geoarchaeologists are also aware of the importance of information from sources beyond archaeological sites, considering aspects of regional relief and non-cultural stratigraphic sequences (WILSON, 2011). Along with the propagation of new approaches to the recovery of archaeological data, the analysis and construction of theories that integrate new forms of information and new investigative methods, there is a growing demand for a multiscalar approach in Geoarchaeology, based on the study of local sites in their regional context (ROSSIGNOL; WANDSNIDER, 1992). This is done without abandoning one of Geoarchaeology's main interests: understanding the formation of archaeological sites while considering the multiple processes at play.

Thus, Geoarchaeology incorporates analyses that span from site to landscape, including geomorphological, sedimentological, pedological, mineralogical, petrographic, and archaeological analyses, encompassing a diversity of techniques adopted in Geosciences and Archaeology. It also involves with information from Palynology, Zoology, and Paleobotany (STEIN; LINSE, 1993). Furthermore, includes the use of new and more precise dating methods, detailed mapping, remote sensing, GIS analyses, computational modeling of geomorphic and biotic systems, and advanced analytical techniques employing Micromorphology, Sedimentology, Geochemistry, and Paleobotany (BENEDETTI; CORDOVA; BEACH, 2011) in approaches that consider the full spatial and temporal complexity of landscapes.

3. Geoarchaeology and Geomorphology

Many objectives in geoarchaeological research can be achieved through the utilization of concepts and paradigms from the Geosciences, particularly those from Geomorphology, considering the numerous intersections between them. These are sciences that conduct fieldwork, maintain a close relationship with environmental proxies, require integration of laboratory methods, and involve analyses based on a complex structure of multiple anthropogenic and natural processes (BEACH; DUNNING; DOYLE, 2008). Similarly, they intersect in their respective research because they provide relevant information about past environments and share historical and methodological aspects.

The scientific body of most Geosciences, including Geomorphology, emerged and developed in the late 18th century (BROWN; PETIT; JAMES, 2003), which also applies to Geoarchaeology, with both fields emphasizing studies of the Quaternary period (KIPNIS; SCHEEL-YBERT, 2005).

Butzer (1982) proposed a complementary paradigm for archaeological studies based on the central concept of human ecosystems, which can be understood through three possible approaches: Geoarchaeology, Archaeometry, and Bioarchaeology. Geomorphology is positioned within the Geoarchaeology axis, as defined by Butzer (1982), serving as a potential focus for a better understanding of the study and interpretation of physical and human landscapes, and is dissociated from Archaeometry and Bioarchaeology (Figure 1).

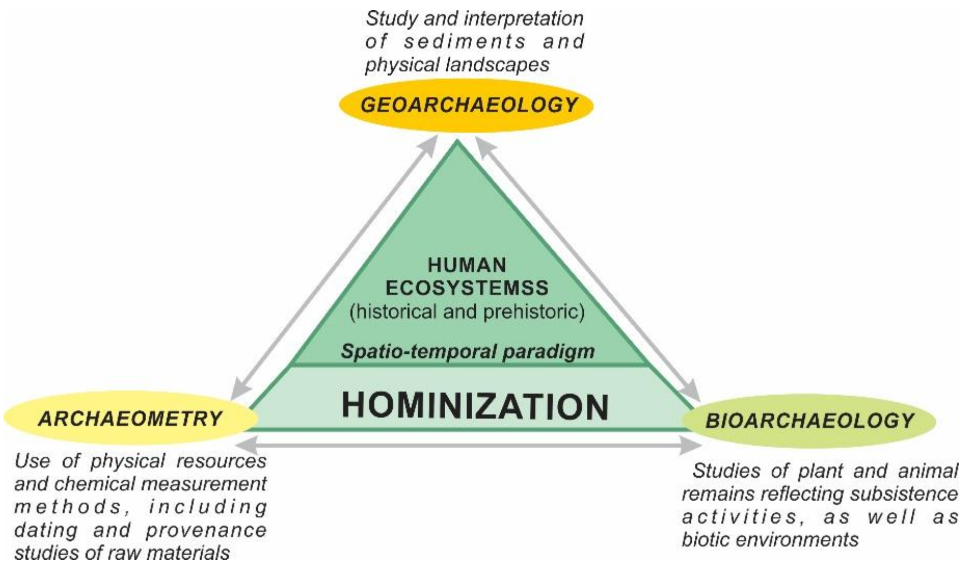

Figure 1. Integrated Analysis of Human Ecosystems. Adapted from Butzer (1982).

The concept of human ecosystems serves as an organizing principle to highlight the interdependence of cultural and environmental variables in archaeological contexts. Butzer (1982) integrated methodologies from the physical, biological, and social sciences based on the interactions between human groups, or societies, and the environment in which they are embedded. According to the author, the location and the dynamic processes occurring within it define human ecology.

With the process of disciplinary diversification associated with the development of Geoarchaeology over the years and considering the inherent complexity of environmental systems, Benedetti, Cordova, and Beach (2011) proposed a subdivision for Modern Geoarchaeology into three main methodological approaches: Paleosurface, Geochemistry, and Human Ecology. The three approaches emphasize surface processes associated with the forms and materials of environments influenced by human activity, particularly in the geochemical and paleosurface approaches (Figure 2).

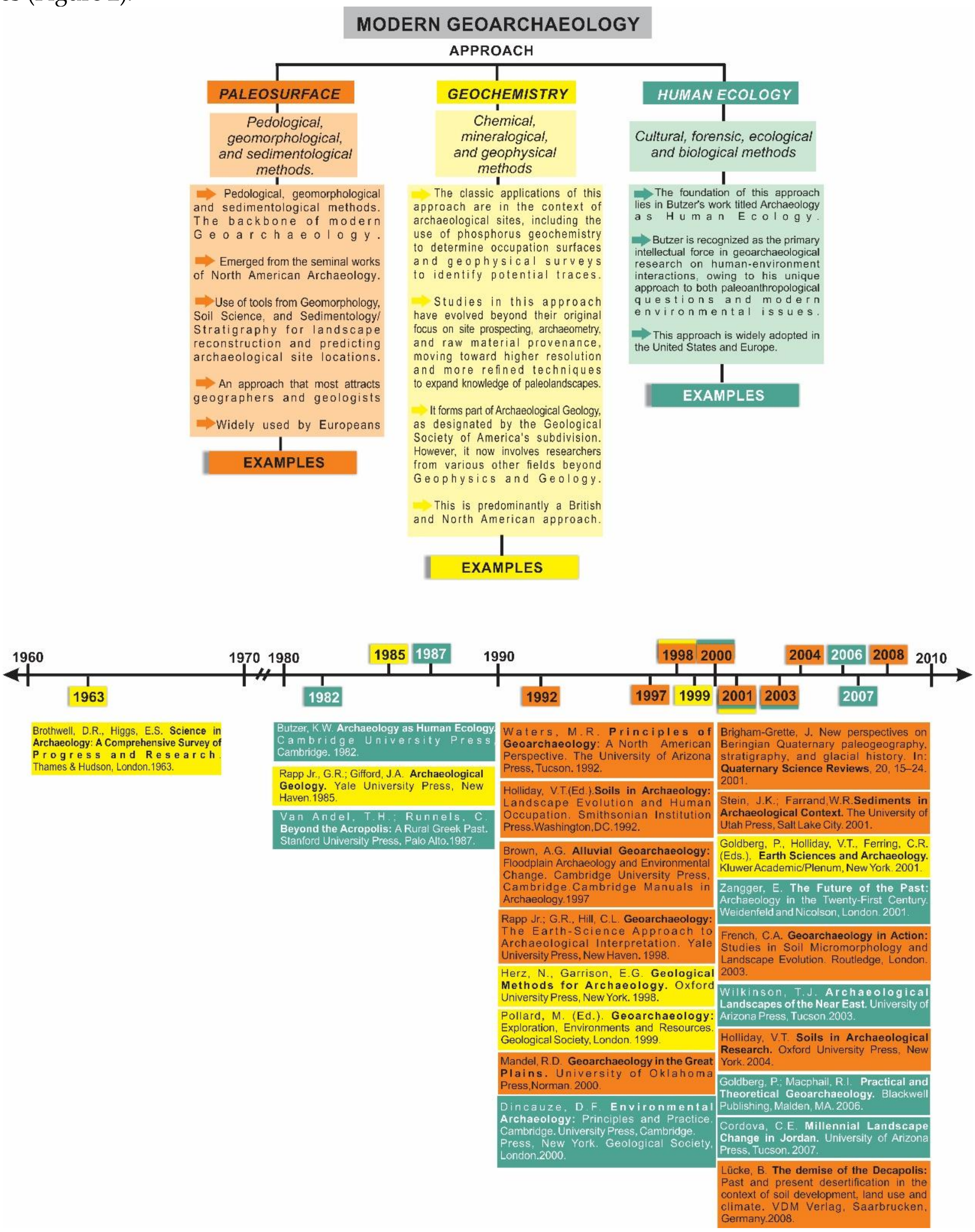

Figure 2. Modern Geoarchaeology and Possible Methodological Approaches. Adapted from Benedetti, Cordova, and Beach (2011).

Modern Geoarchaeology has begun to prioritize the physical components themselves, their relationship with the sites, and the landscapes in which these sites are studied, establishing a direct connection between human occupations and these components. In this context, relief — as well as soils, rocks, and sediments — takes on a prominent role in archaeological analysis. Consequently, the dialogues between Geoarchaeology and Geomorphology are strengthened, and the knowledge produced by both fields becomes interconnected.

While Geomorphology pursues to reconstruct landscapes with a focus on relief through the triad of forms, materials, and processes, Geoarchaeology contextualizes archaeological records and refines the resolution of chronologies (COLTRINARI, 2008). Thus, beyond artifacts, the space in which human groups operated constitutes a mega artifact, the smallest unit of which is the archaeological site (DIAS, 2008). In other words, relief itself is a component of interest for understanding past human occupation of space. To achieve this, the levels of organization and the temporalities of relief and other physical components in the landscapes associated with it must be considered and decoded.

Associated with chronologies, different types and conceptions of time intersect. This includes the time of formation and evolution of rocks, relief, sedimentary deposits, and soils, which, although all present simultaneously in the landscape, can be understood in a strict manner based on the peculiarities of the phenomena embedded in each of them. There is also a distinct hierarchical organization in how these components are structured within the landscape, which impacts levels that have a strong relationship with the spatial scale adopted. These temporalities and levels of spatial organization of the components constitute the first intellectual exercise to be undertaken to chart a path toward a multiscale approach in the relationship between Geoarchaeology and Geomorphology.

4. Temporalities and levels of organization of physical components

The attempt to categorize the short, medium, and long timescales of rocks leads us to consider a division that incorporates, respectively, the Quaternary in the Cenozoic as short time, the Mesozoic and Paleozoic as medium time, and the Proterozoic and Archean as long time. In this temporal dimension, the long time would characterize periods on the order of millions to billions of years, the medium time on the order of millions, and the short time on the order of millions to thousands. The magnitude of these ages shows that the dynamics of rock transformation occurs at a much slower rate in the landscape, although it exerts a strong influence through its compositional, textural, and structural attributes. Geological time is unevenly distributed across physical landscapes, based on the distribution of lithological stocks of various ages and distinct surface covers. For the Brazilian territory, composed of granitic, mafic, pelitic and metapelitic, arenitic, ferruginous, limestone, gneissic, and conglomeratic rocks, the multiple and complex relationships with the distribution of soils, relief, and other landscape attributes are widely presented by Schaefer *et al*. (2000) and Schaefer (2013; 2023).

For relief, short time can be circumscribed, according to Summerfield (1991; Figure 3), to a scale that extends up to 10^1 years, also referred to as stable time. Medium time, or dynamic time, would be on the order of 10^1 to 10^3 years, and long time, or cyclical time, could reach slightly over 10^7 and 10^8 years. Regarding very short and long times, this author emphasizes:

> In a very short timescale, it is possible to concerned solely with the operation of processes and their relationships with the currently existing landforms; at the other extreme, can be established a historical sequence of relief development over a period of millions of years, relating it to long-term changes in endogenous processes (Summerfield, 1991 p.16).

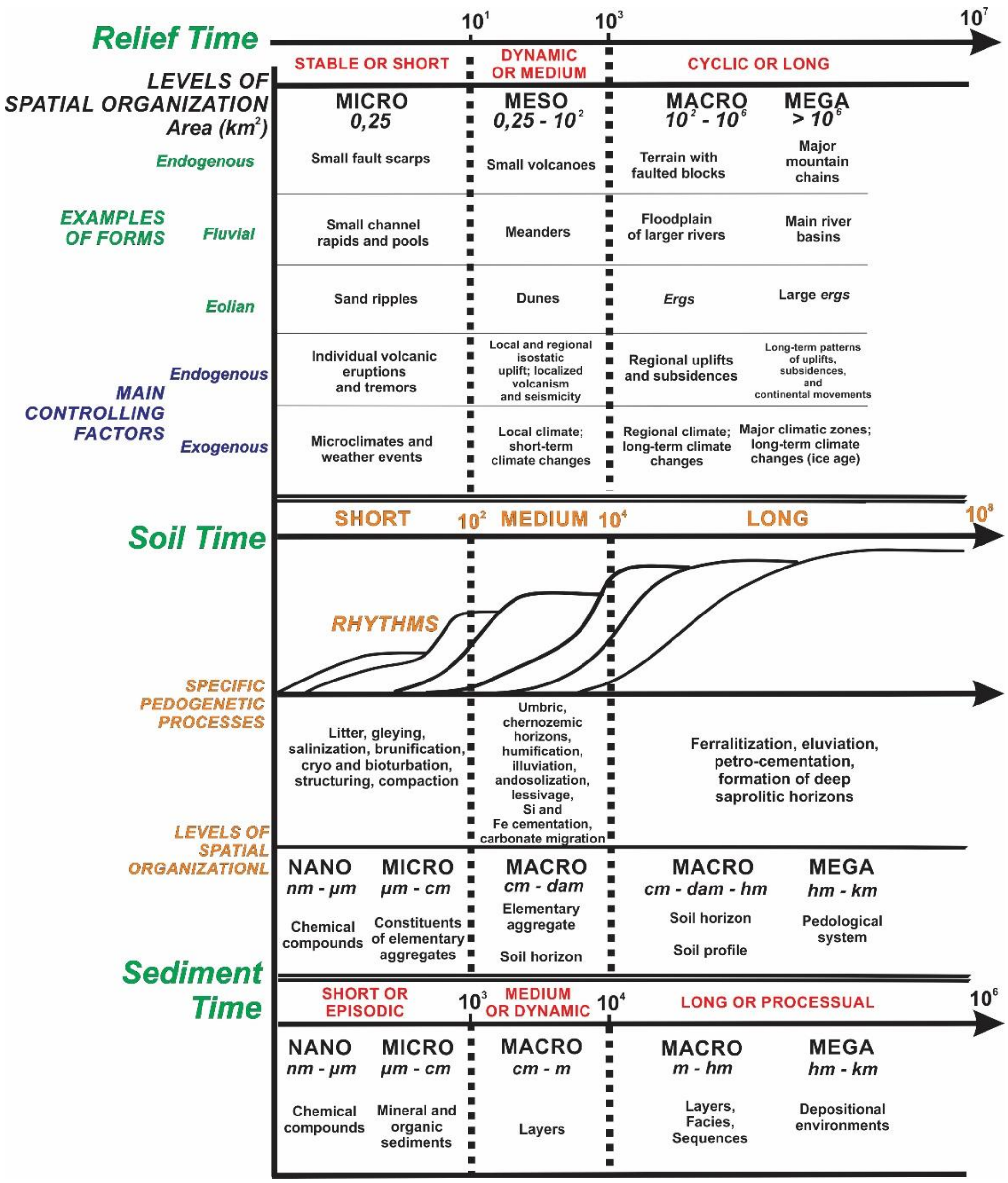

Figure 3. Summary of Temporalities (Short, Medium, and Long Times) and Spatial Organization Levels of Physical Components: Reliefs, Soils, and Sediments. Adapted from Summerfield (1991), Targulian and Krasilnikov (2007), and Cohen *et al*. (2013).

> [...] When looking at the landscape is possible to discover what processes are currently active and their present form in reference to those processes, or to strive to understand the history of the landscape and comprehend its current form in terms of a sequence of landscapes over time. The first approach, termed functional, emphasizes the immanent processes of reality. The second, referred to as the evolutionary or historical approach, emphasizes configurational aspects (SUMMERFIELD, 1991, p. 16, our translation).
>
> While relating present forms to currently active processes can be a successful strategy when working at a small scale, or where landforms are rapidly adjusting to the operation of geomorphic processes, this is not an appropriate approach when considering landscapes at larger scales or those that have experienced long periods of tectonic tranquility, for example (SUMMERFIELD, 1991, p. 16, our translation).

Although there is a relationship between the spatial orders of magnitude of non-catastrophic geomorphological phenomena and a given temporal dynamics, it is important to highlight that time constitutes a dimension that assumes centrality by permeating all fields of study in Geomorphology (THORNES; BRUNSDEN, 1977; FRENCH, 2003; GILBERT, 2017). Whether at a vast spatial scale in the landscape or in a small detail of a slope, coexist forms and materials resulting from processes with multiple temporalities (FRENCH, 2003).

The time of soils is relatively similar to the time of landforms (Figure 3). Considering the scale proposed by Targulian and Krasilnikov (2007), the short time frame is on the order of up to 10^2 years and can be represented by the occurrence of soils affected by processes such as gleying, bioturbation, compaction, structuring, and salinization, among others. In the medium time frame, which can extend to 10^4 years, soils associated with processes of leaching, humification, cementation of constituents (even in isolated, nodular features), and Andosol formation can be found. Finally, in the long time frame, on the order of millions of years (up to 10^8), there are large mantles of weathering, deep saprolites, and soils associated with ferralitization and alitization, often involving the formation of lateritic crusts. Spatially, soils can range from elementary organizations, hierarchically arranged at micro and macroscopic levels, as proposed by Bocquier (1982), to the levels of assemblies, horizons, and pedological systems, as proposed by Ruellan and Dosso (1993).

For sediments, considering superficial depositional records, time is confined to a scale where most deposits (non-lithified) are Quaternary. Thus, the short time frame could be defined as ranging from 10^0 to 10^3 years, the medium time frame from 10^3 to 10^4 years, and the long-time frame from 10^4 to 10^6 years. Similarly, the spatial orders of magnitude at hierarchical levels reveal the relationship ranging from the compositional organizations of layers to their arrangement in sequences (stratigraphic) that define depositional environments with specific environmental characteristics.

5. Do human activities introduce new temporalities for the physical components?

In order for the temporalities and orders of spatial magnitude of the physical components to support geoarchaeological studies, it is necessary to reflect on how they operate together in the landscape, how they relate to human activities, and whether, based on this relationship, they are affected, as human groups appropriate, transform, or even create these components in the organization and reorganization of landscapes.

In the first case, for some components such as rocks, the earliest human presence on the planet witnessed the same lithological sets that we observe today. This is because the temporality and magnitude of rocks operate on scales that are very distinct from the evolution of the human species, on the order of millions to billions of years. Nevertheless, humans have witnessed (and still witness) significant geological events associated with the formation and evolution of rocks, such as volcanism and earthquakes. However, when considering relief, soil, and sediments, these temporalities change, and to some extent, humans have accompanied the evolution of some of these components, primarily in the short to medium term and from local to regional scales. In this case, it should not be thought that human groups accompanied the formation and transformation of soil and landforms within their lifespan. Rather, when these transformations occurred, especially during the Quaternary, human presence was already established and likely experienced the environments and the respective processes that drove such transformations. The Quaternary glaciations, for example, which are so important for explaining some of today's landscapes, are also relevant for explaining mechanisms of human mobility in various parts of the planet (CORDOVA, 2018), serving as the basis for several theories of the expansion of the Homo species. The Quaternary is also known as the period of human groups and glaciations. This association is somewhat misleading, considering that the first hominids are known from the Late Miocene in Africa and that there are records of Arctic glaciations beginning in the Pliocene (POMEROL *et al*., 2013). For this reason, Geomorphology, in its effort to understand the dynamics of landscapes in the Cenozoic, brings with it a set of information that can corroborate archaeological studies.

In the second case, more than merely experiencing the natural rhythm of transformations, humans would be responsible for acting directly and/or indirectly on these rhythms, becoming agents of modification of the physical components. In this understanding, there is therefore an essentially physical temporality, of rhythms in nature, but also a relational, historical temporality, defined by the association between human activities and physical components. These discussions have intensified as a result of debates about the Anthropocene-Technogenic (CRUTZEN; STOERMER, 2000; PELOGGIA, 2015; SUERTEGARAY, 2018).

As highlighted by Peloggia (2015), the proposition of the concept of Anthropocene (CRUTZEN; STOERMER, 2000) was supported by the conception of environmental changes on a planetary scale, and not by the geological record of human actions in landscapes, treated as human agency by the author. A historical landmark would be the Industrial Revolution in the original proposal, when technology effectively became a component of profound global environmental changes. However, Peloggia (2015) reminds us that the record of human action predates the Anthropocene, as defined, and that its study would have a strong connection to Archaeology.

Definitions like Mesolithic and Neolithic apply to the context of the Old World. However, there is no Neolithic south of the Equator, considering the specificities of the development of agriculture and ceramics in the Amazon, associated with the process of human occupation in the Americas (NEVES, 2016). Thus, remain doubts and debates about the periodization of the Anthropocene, considering past human occupation in different regions of the planet. In this regard, Oliveira and Peloggia (2014) and Edgeworth *et al*. (2015) highlight that if records of human action are diachronic around the world, then why could the Anthropocene itself not be considered diachronic? Based on this, Oliveira and Peloggia (2014) proposed a compartmentalization into diachronic geotectogenic units, in which the Anthropocene is the most recent record of a major technogenic event.

The importance of considering these aspects stems from the fact that physical components are appropriated in distinct ways over time and space, diachronically, as indicated by those authors. A simple check of the degrees of anthropization of a component in the prehistoric context compared to the historical context, after the Industrial Revolution at the end of the 18th century, reveals the differences. Rocks, for example, were appropriated by ancient human groups in the lithic industry in such a way as to cause their distribution in space and transformation into tools for various uses. These transformations, however, are very related to their intrinsic properties and, in only a few cases, involved significant compositional changes. It is also important to note that these choices may be linked to symbolic issues. Even if a rock or mineral is not, in fact, optimal for knapping, it may have been chosen because of its symbolic qualities. However, after the Industrial Revolution, the transformation of rocks involves the use of techniques capable of producing significant changes, such as in metallurgy with the creation of alloys and in the ornamental industry with the creation of artificial stones. The same reasoning can be applied to relief, soils, and sediments.

Another relevant aspect is that the very temporality and spatial dimensions of the physical components discussed here respond differently to transformations driven by human activities. In the case of relief, for example, it is possible to think of transformations confined from short to medium time, from stable to dynamic, from centimeters to kilometers, where human activity can act directly or indirectly, performing such transformations (excavations, for example) or influencing processes (accelerating the process of water erosion, for example). This indicates that the transformations of relief that characterize the genesis of anthropogenic forms occur mainly on slopes and at the scale of drainage basins, marked by the dominance of morphodynamic processes. Regarding soils and sediments, Holliday, Ferring, and Goldberg (1993) consider these to be the components that exhibit the most complex and complete possibilities for changes in response to human interventions. These authors highlight that the scalar compatibility between Archaeology and Pedology, much more than the information that soils can provide, reiterates a logic of geoarchaeological work in which pedologists are involved in various phases of work.

6. Multiscale analysis in Geoarchaeology

The physical components found in the archaeological site, in the surrounding environment, and from a regional perspective constitute important systems from which it is possible to measure—at least indirectly—aspects of a paleolandscape, being especially relevant even when current vegetation or climate have limited applicability to the past (STAFFORD; HAJIC, 1992). The forms and materials are associated with processes in the short, medium, and long terms, which intertwine in all spatial dimensions that comprise geoarchaeological studies.

According to Holliday, Ferring, and Goldberg (2003), geoarchaeological studies that utilize physical components can prioritize a specific spatial scale or seek to navigate between them. Therefore, what becomes increasingly necessary in studies that encompass geoarchaeological concepts and paradigms is to understand what the choice of certain scales—at the expense of others—can reveal or respond to the proposed questions. Clarifying the method and its implications elucidates the potentialities and possible archaeological questions that can be better understood through the suturing of Archaeology and Geography.

Analyses that encompass various scales are referred to as multiscale analyses. While scalar analyses can address well-directed questions, it is multiscale analyses that allow for the connection of information provided by the archaeological record intended for reconstructing the possible past environments with which human groups interacted. Scalar analysis can be understood as one that prioritizes certain scales and spatial delineations derived from geoarchaeological investigations. The information obtained from multiscale analyses goes far beyond the characterization of the landscapes of a given archaeological site (FOUACHE, 2013). From these analyses, it is possible to construct prospecting strategies, diagnostics, and indications of areas with greater excavation potential and to initiate discussions about the spatial distribution of archaeological remains before, during, and after archaeological identification and characterization.

Although not always discussed as a research strategy, the multiscale approach, as a defining process of description and interpretation, has great potential in Geoarchaeology (STEIN; LINSE, 1993). Goldberg and Macphail (2006) emphasize that the best results achieved in geoarchaeological investigations are those in which appropriate techniques were employed, closely linked to multidisciplinary studies that provided consensus interpretations. The differences in scales and datasets across the various sciences that comprise multidisciplinary research contribute to strengthening the investigation process. However, it is necessary to facilitate the integration of the complementarity of different data sources, the consistency between datasets, and the congruence of the scale through a well-defined research design (DINCAUZE, 2000).

Dincauze (2000) highlights that understanding the incongruence between local and regional scales can assist archaeologists in interpreting each dataset. To this end, it would be necessary to consider the spatial scales compatible with Archaeology, avoiding comparisons between incomparable entities. Relevant spatial concepts and methodological considerations vary with the scale being considered. For the temporal dimension, methods adjust according to the spatial scale.

In parallel, the choice of research techniques can, directly or indirectly, reveal rates of process operation over time and space. Techniques applied to the study of surface formations allow for predictions of process occurrences at the slope scale, while the morphometry of drainage basins often facilitates extrapolating the relationships between forms and processes in both the present and the past (GOUDIE *et al*., 1990).

Araujo (1999), however, warns that neither Geology nor Geography offers techniques that are a panacea for archaeological problems, especially considering the objectives of each of these fields of knowledge. Similarly, Quaternary geomorphological studies generally do not employ approaches directly applicable to the interests of Archaeology. According to this same author, a static view of sedimentary records is very far from reality, and there is immense fragility in transposing the temporo-spatial principles of sedimentology—originally associated with geological time—too simplistically to archaeological records.

Rubin and Silva (2004) state that understanding the significance of these scales allows for better alignment of the objectives of geoarchaeological work, avoiding disconnected interpretations regarding the nature of archaeological remains. They further reiterate that human action, the closer it is to the contemporary environment, presents a more precise explanation of the organization of human groups and their modes of production. However, the further one goes back in time, and the larger the occupied area, the more complex the geoarchaeological approach becomes.

6.1. Geoarchaeology at the regional scale

The last 20 years are characterized by a proliferation of new approaches to the recovery of archaeological data, analysis, and theory construction that incorporate new forms of information and methods of investigation. The growing importance of these new approaches has resulted in an expansion of the spatial domain of traditional archaeological data recovery and analysis, considering its traditional focus on specific sites within archaeological locations; the incorporation of data both at the site and in its immediate surroundings or landscape; and through extensive regions. Thus, research that considers large areas begins to regard the material results of human organization at the regional scale (ROSSIGNOL; WANDSNIDER, 1992). The analysis of physical components at the regional scale is based on forms and materials whose temporalities refer to long timeframes and higher levels of organization (Figure 3). As spatial scales and temporalities increase, geoarchaeological studies must consider climate change as an important factor in landscape alteration (BEACH; DUNNING; DOYLE, 2008).

The initial stages of a regional archaeological study involve familiarization with the studied regional landscape. Field reconnaissance, along with the study of maps, aerial photos, and satellite images, helps to define the preliminary context. This exploratory stage allows for a first assessment of potential combinations of the processes operating in the region and how sites are or may be affected by their location in specific topographical sectors, for example (BUTZER, 2008). According to Stafford and Hajic (1992), pre-contact human groups traversed different units of the landscape to obtain energy and nutrient resources. Such resources are distributed heterogeneously, not only among the different units but also in the sectors or subunits that compose them.

In geoarchaeological research where sites are already mapped and defined, their occurrence in specific landscape sectors can be identified through peaks that indicate the predominance of their location within different units at the regional scale. Another analytical logic is associated with research where sites have not been fully mapped or identified. In these cases, the peaks of occurrence of the findings are considered based on analysis at the local scale (WELLS, 2001). Therefore, this represents another scale of analysis, the characteristics of which are addressed in the following section. In addition to occupation in specific sectors of the landscape and the use of available natural resources, the choice of locations associated with rock art can also be better understood from the perspectives of space appropriation at the regional scale, combined with local aspects (ESTEVEZ; OUBIÑA; CRIADO-BOADO, 1997; LINKE, 2004).

Although archaeological sites and associated remains can be found in most environments—including what is now marine (FAUGHT; DONOGHUE, 1997) —most human occupations, or at least traces, are not uniformly distributed across these environments. Locations associated with fluvial environments, for example, are considerably more abundant than those in desert or glacial terrains (GOLDBERG; MACPHAIL, 2006). Many geoarchaeological investigations at the regional scale involve complex fluvial landscapes. The analyses, when possible, should extend to the entire watershed (BEACH; DUNNING; DOYLE, 2008).

Tectonically active regions provide unique niches for human occupation and food resources. Active faults and folds alter the flow of surface and groundwater. Fault scarps locally dam sections of river channels, forming lakes that provide resources for survival. The accumulation of sedimentary deposits in tectonic faults or depressions, along with soil development, facilitates the emergence of specific faunal and floral communities. Thus, the reasons for finding archaeological sites in such locations are understood (NOLLER, 2001). Knowledge related to tectonics and epirogenesis should focus on the relationship between landscape structuring, site placement, and surface dynamics (RUBIN; SILVA, 2004).

Considering the above, the application of long-term geomorphological scales to geoarchaeological studies in regional analyses can be utilized: (i) at the beginning of research, where geomorphological aspects are considered foundational information for understanding the potentials of the territory in terms of mobility, accessibility, and also for identifying the presence or absence of possible natural resources; (ii) during the development of research, where the analysis of previously mapped geomorphological units highlights areas with greater or lesser potential for the occurrence of archaeological remains, supporting the prospecting process; (iii) at the final stage of the research process, where the spatial distribution of identified archaeological sites by geomorphological unit evidences and justifies the patterns of organization of ancient settlements in specific regional sectors, the logics of choosing areas for rock art execution considering a regional context, as well as the characteristics of the site and the possible areas for appropriating natural resources used as raw materials, among other possibilities.

6.2. Geoarchaeology at the local scale

The application of local scales confines geoarchaeological study to the site and its surrounding slope, establishing a direct relationship with the study of the superficial formations present, rocky outcrops, and the configuration of these slopes. It is primarily at the local scale that the landforms and associated materials constitute the matrix in which cultural remains occur as a fundamental part of the sedimentary record. Villagran (2010) asserts that archaeological remains are immersed in archaeological sedimentary matrices that, along with artifacts, shape the archaeological record and constitute the sites. The author considers that the superficial formations found at the site provide a fundamental source of information related to taphonomic processes, which alter the integrity of the artifacts and the physical and chemical signatures resulting from human occupation.

The archaeological record is an indicator of biological and cultural evolution, and its study allows the identification of behavioral patterns, encoded in artifacts and embedded in sediments (Butzer, 2008). This author also emphasizes the importance of sampling and studying the superficial formations external to the archaeological site to determine the similarities and differences with the material in the archaeological record.

The superficial formations at sites consist of materials dating back to the Quaternary or to diachronic technogenic events, according to Oliveira and Peloggia (2014), and may present in either consolidated or unconsolidated forms, retaining sedimentation properties or having undergone pedogenesis. The sedimentary or pedological matrices in which archaeological remains are embedded or that have been geochemically altered by past or present anthropogenic activity have a multi-millennial formation history that precedes the process of human occupation.

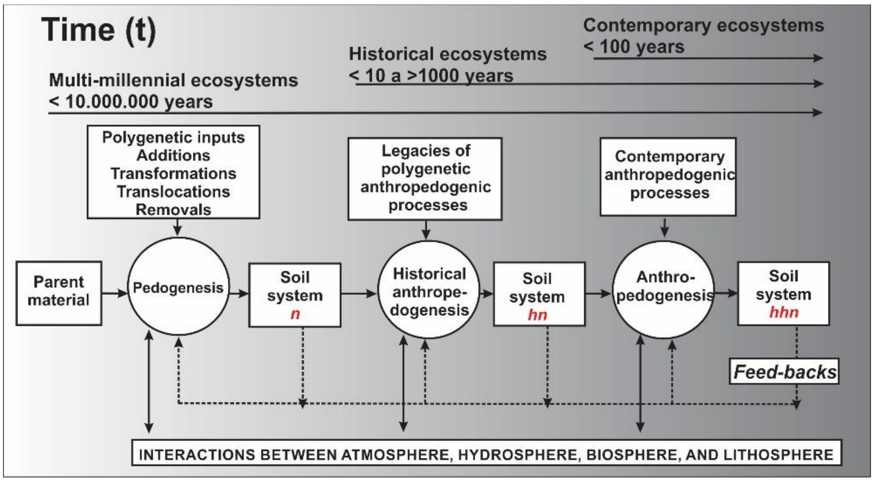

Figure 4. Multiple temporal scales and the processes of genesis of *in situ* surface formations (eluvium) with anthropogenic influence where *n*: natural multi-millennial soil system; *hn*: historical soil system; *hnn*: soil system affected by contemporary anthropogenic activities. Adapted from Richter and Yaalon (2012).

The understanding of the variability of surface formations at the site and slope scale, whether due to slope, drainage, or lithology, holds archaeological significance as it enables the establishment of stratigraphic relationships between what is found at the site and its immediate surroundings, also complementing the interpretation of the site's formation processes (HOLLIDAY; FERRING; GOLDBERG, 1993). Knowing the relationship of an artifact with the surface formations and outcrops in the vicinity provides the research team with the means to determine whether the artifact is in situ—meaning deposited anthropogenically—or if it has been reworked by subsequent physical, natural, or human processes (WELLS, 2001).

Numerous anthropogenic inputs of matter and energy related to successive occupations at the same prehistoric site give rise to anthropogenic surface formations subject to long-term colluvial processes or seismic activities that reorganize and add new characteristics to the archaeological record (Figure 5A).

Although colluvial processes and seismic activities can occur on short-term geomorphological scales, only a specific analysis of the surface formations in each context can reveal whether such processes occurred recently or if they are associated with the long term. The greater the association of multiple colluvial events, seismic occurrences, and occupations in a given location, the higher the likelihood of alterations to the conditions of equilibrium in the environment over a longer time scale (NOLLER, 2001). This author asserts that such complexity is generally associated with a succession of long-term events. However, cases of multiple events occurring in the medium and short term are also recorded, typically in areas subject to constant tectonic instability or superficial geodynamic processes, such as mass gravitational movements (Figure 5B). These statements by the author support the idea that, far beyond pre-established models for long-term geoarchaeological analyses, the singularities of the context take precedence in any type of analysis.

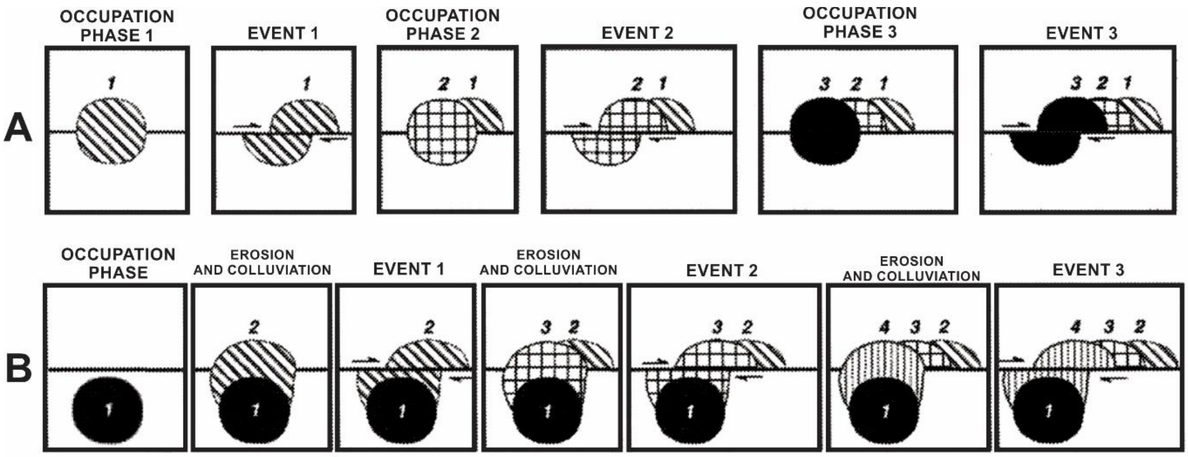

Figure 5. Possible archaeological deposits subject to seismic activity and colluviation. (A) Multiple deposits with characteristics of long-term use during a series of earthquakes. (B) A single deposit located adjacent to an active fault and subject to erosion and colluvial processes. Adapted from Noller, 2001.

The configuration of slope morphology, especially in tropical environments, shows that slope forms are so varied and complex that it is not possible to associate a single mode of development. This aligns with the ideas of Moura, Peixoto, and Silva (1991), who assert that successive reworking processes can occur, erasing or not erasing traces of previous episodes. This approach considers the interpretation of the stratigraphic sequence linked to various processes occurring throughout the Quaternary, where the geometric features that make up the slopes and the associated materials allow for an understanding of the evolution of these slopes.

A series of surface and subsurface processes occurred throughout the occupation of the Americas, which does not mean that the morphological configuration of these slopes is solely related to short-term dynamics. Much of the colluvial dynamics in Brazilian slopes are Holocene and penecontemporaneous. The morphological analysis and delineation of the slope units where archaeological sites are located allow for the recognition of specific patterns related to the context of occupation and/or appropriation of natural resources in the landscape. Thus, the morphological study of slopes constitutes an important geomorphological aspect to be considered in geoarchaeological analysis.

Geoarchaeological approaches at the local scale, emphasizing short-term dynamics, are based on the current dynamics of the landscape, more often examined in a post-hoc manner to explain the form of the archaeological record (FANNING; HOLDAWAY, 2001). Research projects where archaeological sites are identified from the outset and that last more than two years may include subprojects monitoring soil loss rates on slopes, as well as gravitational mass movements (RUBIN; SILVA, 2004).

According to Butzer (2008), concerning the site and the associated archaeological records, analyses at the local scale allow for understanding the formation processes of the records, their modification, and destruction, leading to the assessment of their integrity (Table 2). In practice, according to this author, this specifically constitutes the observation and understanding of the occurrence of numerous processes of horizontal and vertical disturbances of a chemical, physical, and biological nature, identification of current sedimentation and erosion areas, distinguishing them from paleoshapes, assessing the depth of surface formations, and identifying contexts that help preserve archaeological and biological sedimentary records. Such analyses apply to sites and their respective archaeological records, whether open-air or in cavities.

Table 2. Basic aspects for understanding the formation and modification of archaeological sites based on short- and medium-term analyses, adapted from Butzer (1982).

Archaeological Site	Characteristics
Formation	1 - Human or animal geomorphic agents produce archaeological sediments with physical, biogenic, and cultural components that require identification and interpretation. 2 - Distinction of materials. a - Materials introduced to the sites by human or biological action in the form of final products or in their original form. b - Materials that represent the product of alterations from processing conducted at the site or from biochemical decomposition. c - Materials that have been transformed from primary waste on-site and debris into new sediments through human or biological action. 3 - Evaluation of archaeological sedimentary processes that help to understand the insertion of settlements and associated subsistence activities in time and space.
Modification and destruction	1 - Dispersion of archaeological waste before burial through the action of rainfall, gravity, thawing, deflation, animal trampling, or human removal. 2 - Post-depositional alterations by various agents, such as the action of soil fauna, freezing and thawing of soil, expansion and contraction of clays, processes driven by gravity, occurrence of geological faults on a local scale, and biochemical alteration. 3 - Destruction of the site or dispersion of artifacts for various reasons, such as weathering, water action, deflation, mass movements, and human intervention. 4 - Interpretation of exposed or buried remains by interpreting their primary, semi-primary, or secondary context.

Araujo (2008) indicates that the stratigraphy of rock shelters and cavities presents a complexity related not only to the natural sedimentation dynamics in these environments but also to the dynamics of the human occupation process. Considering his statements, the particularities of sheltered sites prevent the data obtained for a region, such as soil or sediment types, from being directly applied to understanding the processes at work within the shelter. Therefore, such understanding presupposes a good mastery of the interface between Geosciences and Archaeology (ARAUJO, 2008).

Butzer (2008) highlights that not all sediments present in the cavity were produced there. Cavities do not constitute closed systems, with rare exceptions. In this sense, humans and animals will bring external sediments and soils into the cavity and vice versa. Clay, silt, and sand associated with these sediments transported into the cavity mix with the sedimentary matrix and contribute to forming more complex cultural records. Some cavities contain indigenous sediments. There are also secondary minerals produced within the cavity that form crusts over deposits or archaeological remains. The organic fraction of the cavity sediments includes materials of human, animal, or plant origin. Specifically, this includes feces, manure, urine, body parts, bones, plant materials used for food, and ashes. These materials exhibit geochemical signatures associated with phosphates, potassium, or amino acids. However, linking each of these elements to the original material is a difficult task (BUTZER, 2008). The frequency of animals in the context of cavities is notable, as these organisms can die within the site and also bring in prey or pellets, as owls do. Wind, in turn, transports leaves and branches that can be deposited in this environment.

Also associated with the local scale are contemporary processes, forms, and materials. This means that current changes in the landscape, whether rural or urban, should be included in geoarchaeological analyses. All alterations must be considered based on their possible implications for the studied site. Butzer (1982) highlights some aspects of contemporary anthropogenic modifications in the landscape in archaeological contexts: i) Disturbances in the soil profile, truncation of horizons, and redeposited soils may indicate contemporary anthropogenic interventions in the landscape; ii) Portions of the slope with active erosive features, alluvial fills, and records in lacustrine sediments may be associated with recent human intervention in elements that compose the hydrological cycle; iii) Filled ditches, various holes, land leveling, roads, terraces, and irrigation networks are commonly present structures adjacent to or over archaeological sites; and iv) Direct and indirect impacts related to land use can have a cumulative degrading effect over time on archaeological sites.

7. Geoarchaeology in scale transition: pathways indicated by Geomorphology

Studies that encompass multiple geographical scales provide a more comprehensive view of the studied landscape. This is not to undermine the importance of studies focusing on specific spatial segments, but rather to highlight the potentialities and complexities of multiscale studies, which, in the context of Geoarchaeology, enable a more systematic consideration of the spatial components surveyed, along with the identification of locational strategies that allow for a dynamic modeling of settlements and the logic of intervention in the landscape, as noted by Butzer (2008).

For example, mapping the shapes of slopes and the correlating surface formations, associated with the archaeological remains identified within them, allows researchers to identify the logics of organic connection among the different parts that comprise them. However, this analysis becomes more comprehensive with the effort to compare such mapped aspects among distinct sites within the same region, concurrently analyzed with the geomorphological units, lithological organization, and surface formations at a regional scale. It is in this sense that multiscale relationships between the analyzed aspects are proposed. From this comparison of the information contained in the archaeological site(s) and the extrapolation of these relationships to the regional scale, some meanings of the landscape as a mega artifact can be inferred (BUTZER, 2008; DIAS, 2008).

Geoarchaeology is gradually moving into a new era, where the use of new techniques combined with increased collaboration and integration with scientific data from other areas, such as those derived from paleoenvironmental analyses, allows for greater precision in interpreting archaeological sites (MORLEY; GOLDBERG, 2017). These authors present possibilities for integrating sedimentary, microstratigraphic, geochemical, and geochronological analytical data that, when applied to the same physical portion of the site and subsequently extrapolated to other scalar levels, facilitate more precise paleoenvironmental reconstructions. In this context, French's (2003) proposal is also included, which defines four scales—microenvironment, site environment, mesoenvironment, and macroenvironment—for obtaining environmental data to complement the interpretation of archaeological landscapes. According to Villagran (2010), questions related to the macro, meso, and microenvironment of site locations are typical geoarchaeological concerns.

In an attempt to contribute to a methodological framework that fosters a multiscalar approach, Geomorphology has contributions to share with Geoarchaeology in the search for interscalar transition. For this purpose, one can refer to the tripartite model proposed by Ab'Saber (1969), in a movement already suggested by Casseti (1981), which, in our understanding, transcends the approach of relief and celebrates an analysis of the landscape as a whole. This model is based, in summary, on three main levels: recognition of the topographical compartmentalization of the study area, analysis of the surface structure, and understanding of the landscape's physiology. These levels were initially proposed by Ab'Saber (1969) for geomorphological studies and adapted for geoarchaeological studies. These aspects correspond to the first, second, and third levels of analysis, as outlined below.

The first level encompasses regional analyses of landscape compartmentalization based on the forms of topography, generally conditioned by the bedrock, including characterization and description of the relief forms of the studied compartments. This level is constrained within the Medium/Long-Term and Regional Scale. At this level, during archaeological prospection, the analysis of the regional topography provides insights into the process of site selection. In this sense, the following aspects are considered: strategic position, taking into account potential defense and the presence of necessary resources for survival (shelter, water, food, and materials for making of tools). The regional geomorphological compartments that contain residual portions of the relief are not, a priori, affected by more recent erosive processes, being remnants of the downwearing and backwearing processes. The identification of these compartments is associated with mapping paleosurfaces or residual portions of the relief.

The second level encompasses the cumulative results of Quaternary events included in the surface structure of the landscape, which encompasses the geology of deposits, ancient features (planated surfaces, residual relief), and recent features (slope shapes, pediments, terraces). At this level, it is possible to propose interpretive considerations of the chronogeomorphology and paleoclimatic and morphoclimatic processes of the study area, understanding a recent kinematics of the landscape, but not modern, which is the domain of the third level. The temporality varies from medium to long, and the spatial scale ranges from local to regional. This involves analyzing the surface structure of the landscape related to the phase of excavations and can be applied with the aim of obtaining the chronogeomorphology of the processes that occurred in that context. This type of investigation is conducted based on the superposition of soils over more recent formations, such as cover deposits and terraces. These observations must adhere to an integrative sequence of regional geomorphology based on identifying residual, planated forms, etc. Given that the pre-contact human groups in Brazil lived after the last Pleistocene glacial phase, it becomes possible that the evidence associated with them has been buried by materials resulting from chemical decomposition and shaped by sub-current and current morphoclimatic processes.

The third and final level comprises the current and global functionality of the landscape, based on climatic and hydrodynamic dynamics. This pertains to the physiology of the landscape, which relates to a temporality associated with short-term and local spatial scale. Morphodynamic processes tend to reorganize archaeological remains, especially when associated with soil fauna activity and recent anthropogenic interventions.

Thus, while the first and second levels have a direct application to understanding the paleolandscapes inhabited by ancient human groups, the third level is crucial for understanding possible recent reworking—both superficial and subsuperficial—of archaeological deposits, affecting the disorganization and redistribution of remains in the landscape based on a morphodynamic logic (CASSETI, 1981).

8. Practical example in the context of Central Brazil: multiscale analysis and the distribution of geoarchaeological facts

The practical example is situated in the northwestern portion of Minas Gerais, specifically in the Currais de Pedras Karst Region (CPKR), located within the extensive plateau of the São Francisco River, encompassing the hydrographic basin of the Fundo Stream in its southwestern section. It includes various geographic and geomorphological features of the Jequitaí River basin, such as the Serra do Cabral, Serra da Água Fria, Serra das Porteiras, Serra da Onça, the Jequitaí River Canyon, and the Espinhaço Plateau or Espinhaço (Figure 6). Research conducted in the region for over two decades has been revealing a vast array of shelters, cavities, sites and archaeological remains that have already been identified and are in the process of excavation. The application of multiscale geoarchaeological analyses to the CPKR highlights characteristics of an ancient territory, with aspects related to occupation that reflect nuances connected to the three levels of Ab'Saber's (1969) tripartite model.

8.1 First level and general aspects of occupation in the CPKR

The occupation process in the CPKR is related to two mega-geomorphological units: the São Francisco Plateau and the Sanfranciscan Depression. These correspond to the South American Surface I and South American Surface II, respectively (VALADÃO, 1998). Archaeologically, Tobias Jr. (2010, 2013), Rodet (2012), and Penha (2015) highlight the CPKR as a topographical contact area between the Espinhaço Mountain, situated to the east, and the vast São Francisco River valley to the west. These two mega-geomorphological units, with very distinct (Figure 6) yet complementary characteristics, provided a range of territorial opportunities for the occupation by ancient human groups. The fragmentation found in the limestone massifs within the São Francisco Plateau represents an anomaly in the landscape, contrasting with the vastness and continuity of the depression floor and the plateau tops.

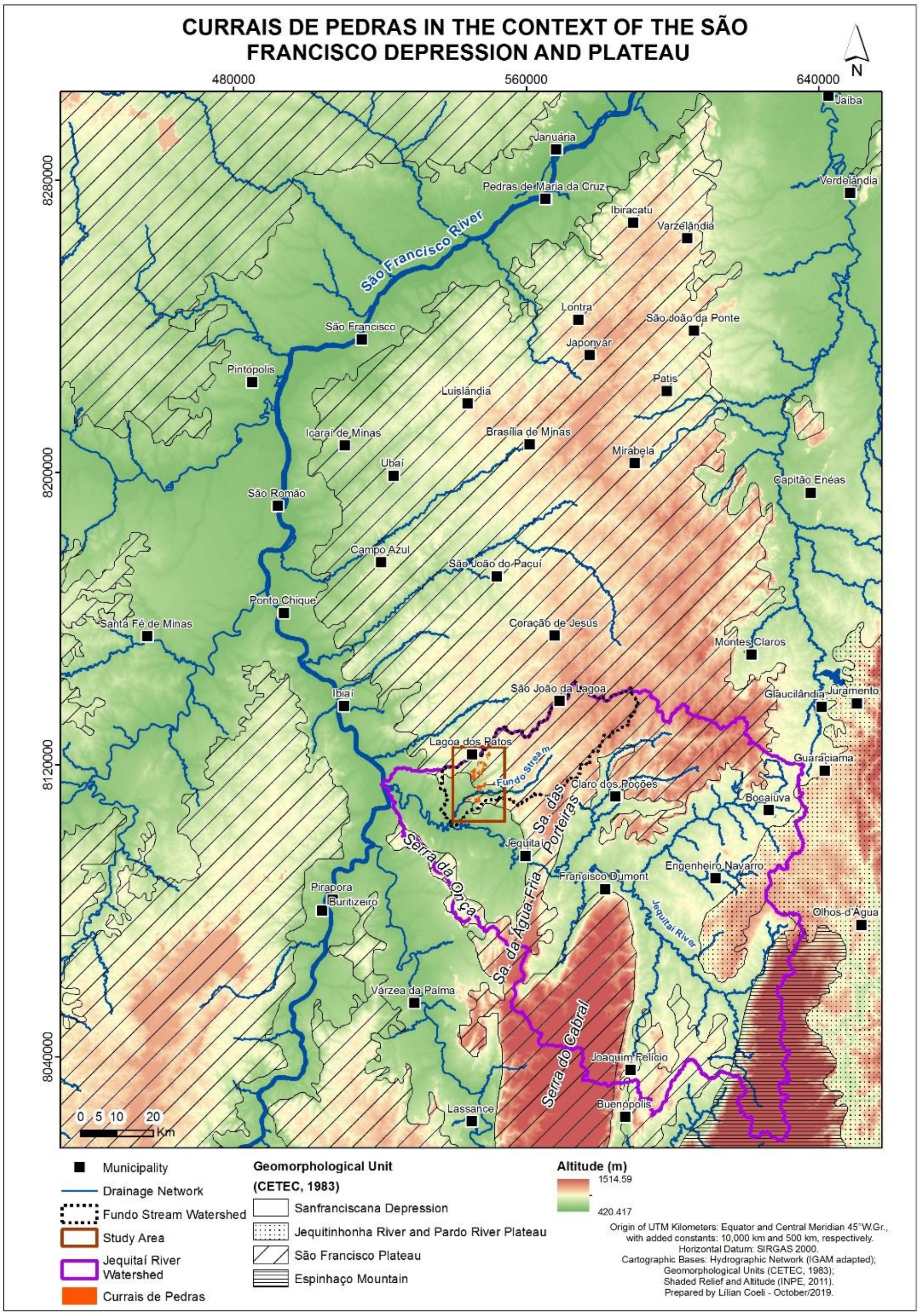

Figure 6. Geomorphological Units in the Context of the Upper-Middle São Francisco River and Currais de Pedras. Coeli, 2020.

8.2 Second level and the definition of organic zones of ancient territory in the CPKR

The megageomorphological units of the Plateau and the Sanfranciscana Depression exhibit very distinct morphological differences, which can be recognized and mapped into various units within the Fundo Stream sub-basin. Plateaus, tabular surfaces, dissected slopes, slightly sloping surfaces, erosive fronts, slope breaks, valley bottoms, and floodplains are morphological units mapped in the CPKR that differ in terms of altitude, slope, rock types, soils, and drainage density. These distinct morphological units are further divided into landscape subunits, each with varying aspects regarding accessibility; potential for hunting, fishing, and foraging; suitability for establishing horticultural practices; and mobility conditions. The articulation and interplay between regional and local scales, as well as the numerous opportunities within the CPKR, indicate the organic zones of an ancient territory (Figure 7).

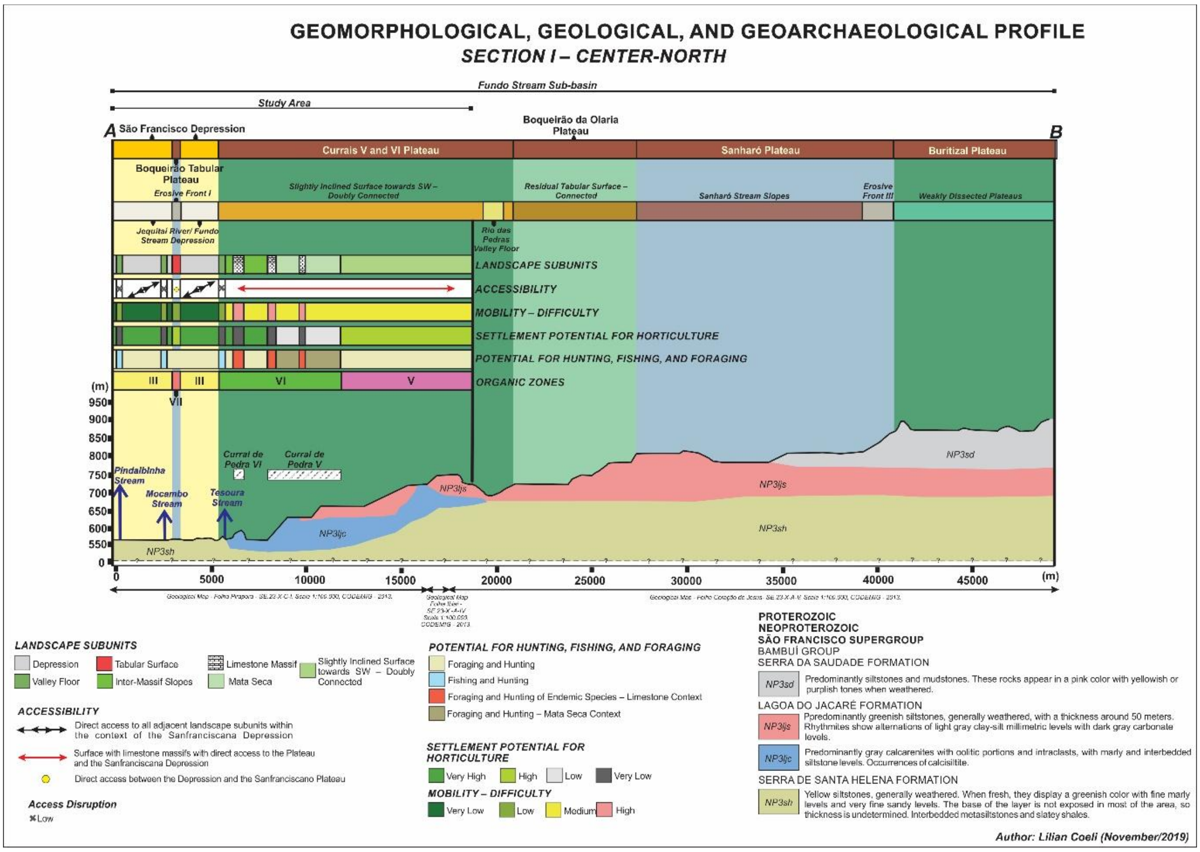

Figure 7. Transversal profile in the upper-middle São Francisco River context. Coeli, 2020.

8.3 Third level and the João de Deus archaeological site pedostratigraphy

In the portion south-southwest of the limestone massif of Curral de Pedra V is located João de Deus cave. Situated in Organic Zone VI of the territory occupied by ancient human groups, the cave is located in a locus of maximum locational opportunities for hunting, as well as a very high potential for horticulture on the slopes between the surrounding massifs (Figure 7). The archaeological remains present in the cave include ceramic, lithic, and rock art artifacts. The excavation and archaeological analysis process are ongoing.

Six pedostratigraphic levels (Figure 9) were delineated from the principles of Waters (1992) associated with ten artificial levels of an excavation block (Figure 8).

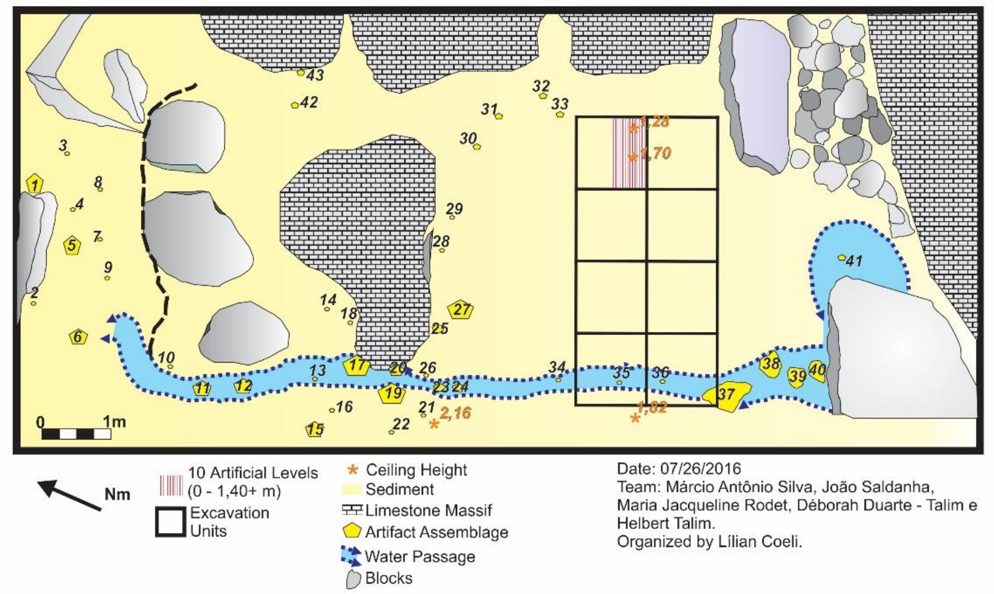

Figure 8. Excavation Units - João de Deus Cave. Coeli, 2020.

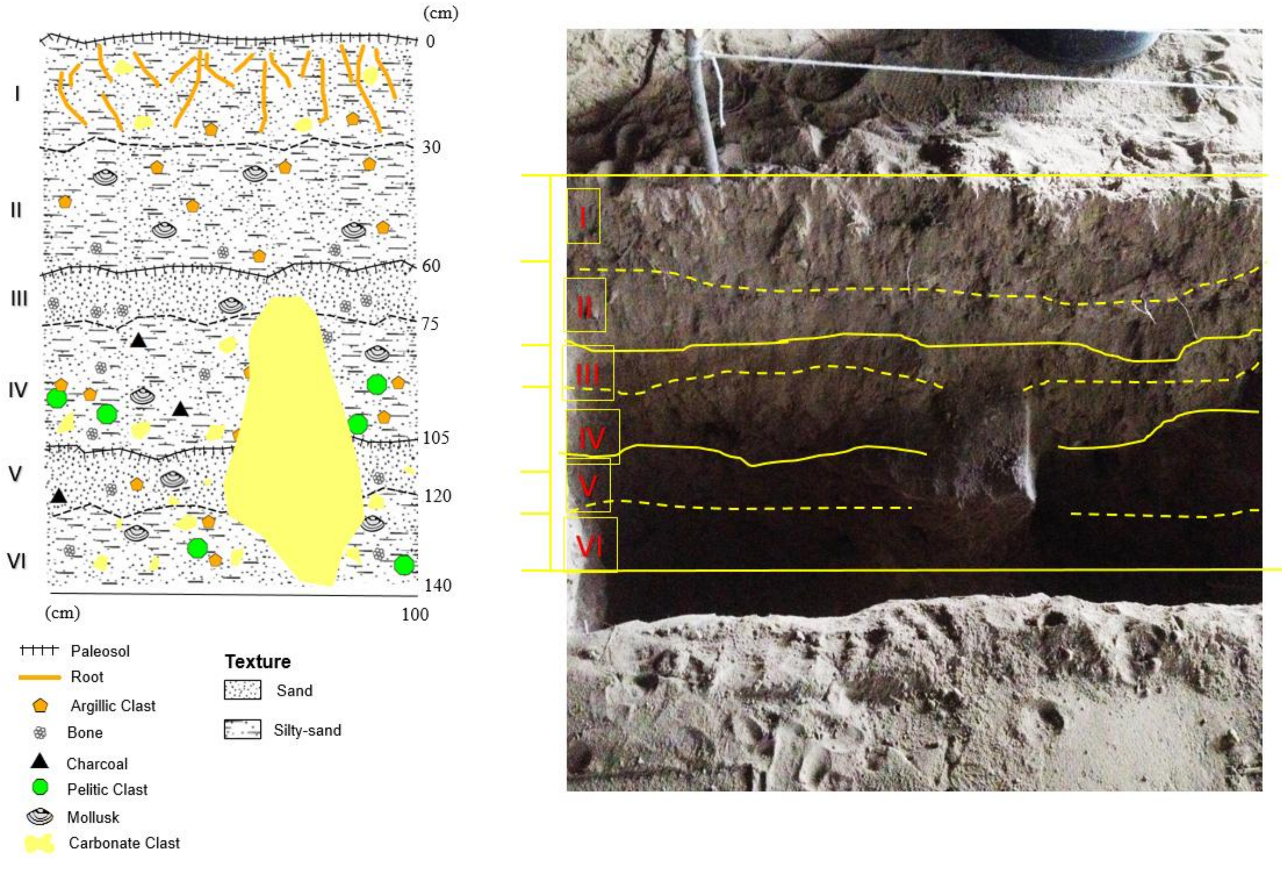

Figure 9. Pedostratigraphy of the excavation unit highlighted in figure 8 – João de Deus Cave.

Argillic fragments, partially burned bone fragments, mollusk shells, charcoal, pelitic and carbonate clasts are intermixed in a pedostratigraphic context with different colors, textures, and chemical, physical, and micromorphological aspects that derive from various sedimentary, anthropogenic, and pedogenetic processes (COELI, 2020; COELI *et al*., 2022). The surface and subsurface hydric dynamics, combined with the activity of soil fauna and past and current human activities, which are intrinsically related to pedogenetic processes, reorganize and obliterate archaeological remains from at least three distinct moments of human presence in the cavity, associated with three possible paleosols (Figure 9).

The development of studies in the CPKR by a multidisciplinary team will bring new information regarding the patterns of occupation and activities carried out by the prehistoric human groups that inhabited or passed through the studied area. Such results, when compared with regional occupation patterns, allow for a better understanding not only of the study area itself but also of the overall dynamics of the ancient populations in northern Minas Gerais, considering the spatial proximity to the archaeological site Caixa D'Água in the municipality of Buritizeiro, the archaeological site Bibocas II in Jequitaí, and the Peruaçu Caves National Park in Januária, Itacarambi and São João das Missões municipalities.

9. Conclusions

Although Earth current population inhabits landscapes modified by human action, the historical roots of the society-nature relationship of which are largely ignored. A more inclusive and long-term view of the interactions between human groups and the geosphere provides important support for those who determine sustainable policies for the future (WILSON, 2011). The reconstruction of bonds between human groups and nature can be supported by the content and methods of Geoarchaeology (COLTRINARI, 2008), through the application of specific geomorphological scales, without disregarding the potential and limitations of each, or the use of multiscale analyses.

Multiscale geomorphological approach complements the various stages of geoarchaeological analysis, integrating the studies of sites and the materials and remains found within them with the characteristics of the slopes in which they are located. It also integrates archaeological sites and materials associated with lithological units, topography, and surface formations on a regional scale.

Beyond merely adopting the principles traditionally presented in North American or European manuals, it is important to consider the age of the occupation of the Americas in multiscale geoarchaeological analyses within the Brazilian context. This is a relatively recent occupation when compared to the Old World, which implies a very special attention to the temporality of formative processes and the transformation of archaeological remains (BUTZER, 2008). According to this author, it is in this sense that a broader academic discourse is constructed around long-term trends, such as the interdigitation of climatic factors and land use in cause-and-effect perspectives or the construction of future scenarios in an era of rapid planetary change. Geoarchaeology, therefore, constitutes a much larger and more complex field of knowledge than merely applying geosciences methods to archaeology.

Regarding archaeologicals sites represents a small dimension of the daily life of past human groups, whose interaction with various other elements of the frequented landscape must be understood jointly with the aspects and relationships with the closer and/or more distant surroundings. These locations form a network that encompasses the diverse interests of the groups and can be directly related to the daily search for raw materials, food, water, and imaginary dimensions. These places were known, frequented, and preserved as a cultural mental map passed down through generations. Understanding, at least in part, this web of occupations requires comprehending the landscape and the various scales of analysis that can be applied, considering its formation, transformation, and reorganization over time.

Rocks, relief, soils, and sediments are physical components of the landscape that present multiple temporalities and are organized into distinct levels, configuring landscapes. These temporalities are associated with human activities and gain new approaches. To understand the landscape in its complexity, a multiscale geographic approach is fundamental, with the central reference being that not only do phenomena manifest in various ways according to scale, but that the observer also derives different aspects. The multiscale approach, therefore, complements all stages of archaeological analysis and has great applicability in Geoarchaeology, as demonstrated in the example of CPKR in Central Brazil (COELI, 2020).

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