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TYPOLOGICAL STUDY AND INFRARED SPECTROSCOPY (FTIR-ATR MODE) FOR ANALYZING MINERAL COMPONENTS OF CERAMICS OF THE EARLY NEOLITHIC SITE OF SALVADOR (MIDDLE TAGUS VALLEY OF IBERIAN PENINSULA, PORTUGAL)

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ABSTRACT :

The archaeological site Salvador was excavated from 2017. During the excavation of 2017 and 2018, a big number of lithic industry and ceramics fragments have been unearthed. With the ongoing study about the chronology of the site, this site indicates the traces of human occupation from the Early Neolithic timeframe of middle Tagus valley of Iberian Peninsula. The C^{14} dating is also supports the chronology of early Neolithic. With the details study of typological analysis of the ceramics assemblage, 812 pieces of ceramics have been registered. After the proper study on typology 23 ceramics fragments have been taken for scientific analysis (Infrared Spectroscopy- FTIR-ATR Mode). The objective of the analysis was to know the mineral components of the ceramic fragments. All the analysis results are to relate and compare with typological work and to understand the raw material collection place. By knowing the raw material, this study will also help to experimental archaeology to reproduce the ceramics.
Keywords: Typology of ceramics, Early Neolithic, Middle Tagus Valley, IR spectroscopy, Mineral composition

RESUME :

Le site archéologique de Salvador (Portugal) est fouillé depuis 2017. Lors des campagnes de fouilles de 2017 et 2018, un grand nombre de fragments d'industrie lithique et de céramique ont été mis au jour. Avec l'étude en cours sur la chronologie du site, ce site indique les traces de l'occupation humaine depuis le Néolithique ancien de la vallée du Tage moyen de la Péninsule Ibérique. La datation au C14 démontre aussi l'appartenance du site au Néolithique ancien. Avec l'étude typologique détaillée de l'assemblage céramique, 812 pièces de céramique ont été enregistrées. Après l'étude typologique, 23 fragments ont été sélectionnés pour une analyse scientifique (spectroscopie infrarouge -Mode FTIR-ATR). L'objectif de cette analyse était de connaître la composition minérale des fragments de céramiques. Tous les résultats d'analyses doivent être mis en relation et comparer avec le travail typologique et d'identifier l'endroit de collecte de la matière première. En connaissant la matière première, cette étude aidera également à l'archéologie expérimentale pour reproduire la céramique.
Mot clés : Typologie des céramiques, Néolithique Ancien, Vallée du Tage moyen, spectrométrie IR, Composition minérale.

CHAPTER 1

INTRODUCTION

Archaeology is a gateway to understand the past and human evolution. It is an interdisciplinary field that constitutes the foundations of prehistory with its hard evidences and methodological advantages. Archaeology is the study of human activity in the past, primarily through the recovery and analysis of the material culture and environmental data that they have left behind, which includes portable artifacts, architecture, eco-facts and cultural landscapes. The discipline involves surveying, excavation and eventually analysis of data collected to learn more about the past. In broad scope, archaeology relies on cross-disciplinary research. It deals with Geology, Bioarchaeology (Fauna), Bioarchaeology (Flora), paleoanthropology, chemistry, physics, statistics etc. All these are fundamental requirements for Prehistory interpretation, which also brings into its scope the whole set of Human Sciences and Philosophy

1.1 Research Objectives and main goals:

Systematic Archaeological Excavation has been carried out at Salvador since 2017. The main objective of the study has been the typological study of a total of 812 ceramics fragments which were unearth in the excavation seasons of 2017 and 2018. The main objective of this study is to do the typological work and scientific analysis of selected ceramics fragments. The typological study was preceded by primary conservation, inventory, documentation, photography, marking/leveling and involved the identification of a series of parameters in terms of the possible macroscopic analysis and interpretation of the morphology and fabrics of the sherds collection. After the typological analysis, a scientific analysis has been conducted to investigate the mineral components of one of the very rare and specific type of decorated ceramics from Neolithic site. The objective of this scientific analysis is to practically learn the analysis process in the laboratoire de spectrometrie infrarouge et fluorescence X (Infrared and X-fluorescence spectrometry Laboratory) in the Musée de l'Homme (Paris, France). In the laboratory of Musée de l'Homme Infrared Spectroscopy also known as IR (ATR-FTIR mode) analysis were conducted to understand the mineral components of the selected ceramics fragments So, the overall objective make the typology of the ceramic fragments and to identify the mineral components of the ceramics, in order to create hypothesis about raw material and try to understand from where the raw material comes. Furthermore, the outcome of this study can be compared with results obtained in samples from other sites of similar chronologies and geographical ranges. The final objective is to contribute to the general knowledge of the population that used this type of ceramic technology, in terms of what were their technological choices and the purpose of use of the ceramics.

1.2 Structure of the study

This master thesis comprises of five chapters with different perspective of research methodologies, site presentation, research aims-objectives and result-discussion.

Chapter one starts with the introduction and includes some other basic beginning parts of the research. This chapter includes a brief explanation of the research background with the literature review in previous years at the same or other related fields of study. It’s one of the key chapters to get an idea about all other research works related to this study and importance of this research work for future archaeometric approaches on this field of studies. Besides, some research questions have been also created which will answer in the discussion and conclusion with the help of output of the result. Moreover, the first chapter contains explanation of the research aim and objectives and explains research structure.

Chapter two focuses on the geological context and the development of early Neolithic of the middle Tagus valley of Western Iberian Peninsula, Portugal. These will help to understand the basic geology and geomorphology as well as lithological substrates. On the other hand, the early Neolithic of the middle Tagus valley will explain the distribution of early Neolithic sites in this specific area. Chapter three is presenting the information about the Salvador site. All the description of the stratigraphic unit is briefly presented along with the artifacts.

Chapter four is one of the most important sections of this work, focusing on the archaeological materials, methods and results. This part discusses the archaeological findings of Salvador site. The methodologies explain the methods of typological and scientific work process. And in the result section, the result of scientific data has been present. Chapter five which is the last chapter of this paper focuses on the conclusion of this study. It comprises many discussions on implications of research findings, practical recommendations for action, research contribution, recommendations for future research. In the appendix, the result of scientific data and the rim chart for measuring the rim are presented.

1.3 Archaeological Context:

The open-air archaeological site of Salvador, located on the left bank of the Tagus River, in the place of Salvador (Freguesia do Pego, Municipality of Abrantes), previously referenced in the Archaeological Map of Abrantes (Candeias et al., 2009), was intervened between 2017 and 2018, within the scope of project *Es.Ter.Tejo – Estratégias de Ocupação do Território no Holocénico no Médio Tejo* (coordinated by Davide Delfino and Luiz Oosterbeek and approved by the Ministry of Culture -DGPC) and the project *MTAS – Tarefas em Movimento Através das Formas: a Dispersão Agro-Pastoril para e partir do Alto Ribatejo* (coordinated by L. Oosterbeek and financed by FCT). The Framework Institution of the intervention was the Instituto Terra e Memória (ITM), in collaboration with the Museu de Arte Pré-Histórica de Mação and the Instituto Politécnico de Tomar.

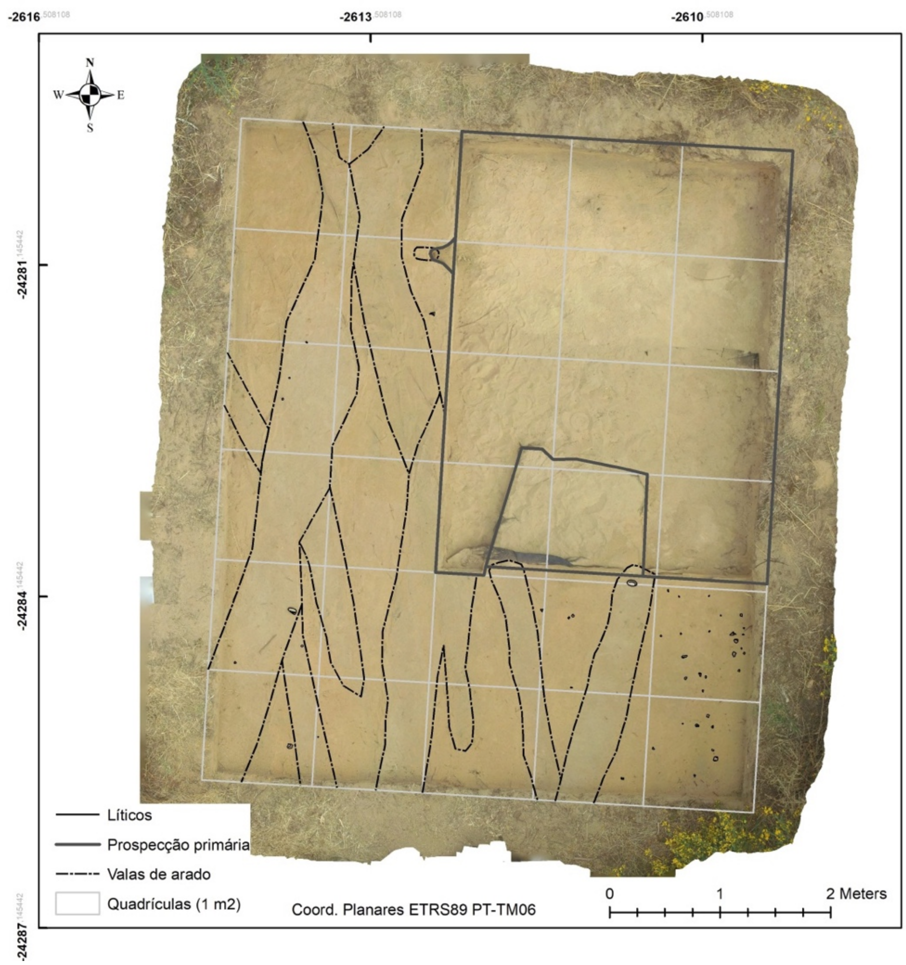


Figure 01: Ariel view of the archaeological site Salvador (Image By: João Bello, ITM archive collection)

The intervened area is located in the place of Salvador (Coalhos), Parish of Pego, Municipality of Abrantes, District of Santarém, with the following coordinates Latitude N 39º26´58.25´´ and Longitude 8º9´48.76´´ W, about 250m to North-West of the rusty geodesic apex. About 70 m above the average level of the sea. The specific area is situated in the Sedimentary Basin of the Tagus River, at less than 250 m from the Ribeira de Coalhos, which is an affluent of the Tagus River, towards which it is heading, with a South-East to North-West direction. This area is dominated by formations resulting from the river activity, so there are Quaternary terraces, colluviums and Holocene alluvial plains.

Figure 02 Map of Portugal (Source: http://legacy.lib.utexas.edu/maps/europe/portugal_rel82 jpg)

According to the Statistical Yearbook of the Central Region 2012, Abrantes is a Portuguese city belonging to the district of Santarém, in the province of Ribatejo, Central region and Middle Tagus sub-region. It is the seat of a municipality with 714.69 km² of area (Portuguese Geographic Institute 2013) and 39 325 inhabitants (Census Definitive Results - Central Region 2011) subdivided into 13 parishes. The population density is 55.02 inhabitants / km².

The municipality is bordered to the north by the municipalities of Vila de Rei, Sardoal and Mação, to the east by Gavião , to the south by Ponte de Sor and to the west by Chamusca , Constância , Vila Nova da Barquinha and Tomar

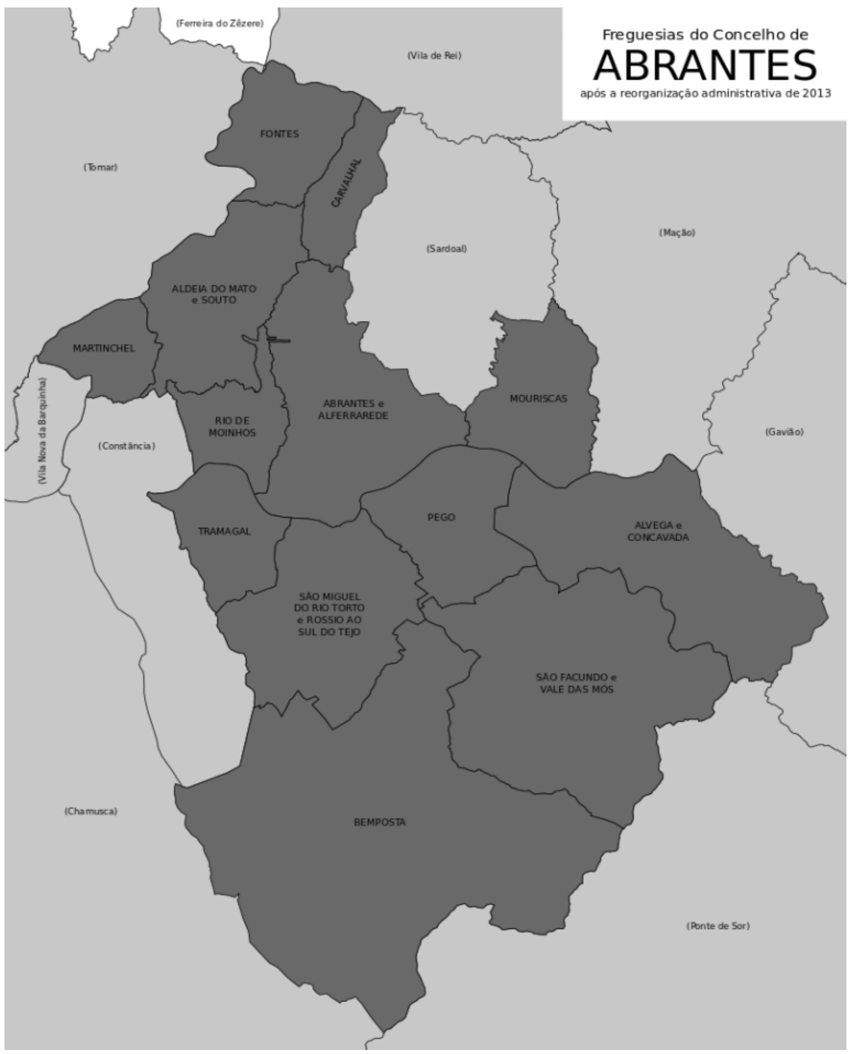


Figure 03 Map of Abrantes freguesias (Source: https://pt.wikipedia.org/wiki/Abrantes#/ media/ Ficheiro: Abrantes_freguesias_2013.svg)

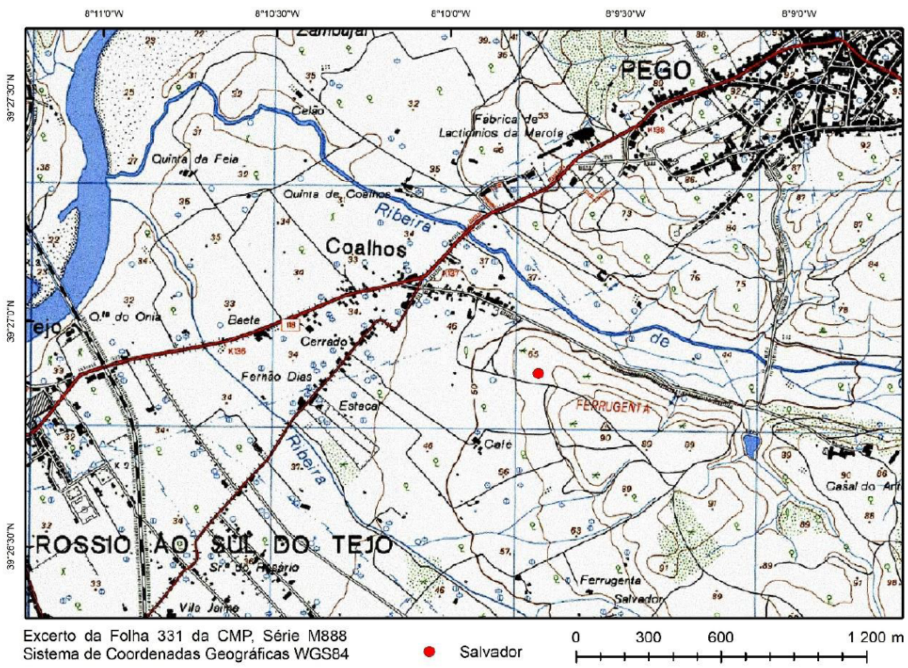


Figure 04: Location of the Salvador site in the Carta Militar de Portugal (1:25,000), Sheet no. 331, Abrantes. (Source: ITM archive Collection)

Figure 05: Location of the Salvador site in Google Earth Pro image (Source: ITM archive Collection)

The municipality of Abrantes has, continuously and increasingly, been the target of archaeological works that demonstrate their importance for the knowledge of the dynamics of occupation and exploitation of this territory since the Palaeolithic. In fact, the Coalhos area has been referred to as a major source of Holocene traces, as other areas in the region, proven through prospection works developed in the past (Oosterbeek, 1994; Candeias et al., 2009; Cruz, 2011;Almeida et al., 2017) and, more recently, within the scope of the studies carried out in the PIPA Ester.Tejo / FCT MTAS (Almeida et al., 2018).

1.4 Research Background:

In the year of 1995, Salvador was first registered as an Archaeological site. From then Salvador site and the artifacts of Salvador have been discussed in some research papers. Scientific analysis of Salvador ceramics demanded a broader background research for developing more reliable and acceptable methodological approaches on this field of study. Necessarily, all the potential literary sources on the related field of study were observed and followed for the accuracy. Here in the section of this paper some of the previously published important work and its influence on this study are discussed briefly.

In 1994 Luiz Oosterbeek publishes his Phd thesis which is titled “Echoes from the East: the western network. An insight to unequal and combined development, 7000-2000 BC”, where he has discussed the Neolithic of tagus valley briefly. Along with Ana Rosa Cruz, he started to archaeological exploration of this specific area of tagus valley since 1983. In his thesis he mentions the Neolithic site description and artifact. (Oosterbeek, 1994)

Salvador was inventoried in 1995 by the Archaeology team of the Abrantes City Hall. Among the materials registered in prospecting, there is a D-shaped scraper, uniface/peak, quartzite chips, nuclei, blades, flaps and chips, punch, flat wheel, net weight, small flying axe in bones, smooth and decorated ceramics and floor or wall clay. The site had been classified as a settlement, chronologically related to Languedocian and/or ancient Neolithic “Cardial” with lithic industry in quartzite, and occupations until the initial/medium Bronze (?) (Candeias et al., 2009).

In the immediate vicinity of the Salvador site, prehistoric materials were recorded recently in Brancas Flores, Casal do (D) António, Ferrugenta, Lobato, Quinta de Coalhos I, Torre do Meio and Vale da Figueira (Candeias et al., 2009). Nevertheless, for some of these sites, the chronology proposed is “Languedocian”, which makes it difficult to understand their specific chrono-cultural framework, since these can be either Pleistocene or Holocene contexts.

In the year of 2011, another prominent archaeologist Ana Rosa Cruz publishes a book in Portuguese. The title of the thesis paper was “A Pré-história recente no Vale do Baixo Zêzere: um olhar diacrónico.”. The publication was from Universidade de Trás-os-Montes e Alto Douro, Vila Real. This article focuses on another Neolithic site which is not far from Salvador. (Cruz 2011)

Besides, ceramics found from 1995 excavation were also analyzed by Cruz et al. (2014) and Beltrame and Cantisani (2014), and a trend indicated for Salvador records of the ancient Neolithic - of its final phase, commonly designated evolutionary Ancient Neolithic, Epi”Cardial” or Ancient Neolithic with ceramics non-cardiac prints -, Neolithic final-Chalcolithic, Initial and Middle Chalcolithic and Age of the final Bronze.

From 2017 Nelson Almeida was excavating the Salvador site and prepares three reports in 2017, 2018 and 2019. Besides, one preliminary study has been conducted by César Neves in 2018 about the ceramics found in the excavation of 2017. Cristiana Ferreira, in 2019 prepares a report about Palinological Analysis of Salvador site. In 2019 one preliminary report on lithic industry of Salvador has been prepared by Sara Cura and Ivana Mircovich. Along with Luiz Oosterbeek, Isabella B. de Queiroz prepares a preliminary report on Ceramics. This thesis is mainly based on the ceramics found in the excavation from 2017 and 2018

1.5 Research questions:

The main research question of the paper is how to relate typological analysis with the scientific analysis? The research question is to also be questioning the origin of raw materials (clay and non-plastic materials), the manufacturing processes and stylistic influences. This study will try to contribute to the development of a broader discussion focused in this specific and rare Neolithic ceramic group. Therefore, main focus of this work will be to determine production technology of decorated Neolithic ceramics through the reconstruction of technological sequences or *chaînes opératoires* (selection and processing of the raw materials, forming, surface treatment, decoration and firing conditions). Moreover, one of the research questions will be to determine what the provenance of this scarce archaeological finds was in order to obtain information about whether they were locally produced or imported. If imported, which side of the site the ceramics were imported? With the use of infrared Spectroscopy scientific analysis and mineral composition it might be possible to make some hypothesis of collecting raw materials which can indicate the probable landscape management of Neolithic time period.

CHAPTER 2

2.1: GEOLOGICAL CONTEXT

The open-air archaeological site Salvador (Pego, Abrantes-Portugal) is located on the left bank of the Tagus river basin (Candeias et al., 2009). The site is located on the western fringe of the Iberian Peninsula in the Portuguese Middle Tagus region, Santarém district. The Middle Tagus region is noted for its geomorphological diversity and for the presence of an important number of archaeological sites. The Jurassic limestone of the Nabão river basin, the Old Massif of the Zêzere river basin and the Quaternary terraces of the Tagus river basin make this region one of the most geologically unique areas in Portugal, and this geomorphological diversity is reflected, in a rather interesting way, by the late prehistoric population's behavior to settlement strategies and the architecture of their funerary monuments which is significantly different from other well-known megalithic monuments (Cruz et al., 2015)The Iberian Peninsula presents a significant diversity in the geological structure and, consequently, in geomorphological features. The Hesperian Massif, formed by Palaeozoic and Pre-Cambric metasediments and igneous rocks, dominates central Iberia, whereas the western and southern borders consist of Mesozoic and Cenozoic sedimentary successions, mainly silici-clastics and limestones The Iberian fluvial network comprises five main rivers: Tagus, Douro, Guadiana, Ebro and Guadalquivir. Only the Ebro drains to the Mediterranean Sea. The Tagus and the Douro rivers shave their mouths on the western Atlantic coast, and the Guadiana and Guadalquivir rivers in the southern coast (Oosterbeek et al., 2010)

The Alto-Ribatejo subregion (after Oosterbeek, 1994) is characterized by the merging of three geological units: in the east and northeast, the ancient relieves from the Pre-Cambrian and Paleozoic outcrops, composed by schists and gneiss from the «Beiras»; to the west and northwest arises the limestone massif of the Portuguese Estremadura, essentially Mesozoic; these formations mark out a third unit constituted by the Tagus and Sado Tertiary Basin. Geo-morphological diversity of this specific area is well represented: on the west, the plain formed by the Cenozoic sedimentary complexes, on the east arise the modest schist relieves of the Pre-Cambrian and Paleozoic shelf, while at the center a small outcrop of highly altered granite. The lithological diversity is reflected on the erosive action of the hydrographic network and consequently on the dynamic of fluvial incisions. The Alto Ribatejo quaternary deposits are mostly represented by the recent fluvial sediments, by wide Pleistocene fluvial terraces, by detritical coverings (sometimes relatively thick) and by karsic caves fillings. (Rosina et. al. 2005).

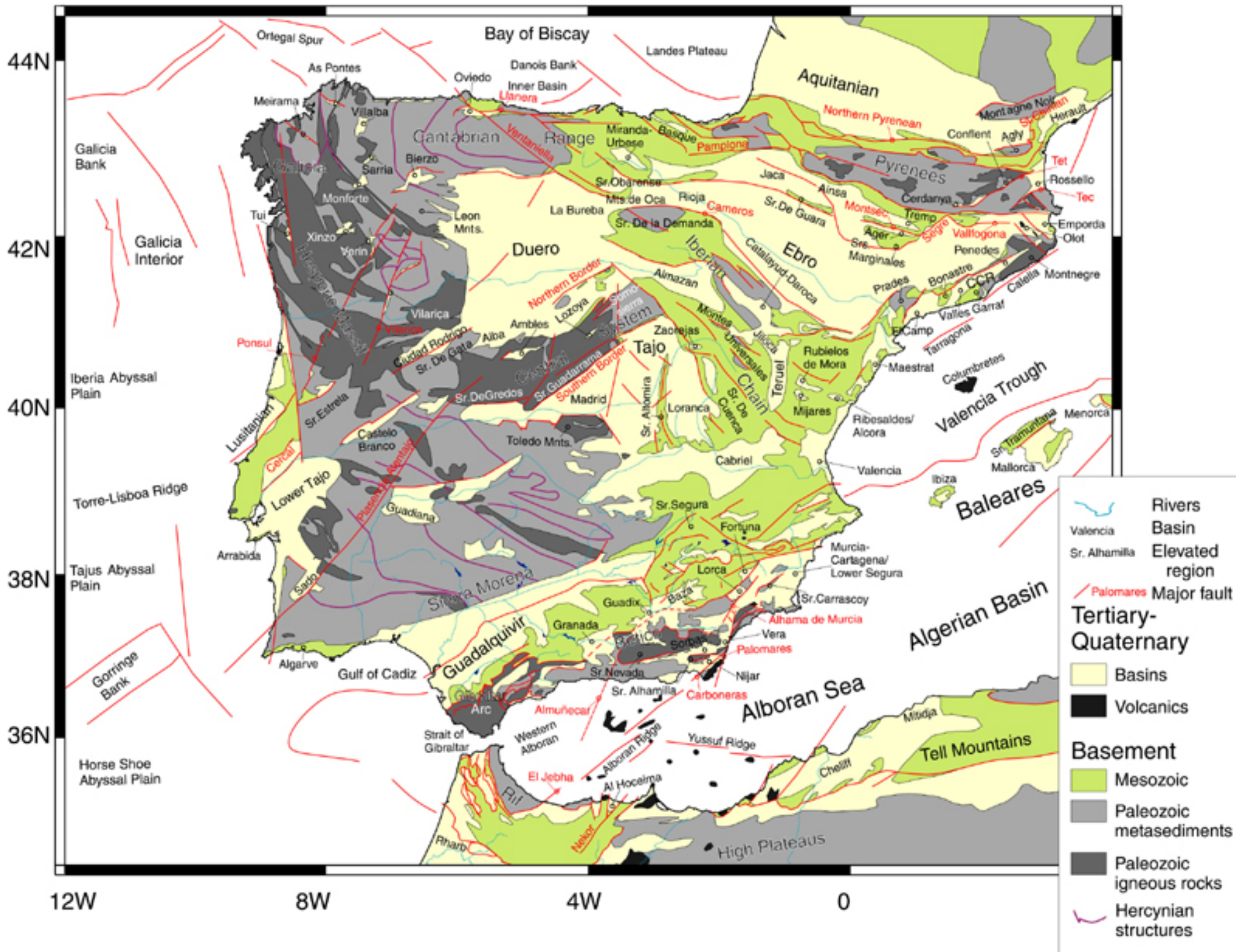


Figure 06: Morpho-stratography of the Iberian Peninsula (Andeweg, 2002: 84).

In the north Ribatejo region, which is distinguishable by the fact that it represents the contact area of three major different geomorphological units – the Ancient Massif to the East, the Estremadura Limestone Massif to the West and the Tagus tertiary basin to the South, has been the focus of systematic research throughout the last three decades (Cruz, 1997: 70-71; Oosterbeek, 1997: 67-75; 2001: 81; 2004: 85). According to some authors, distinct realities of the Neolithic transition process converge into this territory, which seems clear, in terms of the archaeological record, and in a more obvious manner, in funerary contexts. In the karstic contexts to the West (namely in the Nabão valley), there is an extensive use of natural cavities by communities associated with a “Cardial” tradition”, recurrently related to coastal areas such as the Portuguese Estremadura. In parallel, the Tagus valley area is dominated by megalithic tombs, in good accord with the Alentejo and Beira Interior “traditions” (Oosterbeek, 2003, 32). For these authors, these differing realities are considered to also be reflected in the material culture accompanying the dead in both karstic and megalithic burials. Rather than strictly resting on geographic or geomorphological criteria, it would be due to this heterogeneous cultural matrix that North Ribatejo can be perceived as a territory whose limits, more than physical, should be looked upon as human and behavioral, structured around the Tagus basin and its tributaries, in this part of its path (Oosterbeek et al. 2001: 263-264; Oosterbeek, 1994: 137).

The demarcation of the Middle Tagus region stems from both the physical and human geography. On a physical level, the skeleton of this territory consists of the hydrographic basin of the Middle Tagus, encompassing the lower Zêzere, the Almonda, Nabão, Alviela and Ocreza rivers (Oosterbeek et al., 2002), and the Atalaia, Boas Eiras and Rio Frio streams. Their limits are, from this point of view, complicated to uncover because they essentially result in of the relationship established between human settlement and territory (Oosterbeek et al., 2002). The great diversity of resources (hydrographic, geological and biological) offered available less than one or two days' walk away from any of the following his points, promoted his long diachronicity with regard to human occupation. Thus, to find their borders, it is necessary to look at their settlement. In this plan, its limits have been altered over time, increasing or decreasing its area. At different times the Tagus River worked as a natural frontier or, similar to what happens with large formations such as the Serra de Mação. (Oosterbeek et al., 2002; Almeida and Oosterbeek, 2013)

The Tagus basin is formed by a set of more recent formations. Such as terrace deposits, alluvial deposits, dunes and detritus roofing deposits. This catchment area, orientated in accordance with NE-SW, comprises the southern part of the central mountain range and the ECM. It drains a large part of the mountain range and most of the courses of water coming from the massif. The group of archetypal formations that document the Cenozoic and witness a vast river drainage in the Palaeogene due to reactivation of NE-SW fractures on the western edge of the Hercynian Massif, which enabled the opening of the of this basin including the Mondego basin. The area displays clay and sandstone formations on the shore of the to the right of the

River Tagus as 'outcrops of the Miocene series' situated to the north-east of Abrantes, on a strip that includes the rivers Moinhos, Montalvo and Constância (Gonçalves & Zbyszewski, 1979).

The filling of the Tagus river basin culminated in an extensive areno-conglomerate mantle, defined regionally by the Falagueira formation (Cunha, 2000). This basin is formed by sands and coarse, gravel with Pliocene pebbles. The series of conglomerates and sandstones are deposits of the Pre-Tagus, which correspond on the left bank of the Tagus to plateaus cut by lines of water originating a continuous and regular mantle, composed by reddish and brownish clay sandstones with pebbles and clay of the same color. These deposits of typically fluvial nature crown the tops of residual reliefs, having the action of erosion on these lands has led to the formation of debris that fed the quaternary terraces (Gonçalves et al., 1979).The most important Pleistocene deposits in the Upper Tagus region consist of the Tagus terraces, mainly located on its left bank. In addition to these, there are the current and sub-current alluvial deposits, the karst cavities and some wind deposits. Its formation is linked to the combination of climatic and tectonic oscillations (Rosina, 2004). Using altimetry criteria, four river terraces were identified: Q1 (top terrace), Q2, Q3 and Q4 (bottom terrace) (Breuil & Zbyszewski, 1941, Martins & Cunha, 2009). This process has been widely debated, with several amendments being published, which dealt with a subdivision of the text of the directive lower terrace location (Rossina, 2004; Martins and Cunha, 2009). However, six levels of terraces were identified in the Lower Tagus, organized from the highest to low: T1 (~670 ka); T2 (~475 Ka); T3 (~290 Ka); T4 (~140 Ka); T5 (~73 Ka) and T6 (~32 Ka) (Martins et al., 2009, Almeida, 2010). Among the six, only the last three T4, T5 and T6 have the archaeological remains.

The diversity of lithological substrates present in the Ribatejo confers to the region a diverse of landscapes and geomorphological characteristics. Thus, in the Estremadura limestone massif there are mountain ranges that reach 650 meters of altitude; in the Hesperic Massif emerge the quartzite ridges and valleys embedded in the ridges and granite; in the Sedimentary Tagus Basin, terraces and alluvial plains can be admired alluvial, delimited by plateau reliefs. As for land use, the Alto Ribatejo is divided into four areas (Rosina, 2004):

(I) The “Fields” (alluvial plain) with elevations between 25 and 100 meters, formed by alluvial deposits of the Miocene lacustrine and the Holocene, detritic formations of the Pliocene and river terraces, and that has fields where agriculture is practiced intensively;

(II) The “Charneca” (Pliocene deposits and colluvions), with shares of between 100 and 200 meters, which has a higher altitude and soft slopes, where olive groves and cork oaks are cultivated;

(III) The “neighborhood” (substrate formed by metamorphic rocks) presents quotas between the 200 and 300 meters, with steeper slopes and where the pine forests and the eucalyptus are grown;

(IV) The calcareous Zone with higher altitudes (200 to 700 meters) than by the nature of its lithological substrate and reduced amount of water for vegetation, which is not the case in this area. Favors the practice of irrigation agriculture, being predominant the associations of shrubs with Portuguese oak.

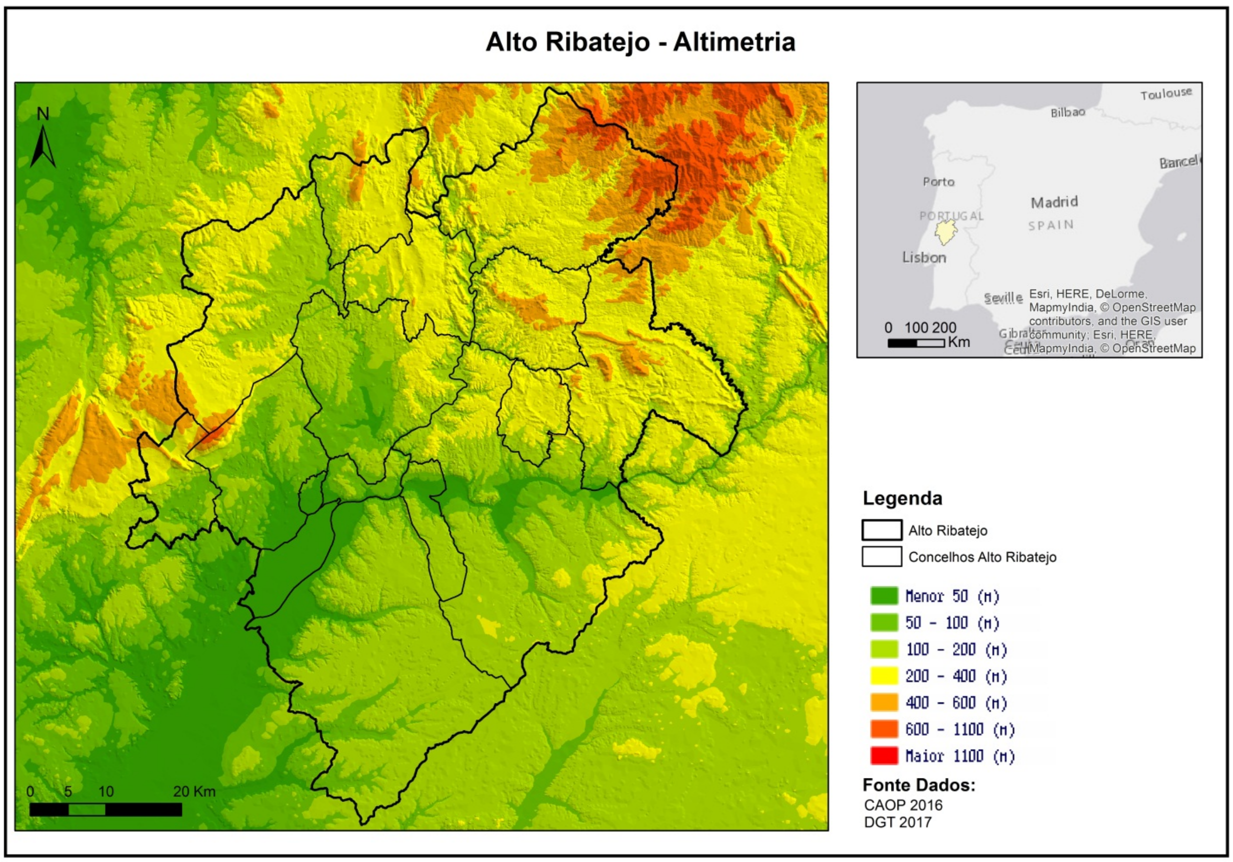


Figure 07: Altimetry of the Alto Ribatejo (By: Jorge Cristóvão, ITM archive collection)

2.2: NEOLITHIC OF THE TAGUS VALLEY

From the late 1960's Colin Renfrew approached New Archaeology in the study of the Neolithic time era. Renfrew (1967, 1979) focused mainly on human behavior (technological, economic, social, ideological) perspectives to make broader studies on the Neolithic. At the same time, while some experts focused on environmental perspectives (Barker 1985; Boggucki 1991; Buxo et al 1991), other researchers rather looked at regional scales (e.g., Beguiristain, 1978; Bahn, 1985; Bernabeu et al 1989; Oosterbeek 1994)

The Central Portugal Early Mesolithic (Epipalaeolithic) is considered to be associated to a complex pattern of territorial occupation partly due to the intensification and specialization of strategies with different models being proposed (e.g., Araújo, 2003; Valente, 2008). Although sites located in the Limestone Area are known (e.g., Bicho et al., 2003; Carvalho, 1998), the inner areas are less characterized with exceptions occurring, as is the case of Amoreira and Fontes (Oosterbeek, 1994; Cruz, 1997, 2011), or other occupation in inland Iberia (e.g., Arias et al., 2009; Canals et al., 2013).

Regarding the Final Mesolithic, problems subsist in the Middle Tagus region with a general lack of evidences besides some surface scatters (cf. Almeida et al., 2017), maintaining a image of a ow number of archaeological sites with a poor record. In other more coastal areas, several occupations were recorded in the Limestone Massif (e.g., Bicho, 1995/1997; Carvalho, 2008) but what is more evident is the concentration of human groups in estuarine areas of major rivers (Mondego, Tagus, Sado and Mira), as is the case of Moita do Sebastião (Roche, 1972) and Cabeço da Amoreira shellmiddens (Bicho et al., 2011).

The Neolithic is classified as mainly three main sub-periods: Early Neolithic (including both the Early "Cardial" Neolithic and "Evolved" Early Neolithic), Middle Neolithic and Final Neolithic are the classification. According to Zbyszewski (1963), most of the Early Neolithic sites were cave sites (Zbyszewski, 1963) and although to some extent that can still be considered, a high number of open-air sites were identified since then (Figure 08). Oosterbeek mention on his research in 1994, these types of open-air indicates a pattern of estuary or riverine groups of round or oval huts, without natural or artificial defenses corresponding to a still mobile settlement (seasonal?), unlike the east Mediterranean villages (Oostebbek, 1994, p.27).

In the year of 2017, César Neves made a primary report on the ceramics found in 2017 excavation in Salvador. According to him, from the analysis of ceramics, the occupation of Salvador seems to be at an early stage of the process of Neolitization of the Western Iberian Peninsula. The observation of possible parallels, namely those that allowed absolute dating to be carried out at intervals between of a time of secure reliability, the Neolithic occupation of Salvador may have taken place between the last quarter of the 6000 BC and the 1st half of the 5000 BC, in a space commonly recognized as Early Neolithic.(Neves, 2017)

He also added, this proposal is supported by some diagnostic elements present in some of the decorative matrixes (pimple motifs - "false acacia leaf"; decoration hairstyle; printing a *punto y raya*), as well as the existence of carrier pottery of grip and suspension elements, such as the nipples and ring wings (Neves, 2017).

In his research Oosterbeek mentioned, the problem of a more complex origin of the Neolithic, with the set of sites without “Cardial” that have been dated in the South-east, dated back to 7000 to 6000 BC. This is to consider that, the very early Neolithic with “Cardial” impressed pottery spread to the interior in Iberian Peninsula on later stage. In the case of Iberan Peninsula of Portugal part, the earliest Neolithic sites do not have “Cardial” pottery (Oosterbeek, 1994)

In the case of Salvador, the absence of “Cardial” ceramics in the set stands out. Its presence in ancient Neolithic contexts is well attested, although its statistical weight is not significant in cultural readings. In the same way, there is also the absence of other decorative shades characteristic of the first phases of the process of Neolitization (plastic cords with impressions; bands filled with incised traces), both in the area of Portuguese Extremadura and Alentejo, local, as it seen, where this stage is best characterized.

Similarly, the set does not seem to fit with the average Neolithic, since the weight of the decorated ceramics in the register is very effective and there is a great stylistic variability in decorations. The printing technique appears very well represented in the register and no container decorated with groove is observed with the decoration of the maple, which becomes the dominant reason in the initial middle Neolithic (Neves, et al., in press). Ceramic receptacles with certain characteristics are absent from the register which are culturally associated with later periods such as the *carenados* pottery, thickened maple plates and symbolic decoration, which appear from the end of the 4000 cal BC, this is the final Neolithic.

Some example of other sites similar to Salvador (According to Neolithic and Decoration of Ceramics): In the area of the Tagus Valley, the closest parallel to Salvador seems to correspond to the occupation of the Cortiçóis (Benfica do Ribatejo). In terms of implementation the similarities with Salvador are evident, especially the occupation over an also sandy substrate, on a wide platform and in low levels, without any defensive concern. Without the possibility of obtaining an absolute dating, the authors rely on material culture to advance with the proposal of ancient Neolithic evolved to the chrono-cultural framework of this context (Carvalho, Gibaja and Cardoso, 2013 apud Neves 2017). In terms of ceramics, particularly in decorative grammars the analogies with Salvador can be seen in the pottery with decoration of the hairstyle, *punto y raya* and in pots decorated with spiny motifs.

In the Tagus estuary, the occupation recorded in the Gaio (Moita), presents a device with a high diversity of matrixes, where the impressions of individual punchings, combed decoration and spiny motifs converging to prints next to the maple (as in Salvador), besides the presence of wings and incisions which led his researchers to locate him in the ancient Neolithic. The end of the 6000 BC and 5500 cal B.C. (Soares, et al 2004 apud Neves 2017).

The decorative theme is also present in the Casal da Cerca (Palmela) site, being situated, chronometrically, between 5286-4957 cal BC, as a result of a absolute dating obtained on coal (Silva and Soares, 2014 apud Neves 2017) The application of the "false acacia leaf", spiny motifs, is quite common in the ancient Neolithic contexts located in Portuguese Extremadura (Nukushina, 2015), namely from a more evolved phase, Neves have proposed the chronology of Salvador early Neolithic. In this regard, the occupations registered in the Carrascal (Oeiras) stand out. and in São Pedro de Canaferrim (Sintra), where these decorations are also present. (together with the trimmed edges - in the case of Carrascal, very identical to those of the in Salvador), since they have absolute dates (Cardoso, 2015; Simoes, 2003, apud Neves 2017). These place these levels of occupation in the last quarter of the 6000 BC, clearly integrated in the chronological horizon that indicates the chronologically similar of Salvador. The stylistic options used in Salvador's decorated pottery are found, also, parallels in the area of coastal Alentejo and inland Alentejo, integrating the same chronological framework, the end of the 6000 BC to the beginning of the 5000. cal BC.

There are also some few other examples like, In the Sines area, observing the published data referring to the Vale Marim II site (Silva, Soares, Coelho-Soares, 2010), there are similarities in style between this context and Salvador. The presence of elements decorated with and on the cob, namely a specimen where the spine motifs converge for a few prints the puncture located just below the edge, in an ovoid container that in addition to the same shape has a very large diameter. next to the specimen of Salvador (Silva, et al., 2010, p.27 apud Neves 2017). In addition to this specimen, there is similarity in the decorated pottery with thin incised thread rows and individual punching, with light weight lateral drag. This occupation is dated between 5208-4851 cal BC.

Already in the Alentejo interior, the place that seems to be located in the same chrono-cultural space with the Salvador corresponds to the village of Valada do Mato (Évora), where in a device (and where it dominates the printing technique), it seems some parallels with the matrices used in Salvador, namely in the specimens decorated with *punto y raya*, comb, in the existence of pottery with double plastic cord, with rows of small incised lines parallel to each other, as well as smooth vases with e.p.s. close to or under the edge, the existence of edges cut out by as well as specimens decorated with *espiga* motifs.(Diniz, 2007 , apud Neves 2017). This occupation is dated c. 5054-4793 cal BC

Possible parallels with the Neolithic occupation of Salvador also seem to occur in the Spanish Extremadura area also. On the Los Barruecos site (Cáceres, Spain), the ceramic estate associated with Phase According to Neves, he mentions that, some affinities with what he has seen it seems the evolved phase of the Ancient Neolithic and for the is still site under analysis. The presence of profusely decorated pottery with printed motifs is verified. (namely *punto y raya*), combing and, in the incisions, the existence of rows with small incised lines parallel to each other and to the edge (Cuenca et al, 2006, apud Neves 2017). Phase I is radiometrically dated, on coal samples obtained from in two different contexts of origin (EU 113 and EU 117). Both dates point to a time interval between 5206-4805 cal BC, i.e. the last and the 1st quarter of the 5000 BC (Cuenca et al, 2006).

This chronological horizon clearly enters into the absolute values described in the other occupations referred to as possible chrono-cultural parallels of the Salvador. As it was made a point of referring throughout this preliminary analysis, the reflections here produced result from the observation of a very small artifact set, from a small intervention area, which will in the future be will bring new elements to the available register. To these factors, in addition, this text corresponds only to the data from a specific component of the material culture - Ceramics - remains to be evaluated the other artifacts and ecofacts (chipped stone, polished, affectionate, faunal remains), in an analysis that will always have to be transversal to all elements of the cultural system.

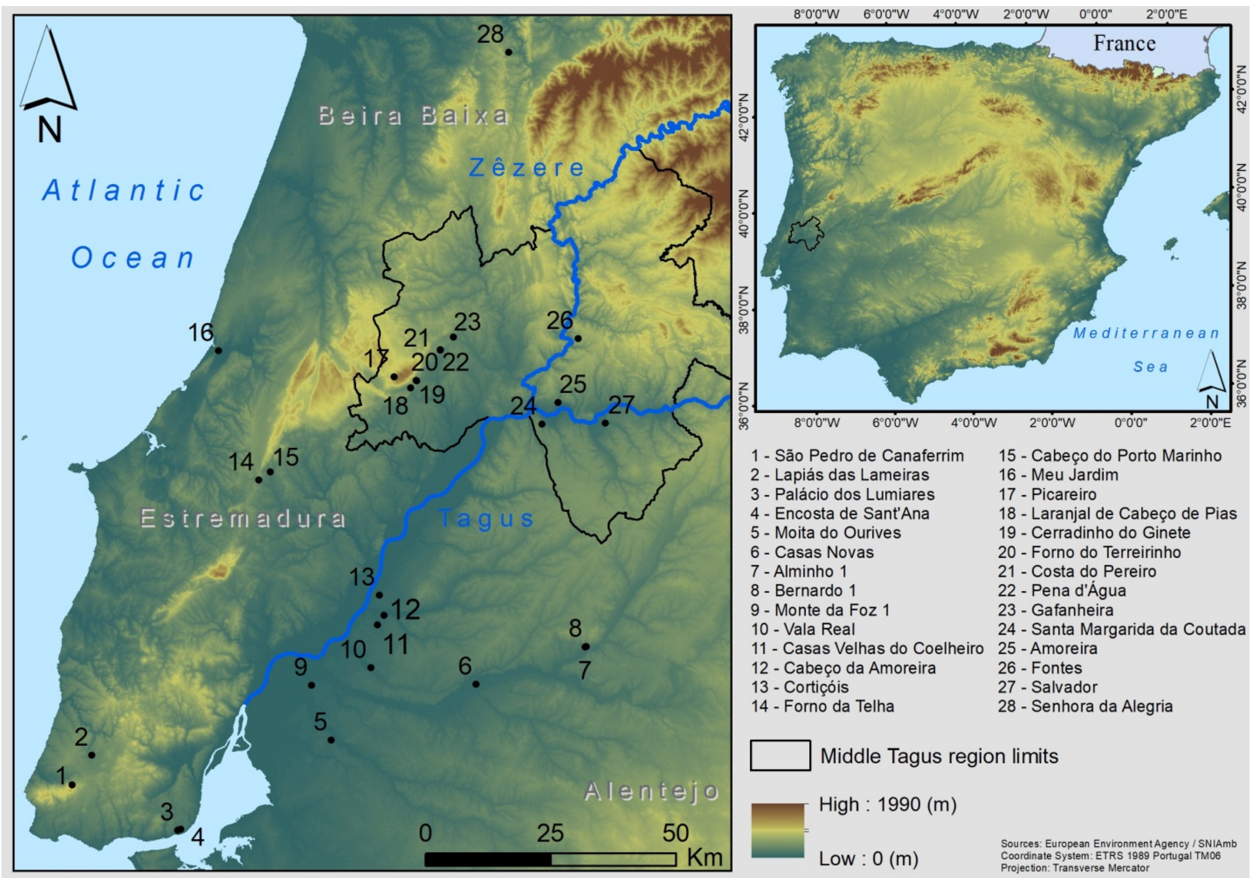


Figure 08: Distribution of Early Neolithic sites in the Tagus valley with indication of Middle Tagus region limits (Source: Luís Costa and Nelson J. Almeida).

CHAPTER 3:

PRESENTATION OF THE ARCHAEOLOGICAL SITE

The aim of an excavation is to identify, define, uncover, date, and by understanding transformation processes -interpret each archaeological context on a site. Usually this process is carried out in the reverse order of the site's construction, cutting or deposition. The term of 'context' is used widely in Archaeology. A context refers to any discrete archaeological entity on site, and so could refer to a layer, a pit or a posthole. It is often the result of a single action, whether it leaves a positive or a negative record on the site (Drewett, 1999: 104-125 apud Manik 2014).

Description of the archaeological excavation in Salvador**:**

Salvador is an open-air site located on the left bank of the Tagus River. This site was excavated in 2017 and 2018 and resulted in several technical reports (Almeida, 2017, 2018, 2019). In the year of 2017, followed by the Harris matrix (Harris 1979 & 1989) stratigraphic sequence method (Figure 09) three manual diagnostic test pits (Sondagem 1, Sondagem 2 and Sondagem 3; in Portuguese test pit is *Sondagem*) of 2x2 m each were excavated resulting in the recovery of some archaeological materials (mainly ceramic fragments and lithic industry).

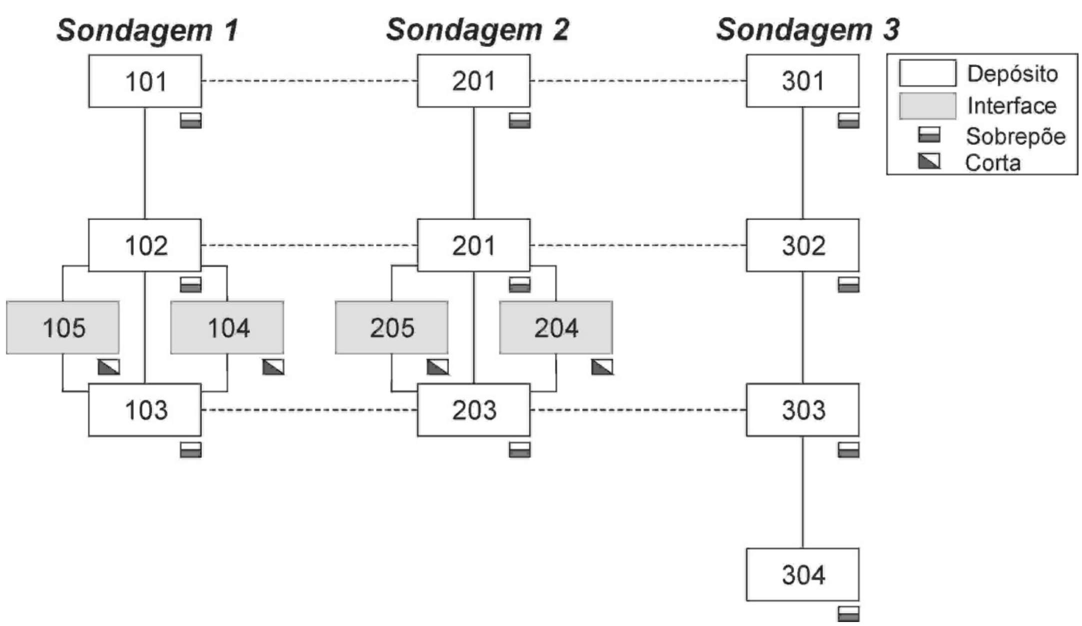


Figure 09: Harris Matrix stratigraphic sequence method (Almeida, 2017a : 39).

This allowed an initial assessment of stratigraphy and its preservation and as a result, test pit 3 was subsequently extended. On the whole, these works revealed an occupation that, despite being strongly disturbed by forestry and agricultural works, namely ditches with different levels of disturbance of the archaeological contexts, showed a remarkable homogeneity in terms of material culture (Figure 10).

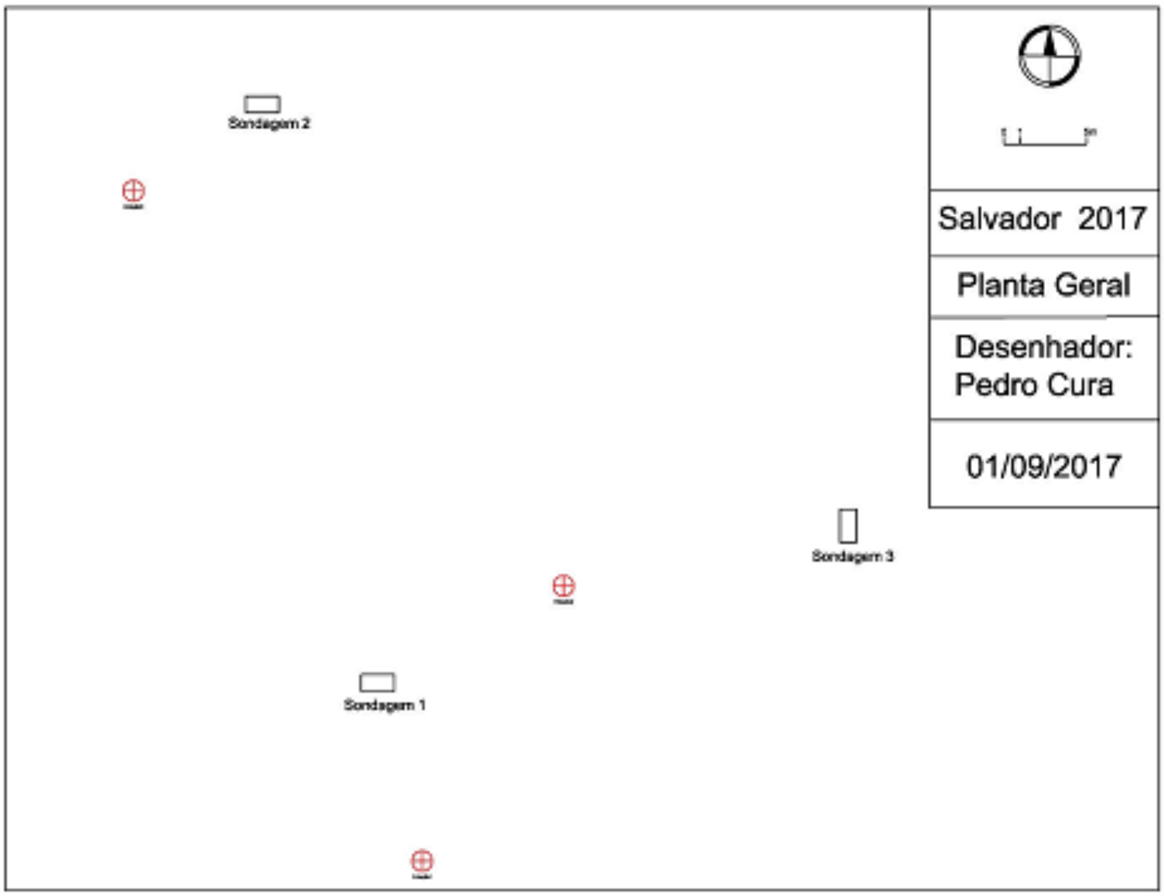


Figure 10: General layout of the Salvador site with indication of the different test pits and total station points (after Almeida, 2017a: 36)

The description of test pit 1:

Closer to the present road and at a lower elevation than the others, test pit 1 allowed for the collection of a small number of archaeological remains. Below is the description of the different Stratigraphic Units (S.U.) of test pit 1(Figure 10), according to Almeida (2017):

- [101] this is the upper surface layer with wavy delineation, greyish brown in color, the sediment is sandy-silt, very fine to fine grain size, powdery, with presence of bioturbation and organic inclusions (roots, trunks, plants, coals). This layer is in bad shape but contained lithic industry and ceramics, namely a flake and quartzite fragment and two ceramic fragments;

- [102] this unit is dark brown in color, the sediment is sandy silt with gradually fine to fine granulometry and semi-compact, with bioturbation and organic inclusions (roots, trunks, coals). It is in an average state of conservation. Like [101], this S.U. also contained lithic industry and ceramics, namely two ceramic fragments, one of which corresponds to a wing shape, a flake and a quartzite fragment. SAL19 ceramic fragment was selected for further analysis;
- [103] the color of this unit is yellow brown with sandy sediment of medium grain size; the sediments are comparatively compact, with occasional sub-rounded clasts, no bioturbation and inclusions of organic material. This S.U. is well conserved with lithic industry and ceramics: 14 ceramic fragments, a flake and a quartzite were collected. SAL48 ceramic fragment was selected for further analysis;
- [104] and [105] these two S.U. correspond to the interfaces of recent agricultural ditches that cut the top of [102] and whose filling was not possible to differentiate being macroscopically similar to [102], semi-compact, with the presence of bioturbation and organic inclusions (roots, coals), in a poor to medium state of conservation level. The main findings are one ceramic fragment and a quartzite flake. SAL46 ceramic was recovered from the infilling of [105] and selected for further analysis.

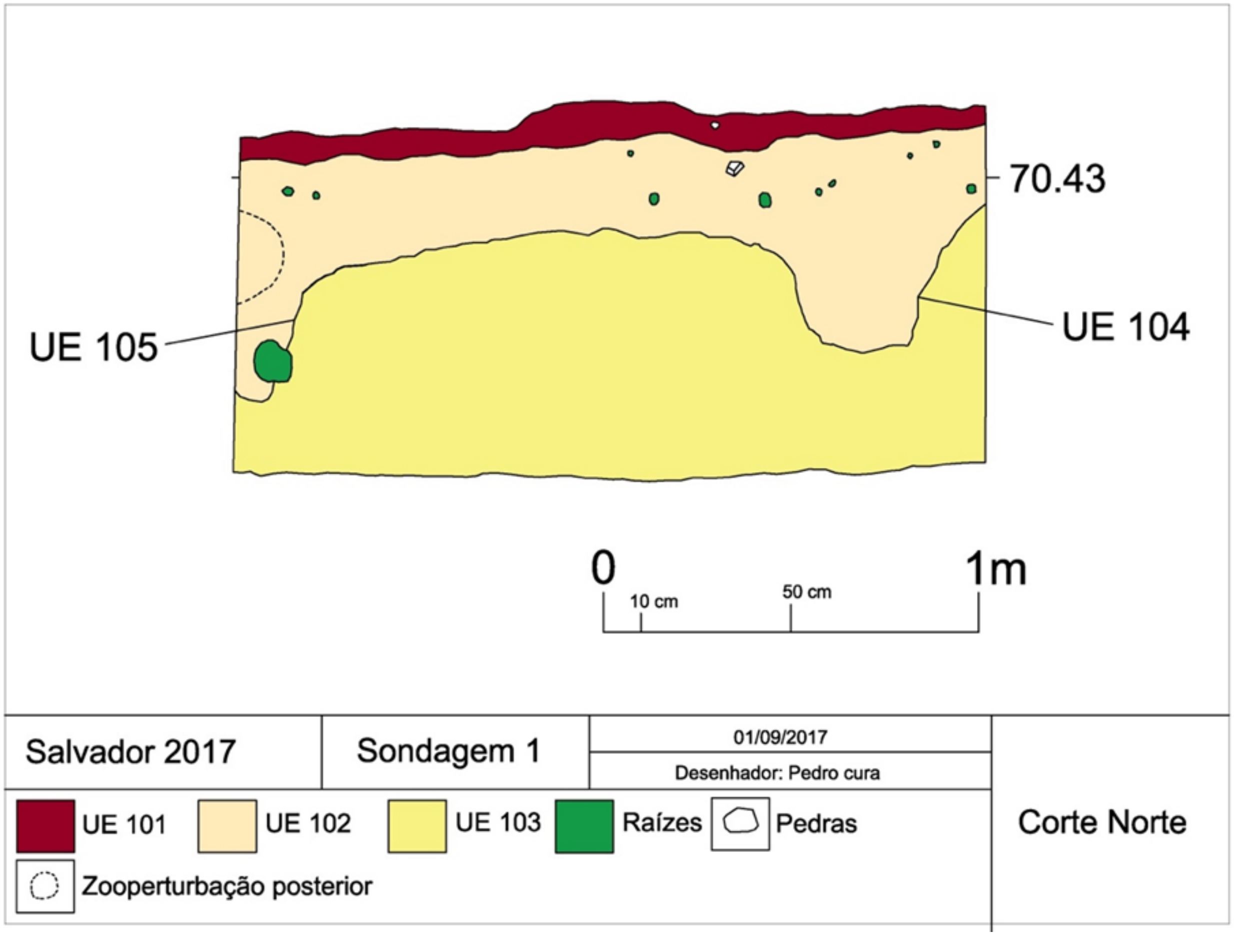


Figure 11: North profile of test pit 1 (Almeida, 2017a: 37)

The description of test pit 2 (Figure 11) according to Almeida (2017) is:

- [201] this is the wavy-delineation surface layer of test pit 2. The color of the sediment is greyish brown. The sediment is sandy-silt, very fine to fine grain size, powdery, with presence of bioturbation and organic inclusions (roots, plants, coals). The condition of conservation is poor. Among the archaeological remains are 13 amorphous ceramic fragments and 12 industry records;
- [202] light brown sandy silt with very fine grain size, semi-compact, with the presence of bioturbation and organic (roots, charcoal) and inorganic inclusions (black plastic bag). This unit is also in a bad state of conservation, with lithic industry (6) and ceramic fragments (13); SAL40 ceramic fragment was taken for further analysis.
- [203] yellow-brown sandy soil with a medium grain size, relatively compact with occasional sub-rounded clasts lacking apparent bioturbation. It is in a good state of

conservation, with abundant lithic industry and ceramics. Charcoal was recovered from the sieve and during the excavation. The amount of material increased significantly in comparison with previous S.U.s, resulting in 51 ceramic fragments (including decorated) and 49 lithic records, the latter mainly corresponding the flakes in quartzite, but also quartz and flint. SAL37 ceramic fragment was selected for further analysis;

- [204] and [205] correspond to the interfaces of recent agriculture ditches that cut the top of [203], filled by sediment that macroscopically was not distinguishable from [202], semi-compact, with the presence of bioturbation and organic inclusions (roots, coals), in a poor state of preservation. Some ceramic fragments and lithic industry were recovered in the sediment infilling.

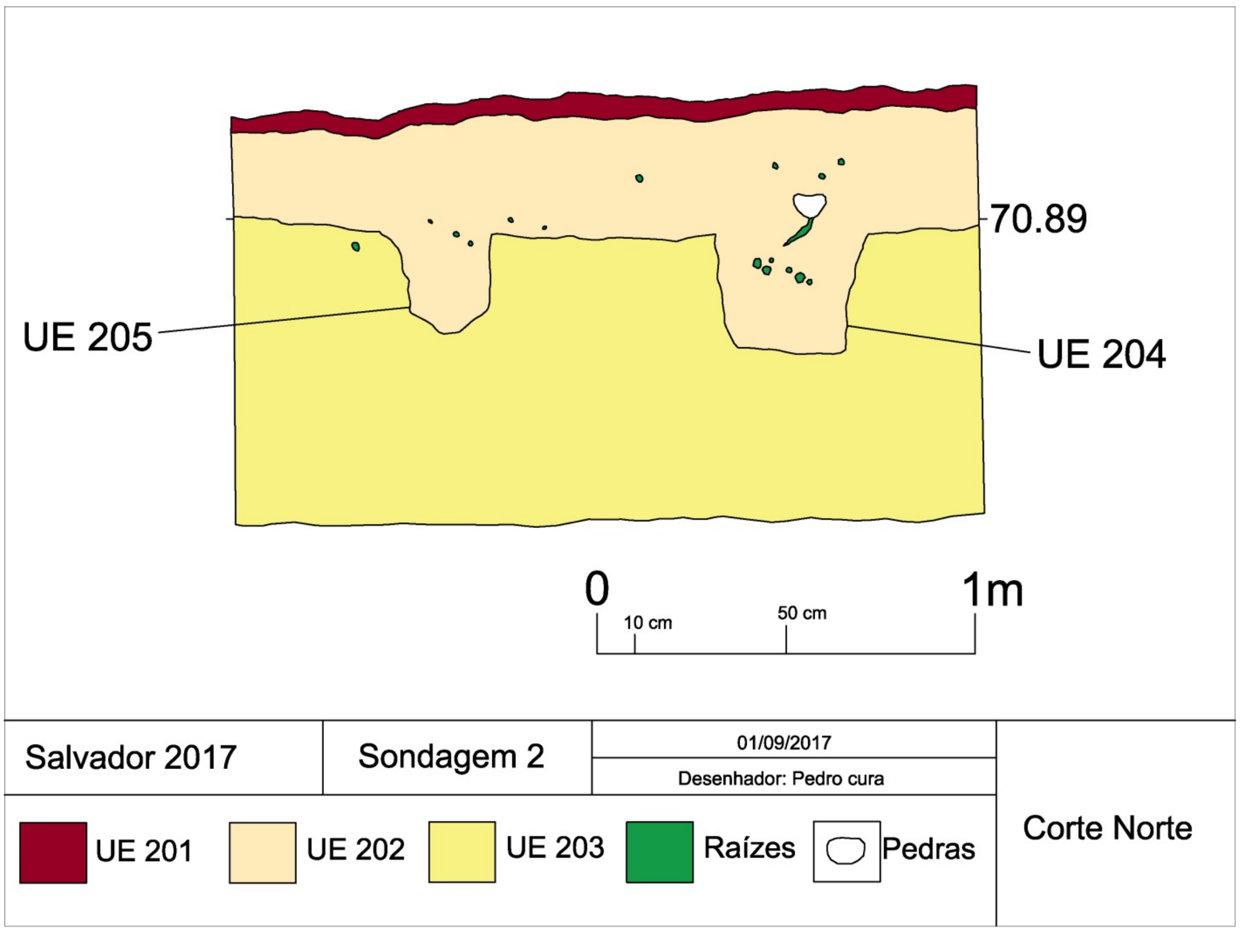


Figure 12: North profile of test pit 2 (Almeida, 2017a: 38)

Test pit 3 (Figure 13) resulted in a greater quantity of materials compared to the other two test pit: Below is the description of different stratigraphic unit:

- [301] surface unit with wavy delineation and a greyish brown color, very fine to fine granulometry, powdery, with presence of bioturbation and organic inclusions (roots, coals). It is in a poor state of conservation but with lithic industry (8) and ceramics (3). SAL170 ceramic fragment, from square N47 quadrant a, was selected for analysis;
- [302] sandy-silt light brown sediment with very fine to fine granulometry, compact with little bioturbation and organic inclusions (roots, coals). It is in an average state of preservation, containing lithic industry and ceramics. SAL123 ceramic fragment, from square L49, was selected for further analysis;
- [303] yellowish brown sandy sediment of medium grain size, compact, with occasional sub-angular clasts at the base. Almost no bioturbation or verifiable organic inclusions from the top of the layer. The conservation of this layer is in good condition, with abundant lithic industry (67) and ceramics (51). SAL42, SAL77, SAL294 and SAL561 were selected for analysis;
- [304] dark orange brown with sandy, medium to large granulometry, absence of bioturbation or organic inclusions. It is in a good state of conservation. Although no materials were collected, the enlargement of this test pit allowed for the recovery of lithic and ceramics in this S.U., as is the case of SAL109 and SAL 472 fragments that were further analyzed.
- [307] a patch of dark sediment, rich in charcoal, including considerable sized fragments was located at P/Q49, within [303] and was fully collected for flotation

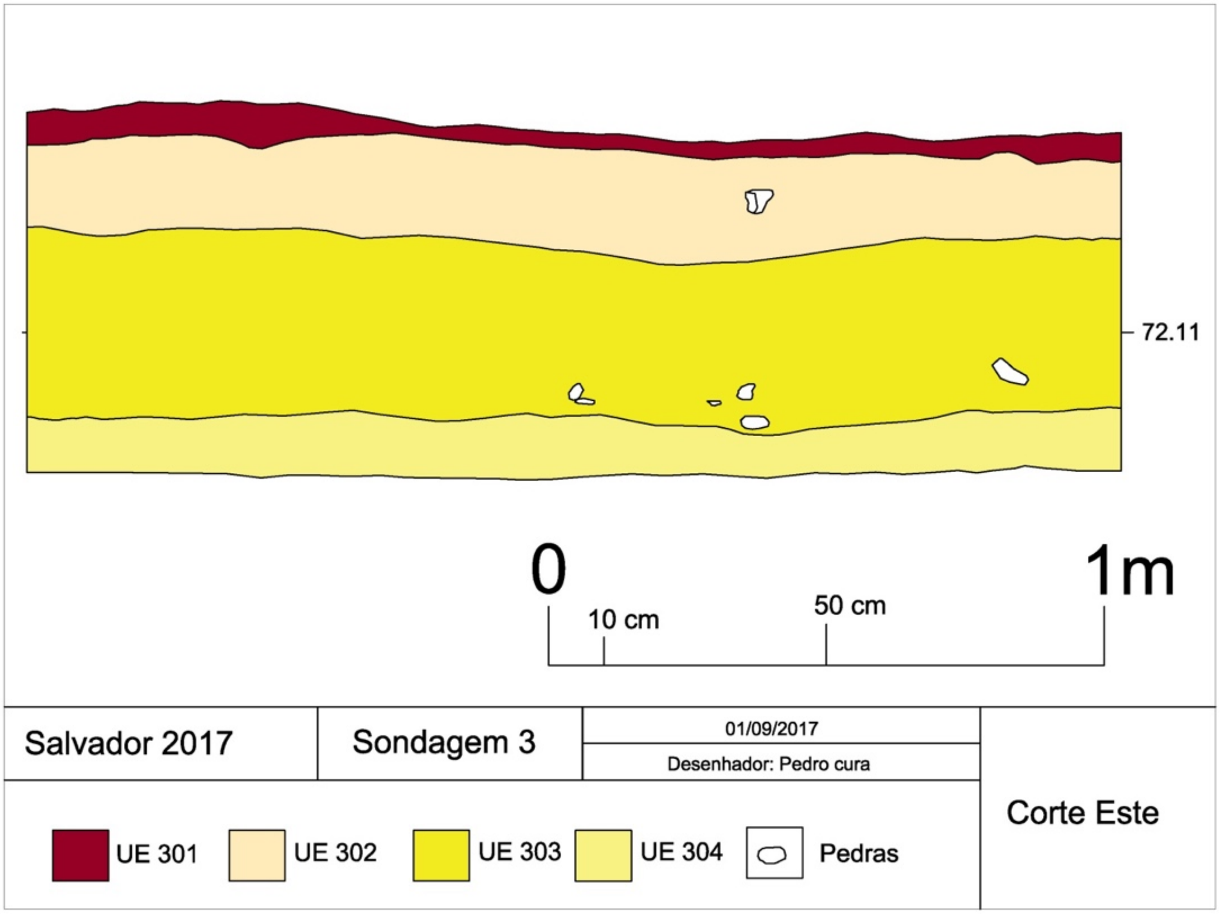


Figure 13: East profile of test pit 3 (Almeida, 2017a: 39)

The potential identified in test pit 3 led to the enlargement of this area (*Área 1* – Figure 14), resulting in the identification of new stratigraphic units and further acquisition of data.

- [305], [306] and [313] the enlargement of the excavation are led to the identification of recent agricultural ditches, in all similar to the ones identified in test pits 1 and 2. Once more, their infilling was macroscopically unidentifiable from [302], with bioturbation and inclusions being identified (roots, charcoals). Preservation is medium to poor, with presence of lithic industry and ceramics. SAL198 fragment was collected during the dry sieving of the sediment filling [305] in square O51 and was selected for further analysis;
- [309], [310], [311] and [312] and [313] correspond to smaller superficial recent agricultural ditches in comparison with [305], [306] and [313], which overlap in the latter larger ones, in certain areas (e.g., P/Q 47/47). With a distinct NW-SE

orientation, they were recorded almost only in the top of [303] since they are less intrusive;

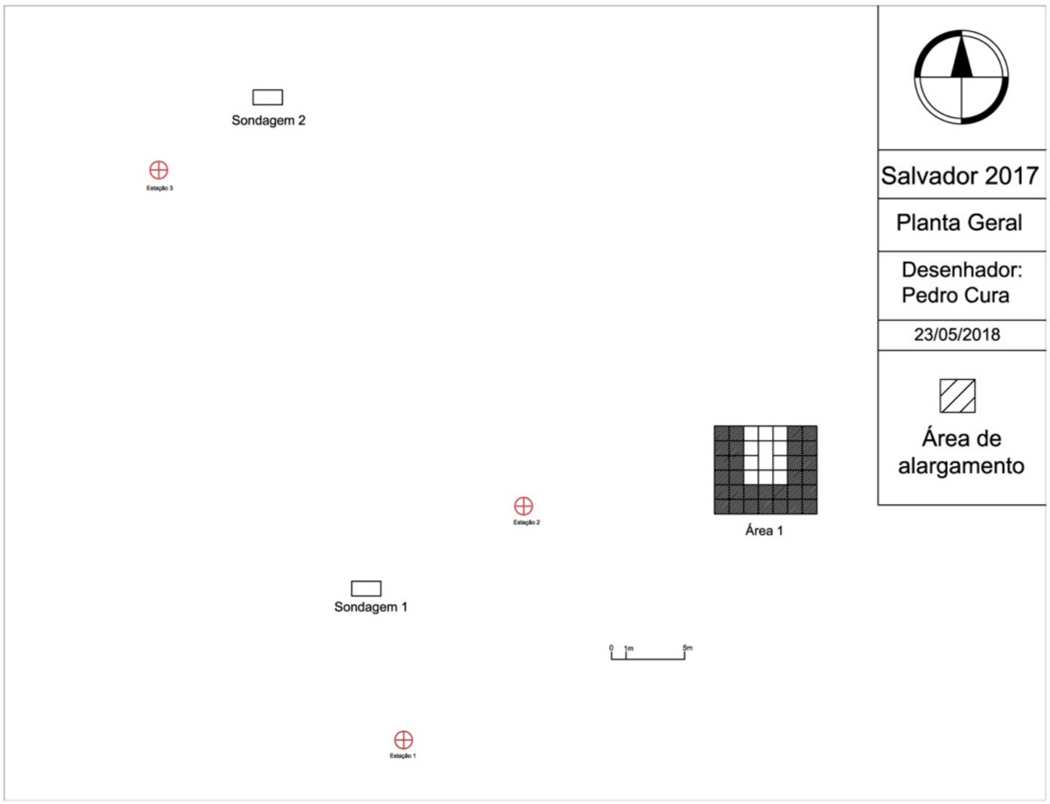


Figure 14: General layout of the Salvador site with indication of the different test pits, enlargement and total station points (Almeida, 2018: 33)

- [308] partially identified during the excavation of test pit 3 when it was cut by the southern excavation profile of 2017, it is one of the main motifs for the enlargement of the excavation area. This structure was interpreted has a combustion structure, (Figure:15)

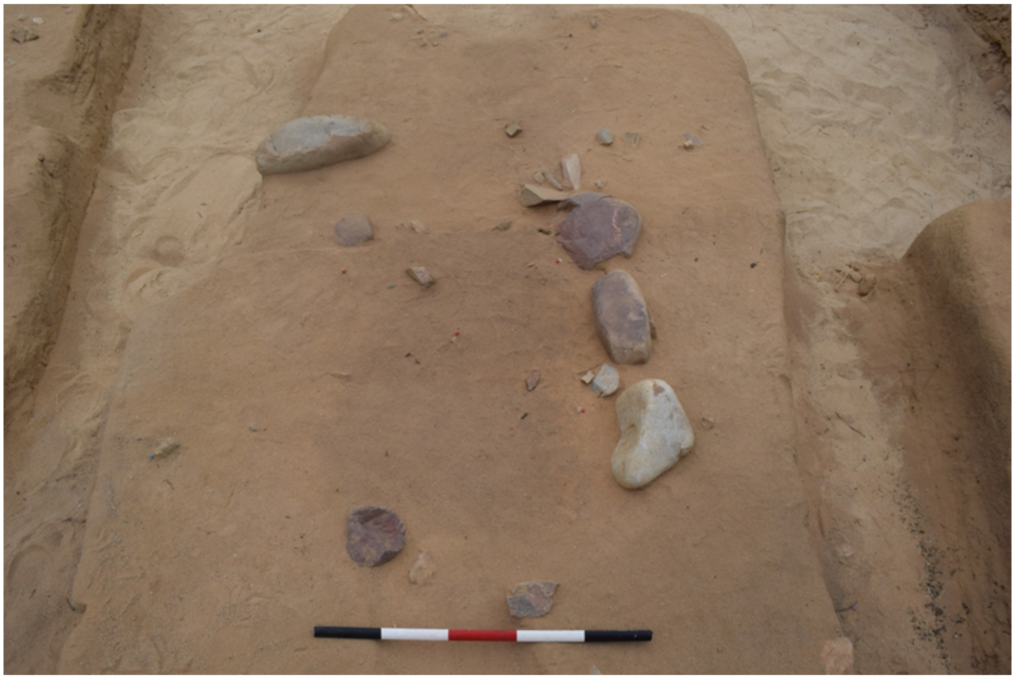


Figure 15: Stratigraphic Unit 308 interpreted as a possible combustion structure, slightly darker sediment (Image by Nelson J. Almeida; ITM archive collection)

- [314] small “pit” identifiable in the top of [303] cutting until [304], with small-sized thermo-clasts in the southern area, filled by a sediment rich in organic matter with scarce charcoals. It was fully recovered for flotation;
- [315] cut by the ditch [305], corresponds to a negative feature filled with a dark organic matter rich sediment, including large charcoals and some quartzite fragments. It is similar to the so-called “cinzeiros” (*ashtray*) commonly identified in other similar type of contexts;
- [316] was also cut by the ditch [305] and is a cluster of thermo-clasts in quartz and quartzite with some archaeological materials associated.

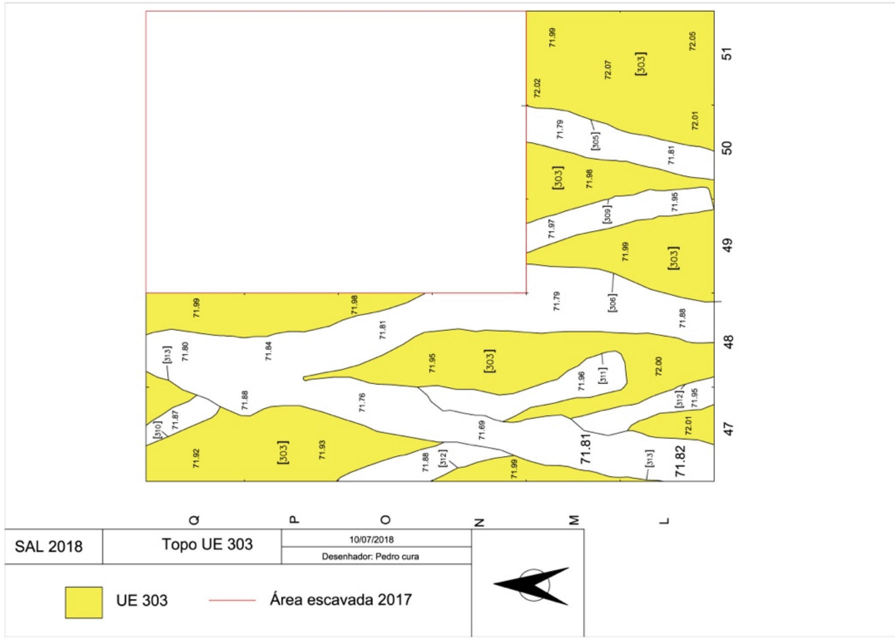


Figure 16: Top of Stratigraphic Unit [303] with indication of the several agriculture ditches identified during the enlargement of test pit 3 (Almeida, 2019: 51)

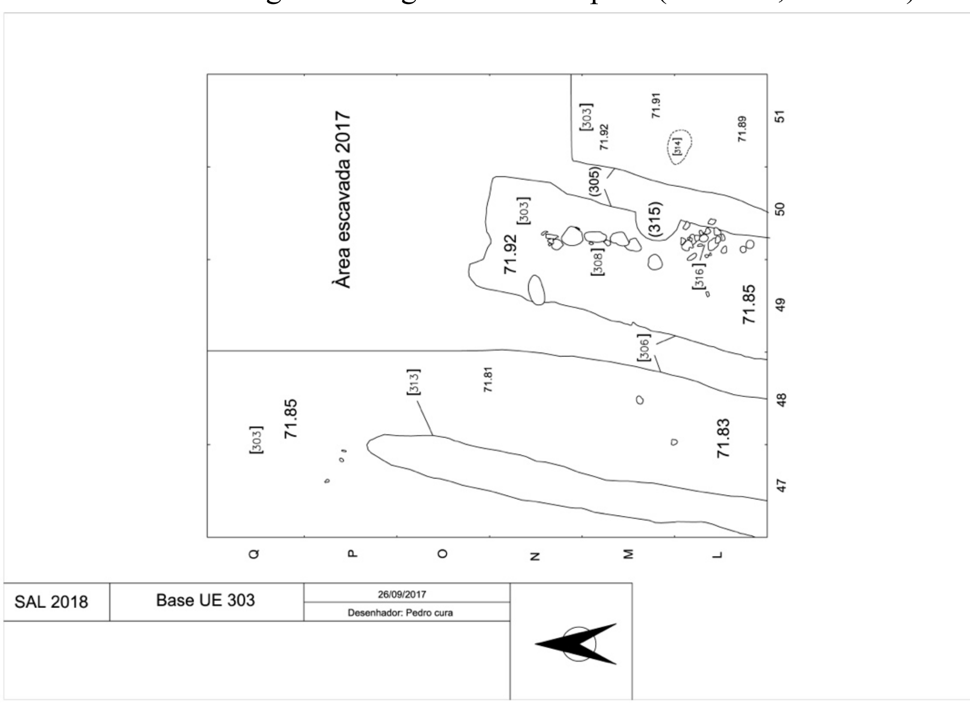


Figure 17: Base of Stratigraphic Unit [303] with indication of the ditches ([305], [306], [313]) and other archaeological structures and features described ([308], [314], [315], [316]) (Almeida, 2019, 52)

CHAPTER 4

ARCHAEOLOGICAL MATERIALS, METHODS AND RESULT

4.1 ARCHAEOLOGICAL MATERIALS

The archaeological artifacts unearth in the excavation were lithics and ceramic fragments, but charcoal and fauna bones were also recorded. Charcoal identification is ongoing but faunal remains were already analyzed. They correspond to 68 bone fragments, mainly from [303] (52 or 76.5%) and [308] (9 or 13.2%), but all with less than 3 cm long, extremely affected by contact to fire (calcined) and dissection, hindering anatomical and taxonomical identifications (Almeida, 2019).

According to available preliminary data, 1867 records have been inventoried (report from Sara Cura and Ivana Mirkovic – Almeida, 2019). The knapped lithic industry was mainly produced from local raw materials, quartz (52%) and quartzite (30%), followed by flint (17%), which is exogenous in this region (Figure 18). An important presence of debris was recorded and a comparatively low abundance of nuclei or even whole flakes, suggesting the occurrence of knapping and refreshing of implements in the site, but the transportation of nuclei elsewhere. The number of retouched parts is also low and, again, may indicate that formal instruments may have been used and revived in place but transported. The lamellar knapping is well represented, either by whole lamellae or by fragments, mostly of flint. Lamellar nuclei were observed in this raw material in an advanced state of exploitation, as well as technological pieces associated with this type of prismatic knapping.

Regarding ceramics, a total of 812 records were collected between the interventions of 2017 (report by César Neves) and 2018 (report by Luiz Oosterbeek and Isabella Brandão). A total of 717 (88%) records correspond to body fragments, 78 (10%) to rims and 17 (2%) to Grip and suspension elements (Chart 01). The use of decorative techniques was verified in 116 (14%) records, with the remaining 696 (86%) lacking decoration The decorative techniques recorded include “jagged” edges with parallel prints to each other, incised lines parallel to the edges and parallel to each other, printing of motifs on the cob ("false acacia leaf "), *punto y raia*, snaking lines decorated with "comb", stamped forming lines and a fragment with possible cardial decoration. Simple decorative patterns are predominant in the assemblage, being worth mentioning that almost 60% of the decorative records come from [303]. Among the 812 record, 23 were selected for further analysis in the scope of this thesis.

Figure 18: Selection of lithic Materials from Salvador site. Scale = 1 cm (Almeida, 2019: 44).

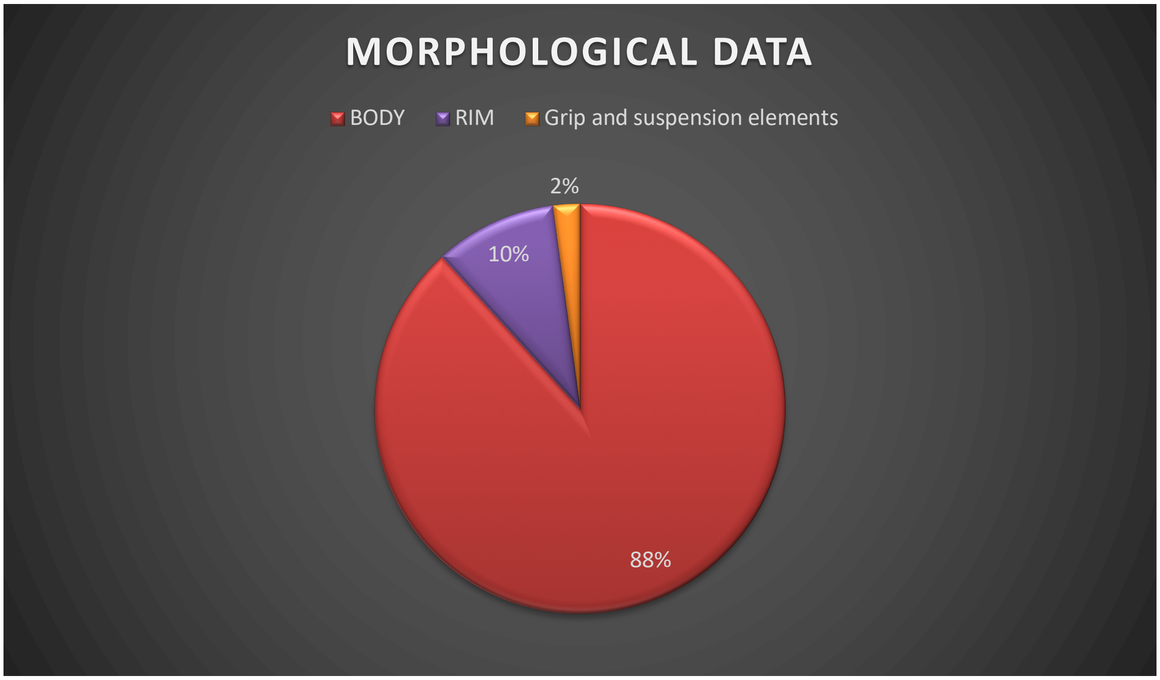


Chart 01: Typological data of ceramic fragments of Salvador

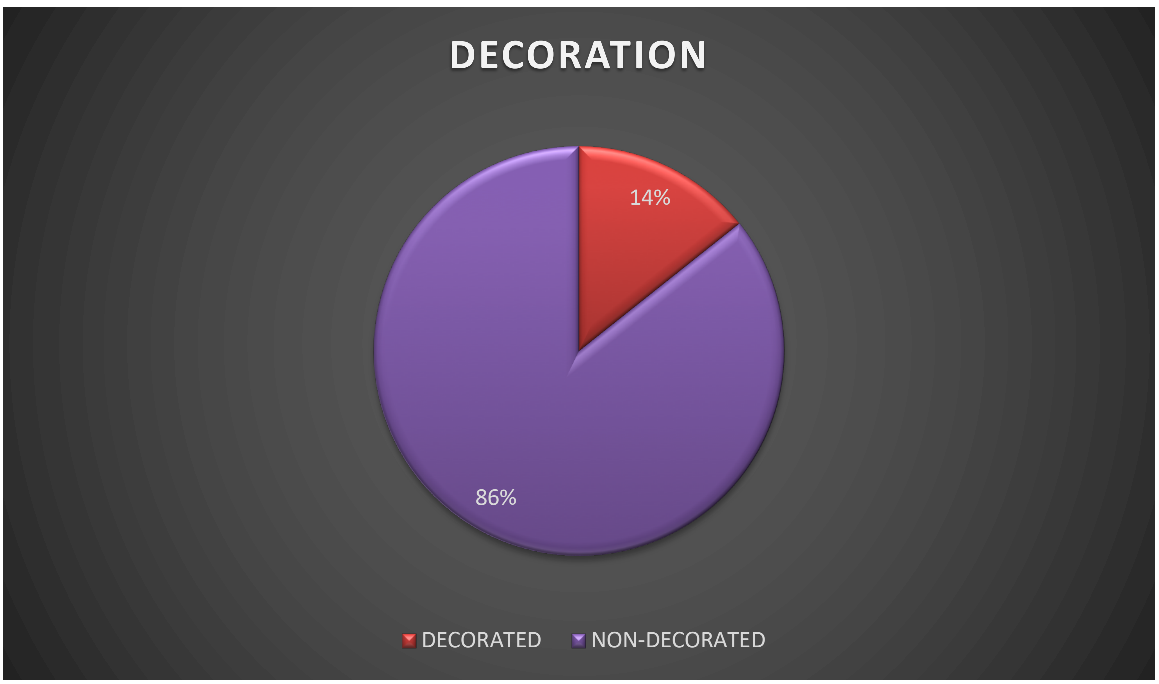


Chart 02: Chart of decorated or non-decorated ceramics fragments from Salvador

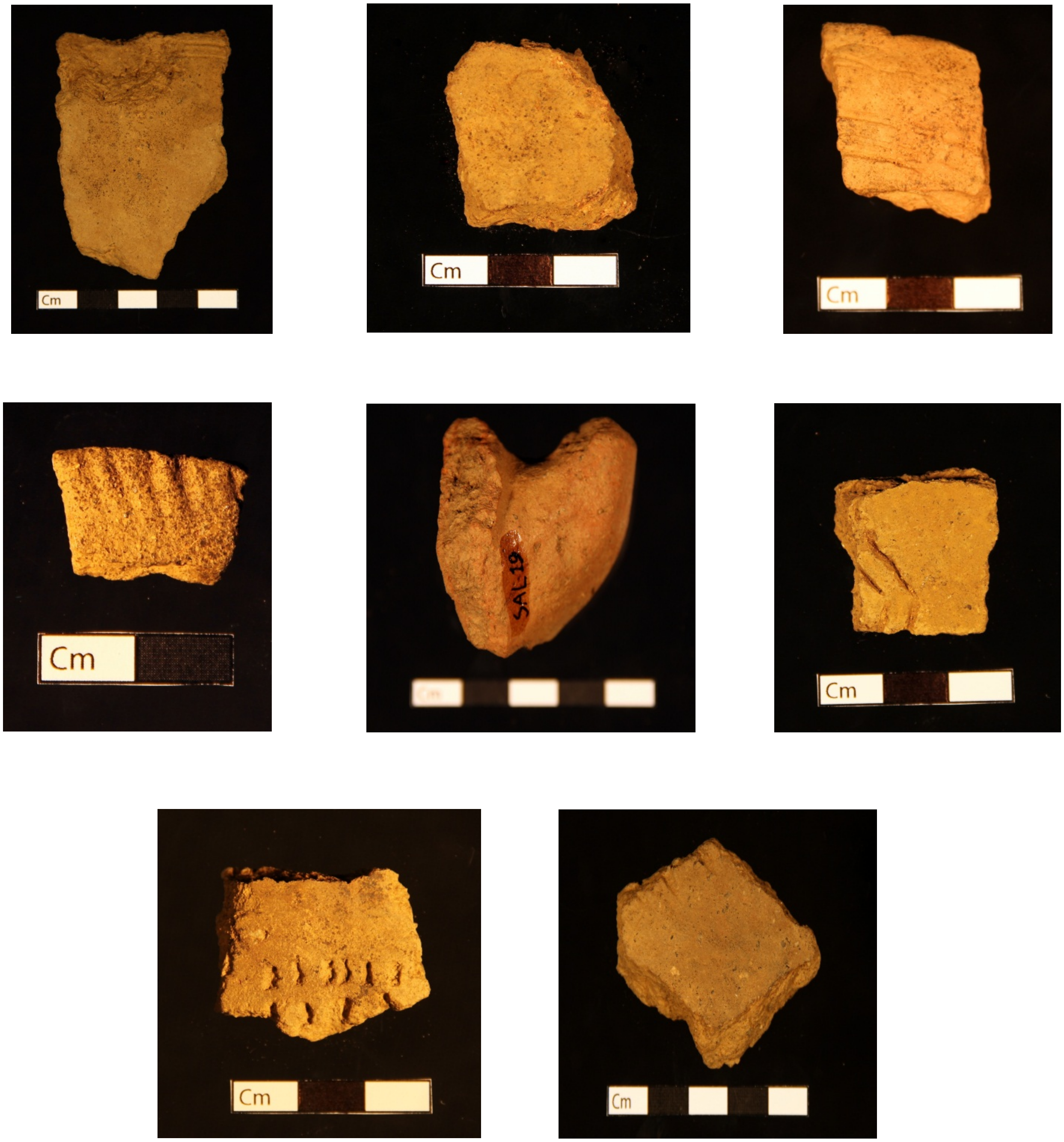


Figure 19: Ceramics fragments from Salvador site

4.2 METHODS AND EQUIPMENTS

The study of the ceramics involved two major work processes. Typological work in the Ceramics Laboratory of ITM Mação, and Scientific analysis in the laboratory of infrared spectrometry and X-ray fluorescence of the Musée de l'Homme, Paris. Below follows the description of work processes and methodologies followed by.

4.2.1 Typological work in Ceramics Laboratory of ITM Mação:

(i) Documentation and Inventory: Methods like documentation and inventory are being completed with the help of different handbook of Guidelines from UNESCO and ICOM Publications (UNESCO, 2007; ICCROM-UNESCO, 2009).One Microsoft office excel sheet has been prepare to input all the details of individual 812 pieces of ceramics fragments. In order to standardize the methodologies and nomenclatures associated with the study of the Ceramics, for the adoption of the analysis criteria used by Ana Cruz and Luiz Oosterbeek in the studies of ceramics of the region (Cruz & Oosterbeek (1993) and Mariana Diniz in the study of the artifacts of the Valada do Mato (Diniz, 2007), the later one revised by César Neves (Neves, 2010, 2016, 2017), and was given the following information added some more concrete elements of classification and analysis, which can be tailored to certain specific features of the various elements of the package ceramic of Salvador. The aim was to characterize and classify this collection by adopting universal description criteria that passed through metric and geometrical parameters (defining dimensions, shapes and volumes) in an attempt to produce a set. The primary objective of the Inventory produced is to be the closest view to the ceramic object, following a methodology that allows for comparison with results from other sites in the region Oosterbeek & Cerezer, 2012). Although it was built with the priorities of this specific study in mind, it assumes a global perspective, so that the elements that are available and that can be read, worked on and interpreted by other researchers that may have on them, different criteria and objectives.

(ii) Photography: The latest methods of photography applied to Archaeology were taken into account and implemented in the Centro de Estudos de Fotografia de Tomar (Instituto Politécnico de Tomar, Portugal). A Kaiser Table Frame with double light (Figure 20) was used as specialized equipment. One of the lectures from QP31 in MNHN, Paris, named *La* *photographie en Archéologie* was also taken into account. For this step, we used a CANON EOS 600 D. Later, the post processing of the photographs was conducted using Adobe Photoshop CS6 and Picasa photo editor software

(iii) After photography, the marking/leveling with special permanent marker pen (Staedtler Permanent Lumcolor S for black and Pilot Super Color EF for white) was made on the selected individual ceramics. The first three letters of site (SAL) and inventory number following the Microsoft office excel sheet have been used, e.g., SAL 47. For body fragments (*bojo* in portuguese), "bj" has been indicated in the end (e.g., SAL 634 bj).

(iv) Sample Selection: A total of twenty-three ceramics fragments from nineteen different stratigraphic contexts were selected for further analysis, taking into account (Table 01), due to the relevance of the Stratigraphic Units [303] and [304], 4 and 2 fragments respectively were selected in order to have a higher representativeness.

For selecting the sample few things have been taken account regarding the site context and typological study. According to the site context the fragments have been selected from different 3 test pits as well as nineteen stratigraphic contexts. Among these twenty-three fragments ten pieces of fragments are been chosen which morphologically belongs to body part (in Portuguese *bojo*). One of them is Grip and suspension element. The rest twelve are belong to decorated ceramics fragments. Nine pieces of decorated fragments are body part. Three pieces are rim with decoration. So, the selection process has been completed very carefully to cover all the stratigraphic context. On the other hand, also belong to different major morphological character such as body part non-decorated, body part decorated, Grip and suspension element, rim with decoration.

Sl. No.	Inventory No.	Year of Excavation	Stratigraphic Unit	Square/Test pit	Total Station #	Intervention Type
1.	SAL 19	2017	[102]	1	45	Excavation
2.	SAL 47-48	2017	[103]	3	284	Excavation
3.	SAL 40	2017	[202]	2	41	Excavation
4.	SAL 37	2017	[203]	2	104	Excavation
5.	SAL 30 bj	2017	[204]	2	117	Excavation
6.	SAL 170	2018	[301]	N47a	975	Excavation
7.	SAL 123	2018	[302]	L49	758	Excavation
8.	SAL 42	2017	[303]	P49	583	Excavation
9.	SAL 77	2018	[303]	L48c	1455	Excavation
10.	SAL 294 bj	2018	[303]	L48b	1409	Excavation
11.	SAL 561 bj	2018	[303]	N47c	1395	Excavation
12.	SAL 109	2018	[304]	P47c	2576	Excavation
13.	SAL 472 bj	2018	[304]	L49c	2462	Excavation
14.	SAL 138	2018	[308]	M49d	2198	Excavation
15.	SAL 126	2018	[314]	L51b	1910	Excavation
16.	SAL 162	2018	[315]	L/R50	N/A	Sieving
17.	SAL 46	2017	[105]	1	N/A	Sieving
18.	SAL 04 bj	2017	[104]	1	102	Excavation
19.	SAL 11 bj	2017	[201]	2	18	Excavation
20.	SAL 198 bj	2017	[305]	O51	N/A	Sieving
21.	SAL 634 bj	2018	[307]	N49a	1570	Excavation
22.	SAL 509 bj	2018	[311]	Q47	N/A	Excavation
23.	SAL 406 bj	2018	[316]	L50a	2444	Excavation

Table 01: Ceramic fragments from Salvador selected for analysis and their provenance.

Figure 20: Kaiser Photography Table frame (Photo Source: https://www.adorama.com/krfsrcs.html)

4.2.2. Scientific analysis in the laboratory of Musée de l'Homme, Paris: After selecting the sample, for the laboratorial analysis, the following methodologies were implemented:

(i) Preparation of samples. Among different analysis modes of Infrared spectroscopy (IR), Total Attenuated Reflection (ATR) is one of the modes. This method is destructive but a minimum quantity of powder (<2 mg) is sufficient for obtaining results. For getting the powder of ceramic fragments, a use of playar (Figure 21) is necessary. Very small parts of the samples were collected using the playar. After that, a mortar-pestle was used for 10 minutes to homogenize the samples (Muller et al. 2014) (Figure 20). To make sure the powder was well prepared for analysis, a desk magnifier lamp (OULUX177ECT) (Figure 20) was used to check each individual ceramic powder. After the preparation, the powder was collected in small airtight tube (Figure 20). During the sample preparation it was necessary to wash the mortar with distilled water with every use, otherwise mixing samples would occur.

Figure 21: Up Left: Playar, Up-right: Mortar for making the powder from the samples; Down-left: Desk magnifier lamp; Down-right: Prepared sample for analysis in an airtight tube.

(ii) ATR-FTIR Analysis: The analysis was carried out in a Total Attenuated Reflection (ATR). This technique uses the reflections of the infrared beam and a diamond (Figure 22). A part of the sample is reduced to powder and then placed on a matrix. The powder is kept in contact with the diamond by a strong pressure. "The infrared beam penetrates into the sample and exits attenuated by absorbing the different modes of vibration with which it has interacted" (Fröhlich and Gendron-Badou 2002, p 672). This analysis does not allow for quantitative analysis. FTIR was performed in the ATR mode. Infrared spectra were collected on a Vertex 70 spectrometer (Bruker) with a spectral resolution of 2 cm^{-1} and the accumulation of 64 scans in the range of 4000–400 cm^{-1}. Less than 1 mg of sample powder was pressed on the surface of a diamond crystal using a single reflection ATR-Golden Gate accessory (Specac) (Lebon et al 2016).

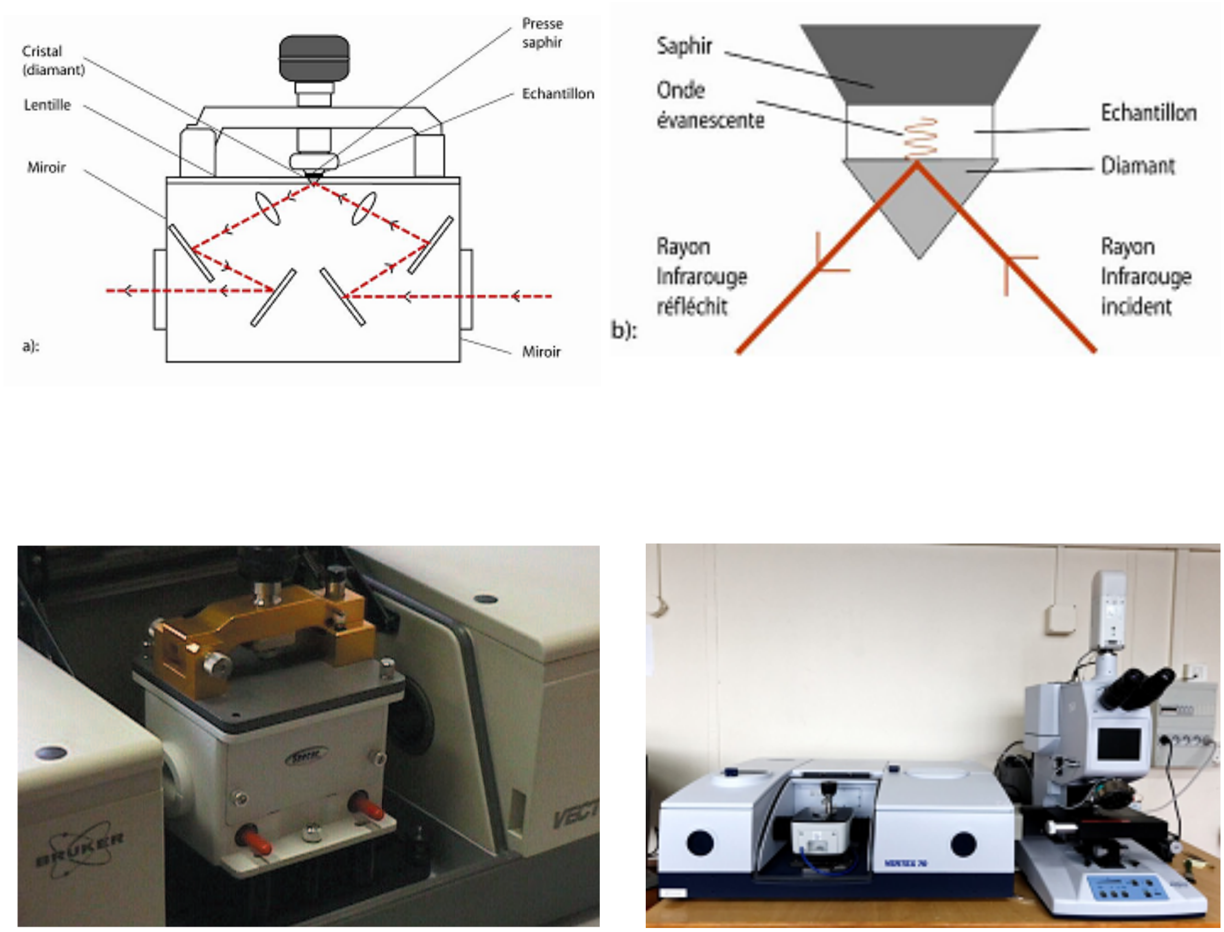


Figure 22: On top: Function of ATR-Golden Gate accessory (Class Lecture of QP18 Approche archéométrique des matériaux préhistoriques By Matthieu Lebon). Bottom: Golden Gate and Infrared Spectroscopy Tray (FTIR).

After the analysis, the machine provides raw data for every individual sample. For getting the raw spectra, using OPUS software (Bruker) is mandatory. Before processing a new sample, we used liquid ethanol to clean the diamond crystal. When the spectrum comes as output in OPUS software it is possible to measure the wave number by using a measurement scale from the software. Then, for every individual sample the wave number is recorded in a Microsoft office excel sheet for analysis. Different wave numbers indicate different mineral components. For example, below is the wave number of Quartz (Figure 23); if the wave number gives bands on 798 to 778, it indicates the presence of Quartz on the sample (Marel and Beutelspacher, 1976)

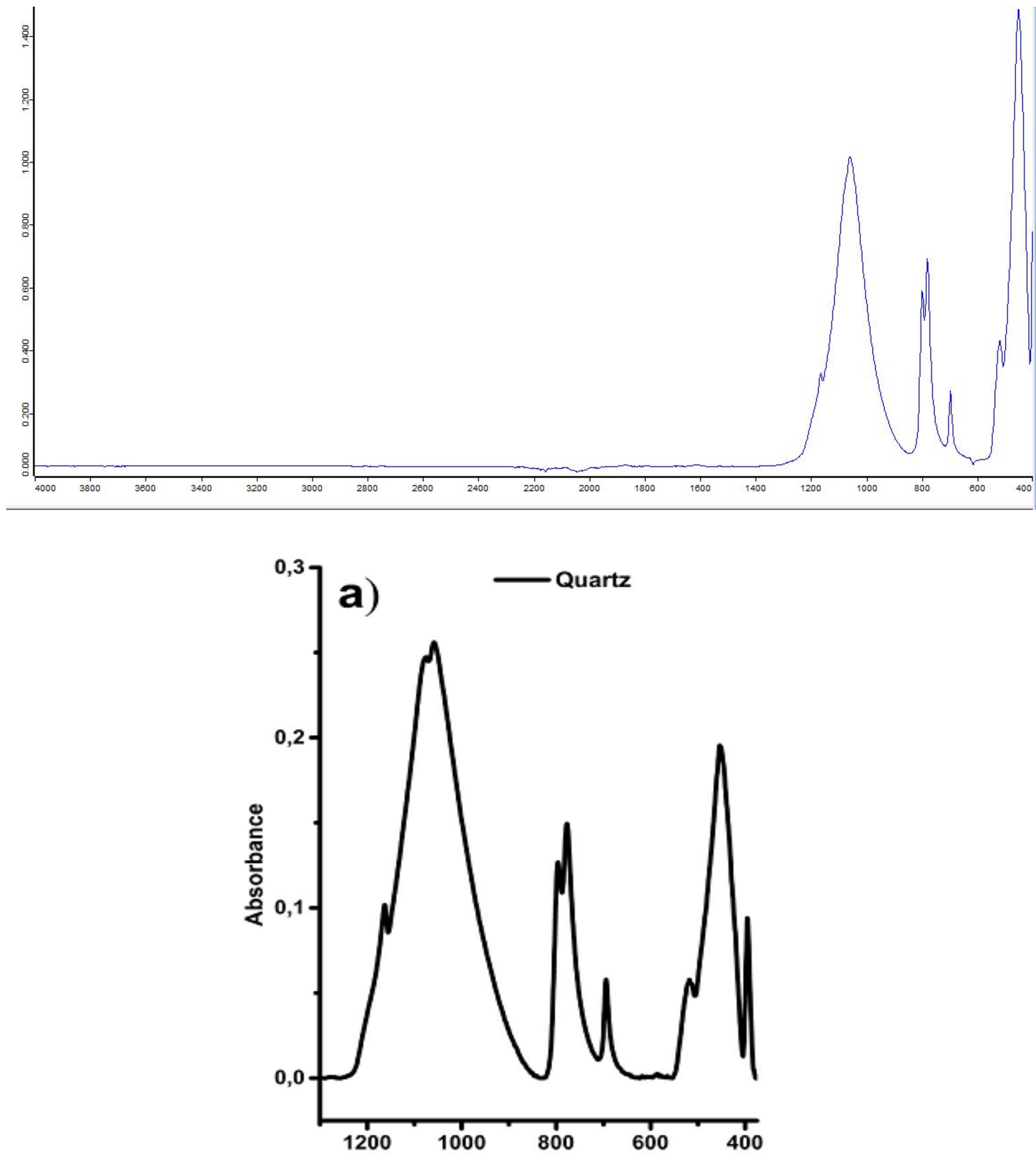


Figure 23: Quartz wave number reference (Source: Xavier Gallet) and (Muller et al. 2014)

4.3 RESULTS

4.3.1. Result of typological study:

Before the scientific analysis of twenty-three fragments a typological study of these fragments has been conduct. Following the methods of have been used by the researcher (Cruz & Oosterbeek, 1993; Oosrerbeek 1997; Diniz, 2007, Neves 2010, 2016, 2017) an attempt has been taken to do the typological study of Salvador ceramics. As for typological information of Salvador ceramics, 88% of ceramics fragments are belongs to body parts. As for this study among twenty-three pieces, ten pieces are body part without decoration and nine pieces are body part with decoration. With the body part it's been complicated to complete typological study. Specially, irregularities at the level the characteristics of manual production, combined with the small size of the fragments, made it impossible to define both the orientation and its size.

About the shape and orientation, Neves mentioned that, there are two general group. The orientations are open and close (Figure 23 and 24) (Neves, 2017). There are three pieces of rim in this study two of them SAL 47-48 and SAL 77 are close shape in orientation. Beside these two SAL 170 is open shape in orientation.

The size of the pottery depends on the diameter of the opening and the diameter and thickness of the bulge were the values used to characterize the dimensions of the pottery. As from Salvador, from the excavation there is no evidence of found any full pottery due to preservation, it is really difficult to understand exactly the size of the pottery. According to the result of Neves, in the ceramics of Salvador from 2017, he found three size of pottery. He presents one table for better understanding.

Size	For Open Shape (in cm)	For Close Shape (in cm)
Small	≤ 9,9	≤ 9,9
Medium	10- 24.9	10- 19.9
Big	≥ 25	≥ 20

Table 03: Typological study of Ceramics size

Following the table 02, for this study sample SAL 170 (open orientation) is in the group of small, the diameter is 8.5 cm. The thickness of this specific sample is 5.5 mm. About SAL77, it belongs to medium group of close orientation. The diameter is 14 cm and the thickness is 6 mm. Compare to other two, SAL 47-48 is bigger in size. The close shape diameter is 16.5 cm. This one is also belonging to medium group of pottery.

The pottery of Salvador has three general morphological shape. They are: Oval, Spherical and Hemispheric (Neves 2017). SAL 170 and SAL 47-48 are in oval shape and the SAL 77 is spherical in morphological shape.

SAL 19 is a grip and suspension element kind of fragments. This fragment is not decorated. The presence of receptacles with grip and suspension elements can be a chrono-cultural indicator of the early stages of Neolithic.

Decoration: Selected twenty-three fragments for typological study are morphologically body part, rim and grip and suspension element. Among them ten body parts does not have any decoration. Also, the grip and suspension element (SAL 19) is non-decorated. Among the other twelve decorated ceramics, SAL 37, SAL 42, SAL 47-48, SAL 138, SAL 170 have the decoration of impression technic. SAL 37 is decocted with special kind of impression decoration called punto y raya. The SAL 47-48 contains also a special kind of impression technic called fake acacia leaf technic. SAL 46, SAL 77, SAL 109, SAL 123, SAL 126 have the technic of decoration named incision. Among them SAL 46 have geometric shape incision, others are linear. The other two samples, SAL 162 and SAL 40 have the decoration called combed technic.

Firing: Among the 812 pieces after the firing few types of cooling process have been used. They are Oxidative, Reductive, Oxidative-Reductive, Reductive-Oxidative and in some cases both. With regard to the possible cooking environment, one of the indicators used is the following for approximate characterization of the cooking atmosphere and cooling of it was the macroscopic observation of the dominant color, conserved on the external surface and on the fractures (Silva and Soares, 1976-77; Juan Eiroa et al., 1999, p.155). In the case of Salvador ceramics, fifty-five fragments have been followed oxidative cooling process, 465 have been identified as reductive cooling process. Five pieces of fragments had been used oxidative-reductive cooling process and eighteen are reductive-oxidative cooling process.

The twenty-three ceramics fragments of this study have also the different kind of cooling process. SAL 19, SAL 47-48 and SAL 46 are cooling in reductive-oxidative way, SAL 40 belongs to oxidative-reductive process. On the other hand, SAL 37, SAL 170, SAL 123, SAL 42, SAL 109, SAL 472 bj, SAL 138, SAL 126, SAL 162, SAL 509 bj and SAL 406 bj are maintain reductive process cooling system. Oxidative cooling process perform on SAL 77, SAL 294bj, SAL 561bj and SAL 634bj. The rest four have not identified.

The texture of the 23 fragments belongs to three groups. SAL 37, SAL 47-48, SAL 19, SAL 30 bj , SAL 42, SAL 77, SAL 294 bj, SAL 561bj, SAL 472 bj, SAL 04bj, SAL 198bj and SAL 406bj are compact, SAL 40, SAL 170, SAL 123, SAL 109 , SAL 138 , SAL 126 , SAL 162 , SAL 46, SAL 11bj and 509 bj are semi compact and 634 bj is friable.

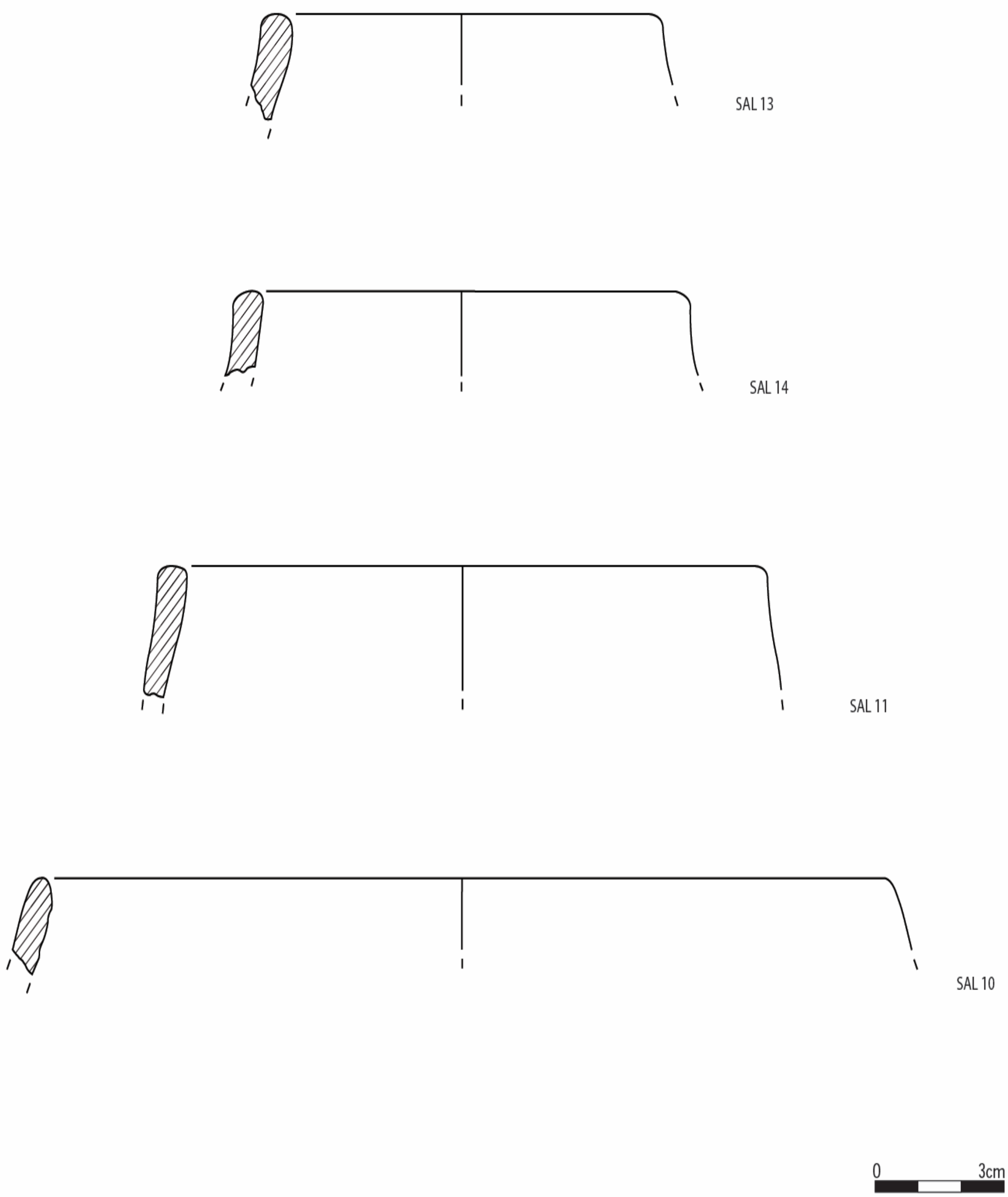


Figure 24: Drawing of Ceramics (Neves, 2017: 30)

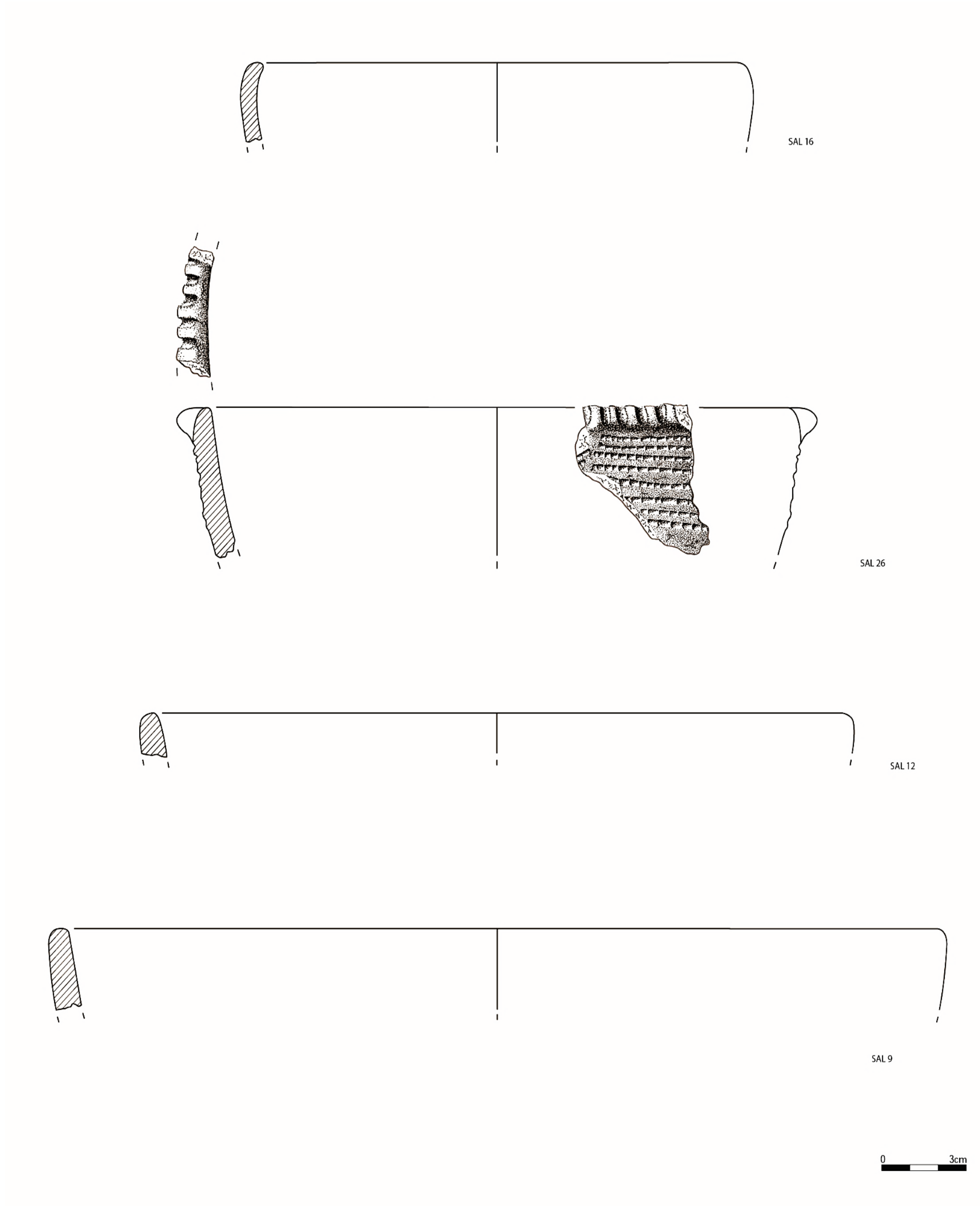


Figure 25: Drawing of Ceramics ((Neves, 2017: 31)

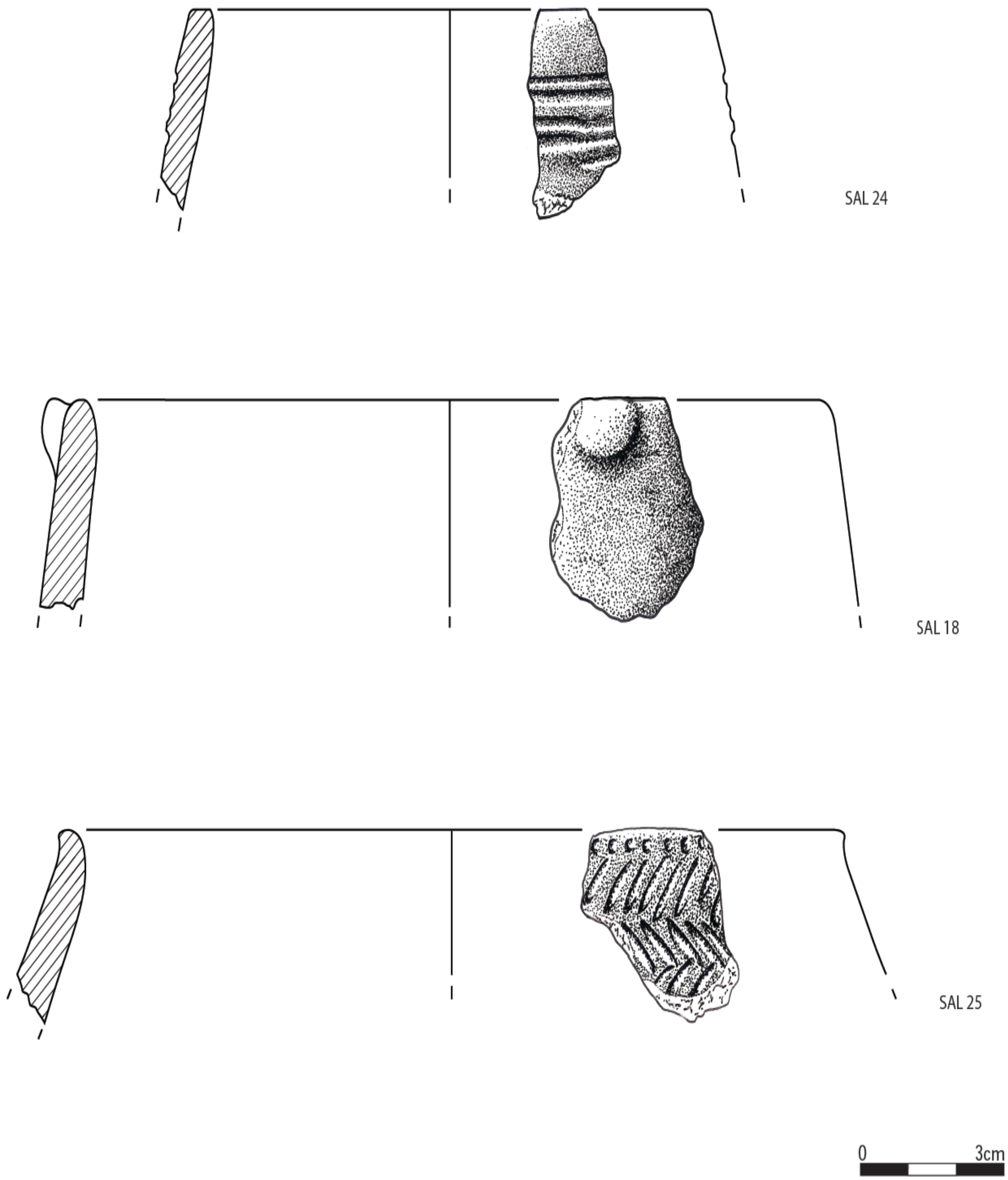


Figure 26: Drawing of Ceramics (Neves, 2017: 32)

4.3.2. Result of Scientific analysis:

As mentioned before, these samples from Salvador were interpreted by archaeologists as Neolithic decorated pottery assemblage. According to Neves 2017, these ceramics as well as the site belong to Early Neolithic site from western Iberian Peninsula. After the scientific analysis of selected twenty-three samples an output of result has been appeared. Below are descriptions of the result for every specific sample. (Table 03 and 04)

WEB LENGHT	MINERALS	SAMPLE NUMBER				
		SAL 17-19	SAL 17-47+48	SAL 17-40	SAL 17-37	SAL 17-30bj
3626	Montmorillonite	OK	OK	OK	OK	OK
3300	Water	OK	OK	OK	OK	NO
2980		NO	OK	NO	NO	NO
2925		OK	NO	NO	NO	NO
2834		NO	NO	NO	NO	OK
2802		OK	NO	OK	OK	OK
2784		OK	NO	NO	OK	OK
2729		NO	NO	NO	NO	NO
2655		OK	NO	NO	NO	OK
1634	Water	OK	OK	OK	OK	OK
1162	Silicates	OK	OK	OK	OK	OK
1132	Silicates	NO	NO	NO	OK	NO
1088	Silicates	NO	NO	NO	NO	NO
1018	Silicates	NO	NO	NO	NO	OK
978		OK	OK	OK	OK	NO
950		OK	OK	OK	OK	NO
919		OK	NO	NO	NO	NO
815		OK	OK	OK	OK	OK
798	Quartz	OK	OK	OK	OK	OK
778	Quartz	OK	OK	OK	OK	OK
743		OK	OK	OK	OK	OK
721	Feldspar	NO	OK	OK	OK	OK
705		NO	OK	OK	OK	OK
691	Silicates	OK	OK	OK	OK	OK
662		OK	OK	OK	OK	OK
643	Oxydes ?	OK	OK	OK	OK	OK
619		OK	OK	OK	OK	OK
582		OK	NO	OK	OK	OK
551		NO	NO	OK	OK	OK
530		OK	NO	OK	OK	NO
516	Silicates	NO	NO	NO	NO	OK
496		OK	OK	OK	OK	NO
457	Silicates	OK	NO	NO	NO	NO
442	Silicates	NO	NO	NO	NO	NO

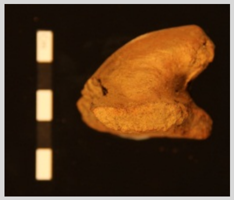
WEB LENGHT	MINERALS	SAMPLE NUMBER				
		SAL 18-170	**SAL 18-123**	**SAL 17-42**	**SAL 18-77**	**SAL 18-294bj**
3626	Montmorillonite	OK	OK	OK	OK	OK
3300	Water	OK	OK	OK	OK	OK
2980		NO	NO	NO	OK	OK
2925		OK	NO	NO	OK	NO
2834		OK	NO	NO	OK	OK
2802		OK	OK	OK	OK	OK
2784		OK	OK	OK	OK	OK
2729		NO	NO	NO	NO	NO
2655		NO	NO	NO	NO	NO
1634	Water	OK	OK	OK	OK	OK
1162	Silicates	OK	OK	OK	OK	OK
1132	Silicates	NO	OK	NO	NO	NO
1088	Silicates	NO	NO	NO	NO	NO
1018	Silicates	NO	NO	NO	NO	NO
978		OK	OK	OK	OK	OK
950		OK	OK	OK	OK	OK
919		NO	NO	NO	NO	NO
815		OK	OK	OK	OK	OK
798	Quartz	OK	OK	OK	OK	OK
778	Quartz	OK	OK	OK	OK	OK
743		OK	OK	OK	OK	OK
721	Feldspar	OK	OK	OK	OK	OK
705		OK	OK	OK	OK	OK
691	Silicates	OK	OK	OK	OK	OK
662		OK	OK	OK	OK	OK
643	Oxydes ?	OK	OK	OK	OK	OK
619		OK	OK	OK	OK	OK
582		NO	NO	OK	NO	OK
551		NO	NO	NO	OK	NO
530		OK	OK	OK	OK	OK
516	Silicates	NO	NO	NO	NO	NO
496		OK	OK	OK	OK	OK
457	Silicates	OK	NO	NO	NO	NO
442	Silicates	NO	NO	NO	NO	NO

WEB LENGHT	MINERALS	SAMPLE NUMBER				
		SAL 18-561bj	**SAL 18-109**	**SAL 18-472 bj**	**SAL 18-138**	**SAL 18-126**
3626	Montmorillonite	OK	OK	OK	OK	OK
3300	Water	OK	OK	OK	OK	OK
2980		NO	NO	OK	OK	NO
2925		NO	NO	NO	NO	NO
2834		NO	OK	NO	NO	NO
2802		OK	OK	NO	NO	OK
2784		OK	OK	NO	NO	OK
2729		NO	NO	NO	NO	NO
2655		NO	NO	NO	NO	OK
1634	Water	OK	OK	OK	OK	OK
1162	Silicates	OK	NO	OK	OK	OK
1132	Silicates	NO	OK	NO	NO	NO
1088	Silicates	NO	NO	NO	NO	NO
1018	Silicates	NO	NO	NO	NO	NO
978		OK	OK	OK	OK	OK
950		NO	OK	OK	OK	OK
919		NO	NO	NO	NO	NO
815		OK	OK	OK	OK	OK
798	Quartz	OK	OK	OK	OK	OK
778	Quartz	OK	OK	OK	OK	OK
743		OK	OK	OK	OK	OK
721	Feldspar	OK	OK	OK	OK	OK
705		OK	OK	OK	OK	OK
691	Silicates	OK	OK	OK	OK	OK
662		OK	OK	OK	OK	OK
643	Oxydes ?	OK	OK	OK	OK	OK
619		OK	OK	OK	OK	OK
582		OK	OK	NO	NO	OK
551		OK	OK	NO	NO	OK
530		OK	OK	NO	OK	OK
516	Silicates	NO	NO	NO	NO	NO
496		OK	OK	OK	OK	OK
457	Silicates	NO	NO	NO	NO	NO
442	Silicates	NO	NO	NO	NO	OK

WEB LENGHT	MINERALS	SAMPLE NUMBER				
		SAL 18-162	**SAL 17-46**	**SAL 17-04bj**	**SAL 17-11bj**	**SAL 18-198bj**
3626	Montmorillonite	OK	OK	OK	OK	OK
3300	Water	OK	OK	OK	OK	OK
2980		NO	OK	NO	NO	NO
2925		NO	NO	NO	NO	OK
2834		OK	NO	OK	NO	OK
2802		OK	NO	OK	OK	OK
2784		OK	NO	OK	OK	OK
2729		OK	NO	OK	NO	OK
2655		NO	NO	NO	OK	OK
1634	Water	OK	OK	OK	OK	OK
1162	Silicates	OK	OK	NO	OK	OK
1132	Silicates	NO	NO	OK	NO	NO
1088	Silicates	NO	NO	OK	NO	NO
1018	Silicates	NO	NO	NO	NO	NO
978		OK	OK	OK	OK	OK
950		OK	OK	OK	OK	OK
919		NO	NO	NO	NO	NO
815		OK	OK	OK	OK	OK
798	Quartz	OK	OK	OK	OK	OK
778	Quartz	OK	OK	OK	OK	OK
743		OK	OK	OK	NO	OK
721	Feldspar	OK	OK	OK	NO	OK
705		OK	OK	OK	OK	OK
691	Silicates	OK	OK	OK	OK	OK
662		OK	OK	OK	OK	OK
643	Oxydes ?	OK	OK	OK	OK	OK
619		OK	OK	OK	OK	OK
582		NO	NO	OK	OK	OK
551		NO	NO	NO	OK	NO
530		NO	OK	OK	OK	OK
516	Silicates	OK	NO	NO	NO	NO
496		OK	OK	OK	OK	OK
457	Silicates	OK	NO	OK	OK	NO
442	Silicates	OK	NO	OK	NO	OK

WEB LENGHT	MINERALS	SAMPLE NUMBER		
		SAL 18-634bj	**SAL 18-509**	**SAL 18-406bj**
3626	Montmorillonite	NO	OK	OK
3300	Water	NO	OK	OK
2980		NO	NO	NO
2925		NO	NO	OK
2834		NO	NO	OK
2802		NO	NO	OK
2784		NO	NO	OK
2729		NO	NO	OK
2655		NO	NO	OK
1634	Water	NO	OK	OK
1162	Silicates	NO	OK	OK
1132	Silicates	OK	NO	NO
1088	Silicates	OK	NO	NO
1018	Silicates	NO	NO	NO
978		OK	OK	OK
950		NO	OK	OK
919		NO	NO	NO
815		OK	OK	OK
798	Quartz	NO	OK	OK
778	Quartz	OK	NO	OK
743		OK	OK	OK
721	Feldspar	OK	OK	OK
705		OK	OK	OK
691	Silicates	OK	OK	OK
662		OK	OK	OK
643	Oxydes ?	OK	OK	OK
619		OK	OK	OK
582		OK	NO	NO
551		NO	NO	NO
530		OK	OK	OK
516	Silicates	NO	NO	NO
496		OK	OK	OK
457	Silicates	NO	NO	OK
442	Silicates	NO	NO	NO

Table 03: Web length and minerals in Scientific analysis

Sl.	Inv. No.	Photograph	Year	Stratigraphy/ Layer	Area	ATR Web Length (In the Range of 4000-400 cm^{-1})	Minerals and their chemical formula
1.	SAL 19		2017	102	1	3626, 3300, 2925, 2802, 2784, 2655, 1634, 1162, 978, 950, 919, 815, 798, 778, 743, 691, 662, 643, 619, 582, 530, 496	Smectites, Montmorillonite {$(Na,Ca)_{0.33}$ $(Al,Mg)_2$ $(Si_4O_{10})(OH)_2 \cdot nH2O$}, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8 – NaAlSi_3O_8 – CaAl_2Si_2O_8$), Anorthoclase {(Na,K)AlSi3O8)}Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)
2.	SAL 47-t48		2017	103	3	3626, 3300, 2980, 1634, 1162, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 496	Smectites, Montmorillonite {$(Na,Ca)_{0.33}$ $(Al,Mg)_2$ $(Si_4O_{10})(OH)_2 \cdot nH2O$}, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8 – NaAlSi_3O_8 – CaAl_2Si_2O_8$), Anorthoclase {$(Na,K)AlSi_3O_8)$}, Oxydes (?), Water ($H_2O$) (Marel and Beutelspacher 1976)

3.	SAL 40		2017	202	2	3626, 3300, 2802, 1634, 1162, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 582, 551, 530, 496	Smectites, Montmorillonite {$(Na,Ca)_{0.33}$ $(Al,Mg)_2$ $(Si_4O_{10})(OH)_2 \cdot nH2O$}, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8 – NaAlSi_3O_8 – CaAl_2Si_2O_8$), Anorthoclase {$(Na,K)AlSi_3O_8)$}, Oxydes (?), Water ($H_2O$) (Marel and Beutelspacher 1976)
4.	SAL 37		2017	203	2	3626, 3300, 2802, 2784, 1634, 1162, 1132, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 582, 551, 530, 496	Smectites, Montmorillonite {$(Na,Ca)_{0.33}$ $(Al,Mg)_2$ $(Si_4O_{10})(OH)_2 \cdot nH2O$}, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8 – NaAlSi_3O_8 – CaAl_2Si_2O_8$), Anorthoclase {$(Na,K)AlSi_3O_8)$}, Oxydes (?), Water ($H_2O$) (Marel and Beutelspacher 1976)
5.	SAL 30 bj		2017	204	2	3626, 3300, 2834, 2802, 2784, 2655, 1634, 1162, 1018, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 582, 551, 516	Smectites, Montmorillonite {$(Na,Ca)_{0.33}$ $(Al,Mg)_2$ $(Si_4O_{10})(OH)_2 \cdot nH2O$}, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8 – NaAlSi_3O_8 – CaAl_2Si_2O_8$), Anorthoclase {$(Na,K)AlSi_3O_8)$}, Oxydes (?), Water ($H_2O$) (Marel and Beutelspacher 1976)

6.	SAL 170		2018	301	N47a	3626, 3300, 2925, 2834, 2802, 2784, 1634, 1162, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 582, 530, 496	Smectites, Montmorillonite $\{(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2 \cdot n\text{H2O}\}$, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8 – NaAlSi_3O_8 – CaAl_2Si_2O_8$), Anorthoclase $\{(Na,K)AlSi_3O_8)\}$, Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)
7.	SAL 123		2018	302	L49	3626, 3300, 2802, 2784, 1634, 1162, 1132, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 530, 496	Smectites, Montmorillonite $\{(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2 \cdot n\text{H2O}\}$, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8 – NaAlSi_3O_8 – CaAl_2Si_2O_8$), Anorthoclase $\{(Na,K)AlSi_3O_8)\}$, Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)
8.	SAL 42		2017	303	P49	3626, 3300, 2802, 2784, 1634, 1162, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 582, 530, 496	Smectites, Montmorillonite $\{(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2 \cdot n\text{H2O}\}$, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8 – NaAlSi_3O_8 – CaAl_2Si_2O_8$), Anorthoclase $\{(Na,K)AlSi_3O_8)\}$, Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)

9.	SAL 77		2018	303	L48c	3626, 3300, 2980, 2925, 2834, 2802, 2784, 1634, 1162, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 551, 530, 496	Smectites, Montmorillonite $\{(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2 \cdot nH2O\}$, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8 - NaAlSi_3O_8 - CaAl_2Si_2O_8$), Oxydes (?), Water ($H_2O$) (Marel and Beutelspacher 1976)
10.	SAL 294 bj		2018	303	L48b	3626, 3300, 2980, 2834, 2802, 2784, 1634, 1162, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 582, 530, 496	Smectites, Montmorillonite $\{(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2 \cdot nH2O\}$, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8 - NaAlSi_3O_8 - CaAl_2Si_2O_8$), Anorthoclase $\{(Na,K)AlSi_3O_8)\}$, Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)
11.	SAL 561 bj		2018	303	N47c	3626, 3300, 2802, 2784, 1634, 1162, 978, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 582, 551, 530, 496	Smectites, Montmorillonite $\{(Na,Ca)_{0.33}(Al,Mg)_2(Si_4O_{10})(OH)_2 \cdot nH2O\}$, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8 - NaAlSi_3O_8 - CaAl_2Si_2O_8$), Oxydes (?), Water ($H_2O$) (Marel and Beutelspacher 1976)

12.	SAL 109		2018	304	P47c	3626, 3300, 2834, 2802, 2784, 1634, 1132, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 582, 551, 530, 496	Smectites, Montmorillonite $\{(Na,Ca)_{0.33}\ (Al,Mg)_2\ (Si_4O_{10})(OH)_2 \cdot nH2O\}$, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$), Anorthoclase $\{(Na,K)AlSi_3O_8)\}$, Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)
13.	SAL 472 bj		2018	304	L49c	3626, 3300, 2980, 1634, 1162, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 496	Smectites, Montmorillonite $\{(Na,Ca)_{0.33}\ (Al,Mg)_2\ (Si_4O_{10})(OH)_2 \cdot nH2O\}$, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$), Anorthoclase $\{(Na,K)AlSi_3O_8)\}$, Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)
14.	SAL 138		2018	308	M49d	3626, 3300, 2980, 1634, 1162, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 530, 496	Smectites, Montmorillonite $\{(Na,Ca)_{0.33}\ (Al,Mg)_2\ (Si_4O_{10})(OH)_2 \cdot nH2O\}$, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$), Anorthoclase $\{(Na,K)AlSi_3O_8)\}$, Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)

15.	SAL 126		2018	314	L51b	3626, 3300, 2802, 2784, 2655, 1634, 1162, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 582, 551, 530, 496	Smectites, Montmorillonite $\{(Na,Ca)_{0.33}\ (Al,Mg)_2\ (Si_4O_{10})(OH)_2 \cdot n\mathrm{H2O}\}$, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$), Anorthoclase $\{(Na,K)AlSi_3O_8)\}$, Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)
16.	SAL 162		2018	315	L/R50	3626, 3300, 2834, 2802, 2784, 2729, 1634, 1162, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 516, 496	Smectites, Montmorillonite $\{(Na,Ca)_{0.33}\ (Al,Mg)_2\ (Si_4O_{10})(OH)_2 \cdot n\mathrm{H2O}\}$, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$), Anorthoclase $\{(Na,K)AlSi_3O_8)\}$, Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)
17.	SAL 46		2017	102/105	1	3626, 3300, 2980, 1634, 1162, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 530, 496	Smectites, Montmorillonite $\{(Na,Ca)_{0.33}\ (Al,Mg)_2\ (Si_4O_{10})(OH)_2 \cdot n\mathrm{H2O}\}$, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$), Anorthoclase $\{(Na,K)AlSi_3O_8)\}$, Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)

18.	SAL 04 bj		2017	104	1	3626, 3300, 2834, 2802, 2784, 2729, 1634, 1132, 1088, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 582, 530, 496	Smectites, Montmorillonite {$(Na,Ca)_{0.33}$ $(Al,Mg)_2$ $(Si_4O_{10})(OH)_2 \cdot n\mathrm{H2O}$}, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$), Anorthoclase {$(Na,K)AlSi_3O_8$)}, Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)
19.	SAL 11 bj		2017	201	2	3626, 3300, 2802, 2784, 2655, 1634, 1162, 978, 950, 815, 798, 778, 705, 691, 662, 643, 619, 582, 551, 530, 496	Smectites, Montmorillonite {$(Na,Ca)_{0.33}$ $(Al,Mg)_2$ $(Si_4O_{10})(OH)_2 \cdot n\mathrm{H2O}$}, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$), Anorthoclase {$(Na,K)AlSi_3O_8$)}, Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)
20.	SAL 198 bj		2017	305	O51	3626, 3300, 2925, 2834, 2802, 2784, 2729, 2655, 1634, 1162, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 582, 530, 496	Smectites, Montmorillonite {$(Na,Ca)_{0.33}$ $(Al,Mg)_2$ $(Si_4O_{10})(OH)_2 \cdot n\mathrm{H2O}$}, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$), Anorthoclase {$(Na,K)AlSi_3O_8$)}, Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)

21.	SAL 634 bj		2018	307	N49a	1132, 1088, 978, 815, 743, 721, 705, 691, 662, 643, 619, 582, 530, 496	Silicates, Quartz (SiO_2), Feldspar ($KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$), Anorthoclase {$(Na,K)AlSi_3O_8$)}, Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)
22.	SAL 509 bj		2018	311	Q47	3626, 3300, 1634, 1162, 978, 950, 815, 798, 743, 721, 705, 691, 662, 643, 619, 530, 496	Smectites, Montmorillonite {$(Na,Ca)_{0.33}$ $(Al,Mg)_2$ $(Si_4O_{10})(OH)_2 \cdot nH2O$}, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$), Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)
23.	SAL 406 bj		2018	316	L50a	3626, 3300, 2925, 2834, 2802, 2784, 2729, 2655, 1634, 1162, 978, 950, 815, 798, 778, 743, 721, 705, 691, 662, 643, 619, 530, 496	Smectites, Montmorillonite {$(Na,Ca)_{0.33}$ $(Al,Mg)_2$ $(Si_4O_{10})(OH)_2 \cdot nH2O$}, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$), Anorthoclase {$(Na,K)AlSi_3O_8$)}, Oxydes (?), Water (H_2O) (Marel and Beutelspacher 1976)

Table 04: Result of the FTIR-ATR analysis

CHAPTER: 5

DISCUSSION AND CONCLUSION

This master thesis has provided thorough typological and technological insights into the production (raw material) of Early Neolithic Ceramics from Salvador, touching on a number of issues within western part of Iberian Peninsula, including other archaeological studies from middle Tagus valley. The chosen analytical method Infrared Spectroscopy (FTIR-ATR mode) resulted in enhanced understanding and the development of new interpretations concerning the early Neolithic ceramics of Salvador. The focus of the thesis has been to build a wide-ranging dataset of mineralogical compositions revealing the nature of clays for this specific and rare type of pottery in order to understand how these artefacts were produced, treated, used and discarded. As from this kind of typological study and archaeometric characterization study together for this type of ceramics, the dataset also provides a basis for comparison to other ceramic assemblages. This helps to place the ceramic found in within the wider context of a network of cultural traditions that spanned the early Neolithic human lifestyle in time of 6000 BC to 5000 cal BC. This study produce the dataset Greater understanding of the ceramics also leads toward a better understanding of Salavador, as a mobile settlement; its culture, perhaps even a local industry.

Discussion: The research questions set out at the beginning of this thesis are addressed in the following:

How to relate typological analysis with the scientific analysis ?

The typological study of these selected ceramics gives a general idea about the ceramic assemblage. All the information like morphological character, decoration, size, shape, orientation, firing/cooling process, textures are identified. According to the result of typological study the main morphological characters of the ceramics fragments are rim (Three samples), body part (Nineteen Samples) and grip and suspension element (One Sample, SAL 19). There are twelve fragments which are decorated, ten sample non-decorated and one grip and suspension element (SAL 19) is also without decoration. Among the twelve decorated fragments five are decorated by using impression technic, five are using incision technic of decoration and the rest of two are decorated with combed technic. Three samples have been possible to understand the shape and size. SAL 170 and SAL 47-48 are oval shape and SAL 77 is spherical in shape. From the result it seems, SAL 170 is small is size, SAL 77 and SAL 47-48 are belonging to medium size group. About the orientation of the three rim, SAL 47-48 and SAL 77 are close shape in orientation, on the other hand, SAL 170 is open shape in orientation. The result of the Firing/Cooling process indicates that, eleven fragments are maintaining in reductive process firing/cooling system. Four are maintain in oxidative firing/cooling process, three sample belongs to reductive-oxidative process, one followed oxidative-reductive way and the rest of four is not identified yet. The texture of the fragments belongs to three groups. Twelve fragments are compact, ten of them are semi compact and one is friable in texture. After the data of typological study, identification of mineral components can produce some new concept. As the FTIR-ATR is non quantitative analysis, the mineral identified in the analysis can led to do some reproduction in experimental way. To reproduce the Neolithic ceramics, the experimental archaeologists can make different kind of fireplaces (Open and Close) to have the same texture of ceramics from Neolithic. As FTIR-ATR analysis don't give the output of percentage of mineral in ceramics, to reproduce the Neolithic ceramics, experimental archaeologist can mix the mineral in different composition to have the same texture of the ceramics as Neolithic. Same process can also follow to understand the firing/cooling process. With the typological study and scientific analysis result, it can mention that, the body part and rim have the same kind of mineral. As example, SAL 77 and SAL 509 bj belongs from two different morphological group, SAL 77 is rim and SAL 509 bj is body part. But according to the scientific result, both have the same mineral components (Smectites, Montmorillonite, Silicates, Quartz, Feldspar). From this information a general interpretation can derive, the body part and rim are made from same raw material. From typological study and scientific analysis one more thing is also interpreted that, during the making process of ceramics, the potters might not make any joint of body part and rim. If they make any joint, still from the excavation of Salvador, we have not found any fragments that seems to have joint, on the other hand we don't find any difference in the mineral composition in rim and body part in scientific analysis also.

What are the mineral components of the Salvador ceramics assemblage and from where the raw materials come from?

This question was addressed by combining previous archaeological research and undertaking new scientific research on early Neolithic ceramics of Salvador. This revealed information on technical choices regarding raw material procurement, forming processes and firing conditions. Neves (2017) mention in the preliminary report that, the raw material could have been quartz, feldspar and mica (microscopic analysis). But according to the result, quartz, feldspar is present, but mica is absent. Result of scientific analysis also support the map of minerals found in present day. According to the Figure 26, the map show that, there is no place for collecting mica from nearest place, on the other hand there are few places from where smectite can collect easily (Figure 27 and 28). So, according to these results, it could mention that, for lacking scientific analysis Neves assume that, mica is present on the ceramic fragments as raw material, but after the precise scientific analysis, it seems that, it was not mica, it was smectite. Scientific analysis has this kind of advantage to remove confusion which is possible in microscopic analysis.

In the place of mica, the result shows montmorillonite (Smectites Group). So, answering the research question, the minerals are: Smectites, Montmorillonite {$(Na,Ca)_{0.33}$ $(Al,Mg)_2$ $(Si_4O_{10})(OH)_2 \cdot nH_2O$}, Silicates, Quartz ($SiO_2$) , Feldspar ($KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$), Anorthoclase {$(Na,K)AlSi_3O_8$)}, Oxydes (?), Water (H_2O).

Figure 27: Map of Mica found in Spain and Portugal (https://www.mindat.org/min-3337.html)

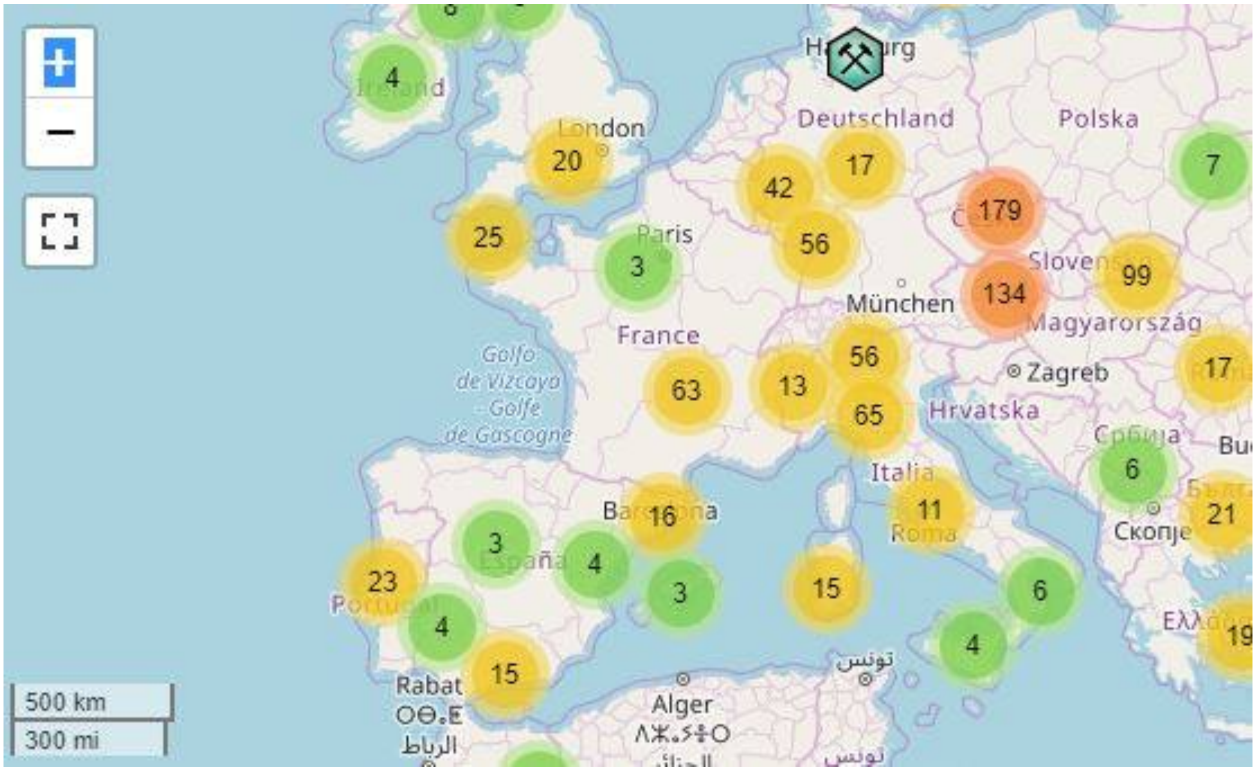


Figure 28: Map of Smectite found in Spain and Portugal (https://www.mindat.org/min-3337.html)

Figure 29: Map of Smectite found in Spain and Portugal (https://www.mindat.org/min-3337.html)

Another interesting perspective about the result is, among 23 fragments, twenty-two of them have almost the same components except SAL 634bj. The result shows that, for this specific fragment contains Silicates, Quartz (SiO_2), Feldspar ($KAlSi_3O_8$ – $NaAlSi_3O_8$ – $CaAl_2Si_2O_8$), Anorthoclase {$(Na,K)AlSi_3O_8$)}, Oxydes (?), Water (H_2O). In this case the Smectites is missing. This might be not ceramics, but it looks like ceramics fragment.

Below is the general description of identified minerals:

Montmorillinite is the main constituent of Bentonite, derived by weathering of volcanic ash. Montmorillinite can expand by several times its original volume when it comes in contact with water. This makes it useful as a drilling mud (to keep drill holes open), and to plug leaks in soil, rocks, and dams.

Approximately 25 percent of all known minerals and 40 percent of the most common ones are silicates; the igneous rocks that make up more than 90 percent of Earth's crust are composed of virtually all silicates. (https://www.britannica.com/science/)

Quartz is a mineral composed of silicon and oxygen atoms in a continuous framework of SiO_4 silicon–oxygen tetrahedral bond, with each oxygen being shared between two tetrahedra, giving an overall chemical formula of SiO_2. Quartz is the second most abundant mineral in Earth's continental crust, behind feldspar. (https://www.britannica.com/science/)

All the rock-forming feldspars are aluminosilicate minerals with the general formula AT4O8 in which A = potassium, sodium, or calcium (Ca); and T = silicon (Si) and aluminum (Al), with a Si:Al ratio ranging from 3:1 to 1:1. (https://www.britannica.com/science/)

The mineral anorthoclase ((Na,K)AlSi3O8) is a crystalline solid solution in the alkali feldspar series, in which the sodium-aluminium silicate member exists in larger proportion. It typically consists of between 10 and 36 percent of KAlSi3O8 and between 64 and 90 percent of NaAlSi3O8. (https://www.britannica.com/science/)

What new interpretations can be derived from the scientific evidence regarding technical analysis?

The scientific evidence provided certain insights to the process used by the potters of these wares regarding manufacture which to some extent question the current archaeological interpretation. Using this data there might be possibilities to start regional study of the middle Tagus valley. Using the results of this thesis, it is also possible to make further study on identifying the place where the raw material comes from, which part of middle Tagus the raw material comes from. It is also possible to understand that the ceramics are produce in Salvador or the ceramics were carrying from other places. To understand this, some more sample from the site or nearest place should conduct scientific analysis, so this after compare with this data there might be some understanding from which side of the site the minerals come from. Besides, if the ceramics produce in the site, it can be also better understanding that for collecting raw material how many days or times it takes. Ceramics production provenance has been of interest to archaeologists studying migration pathways, social interaction, and organization have all focused-on pottery production provenance. But, in this case we cannot pinpoint the exact location from where raw material collection place originated because, as previously noted, there are not enough comparable datasets as Neves comment in his report, Analysis of the provenance of the raw material used in the production of the containers (clays and non-plastic elements), will have to be supported by archaeometric studies which, at this stage, have not yet been tested for the whole of Salvador. Likewise, no archaeological prospecting work has yet been carried out with a view to identification of possible clay exploration/captation areas (clay pits), from where they can be found the components for the containers of the Neolithic occupation of the Salvador (Neves, 2017). Nevertheless, it cannot unwise to propose that in the studied samples it can distinguish at least few compositional groups (Smectites, Silicates, Feldspar, Quartz) that probably used different raw materials for manufacture, therefore different production technology was applied. According to Rosina (Rosina et al 2005), Geo-morphological diversity of middle Tagus Valley is well represented: on the west, the plain formed by the Cenozoic sedimentary complexes, on the east arise the modest schist relieves of the Pre-Cambrian and Paleozoic shelf, while at the center a small outcrop of highly altered granite. Below is table of weathering of rock and their residual minerals.

Rock/Main Source	Primary Minerals	Residual Minerals
Granite	Feldspars	Clay Minerals
	Quartz	Quartz
Clay	Smectite	Montmorillinite

Table 05: Weathering of Rocks

So, from Rosina and the table it could mention that, the minerals present inside the ceramics fragments comes from the residual elements of Granite and clay.

Conclusion: Twenty-three ceramics fragments have been thoroughly studied of typology and after scientific analysis. The result of the typology goes to early Neolithic time period (Epicardial and Impression). Besides, previous researcher mentions about one of the raw material Mica, but this study found smectite in the place of mica in Salvador ceramics. To identify the raw material place of smectite (Montmorillinite) one article can be quoted, Research has been carried out in Alto Ribatejo (central Portugal, western Iberia) with the purpose of contextualizing Late Pleistocene and Early Holocene archaeological remains within the coeval landscape. Several regional Quaternary deposits were analyzed in terms of their sand fraction mineralogy (microscopic observation) and clay mineralogy (X-ray diffraction of orientated aggregates) The sedimentary record ascribed is represented by colluviums and aeolian sands with predominance of illite. Illite is progressively replaced by vermiculite and some kaolinite or smectite in the upper stratigraphic levels of the Holocene deposits. The obtained data indicates cold and dry conditions during the Last Glacial/Tardi-glacial and a temperate climate in the Holocene (Gomes et al 2012). From this data it could be add that, the ceramics of the Salvador might produce locally, and the raw materials are collected from nearest place from the site which belongs to clay mineral associations of Quaternary sediments at alto ribatejo. The raw materials of Early Neolithic assemblage might be collected from exclusively immediate local material near the site of Salvador.

Priorities for future research: In order to explore further cultural and social significance of the ceramics industry in Salvador, and the rest of Early Neolithic sites in the Iberian Peninsula, additional work is needed regarding the provenance of the vessels. Much larger sample sets must be subjected to IR analysis, on all types of ceramic wares from several sites like Casal da Cerca, Gaio (Moita), Gaio (Moita), Gruta do Cadaval, Colos. Pinning down provenance as closely as possible will bring new avenues to the study of ceramics in the region. Density, distribution and exchange all come into play at this point and may reveal differences between sites regarding their material culture in ways typological analysis cannot. Large data sets can then be cross-checked against technical variations to look for any coordinated patterns of development over time.

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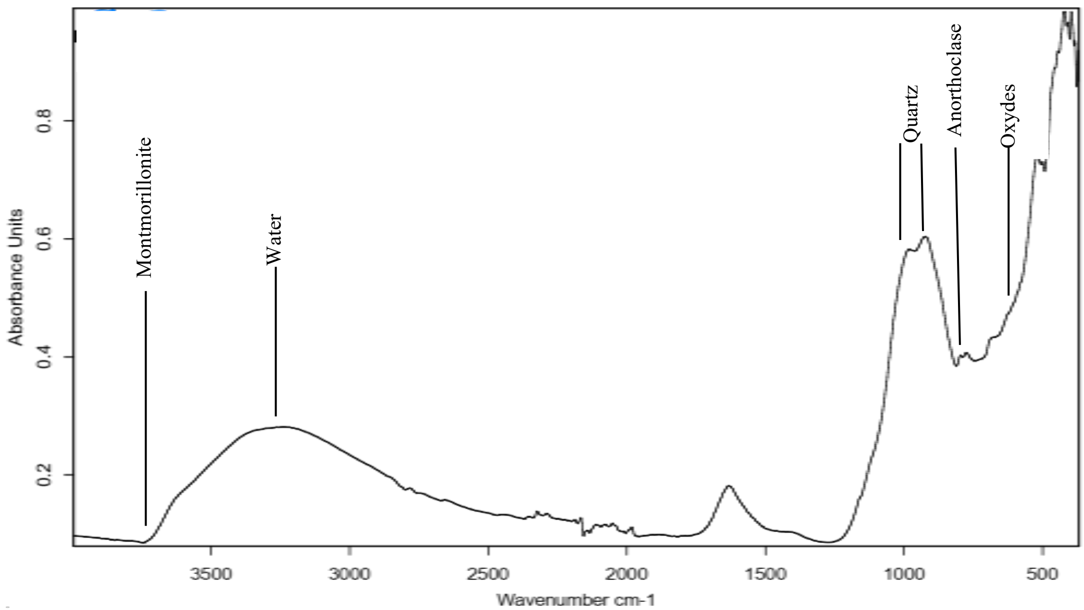
APPENDIX



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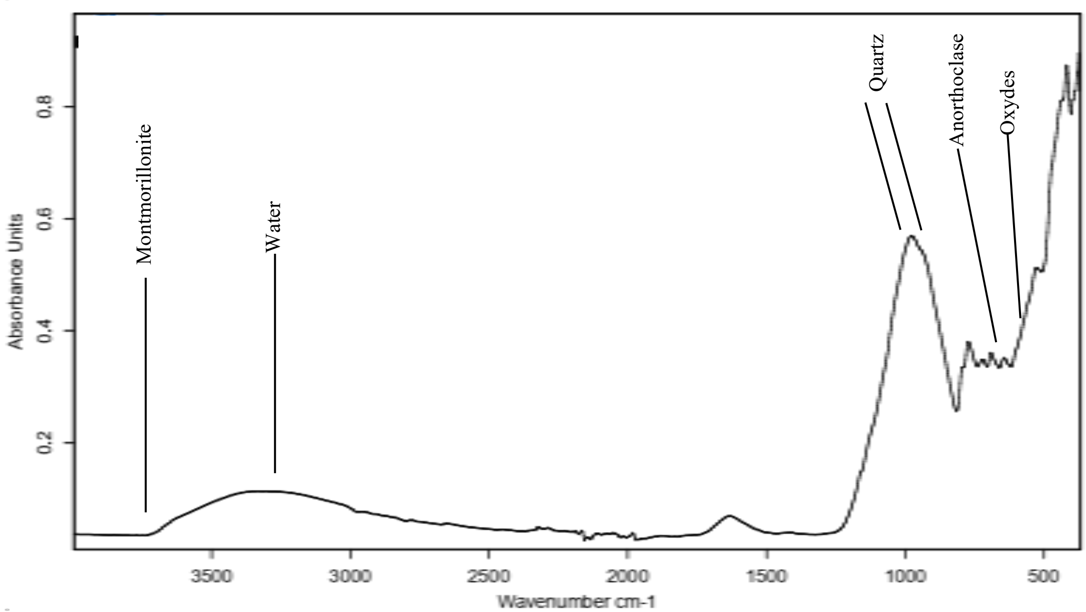

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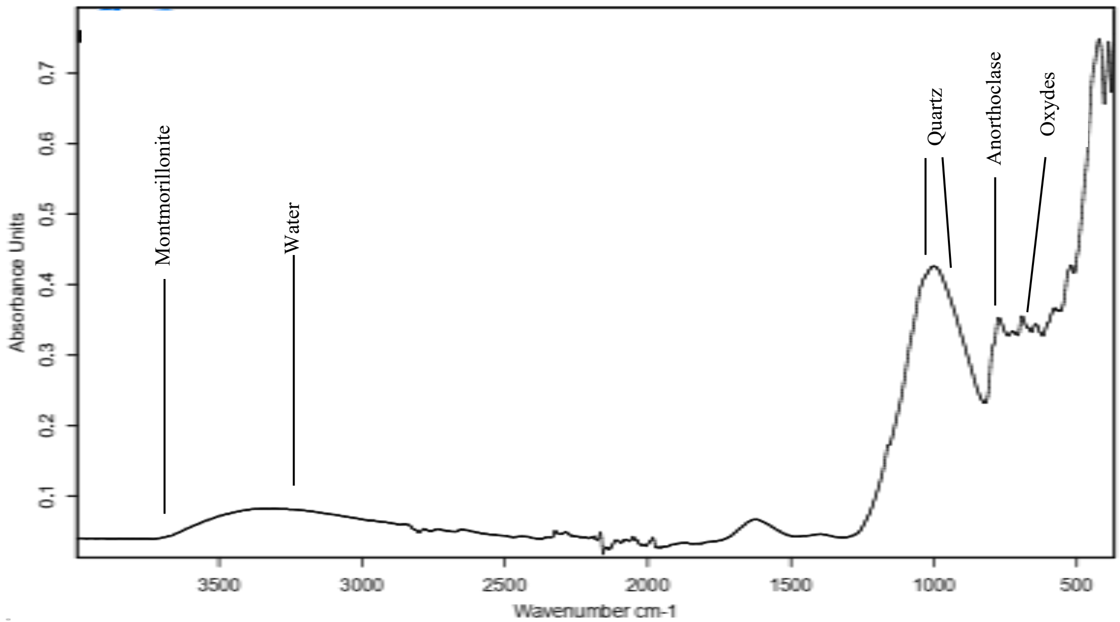

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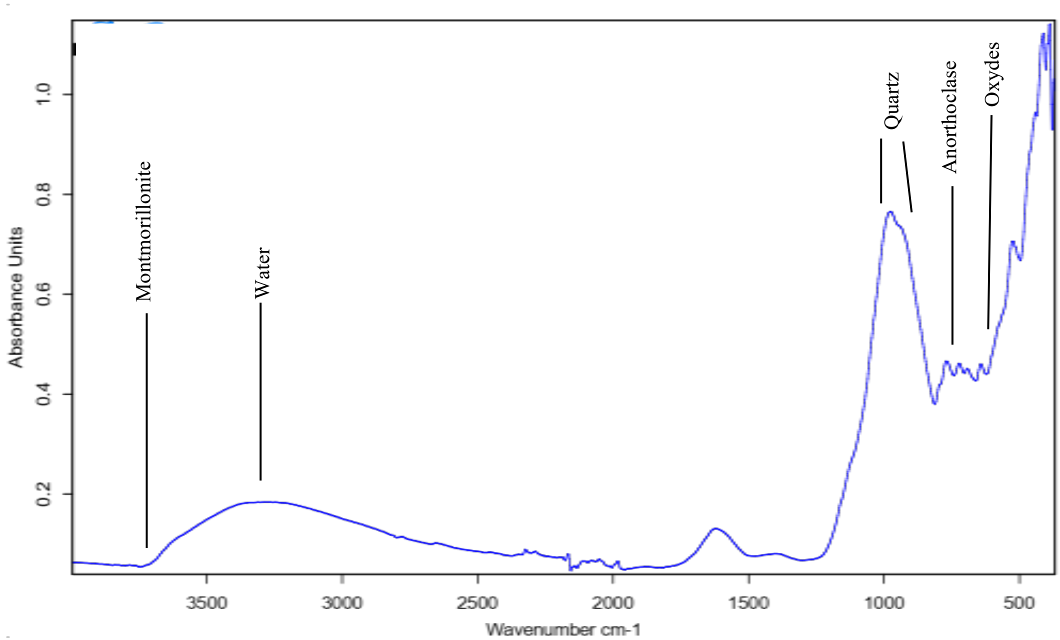

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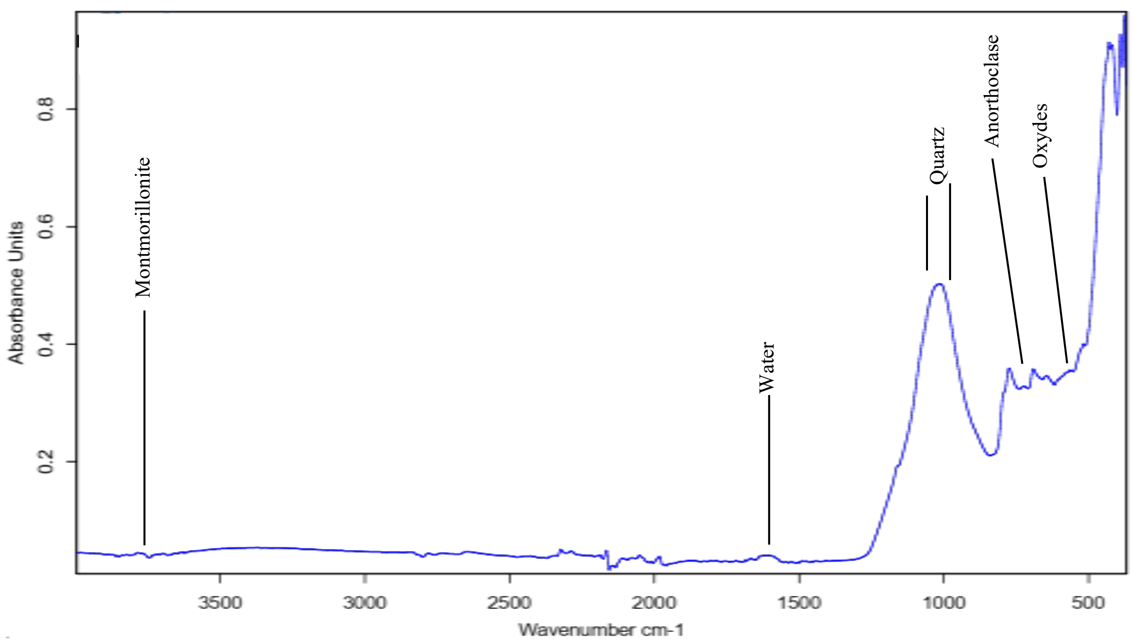

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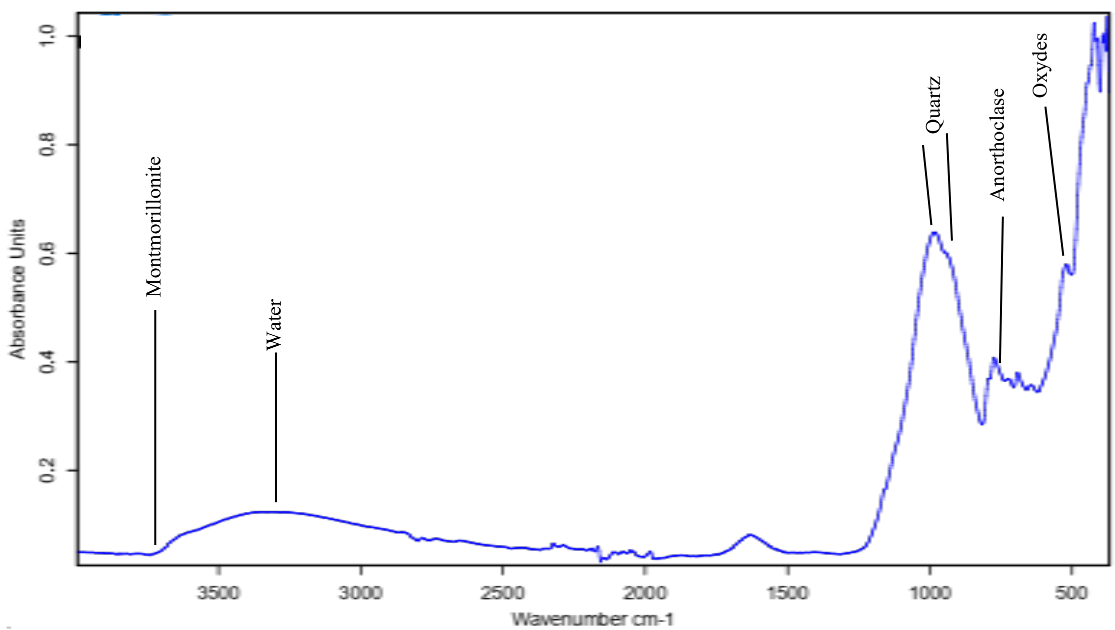

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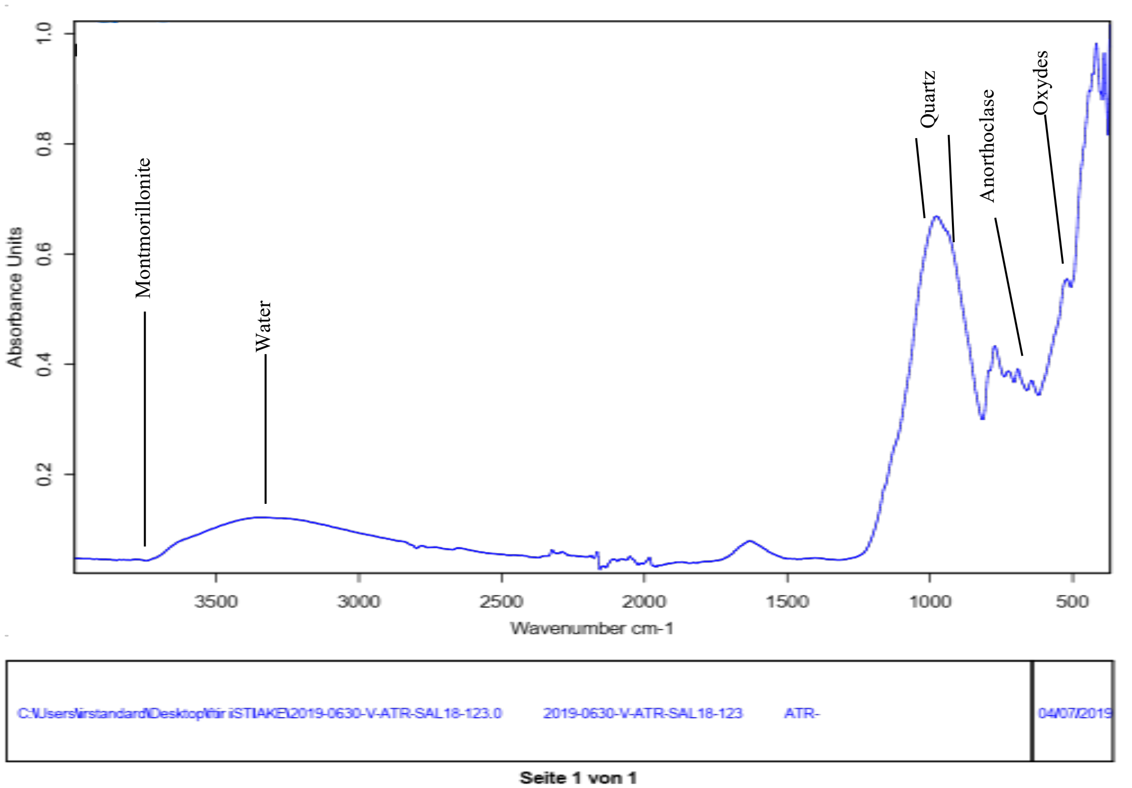
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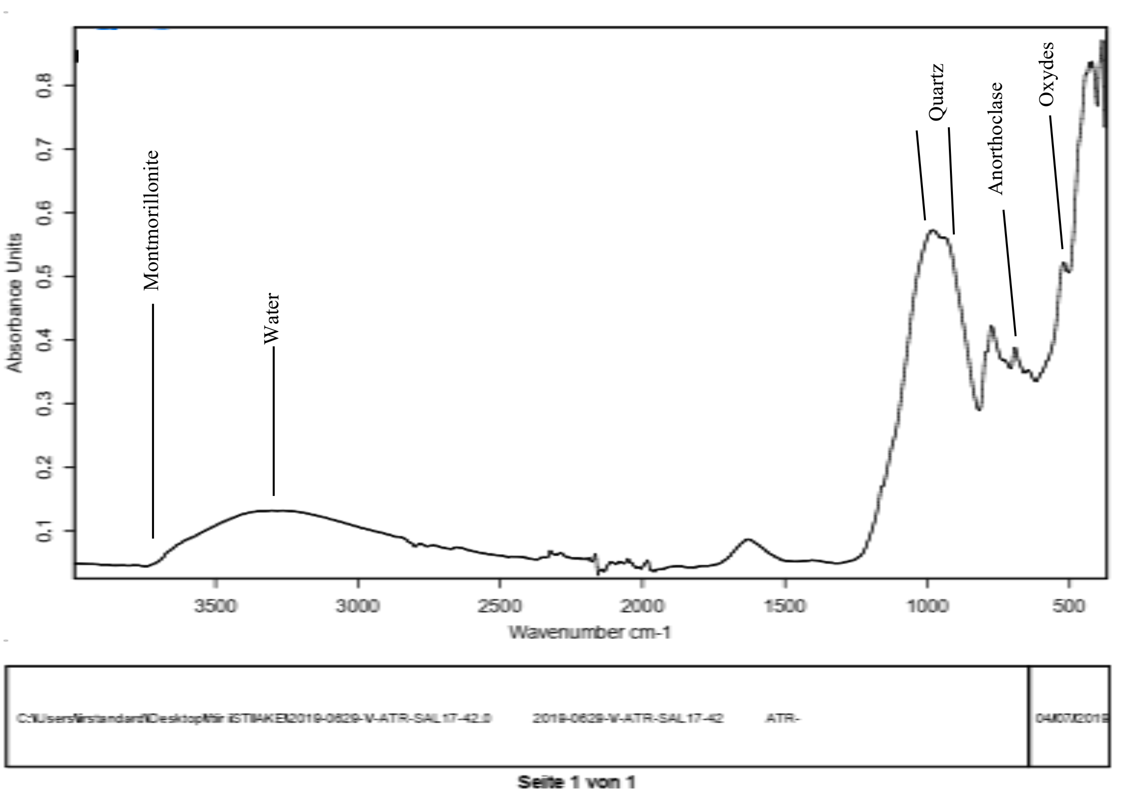
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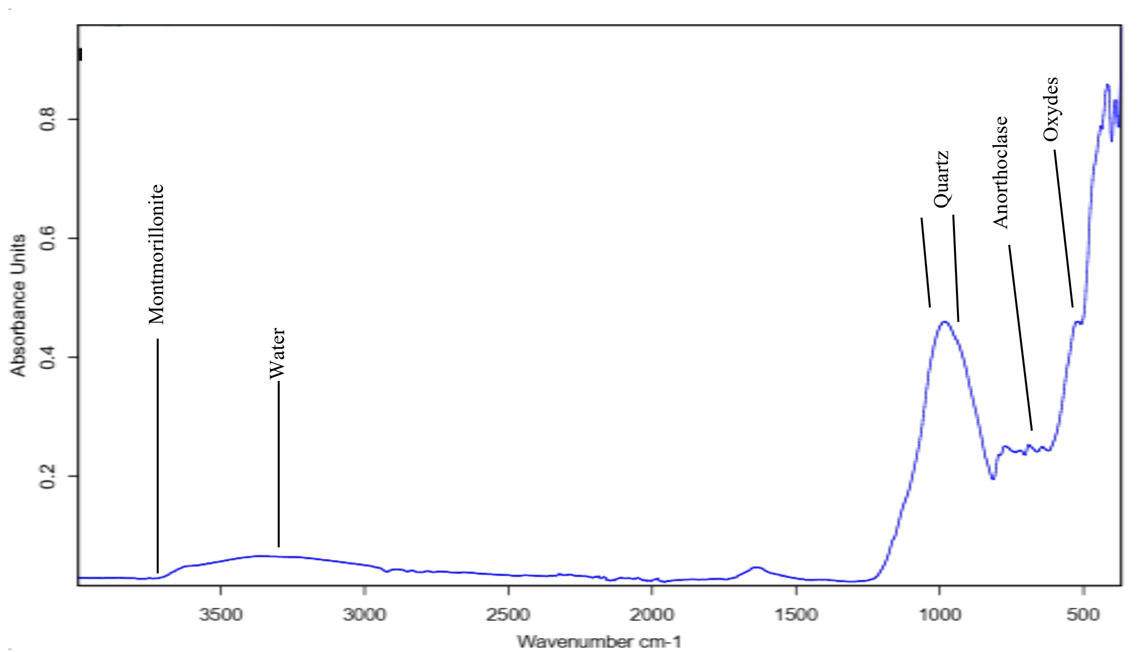

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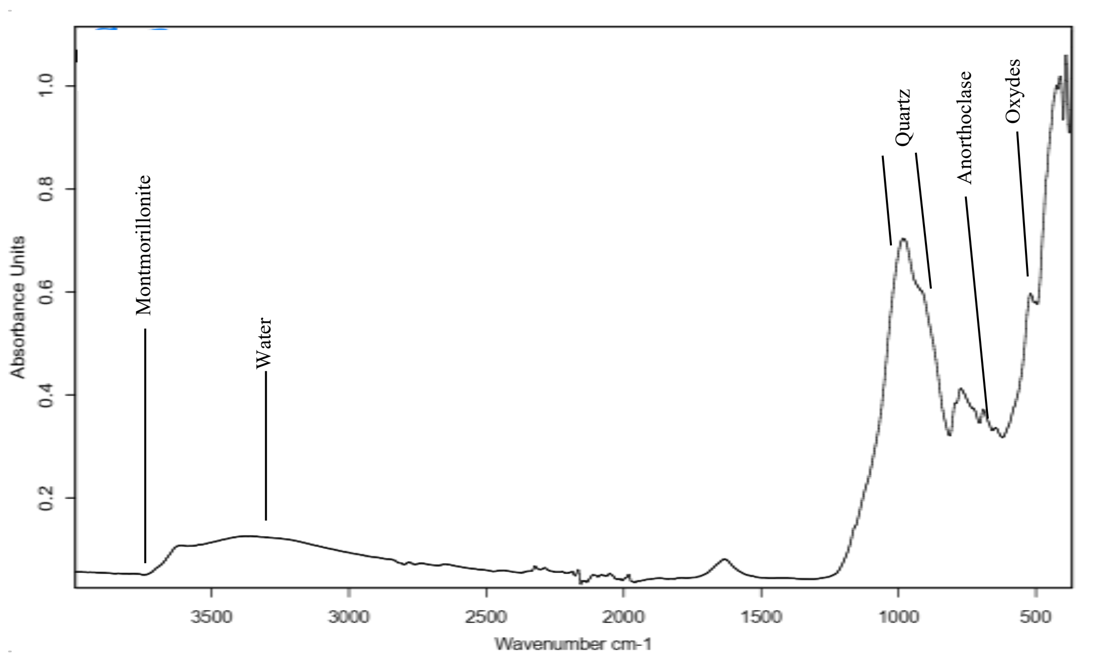

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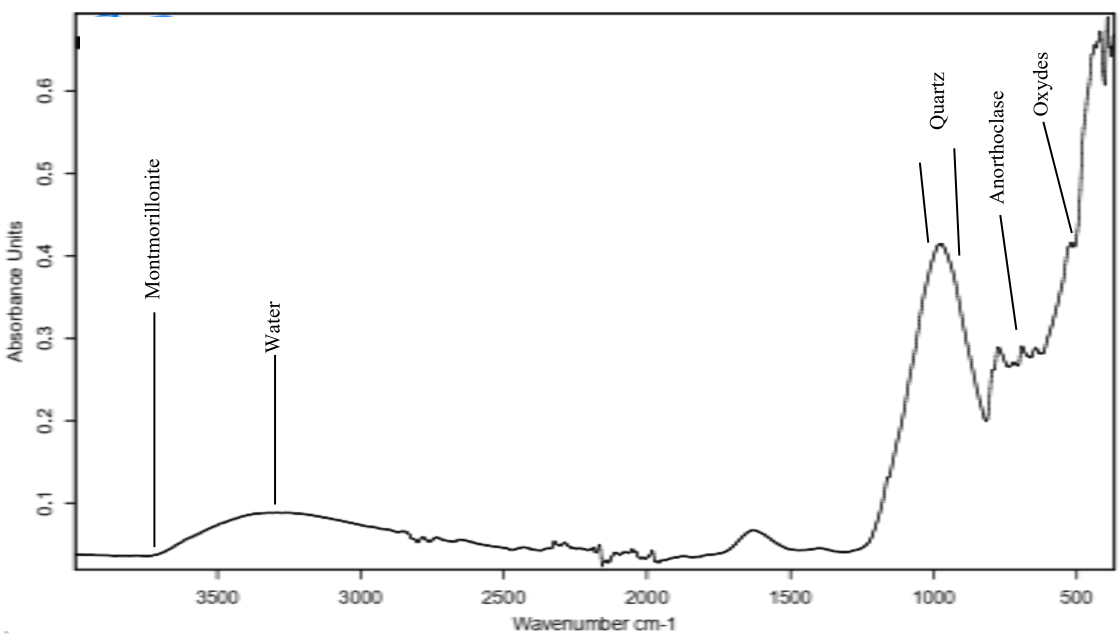

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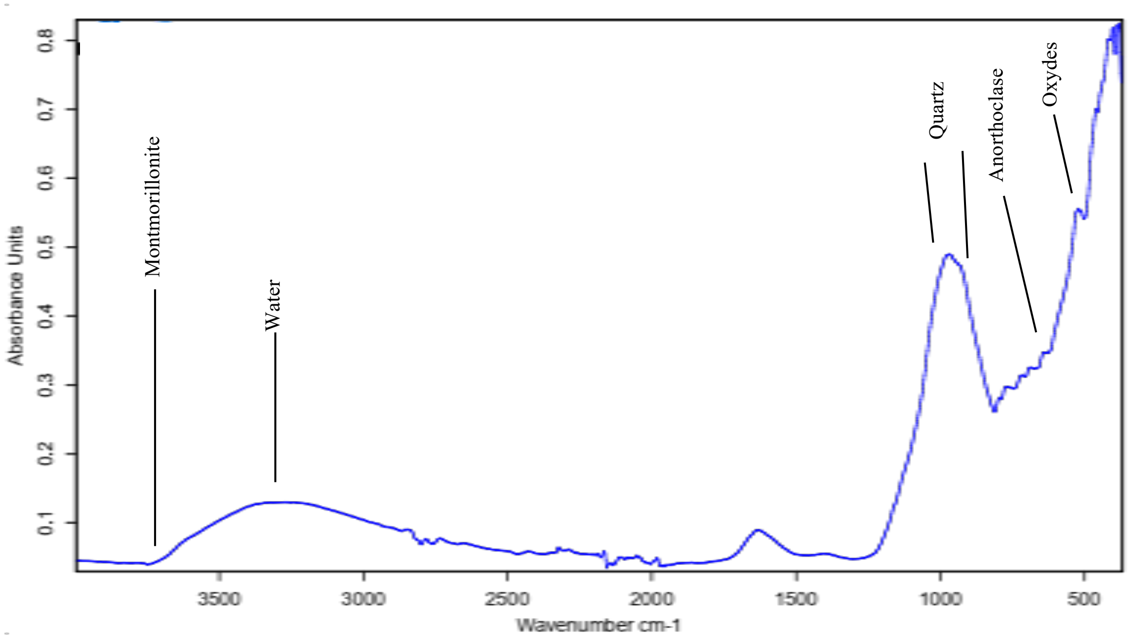

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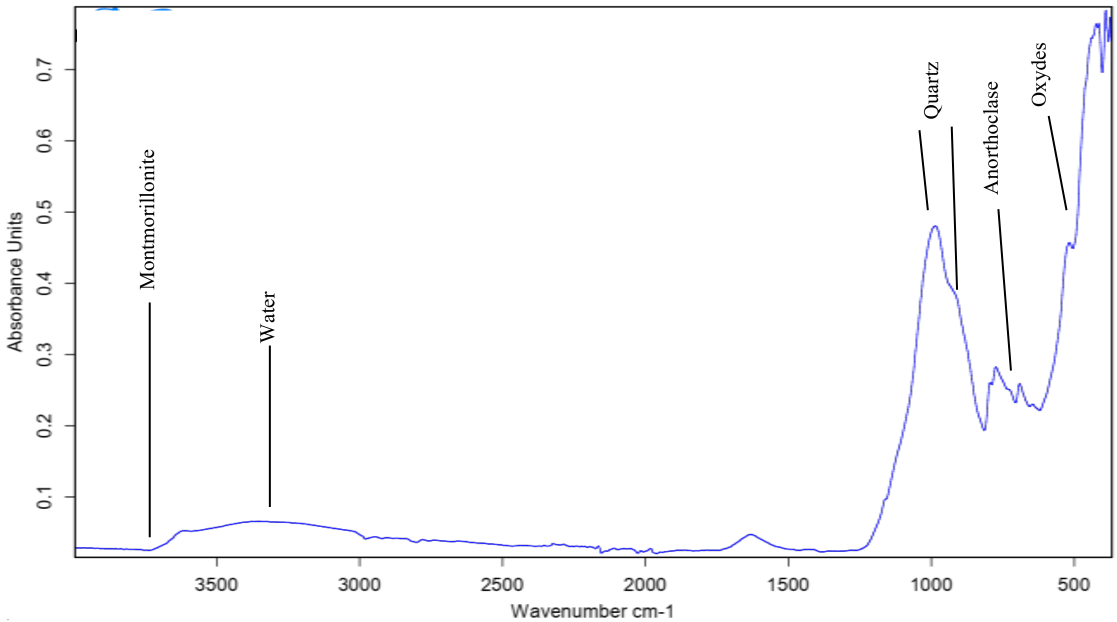

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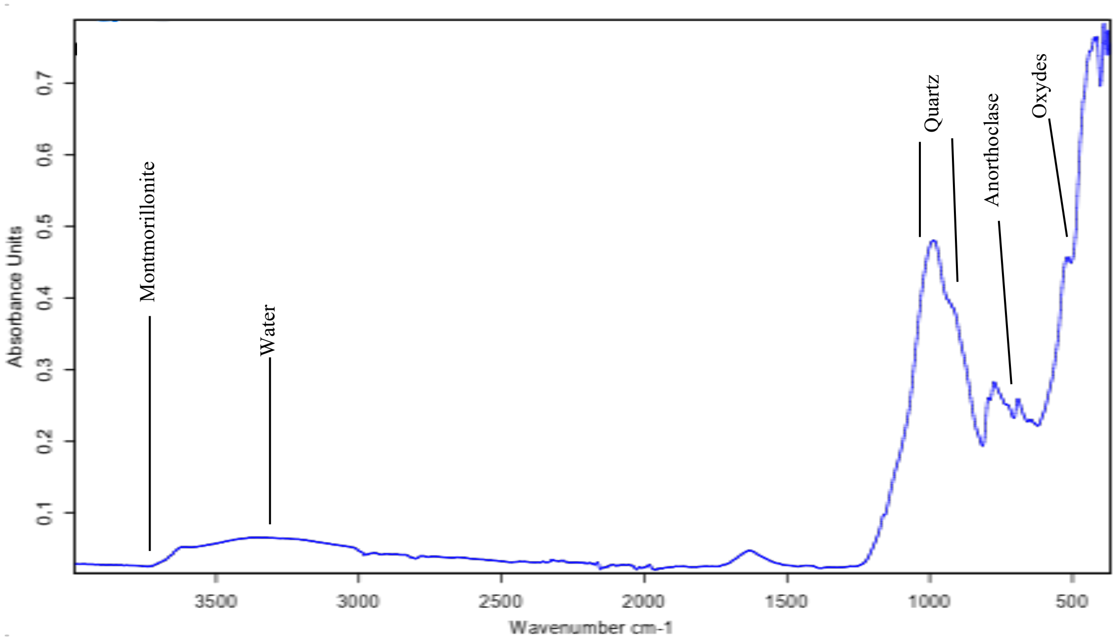

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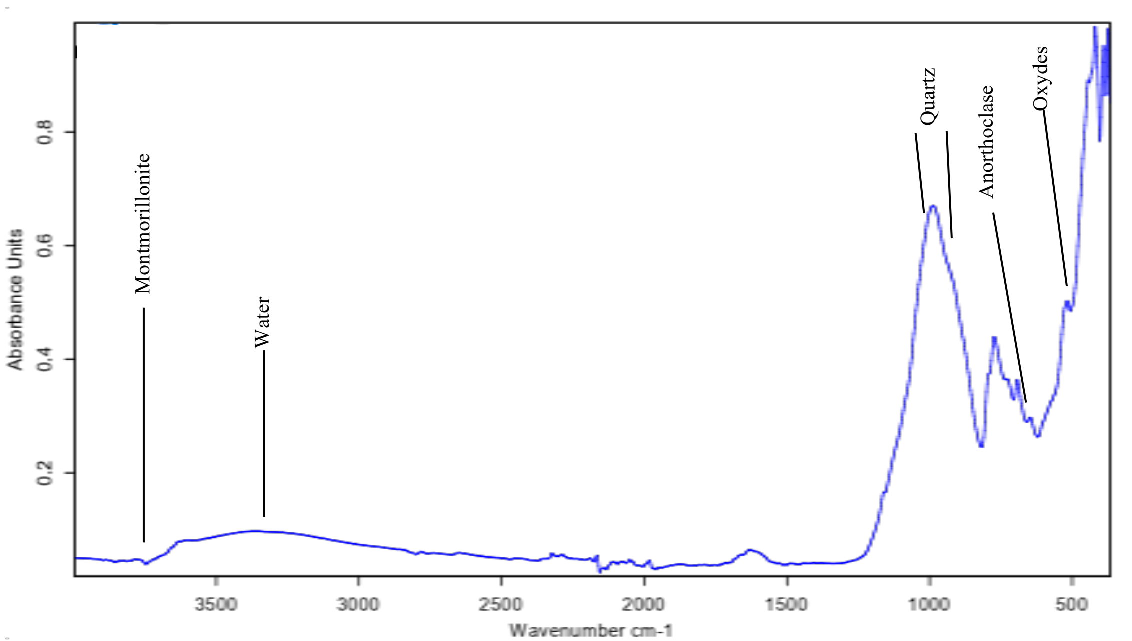

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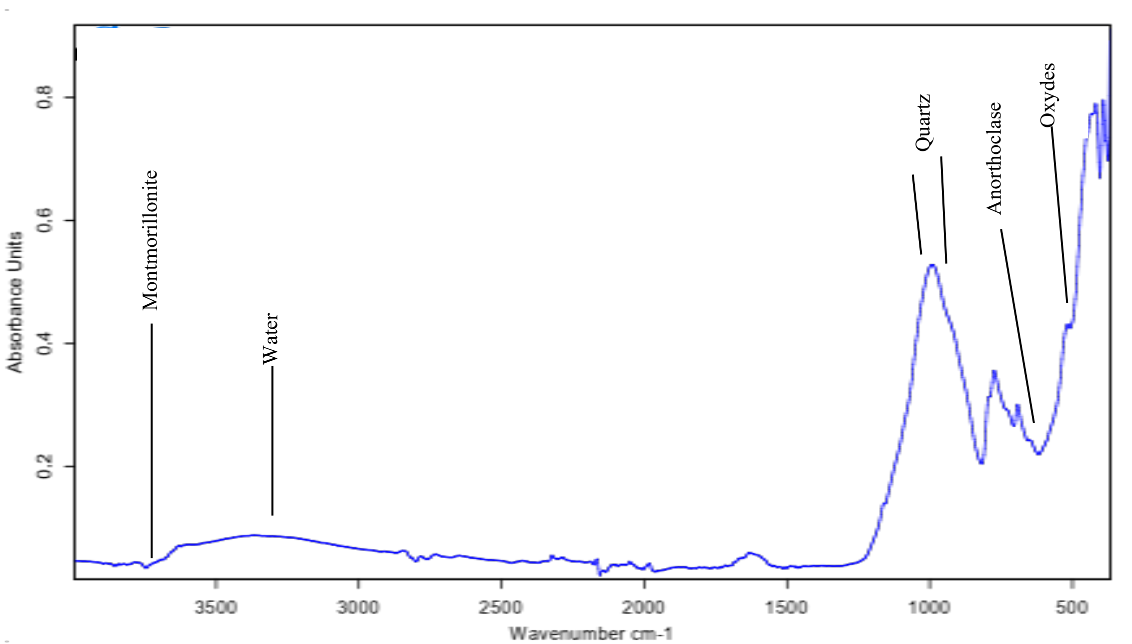

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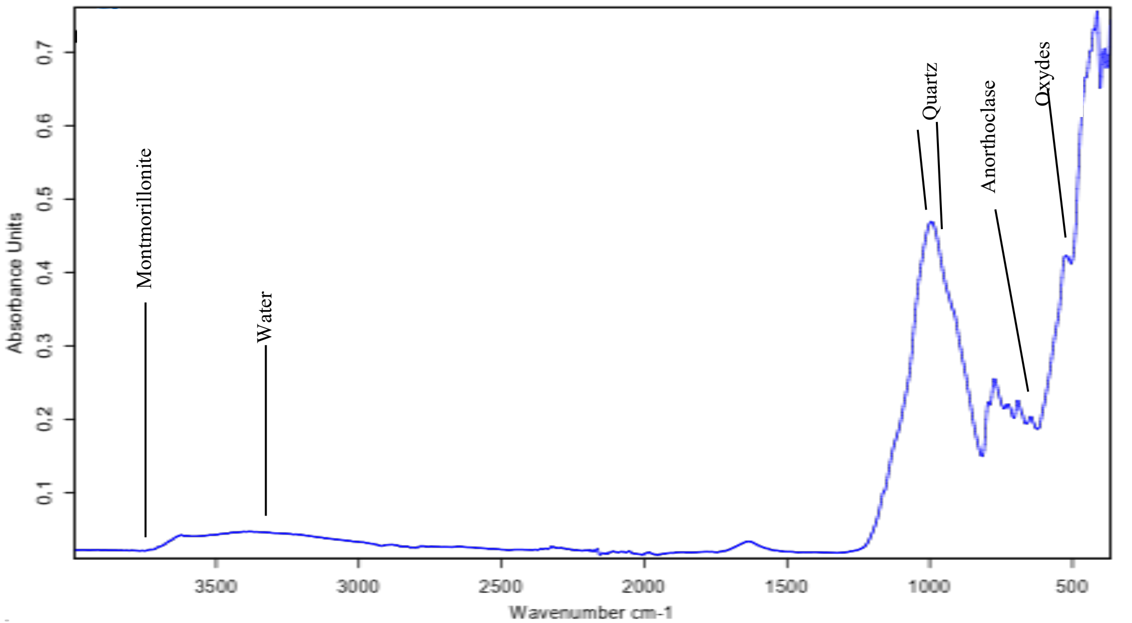

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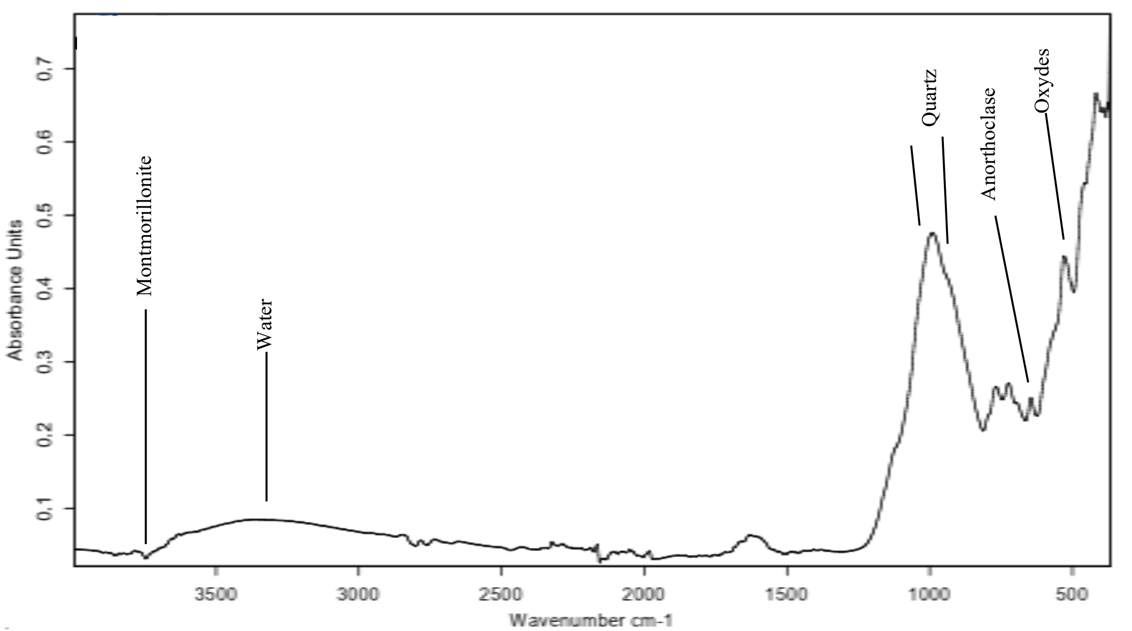

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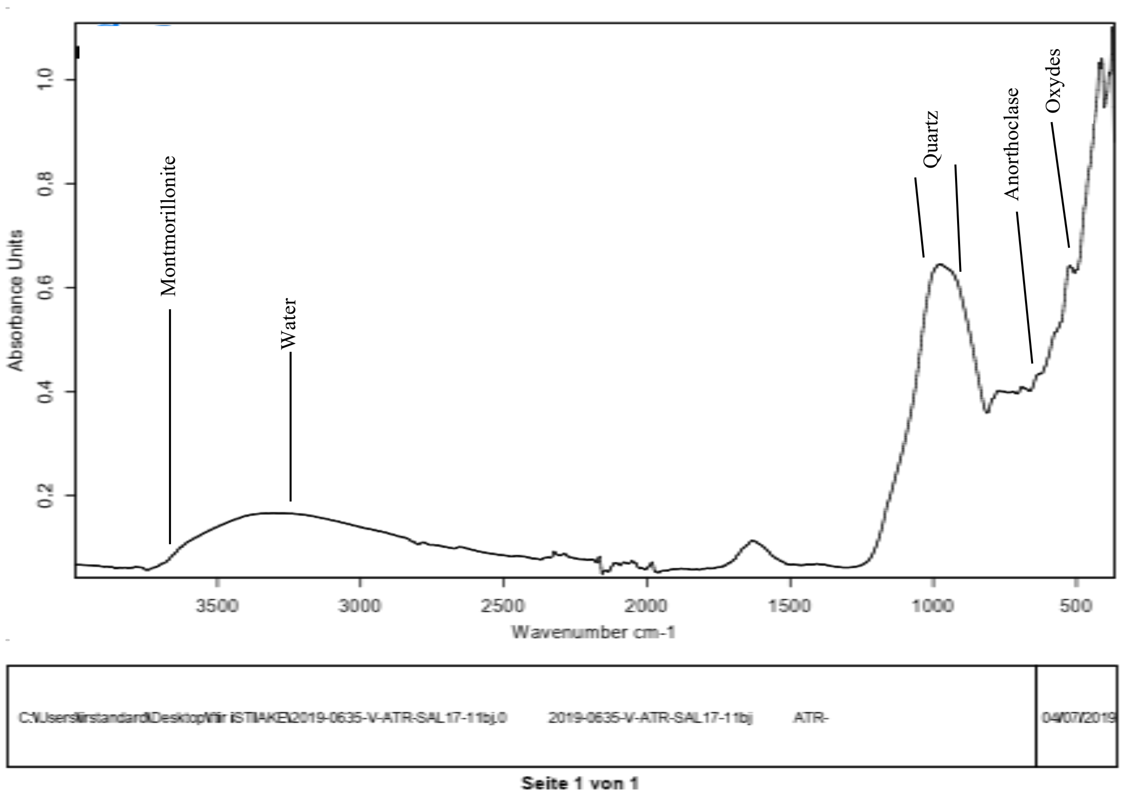
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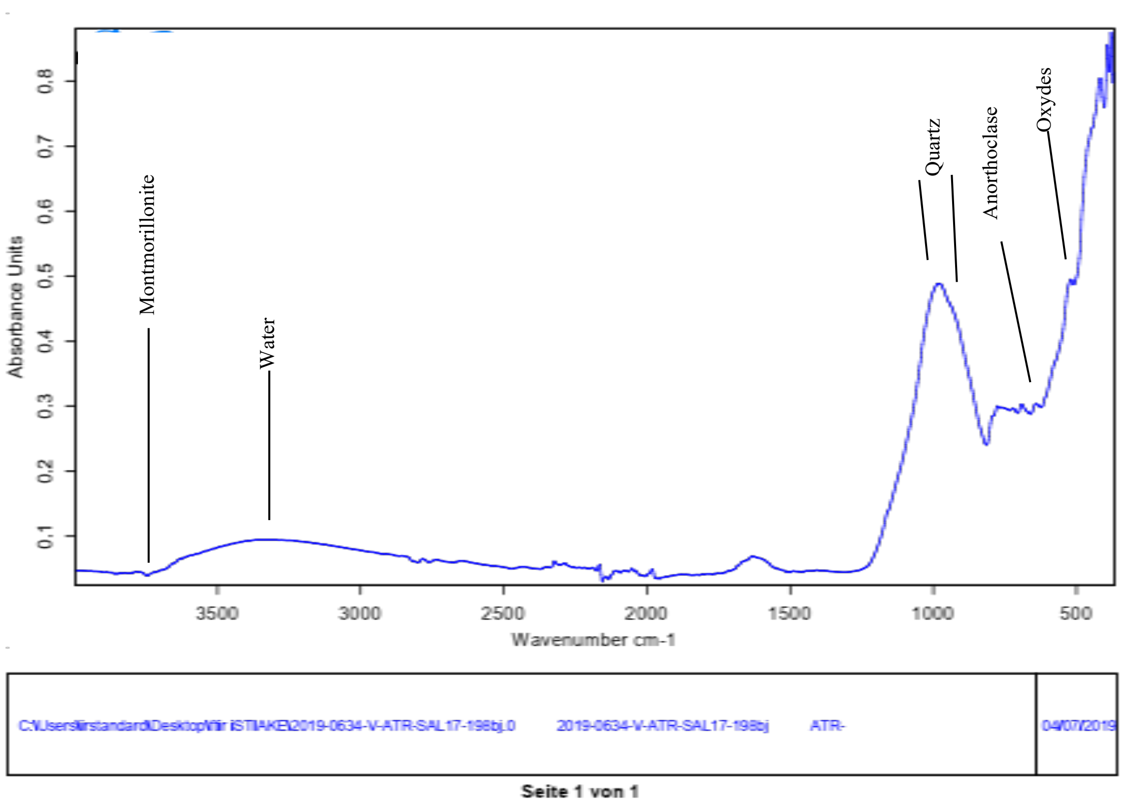
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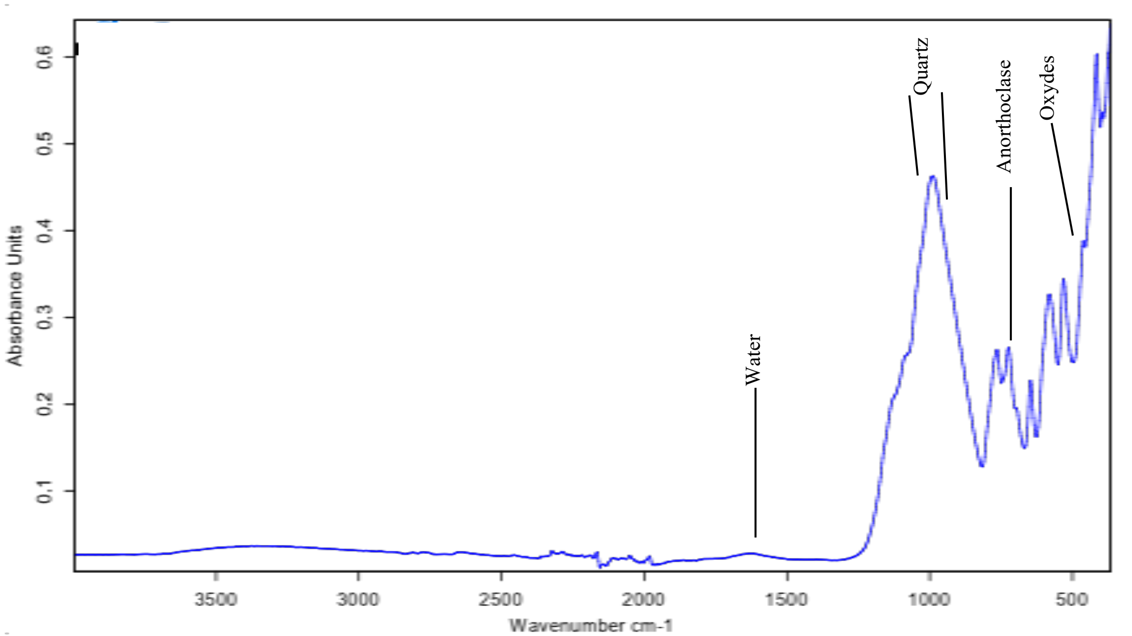

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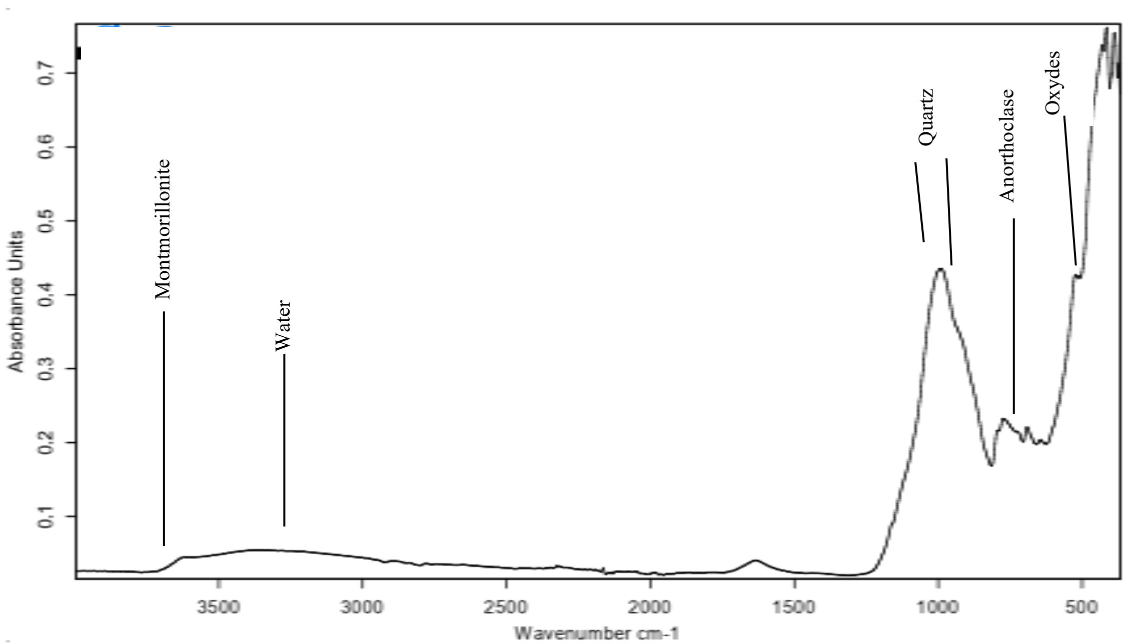

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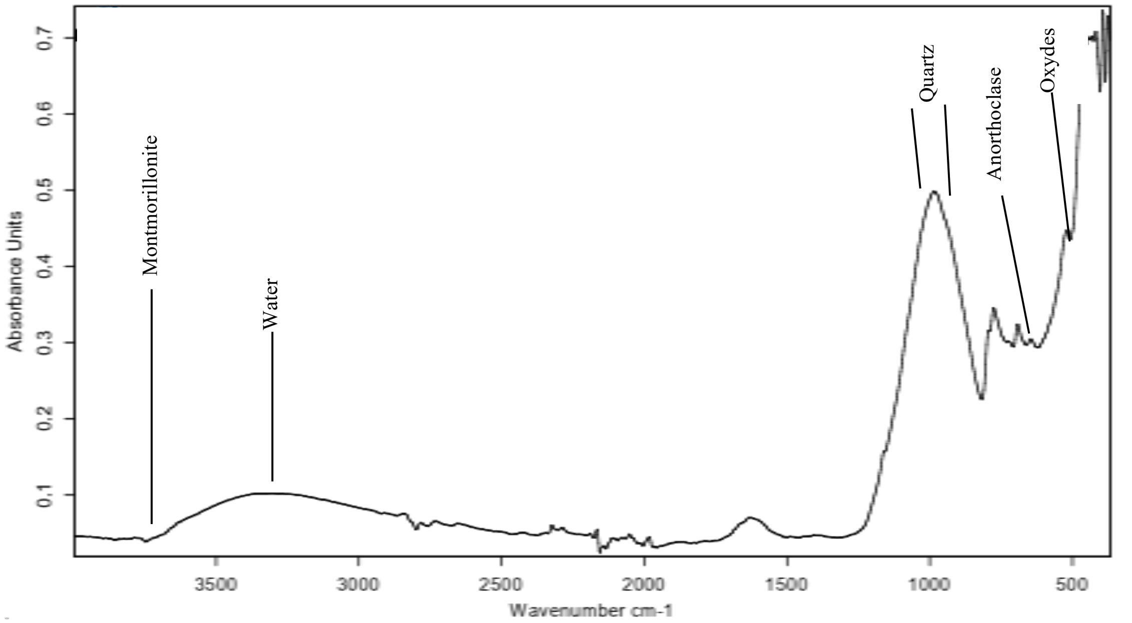

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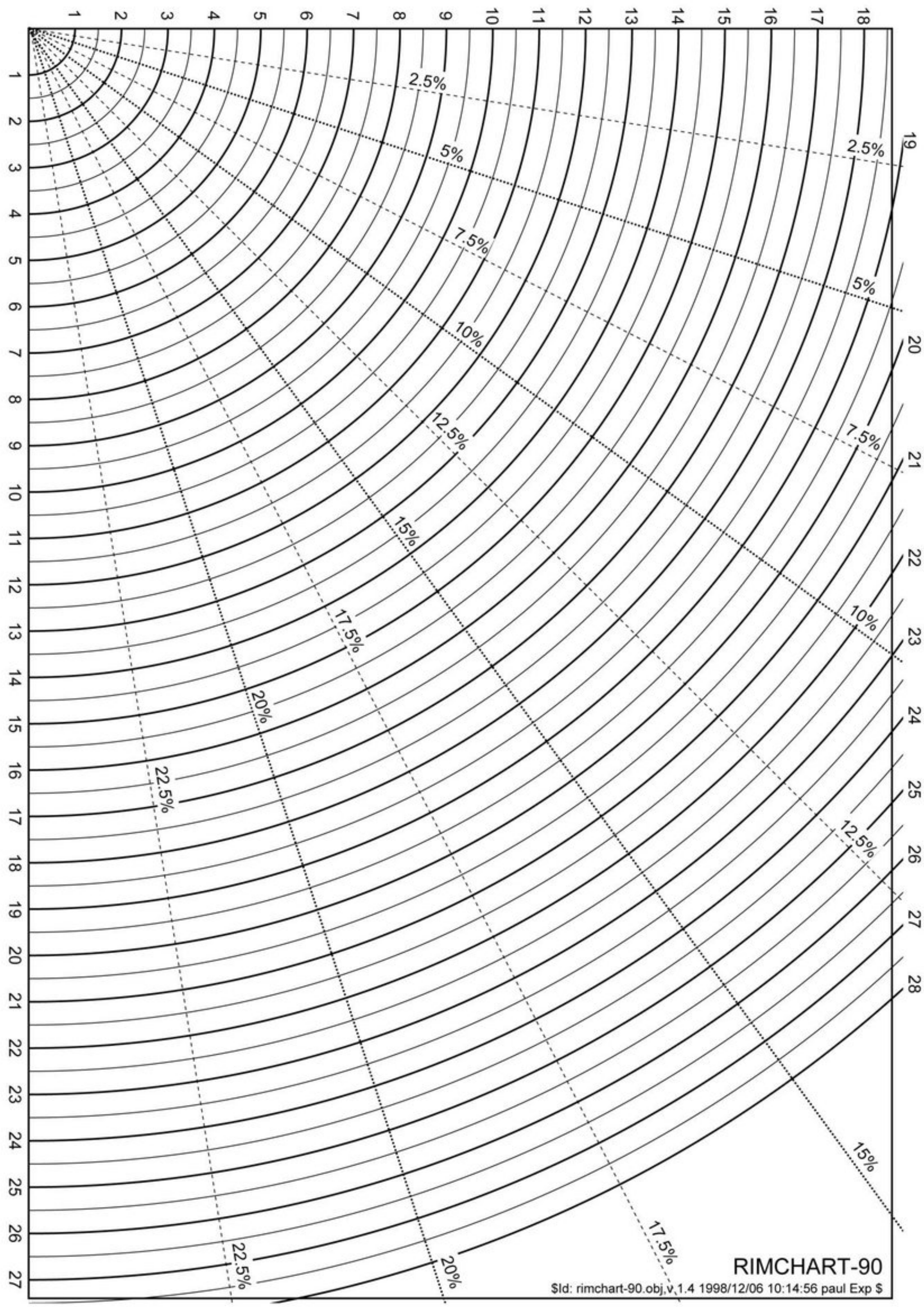
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