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Strontium isotope ratio analysis ($^{87}Sr/^{86}Sr$) in the post-classical population of La Selvicciola (Viterbo, Italy, VI-VIII century CE)

Master Thesis

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Abstract

The Longobard cemetery of La Selvicciola, located in the province of Viterbo, Italy, has been the subject of systematic excavations since 1982. The archaeological artefacts recovered from the cemetery suggest that it was used from the end of the VI century to the beginning of the VIII century CE. To date, the pattern of occupation of the cemetery by the Longobards and the relation between these invading peoples and the earlier roman population is still to be fully assessed. The thesis intends to offer a description of mobility patterns observed in the Longobard burials employing strontium isotope ratio ($^{87}Sr/^{86}Sr$) measured in human and animal bone and dental enamel. Data obtained are compared with bioarchaeological, geological and historical context. This study aims to understand the cultural identity of individuals, firstly by determining if reconstructed isotopic signatures support the existing historical, archaeological and anthropological information about these skeletons, and secondly by identifying any distinguishable trends between cultural groups which can be linked to status or behavior.

Keywords: La Selvicciola, Longobards, Italy, mobility, TIMS, strontium isotopes ratio

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List of Abbreviations and Terms

AD: Anno Domini

Ba/Ca: Barium to calcium ratio

Ba/Sr: Barium to strontium ratio

TIMS: Thermal Ionization Mass Spectrometry

ICP-MS: Inductively Coupled Plasma- Mass Spectrometry

LA-ICP-MS: Laser Ablation – Inductively Coupled Plasma- Mass Spectrometry

C: Canine

M1: First permanent molar

M2: Second permanent molar

mL: Milliliters

Ppm: Parts per million

Sr/Ca: Strontium to calcium ratio

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Strong relations between human identity and their chemical composition counterparts are nowadays reflecting the historical narratives through modern isotopic studies of ancestors. Human species has never been completely sedentary and our drive to move and settle in different periods of our lives is now being empirically tested with the strontium isotope ration ($^{87}Sr/^{86}Sr$) which is a part of each one of us, where it stands as a torchbearer carrying the signal of our origin. The latter represents a mighty insight into the subject as it is a useful proxy in the assessment of residential mobility and social practices of past populations. However, its usage in the study of the post-classical world of Europe is just unfolding and in this thesis, a strontium isotopic data of human and animal samples from a cemetery of Selvicciola located near Viterbo in northern Latium, Italy will be presented.

The arrival of the Longobards in 568 AD pinpoints to a star of the refreshed political and military atmosphere in the remnants of the Western Roman Empire on the Apennine peninsula. This occasion was described by contemporary and later historical sources, and it is well known that the itinerary followed by this migrating population from modern-day Hungary spread across the Alps into the south. Nevertheless, the pattern of their movement along with settlement choices remain shaded thus far. During the archaeological research that happened more than 30 years ago, a necropolis dated between the 4th and 8th century AD was found as a part of a larger rural Roman villa complex. Among the ruins of the villa, a Christian church dated to the 5th–6th centuries AD has been brought to light and the burial that are the subject of this research were clustered around it. While some of the post-classical burials are identified as of Longobard origin, the earlier burials are most likely belonging to the autochthonous Roman population. In the end, archaeological excavations yielded 85 tombs, of which 19 double burial tombs and 4 triple burial tombs bringing a total of 110 individuals.

The geographical location of Selvicciola site is indicative: located near *via Cassia* and *via Clodia* two communications leading from Rome northwards and as such forming an important pathway. Also, being in the vicinity of the Byzantine corridor between Rome and Ravenna based upon via *Flaminia*, made the site of Selvicciola an interesting prospect for settling as it could serve as a military outpost as well.

Data procured from dental enamel of both human and faunal origin, accompanied by soil samples reflect the local origin of the sample individuals and allow us to characterise the nature of society living in the turmoil of post-classical Lazio region at the site of Selvicciola. The relative variation of the Sr signature among individuals, either inter- or intra-site, integrated with archaeological evidence will allow us to attempt to determine the presence of individuals from different regions of origin, consequently mapping the dynamics of their migration and reflecting patterns of the same.

The unique circumstances of these burials, among which all age groups are presently followed by distinct grave goods, warrant further archaeometric investigation to understand the social standing and cultural practices through the origins of these individuals. This case study aims to understand the cultural identity of these individuals, firstly by determining if reconstructed provenance supports the existing historical, archaeological and anthropological information on who these skeletons represented in life, and secondly by identifying any distinguishable trends between these two cultural groups, local and non-local, which can plausibly be linked to their status or behavior of their members. It will be interesting to see if mobility information can reveal more about the origin or movements of this foreign population to the site of Selvicciola who are assumed to be non-native to Italy, only arriving in the city during the Longobard conquest of Apennines to understand how and to what extent it has changed the social and cultural landscape of the Peninsula itself.

Chapter 1. THE LONGEST JOURNEY SHORT – LONGOBARD ARRIVAL TO ITALY

Modern Scandinavia is deemed as the birthplace of the Winnili, as the ancient Roman sources named groups of people that later came to be known as the Longobards.

Figure 1. Longobard migration and settlements from 1st to 6th century AD (Rheinisches Landesmuseum).

The surviving contemporary sources for what is deemed as Longobard history are limited and often fragmentary, as is the frequent case for late Antiquity and the early Middle Ages. The following lines intend to advise only the ones that are regarded as of utter importance, and less with the ones who do not give more than several lines of attention to Longobards in Italy, as this would go beyond the necessities of this thesis.

Our primary historical lines of Longobard history are the writings of Paul the Deacon from the 8th century AD, preserved in the six books known as *Historia Lanogbardorum.* Paul, a noble Longobard himself, became a monk living in the kingdom's capital of Pavia where he encountered the remnants of the royal family, and of course older historical documents. Finally, he witnessed the collapse of the kingdom, however, he remained active at the court of Charlemagne himself, as a teacher of grammar that at the last decade of his life wrote about myths and history of his people, all the way from their Scandinavian origins to their arrival in Italy, with the last chapter finishing before the end of the reign of the last king Desiderius (Figure 1.). As with other similar works, we can argue how the main goal of Paul's work was to include the history of Longobards into the workflow of global or betters said history of Roman and Christian world. What is more, every other history of the Longobards is pulling from *Historia* itself. On one hand, it is very valuable as it is the most thorough and clear narrative of the events and on the other hand, it was born in the 8th century, and clearly shows influences to a certain agenda and narrative.

The earliest history and origins of the Longobards are also based on historical lines of the so-called *Origo gentis Longobardorum*, a source from the middle of the 7th century CE that tells us how first migrations are a reaction to increase of population that thus had to search for new lands. The population was divided into three groups, among which one had to leave their homeland and the chosen third was then led by brothers Ibor and Aio into the region of Scoringa or what is today northern parts of Germany near the Elbe River, thus marking the start of a long journey lasting for several centuries which finally ended in the lands of modern Italy (*Hist. Long.* I ,2-9). However, some may oppose this as a tradition based on lesser facts and more legendary and fabled oral passovers, as the first historically attested homeland was found in the lower course of the Elbe in modern-day Saxony, close to Denmark (Goffart, 1988; Pohl, 1994; Christie 1995).

1.1 The Longobards before Italy

Be it as it is, the Longobards have been firstly attested in the reference from Strabo's Geography (VII, 1.3) in the 1st century AD, as well as later one from Claudius Ptolemy (*Geog*. II, 11.9) and Tacitus (*Germ*. 40.1), affirms them among those encountered by Roman legions during campaigns of Tiberius on the Rhine and the Elbe.

Later on, as Marcus Aurelius fought the Marcomanni, while Cassiodor (*Chronica*) and Cassius Dio (*Hist. Romana, LXXI*, 3.1*)* mention several thousand Longobards who tried to cross the Danube unsuccessfully in 167 AD, eventually settling in the middle part of the Elbe Valley and northern parts of Bohemia, that is nowadays Czechia. It seems that aftershocks of this war disrupted the previous stability, and demand for land with population increase prompted further chain reactions and movement (Goffart, 1988; Christie 1995; Posan 2015). Longobards in the 4th century moved towards Pannonia, a province roughly replicating the borders of modern-day Hungary. Paul (*Hist. Lang.* I. 16-17) mentions battles with the Bulgarians that are the Huns, during the reign of Agelmund when Longobards were probably dwelling around the middle Danube that is Bohemia. The latter was killed during battles, but new king Lamisso managed to fend off the Hunnic assault.

During the early 5th century, ashes of the Roman power created a political vacuum which many armed groups used and through the crossing of the limes at Rhine and Danube, settled in the Roman provinces where they gain the status of *foederati* – allies of Rome (Wickham 1983; Goffart, 1988; Christie 1995; Posan 2015). Jordanes (*Getica*), Procopius (*De Bellis* VI. xiv,9-10; VII. xxxiv, 34,40) and *Life of St. Severinus* (*Vita Sev*. 42-44) mention that the land of the Rugi, who was part of Hunnic confederation in the province of Noricum that occupied most of modern Austria and part of Slovenia, was desolated by Visigoths and how they were followed by Longobards who entered it in 489 AD led by king Godehoc (Paul, *Hist. Lang.* I.19; *Orig. g. Lang.* 4). At that point of time, they came under Byzantine eye as the occupation of the land around Vinodbona was taking place and were plausibly invited to settle in Pannonia around 520 AD and to act as a vanguard against the Gepids.

Thus, they confronted the Heruls, replacing them as the dominant power on the middle Danube. As the latter were allies of Ostrogoths, the Byzantine Empire wanted to bring the Longobards led by king Waccho (c. 510-540) to their dominion as they moved into the territory of modern Moravia (Paul, *Hist. Lang.* II.7; *Orig. g. Lang.* 5). Justinian seemingly included Longobards to his Christian alliance (Proc., *De Bel. Got.* II.22) and under the rule of Audoin (546-565 AD) and his son Alboin (560-572 AD), Longobards already thrived in Pannonia to an area lying between the rivers Drava and Sava and defeated the Gepids through an alliance with Avars. In the next forty years, the Longobards were in the midst of a changing world, as the Roman power slowly crumbled with the formation of Hunnic, as well as Ostrogoth and Gepidian kingdoms afterwards, and so the economic and political framework of the late classical world that was still holding on the shoulders of the native Roman population has albeit been used by Longobard rulers (Paul, *Hist. Lang.* I.20-21; *Orig. g. Lang.* 4). In these conditions, political shifts and pressures of different powers as Franks, Byzantine Empire and new power found in Avarian Kaganate influenced the ever-migrating Longobard population towards making the final step towards Italy (Wickham 1983; Goffart, 1988; Christie 1995; Rosen, 2002; Curta 2006; Posan 2015).

Thus, despite their victory, the Avars slowly moved into the Danube region and emerged as the dominant political entity, with Longobards eventually leaving towards the Apennine peninsula. Part of the population served in the army of Byzantine general Narses in Italy just before, as he defeated the Ostrogoths and re-conquered Italy after the battle of Taginae (Gualdo Tadino) in 552 AD and according to some these soldiers were the driving force that influenced the king himself (Proc., De *Bel. Got*. IV.26). By 561 AD, Byzantine forces controlled all the Peninsula as far as the Alps. In effect, the Byzantines and the Longobards became neighbours, so it was in the Empire's interests to keep the Longobards on their side. From this time on, the Longobard aristocracy may have formed the idea of moving into Italy from Pannonia as the allies of the Romans, unlike Ostrogoths under Theodoric before them. Soon after the death of Justinian, Alboin engaged into new hostilities with Gepids and their leader Cunimund as they settled along the river Tisza, and as was mentioned above, formed an alliance with the Avars which in return demanded a large tribute in lands, livestock and booty, and consequently, after achieving victory they started moving along the Danube into Pannonia (Paul, *Hist. Lang.* I.27). Furthermore, new Byzantine ruler Justin II terminated the peace with Longobards and wanted to regain possessions and decide to favour Gepids instead, thus pushing the Longobards beyond the Danube again. The rapid growth of Avarian power, as well as evident weakness of Byzantine Italy, as it has suffered from plague, religious and military rebellions, as well as the probable low number of

Byzantine troops, must have influenced the Longobards and in 568 AD they finally left Pannonia that became a dangerous region and migrated to Italy (Wickham 1983; Christie 1995; Rosen, 2002; Curta 2006; Posan 2015). According to Paul (*Hist. Lang*. II.5), they were in reality invited by Narses himself to conquer and populate Italy, as they have proved themselves as allies, and still be regarded as such, with previous granting of Pannonian and Noricum lands proving as good experience and a good choice for the Byzantine court (Christie, 1991).

1.2 The Longobard Kingdom of Italy

The Longobard arrival to Italy came after three decades of unrest which came as a consequence of Justinian's reconquering policy, and the population must have been undergoing economic stress. After wars, and subsequent rebellion against the newly formed Byzantine administration and its greed. Finally, Narses managed to first defeat the armies and then put down all uprisings that came after, however, he was dismissed and the government nearly collapsed and the opportunity for Longobard arrival soon opened (J. Evans, 1996).

According to Paul, Alboin and "all his men at arms and masses of all kinds of people" (*Hist. Lang.* VIII 1-2), together with their livestock and possession set out for Italy. On their journey, the Longobards were joined by Gepids, Sarmatians, Bulgars, Saxons, Thuringinasn and Heruli, as well as their culture and customs that finally gave a frame to a new complex cultural entity (Posan 2015). The sudden appearance of the new nation marked a change in the history of Apennines. From this point on, several centuries brought a continuous shift driven from inward and outward forces of change, reaction, and consolidation.

As the consequence of the war with Ostrogoths, the country was desolated and Longobards found little to no opposition and by 572 AD, most of Italy was under their control. It may seem that the mentioned invitation might explain why there is no record of an invasion and similarly why there was so little opposition to Longobard arrival. Paul mentions that occupation was carried out „without any obstruction" and soon Forum Iullium (Cividale) was captured and a duke named Gisulf, accompanied by the leaders of farae, was installed at the head of new duchy (Hist. Lang. II. 9-14). Penetrating westward on the main roads into the Po plain, and thus arriving at the economic heart of Italy, Alboin captured Vicenza, Verona and finally Milan by the end of 569 AD. Interestingly, we have numerous documentation of bishops surrendering and fleeing cities like

Aquileia, Treviso and Milan, which tells us about the atmosphere of an impending army approaching and the reaction to it. On the other hand, Pavia is one of the towns that resisted and was soon found under siege that lasted three years, thus telling us that there were still Byzantine forces that resisted. After conquering Friuli, the Longobard rule started to subsequently extend over the peninsula as the Byzantine rule did not possess an answer to the newcomers. In a short time, only coasts of Veneto and Liguria remained in the hands of Byzantine, as well as the Exarchate of Ravenna and a patch of land linking Ravenna and Rome. The latter divided the Longobard kingdom into northern Longobardia Major and southern Longobardia Minor. The duchies of Spoleto and Benevento were formed in the middle and south, with the kingdom's capital being in Pavia and the new land divided into thirty duchies (Wickham 1983; Christie 1995; Rosen, 2002.).

Figure 2. The Longobard Kingdom of Italy in the 8th century AD.

While this made up for the efficient government from an administrative point of view, it seems to have left too much power in the hands of the individuals who after the death of Alboin, started to fight among each other until they found a common foe in the newly-formed Byzantine exarchate in Ravenna at the end of 6th century. What is more, it is difficult to draw the lines of Longobard controlled territories, as Byzantine garrisons seem to have been scattered across at these times still (Figure 2.).

From 574 to 584 AD, a decade known as the „Period of the Dukes“ was diminishing the power of the newly formed kingdom as it was splintered among numerous duchies that became and acted autonomously. Alboin was murder in Verona in a Byzantine led coup, after which Clef was elected king (572-574 AD). The latter continued the struggle, only to be murdered, after which the dukes decided to not elect the new king while murdering and enslaving the leftovers of Roman nobility and clergy (Paul, *Hist. Lang*. II. 29-31; III. 1-8). This, unfortunately, led to an alliance of the Byzantine Empire with the Franks, whose lands were raided after the death of Alboin, and soon an invasion of Italy took place bringing a chaotic end to a century (Christie, 1995). For the next twenty years, several invasions occurred, and as the opposition was gaining momentum, dukes started to switch sides, and at one moment seriously threatened the Kingdom itself. What is more, at one point there were as many Longobards fighting side by side with Byzantines as those who fought against them (Wickham, 1983). Nonetheless, as the enemy was wandering around the countryside, Longobards shut themselves in fortifications for so long that hunger stroke among the Frankish ranks and lead to their withdrawal (Paul, *Hist. Lang*. III. 31).

Finally, Authari (584-590) was crowned a new king and rallied his countrymen, as they gave him half of their wealth and possessions to stabilise the crown itself, made peace with Franks and his relative, king Agiluf (590-616 AD) secured peace by controlling the insurrection and pushing out the Byzantines, all while bringing in the almost whole of Italy to a more centralised rule to strengthen the position of the throne against the dukes (Collins, 2010). At the same time, the Frankish and the Byzantine influence was very constrained, however, the land link between Rome and Ravenna was still out of Longobard reach even though they controlled southern regions around the duchies Spoleto and Benevento. During this time, Pope Gregory the Great mentions the constant search for peace through numerous contacts with both king, dukes and their enemies, even though Authari implemented an anti-Catholic edict and the Pope himself acted in concordance with Constantinople and the Franks soon after (Lib. Pont., *vita Gregorii 66*). Nonetheless, battles reached the outskirts of Rome and elsewhere Byzantine territories have been constrained to coastal centres in Naples, Taranto, Otranto, and Sicily (Magdalino, 2004). Soon after further success in the North, the Byzantine exarch Smaragdus had to sign a truce, thus marking a failure to stop Longobard uptake of Italy (Paul, *Hist. Lang.* IV. 20-25). Through this peace, which was broken by a Longobard king only twice in more than a century that follows, Agiluf managed to submit dukes to his will, as they were still acting independently in Friuli, Tuscany, and especially the south, where Spoleto and Benevento acted independently during next century, but they seem to recognize his dominion (Wickham 1983; Christie 1995; Rosen, 2002). Furthermore, a peace succeeded Bagnarea and Orvieto in Tuscia, modern Tuscany, to Longobard rule, close to the main subject of this work.

The landscape must have been affected by the constant state of war, and the population must have been relieved to finally put an end to swapping of the rule and rulers. Borderline zones between Byzantine possessions and Longobard duchies have most probably been reduced to scattered villages and isolated farmsteads as the old patterns of settlements must have been gone as we have been told from the Dialogs of Pope Gregory (III.8), where he vividly describes depopulation of cities, burning down of churches and monasteries, the desolation of landscapes and humans living inside it. Even if the latter over-emphasized the post-war atmosphere it most certainly came from the fact that the countryside must have been deserted and previous centres declining to the greatest extent in centuries. What is more, pestilence, epidemics, floods and fires and locust swarms seem to have harassed the Apennines in late 6th century, however, the Longobard ability to defend inside walled towns during the invasion shows clearly that there have also been ample surpluses of food, and simultaneously that production at least in the north was still available (Wickham 1983; Christie 1995).

After the death of Agiluf, the reign was exchanged by his wife Tenodolina and her son Adaloald (c. 616-c.626), until he was deposed by his brother-in-law Arioald (c.626-636). After this turbulent period, in 636 AD, one of the greatest Longobard rulers came to the throne, king Rothari (636-652), a former duke of Brescia who managed to bring down the Byzantine possessions in Liguria, Tuscia and Emilia as incursions and skirmishes do not seem to have ever stopped, even though this was the first record of campaigns against the Byzantine forces since the peace established by

Agiluf, down only to Rome and several smaller areas. During his tenure, first written law of the Longobards, the *edictum Rothari*, finally translated the rule of law from previous semi-tribal legislation. In the end, he was succeeded by his son Rodoald (652-653) who was assassinated soon after ascending to the throne, which marked a new decline as the Kingdom split between pretendants to the throne, Aripert, Perctarit and Godepert for ten years, while Avars and Slavs were building pressure at the eastern borders (Christie 1995; Wickham 2016). It must be noted that Byzantine interests during this period were marked by constant internal struggle and religious disintegration between Constantinople and Rome culminating in the arrest and exile of Pope Martin and emperor Constans raid of Rome. The latter led an expedition in the south, besieging the duchy of Benevento, where Grimoald was acting as duke, before becoming the king (662-671) after the civil war. At the same time, there has been another rebellion led by duke Lupus of Cividale that was shut down by an invitation to the Avars who in the end had to be forced to withdraw from Veneto by the king himself. After the death of Grimoald, the throne was held by Perctarit (671-687), who interestingly lead a coup against the former ten years before, but seems to have been welcomed as his rule is marked by multiple architectural projects in Pavia. However, internal foes seem to have become a norm by this time, and even though there was a peace treaty with the Byzantium, rebellions by dukes of Brescia and Friuli took place, while southern ones gained momentum and power surge through enlarging their possession and what brought them more autonomy (Paul, *Hist. Lang.* VI. 27; Wickham 1983; Christie 1995).

Later on, at the beginning of 8th century, Liutprand, regarded as equally great ruler as Alboin, came to the throne in 712 AD and allied with at that time the emerging overlords of Europe, the Franks, thus establishing an era of peace after a bitter battle inside the kingdom with usurpers, rebels and internal warfare brought the survival of the kingdom to question. The rule of Liturpand lasted until 744 AD and can be deemed as the last uprise before the final demise of the Longobards as his aggression led to attacks on the Exarchate and Rome (Paul, *Hist. Lang*. VI. 5-40), as well as internal moves against dukes of Benevento and Spoleto where he installed his relatives. The aftermath was that state of might in which Longobard military had no rival in Italy for the first time. At the same time, Rome and Constantinople found themselves in iconoclastic conflict, enabling Liutprand to establish himself even further as the greatest adversary of the Papacy that will lead to political manoeuvring and intentions to create a new enemy in form of Frankish kingdom, which at this time was still an ally of the Longobard kingdom (Wickham 1983; Christie 1995; J.L. Nelson 2016).

Unfortunately, Liutprand's successors were not as nearly efficient rulers. Thus, during the tenures king Ratchis (744-749) and Aistulf (750-756), we observe further actions against the remnants of the Exarchate and Rome as the power balance shifted once again, while at the same time attempting to strengthen the royal power against the dukes by introducing new laws that included military obligations as the Frankish threat seemed to become more and more realistic. Just as Ravenna, the last Byzantine stronghold, fell, and as the duchy of Spoleto had to be made a part of the kingdom once more, Aistulf captured fortresses around Rome, thus prompting Pope Stephan II, after the negotiation failed, to call the Frankish kingdom to aid, ultimately leading to an intervention that - will spill over the rule of the last king, Desiderius (757-774). Even though first Frankish incursions led to surrendering of exarchate to Rome, Desiderius managed to stabilise the kingdom as there were internal succession struggles among both papacy and Frankish court. What is more, the daughter of Desiderius was married to Charlemagne, but by the end of 771 AD, the marriage fell apart and the former succeeded to finally bring the city of Rome under his rule (Wickham, 1983; J.L. Nelson 2016). However, this represented an immaculate threat to Pope Hadrian I, who called upon Charlemagne, and in such a way completely broke the ties of their alliance to Longobards, leading to their defeat in 774 AD, as the lands of the Longobard were seized and the resistance was short-lived after the Frankish army crossed the Alps and besieged Pavia and Verona, where Charlemagne crowned himself as a king. Finally, the kingdom with its people and culture ended up being assimilated into the new kingdom of the Franks (Wickham, 1983; Christie, 1995).

Longobard society in Italy – Who and What shaped it?

Late antiquity is framed by the collapse of the Western Roman Empire and invasion of barbarian populations, starting from Huns, and continuing with Vandals, Goths, Gepids, Longobards, Franks and others. Simultaneously, the period of great migrations is key to our point of view of the end of the Roman Empire in the later fifth century AD and the development of the Early Medieval polities afterwards. Historically, the Hunnic migrations into the Carpathian Basin in the fourth and first half of the fifth centuries AD have been thought of as the start of the domino effect that set in motion the migrations of other societies who ultimately leading to the collapse of the entire

Western Roman Empire (Hakenbeck *et al.*,2010). Yet, the extent and nature of population movements during this time are still poorly understood.

Archaeology is the greatest evidence procurer about these populations as they, in most cases, have not left us direct written records of their histories, unlike the later sources that give us an indirect point of views. Same goes for reasons and patterns of their migration. However, archaeology is always frustrated with the difficult interpretation of archaeological remains as grave goods, for instance, do not give answers to questions about reasons for action, or social complexities.

When looking at migration, many questions are left hanging in the air because we simply are not able to answer the question as to whether the populations we are observing represented a homogenous society or who, how and in what capacity decided to change its living place for another with material culture and archaeological context purely. The latter only provides the dot on the exclamation mark and not the sentence before it.

The Society of Longobards – from fara to confederation

The Gothic war left disaster upon both native Italian population as well as the minorities as the complex infrastructure broke apart and society could not regenerate in the scarcity it found itself in. The Longobard rule saw the rise of the military over civilian political function and resources were more oft than not put to the aid of the forces, forcing constant insecurity in the agriculture. As has been seen, authority was not centralised and effective rule was diminished especially by the fact that the territories of the kingdom were separated into two larger parts in the north and south. The delicate nature of the relationship between conquered and conquerer in the newly formed societies are not easy to define (Christie 1995).

Upon arrival in Italy, the Longobards represented a group of people led by warrior aristocracy and king elected among the same (Morandini 2013). However, a simplistic barbarian point of view in the sense must be deemed as false, as can be seen by the ability to absorb a Roman province, and more than plausibly some of its cultures, and hold it for forty years in a similar political manner (Wickham 1983). However, the scarcity of written word does not allow us to base our assumptions and preconceived notions about the Longobard society outside the militaristic framework, simply as that is the only one we nowadays possess. What we can be certain is that the Longobards might represent a confederation of several ethnicities, and this diversification of society can be seen in difficulties of maintaining cohesion and unity, and which might be seen in archaeological finds as well.

In terms of social structuring, warrior clans with dukes at the head of them known as *farae* were present, and a free population known as *arimanni* belonging to the aristocracy were bound to the duke by kinship ties (Christie 1995). When migrating to Italy, Longobards moved *in fara*, and in the lines of Paul, we determine this as „generation or linage“ (Wickham, 1983). Unfortunately, the terminology of the latter remains obscure as the later edicts also do not precisely determine its social meaning, but it can be hypothesised that it represented a group of people with inheritance rights among each other. The structure of this kinship was male-based families, and more recently there have been attempts in linking it with a military unit, a basic detachment or expeditionary force with a soldier as the base variable of the entire social structure (Murray, 1985). Further, the middle class were the *aldii*, semi-free population with the obligation of military service under the protection and with ties to the service to their dukes, and finally at the bottom of society were the slaves and servants. Needless to say, this classification was diminished with the legislature, as the economic relationships changed with freeman becoming tenants and renters on lands and so on (Wickham 1983). Dukes were seated in the cities and countryside was separated into *arimannie*. Thus the dukes presented the king's legislative representative and not just a person who leads a *fara*.

This social stratigraphy was inherited in the settlements, thus cities were occupied by the aristocracy and were so the strongholds and holders of political power. Such were, for instance, Pavia, Friuli or Brescia, while the other nobility lived in more rural counterparts with farmlands and craft productions (Wickham 1983; Brather 2009). Those who became new landowners seem to have established new dwellings near communication in rural and peripheral hinterlands, maybe as a means to occupation and repopulation of abandoned lands (Christie 1995; Valenti 2009). The rural settlements show the transformation from cereal production and cattle herding to a mixed farming system during the late 6-7th centuries AD and, e.g. paleoenvironmental data from Trentino, north of modern Verona, indicates that there was a new pattern of land use. Simultaneously, the areas that were considered abandoned went through a reforestation process which converted the landscape for wild farming practices, pastures and wood exploitation (Forlin, 2013).[1] Finally,

[1] Cultivation of inferior grains as rye and flax and Buckwheat was introduced (comapre with P. Forlin 2013).

landowners would control small villages of a couple of hundred people (Valenti, 2009; Brather 2009).

It is interesting that in the earliest stages of settling we can observe a social distancing and obvious separation between Roman or better said Byzantine population and the new-comers. The language, religion and social differences clearly played their part and intertwining of the societies was not present, as can be seen by the earliest cemeteries and grave goods found in the same. During the 7^{th} century, a gradual change in nature of Longobard society seems to have taken place, as more people settled as landowners, and the mentioned Edict of king Rothare can be regarded as as the frame of the latter in that point of history and shows that society needed to legalize new realities. It would go beyond the point of this thesis, nonetheless, new economic opportunities might have provided reactions and influxes of new waves of people arriving into Italy (Wickham, 2005).

This should not come as a surprise as the relationships between the two groups started violently, and several generations were needed to build bridges between them. The first act that started this kind of reparation is the Longobard gradual conversion to Christianity, which started in Noricum and Pannonia and that allowed integration and their presence within the domicile society. On the other hand, only a few passages are describing pagan practices, as it seems to have been avoided by the aristocracy that was slowing becoming synchronized with Chrisitan, as well as Arian identity. However, there seems to have been a constant struggle between tradition and new catholic identity, stirring from political activities to the downtrodden of society. Soon after, laws were established and written in the Latin language, consequently creating the foundation of new non-barbarian customs that included a society that became based on owning a piece of land that can be inherited. This is important as the same changes can be observed in the archaeological context (Wickham 1983; Christie 1995; Rosen, 2002). Be it as it is, this picture and its details are stretching beyond the frames of this thesis.

Kinship structure and relations inside an archaeological context are nowadays intriguing anthropological analyses of burial sites as new multidisciplinary methodologies as e.g. ancient DNA in combination with isotope analysis, show the existing potential to scrutinize connections between individuals and estimation of kinship groups in ancient samples (S. Vai *et al.*,2020). Moreover, kinship in most cases can only be hypothesized through the spatial organization of cemeteries, the relative positioning of burials, similarities of grave goods, and age classes.

Relations between individuals inside a population is also made through physical anthropology through morphological traits and material culture.

The Longobard Cemeteries – Story of the Living told by the Dead

Most Longobard cemeteries from the 6th and 7th century are in essence very similar to the once found in older burials of Pannonia. What is interesting is the fact that burials in some sites, e.g. Nocera Umbra in Umbria, seem to belong to a Longobard communities only, however, at the same time the numbers of pottery finds among grave-goods in the same that are from a typological point of view similar to late Roman coarse ware suggests that there had to be a clear interaction between two populations (Wickham, 1983). On that note, we can observe the so-called *ceramica longobarda* in the earliest period, and its disappearance from the middle of 7th century, when the industry crashes due to changes in demands and procurement (Wickham, 2005). What this means is that from a certain point artefact are no longer a secure guide to ethnicity, but importantly they are a door to cultural contacts.

Longobard cemeteries are found in the proximity of urban sites which could lead to a conclusion that societies intertwined for various reasons, not just because of ones rule over the other. Influences most certainly developed in Italy as subtle changes had time to develop, unlike shorter dwelling of Longobards along the Danube. The social structure of Longobards most certainly was affected by their Roman counterpart, as can be seen by grave goods that attributed the burial in Pannonia and Italy afterwards. The latter implies social stratigraphy and planning of necropolises for use by extended family or kin groups – the *fara*. This kind of social units was prominent in the early conquest as the dukes shared their land with faras under their jurisdiction, but during the 7th century, they started to lose their shape as government became more inclined into the persona of the King and his legislature (Christie 1995).

Longobard grave goods show a progression and intake of Roman traits through the 7th and 8th century. At the same time, by the middle of the 8th century, the Longobards had by large become Catholics. Amongst other things, a conversion meant a virtual stop to the custom of providing funerary gifts to the deceased, thus changing the burial rites. However, these changes show the adoption and evolution of new dress codes into decoration types that include Christan symbology (Christie 1995). We do not know at what rate and in which *modus operandi* the Longobard conversion took place.

The use of weapon sets and goods such as saddle fittings, stools and similar should indicate status, though we must bear in mind that it was the deceased's relatives who were responsible for the provision of grave-goods, thus we are not allowed to be certain of the assumed equation of wealth with the status. Nonetheless, the quality and quantity of grave goods must give some relation to the status of the deceased and to that of his immediate kin, and it seems plausible to view wealth as expressions of social hierarchy. Social inter-connection can be presumed in the cemeteries found near the cities and the military infrastructure. Just in Pannonia, over forty cemeteries with several thousand burials dated to Longobard reign are known, and thus they serve as the strongpoint of funerary characteristics and grave goods for the comparison of the other locations of the migration route as such (Alt *et al.*,2014). Nonetheless, the social identification of the Longobards just derived from archaeological evidence and scurry historical sources remains fogged as well as the scale of migrations, and which, if not all, parts of the population were part of the same. Furthermore, if several generations were part of successive migrational waves, we have to ask ourselves how they were incorporated with domicile populations, and among themselves also. In case of those that have arrived in Italy, it has been shown that they are of many different backgrounds and ancestry (P. Iacumin *et al.*,2014).

Two types of cemeteries have been identified in northern Italy, either small and near rural communities living near forts and villas so to speak, and the larger ones used by several communities (Christie, 1995; Possenti 2001; Brogiolo and Arnau 2008). There are numerous cemeteries over the peninsula, from Cividale, Collegno, Dueville, Reggio Emilia, Verona, Vicenza, Brescia, Testona, Molise, Parma, Nocerna Umbra and Castel Trosino, among some with clear heterogenic usage by both locals and Longobards (Giostra 2001; Verreyke and Vermeulen 2009; Carrara, 2012; Squazza *et al.*,2015).

In the Apennine peninsula, Longobard cemeteries are showing the social structure as the members of different kinships and families form a certain community determined also by common cultural elements, both found on the living an the deceased in form of dress and grave goods (De Vingo, 2015). This prominence of wider family groups among burials is seen in the separation between the areas of the cemeteries, as well as spatial distribution among the wider groupings of the latter as well as differentiation in grave goods in terms of gender and age, as will be seen later. From the second half of the 7th century, the grave goods begin to decrease significantly, and more neutral elements, that is those that are not determining one's ethnicity, are increasing. Finally, during the 8th century, grave goods are no longer part of the burial (De Vingo, 2015). By the 8th century, it seems that Longobards were speaking a different language, and lost the cultural determinant in form of hair and dress styles and adopted Roman customs – a probable consequence of wide fusion instead of radical change in the social structure (Wickham 1983; N. Chrisite 1995).

Furthermore, the migration and the possible invasion itself has not affected every region the same, and it must have had a subsequent influence on settlement patterns and intensity as can be seen by the differences between the Po valley and the southern parts. What is more, it seems that by the end of the 7th century, duchies developed local culture – from social hierarchy to laws and customs – that formed through absorption of Roman landowners.

Burials as an archaeological premise

The burials inside the cemeteries are laid out in parallel rows outside settlements and along the communications formed the resting places of Longobard societies of the past. Plains at the foothills usually consisted of several grouped burials, but with the adoption of a new religion, a new common ritual was slowly established and it became common to bury alongside churches or funerary chapels. Most usually, the burials were in row graves from north to south, with orientation in the opposite, that is the east-west way. The burials or tombs had various typology, from simple earthen grave burials with or without wooden coffins, rectangular stone slabbed or dry-stone walled tombs, that might include a roof-like tiling cover, to the so-called houses of the dead. In terms of mobility, it is important to note that both in Pannonia and Italy we can observe the custom of marking a grave of the ones who died far from their home, as they were marked by a pole topped with a representation of a dove. The latter houses of the dead were also present in the society before arrival to Italy and were held up by wooden poles and represent the richest burials in terms of grave goods that were sometimes accompanied by horses of the deceased, thus clearly indicating their aristocratic position (Figure 3.) (Christie 1995; Brogiolo and Arnau 2008; Giostra 2011).

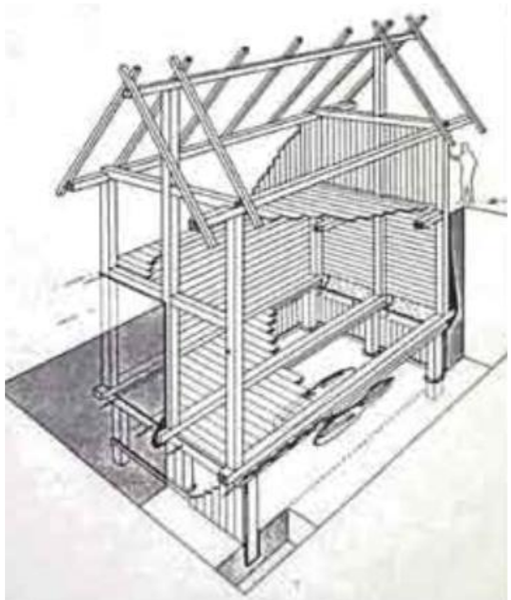

Figure 3. Idealistic representation of the "house of the dead" (Morandini 2013).

Archaeological material in form of grave goods represents a tool of identification of individuals in the earliest phases of cemeteries, as the dress and the garment acted as a representation of belonging to a social group before the traditions started to mix and create a new dress code (Table 1.) (Christie 1995).

The Longobard male dress included a linen or wool jacket and leggings or trousers that were decorated with broad bands of various colouration and secured at the waist with a belt that had a distinguishable suspension system for weapons and equipment as well as decoration with fittings, tabs, appliques and buttons. In terms of the latter, it usually included leather bags, armoured with horse equipment as spurs, saddle and stirrups, followed by shield, spear, a spatha type of double-edged sword and a dagger or sax. Furthermore, accessories as whetstone, flints, knives, combs or tweezer all represent common finds (Figure 4-5.) (Wickham, 1983; Christie, 1995; Koncz, 2015).

On the other hand, females wore long-sleeved uniform linen garments extending down to the knees and an outer one hanging down the shins while being adorned with jewellery, starting from brooches, earring and necklaces to hairpins. Among brooches, the most typical ones are the so-called Pannonian S-shaped, bow-shaped, disc and stirrup types. Similarly to men, ladies and girls wore a belt with ornamental cords as well as everyday artefacts as small knives, combs and pouches with spindle whorls, needles and scissors (Wickham, 1983; Christie, 1995; De Vingo, 2015).

From the chronological point of view, three phases of Longobard burials can be differentiated in Italy (Brogiolo and Arnau 2008; Giostra 2011; Possenti 2014). The first one lasting from 570-640 AD is determined by more complex burials with weaponry – spatha, scaramsax and shield bosses (umbos), belt fittings and characteristic S-brooches with zoomorphic motives. From 640-700 AD we can observe a general simplification and assimilation of customs as females start to wear Byzantine style brooches, while their counterparts start to lose their weapons. Finally, from 700-800 AD, females are usually buried without grave goods, while males show progressive loss of weaponry.

Table 1. Relative chronology of the Longobard burials

Phase	Local population	Longobard population
500-570 AD	Less grave goods Dress/Clothing Knives Combs	S-shaped fibula Gold zoomorphic crosses
570-640 AD	Byzantine Mask fitting belts Glass Basket or globular earrings Amphorae	S-shaped fibula Zoomorphic belt buckles Shield Scramasax and/or spatha Byzantine belts Gold crosses with Christian motives Combs Knives Longobard pottery
AD 640-700	Brooches Basket or globular earrings Combs	Disc fibula Geometric belt buckles Scaramax Basket earrings Combs Knives
AD 700-800	/	Rare weapons

Figure 4. Longobard male grave from Collegno (Turin) (P. De Vingo 2015).

What is more, these material possessions have been tied with divisions in Longobard society. Henceforth, heads of *farae*, the dukes, nobility, *arimanni/barones*, young or poorer freemen, the *faramanni*, semi-free people, the *aldiones* and servants or slaves that bear no arms, the *skalks/servi* can be hypothetically identified by their grave goods (Christie, 1995). It is interesting to note that among Pannonian burials, some anthropological studies have shown that the nobility seems to have been composed by Germanic part of the population, while the semi-free population was an of German and Roman descent, as well as the women, while the servants were mostly Romans or indigenous (Wickham, 1983; Christie, 1995).

We can attribute the grave finds to the classes of society as the laws from the 8th-century mention, for instance how a freeman, *arimannus*, should possess horses, shield, armour and a lance (Christie 1995). By the time of Agilulf's reign, the native customs, dress, and mannerisms of the Longobards had been largely replaced by those of the Romans. It is important to emphasise that our ideas of typical garments come from the part of the society that could afford one, meaning that we do not know much about the dress of broadest part of the population as such.

Question of Migration and Identity

If one determines the year 568 AD as the cornerstone of Longobard society, it should also be emphasized how the chapter of Paul probably does not represent an overwhelming evacuation of Pannonia, but rather that parts of the population might have moved to Italy in waves that could have differed in quantity as well as quality in terms of different social groups arriving at different time. Within the framework of this thesis, it is of lesser relevance to summarise the historical research thus far, but it can be said that the immigration to Italy has brought up several ideas – from one big migration (Pohl 2007), several smaller waves of migration led by dukes (M. Borgolte 2014), to only one part of the whole society migrating to Italy and the other staying in Pannonia (Koncz 2015). In regards to the same, the migration process represents an enormous logistical and organisational task that is rarely achieved for the whole populations. Furthermore, the parametric of the local population and their reaction to incoming Longobard population is still debated, and it varies from peaceful and negotiated accommodation on the land rather than extraction of property from the locals (S. Barnish 1986).

Archaeology or any other, be it humanist or natural, discipline does not possess the ability to access past social structure, ideology, habits, customs and rituals on its own. The latter can and often are broad and different than what is assumed and the best tool for interpretation is a multidisciplinary approach. The different analysis sheds different data that act together to give us better consideration of cemeteries and their spatial distribution, structure, presence and shape of grave goods, thus consequently leading to hypotheses of inter-connection between human remains and archaeological and historical context. For the latter, when it is available in written or oral form, we can specify plausible changes in a certain culture and see patterns within historical events. Anthropological markers such as age, sex, morphology, histology, traces of stress and disease, and of course the cause of death provide the texture to the history of individual and population at the same time. Only in this way can we model that acts both as „bottom-up“ and vice-versa information about past societies.

Longobards, Longobards or *Longobardi,* according to written sources, were a society first found living east of what is nowadays the lower Elbe River in Germany, during the first century AD (Jarnut, 1982; Hutchinson, 2005; Ausenda *et al.*,2009; Grimm, 2010). After not leaving a mark in historical sources for almost three centuries, they appear around 5th century north of the middle Danube, and after a crossing of the river, they expanded into the Roman province of Pannonia (modern-day Western Hungary, Lower Austria and parts of north Croatia).[2]

At the point of Longobard arrival, Italy composed a complexity and mixture in ethnicity's terms, with a late antique population representing the foundation on which levels of the new-coming Longobard nation was layering upon. Immigration, same as today, never happens at one instance but in a flow of steps, and at the time of Longobard Kingdom, it shaped itself from various directions. As the people of germanic origin came from east and north continental pathways, so did the eastern Mediterranean immigrants in those parts that remained out of reach for the Longobard rule (Wickham 1983). Questions about intertwining and connection between different people inside three centuries of historical Longobard context is a difficult one, ranging from the arrival and how it defined the existing society or has it formed a new one completely to patterns of shifts connected to the highest levels of society.

No matter how large the mass of people moving to Italy with Alboin was, among those said to be Longobards, they were a multi-ethnic group formed among others by Gepids, Heruls, Thuringians, Bulgars, Romans and others. Their number is estimated to have been around 80-200,000 individuals, it cannot be conceived to have migrated at once and all together in one crowd (Wickham, 1983; Christie 1995). What is unclear is if the whole population migrated at once or if it occurred in multiple waves (Posan 2015).

To conclude with, the Longobards seemingly did not move to Italy in one, but, more plausibly, in several migrational waves. Not everybody migrated to Italy after 568 AD, some must have remained in Pannonia (Posan 2015). Even Paul mentions that Alboin ceded Pannonia to Khagan Bayan only when the latter obliged to permit the return of Longobards in the next two centuries, while also being of helping hand to those who remained in Pannonia in peace under his authority (*Hist. Lang.* VII).

[2] Interestingly, we do not know if the mentioned represent the same society and poulation or it is acutally and adoption of an old ethnic name.

How to frame the movement of a population?

To begin with, it must be stated that we know far more about the Longobards in death than in life. Settlements are far behind and elusive in terms of our knowledge, whereas thousand of burial are known and attested. In Italy, large cemeteries such as Testona, near modern-day Turin or Castel Trosino in Marche have over two hundred graves, and similar concentration is evident in the region of Cividale in the north (Christie 1995). Needless to say, a lot of excavation happened during the middle part of the last century, when anthropological data and analysis were in its formative years, thus leaving us with restricted pieces of information. The state of the archaeology of that time focused mainly on the material, and establishment of chronological frames.

The Longobard identity in archaeological context includes their burial practices, along with the goods found in the latter. Archaeological material remains as the most used in researches that focus on their distributions across the plausible migration routes (Giostra, 2011; Possenti 2014). One can argue if an individual's objects or dress define its ethnicity, but it is more than welcome to use different evidence that will frame the same – thus, the combination of historical, archaeological and biological record would provide a more complete picture of the process that took several generations.

Some authors argue that social dynamics of Longobard migration to Italy (Roymans and Heeren, 2017; Heeren, 2017) demand exactly this kind of approach as the grave good assemblages do show how local population intertwined and integrated newcomers gradually, as the material goes through gradual change at the same time (Giostra, 2011). Needless to say, ethnicity represents a complex concept prone to change and layering in a different environment, and so the identification through grave goods could be regarded as the formation of identity that is confident to a cultural environment one finds himself in, rather than marking a definition of a specific ethnicity.

Inside new historical occasions, societies go through a transformation, and interaction clearly shows the exchange of customs. Recently, some authors (Burmeister, 2000) pondered how migration requires archaeological proof and a theory that comprehends migratory behaviour. On that note, historical sources should not be interpreted solely but in combination with archaeological material, anthropological record and archaeological sciences that analyse human remains. In terms of the former, deviations from typical burial typology and grave goods can be regarded as a potential non-local origin, in addition to demographics that can indicate migration as sex and age distribution suddenly show change. Following, the later can enhance our understanding of the mobility in combination with their burial context through isotopic study which makes up „bottom-up“ approach formed on evidence (Hakenbeck, 2008; Killgrove and Montgomery, 2016). On the question of migration, we must hereby enhance the question of whom migrates, and thus it represents selection inside one population – thus leading to a different generation of migrants that can be identified in isotopic studies. This selection can be driven by a multitude of motives and factors, and have a different impact (Anthony, 1997; Burmeister 2000). Migration can be driven by economic reasons, natural disasters, food shortages, war, overpopulation and so on. Furthermore, genders differ in the ability to move and be mobile so to speak. It can easily be deduced that migration exists on many variables that can differ on local and regional movement patterns. One specific type of movement creates a chain reaction where a known route to new destination represents information that is passed on from earlier to later populations that migrate, and this seems to happen during the movement of late antique societies that are based on kinships (Anthony 1990). What is more, when movement is across long distances, it usually happens on previously shaped routes and paths and more often then not creates a series of segmented movements inside migration.

Tracing the Longobard migration to Italy in form of archaeology had proven to be difficult as traces are not numerous, thus analyses on remains are more and more used for its reconstruction in addition to new linguistic studies and settlements planimetry being discovers (Ausenda *et al.*,2009).[3] Grave goods that belong to Longobard material culture are readily found along the routs from modern-day Hungary to Italy, while DNA studies have also very recently identified non-locals from northern Europe that can be seen in the lines of historical sources as well (Possenti 2001; Amorim *et al.*,2018). Despite the multidisciplinary approach, the question of whether Longobards moved or invaded, how many of them took part in those actions, and which part of the population migrated remains open. Therefore, the goal of this thesis is to try and interpret the obvious changes seen from material cultural onwards, but in form of human remains to inquire that might shed new light on migration process that took place. This research aims to identify possible migrants from the Longobard migration into Italy and reconstruct the historical context using strontium stable isotopes analysis.

[3] For new research on settlement architecture that shows similarites to the ones found in Hungary see Negrelli 2013.

Some authors have estimated that the Longobards made around 8% of the population when they arrived and finally settled among a heterogeneous population of Romans and those who invaded Italy before them (Barbiera and Dalla-Zyanna 2009). Whether they were assimilated through social and economic trends remains to be seen (Wickham 1983; Christie 1995)

Until today, the mobility of the Longobards has only been analysed by a pair of researches based on cemeteries from Pannonia and Italy. Firstly, migration of the society from Szolad during the 6th century AD has been studied with help of strontium isotope and ancient DNA (aDNA) (Alt *et al.*,2014), and similarly, not long ago, an ancient DNA study that incorporated both Szolad and Collegno cemetery in Italy has been made (Amorim *et al.*, 2018). From an archaeological perspective, Castel Trosino and Nocera Umbra which were located towards the Adriatic in the corridor from Ravenna to Rome, represent the best-excavated cemeteries with broadest ability to give insight to Longobard populations of the first half of the 7th century (Parolli, 1997; Parolli and Ricci, 2005). The latter represents a location on the borders between the Kingdom and the Exarchate, and as such show similarity to Selvicolla cemetery.

Based on the historical records, the Longobards spent just twenty years in Pannonia, and the researchers aimed in confirming their presence among the population through the sampling of teeth enamel, thus the results showed that inside the heterogeneous society, at least 22 different haplogroups of European and Near Eastern origin. Some groups showed plausible kinship relationships, on the other hand, it shows the heterogeneous nature of the migrating Longobards as well. Almost a third of the individuals were buried outside their birthplace, and interestingly females seemed to be more mobile. One important fact that was also confirmed is that newcomers laid their members to rest next to the local population.

Likewise, the cemetery of Collegno has a historical overlap with arrival of Longobards, and through comparison of ancient DNA results with those deriving from Szolad, researches found clusters of ancestry, within which individuals belonged to northern or central Europe and South Europe. By identification of these groups, a comparison with the grave goods was enabled, thus showing that the Longobard material culture matches with the former group of individuals, who were also more related to populations from the north. The other group with southern origin ties up with more simple burials or with those that had no possessions in them, leading to their identification as locals. Furthermore, strontium isotope ratios signalled that individuals with northern ancestry have a signal separated from the local range.

As for Castel Trosino and nocerna Umbra, they were in use for around a century and a half stretching from the end of the 6th century or better said the arrival of Longobards per se. It seems that the population of the former, which also hosted a church, was represented in several groups of families buried in clusters, and a similar situation is found in the latter. Based on the fact that Nocerna Umbra shows graves richer with weaponry, it has been hypothesized that it could have been a military outpost with a settlement on the route between Rome and Ravenna, while Castel Trosino has more concentrated grave goods of Byzantine origin for instance, deeming it a more rural community. Similar characteristics can be searched for in the case of La Selvicolla as well.

At the end of the chapter, it can be concluded how the integration of historical data, archaeologically recovered remains, and stable isotope analyses will provide the theoretical foundation within migration research to understand the processes in the Longobard arrival. Understanding who migrated and when is important for interpreting the diffusion and assimilation of societies and cultures with help of the following questions: 1) are non-local populations (Longobards) identifiable in the cemetery samples; 2) if they are, are their variations in between non-local and local populations in terms of archaeological context and 3) are there any socioeconomic differences in status and sex.

Figure 5. Grave goods from Longobard burials of Castel Trosino (L. Paroli 2005).

Chapter 2. THE ARCHAEOLOGICAL SITE OF SELVICCIOLA

The following chapter intends to introduce the archaeological site of Selviccola from which the derivate sampled human remains come from. Focus is centred on simplified historical and archaeological context, without exhaustive and detailed introspection of the material itself as it serves as a chronological and cultural identification.

The site of Selviccola is located on the fringes of Lazio and Tuscany, along what was once the *via Clodia*, stretching somewhere around 40 km north-west of modern Viterbo in the town of Ischia di Castro. More precisely, the site is found on, among many other, on a plain between the coast of the Tyrrhenian sea and lake Bolsena, with the latter attracting people in historic times as essential water and agricultural source (Tafuri *et al.*,2018).[4]

Historical source about this region are scarce, however, lines form the manuscript *Registrum gregorii*, a collection of letters by pope Gregory the Great, produced at the end of the 10th century by an anonymous working in churches of Trier (Greg. Magn., Ep. II), shed some light.

Most important information is obtained from the mention of the first siege of Sovana by the Longobards, which is found roughly 40 km to the north-east from the site of Selvicciola (Greg. Magn., Ep. II, p. 29 e p. 38). Furthermore, the skirmishes and attacks in outskirts of Rome by king Agiluf in 592 AD are attested, as well as Byzantine response when the centres of upper Lazio and lower Umbria in Sutri, Bomarzo, Orte, Todi, Amelia, Perugia, Luceoli and others succumb to their forces. Soon after, Agiluf attacked once again and managed to capture Perugia, Orvieto and Bagnoregio (Paulus, *Hist. Lang.* IV, 32). Nonetheless, as has been mentioned before, all of this region finally fell under Longobard rule at the beginning of 7th century, most probably around 607 AD (Rasppi-Serra and Laganari Fabiano, 1987; Cambi and Valenti 1994; Citter 1997; Incitti, 1997).

What this meant for old landowners, and how the landscape changed is still being hypothesised. Archaeology has been able to identify some edifices, villas and churches such as San Marcellino in Chianti near Siena, Mola di Monte Gelato near Mazzano Romano and the ones of Selvicciola

[4] *Exempli gratia* barley and wheat have been found in latest studies. For isotopic studies of late antiqutiy in Italy see M. Marinato 2019.

which all seem to imply establishing of new communities and networks in the new territory (Citter 1997). The latter is confirmed by the formation of the truces in 605 and 606, and finally the peace treaty in 607 AD (Rasppi-Serra and Laganari Fabiano, 1987; Maetzke 2002). Longobards seem to have established a defensive line in form of forts and promontories or *castra* stretching from Viterbo to Orvieto as the geographer Georgius from Cyprus describes in his *Descriptio orbis Romani* (Petracco, 2018), while a century later, under king Liturpand, the territory expanded furthermore. However, during pope Zaccaria (*L.P.*, I, *Zacharias*, XCIII, p. 429) some parts were released to the Papacy, but this kind of arrangement has not lasted long, as the Frankish conquest happened shortly after, and Charlemagne acknowledged the sovereignty of Rome through series of land donations.

Some authors argue (Pellegrini 1990; Incitti 1997) how toponyms still hide names of the places in upper Lazio with Longobard origin serving to accompany the present archaeological information in the same. Based on the topographical analysis and archaeological remains, it seems that Longobards reorganised the territory based on the small settlements; thus their distribution allows us to distinguish continuity and abandonment (Pavera 2008).

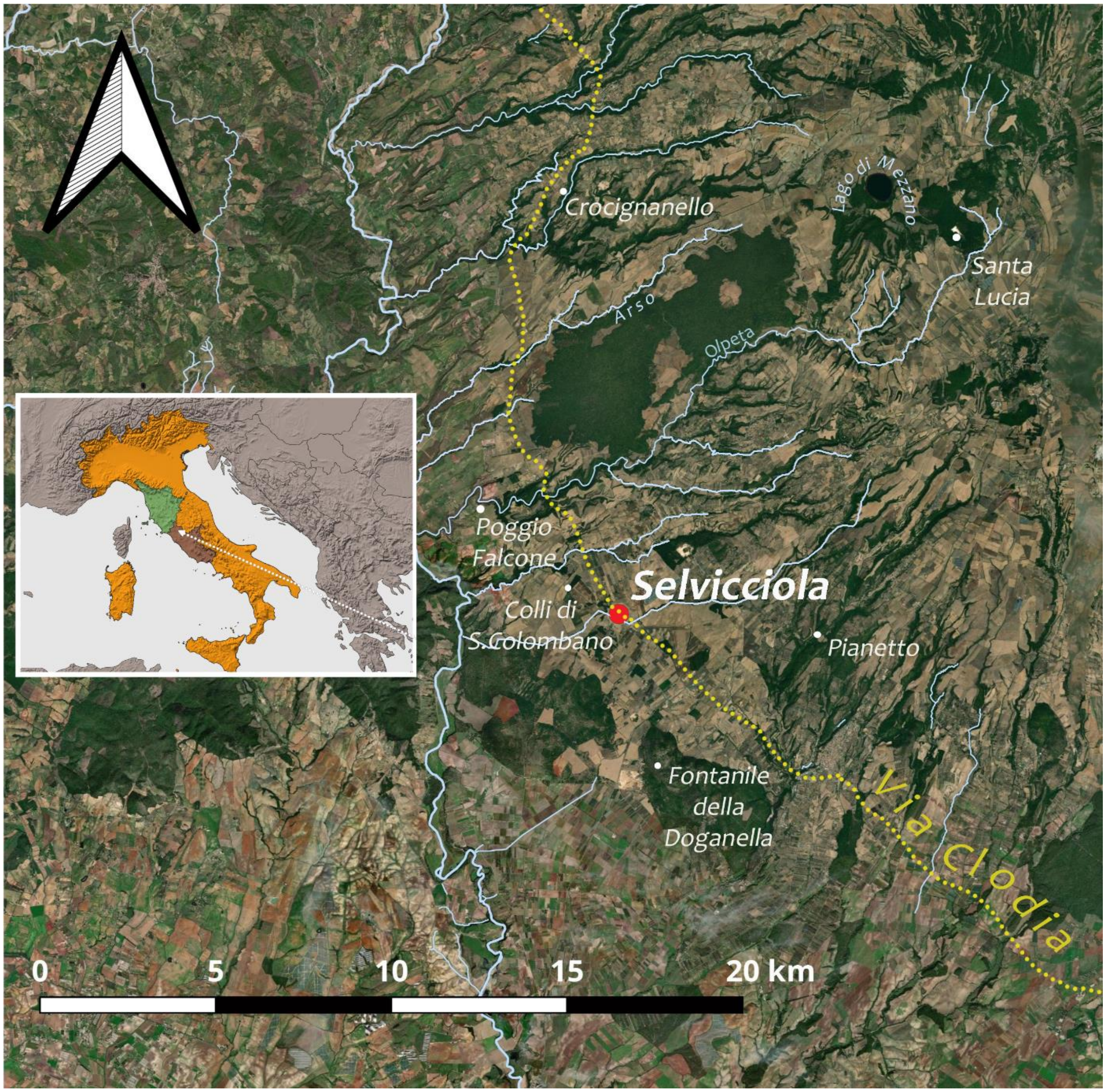

Figure 6. Location of the archaeological site of Selvicciola and other Longobard sites in the area (Luka Drahotusky-Bruketa).

Q2.1 History of research

Before attempting to create new contexts in the shape of a migration study of an archaeological site and its population, one ought to present and consider the history of studies of the same – from excavation, documentation and bioarchaeological data present thus far. A reference was created with documentation of tombs and their grave finds[5] to accompany the new data and allow summarized overview (see Micarelli, 2020; Table 2.2.2-3).

Based on the surveys and excavations in the area of Ischia di Castro that have taken place since the end of last century, most sites are dated to the periods before the Longobard kingdom (Incitti 1997). Excavation of Selvicciola began in 1982 after the intervention was needed due to illicit activities at the site, and so the remains of the Roman villa and cemetery nearby have been brought to light (Gazzeti 1997). The archaeological research is still ongoing in the area of the villa, wherein the earliest campaigns, the focus was on the remains of the church and its perimeter (Toiati and Pontacolone, 1985; Incitti 1997). In the next ten years, most of the funerary area has been excavated and most of the hereby presented documentation is derived from the same (Figure 7-8.).

Figure 7. Aerial view of the site with the remains of edifices and the funerary area.

The earliest publication followed the same course, so during the first years of the excavation preliminary reports about the finds have been regularly published and first attempts at creating of the chronology of the site has been made (Gazzeti, 1985; 1995; 1997). Thereupon, the site has

[5] In this way I thank my colleague Ileana Micarelli for sharing precious information, data and photographs coming from her unpublished PhD thesis.

been chronologically framed between the second half of the 3rd century BC and the 8th century AD (Gazzeti, 1985; 1995; 1997; Toiati and Pontacolone, 1985; G. Chini 2009). Besides, analysis of the funerary area and grave goods, more specifically the garment and clothing has been made by Incitti (1992; 1997), who recently also classified the burials by typology, and whether the deceased wore weaponry and armour, as well as whether they possessed pottery, glass, jewellery and coinage (2002). Finally, the presentation of the excavation of the church and funerary area, as well as the catalogue of finds in the *Museo Civico Archaeologico „Pietro e Turiddo Lotti"* in Ischia Di Castro had recently been done by Patera (2008).

Regarding the anthropological collection, is found almost entirely in the Museum of Anthropology "Giuseppe Sergi" at the Department of Environmental Biology of the Sapienza University in Rome. Study of the skeletal morphology and dental pathology, as well as the recent works on the paleo diet and possible presence of infections, have been published and serve as further differentiation inside the population itself (Manzi *et al.*,1995; Passarello *et al.*, 1995; Salvadei *et al.*, 2001; Tafuri *et al.*, 2018.; Micarelli *et al.*,2020).

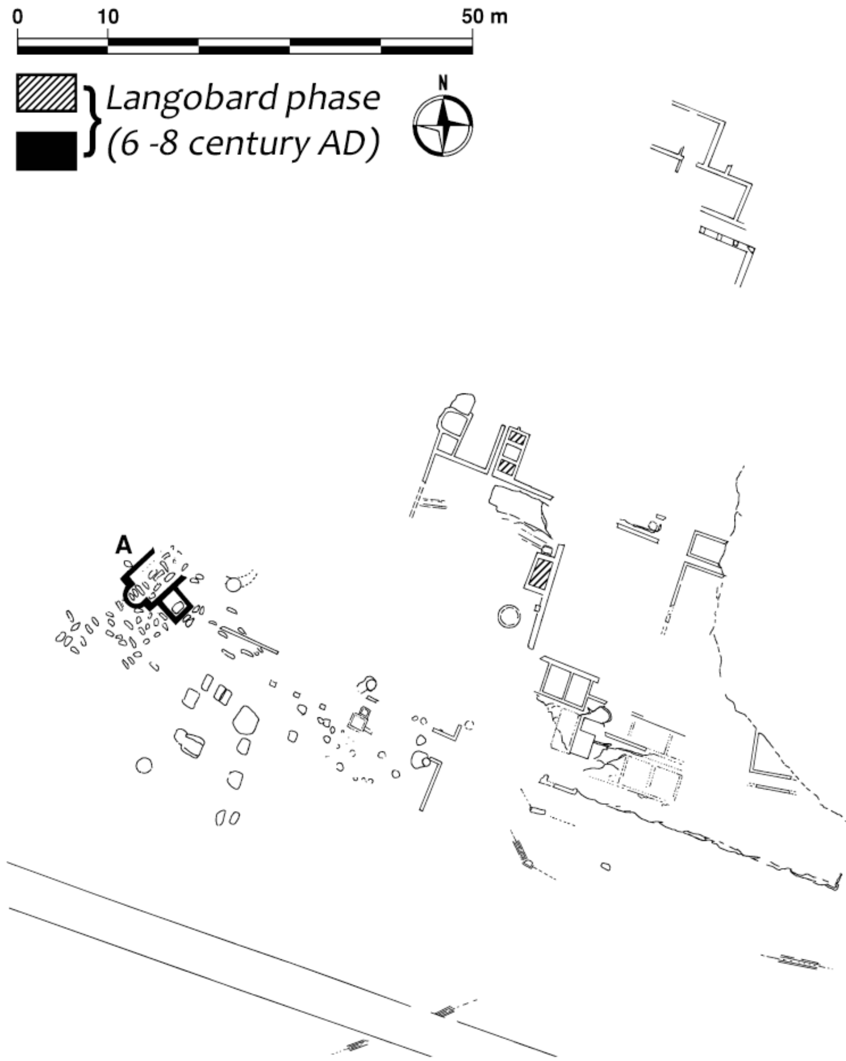

Figure 8. The site during the Longobard phase (adapted from Incitti 1997).

2.2 The Roman villa

The earliest of the six identified phases of the Roman edifice (Figure 8.), spreading on the natural terraces of travertine and tuff forming the natural ground of the site, has been built between the end of the 4th and the beginning of the 3rd century BC, and mark the oldest traces of the late Etruscan settlement (Gazzeti, 1985; 1995; 1997; Carandini *et al.*, 1985; Toiati and Pontacolone, 1985; Patera 2008). From this oldest phase-only three wells remain and similarly scarce are the traces of the subsequent republican phase that is represented almost exclusively by the material and artefacts used for the in-filling of the wells later on.

Shortly after the fall of Etruscan Vulci to Romans in 280 BC, it must have been attached to the aforementioned *via Clodia* as well as *via Aurelia* nearby (Figure 6.), Afterwards, we can witness several series of structural change until the time of Augusts when greatest renovation happened, as additional rooms, thermae and adjoining hypocaust with adjacent aqueduct leading from nearby mountains named Canino, and which also branched out furthermore, are being built. During the 2nd and 3rd century AD some renovation and maintenance have been made, e.g. new tiling and cisterns for animals thus clearly indicating that the villa and its production were also active as is evident in the existence of a torcularium for crushing of the olives with the collective tanks on the northern side of the peristyle, also a small quarry was active in this phase (Figure 9.).

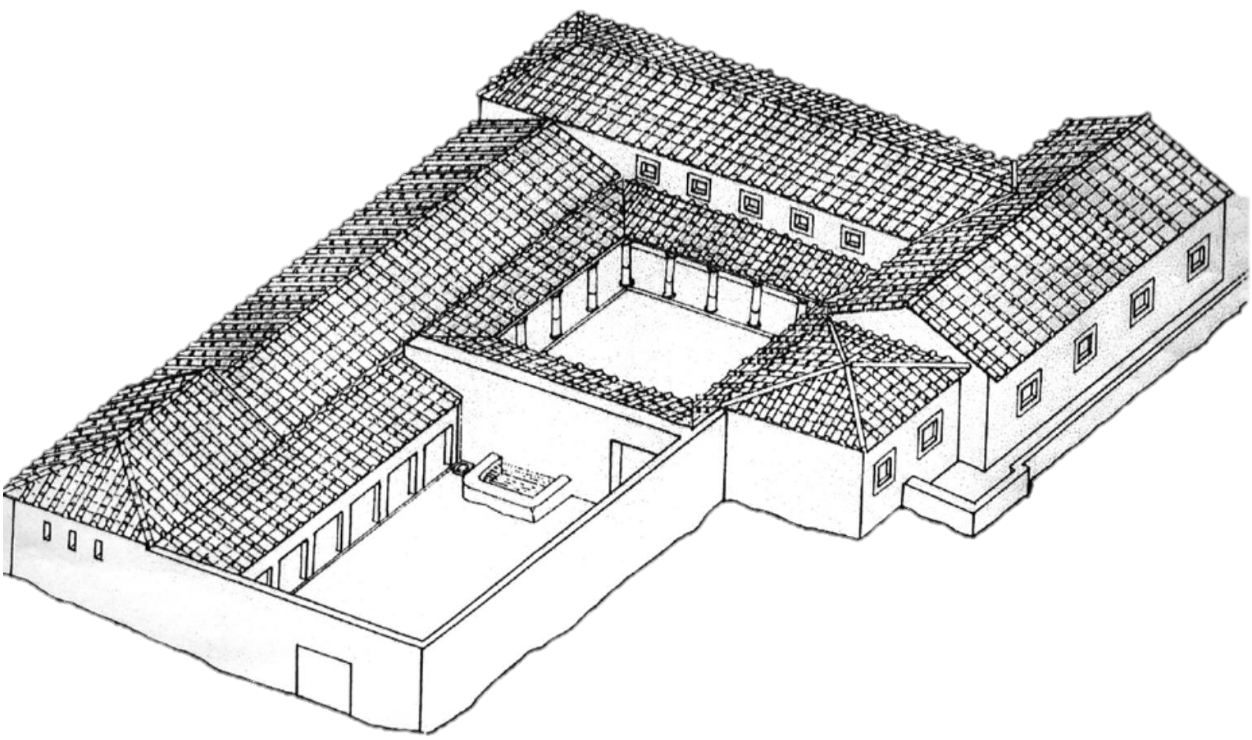

Figure 9. Reconstruction of the villa (Patera 2008).

In the end, sometime during the first half of the 5th century villa was abandoned as can be seen through the layers of rubble and decay as finally at the dawn of 7th century we can attest that the earlier flooring of the thermae being remodelled as wooden pile holes was dug through *opus signinum*. A similar transformation is seen in the peristyle, while the atrium and oil reservoirs were filled up by older discarded material, e.g. north African ware or Lunesse marble (Gazetti, 1997). Some authors interpret the changes as a consequence of lowering the nearby groundwater as it might have affected the production of the villa, thus leading to pastoralism (Patera 2008).

At the present state of research, it can be deemed that the villa formed a large rural complex with several parts – the centre based around the peristyle with the eastern side that collapsed in the nearby stream. Following, the second part is formed in the southern areas around the atrium with a cistern (*lacus*) and finally the oil production areas (*pars rustica*) with garbage disposals and animal housing (Gazzetti 1997; Patera 2008). Furthermore, a granary with wells and silos seem to have functioned at a certain point. As the villa is being excavated still, we can only wait for new data to attribute the changes that might be connected with the arrival of the Longobard community.[6]

2.3 The Church and the Cemetery

As for the funerary area, the oldest burials date between the end of the 4th and early 5th century, some of which were subsequently destroyed by the foundations of the church dated to the middle of 7th century (Gazzetti, 1995, 301-302; Incitti, 1997, 216; Patera, 2008, 59-60). The church itself, as can be seen by its foundations, is orientated south-west to the north-east and represents a fairly simple structure consisting of the single nave ending with an apse (approximately 14.55 x 8.55 m) and additional spaces on its eastern side (Figure 10.).[7] Outside, the foundation of a circular building, perhaps a baptistery have also been found. Fragments of painted plaster, marble tesserae and vitreous plates have besides been recovered inside and will certainly create a new hypothesis about interior decoration in the future.

[6] Plant remains are being studied at the Faculty of Botany of the Sapienza University of Rome, while the wood and bronze materials is analysed in th elaboratories of the Soprintendenza Archaeologica per l'Etruria Meidional di Civitavecchia and Viterbo.
[7] The church is still being excavated under directon of Gazzetti and GAR Romano.

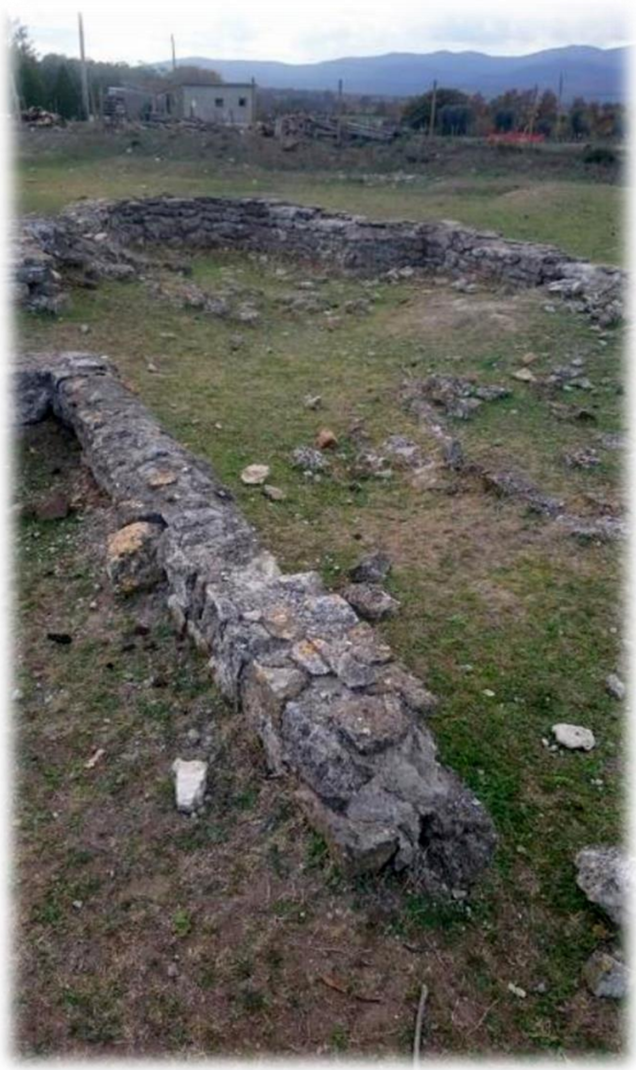

Figure 10. The remains of the church (Photo Micarelli 2020).

More than a hundred burials have been excavated and documented in various states, as unfortunately some tombs were damaged to a certain degree by extensive ploughing and exploitation. On the other hand, some tombs have been reused for several burials or reopened even during ancient times as they were either looted or for transfer of the deceased to new resting ground inside the church.

The burials themselves are organized in four groups, forming sort of clusters or “core groups” based on their proximity to each other which seems to follow different chronology and orientations as well. In a total of 97 burials are present within the area (Incitti 2002; Patera 2008). Despite the devastation due to continuous ploughing, we had the fortune to identify the type of structure that formed the tombs. From the point of view of their architecture and construction, they can be divided into three categories distinguished by coverage or simply put roofing in form of stone slabs, the double-pitched slabs or the so-called *cappucina* or brick roof-tiles (Figure 11.). The grave pits and their construction can also be further divided into three types of structures – ones with travertine, tuff or volcanic rocks, with smaller chipped stone and pebbles and in the end with reused material or spolia from earlier Roman graves. What is more, in terms of stratigraphy, which is mostly established inside the area of the first group, which will be represented later, it shows that the tombs covered by roof tiles are sometimes earlier than those covered with slabs. Also, some of the former are disturbed by the foundations of the church. It seems that burials that followed the construction of the church wherein most cases built with a stone instead of roof tiles. Thus, it seems that the choice of the same is related to chronology instead of a specific social phenomenon (Incitti 2002).

By the same token, it is important to note that the oldest burials are contemporary to the church as can be seen by the grave goods as well. The establishment of the Longobard community on the pre-existing Roman villa happened at the end of the 6th or the beginning of the 7th century. Still, we do not possess elements of equipment among the grave goods that can be dataset to that age, and it has been speculated that the oldest phase has been destroyed as a consequence of agricultural activity in more modern time (Incitti 1997; 2002; 2002a).[8]

[8] Incitti interestingly notes that the absence of the oldest weaopnery and garment is attributed to decline of Langobard traditions (2002, 374).

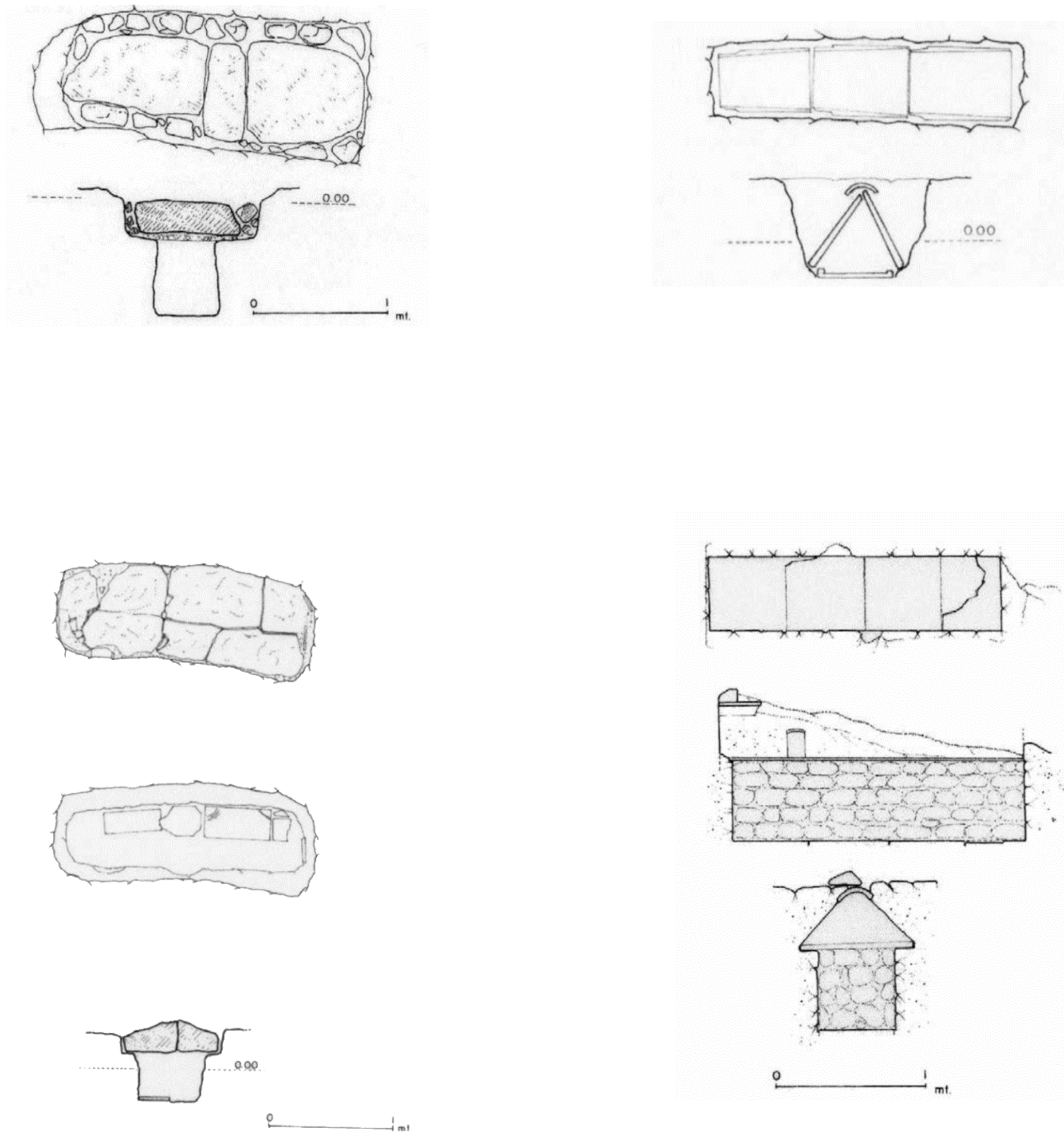

Figure 11. Different types of tombs found at the cemetery (adapted from Patera 2008).

The entire area of the cemetery, covering roughly thousand square meters, is a space in whose centre the church is found and the burials are distributed both inside it, and across the space spreading south of the latter (Figure 15.).

Collectively, tombs are sometimes used for several burials, thus meaning they were at certain point opened and cleaned by the community using the cemetery, and as archaeologists, we ought to be careful in our interpretation as one can easily assume it was a consequence subsequent agricultural activity. With the help of archaeological and skeletal documentation, the tombs can be identified, and the remains of the deceased can be found intact or with above mentioned secondary or tertiary burials in the later fillings or individuals being placed over the covers of the previous ones (Micarelli 2020).

Chronologically, the cemetery was in use from the end of the 4th until the beginning of the 8th century AD in what seem to be three different phases connected with historical changes occurring at the same time (Micarelli 2020):

- **1st phase**, lasting from the *late 4th century* until the early *6th century*. is associated with the abandonment of the villa
- **2nd phase**, starting at the end of the *6th century* until the *7th century* as the church was constructed
- **3rd phase**, from the middle of the *7th century* until the early *8th century*, is attributed as the Langobrad phase.

As can be seen, the cemetery developed in stages, and in a relationship with the building of worship, that is the church, as the closest burials being contemporaneous with its foundation. Later on, the changes in typology and orientation of the burials, followed by grave goods patterns give us the idea of the organization of the funerary area that seems to have a binary direction of clustering. Firstly, grave rows developed in the directions of north and south both inside the church and in the south of the same. Secondly, the organisation of the new burials took place following the church. Finally, some east-west oriented burials are also placed side by side by establishing a north-south alignment that is attested in what we might define as the Germanic environment and customs found in several other Longobard cemeteries found in Testona, Nocera Umbra, Collengo and Castel Trosino (Amorim *et al.*,2018). As it is present elsewhere, it should be related more to social and topographical causes rather than ethnic or ritual ones (Incitti 2002). Since we do not possess information about all of the singular burials, some are left undocumented thoroughly or better said without numbering and description or better said without proper identification.

This is important due to the necessity of identification of burials as Longobard or other, and for us to attest the stratigraphic and grave good relations, before attempting to do further migration study. The following lines will try to describe some of the burials and the material found in them to establish the aforementioned, without specifically choosing the ones that will be used in the isotopic study, as they do not necessarily represent the ones that describe the development of the funerary area in this sense.

As can be seen from the plan of the cemetery (Figure 15), the construction of the church, as has been mentioned before, has affected the burials that seem to have been constructed before it. Based on the documentation and by the look at the area of the cemetery it can be seen that several burials located at the apse and along the southern perimeter wall that has been somewhat disturbed by the foundations of the building (*t 86/3 ; t 85/5 ; t 85/11*). Moreover, based on their positioning and orientation, that differs from that of the church perimeter walls, and accordingly, it was concluded how the funerary area certainly predates the church. Besides, their typology was not determinable as it was destroyed in all cases but one of the tomb (*t 86/3*) on the outside edge of the apse which showed a brick tiled paved bottom and coverage in form of roof tiles. This burial is important in senes that it represent a *terminus post quem* for the construction of the church as the grave goods, especially the earrings, jugs and pitchers with characteristic red decoration, allow the dating between the second half of the 5th and first half of the 6th century or what is deemed as the last stage of the initial period of use of the whole cemetery.[9] What are more, glass fragments and lamps from other two earlier tombs represent the finds that are more often found in the period preceding the Longobard arrival (Incitti 1997, 216-218; Micarelli, 2020). On the other hand, the *terminus ante quem* of the construction has also been framed before the 7th century through grave goods of the other roof-tile burial inside that follows the orientation of the perimeter wall (*t 82/1*). These included a bowl and olla shapes with decoration characteristic of the 4th and 5th century and silver earrings dated between the 6th and 7th century belonging two different individuals of the burial above (Fumo, 2010; Micarelli, 2020).

[9] Dating is based on the comparison with similar findings among other Langobard cemeteries. Compare with the Catalog of the exhibition „Lonogbardi. Un populo che cambia la storia“ and tables with finding of Bardonecchia (tab. 7), and Cesana (tab. 2). On the typology of earrings see (Baldini Lippolis 1999).

Figure 12. A selection of grave goods from tombs of Selvicciola - shield umbo (t 82/2), pottery (t 82/1), earrings (t 85/3) silver and bronze pins (t 86/6 ; 85/18), saxes and reconstruction of the belt (adapted from Pavero 2008).

To conclude with, based on the goods, the dating of the construction of the church most certainly precedes the beginning of the last, that is the Longobard phase of the cemetery (Figure 12). Interestingly, the intact roof tile burial with the brick tile paved bottom (*t 82/2*) inside the church that is completely aligned with the above mentioned, held remains of an adult male with remains of a defected shield and datable umbo that are characteristic to the middle of the 7th century (Incitti 1997, 220; Micarelli, 2020). This individual seems to represent a person of higher rank placed in what might be interpreted as a privileged position, and this can be seen in other sites such as Pisa, Lucca or Chiusi (Citter, 1997). It is hypothesised the latter might be the founder of the church himself as next to his remains, a niche was found with repositioned remains and it seems to have been built at the same time as the tomb. Be it as it is, the whole church was used as a funerary area as several tombs show. Among the latter, one can distinguish between those that follow the layout of the church, while others seem to have been incorporated after the construction – as is the case with the ones, once again roof-tiled, found in the apse (*t 85/1 ; 85/10 ; 85/14*). Hence, it should be concluded that of the church is based on the dating of the goods and will most certainly be advised in the future with the analysis of C-14 on bone remains coming from the burials aforementioned.

Figure 13. Reconstruction of **cappucina** ***burial (t 82/3). (Patera 2008)***

Having said that, looking at the area outside the church, spreading along the south perimeter wall another set of grave rows (*t 85/5; 85/11; 85/16; 86/1* and other without documentation), positioning from north to south, can be seen arranged in the same orientation as the ones found in the apse and centre of the church (*t 85/2; 82/9*). Also, seven of them showcase the *cappucina* roof (Figure 13.) tile cover with brick tile paved bottom (*t 85/3; t 85/4; 85/9; 85/13; t 85/15; t 85/17 and 86/1*), four are simple earthen pits (*t 86/6 ; 85/7 ; 85/8; 85/12*) and in further two cases, the cover has been made out of double-pitched stone slabs slope (Figure 14.) (*t 85/18 ; 85/19*). Most of the latter are without any grave goods, but jewellery in form of pair of glass pearled earrings and banded, as well as pearled rings from two burials *(t 85/3 ; 85/15*), allows the dating of the same around the middle of the 6th to the middle of the 7th century (Micarelli, 2020, note 598). Ultimately, it is possible to place all the burials of this group before the last phase of the cemetery, but at the same time after the construction of the church.

Figure 14. Reconstruction of the tomb 86/16 with stone architecture (Patera, 2009).

Further on, two more groups of burials are stretching towards the west of the church, one in the proximity of the apse and the other on the western edge of the funerary area. Hereby, the orientation seems not to follow one course, thus south-east/north-west orientation is found among the burials adjacent to the church (*t 86/10 ; 86/2 ; 86/4a ; 86/4b ; 86/6a ; 86/6b ; 86 /7; 86/8 ; 86/14 ; 86/12 ; 86/13*). Moreover, this group is almost completely formed by earthen pits, with exceptions where again roof tiles and paved bottom occur (*t 86/7*), along with one interesting case (*t 86/8*) where spolia in form of older roman marble tombstone next to irregular stone grave walls and roofing is found, by the side of two examples of burial pits formed again with larger stone slabs (t 86/6 ; 86/14). In the case of the former with architecture, once again we do not observe grave goods in the *cappucina* burial, nonetheless, in the latter ones where the use of stone is observed, knives, parts of the same or the sax swords, and a pin with a characteristic banded shaft that show similarities with the ones found in Castel Trosino and Nocera Umbra, where they have been dated at the beginning of the 7th century,[10] are found. Consequently, we can frame the same in the last phase, except for the *cappucina*, whose typology is found only during the first phase and is never associated with warrior burials (Micarelli, 2020, note 603).

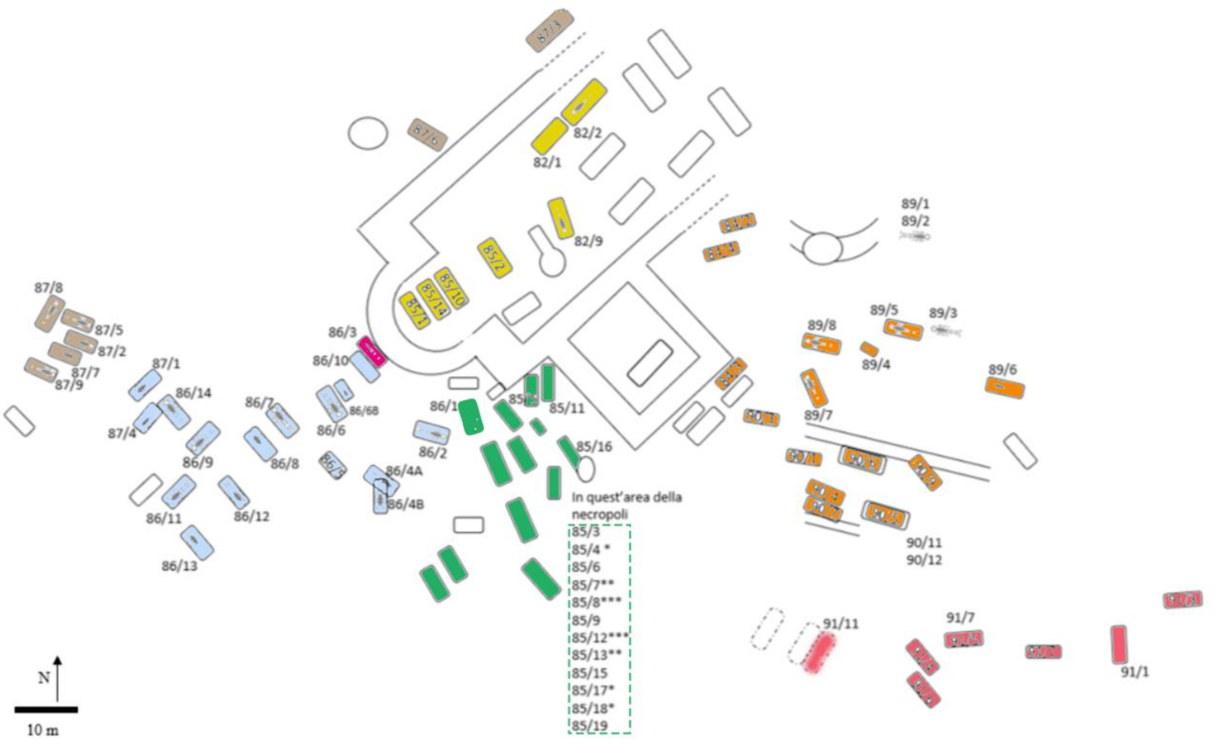

Figure 15. Plan of the cemetery - different groups of burials (Adapted from Micarelli 2020).

It should be noted that during the final phase, grave goods of the male population are always based upon weaponry, while in the female burials we observe a complete lack of objects which seems to point to the wider phenomenon in Italy in this period, but it could also mean that these individuals do not necessarily belong to Longobard community *per s*e. This is evident in the group of male adults (*t 87/4 ; 86/9; 86/11; 86/8 ; 86/13*), that might be deemed as warrior burials found clustered southwest from the church, as they have been buried with weapons and in some cases belts with

[10] Compare with L. Parolli and M. Ricci, 2005, tab. 147, t. G no. 5; t. 115 no 2; t. L no. 2.

sealings that date them in the final third of the 7th and the beginning of the 8th century (Incitti, 1997, fig. 1;11-12.). In the case of the weaponry herewith, finds of spurs and belts with seals of different typology are a rare artefact as they plausible represent a symbolic and prestigious accessory, nonetheless, all together can be dated in the latter time-frame mentioned. In several burials, individuals are accompanied by a sax or scaramsax sword found throughout the 7th century, similarly to plate-shaped belt buckles (Incitti, 1990; Patera 2008). On top of that, bone combs, usually without decoration, and flints are usually both associated with the burials above. One specific case from this group and in the whole cemetery is the individual (*t 86/8*) buried with several arrowheads and possibly parts of the quiver, as the positioning of the former indicates, and more importantly a series of coins out of which only one is preserved enough to be identified, thus it was dated in the first half of the 4th century. However, the rest of the grave goods belong to the second half of the 7th century (Patera 2008).[11] Also, one interesting case of this group is seen in the infant individual (*t 86/5*) with grave goods that are usual for warriors, such as belt elements and buckle accompanying him. Coming to conclusion, it can be perceived how this group represents a group of younger warriors buried and deposited at a separate part of the necropolis for certain reasons.[12]

The westernmost group of burials (*t 87/8 ; t 87/5 ; t 87/2 ; 87/7 ; 87/9 ; 87/6*), shares similarities to the former one with different orientations, as either south-east to north-west or north-east to south-west orientation is evident. In terms of tomb typology, once again we can find an earthen pit (*t 87/2*), a *cappucina* cover with a brick tile paved bottom (*t 87/7 ; t 87/9*), one case of paved bottom and stone walls (*t 87/5*). Interestingly, none show finds associated with the garment, thus it can be hypothesised that this group belongs to the earliest phase as the *cappucina* burials are present only during that period.

Besides them, a large group of burials found east of the church, among which most are simple earthen pits with few exceptions in form of the paved bottom (*t 84/2*), stone structure (*t 90/4 ; 90/5 ; 90/6*) and tombstone, that is a spolia cover (*t 89/8*). Some cases in this groups seem to follow the orientation of the church (*t 84/2 ; 84/3 ; 84/4*), but here we also observe two parallel walls of an unknown function, and curiously the burials (*t 90/3 ; 90/1 ; 90/6 ; 90/4 ; 90/7 ; 90/5 and 90/9*)

[11] There are other coin finds (*t 86/9 ; 86/14*) but unfotunately their state does not allow us to date them.
[12] Based on anthropological analysis they are from 20 to 40 years of age (I. Micarelli, 2019, note 607).

placed there to follow their southeast to northwest orientation. On the other side of the walls, burials also follow the same pattern and order (*t 89/8 ; 89/4; 89/5; 89/7; 89/3; 89/6*).

In the end, a group at the southeast part of the cemetery shows a cluster with different orientation (*t 91/11 ; 91/4 ; 91/6 ; 91/1 ; 91/2; 91/3*). Among them we can observe a tomb (*t 91/5*) that was reused, thus the younger individual's resting place was reshaped as another woman, along with a ceramic mug and a double rowed comb without, was placed there too. Inside other, only pins and elements of the belt are found, all in all belonging to the second half of the 6th century or somewhere in between the middle and last phase of the cemetery.

Anthropological analysis of the skeletal remains showcased the presence of 116 individuals, of which 69 are adults and 42 sub-adults, 31 are male, 18 female and 20 individuals of undetermined sex (Manzi *et al.,*1995; Micarelli, 2020). The latter remain indistinguishable due to upsets and reopenings of the burials linked to a repositioning of individuals, sometimes even partial on the covers or to later agricultural activity. In the former case, repositioning is somewhere identified as symbolic and is present during all three phases. As such it represents reopening of graves for the newly deceased and replacing the remains of the previous occupant in one corner or on top of the cover. Additionally, adults and sub-adults are never divided into separate spaces, as well as the male and female burials.

Longobards of Selvicciola among communities in the area

If we want to attribute a burial to a certain social group or people, we often look at clues hidden in their outfit and personal belongings or equipment found inside them – pottery or metal objects (Amorim *et al.*,2018). Needless to say, some of the objects are attributed to only one type of burial. For instance, pottery, made out of fine clay with traces of orange and red mat paint is an exclusive find of female burials covered in capuccina, with two lamps belonging to male burials under the same. Glass finds represent have been found in burials of infants and adults of the same style. Weapons, exclusive of the second group include four large shortswords of sax type that are found in tombs covered with slabs, along with iron knives and belts. One isolated find is represented in the tip of a spearhead and otherwise, an umbo of a shield has been found in one *cappucina* tomb. Horse equipment is also present with ornamented iron stirrups, as well as bronze and iron spurs. Bone tools from the first two groups of burials covered with slabs include combs and fragments that are difficult to interpret for the time being. Jewellery, mostly iron and bronze bracelets, or earrings and rings made out of bronze along with pins and needles made out bronze, iron and silver. Coinage was found inside the church, unfortunately for us – looted tombs. They belong to late antique and barbarian emperors and were often found in the same context, with only one nominated to a Byzantine ruler (Incitti 2002).

The presence of tombs in combination with weapons and belts could allow us to speculate that the necropolis had been used by a Longobards who settled in the existing Roman villa between the end of the 6th and the beginning of the 7th century AD; however, in this case not as many objects associated with Longobards are found, unlike those of the 7th century. We can hypothesize the presence of the indigenous Longobard population, but it should come under scrutiny as the stratigraphy in the oldest part of the necropolis, and subsequent disruption by the construction of church and agricultural utilisation, followed by looting have destroyed the oldest burials. Consequently, most of the excavated burials should be put later, when cultural elements associating with the deceased with their Longobard identity had already diminished. However, the isotopic study should provide an insight that might allow the broader distribution of several generations of individuals with different histories and migrational patterns.

The site of Selvicciola is just one of its kind, thus in addition to Vulci or Castellardo, located just a few kilometres away from both to north and south, other similar sites with remains of Roman villas and baths, as well as churches with tombs and finds such as the fibulae, jewellery, belt buckles, weapons and spurs dated, based on typology and decoration, to the period of the Longobard rule are found in Fontanile della Doganella, Colli di S. Colombano, Poggio Falcone, Crocignanello, Pianetto and S. Lucia near Valentano. Based on the distribution of the latter, it seems the communities were based adjacent to the communications, especially the *Via Clodia* (Incitti, 1997).

Chapter 3 STRONTIUM ISOTOPE STUDIES IN BIOARCHAEOLGY

3.1 Bone Composition and Structure

Due to its taphonomic resilience, bone is one of the most common finds inside archaeological contexts. What makes it a material of preference is easily attributed to the fact that it can serve as a reconstruction of an individual's life on several levels – from physical characteristics of the bone itself we can conclude on age, gender, health and stature, while its chemical composition serves as a record of information about the nature of the diet and what is of our interest in the present case – the mobility, all of it accessible through stable isotope analysis (Krueger and Sullivan 1984; Pate and Anson 2008; Waterman *et al.*,2014). Human remains in simplest terms are the physical presence of human ancestors. Moreover, they can represent a variety of several types. The variation occurring with the growth of the individual e.g. childhood and adult stage is a variation known as ontogeny. Another example is sexual dimorphism. The third type of variation is population-based, in which diverse human groups can have distinctions, e.g., commonly longer bones in individuals from north Europe in comparison with individuals from Mediterranean Europe. The fourth and final variation is the idiosyncratic variation, which are individual disparities between people belonging to the same population, age, and sex (Pollard and Heron, 2008; White *et. al.* 2011).

In terms of the isotopic analysis of human remains, choice of the particular bone or part of the same, the criteria are framed upon several factors, from physical properties to chemical composition. Bones can be distinguished according to their porosity, into cortical (compact) and trabecular (spongy or cancellous). Compact bone is a dense external layer, which serves as a protection and support, and makes up around 80% of the osseous tissue (mostly of long bones) in the human skeleton. Highly porous spongy tissue forms the interior structure of bones, making them lighter and alleviating the body movement, and it is represented with 20% (mostly vertebrae and ribs) in the skeleton (Price *et. al.* 2008; Parks and Marcos 2009; Tortora and Derrickson 2014; White *et. al.* 2011).

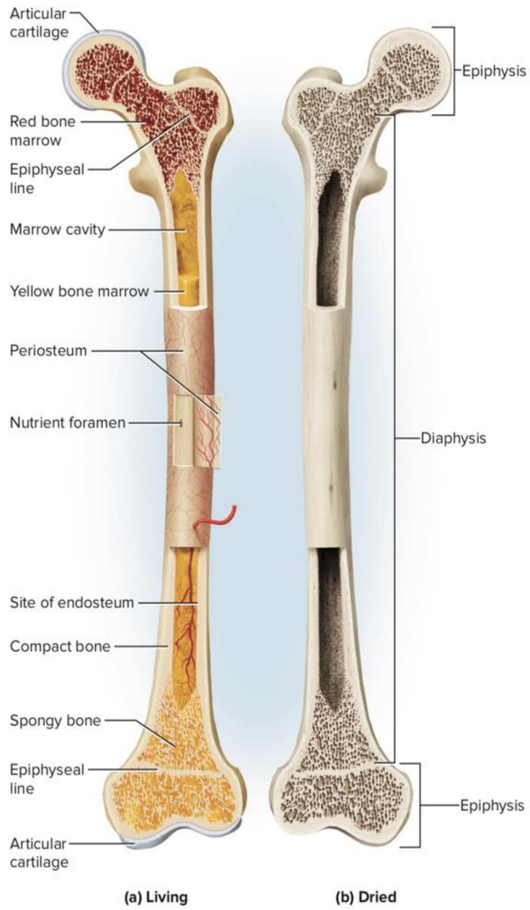

Figure 16. The internal structure of a long bone (Max, 2010).

From the histological aspect, bone is a complex ever-changing composite tissue made of several types of cells embedded in the extracellular matrix (Figure 16).. The building blocks of the so-called bone extracellular matrix are either organic - mostly protein - components (approximately 25%), and the inorganic - mineral part - divided between water (approximately 10%) and crystallized mineral salts (approximately 65%) (Tortora and Derrickson 2014; Price *et. al*. 2008). The structure of the matrix, with mineral crystallites, water and protein fibres which are intertwined, allow the bone to possess flexibility, hardness and resilience (Krueger and Sullivan 1984; Ortner 2003; Turner–Walker 2008; Parks and Marcos 2009; Tortora and Derrickson 2014)

The cells that can form the bone tissue are as follows. Osteoblasts, whose purpose is to synthesize and deposit hydroxyapatite throughout the tissue, secrets a material called osteoid (the non-mineralized portion of the bone matrix that forms prior to the maturation of bone tissue) and other proteins. As the osteoid becomes mineralized it develops into new bone tissue. The osteocytes represent the most common cell in the bone tissue and finally, the last type of the cells known as osteoclasts are responsible for the resorption of the bone tissue. These three different cells are part of a cycle of bone renewal known as ontogeny in which they play the main role and give the possibility to differentiate between osseous tissues of adult and sub-adult (Tortora and Derrickson 2014).

The inorganic fraction of a bone, biological calcium hydroxyapatite, is an impure version of naturally occurring mineral hydroxyapatite with chemical formula [$Ca_{10}(PO_4)_6(OH)_2$] or the carbonate hydroxyapatite *dahlite* [$(Ca,X)_{10}(Po4,CO2)_6(O,Oh)_{26}$]– a form of calcium phosphate (Katzenburg and Saunders, 2008; Pollard and Heron, 2008). Hydroxyapatite or bioapatite is a poorly mineralized salt prone to variability in sense of ionic substitutions in the crystal lattice. Such are, e.g., the ions of carbon, whose isotopic composition derives from the major macronutrient groups such as carbohydrates, lipids and proteins (Krueger and Sullivan 1984; Lee-Thorp *et al.*,1989; N. van der Merwe *et. al.* 1993). It is important to emphasise that it contains 99% of the calcium and 80% of the phosphorus reserves in the human body (White *et. al.* 2011). The latter occurs as it acts as a reservoir for ions of the same elements, stored and used upon bone remodelling when they are introduced into the tissues (Pollard and Heron, 2008).

On the other hand, the organic portion of bone matrix is almost completely made of (nearly 90%) the fibrous protein collagen, with lesser portion of what are non-collagenous proteins (NCPs), lipids, mucopolysaccharides and carbohydrates (Mays 2010; Allmae *et al.*,2012). There are several types of collagen in the body, but the primary and most abundant form found in bone is type I collagen. It represents a highly ordered structural protein, constituted of various amino acids – among which glycine, proline, alanine and hydroxyproline make up more than half. The latter are connected with strong chemical bonds and twisted to three helical polypeptide strands into a triple helix macromolecule, which are subsequently organized into fibrils and then grouped into fibres. The triple-helical form, giving collagen its stability, is possible due to glycine possessing just two carbon atoms in the chain, thus making it small enough to fit inside this three-dimensional arrangement (Krueger and Sullivan 1984; Schwarcz and Schoeninger 1991; Bryant *et al.*,1996; Ortner 2003; Turner–Walker 2008; Price et. al. 2008; Pate and Anson 2008). We can divide the amino acids of collagen into those that are non-essential and essential, nonetheless, this kind of division is important on the level of their isotopic composition. Both types are supplied from the ingested protein, but the non-essential amino acids are sometimes not directly related to diet because they can be synthesized from other biochemical products in the body itself (Schwarcz, 2002; Katzenberg and Saunders, 2007).

Collagen is of utter importance in paleodiet studies for several reasons – it is abundant, more resistant to degradation and very importantly - it can be easily isolated. However, unlike bioapatite which will reflect the diet, the composition of collagen isotopes reflects solely the intake of protein (Schoeninger and Moore, 1992; Ortner 2003; Turner–Walker 2008). When analysing mobility, one searches for circulation of chemical intake that can reproduce the circulation of an individual in terms of change of habitat and dwelling. This is where bones ability and characteristic of systematic creation of new tissue in the place of the old or fragmented, that is injured tissue. This feature is known as remodelling or turnover of bone and it represents a constant process in the life of a human being and its inorganic portion can showcase the same (Lee-Thorpe, 2003; Mays, 2010). What is of special concern in mobility studies is the rate of turnover as it is not the same for certain parts of the skeleton. Thus, the shaft of the femur might take decades to remodel, while the distal end of the same is substituted in a few months' time. What is more, as humans age the speed becomes conditioned. In the same way, the bones show the temporality of a diet and show the food intake of different time periods – e.g. clavicle or a rib could give information about food intake of the last 5 years of an individual (Ambrose, 1989; Hedges *et al.*, 2007). To conclude with, the turnover of compact bones takes 10 to 15 years which tells us that the stable isotope signature of an individual is the response of the time interval prior to death (Jowsey, 1971.; Lightfoot *et al.*, 2009; Tortora and Derrickson 2014; Waterman *et al.*, 2015; Fahy *et al.*, 2017). The ability to observe these changes and their patterns in the life of an individual, at the same time allows us to infer the causes behind them.

3.2. Teeth Composition and Structure

During the life of a human being, two sets of teeth develop. First, deciduous or milk teeth grow, followed by a set of teeth that are permanent. Morphologically, four types of teeth are distinguishable with their distinctive shapes that reflect their function – incisors, canines, molars and premolars. Permanent teeth replace the deciduous during childhood, with third and final molars erupting only through adulthood. Three phases of teeth formation can be followed too, the first one being the crown formation followed by lengthening of the root and finally the closure of the root apex (Mays, 2010).

The eruption of each tooth into the gum usually occurs before the root apex has completely closed, although this is happening at a different time for each tooth. The formation of teeth at different times of life can is vital in isotopic or trace element studies, because they will retain information about dietary intake from different points of life which are, in turn, of crucial importance for reconstructing mobility along with long term dietary patterns (Smith, 1991).

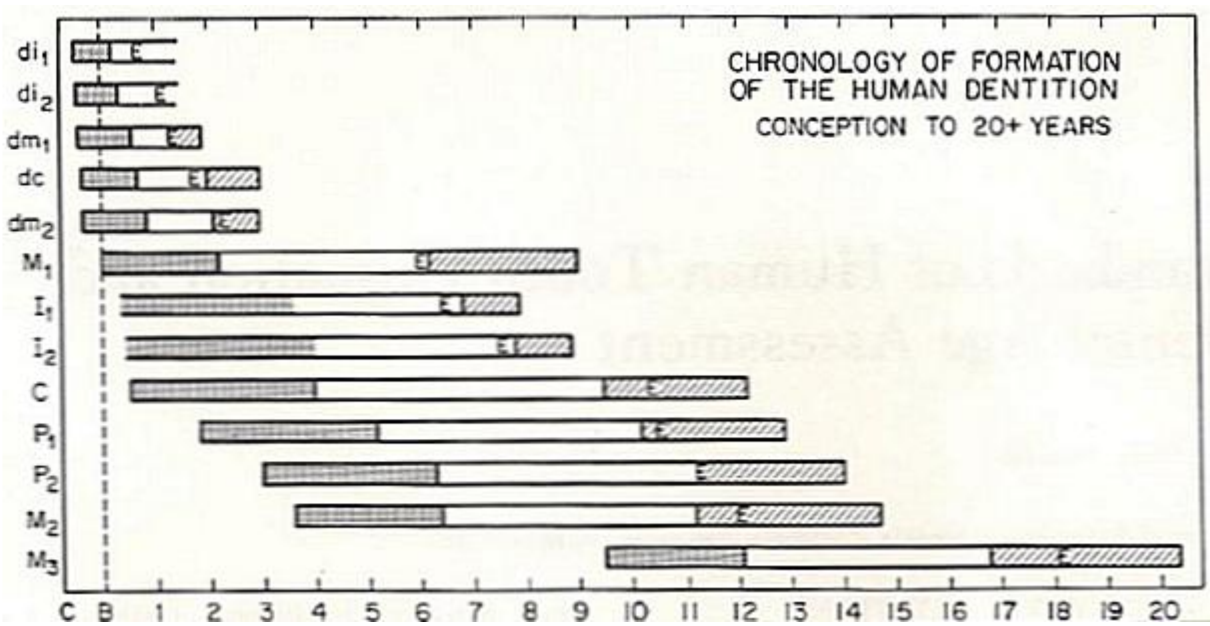

Figure 17.Estimated time phases of tooth developmental where shaded bar equals crown formation; unshaded bar represents growth in length of the root; the hatched bar is the closure of root apex. (B. Smith, 1991).

The tooth itself is divided into three regions, starting from the crown which protrudes above the line of the gum, followed by cervix or the neck and ending with the root (Mays, 2010). The softer dental pulp made of enamel, dentine and cementum encloses the hard tissue. The dental pulp is in its essence a living tissue like bone, connected to nerves and blood supply, thus being subjected to the same processes of mineral replacement and elemental turnover. Dentine, a hard and dense bone-like feature forms the bulk of the tooth underneath the enamel, which is a resistant matrix that does not go through remodelling after its formation (S. Hillson, 1996; Budd *et al.,* 2000; Webb *et al.,* 2005; Galiová *et al.,* 2010). Enamel and dentine contain the same carbonate hydroxyapatite mineral phase but their structure, formation process, crystal size and organic content are very different, and they reflect their function.

Tooth enamel is almost exclusively inorganic tissue without blood vessels and (96%) with small amounts of water, protein, and lipids (3-4%) (Cameron *et al.,* 2012). It possesses a mineral composition very similar to hydroxyapatite found in bone though their arrangement is different and here it forms the prism-like structure. After mineralisation, enamel stops being living tissue, missing a cell structure, thus it is not prone to the chemical alteration which tends to occur in other skeletal tissues and as such, has the potential to *trap* the isotopic signatures and dietary information from the time of formation – that is from the childhood. Thus, the analysis of teeth enamel can reveal the nature of one's mobility as it incorporates the isotopic composition of the ingested food from the period even before birth up to 16 years of age and thus archives the diet of childhood and geographic origins one caries within in life afterwards. Once mineralization stops, a change in isotopic ratios incorporated stops and does not reflect dietary needs and changes occurring later during an individual's life (Boaz and Hampel 1978). The study of different teeth of a person contribute to understanding shifts on diet-related to the age (e. g. weaning), culture (allowance or forbiddance of consumption of a product) or migration (Tykot, 2004; Montgomery, 2010).

Permanent teeth begin to mineralize with an established pattern, with deciduous tooth formation instigated in the developing foetus within 14–19 weeks of fertilization with first mandibular and maxillary molars around 10 weeks before birth, with permanent crowns being constructed before the age of nine (Montgomery *et al.,* 2000; Montgomery, 2010).Thus, the period of life seen in the individual teeth ranges from peri-natal period to about nine years of age when all but third molar mineralization is finished (Figure 17.). The mineralization of tooth enamel is based on a series of five distinct phases. The first phase, including secretion and formation, involves the formation of thin crystallites, but it is not until the last phase or the maturation that the hydroxyapatite crystals grow parallel through a quick increase in mineral ions (Montgomery *et al.*,2016).

Further, according to estimations the tooth enamel for the first molars (M1) would have been laid down between birth and two years old, while the enamel of the second molars (M2) is representative of the time period between 3.5 and 6.5 years old (Figure 19).. Third molar (M3) is highly variable but is usually constrained within adolescence and up to 16 years of age (Smith 1991). Consequently, with this information, it is possible to target and focus specific teeth that show constant mineralization process, and by doing so, at the same time, to focus a specific period of life.

Tooth enamel thus forms in two phases, the secretion and the maturation, and is laid down at a rate of around 4-6 nm per day, in sequences of calcified layers starting at the top on the cusp with subsequent layers being laid down outwards and downwards towards the root. The cell structure is present in the dentine and the cementum which are mostly inorganic, even though they do possess collagen which makes them a living tissue like the bone too (Figure 18). What is more, dentine possesses tubules that connect it to the dental pulp, consequently allowing the exchange of body fluids and turnover affect it during a lifetime. Nevertheless, it is more prone to diagenesis than the tooth enamel which remains inert (Webb *et al.*,2005; Humphrey *et al.*,2008).

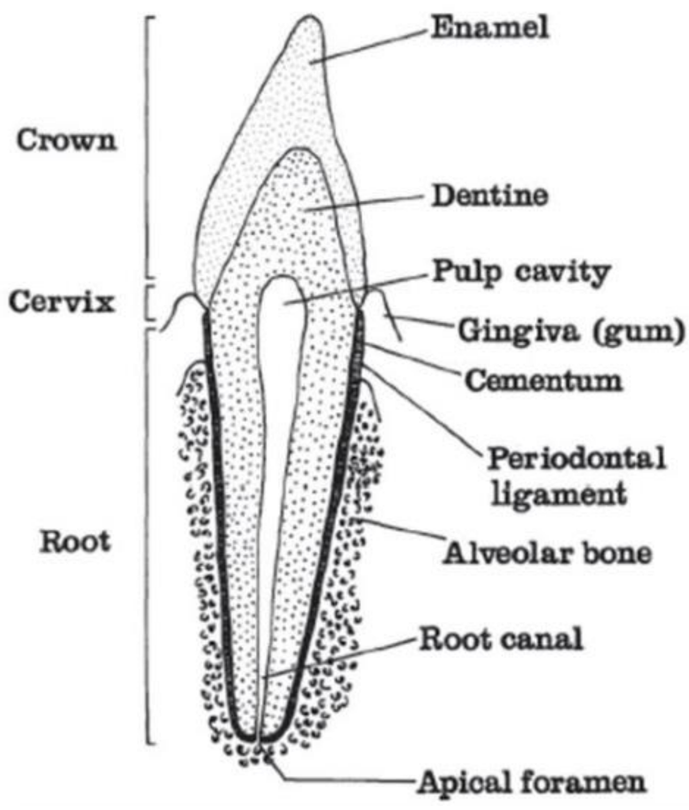

Figure 18. The internal configuration of the human tooth (Mays, 2010).

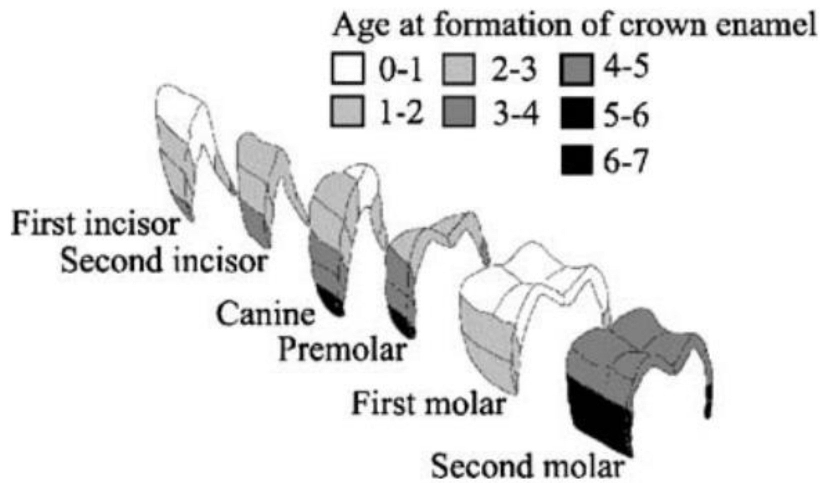

Figure 19. Crown formation of tooth enamel in incisors, canines and molars in terms of age (Bentley, 2006).

3.3 Diagenetic Alteration of Bones and Teeth

When an individual becomes a part of a new environment under the earth, a series of post-mortem processes unfold and affect what is from that point on a fossil. Perseverance of bone structure, and undoubtedly its chemical composition becomes a variability in sense of obtaining a valid isotopic signal. It is important to determine the scope of these mechanisms and do a quality control indication check (Tuross *et al.*, 1997; Nielsen-Marsh and Hedges, 2000; Harrison and Katzenberg, 2003; Jørkov *et al.*, 2006; Lee-Thorp, 2008).

In other words, the process during which skeletal material is exposed to deterioration, be it physical, chemical, and biological, inside a burial context from the moment of deposition until archaeological retrieval is known as diagenesis. The magnitude and the state of preservation of inorganic trace element for study of archaeological bones and teeth depend on the burial environment more than it does on the length of the deposition. If the physical alteration of bone occurs it is most often seen, as it includes macro-changes on the surface as a consequence of insect, rodent or faunal activity. However, when discoursing chemical degradation as well as microbial activity, it must be emphasised that it can cause more serious modifications, either microscopic or internal, accompanied by those on the surface of the material. Numerous external factors, for instance, sediment pH, temperature, humidity or groundwater conditions are all variables that strongly influence the course of diagenesis, and they tend to be pronounced by intrinsic features of bone as age, porosity and size (Child 1995, Koch *et al.,* 1995; Pfeiffer and Varney, 2002; Montgomery, 2010; Turner-Walker and Jans, 2008; Saragoça *et. al,*. 2016).

In terms of fastness and occurrence, microbial decomposition is the most common mechanism that unlike chemical alteration, which is accelerated by temperature and high pH environment, microbial activity will thrive in the neutral environments and as it main target it most often has the protein part of the bone. Microorganisms living in soil secret proteolytic enzymes in order to break collagen chains in order for the same to be used as nutrient substrate (*Collins et al.,*2002; Grupe *et al.,*2006; Turner-Walker and Jans, 2008; Pollard and Henderson, 2008). Proteins are especially susceptible to microbial, this chemical and physical alteration.

By knowing the bone as the composite material, the problem behind chemical deterioration can be addressed from two aspects. First, in the organic portion of the fossil bones, preservation of non-collagen proteins, lipids or carbohydrate is rare, unlike collagen that can retain in the former for thousands of years due to its deep bond to the mineral matrix. Hydroxyapatite has the ability to slow down the speed of protein hydrolysis while collagen protects the mineral crystal from dissolution by groundwater (van Klinken 1999; Lee-Thorp, 2008; Pate and Anson, 2008; Turner-Walker and Jans, 2008). Collagen denaturation is more rapid in a warm and wet environment as humidity, temperature and pH conditions contribute to the breaking of hydrogen bonds of amino acids, thus leading to complete full dissolution of fibrils through leaching. This is the same reason why collagen is more readily preserved in temperate environments, even though in such environment exogenous substance as humic and fulvic acid can contaminate it. It should be emphasised that bones with degraded collagen are still usable in isotope studies – especially those of carbon (Lee-Thorp 2008; Katzenberg, 2008).

On the other hand, assessing the diagenesis of bone mineral part is more complicated as modifications can occur in many instances, starting with dissolution, ion substitution through re-crystallisation and eventual complete disintegration of bioapatite. If the organic phase of the matrix is damaged, it leads to increase of porosity that will consequently enable penetration of groundwater into mineral structures. Moreover, increased solubility of calcium phosphate comes in lower pH that is acidic environment while in alkaline one, the mineral can re-crystallize. More precise, this involves reorganization of the bioapatite internal crystal structure through dissolution of smaller sized crystal, which will thus be precipitated as larger and more stable forms with introduction of foreign ions (Nielsen-Marsh and Hedges, 2000; Surovell and Stiner, 2001; Berna *et al.*,2004; Turner-Walker and Jans, 2008). In contrast to collagen, hydroxyapatite is extremely prone to the elemental substation from burial deposit. Ions that are exogenous are readily adsorbed to the surface or deposited within crystal lattice and their presence and reactivity are co-dependent on the groundwater pH. For instance, acidic soils with metal ions such as iron or manganese tend to react and discolour bone to a brownish tone, while the opposite, alkaline environment these ions emerge as insoluble hydroxides or carbonates (Turner-Walker and Jans, 2008; Clementz, 2012).

Mature enamel, however, has very low porosity and high density than any other tissue and is more stable with its matrix remaining morphologically equal over millions of years (Montgomery, 2010). It is therefore expected that enamel will not react in the way bone does when it is subjected to diagenetic processes. When reconstructing migration it is of essence to isolate the biogenic strontium from the diagenetic strontium, and even though first approaches relied on deriving the former from compact bone, nowadays enamel is proved and attested as the best methodological solution (Budd *et al.* 2000).

Both bones and teeth from archaeological context undergo post-excavation processes which are potentially dangerous in terms of mechanical or chemical alteration. Most usual obstacles in an isotopic analysis of bone apatite come from the mere fact that the original signal can be altered because of the exchange of carbonates from the burial deposit. Carbonates of bioapatite occur naturally in two forms – either structural one which acts as a substitute for phosphates in the crystal lattice or the ones that adsorb on the surface. Former is more resistant to diagenesis, however by using proper decontamination method, the more soluble geochemical carbonates are removed while preserving the biogenic ones that are due to be analysed (Schoeninger and Moore, 1992; Ambrose and Norr, 1993; Katzenberg, 2008; Pollard and Heron,2008). It is important to take preventive steps by carefully cleaning and removing possible contaminants from samples prior to analysis, as it will be mentioned later.

After all, any study of dietary or environmental patter needs to be accompanied by the assessment of the bone isotopic integrity. Although a bone may appear to be poorly preserved, this is not always indicative of the state of preservation. Thus far, there has not been a single method with a sensitivity that can assess bone preservation itself. Instead, parameters like ratios and percentages of certain element content of whole bone are good indicators of preservation or deteoriation *per se* (Ambrose 1989; Nielsen-Marsh and Hedges 2000; Trueman *et al.*,2008).

Many methods have been developed to study the degree of alteration, including histology, measuring the amounts of collagen left in the bone and the carbon to nitrogen ration of the latter, measuring of bone density and porosity among other physical properties of bone (Hedges and Millard, 1995; Pollard and Heron, 2008). The crystalline index gives info about average crystal size, while rare earth element profiling is in direct link with the beginning diagenetic environment and is affected by sedimentation and bone change.

Physical methods of removal have firstly used the difference in solubility and later on the bone density-based separation (Bell *et al.*, 2001). Simply, through assuming that newer mineral is more soluble than the bioapatite, and therefore through a repeated washing in a buffered, dilute acetic acid, contamination is removed (Pollard and Heron, 2008). Another method using differences in solubility involves an overnight soaking of bone samples in acetic acid and analysis of the residue rather than the solution (Price et al., 1994). Furthermore, three is the usage of deprotonation of the bone, and separation of various densities with heavy liquid flotation techniques. Again, simply it is assumed that newly altered mineral is denser. Finally, with abrasive removal of outer material through, dilute acetic acid will dissolve both the soluble carbonates and the portion of the bone mineral that is most likely to be contaminated.

Even though that leaching in weak acid certainly removes at least a part of diagenetic strontium from contaminated tissue, if diagenesis has taken more insidious form, including re-crystallization of hydroxyapatite or direct exchange with strontium or calcium in the original hydroxyapatite crystals, then acid treatment will not be able to isolate the strontium as it might even have been completely replaced during deposition (Price *et al.*,1994; Bentley, 2006). Luckily, the enamel possesses density, hardness and chemical inertness that shields it from post-deposition contamination as the crystal lattice of phosphate in enamel represent a compacts structure that is not porous and thus less susceptible to diagenesis (Hillson 1996; Kohn *et al.*, 1999; Budd *et al.*, 2000; Price et al., 2002).

Nowadays, methods for estimating the degree of diagenetic contamination and for chemically cleaning bone and teeth to recover the biogenic signature is in place as monitoring the values of a spectre of elements including calcium, phosphorus, iron, aluminium and manganese are used to determine if known biological values are recovered. For example, ratios of calcium to phosphorus in the biological bone should have a ratio of 2.1 – 2.2 and any variation suggests contamination of calcium carbonate which is at the same time the main source of diagenetic strontium (Price *et al.*,1994). Similarly, the presence of iron, aluminium and manganese is not normal in the uncontaminated bone. Elevated amounts indicate that the bone is contaminated with derivates from the soil.

Non-biological strontium, which could be introduced through deposition of new minerals or through the isotopic exchange during water/mineral interaction. As shown above, deposition of new diagenetic minerals would certainly include carbonate, which is completely removed by our acid-washing procedures. The second possibility is the isotopic exchange with bone or tooth enamel apatite. Moreover, comparison of strontium contents in archaeological faunal material to modern faunal samples of the same species from the same region act as a further test of diagenesis concentrations.

3.4 Stable isotopes and Strontium – general principles

Archaeological field nowadays is enriched by reconstructions of the diet in the societies of the past, followed by patterns of animal husbandry and crop domestication and dispersion with the help of isotopic investigations that developed inside bone chemistry investigations.

“You are what you eat” - several techniques have been developed to study this premise in both social and natural sciences (Hedges *et al.*, 2004; Pollard and Heron, 2008). Both bone and teeth are used in stable isotope studies, and dietary reconstruction had been traced by levels of the element in human remains. Stable isotope analysis represents a revolution in how we approach our past as the food we eat, and the water we drink from the environment we spend our life in represent a chemical imprint left in our body. What is more, historical, and archaeological sources are either proven or disproven when it comes to the different hypothesis that arises from the latter. Stable isotope studies are the direct accesses to the aforementioned. Thus, unlike archaeologists in the past, we now possess the ability to research so deeply each individual and scrutinize their lives in order to infer about their health, diet, origin and places they might have dwelled (Waterman *et al.*,2015; Tafuri 2019). Moreover, inside archaeology, isotope studies are used for paleoclimates, diet and mobility patterns of animals too due to them being present in many different materials and matter, starting from the flora and fauna to stone, minerals, metals and organic residues (Schoeninger and Moore, 1992; Katzenberg, *et al.,* 2002; Van Klinken *et al.,* 2002.; Hedges *et al.,* 2004; Jørkov *et al.,* 2007; Mays, 2010). Further, the information deriving from an individual is readily quantified for more in-depth frames of past populations and societies. In terms of one's origin and tracing of possible movement, be it individual or of the collective cultural group, we can now bridge historical sources mentioning such actions to a piece of more inclusive information framed inside shorter time and closer archaeological context (Sealy et al., 1995; Sealy, 2001).

The bulk elements of the tissues of a living organism are oxygen (O), hydrogen (H), carbon (C), nitrogen (N), and sulphur (S), which make up about 98% of body mass. Along with them, essential elements in the development of organic functions are calcium (Ca), phosphorus (P), potassium (K), chlorine (Cl), sodium (Na) and magnesium (Mg) (Tafuri, 2019). Just by observing the fact that some of these elements are present in higher quantities can suggest that they are representing the intertwined connection between organism and the environment as they were exchanged among the same (Allègre, 2008). Thus, isotopes linked to the environment in which an organism thrives will due to their mass difference have different tendencies during chemical processes. The principle that governs isotopic investigations is therefore linked to behaviour in nature of its isotopes that, as already discussed, having different mass will tend to behave differently. The studies of stable isotopes in bones can be done in the organic and inorganic part since these two provide different information about the diet of an individual. Collagen is composed by amino acids and in its biosynthesis, it is based on the protein intake of the individual's diet; meanwhile, hydroxyapatite records the three major macronutrients of the diet - proteins, carbohydrates and fats (Tykot 2004). Further, analysis is also carried on teeth, both in enamel and dentine and the use of the latter through different approaches together provides detailed information about the life of an individual (Tafuri 2019).

As different tissues differ in terms of metabolism, so must we be careful in selecting those that are most appropriate for specific isotopic analysis. Further, a need for establishing if an organic or inorganic fraction of tissues represent the original chemical composition is very important (Tafuri, 2019). However, in the perspective of archaeology this is represented by the most available "find" – the bone and teeth tissues – and till this day the collagen and bioapatite remain extracted from the latter are the most common type of isotope analysis. It is plausible to find specific characteristics through the analysis of dental macro- and micro-wear, as well as in dental caries and calculus (Gamza and Irish, 2012). The contribution that stable isotopes provide is the option of further in-depth understanding of past mobility as it can focus on population inside a smaller "frame", and even at an individual stage. This comes to light when the cultural and social characteristics are envisaged – the differences between sex, status and age in one society. Moreover, there is a plausible option of observation of different populations, sites and periods of time (Tykot 2004).

The incorporation of the isotopes of the elements that tell us about mobility, such as strontium (86Sr and 87Sr), hydrogen (1H and 2H) and oxygen (16O and 18O) in the human body and how it is used as an isotopic trace needs to be explained with the help of more generalised principles to start with.

The atoms of the single chemical element possessing the same number of protons and electrons, but their number of neutrons is different are, as has been said, known as isotopes (Allègre 2008; Hoefs, 2009). By having the equilibrium of protons, all isotopes of one element are simply ascribed to the same atomic number. Even their chemical properties are the same as they depend on the equal number of electrons. After all, the different number of neutrons affects their atomic mass or in other words creates variable rates of a chemical reaction (Schoeninger and Moore, 1992; Pate and Anson, 2008). When we look at elements, more than sixty of them have naturally occurring isotopes, what is more, the majority has at least two (Hoefs, 2009; Parks and Marcos 2009). In terms of the decaying nucleus, the latter can be grouped into those that are stable or radioactive, that is the ones that have a constant number of protons and neutrons, while the radioactive one's decay over time due to their ratio of neutrons to protons being either too high or too low.

The first step in stable isotope analysis is the fact that their natural abundance is fixed since the genesis of the Earth itself and does not change on a global scale. Light elements, such as carbon and nitrogen usually have one dominant isotope while others appear in trace amounts. On the other hand, elements as strontium have more, and thus we find four stable naturally occurring isotopes ^{84}Sr (0.56%), ^{86}Sr (9.86%), ^{87}Sr (7.0%) and ^{88}Sr (82.58%) (Fietzke and Eisenhaure, 2006; Allègre 2008; Tafuri *et al.,*2016; Nebel and Stammeier 2018). Radiogenic ^{87}Sr is formed in rock over time by the decay of rubidium ^{87}Rb and comprises approximately 7.0% of total natural strontium. The latter is abundant in the mantle and its half-life measures at 4.88 billion years (Bataille *et al.,*2018;

Tafuri 2019).[13] The resulting variation in the ratio of $^{87}Sr/^{86}Sr$, as well as other stable isotopes, can be exploited in geochemistry, environmental condition measures, dating of rock formations and finally archaeology (Allègre 2008; Rasskazov *et al.,* 2010). Strontium isotope ^{87}Sr forms by decaying rubidium which is present in all rock in Earths strata, either those that are older than 100 million years, which are rich in rubidium, such as granites or gneiss and which possess a higher ratio of $^{87}Sr/^{86}Sr$. Basalt is therefore isotopic courier of strontium from the mantle and granite represents the same for the continental crust. This is merely a result of long and different geological history they possess, which has led at the same time to the creation of different patterns of bedrocks accumulating and forming the surface of the Earth. Consequently, younger rocks, as basalts have a lower ratio as they simply have less rubidium. In other words, the ratio is co-dependent on the time of formation of the rock itself. The strontium ratios of minerals found in the geological substrate of residence have a prehistoric signal which can by paths of diet resonate in an individual, if it goes unaltered through the food chain. The mobility of organisms is therefore based on the assumption that we possess the ability to identify the place of origin and movement in last years of life in different geology as it reflects the geochemical signal with different strontium isotope ratio between dental enamel and bone tissue (Pollard and Heron, 2008; Tafuri *et al.*,2016; Francisci *et al.*,2019). In summary, because modern databases are developed it is possible to predict the regions of the mentioned as their geological values are not changing proportionally in the recent era.

However, when we look at them on a more local level, the average ratios of stable isotopes become less fixed. In terms of organic elements, they may be subjects of fractionation, even though these are usually very small, by processes such as plant photosynthesis and it leads to selective enrichment/depletion of the stable isotope composition in plant and animal tissues (Ambrose 1993; Katzenberg 2008; Hoefs 2009). In terms of strontium, no fractionation occurs, and it is absorbed through diet into tissues in an unaltered form and its ratios do not fractionate when they are introduced from the geological source into other parts of the environment (Allègre 2008; Montgomery, 2010; Tafuri *et al.,* 2016; Hoogewerff *et al.,* 2019). This represents the key difference between light and heavy elements, and there are much greater differences in the isotopes of the former as they go through kinetic or mass-dependent fractionation (Allègre 2008; Hoefs

[13] Half-life of a radioactive element is defined by the time it takes for half the radioactive isotope to disintegrate.

2009). Strontium of the rock and soil or water flowing is stored in bone tissue of humans and animals as it is favoured in place of calcium for the synthesis of bone tissue (Sandford 1993; Pollard and Heron,2008). As has been introduced above, the mechanism behind strontium absorption in human tissue is a complex process that can vary (Montgomery, 2010). So, if the geology beneath the ground changes, so does the isotope ratio of the strontium that is released from the bedrock into the biosphere.

3.5 Reconstructing Mobility using Strontium Isotopes Recorded in Bones and Tooth Enamel

The mechanism of strontium metabolism represents a passive substitution of cations of strontium and that of calcium during the dietary uptake and their later distribution and excretion (Matsunaga and Murata, 2009; Montgomery, 2010). Therefore, after active transport of strontium in place of calcium it incorporates into the hydroxyapatite lattice, while its amount depends on its availability in the environment especially as it is a non-essential nutrient that is therefore not regulated at a specific level by the human organism.

Henceforth, this leads to a model of biopurification where the elements becomes non-essential and incorporated into bone and teeth structure. It must be stated, even though it was mentioned earlier, that the principle stating that we are what we eat is not as simple as the statement. The elements should be absent from the metabolic control and become incorporated in the bone with certain concentration due to their incorporation being higher than that of the process happening after deposition. Strontium is incorporated into enamel through plasma during the period of mineralization. The maturation can vary from months to years and strontium can therefore be incorporated during the same period (Burton and Price, 2002).

Concentrations of strontium that appear in both teeth and bone measure around 50-500 ppm and animals tend to exhibit similar values (Elliot and Grime, 1993; Bentley, 2006; Montgomery, 2010; Goude *et al.,* 2012). Even though strontium distributes in relative homogeneity throughout the human body, tooth enamel generally has a lower concentration of strontium compared to bone, nonetheless, the latter is more usually contaminated and most of the studies today focus almost exclusively on tooth enamel (Price *et al.*,1994; Chiaradia *et al.*, 2003; Bentley, 2006; Montgomery, 2010).

Strontium as a part of the Earth's strata – the bedrock.

Strontium atoms in geology are the base of the geographic distribution of its isotopes in the environment. The former is an alkaline earth element found in the same group as calcium, and is just a fraction larger in ionic radius (1.32A – 1.18A), strontium cations (Sr^{2+}) substitute for calcium

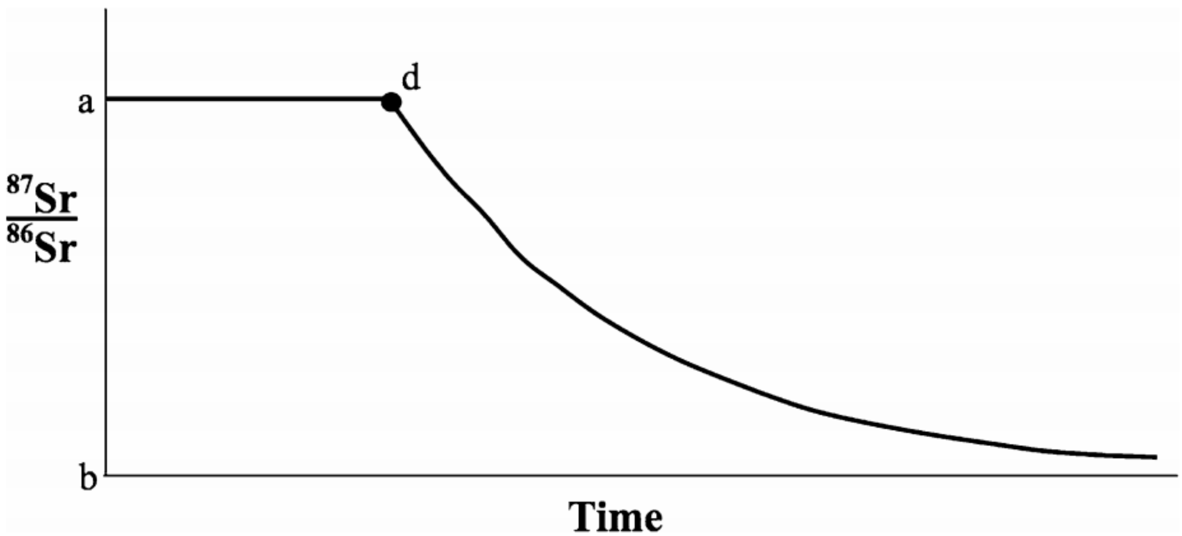

Figure 20. Change in Sr isotope signature in tissue between point of migration (d) and origin (Schweissing and Grupe, 2003).

cations (Ca^{2+}) in minerals found in rocks, e.g. feldspars, calcite, gypsum, dolomite and others calcium carbonates etc., and equally in the apatite of human tissues (Aberg, 1994; Bentley, 2006). Both chemical and physical properties make strontium's incorporation passive processes as it acts as substitution between the cations mentioned above during nutrient uptake (Montgomery, 2010).

Rubidium is an alkali metal with a radiogenic isotope ^{87}Rb goes through decay and forms radiogenic ^{87}Sr – which represent around 7% of strontium isotopes in terms of their abundance in the geosphere. Exactly the decay from rubidium to strontium is the usually used tracer in geochemistry as the $^{87}Sr/^{86}Sr$ ratio relates to an abundance of rubidium and the age of the rocks. In other words, the ^{87}Sr content of rock is mirrored by how much rubidium there has been it he bedrock and for how long (Aberg, 1994; Bentley, 2006). The strontium isotope ratios for granites varies in different continents, ranging from 0.705 to 0.850 or more, unlike basalts that show much greater equilibrity as they range from 0.702 to 0.770 (Aberg 1994; Price *et al.*, 1994; Bentley, 2006; Allègre, 2008; Pollard and Heron,2008).

Therefore, we observer geological variation in abundances of strontium. Due to differences in solubility and concentrations, there are variations between present-day geological terrains. Therefore, older rocks (>100 mya) with a higher concentration of original rubidium and strontium have higher $^{87}Sr/^{86}Sr$ ratios and more recent formations (<1-10 mya) possess the opposite with ratios being lower. Present-day mass spectrometers possess an instrumental error (+/- 0.00001 or better) that allows their distinguishing. Within the decay system of rubidium to strontium, we can compile geological maps with bedrock types and their age with expected $^{87}Sr/^{86}Sr$ isotope ratios, as will be explained later on (Price *et al.*,1994; Beard and Johnson, 2000).

Strontium exchange pool as a part of the Earth's environment

The environment acts as an exchange pool of strontium concentrations with different inputs and outputs from the atmosphere and the bedrock. Consequently, isotopic ratios are constantly affected by weathering, cycling through the soils and waterways, but unlike lighter elements, the decay of ^{87}Rb into ^{87}Sr is not affected, and the fractionations are in most terms are negligible at lower temperatures present in most biology. Finally, unaltered biologically available strontium isotopes pass from bedrock to soil. The variation occurs as the minerals found in rocks differ in concentrations of strontium and are more or less prone to weathering and atmospheric deposition, and it needs to be emphasised that a mere geological map is not sufficient to predict this variation (Aberg, 1994; Price *et al.*,1994; Beard and Johnson, 2000; Evans and Montgomery, 2010).

That being said rivers and oceans are homogenous reflections with the average concentrations of the crust's bedrock that were weathered. Soil can show local variability as the mixture of sediment and sources they come from, for instance, if there is an exchange in the fraction of granite and basalts. Flora however usually consistently follows ratios of the available ratios of each terrain it grows in. On the other hand, strontium concentrations in soils are a dependant of the depth as the available strontium increases in relation to it. In all this diversity of sources and their intertwining ranges, local geology still has the largest effect on the isotopic ratios of most environments. In a temperate climate, where weathering is as average as it can be, with medium levels of precipitation, bedrock and its strontium component will determine most of the strontium found in the soil above and plants with roots in the same.

Strontium incorporation in animals and humans

As an alkaline earth element with no essential biochemical or physiological function, strontium will in its chemical behaviour, metabolism and distribution mirror the calcium. The major sites of retention of both elements are the skeleton and teeth (Price *et al.*,1994; Mertz 2012). The framework of strontium isotopic signatures is conceived through a pathway of geological material transferring through overlaying soils and food chain into human skeletal as strontium takes place of calcium in the minerals of the tissues. Moreover, as there is also other, non-geology related source of strontium in the environment, the concept tries to find the right keyhole in the latter for the key found in the form of our sample. In other words, the goal is to match the isotopic signature of an analysed individual with the signature of biologically present strontium in suspected origin (Bentley, 2006; Mertz 2012).

As it has been mentioned above, strontium isotopes should be extracted from the most appropriate body tissues for specific isotopic analysis. This is where diagenesis, as it was explained also earlier, comes to importance. If we study bioapatite of the bone, we might be studying something that has gone through ion exchange with the minerals in the soil after deposition. On the contrary, teeth do not go through diagenesis as the inorganic matrix does not subject to it. By targeting the inorganic matrix of the hard tissues – the dental enamel and bone hydroxyapatite we can get results we search for in terms of strontium isotope ratios. Isotopic composition of archaeological remains is influenced by diagenesis, pollution from atmosphere and fertilizers that worsen the signal-to-noise ratio of the measured geological or residential signal (Price *et al.*,1994; Sealy *et al.*,1991; *Collins et al.*,2002).

We have already established that the process of the climbing trophic level reflecting as a decrease of Sr/Ca ratios is known as biopurification. The reason behind it is the fact that strontium ingested by the metabolism of mammals is usually able to absorb only half of the absorbed calcium percentage (40-80%) (Burton and Price, 2002). What is important that same process is applicable to ratio $^{87}Sr/^{86}Sr$ in animals opposed to plants and soils due to herbivores diet adding to the average ratio of the local signal over time (Koch *et al.*,1995; *Chamberlin et al.*,1996; Bentley, 2006).

When analysing the mobility of fauna, we analyse animal husbandry practise in domesticated animals at the same time. Thus, if their isotope ratios of strontium are consistent with locally available strontium range, or either higher or lower than the same, we can get the estimate of grazing areas in the surrounding landscape of our sampled site (Žalaite *et al.*,2018). Small-sized fauna is may serve as a good forecast of average available $^{87}Sr/^{86}Sr$ of their local feeding grounds.

With an assumption of an individual moving only once from an origin, or a certain location to another during one point of his lifetime, we can predict the ratio in different bones as they approach the local values at different rates as it will be directly related with bone turnover, that is mineralization rate and the time an individual spent in the location (Schweissing and Grupe, 2003).

If we assume that a migrant individual moved only once from one place to another during his or her lifetime, it is possible to model how the $^{87}Sr/^{86}Sr$ ratio in the different bones approach the local ratio at different rates (Price *et al.*,1994; Montgomery, 2010).

How do we determine a local signature?

The variations of strontium isotope values found in bedrock, soil and water from a local area can vary, as well as the values of human bone and enamel isotope ratios that fall close to the local range. Nowadays it is clear that the values of the dietary intake should not be derived directly with the established values of the local geology. In essence, we cannot determine our biological system as a controlled one.

First and foremost, an archaeological site should have its strontium isotope ratios measured for them to be attributed as local signal. By procuring the latter with information from local feeding grounds and groundwater, followed by animals that utilise them as they act as a forecast for local ratio of $^{87}Sr/^{86}Sr$ in mammals as it has been shown in studies that their values are very close to the range of values of human bones and tooth enamel (compare with Beard and Johnson, 2000; Price *et al.*,2002, T. II; Bentley, 2006). With more than a plausible assumption that animals during historical periods fed on the food available in their dwellings, we can measure the teeth enamel of animal species found in archaeological context (Price *et al.*,2002; Bentley *et al.*,2004; Bentley, 2006; Tafuri *et al.*,2018). The choice of animal is readily made for a particular archaeological context and if it is possible it will include different species. One of the best choices due to the similarity of protein requirements and similar omnivorous diet, are domestic pigs and pets such as dogs (Bentley *et al.*,2008). Without a doubt, animals could also be part of exchange with other communities and this must be considered critically (Cavazzuti *et al.*,2019).

A local range is therefore compared through several variables - the ratio $^{87}Sr/^{86}Sr$ of the soil from the archaeological site; the ratio $^{87}Sr/^{86}Sr$ of the faunal bone; the ratio $^{87}Sr/^{86}Sr$ of the human bone and the range of values between ± 2 standard deviations. Using the strontium isotope ratio derived from archaeological skeletons to the prehistorical environment is more than a simple search for the closest equilibrium between the remains and the bedrock as it is a number that is based on an average of all strontium that incorporated in the archaeological sample. This means that strontium from a skeletal of an individual has gone through many steps before arriving in the same, for instance firstly through formation and crystallization of a volcanic rock which was later introduced to a waterway that found a way into landscapes through streams or sublimation and surrounding soil on which cereal has grown, and which was consequently eaten by an animal that was finally hunted down by a hunter-gatherer. What is more, these pathways may be multiple and different before joined in the tissue.

Moreover, a single $^{87}Sr/^{86}Sr$ ratio from enamel does not instantly identify a migrant, since a non-local $^{87}Sr/^{86}Sr$ ratio simply implies that that person once ate foods which, averaged over the formation of the enamel from our sample and it came from non-local sources. If we possessed a menu of what certain people ate a point of time and where this food came from, we might model and calculate what the overall enamel-average ratio should be.

The bioavailability strontium and thus its concentrations in flora depends on the geochemistry and these parameters are strongly influenced by soil properties of a region on the smaller scale themselves (Zampella 2011)[14]. Isotopic ratios in the local environment are composed of a mixture of strontium derived from both atmospheric sources and mineral weathering, what is more, various minerals (e.g., feldspar or mica) within a single rock can have enormous variability in their $^{87}Sr/^{86}Sr$ ratios (Price *et al.*,2002). At the same time, local soils can show a range of $^{87}Sr/^{86}Sr$ values, rather than any precise rock average, depending on the differential weathering and the mixing of various sources of sediments in the soil (Sealy *et al.*,1995). Long story short, biologically available strontium isotope ratios can and will differ between the bedrock and other environmental variables. The solution for this has been found in the study of fauna as the animal remains show lesser deviations and variation despite various geology as a source (Price *et al.*,2002). The fact that

[14] Authors here examined geological signals through a model that combined strontium isotopic signature with percentages of six other elements to predict on which kind of substrate potatoes have grown.

bone $^{87}Sr/^{86}Sr$ reflects the assimilation of locally available $^{87}Sr/^{86}Sr$ over time, as the tissue is remodelled over time and over a range of available food, then the bone should provide a summary measure of the local $^{87}Sr/^{86}Sr$ ratio. It is then clear that animal skeletal tissue can provide a good estimate of biologically available strontium isotope ratios for a local area, averaging variability of that area into a final value and showing similar results to human values. Furthermore, different species differ in living spaces and this should be addressed in the choice of our fossil specimens.

Problems can arise if food source does not derive its strontium values from the location where it is consumed. For instance, if grazers were fed on mountains and cereals were grown in the river valley below it would reflect in a possibly different strontium ratio. Equally, if food was traded the same observation could be made and even though in archaeological framework most of the diet derives from the local sources and when the ratio is inconsistent with the local strontium values it shows that the individual was originating from elsewhere (Bentley, 2006; Montgomery, 2010). Availability of the food and water sources will depend on their exploitation and ingestion and metabolisation of strontium will directly depend on how much and where from the food or water comes. This can result in incorporation of strontium from geological sources that are distant to the dwelling. However, as was mentioned, in dietary sense plants act as richer sources of strontium and contribute more in strontium uptake, and even if the aforementioned might seem as a problematic fact inside research, it can be assumed that strontium isotope ratios will ratios of the living area. Hence, difference in sustenance procurement and groups of individuals occupying different spaces inside this living, or simply put isotopic frame, can be sometimes seen and the date will show these deviations (Montgomery, 2010; Mertz 2012.). Milk and milk products, same as is the case of calcium, can contribute to a major percentage of strontium intake, as well as drinking water. Interestingly, some suggest that strontium intake in animals is different if forages are based on legumes (Burton and Price, 2002; Mertz, 2012).

Obviously, geographic variation in strontium isotope ratio is therefore more than a mere mirror of underlying geology based on their age and composition, but a more complex variable that is controlled with multiple factors such as atmospheric and weathering patterns that ought to be considered before conclusions are made. Communities could be thus seen as a cluster that exchanges it isotopic ration with different sources of strontium, and this can provide more information than just the origin as it could reveal food necessities and strategies behind acquiring of the same (Montgomery, 2010). Idealistically, our study will show values of individual that are completely different of the local population, however, when we do not possess higher differences or extremes in our values, we do not actually possess the means to objectively separate individuals with values close to local ranges. This is where the variability of the study comes to light, as the basis in comparing values of flora and fauna with human ones (Figure 21.). Proxies as diet, length of residence due to bone remodelling, and assumption that a migrant might have had more than one movement in his life, that is that he dwelled and resided in more than just one place of origin, are used as small values of variability within the individuals close to local ranges (Price *et al.*,2002). We still cannot know all the variations that might exist today.

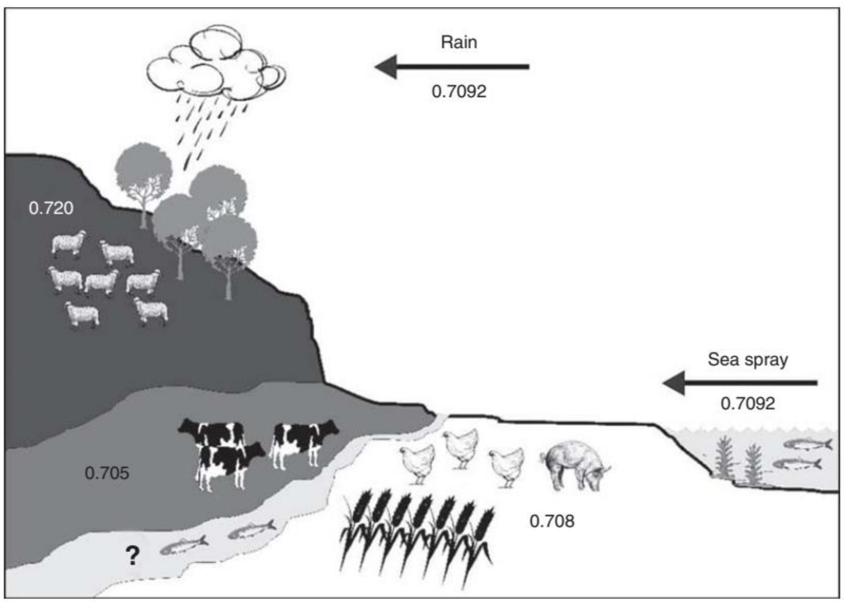

Figure 21. Sources of strontium with different values in the biosphere (Montgomery, 2010).

Matching the Unknown to a Known – The Mapping of Strontium Values

It should be emphasised that ratios of strontium isotopes do not pinpoint unique geographical location, simply at the isotope ratio does not correspond to a singular geological region (Figure 22-23.). Deriving from this, the type of analysis being made may not provide an answer to certain question or hypothesis, and unfortunately, sometimes it may be difficult to distinguish between a migrant and indigenous, especially in the regions possessing very similar geochemical backgrounds. If isotopic values are different than those local ones, we assume the existence of different origins. However, if they are close to each other, we are not allowed to simply exclude that they could then match some other possible area (Francisci *et al.,*2019). In order to succumb this, establishing a larger database with isotopic value maps of regions, with samples from lowlands, mountains, riverside and similar geological frames should be made as it will allow matching or distinguishing between ratios that are compatible.

The strontium ratio is predictable spatially with patterns that follow regimes of a certain geological regime inside a temporal frame that does not vary and can thus represent a high resolution of the same (Bataille *et al.,*2018). The basis of the $^{87}Sr/^{86}Sr$ geolocation signal is to compare the $^{87}Sr/^{86}Sr$ profile of a sample of interest with that of the $^{87}Sr/^{86}Sr$ bedrock to estimate geographic origin. There are different ways of 'matching' a sample of unknown origin to location through its isotopic value (Hoogewerff *et al.,*2019). This is done through what is termed as nominal or the Bayesian continuous approach.

The nominal approach divides the studied area into smaller potential areas of origin assumed on previous knowledge one possesses. For each area, a mean value is calculated as well as the variables in the locally available strontium data. The values of the sample are then compared to these areas to achieve geographic assessment and classification.

The Bayesian continuous approach, strontium values coming from the sample are compared to models that predict the values of strontium over the whole area that is being analysed, and as these values are distributed through larger geographic areas, and as their values may overlap even if they are distinct – this kind of approach allows continuous assessment that is more preferable nowadays (Bataille *et al.,*2018).[15]

If our sample is provenance inside space, we have divided into a grid with ranges of $^{87}Sr/^{86}Sr$ we are using are measured values in a likelihood manner. With the Bayesian approach, we try to match a grid cell with how likely it is the closest to the values of our sample and how common this match might be (Hoogewerff *et al.,*2019).

These predictive models help in the development of isoscapes or spatially models of the predicament of elemental isotope ratios that are produced by executing process-level models of elemental isotope fractionation or distribution in a GIS framework (Hoogewerff *et al.,*2019). The

[15] Nonetheless, this requires accurate predictive models with spatial uncertainty assessed (Bataille et al 2018).

latter are derived by interpolation of a large number of $^{87}Sr/^{86}Sr$ ratios gained from different sources in order to get an estimation of the available strontium pool inside a geological system (A. Poszwa *et al.,* 2004; Copeland *et al.*,, 2011; Williems *et al.*,, 2014; Bataille *et al.*,2018). Most used data is extracted from surface water, soil leachates, as well as flora and fauna that has a contained feeding range or a combination of these. It must be emphasised that the number of samples must be very high to produce spatial prediction (Evans 2010; Williems *et al.*,2018). The starting point is modelling of the possible variations in bedrock based upon the age and lithology derived from geological and lithological maps, upon which atmospheric depositions and weathering processes are modelled and checked with available datasets (Hoogewerff *et al.*,2019). Of course, the limitations are born among these models due to low-resolution databases in some countries and the combination of multiple factors and sources mentioned (Bataille *et al.*,2012). The maps show that major lithological trends are reflected in soil geochemistry and thus regions have their own characteristic elemental soil signatures.[16] In terms of archaeological research, sample collection and various types of samples are not represented unanimously between different studies and can as such create liability or limitation in the dataset of an isotopic study.

[16] The maps however have a low resolution, e.g. 50x50 km scale.

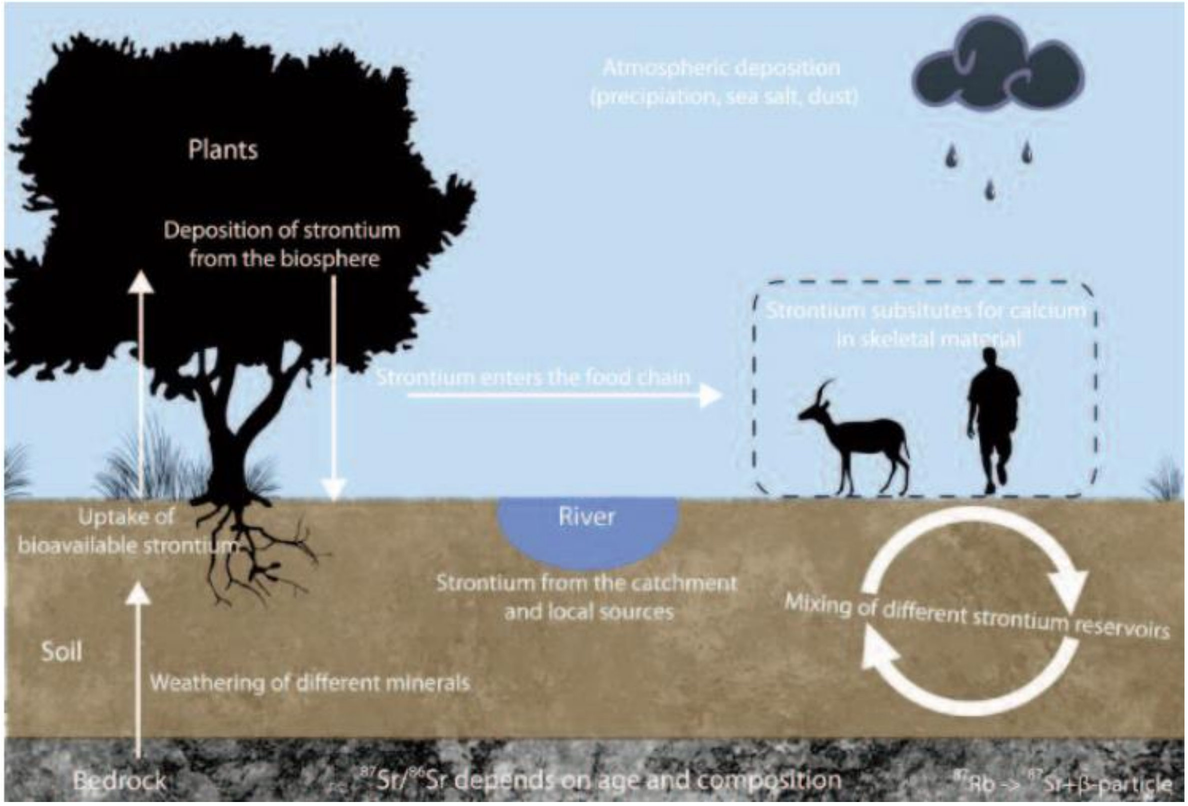

Figure 22. Strontium exchange pool (Willmies et al.,2014).

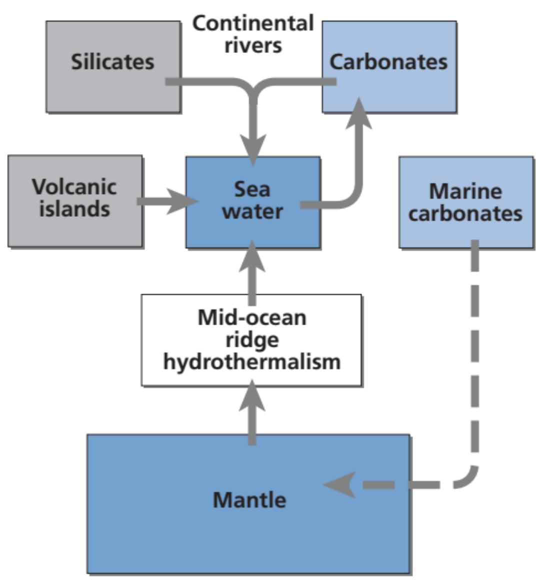

Figure 23. Different factors that make up the isotope composition of strontium in the example of seawater (Allègre 2008).

3.6 Strontium isotopes and mobility in archaeology – Who are you and where do you come from?

Although the chemical analysis of teeth and bone has gained widespread recognition as a tool for paleodietary and paleoenvironmental research, the primary focus of such research is now mainly isotopic. The analysis of mobility is based on the never-ending cycle of bone remodelling and the different rates of bone turnover during life, as has been stated before.

As science developed during the last two decades of the 20th century, ideas about various isotopes studies arose and among the elements used in establishing the scale and character of movements in historical sequences, strontium stands as one, if not the most effective one.

Information about where an individual or a group of people originates from was thus enthralled with the ability to analyse human remains and get a pinpoint of their provenance, which was not an option within previous archaeological research. The latter used archaeological material and its changes, along with anthropomorphic changes as arguments in human mobility patterns, nonetheless this was only based upon interpretation. Even when there is the historical source that sheds light on such actions during history, it still possesses a whole spectrum of unanswerable questions such as – how many people, which part of society, who were involved more, the men or women and so on – are not readily answered within archaeology itself (Ericson, 1985; Montgomery, 2010). Information conserved in elements as strontium that is enclosed since childhood in the tooth enamel of ancient people gives a fantastic strain of opportunity for archaeologists to explore, compare and give new definitions to populations and those that have become a part of the same by moving from another location.

Initial research on human remains and modern animals (Ericson, 1985, 1989; Sealy, 1989) has brought to light the potential of using strontium isotope ratios for studying questions of movements, migration and inter- or outer-regional movement. One of the most influential studies (Sealy, 1989) of continental versus marine diets in South Africa represents the ability to distinguish groups of people on the basis of the type of diet and sequential inference of patterns of movements of the different groups.

Establishing whether a skeleton is of a local origin is however rarely the ultimate goal of strontium isotope analysis. The vast majority of research questions focus on the identification of immigrants as they may illustrate why major changes in material culture, shifts in population or colonisation, invasions and similar even occurred, and even when immigration is evident, isotope ratios can only rule out a place of origin and we can be left only with an assumption (Price *et al.*,2002; Evans *et al.*,2006; Bentley, 2006, H. Schroeder *et al.*,2009; Montgomery, 2010). This is where archaeological framework must be scrutinized, before any further conclusion.

Strontium levels in the global exchange pool have been affected by thermonuclear tests in the last century as the strontium-90 was produced in high quantities, and strontium was studied intensely as a scientific community thought that whole generations might be affected. However, this led to the recognition that almost all of the strontium (>90%) is incorporated into the skeleton and that strontium levels decrease as the trophic level, or as the one moves up the food chain as it is not processed as efficiently as calcium (Degteva and Kozheurov, 1994; Toots and Vorhies 1965; Rosenthal, 1981; Burton and Price, 2002; Katzenberg, *et al.*,2002; L'Annunziata 2003; Shagina 2012). Therefore, the strontium to calcium (Sr/Ca) ratio of animal tissue is lower than what it consumes (it usually reflects around 20% of diet) and this is termed as biopurification, and interesting same happens in the mammary gland and milk consumed by babies has lower Sr/Ca ratio than that found in what is consumed.

Thus, first and foremost strontium to calcium levels in bone tissues were used in studies of meat versus plant diets through comparison of levels in human opposed to levels of fauna (Sillen 1981; Price and M. Kavanagh 1982; Pollard and Heron,2008). What is more, comparisons among social groups have been done, for instance, if one had more various diet and similar. However, there is an error in using bone Sr/Ca as a tool for measuring plant to meat ratio because it itself is not in proportion relation with plant/meat ratio itself as the usual mixture of plan and vegetable food sources does not correlate to the ratio itself (Burton and Price, 2002; Montgomery, 2010). Controlled experiments, where feeding of animals was observed to test the above and the complexity behind it, what is more, it has been observed that Sr/Ca ratio reflects the same ration in food, but the food with higher amount of Ca shows up disproportionately in the bone tissues (Burton and Wright, 1995). Thus, a mixed diet is not seen always in the Sr/Ca ratio. In other words, none of the analysis showed that strontium ratios will reflect consumption of meat and in humans, that is omnivores exists a likelihood of obtaining strontium from plants rather than from animals. To summarise, in a balanced diet, such as one in omnivores such as humans, the dominant contribution of strontium intake comes from flora, and as such it represents a fortunate fact as both humans and animals will thus more precisely represent the landscape's signal (Montgomery, 2010).

Before being brought into archaeological studies (Ericson 1985), it was used in ecology for tracking movement of flora and fauna (Ericson 1985; Aberg, 1994; Koch *et al.*,1995; Chamberlain *et al.*,1996). The earliest application of strontium isotopes in archaeology was born with the realization that a migrating individual that cross geologic regions are identifiably through the ratio in adult tooth enamel which forms between 4 and 12 years of age with that of the bones that remodel throughout one's life.

Through comparison of the isotopic ratio of strontium $^{87}Sr/^{86}Sr$ of the two tissues, we get an ancient *passport* of an individual as it serves as a proxy for reconstructing its dynamics of mobility (Tafuri 2019). The mobility is traced through ratios of dental enamel that forms during the first years of life or bones that are subject of never-ending chemical turnover which thus reflects the place of residence over the years prior to death. If we observe a homogenous ratio $^{87}Sr/^{86}Sr$ it could thus suggest a stationary life, while the opposite can reveal mobility between two different environments. At first exactly ratios of teeth enamel and bones were compared but nowadays analysis is usually based on an investigation of the dental enamel as it is, as has already been said, less prone to diagenesis intertwined with fauna associated with the same archaeological context in order to get a reflection of what might be a local signal (Price *et al.*,.1998; Bentley *et al.*,2004) As specific teeth with the smaller time of mineralization are targeted, or simply by using the teeth which do not vary in terms of the age of mineralization, thus specific life periods are observed (Montgomery, 2010). In order to determine what is local and what is foreign – to establish what strontium isotope ratios reflect local geology as it is the baseline to which individual values are referred – a series of samples from the micro-region and framed closed archaeological context must be analysed (Knipper *et al.*,2012; Francisci *et al.*,2019). Henceforth, fauna and soil coming from associated archaeological sites are analysed along with teeth and bones.

Nonetheless, this method was in its beginnings used for mapping the movement of animals (C. Chamberlain *et al.*,1996). Later, studies of pastoralism, transhumanism, breeding and hunting of animals have come to light too, but more importantly, successful observation on broad-scale migration during prehistory have been done, as well as those that showed mobility within smaller societies that might have reflected their cultural customs and phenomena, for instance, immigration, social practices and organisation, food accessibility or funerary practices (Sealy, j-1991; Groupe *et al.*,1997; Price *et al.*,2002; Bentley *et al.*,2003; Bentley, 2006.; Giblin 2009; Goude *et al.*,2012; Scheeres *et al.*,2013, Tafuri *et al.*,2016).[17] Furthermore, strontium isotopes are nowadays measured along with the oxygen isotopes ($^{18}O/^{16}O$) inside the carbon or phosphate of the enamel as it is reflecting the isotopic ratio of oxygen in drinking water, as well as carbon isotopes ($^{13}C/^{12}C$) that give insight on the past diet (Bentley, 2006; Pollard, 2011; Kenoyer *et al.*,2013).

Furthermore, mobility can be examined also with the use of carbon and nitrogen isotope but it is then limited to intrapopulation comparisons. In a sampled population, a potential migrant individual will have an isotopic composition that is very different from the rest of the population as it assumed its diet was unusual and it can be seen it the ratios of the mentioned elements (Schroeder *et al.*,2009; Hakenbeck *et al.*,2010). Nonetheless, this kind of interpretation is difficult as it is influenced by many underlying factors – from access to animal meat, collagen turnover itself or for instance simple individualistic preference of vegetable over meat products. However, a careful interpretation of the isotopic compositions of teeth and bone and their correlation to burial practice and associated grave assemblage may give a more resolute picture of mobility.

To succumb obstacles that may evolve with the usage of just strontium isotopes for research of mobility, a multidisciplinary approach should always be envisioned. For example, one such examined pastoralism in Libya by including analyses of animal remains from rituals through isotope ratios of strontium, carbon and nitrogen that were intertwined with excavation data, radiocarbon dating, stone art and archaeobotanical information, all together enclosed within GIS environment (di Lerna *et al.,* 2013). This allowed a more thorough connection of a cultural practice which included the seasonal gathering of different groups, the ritualistic slaughter of cattle that were brought from different regions, erection of associated rock art that was previously impossible through analysis based solely on archaeological material.

[17] It interesting how mobility can also be studied through patterns of carbon and nitrogen isotopes that can server as indication of marine sources of food in hunter-gatherer societies (see Sealy, 2006.).

Similarly, analysis of the neolithic Bell Beaker society and their mobility inside what is nowadays deemed as Bavaria in Germany, has previously been interpreted through the morphological specification of the human remains, however without knowing what the cause of the differences in sizes of the skelet is, it was highly dubious and thus the strontium isotope ratio analysis proved as a means to an end (Groupe *et al.*, 1997). Finally, it was confirmed that maybe even one-quarter of the population was a part of immigration or emigration as such to an even very distant location over 200 kilometres and interestingly a surplus of females which was identified as an example of exogamy and that these groups of people were not invaders.

Are Archaeological Questions answered by the Strontium Isotopes?

Recently, Pollard (2011) discussed the existing need to create a separation of isotope studies done in geochemistry with those that are done on archaeological material due to a variable found in human factor itself. In other words, humans in their complexity should still be acknowledged in the development of research questions and plan from the beginning. Moreover, the archaeologists and geochemists should be on the same page in order to produce data that can relate to what is always difficult in archaeology – an interpretation. This means that conclusions should not be overemphasized because as such they will compromise the strontium analysis itself. In essence, scientific research is a compilation of observations that produce new ideas and form models that are birthing questions and interpretations while collecting new data if possible. Archaeology tends to gain defined answers to question with the help of science. The problem lies in simplification coming from the need to produce answers from archaeological samples – in essence, the terminology of someone in the past originating from a certain part of the world is used too easily.

Signal of humans living in a particular location is affected by shifting geology, water sources, farming and dietary practices, trade-in food and social norms and practices and not simply by geology. What is more, the strontium isotope ratios in the bedrock can vary in very short distances making even more emphasis on food sources.

The biology of strontium uptake in dental enamel might differ in the early-formed and later formed enamel, but the reasons behind it are not easy if it is even possible to interpret from an archaeological perspective. What is more, it does not necessarily have to reflect the local biosphere directly, and it important not to ignore geology itself through the usage of the isotope data without critical thinking (A. Pollard 2011). In the simplest words – there exists a possibility that a certain number of individuals might be wrongly interpreted as foreigners if the isotopic data is not considered inside the broader archaeological frame from the get-go and if we are only looking at a specific point of origin. Strontium ratio analysis should not be used in the exploration of past mobility as such but as an advocate to archaeological questions (Goude *et al.*, 2012).

This has to be tested with archaeological evidence itself and within the nature of the archaeological question itself. *Summa summarum*, even though we possess the number of suggestions of movement and residential changes in archaeological populations, the archaeological record is still ambiguous as evidence even though it is studied meticulously. In other words, it is virtually impossible to distinguish the movement of humans and the movement of their ideas and products.

3.7 Thermal Ionization Mass Spectrometry (TIMS) – Principles and Instrumentation

In the last several decades, archaeology has increasingly used the technique of mass spectrometry for answering questions about historical patterns and behaviours. Mass spectrometry has the ability to determine isotope ratios of either heavy or light isotopes, either as a system on its own or as an add-on to various other instruments, better-said methods such as gas or liquid chromatography and elemental analyser and so on. As such it represents a sensitive detection with a broad range of application in analytical chemistry.

Mass spectrometry is formed on the basis of physical properties of electrically charged atoms and molecules, whose different atomic masses or more precisely mass-to-charge ration allows their separation in a controlled environment – an external electromagnetic field in which their motion is controlled (Pollard and Heron, 2008).

The principle of the mass spectrometer always consists of a source of positively charged ions that possess the same energy level and a magnetic or electrostatic system that will deflect and sperate the charged ions that will end up collected in an ion collector, thus measuring the flow of the same. In other words, atoms of the chemical element in analysis whose isotopic composition we ought to measure are analysed in a vacuum chamber where he pressure is always kept low in order not to influence the separation, as they would lose the charge by colliding with air molecules, which is based on a stream of ions in an electric current that is passed through a controlled magnetic field which bends the flight of ions, with those who are lighter being deflected more and thus their sorting to the mass can be done according to their time of flight. Finally, the mass analyser separates the ion beams emerging from the ion source according to their *m/z* (mass/charge) ratios as they are collected (Allègre, 2008; Hoefs 2009).

The aforementioned is expressed by the formula $E = eV = 1/2mv^2$.

If an ion with a mass **m** and a charge of **e** is extracted from the ion source by an applied voltage **V**, then it is given kinetic energy of **E**. In other words, all ions will have the same kinetic energy, but different velocity (**v)** that is reflecting their mass. Similarly, by knowing the strength of the magnetic field (**B**), as it is controlled, and the radius (r) of the circular track they take upon we can establish the following: $r = 1.414\ (V \times m/e)^{1/2}\ /B$.

Thus, the detector can send electronic signals that act as a measure in accordance with the latter. Faraday cup detectors are the most usual and simplest of their kind and it simply counts the number of ions that are on the receiving end of the flow that is the beam current.

The most important factor is the ability to measure the precise value of the mass and in case of geochemistry and archaeology the abundance of the ions or the ration of two ions and for which a dual collector is used so that the ion beams of both heavier and lighter are screened at the same time in order to reduce any possible fluctuations and achieve the best resolution (Duckworth *et al.*, 1986; Schoeninger and Moore, 1992).

Spectrometer today use gaseous or solid samples that are subsequently ionised. In the first case, this is achieved by injection into the vacuum system and bombardment of the gaseous substance with a beam of electrons. The positively charged particles are then extracted, accelerated and focused by negative chare coming from the plates into the analyser tube and finally to the collector. On the other hand, heavy elements that are mostly used in isotope geochemistry require a solid source such as thermal ionization. The sample, in this case, is put on a refractory metal wire that is introduced to the mass spectrometer and heated from an electrical source to achieve volatilisation and ionization. The electronics of these instruments must operate to very close tolerances in order to produce isotope ratios that are precise to 0.01–0.001%. Currently, several ionization techniques are used in mass spectrometry depending on the chemical properties of elements that is their ionization potential (Allègre, 2008; J. Hoefs 2009).

Thermal ionization mass spectrometry (TIMS) began moments after the discovery of the atom and understanding of the behaviour of charged particles in electric and magnetic fields.

TIMS instrumentation is based on a magnetic sector mass spectrometer capable of precise measurement of isotope ratios of elements that are susceptible to ionization through thermal energy as they are passed through a thin metal ribbon or ribbons under vacuum (Constantinos and Danezis, 2015; Makishma 2016).

Thermal ionization implements a previously chemically purified sample that is deposited on either a single or multiple filament. One is used for the liquid sample and it consequently evaporates during ionization. The other filament will consequently be used as a landing ground for the same ions, and on it, the electrons are lost. Usage of single filament is also possible, and after evaporation, the ions will land down on the same filament and be ionized. The filament is usually made of rhenium (Re), Tungsten (W), platinum (Pt) or tantalum (ta), which is firstly treated with activators to repress the evaporation and balance, that is either increase or decrease the ionization potential, and afterwards dried and then heated up to 2300°C by an electrical current in the vacuum, thus achieving the ionization and forming cations or anions as the temperature of the filament surpasses the vaporization point of the samples.

After positively charged ions are introduced to the system, they are accelerated across an electrical current and focused into a beam with a series of slits and electrostatic plates. Afterwards, they are separated according to their mass by deflection device – an electromagnet keeping a uniform magnetic field that disperses the beam into separate ones based on their m/z ratio. As the former has different masses – the heavier is less influenced and its time of flight is longer – and the ion beam carrying them is finally converted into a voltage signal as the particles are collected in a faraday cup, electron multiplier or Daly detector, which act as the most common detectors nowadays. In the end, by comparing the voltages to the individual ion beams produces a precise isotope ratio.

As each technique possesses strengths and limitations, so does the TIMS. Therefore, one of the obstacles is that not all elements are easily ionized and ionization itself is not equally efficient for all. Further, extensive sample preparation is needed, and mass fractionation tends to change as the analysis is being made, thus creating a need for corrections. TIMS can measure isotopic ratios on picogram (10^{-12} gram) to nanogram (10^{-9} gram) samples or down to tens of femtograms (10^{-15} grams) using special pre-concentration techniques. TIMS routinely measures differences in isotope mass ratios on the order of 1 in 10^{6}.

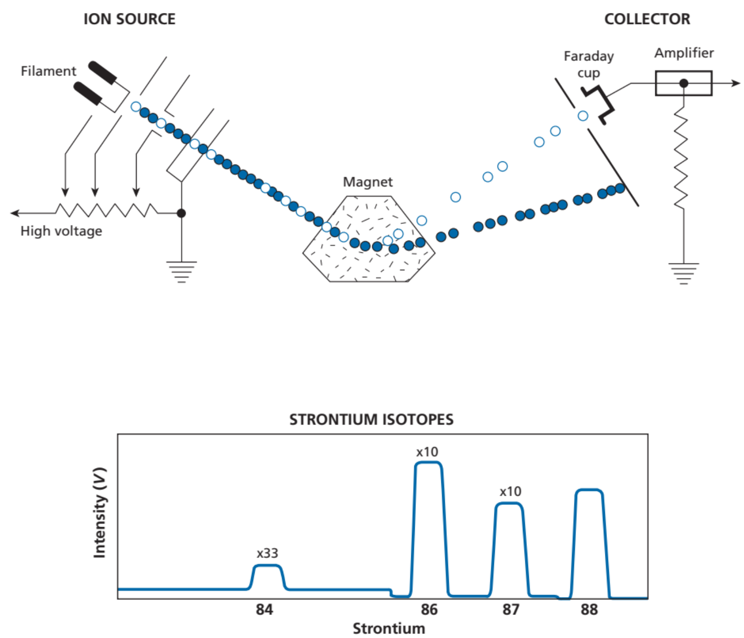

Figure 24. A thermal-ionization mass spectrometer and attributed mass spectrum of strontium as an example (C. Allègre 2008).

Chapter 4. MATERIALS AND METHODS

4.1 Introduction

Stable isotope analysis of human and faunal remains from the same archaeological context and period is valuable for establishing a baseline of values that can be explored in studies of migrations (Ericson 1985; Faure 2005). Strontium isotopic ratio ($^{87}Sr/^{86}Sr$) are usable in a direct relationship between food consumption and the corresponding signatures from the local geology that is transferred to the human tissues without fractionation. Therefore, they act as a geographic signature that reflects diet and an individual's geographical origin druing childhood, if measured in the teeth and later life if measured in the bones of an individual .

Patterns of human occupation are linked to the historical environment and subject to extreme change. In the same perspective, occupation might be a consequence of movement due to various reasons ranging from climate to war. Furthermore, this kind of conditions fuel mobility and reconstruction of one's movement and origin through studying the skeletal remains is the cornerstone of isotope geochemistry.

The purpose of this study is to investigate the skeletal (bones and teeth) material and reconstruct a part of the lifestyle of the Selvicciola community, dated to the post-classical period. The aim is to represent and study the mobility patterns of a selection of individuals from the cemetery dated to the Longobard period, so asto assess their origin. The site of Selvicciola is found at the crossroads between north and south of Italy, and at the same time between different political entities during VIth and VIIth century, thus together createing the perfect scenario for an analysis of the mobility of a certian historical population. Given the archaeological information (Micarelli, 2020), the isotopic investigation has the aim to analyse the possible different origin of individuals found at the Selvicciola necropolis.. Thus, grouping and clusters found in the cemetery itself, as mentioned earlier, might correlate to different origins as well. Finally, the goal is to study and understand the response of a population to historical events and compare the results with similar archaeological contexts in Italy and abroad.

4.2 The skeletal sample

Excavation campaign of Selvicciola cemetery yielded skeletal remains of 116 individuals, of which 69 are adults and 42 sub-adults, 31 are male, 18 female, while 20 individuals of undetermined sex (Manzi *et al.*,1995; Micarelli, 2020). The latter are indistinguishable as they are a part of secondary depositions, hence extracted from the burials where the skeletal remains are moved from its original burial deposition. Consequently, their context is obstructed and changed, and attribution of the grave goods to those individuals may be difficult and questionable. Tombs were chosen based on grave goods (typology and chronology) preserved. The burials selected for this study belong to Roman (beginning 4^{th} - beginning 7^{th} century CE) or Longobard phase (half 7^{th} - beginning 8^{th} centuries; Micarelli, 2020).

The tombs were thus selected based on the typology and dating of the grave goods, the position within the cemetery, as well as their structural typology while trying to stay in balance in terms of the sex and age of the individuals.

The analysis of the skeletal samples has, in essence, started with the recording of the skeletal profiles of the population through sex and age determination of each individual (Micarelli, 2020). This study serves as the foundation for the interpretation of the results of other specific analyses aimed at assessing anthropological, pathological, historical and cultural aspects of the ancient population from Selvicciola cemetery.

Teeth and bones of 21 individuals were selected for strontium isotopic analysis, with associated animal samples serving as indicators of the bioavailable Sr signature of the local geology. The tooth preferentially selected for analysis was the canine as was mentione previously, due to the crown formation of tooth enamel prefernces in terms of age – as canines form enamel in the first five years of life (Bentley, 2006; Francisci *et al.*, 2019). Due to the various state of preservation of some of the human teeth, sampling has been done on the most representative tooth available, with molars and premolars acting as substitutes in only two samples (namely SLV 85/18 A and SLV 86/13).

We measured strontium isotope ratios from human tooth enamel (n=19), human bone (n=8), animal enamel (n=8) and soils (n=6) from the Selviccola site. From five individuals (*t. 85/10 ; 86/2 ; 86/4 B ; 86/17; 87/4*), we collected strontium both in teeth enamel and bones .

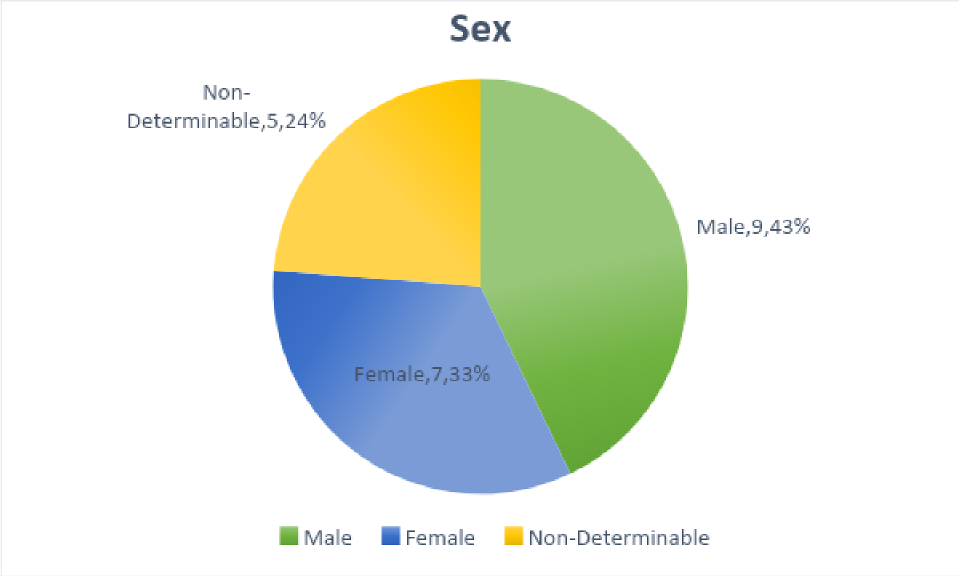

Figure 25. Sex distribution of the samples.

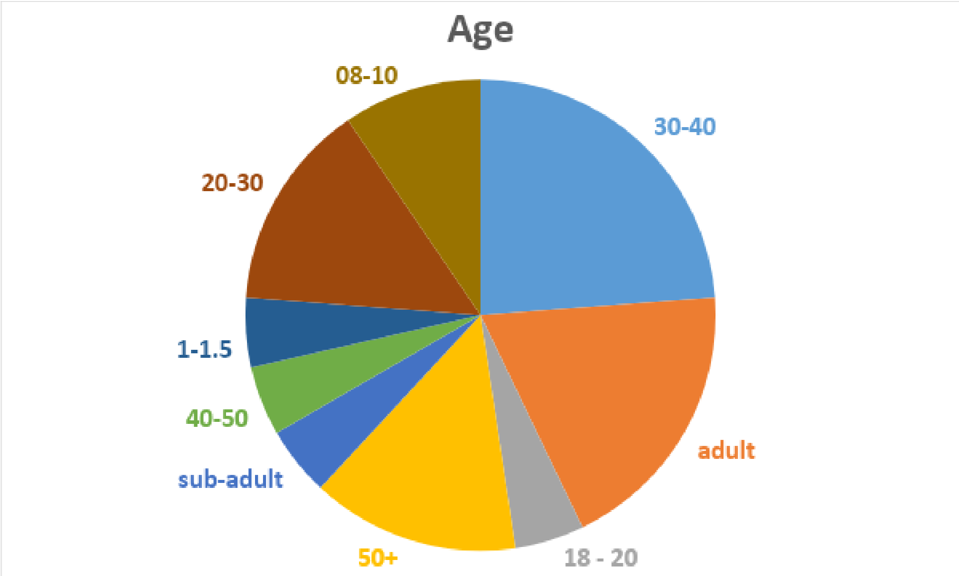

Figure 26. Age distribution of the samples

From this set of individuals, nine belong to males, seven to females, while others are non-determinable (Figure 25**)**. The age at death of this group is more dispersed, with the youngest being an infant of one year of age among the most older individuals whose age is 30 or older (Figure 26.).

Eight individuals belong to the late antique phase of the cemetery, dated from the middle of the 5th until the middle of the 7th century and are presumed to be of the Roman phase. The other thirteen individuals are presumebly Longobards.

4.3 Sampling

4.3.1. Bone sampling

The procedure in this study is formed within three stages: (1) sampling through micro-drilling, (2) sample digestion and purification of the Sr, and (2) measurement of the isotope ratio through thermal ionisation mass spectrometry (TIMS).

For this study soil, tooth, and bone specimens of humans and animals were sampled for strontium isotope ratios ($^{87}Sr/^{86}Sr$). Sample collection and pre-treatment was performed in the Paleoanthropology and Bioarchaeology Laboratory of the department of the Environmental Biology at the University of Sapienza. Sample preparation for mass spectrometry was carried out at the Department of Earth Sciences. Analyses were carried out at the Department of Geological Sciences at the University of North Carolina at Chapel Hill [18].

[18] We thank Prof. Paul Fullagar for providing lab facilities as well as Dr. Ryan Mills for assistance with analyses.

Figure 27. Bone sampling example (Luka D. - Bruketa).

Even though it is argued that bone samples tend to show diagenetic contamination (Bentley, 2006), they can still usefully attribute the estimation of the local $^{87}Sr/^{86}Sr$ signal. Hence, 50 mg of the cortical portion of the long bones (ribs, femur, fibula and tibia) which yield higher proportions of cortical bone were chosen (Figure 27.). The choice of the latter is, as is mentioned above, due to the turnover rate of this type of bones being long enough to reflect living environment prior to death (Tafuri *et al.,* 2006; Fahy, 2017). Furthermore, any post-deposition contamination would likely reflect local Sr values (Grupe *et al.,* 1999).

From the pathological viewpoint, several studies of the human remains belonging to Selviccola show a population with health issues derived from hard-working life and poor nutrition(Micarelli *et al.*,2020).

As has been mentioned in the previous chapter, diagenetic alteration is a common problem in archaeological bones and teeth as it affects both the inorganic bioapatite and the organic components (Bentley 2006; Evans *et al.,* 2010; Pollard *et al.,* 2011). Accordingly, when chemical analysis of bone material is being performed, it is necessary to measure the possible extent of damage that occurred post burial. As techniques for stable isotope analysis are mostly destructive, methods which can anticipate the content for bones are developed.

4.3.2 Dental enamel sampling

As is stated above, the availability of the teeth was attested visually for the suitability of the analysis. Accordingly, cracked or poorly preserved samples were excluded.

Tooth samples were obtained for nineteen individuals (9 belonging to Roman and 10 to the Longobard phase (Table 2.). All teeth were either canines or first permanent molars, with one exception of the child (t. 89/4) where primary canine was used. As has been said before, according to estimations (Hillson 1996), the tooth enamel for the first molars (M1) would have been laid down between birth and 2 years of age, additionally, the enamel of the premolars (P) and second molars (M2) is representative of the 3.5 and 7 years of. As for the preference of the canines, the enamel in this case form from 4 months to 6 or 7 years of life. The strontium isotopic ratios in tooth enamel are therefore connected to the time of its formation.

For the dental enamel sampling, we collected approximately 30 mg of enamel powder from the lingual surface of the tooth using a micro drill with a mounted diamond burr (Figure 28.). The position of extraction came to form the lower half of the crown to avoid alterations linked to metabolism in the early formation phases of the teeth (Bocherens *et al.*,1991).

Figure 28. Tooth enamel sampling example (Luka D. - Bruketa).

4.3.3 Faunal samples

Zooarchaeological samples **(**Figure 29.**)** were taken in order to create a baseline of the site's context and provide input of what is the local strontium signal. Thereupon, the fauna provides information about the surrounding environment and makes it possible to assess mobility and understand the viability of the research through different sources. Hence, eight samples of animal teeth were selected to create a thorough and more complete isotopic picture. These samples came from the excavation of the tombs (namely *t. 85/5; 85/10; 85/13B; 85/15 ; 86/18 ; 89/4*) and some have also been used for dietary studies as they were derived from the layers inside the area of the church (SLV Q U.10 - U.11). The latter are located inside the area of the site and are considered as a viable reference for the faunal sample collection. According to the excavators (Gazzetti 2009), they belong to the same period of use of the cemetery.

From the samples, the teeth are either premolars, molars or incisors. In terms of species, both domesticated and wild species were available, however only several samples are defined as pig/boar (*Sus scrofa*), domestic cattle (*Bos taurus*) and a sheep/goat (*Ovis aries/Capra hircus*) acting as baseline proxies of local herbivore and omnivore diet for comparison to human isotope levels (Table 2).

Sample collection of bone and teeth material followed the same procedure of the human samples (see above).

Figure 29. Fauna enamel sampling example (Luka D. - Bruketa).

4.4 Defining the local range

The bioavailable strontium represents the range of the strontium locally available to flora and fauna in an ecosystem, that is thus brought to the consumer as an $^{87}Sr/^{86}Sr$ isotope value. Studies have shown that the strontium isotope ratios of terrestrial herbivores ranges as a reflection of the valeus found in the geological substrate of the area (Bain and Bacon, 1994; Capo *et al.*,1998).

Strontium isotope ratios of an envirnoment are defined by the age of the bedrock and its chemical composition as its mineral weathering and atmospherically found strontium in form of continental dust and precipitation form its values. Accordingly, plants have $^{87}Sr/^{86}Sr$ ratios that are mirroring those of the available strontium in the soil that is prone to change and easier alteration (Bentley, 2006). As the strontium is an element with high-mass, its fractionation is at such a low level that we can deem it negligible and that is why strontium isotope ratios of the ecosystem reflect the ones found in the sources of strontium (Capo *et al.*,1998; Castorina and Masi, 2011). The enamel of both archaeological and modern faunal teeth from a site are one of the best indicators of the local range (Price et al., 2002; Bentley, 2006), but their exact origin may come into question. In some cases domestic animals fall within the predicted strontium isotope ratios of the surrounding geology, and ideally local bioavailabile strontium base should in best case be determined from smaller fauna and plants, moreover than extrapolating from the bedrock alone as it could diminish the presence of „non-locals“ due to values estimated from the bedrock being more varied than those of faunal samples (Fronander *et al.*, 2015; Whelton,2018).

By comparing each tooth to a local range, as it is defined from the site as a whole, we obtain a reliable value (Grupe *et al.*, 1997; Price *et al*., 2002; Bentley *et al.*, 2003) of the geological background of the locale of origin of an individual - this in consideration that teeth form during childhood. As stressed, this is due to the definition of "local" that might include also a person who migrated but from a similar geochemical province. By the same token „non-local“ signal might be seen in someone who procured food differently during juvenile and adult age, e.g. a hunter turning farmer (Bentley 2002).

Local ranges are further defined through geological maps, as it will be seen later, For the faunal enamel results, ovicaprians and pigs are preferably chosen if possible as it has been found that they usually present the narrowest ranges of strontium isotope values that can as such define the local values in greatest stretch possible, as cattle has shown to be herded over long distances (Bentley *et al.,*2004; Bentley, 2006; Knipper 2009; Whelton,2018).[19] To define the local range at Selvicciola that was to be used as a comparison with the data obtained from the teeth and bones of humans, eight fauna samples from the burials and the church (Q.U.10.- U.11 ; T. 85/5; 85/10; 85/13b ; 85/15; 85/18; 89/4, see above) were used to test whether there were regional differences in the local strontium signature. The latter faunal samples come from a closed context of tombs covering all three determined chronological phases along with grave goods that are attributed as being of Longobard or post-classical origin.

In essence, the local range will be defined by two standard deviations from the average $^{87}Sr/^{86}Sr$ found in faunal teeth - $^{87}Sr/^{86}Sr \pm 2$ SD as suggested by the relevant literature (Bentley, 2006; Goude *et al.,*2012).

[19] There is no evidence thus far for or against the adoption of transhumance for sheep and goats during Longobard era and this is yet to be defined.

4.5 Sample preparation for TIMS Analysis

Hereby, measurement of isotope ratios from dental enamel powder of lower/upper canines or molars followed a protocol through TIMS, as described elsewhere (Tafuri *et al.*,2013). Traditional analytical protocol for the separation of strontium in tooth enamel has been used (Bentley *et al.*,2004.; Chao *et al.*,2014.). Hence, mechanical abrasion and bulk sampling of enamel in the region of the tooth crown was drilled (Bentley, 2006).

Figure 30. Analytical procedure - ion-exchange columns for strontium extraction from teeth (Luka D. - Bruketa).

In order to proceed with the estimation of strontium isotope ratios, samples were put through a procedure of strontium purification from intact enamel (Figure 30.) (Price *et al.*, 2002; Bentley *et al.*, 2003).

After cleaning the surface of tooth and bones by abrasion with a Dremel diamond burr, 20-30 mg of enamel powered were extracted and put in Savillex © 15 mL standard vials. Teeth samples provided c. 7 mg of clean enamel for $^{87}Sr/^{86}Sr$ analysis. Bone samples were fragmented and put to 20 ml glass vials and afterwards inside the ultrasonic bath where they were repeatedly sonicated in 18 MΩ deionized water with 10-15v minutes at a time until the water is no longer discoloured or until the point of diminishing returns. Following, a further sonication has been done for 20 minutes with 5% acetic acid (CH_3COOH) to dissolve any poorly crystalline apatite and carbonate and finally once more with deionized water to rinse the acetic acid (CH_3COOH).

Bone and enamel samples weighing 3–5mg were dissolved in 5M nitric acid. The Sr-Spec resin was cleaned repeatedly with deionised water to remove Sr present from the resin manufacturing process. Sample solutions were placed on the columns, and approximately 7 mg of the crushed sample was dissolved in 15 mL Savillex PFA vials using 5 mL of 3.5M HNO_3 in a class 100 filtered air environmental hood and the samples were evaporated and redissolved in 2.5 mL of 5N HNO_3. Strontium was then purified from the matrix using Eichrom Sr-Spec resin, a crown-ether Sr-selective resin (50 and 100mm diameter) loaded into the tip of a 10 mL BioRad polypropylene column with elution of Sr in water. Total resin volume was approximately 50mL. The Sr-Spec resin was pre-soaked and flushed with H_2O to remove strontium present from the resin process. The resin was further cleaned in the column with repeated washes of deionized H_2O and conditioned with 5N HNO_3. Resin was used once for sample elution and discarded. The dissolved sample was loaded and washed in 5 mL of 5N HNO_3, and then strontium was eluted with 1 mL of H_2O.

Strontium isotopic compositions of samples were obtained through separation by isotope dilution thermal ionization mass spectrometry (ID-TIMS) at the University of North Carolina at Chapel Hill. Strontium was analyzed on a VG Sector 54 TIMS as a metal in dynamic multi-collector mode with ^{88}Sr = 3V. Strontium isotopic ratios are corrected for mass fractionation using an exponential law correction and normalized to $^{87}Sr/^{86}Sr$ = 0.1194. Replicate analyses of the NBS 987 Sr standard currently yields $^{87}Sr/^{86}Sr = 0.710250 \pm 0.000016$ (2σ, n =20). The internal precision of each sample is better than the reproducibility of the standard, and thus the uncertainty of the standard is the uncertainty ascribed to each unknown.

Table 2. Selvicciola Sampling (Adapted from Micarelli 2020)

Grave	Tooth sample	Enamel growth range	Bone sample	Fauna sample	Sex	Age at death	Grave Typology	Phase
85/3	URC	0-5 y			F	30 - 40	*Cappucina*	Romans
85/5	LRC	0-5 y		Ovis v. Capra P	M	adult	-	Romans
85/9	URC	0-5 y			M	18 - 20	*Cappucina*	Romans
85/10	LLC	0-5 y	Rib	Ovis v. Capra P1M	M	50+	*Cappucina*	Romans
85/13 B	LLC	0-5 y		Ovis v. Capra I	ND	sub-adult	*Cappucina (MNI=2)*	Romans
85/15	ULC	0-5 y		Sus s. M	F	30 - 40	*Cappucina*	Romans
85/18 A	LM1M	0-3 y			F	50+	*Stone cover (MNI=2)*	Romans
86/3	URC	0-5 y			F	40 - 50	*Cappucina*	Romans
86/2	URC	0-5 y	Fibula		M	30 - 35	*Cappucina*	Longobards
86/4 B	LRC	0-2 y	Rib		F	1 - 1.5	*Single pit*	Longobards
86/5			Rib		ND	1 - 1.5	*Single pit*	Longobards
86/6			Femur		F	adult	*Stone cover*	Longobards
86/8	LRC	0-5 y			M	20 - 25	*Stone cover (MNI=2)*	Longobards
86/9	URC	0-5 y			M	20 - 30	*Stone cover*	Longobards
86/11 A			Tibia		ND	adult	*Stone cover (MNI=2)*	Longobards
86/13	LL2P	0-5 y			M	adult	*Single pit*	Longobards
86/17	ULC	0-5 y	Rib		F	50+	*Single pit*	Longobards
86/18	LLC	0-5 y		Ovis v. Capra P/M	M	30 - 40	*Single pit*	Longobards
87/4	LRC	0-5 y	Rib		M	30 - 40	*Stone cover*	Longobards
89/4	ULC	0-5 y		Ovis v. Capra P	ND	08 or 09	*Stone cover*	Longobards
90/8	LLC	0-5 y			ND	08 or 10	*Stone cover*	Longobards
91/5	URC	0-5 y			F	25 - 35	*Stone/Cappucina (MNI=2)*	Longobards

Tooth Legend: UR/LR/UL/LL - Upper/Lower Right/Left LM – Lower Mandibular C- Canine M-Molar P-Premolar ND = not determined; MNI = Minimum Number of Individuals.

4.6 The Geological setting of the area - $^{87}Sr/^{86}Sr$ variation map

In order for strontium isotope analysis to have any effect, regional geological variations must exist. Thus, many $^{87}Sr/^{86}Sr$ variation maps have been made in order to ease and facilitate the provenance of $^{87}Sr/^{86}Sr$ values obtained from archaeological data (Bataille and Bowen, 2012; Evans *et al.*, 2010; Laffoon *et al.*, 2017; M. Emerey *et al.*, 2018).

Bioavailable and non-bioavailable strontium sources are, as has been stated in the previous chapter, derived and determined by the evolution of the geological substrate they are based upon (M. Grilotti di Giacomo, 1989). Inside the frame of the Apennine peninsula, we can observe a relative heterogeneity of the geological substratum that can facilitate our interpretations of mobility and lead to definitions of movement of different groups in what is already a very complex social and cultural-historical picture (Francisci *et al.*,2017). A strontium isotope map of Italy is unfortunately still based upon low resolution, but in terms of interpretation of archaeological samples it can be utilised as it was derived from multiple various data sources – archaeological samples, fauna, modern plants, sediment, soils, natural spring, water, fossils and other (Emery *et al.*, 2018; Cavazutti *et al.*, 2019, Table S1-2).

Furthermore, geological sources of strontium are subject to a variety of processes that might potentially offset the bioavailable $^{87}Sr/^{86}Sr$ values of biological samples that normally reflect the average of the food sources. A high-resolution strontium variation map for the Apennine peninsula is still missing, however, Emerey *et al.*, (2018) have attempted to fill this void of baseline information through cross-referencing of archaeological human as well as faunal data, which were additionally intertwined with fossil, modern wine, beef, cheese, sediment, natural spring water and tomato sauce data.[20] The sample points were collected across the Peninsula in order to generate a map through GIS spatial dataset and Inverse Distance Weighting (IDW) output that resulted in an environment with average values rangers.

The Apennine Peninsula is shaped by lower structural and morphological relief, formed with carbonate series, turbidites, marls, limestones and flysch from Cenozoic, with outcrops of chalks

[20] Compare Supporting Information 1. of the M. Emery *et al.* 2018.

from Miocene (Cavazzuti *et al.*,2019). In addition, geological elements of the Selviccola (Figure 31.**)** shows geo-morphological features of an environment that has been shaped through interaction between thermal springs present in the area and the travertine plate of Canino, whose age ranges between Middle Pleistocene and Holocene (C. Carrara *et al.,*2002). Additionally, the formation of a volcanic substrate, consisting of tuffs from Upper Pleistocene is greatly influenced by irregular erosion. Travertines begin to settle before 300 ka BP and deposition by 90 ka BP (C. Carrara 1994). Furthermore, stratigraphy shows levels of calcareous levels found in the basal parts of the travertine surface, on whose upper portions a blackish organic soil occurs.

The distribution of $^{87}Sr/^{86}Sr$ values (Figure 32.**)** is following a North/South gradient, where higher $^{87}Sr/^{86}Sr$ (>0.710) are found in the Alps due to their older granitic and metamorphic substrates that formed in the late Mesozoic and Cenozoic orogeny (Emery *et al.,* 2018). In the central and southern regions, the values are lower (<0.710) as their base is found in dolomites, evaporites and young igneous stone. he values obtained were compared with a geochemical map of the region that was created through local soil samples and data collected in the literature (Bertini *et al.,* 1971).

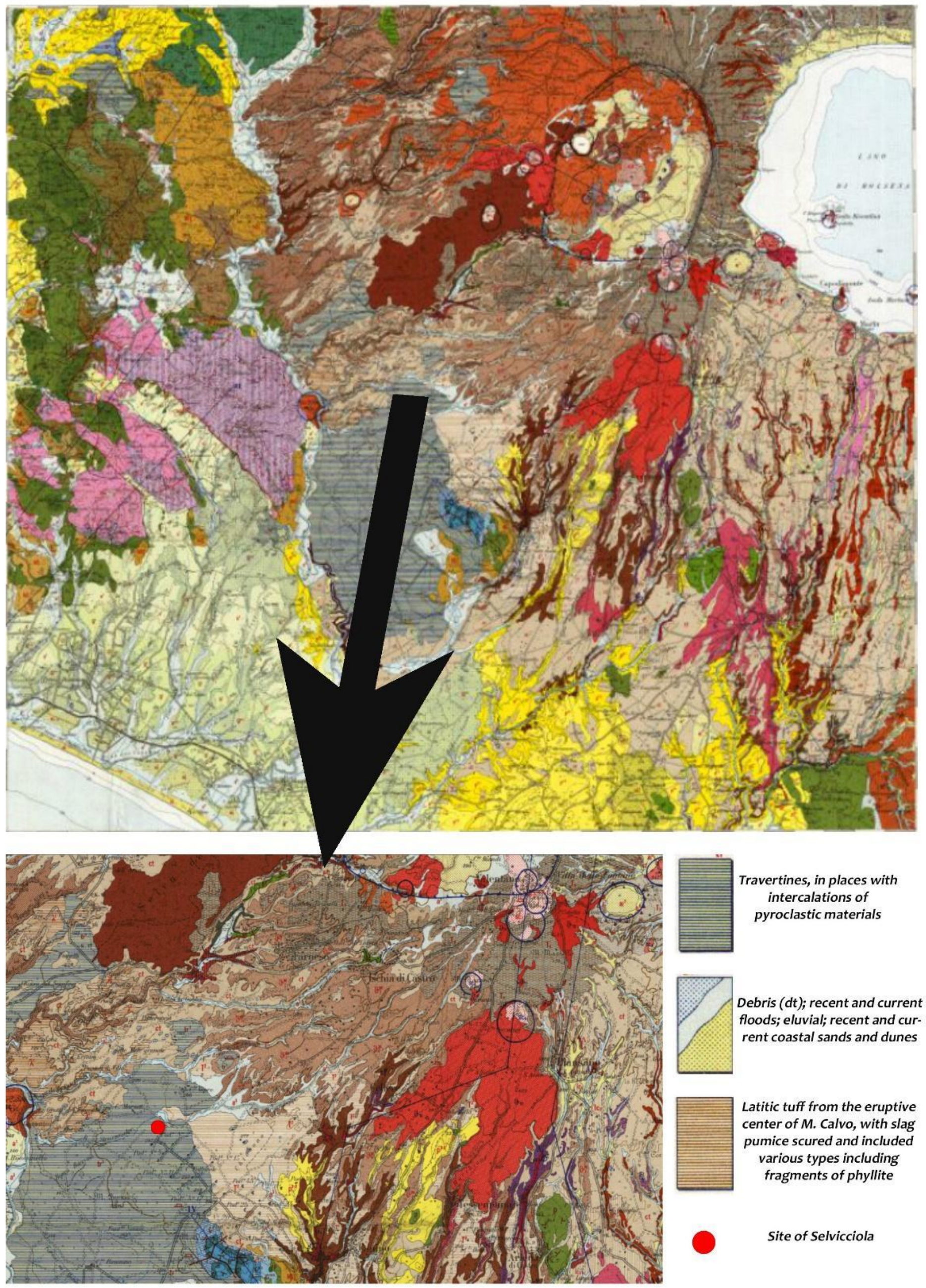

Figure 31. Geological map of the Selvicciola area (Adapted from Grillotti Di Giacomo (1989) and Carrara et al., 2002).

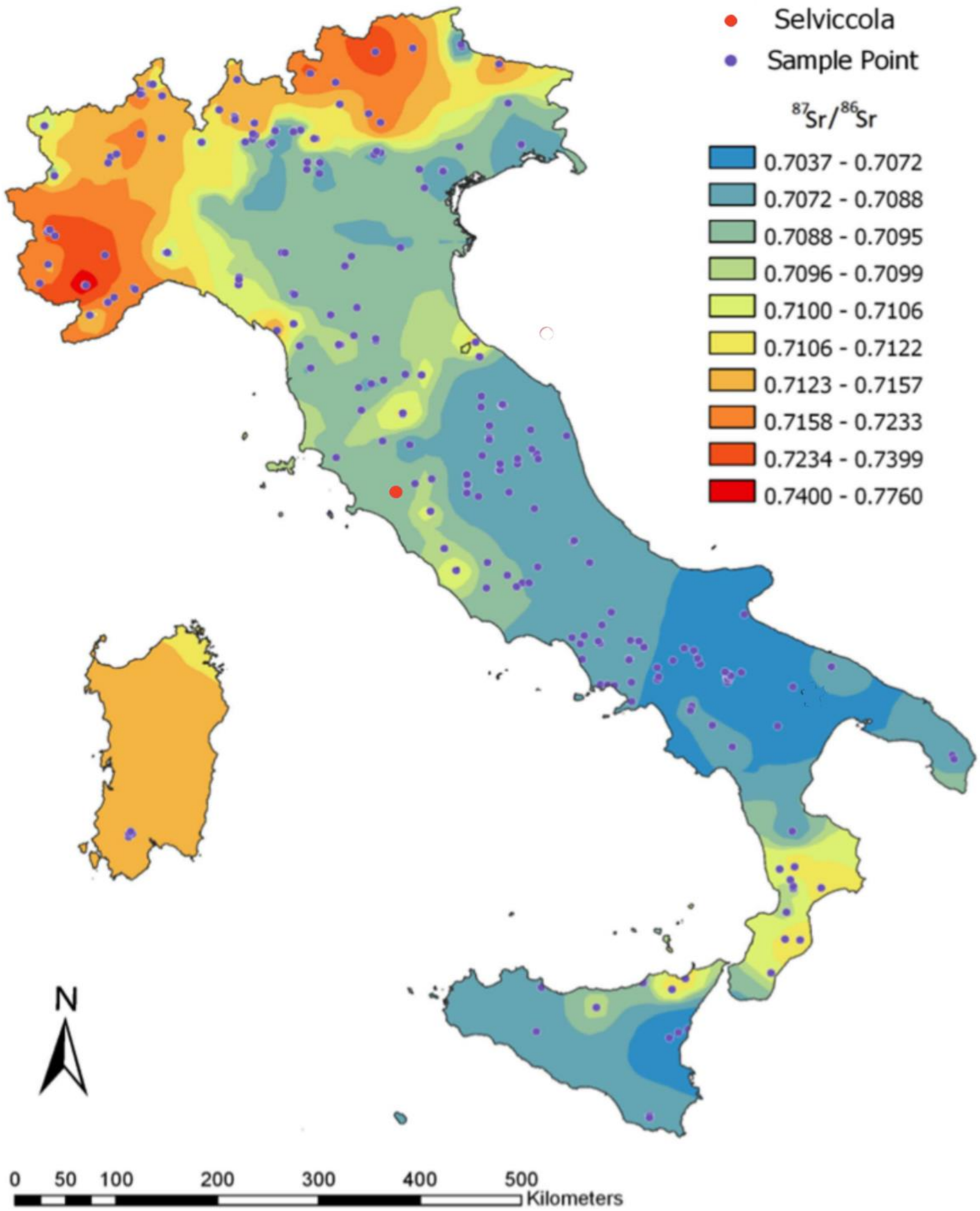

Figure 32. 87Sr/86Sr variation map of Italy using disparate sources of 87Sr/86Sr sources (Adapted from Emery et. al. 2018).

Results of the strontium isotopic analysis are summarised in Table 3. Statistical data was investigated through Excel, PAST (Hammer *et al.*, 2001) and SPSS licensed to Sapienza University of Rome (see Appendix IV).

Strontium isotope ratios

Human teeth ratios range from 0.7086 to 0.7100 with a mean of 0.7093 (n=19), insomuch as for the bones (n=7) the ratios are 0.708782 and 0.709028. Mean strontium isotope ratio for the fauna is 0.7096550 (n=8) and ranges from 0.708691 to 0.710037 (Figure 33-35).

Most human samples fall in the range of the fauna samples, with 4 humans (2 enamel and 2 bone) and 1 ovicaprid (enamel) that fall outside of the range of analysed fauna.

Cluster analysis derived from the Sr human teeth data (n=19) shows three distinct groups, which by the same premise might correspond to an equal number of different geochemical signatures. The larger group which consists of 9 individuals has a Sr ratio (0.7090-0.7097) that also includes the ranges of the fauna of Selvicciola area. The same conclusion comes for the second cluster of 7 individuals ranging (0.7094-0.7100). These might represent part of the local population whose origin, based on the dental enamel data is in greatest part consistent with the defined local strontium signatures of the site which is defined as ± 2 standard deviations of the mean faunal values.[21] This group thus showcases a strontium range that is deemed as "autochthonous".

Despite progress being made in recognition of strontium signatures in the parts of northern Italy (Cavutti *et al*. 2019.), very little is known on the geochemical background of the area of central Italy. What is more, isotopic information for Lazio is yet to be published, and the existence of a database is related mostly to food production and several broad ratios for few stone typologies in

[21] The 2 SD method is a conventional measure of scale that evaluates how far a value deviates from the mean. This measure considers every variable in the data set and is appropriate to apply to data that is normally distributed (Killgrove and Montgomery 2016). Any values that are 2 SD from the mean are considered outliers (Bentley, 2006). The goal of assessing the mobility data was to construct a baseline for approximations of individuals as local or non-local, that is autochthonous or allochthonous.

the area of Lazio and Tuscany (Emery *et al*., 2018. SI).[22] The strontium range of the group above is furthermore consistent with the mentioned modern values.

The final group of only three individuals is showing a less radiogenic range (0.7086-0.7088), with two female individuals (namely SLV 86/3 and SLV 85/15) that show the lowest Sr ratios (0.708806 and 0.708645) that is different than the previous groups, thus leading to the conclusion that they originate from a place outside the resident isotope range. Further they can be defined as “allochthones” that might, as can be seen in the dental enamel have different birthplace than the rest. What is more, one faunal sample of an ovicaprid shares the signature of this group – clearly provoking idea of its movement at one point of time.

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22 $^{87}Sr/^{86}Sr$ range or average value for area of Lazio and Tuscany: Lazio Wine (0.709174 – 0.709177) / San Giovenale/Cerreto – Wine (0.709168-0.710586) / Southern Tuscany sedimentary rocks (0.71472) / Central Latium volcanic rocks (0.71038).

ID	Material	$^{87}Sr/^{86}Sr$	± 2se
Humans			
85/3	Enamel	0.709610	0.0006
85/5	Enamel	0.709005	0.0007
85/9	Enamel	0.709292	0.0007
85/10	Enamel	0.709090	0.0007
85/13 B	Enamel	0.709367	0.0008
85/15	Enamel	0.708806	0.0006
85/18 A	Enamel	0.709216	0.0007
86/3	Enamel	0.708645	0.0007
86/2	Enamel	0.709181	0.0008
86/4 B	Enamel	0.708876	0.0007
86/8	Enamel	0.709075	0.0007
86/9	Enamel	0.709179	0.0007
86/13	Enamel	0.709367	0.0005
86/17	Enamel	0.709998	0.0006
86/18	Enamel	0.709518	0.0007
87/4	Enamel	0.709160	0.0007
89/4	Enamel	0.709718	0.0007
90/8	Enamel	0.709484	0.0007
91/5	Enamel	0.710033	0.0007
85/10	Bone	0.708944	0.0006
86/2	Bone	0.709028	0.0006
86/5	Bone	0.708810	0.0006
86/6	Bone	0.708970	0.0007
86/11 A	Bone	0.708865	0.0007
86/17	Bone	0.708975	0.0006
87/4	Bone	0.708782	0.0006
Fauna			
F1 *Sus spp.*	Enamel	0.710037	0.0006
F2 *Bos taurus*	Enamel	0.709787	0.0007
F3 *Sus scrofa*	Enamel	0.709687	0.0007
F4 *Ovis v. Capra*	Enamel	0.709825	0.0006
F5 *Ovis v. Capra*	Enamel	0.709988	0.0006
F6 *Ovis v. Capra*	Enamel	0.709754	0.0006
F7 *Ovis v. Capra*	Enamel	0.709471	0.0007
F8*Ovis v. Capra*	Enamel	0.708691	0.0006

Table 3. Values of strontium isotopes ratios of human and animal samples with standard error.

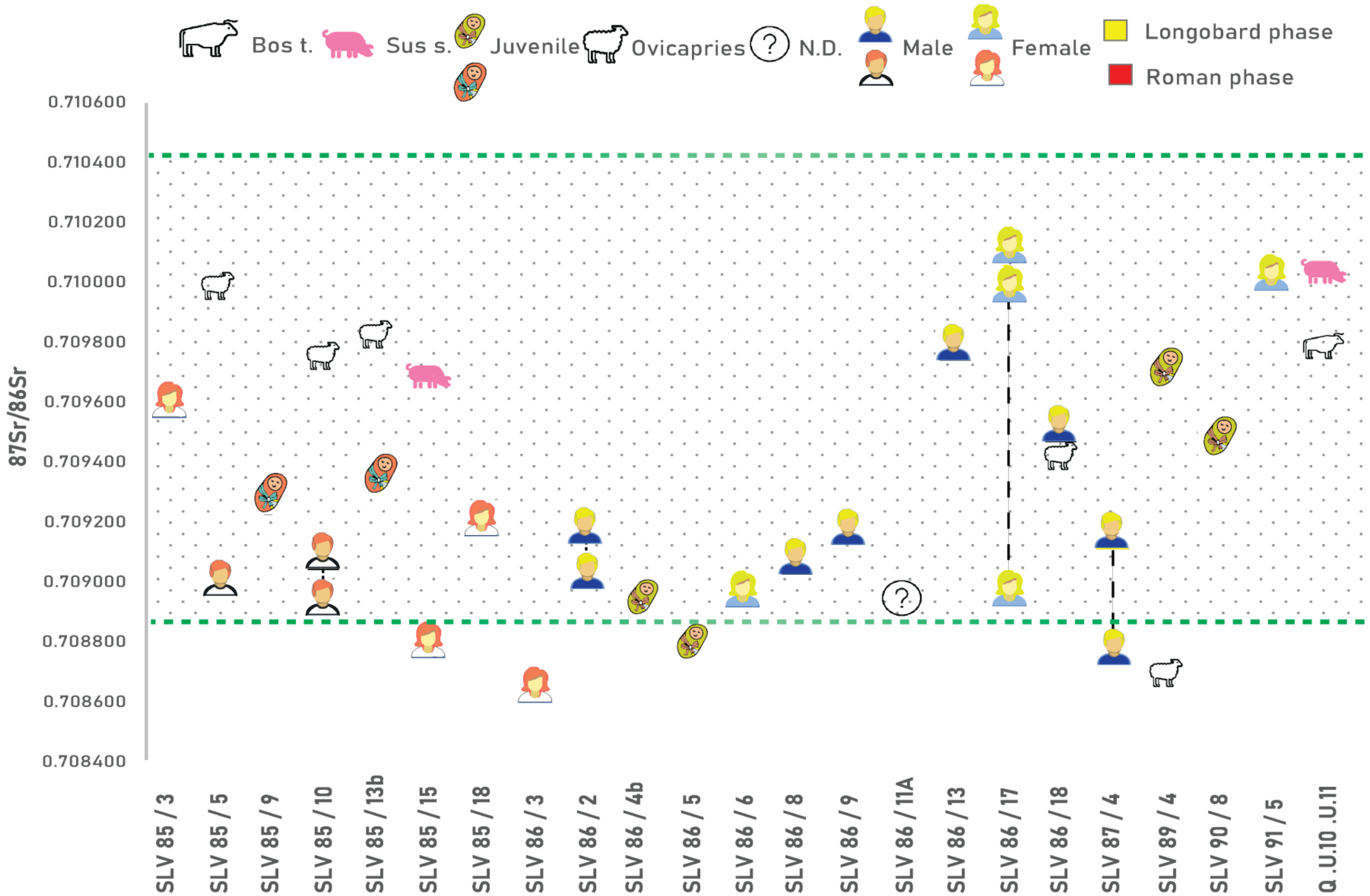

Figure 33. Jitter plot of Strontium isotope ratios of human dental enamel, bone, and associated fauna. The dotted area corresponds to the local Sr range calculated as ± 2sd of the mean fauna values (Bentley, 2006). Human sex and age group (adult, infant, juvenile) are indicated. Individuals linked by dashed line provide both enamel and bone data. Hair color (females) or body and hair color (male) indicate the period.

Discussion

If seen as proxies of origin, that is geological and landscape contexts, isotopic parameters and variations in enamel strontium isotopic composition can suggest differences in the same (Bentley 2006).

With evident variation in enamel strontium isotopic ratios, we can argue the existence of a different geological background. As was mentioned before, this is due to individuals living in areas with different strontium isotope values or better-said due to their food procurement that originated in broader environmental contexts at the time of the enamel formation. Therefore, a wider variation may come as a characteristic of an area larger than the one site investigated.

Due to the previous archaeological attribution of the burials and goods found in them, which forms relative chronological relations between the individuals analysed here, we are able to assess if there is a plausible relationship between the origin of the individuals and the period of the cemetery through comparison of the strontium ratios.

Thus, the "autochthones" clearly include individuals belonging to both early and late period of the cemetery, better said to both Roman and Longobard phase, where grave goods in some cases act as an indicator of cultural identity. The individuals with grave goods dating them to the Roman phase (most probably until the ending of the 6^{th} century) might represent an autochthonous community that at certain point intertwined with the migrating group. Likewise, individuals dated later might represent Longobards born around Selvicciola. This is the most probable cause for the pair of juveniles among them, showing strontium signatures consistent with those of defined local proxy.

"Allochthones" have a Sr ratio range that indicates that there must have been a movement among Longobard settlements, at least in the region. On the other hand, when looking at the historical, as well as isotopic studies made both inside and outside Italy, it can be seen that there is an alternative hypothesis in which the values of the Sr ranges from other Italian regions as Emilia-Romagna (Durante *et al.* 2015; Francisci *et al*. 2020), Campania (Matano *et al.* 2005; Marchionni *et al.* 2013.) and Puglia (Emery *et al.* 2018; Lugli *et al.* 2019), coming from the soil, wine and rock samples, are intertwining with once we possess in Selvicciola. As was discussed earlier all these regions were homes to different Longobard dukedoms since the end of the 6^{th} century. This might be further supported by the grave goods whose dating corresponds to the well-established phase of both the cemetery occupation and Longobard kingdom in the 7th century (Micarelli 2020). Similarly, before the arrival of Longobards, there was an evident movement of the Roman population. Overall, the mentioned regions might represent the dwelling place of some of the individuals in the sample whose life ended in Selvicciola.

Further, as we do not see outliers in our data, it seems that most of the individuals represent a cohesive group. At the same time ratios found here do not fall into the range of isotopic studies carried out on Longobard populations outside Italy, that is central Europe (Alt *et al*. 2014; Knipper *et al*. 2020) and as such lead to the hypothesis of the population not representing the initial generations of Longobards that came from central Europe, but rather their descendants that settled in Lazio afterwards.

Bone signatures of five humans show $^{87}Sr/^{86}Sr$ values that are in the local fauna range.

Four individuals (T 85/10; 86/2; 86/17; 87/4) are the only ones providing strontium isotope ratios from both teeth and bones. Out of them, just one individual, a male, between 30 and 40 years of age (T 87/4) belongs to the “allochthones” and unlike the rest, show that he might have been born in Selvicciola, as his enamel signal is inside the local range, unlike the bone that falls outside, thus suggesting that he might have lived his last part of life in a different geological region (Figure 34-35.).

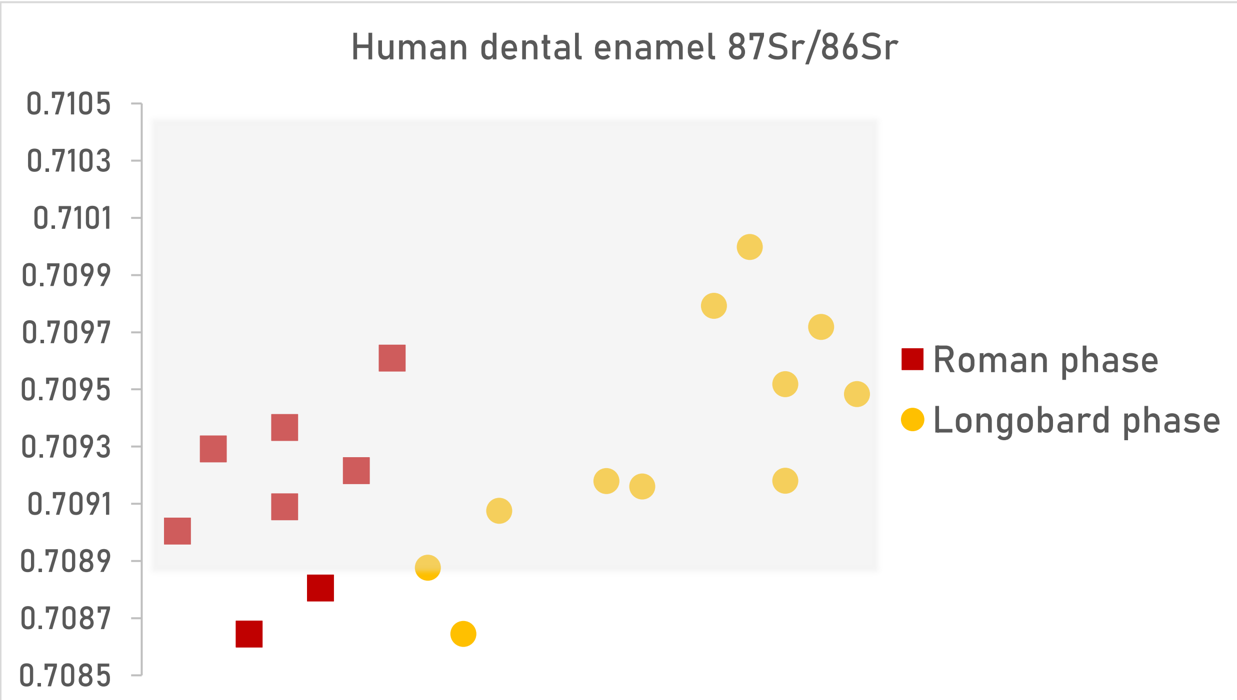

Figure 34. Strontium isotope ratios of human dental enamel. The grey area corresponds to the local Sr range calculated as ± 2sd of the mean fauna values.

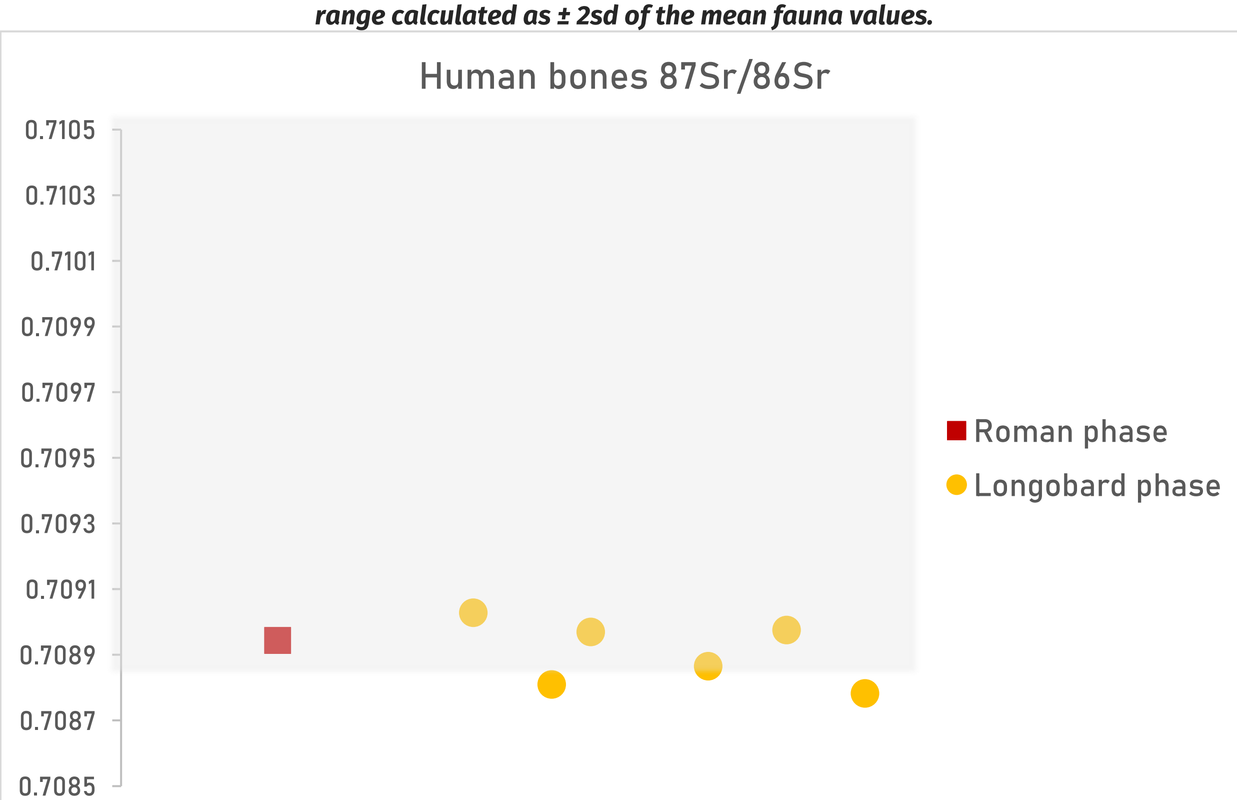

Figure 35. Strontium isotope ratios of human bone. The grey area corresponds to the local Sr range calculated as ± 2sd of the mean fauna values.

The same individual represents an adult male, buried with interesting grave goods, including a knife and comb, but also belts, out of which one has a clear Byzantine type plate buckle, typical for the second third of 7th century (Micarelli 2020). What is more this adult man who died in as a mature adult (30-40 years), is buried in the part of the cemetery that is near to the group of graves named “the Longobard group” – maybe indicating a group of individuals buried in the same part for reasons that call for further investigation.

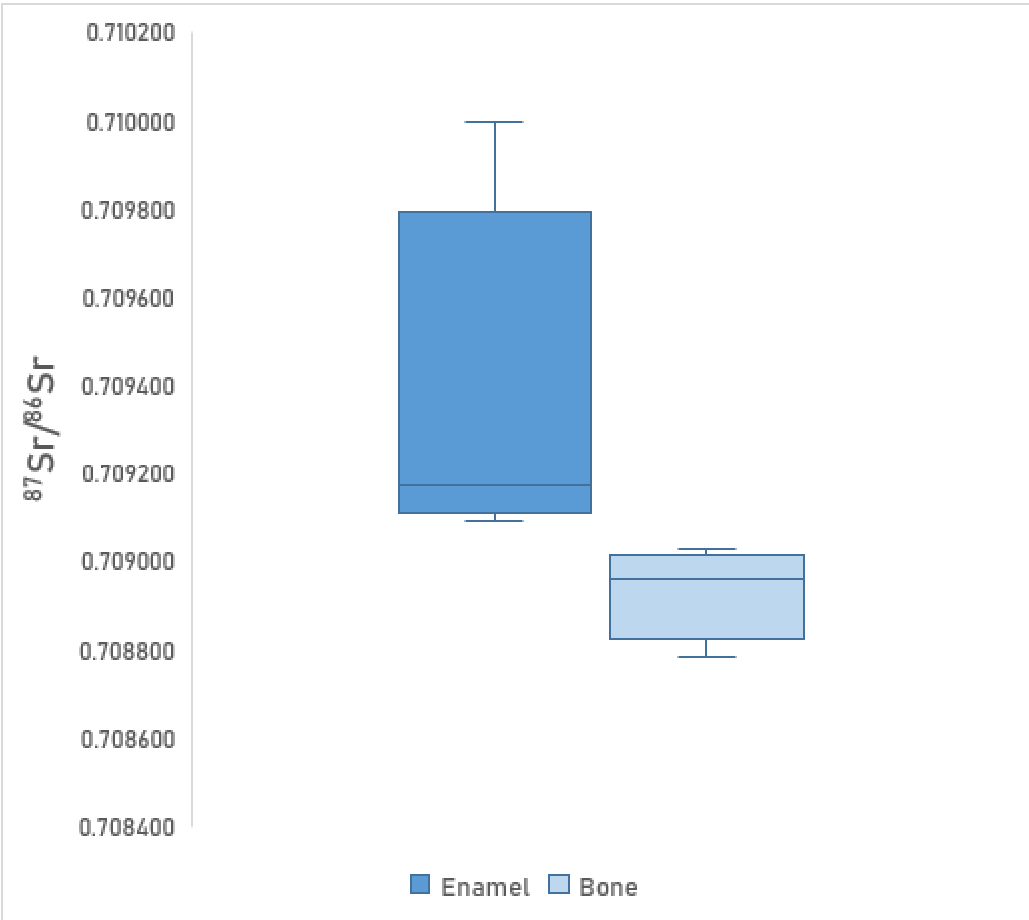

Figure 36. Whisker and box plot of 87Sr/86Sr in dental enamel and bone for individuals with both values.

We could also examine the values in enamel and corresponding bone for four individuals (Figure 36). The ratios of enamel are displaying large variations opposed to values of bones. Moreover, all enamel values differ from those of the corresponding bones, indicating a change in the food sources of the individuals in different phases of their life. The widest range is found in T 86/17 (0.7089 -

0.7099), however, same as with the others whose range varies less (around 0.0002), both values fall inside the local range.

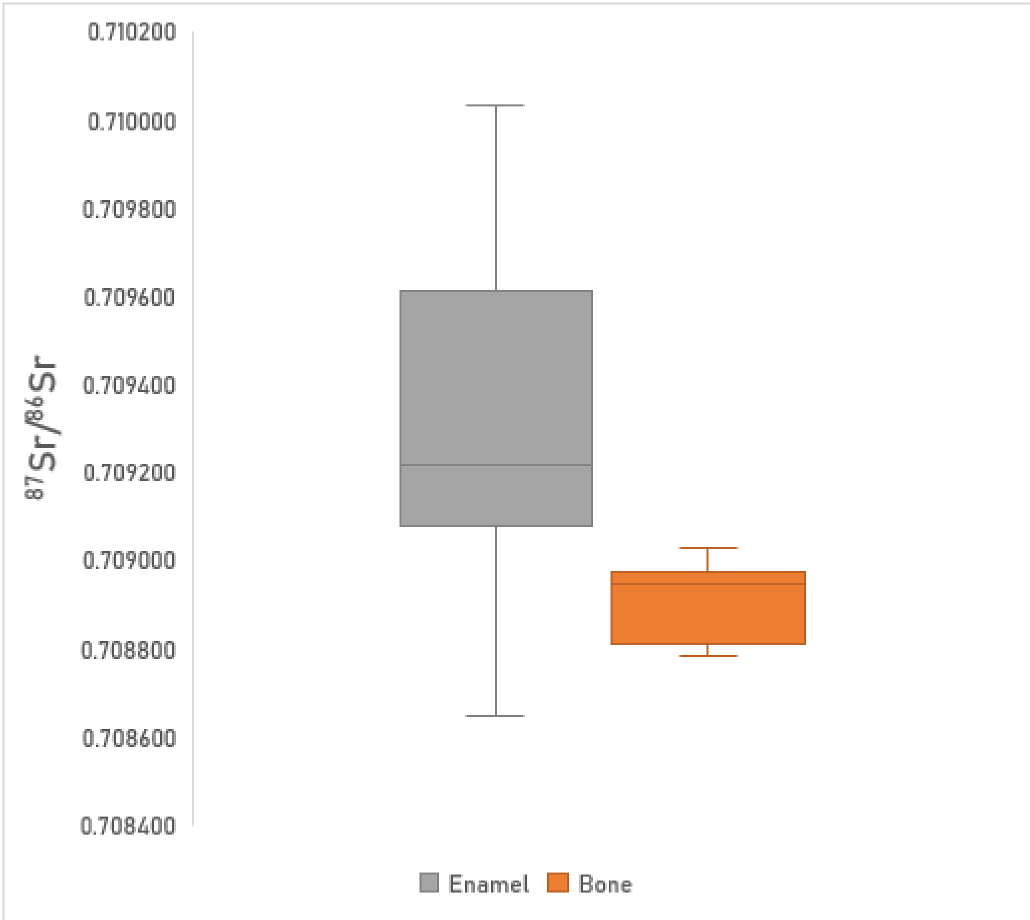

Figure 37. Whisker and box plot of 87Sr/86Sr in dental enamel and bone for all Selvicciola humans.

Comparing the isotope ratio in enamel and bone of the overall human sample (Figure 37.), the ratio found in bones has more homogenous distribution, unlike the wider spread examined in the enamel values for the teeth. The sample size of the two sub-groups might contribute to this picture, however., this variability in sixteen out of nineteen enamel values, differ from those of the bone, which might suggest how people of different birthplace, that is of different geological background seem to have died in Selvicciola.

When comparing the sexes, most male individuals have an isotopic value of Sr inside the local range, as well as females. Even though, the few which fall outside represent a small sample and it is difficult to argue based on such that one sex might have been more mobile or that this is merely statistically significant. Nonetheless, it shows that there is mobility both inward and outwards Selvicciola at young or adult age. As for the distribution of the Sr values among different age groups, it is shown that inside the local range there is more variability seen in the older age groups, especially among females, while young individuals up to the age of 18 are showing local values in all but one example (Figure 33)**.**

According to the central values of enamel and bones, there appears to be a statistically significant difference (t-test: $p_{same\ mean} = 0.110$; Mann–Whitney: $p_{same\ mean} = 0.031$). Thus, we can how the strontium signature of bone is not identical to the signature of enamel. Therefore, the last place of residence (in this case Selvicciola), is not identical to the place of origin – leading to the hypothesis that (a) at least a segment of the population originated from somewhere else or (b) grew in an environment that provided different geological background. As for the strontium signatures of individuals belonging to Roman and Longobard periods, we cannot observe a statistically significant difference in the enamel values (Mann–Whitney: $p_{same\ mean} = 0.117$; Kolmogorov-Smirnov test).

The results ratios lead to the following conclusions (Table 6.):

a. Sr isotope ratios measured for 22 samples from the cemetery of Selvicciola had values (0.7090-0.7100) indicating that most of the individuals inside the analysis, of both the early and late phases were locals. This might suggest that these individuals are ”autochthonous“ to the region.

b. Sr isotope ratios (0.708640-0.708876) measured for the five samples are an association with signatures of a different geological setting. This could be explained with the movement from different geological regions. As the historical sources state a spread of Longobard rule from the area north to south Italy and the consequent establishment of kingdom with dukedoms, we can hypothesise that some of the individuals here analysed belong to the group that originated from one of the latter. Moreover, the date of their grave goods belongs to the later phase of the occupation of the site and the cemetery (7^{th} century), giving more uphold to such hypothesis, as that period is represented by the consolidation of the Longobard kingdom.

To conclude, strontium data measured in the skeletal tissues deriving from both human and animal remains from Selvicciola appear to confirm the scenario proposed for the Longobard mobility in the Apennine peninsula. Following the results from similar sites (Francisci *et al*., 2020) with the intertwining of archaeological evidence and isotopic studies, it can be suggested that the descendants of the earliest generations of Longobards in Italy most probably incorporated with the already existing society of the local inhabitants. Furthermore, the following generations became exactly the one – a native to the area with acquired patterns of food procurement from the local landscapes.

Table 6. Selvicciola – Strontium isotope ratios (Adapted from Micarelli, 2020).

Grave	Tooth sample	Enamel growth range	Bone sample	Fauna sample	Sex	Age of death	Tooth $^{87}Sr/^{86}Sr$	Bone $^{87}Sr/^{86}Sr$	Fauna $^{87}Sr/^{86}Sr$	
85/3	URC	0-5 y			F	30 - 40	0.709610			Romans
85/5	LRC	0-5 y		*Ovis v. Capra* P	M	adult	0.709005		0.709988	
85/9	URC	0-5 y			M	18 - 20	0.709292			
85/10	LLC	0-5 y	Rib	*Ovis v. Capra* P1M	M	50+	0.709090	0.708944	0.709754	
85/13 B	LLC	0-5 y		*Ovis v. Capra* I	ND	sub-adult	0.709367		0.709825	
85/15	ULC	0-5 y		*Sus s.* M	F	30 - 40	0.708806		0.709687	
85/18 A	LM1M	0-3 y			F	50+	0.709216			
86/3	URC	0-5 y			F	40 - 50	0.708645			
86/2	URC	0-5 y	Fibula		M	30 - 35	0.709181	0.709028		Longobards
86/4 B	LRC	0-2 y			F	1 - 1.5	0.708876			
86/5			Rib		ND	1 - 1.5		0.708810		
86/6			Femur Dx		F	adult		0.708970		
86/8	LRC	0-5 y			M	20 - 25	0.709075			
86/9	URC	0-5 y			M	20 - 30	0.709179			
86/11 A			Tibia		ND	adult		0.708865		
86/13	LL2P	0-5 y			M	adult	0.709792			
86/17	ULC	0-5 y	Rib		F	50+	0.709998	0.708975		
86/18	LLC	0-5 y		*Ovis v. Capra* P or M	M	30 - 40	0.709518		0.709471	
87/4	LRC	0-5 y	Rib		M	30 - 40	0.709160	0.708782		
89/4	ULC (Dec)	0-5 y		*Ovis v. Capra* P	ND	08 or 09	0.709718			
90/8	LLC	0-5 y			ND	08 or 10	0.709484			
91/5	URC	0-5 y			F	25 - 35	0.710033			

Tooth Legend: UR/LR/UL/LL - Upper/Lower Right/Left LM – Lower Mandibular C- Canine M-Molar P-Premolar ND = not determined; MNI = Minimum Number of Individuals.

Chapter 6. A PERSPECTIVE INTERPRETATION

The aim of this work was to address specific research questions related to Longobard mobility in post-classical Italy, such as: a) are non-local populations (Longobards) distinguishable in the sample, b) are there variations in mobility between non-local and local population during the course of the usage of the site, c) is there an overall mobility pattern present, d) are there changes in the mobility since the arrival of the Longobards e) are there any socioeconomic differences in status (based on grave goods) and sex, f) whether cultural norms in burial tradition were differentiated and g) are there similarities with communities elsewhere in Italy or abroad.

The previous chapters have presented the historical and material data that was assembled and analysed in this study. The goal of the same was to use the stable isotope analysis on both human and faunal remains to reconstruct human mobility during an important period after the collapse of the Western Roman Empire. In the region of Lazio, Tuscany and Umbria, the post-Roman landscape has seen the fragmentation of territories with a new urban and especially rural landscape being formed. Except for urban centres, the small and dispersed farmstead and dwellings felt the social, political, and economic changes which are intertwined in the historical and archaeological record, and the results of the stable isotope studies revealed patterns of migration and effects of these changes (Wickham, 1995; Rotili, 2010; Rotili and Ebanista, 2015).

When looking at the structure and scale of the Longobard migration, it is difficult to interpret the impact and size of the migrating population just by looking at the historical sources as they may be distant from the truth as has been stated before (Alt *et al*. 2014; Iacumin *et al*. 2014). Secondly, we cannot attest that the latter may have had a significant effect on the demographics of the receiving communities (Anthony, 1997; Cabana and Clark, 2011). Those who do migrate are travelling through a large landscape of the Apennine peninsula, starting from the northeast and downward to the south of Italy. King Alboin arrived in Cividale del Friuli and followed the Po Valley, leaving behind a selection of warriors in dukedoms (Christie, 1995). It is most probable that the forerunners of migration and settling are the member of the military and traders, seeking formidable centres (Burmeister, 2000). Brather (2009) mentions the nobility of Longobards dwelling in more rural settlements with farmsteads and craft production areas, which may be the case for the sites of Selvicciola. Grave goods show weapons being parts of the burials which might be attributed to the same. The choice of the individuals selected for this research seems thus representative to the question mentioned, as they seem to be of local origin (e.g. T 86/8 with a male adult who had a weapons assemblage including a quiver with arrows and scramasax).

Analogy: Longobard Migration Studies

The Longobard migration to the Apennine peninsula is one of the events that stirred the end of late antiquity and established the Early Middle Ages. One of the modes of understanding such a wide-scale action and to characterize it within modern-day Italy is through analysis of skeletal remains of various archaeological sites.

Until now, the use of stable isotope analysis for understanding post-classical migration in Italy and Europe has been limited, with only a few published studies from the post-classical period from 6th to 8th century AD which is the focus of this thesis (Amorim *et al*., 2018; Francisci *et. al.*, 2016; 2020; Iacumin *et al.*, 2014; Marinato, 2016; 2019; Paladin *et. al.*, 2020). These studies show that migration occurred in and outside of Italy from the 6-8th centuries AD.

One of such sites it Povegliano Veronese, a cemetery used from the end of 6th to the beginning of the 8th century AD, located near modern-day Verona on what was once *via Postumia* (Francisci *et al.,* 2020). The point of interest was distinguishing first and subsequent generations of those individuals that are deemed Longobard. This had one goal – determination whether some of the individuals moved from a different region in addition to the possible exploration of movement that was collective and comparison with existing historical and archaeological data. The preliminary results support the idea of the first generation of Longobards using the cemetery.

The tombs are arranged in larger groups and aligned in rows (Hudson, 1996; Giostra, 2014). It is interesting that the groups might represent a nucleus for a broader family which can be read by sex and age distribution. This kind of division of the space seems to be generated by a relationship based on kinship with the clear delimitation of the funerary area, which can be seen at sites like Collegno, Leno or Sant'Albano Stura. It is estimated that over 220 individuals were buried on the site in a century and a half, out of which 39 have been analysed for strontium isotope ratios (Francisci *et al.,* 2016; 2020). Results obtained, along with cluster statistical analysis showed the existence of sub-groups with different origins within a population – one with local values within the interval of local soils, thus being indigenous to the area, a second one showing non-local provenance compatible with region of Lake Balaton in Hungary, to whom the migrating individuals belong and finally, two individuals, whose values indicate that they came from a very different geological region than the rest. What is more, the proportion of males to females in non-local individuals shows a greater number of former and suggest that the Longobard settlers at Povegliano Veronese might have been formed by men mostly. Finally, the comparison of strontium signals with the phases of burials shows that earliest tombs, as well as those in a *Totenbrett* type (with wooden chamber) display exactly migration, that is a non-local value, opposed to later burials. As some individuals have values that might point to this region it might be that the descendants of migrants hereby move to southern regions of Italy later.

Alt *et al.* (2014) conducted a study of the population from Szólád, Hungary during the period of migration in the 6th century AD, while an aDNA study by Amorim *et al.* (2018) was based on the individuals of Szólád and Collegno necropolis near Torino, which hosted both Goths and Longobards during the 6th and the 7th century AD. Former sampled 35 individuals for the strontium isotope analysis and at the same time 28 individuals for aDNA analysis of the Longobard presence in the Szólád cemetery in order to attest the historical sources placing these populations in Hungary during the short time frame of only twenty years during the 6th century, as was mentioned in the first chapters. The results showcased clear heterogeneity of the population with at least 22 different lineages with both European and Near Eastern haplogroups present, and with the presence of kinship social hierarchy and the migrating nature, this result is not surprising. On the other hand, strontium values indicate almost one third (31%) of individuals are migrational, that is they died outside their birthplace. Among the results, females interestingly are more widespread and thus more mobile. In conclusion, it was shown that the Longobards have indeed migrated into Pannonia and that they dwelled among the local population with whom they also shared final resting place. Ancient DNA study sampled among the 39 individuals from Szólád and Collegno, some of whom lived at the same time as individuals of Selvicciola, show them being of central or northern European ancestry as well as that of the southern European one. Further, the results were integrated with grave goods and showed how the former group, numbering 32 individuals, correlates with individuals interpreted as Longobard. This was further reinforced by strontium isotope values from the site of Collegno where those who fell in the southern ancestry had local signatures, unlike the others, indicating the existence of migrants at the site.

The interaction between Longobard and Romanised populations at Szólád and Keszthely-Fenékpuszta around Lake Balaton in Hungary are evident through archaeological remains as well (Winger *et al*. 2014). It is interesting to note that the Longobards do not seem like a uniform population here and this is evident in grave structures and goods that are more suggestive of the Roman provenance, what is more, Longobard artefacts were found inside what is determined as Roman graves. As a result, strontium isotopes were used to investigate their relationships and the results clearly show differences in the amount of mobility, however, there are clear indications of at least a temporary coexistence between two populations.

The late antique necropolises from Veneto – Sovizzo and Dueville - were used in dietary and migration studies based on oxygen isotopes (Maxwell 2019). The 60 sampled individuals, dated to the end of the 6^{th} and the early 7^{th} century AD, used in the sample were identified as both Longobard and Roman/Byzantine population, however, the $\delta^{18}O$ values indicate that individuals from the coasts of Italy, Greece and North Africa move to the region probably as refugees from within other regions of the Byzantine Empire and only two individuals had the isotopic values of drinking water that might have belong to the migrating Longobards from the east. Thus, in this case, the first generation of Longobards in Italy was not represented there. Most non-locals from Sovizzo were young males, while at Dueville, there seem to be more regional migrants. Along with that, higher variability in $\delta^{34}S$ values in the Adige valley in Early Middle ages, where historical sources document that allochthonous groups of "Germanic" origin entered the territory (Paladin *et al*. 2020).

This clearly shows that Longobards integrated with local populations, as in the former case and possibly Selvicciola and future genetic studies might shed light on their ancestry. If we once more look at Selvicciola we see the possibility of regional migration at the almost same time, though it would be certainly interesting if some of the cases belonged to non-Longobard populations of that age, i.e. those that do not have garments determining them as most likely to be of Longobard origin.[23]

[23] It is also important to note that the definition of an individual as Longobard is not a topic of discussion here, as an individual of different ethnic background might have had or taken on what is interpreted as Longobard cultural practice, and consequently using the same burial customs (Possenti 2001). Thus, an identified migrant can be interpreted as Longobard, but at the same time could be a part of a regional local population. Thus, the definition of the cultural belonging and integration is beyond the capacities and necessities of this work.

There have also been studies that have not conducted isotopic analysis but have indications of Longobards being present at the site. Interestingly, one similar site to Selvicciola is the site of Bardolino, where 7 burials were found inside a former Roman villa (Bruno, 2013), and at the necropolis of Campo Marchione in Brescia, there seems to have been around 35 Longobard individuals belonging to the first generation of immigrants on the site where seven generations seem to have used the same burial site (Giostra, 2011). One of the best examples of Longobard cemetery is one found in Nocera Umbra near Spoleto, where the pattern is also similar and there is an initial migrant generation counting about a dozen individuals (Jorgensen, 2011).

At Selvicciola, when we ask ourselves, who are the locals and non-locals, we can assume the non-regional and regional migrants. Reasons for migrating or resettling could be various – as has been mentioned before (Wickham 1981), Byzantine rule, as was confirmed by Gregory the Great at the end of 6th century, in Italy took land from the locals for the needs of its military and heavily taxed them, unlike the Longobards who imposed a new system that allowed the lowest of classes to leave with more economic ease, and this might be the reason behind newly formed Longboard sites.

It is evident that Longobard presence existed along the route found in the ancient sources, but the scale is not such that it means a complete turnover of populations. Further, it is evident that the Longobard buried their dead with other cultural groups. A survey of Longboard burials in Italy clearly shows a continuation of the utilization of Roman necropolises or reuse of a previously abandoned one (Brogiolo, 1996).

If we look at the grave goods from Selvicciola we find tombs with none or those with just a simple toolkit assembly of bone combs, knives, pins and similar which might indicate a lower social and economic status of the buried individual. If the ancestors of these individuals moved to a narrow area around the site for economic prosperity this might be the clue and performing the oxygen isotope analysis in the future might show us if, even though they originated here, they moved around the region in the later stages of their lives as the political and economic life shifted more rapidly.

Hypothetically, Selvicciola might fit a village model, where the organization of the cemeteries, and homogeneity in terms of strontium isotope values of the individuals buried at the site indicates that regardless of sex, class, or ethnic background, the opportunity for economic productivity forged a collective community. Over the course of the Longobard occupation, they seem to have integrated or better said formed into a new local community.

Considering the existence of the Longobard Kingdom for several centuries, the historical narrative gives an idea of new Longobard identity being formed after their arrival in Italy (Rotili, 2010; Rotili and Ebanista, 2015). The fusion with the Italic population was an ongoing process, and with considerations that ethnic markers as cultural customs, dress, religion, language and law are sometimes difficult to address archaeologically we ought to use a more holistic approach and allow the inclusion of isotopic proxies as an objective point of view in a hypothesis about one's identification and life-changing actions as migration (Gasparri, 2005; 2012). It is even more profound to deem them as frames for social practices of the historical framework we are dealing with – as populations such as these do not seem to achieve stability, thus internal migrations, the interaction between various communities and resettlement are all variables we cannot assess without interdisciplinarity (Geary and Veeramah, 2016).

Along with the origin, a historical perspective arises as these results might further implicate that new meaning of Longobard identity was slowly developed after the initial settlement. The results obtained here might provide the base for the same and allow to question the Longobard population of Selvicciola, as well as to question the reasons for their actions as a social group in the certain point of history. The future insights in dozens of similar communities, both in Italy and outside, will allow us to come to conclusion about the historical society as a whole by implementing the studies of the portions of the same through specific studies.

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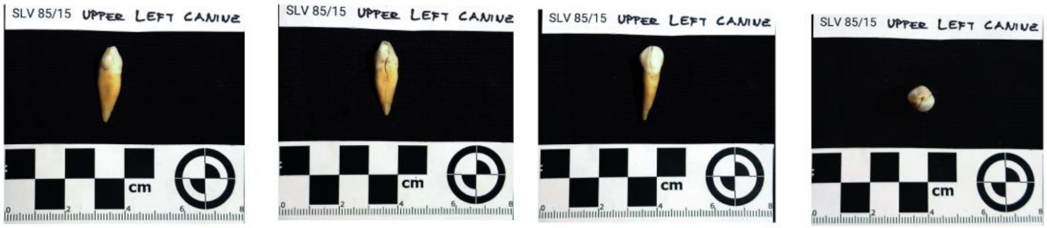
Appendix I: Sample Photographs

SLV 85/3

SLV 85/5

SLV 85/9



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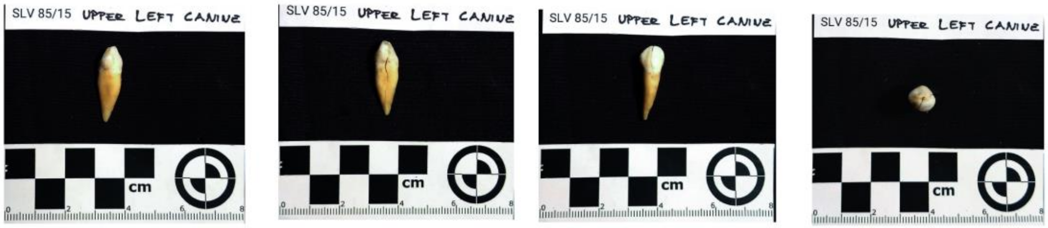

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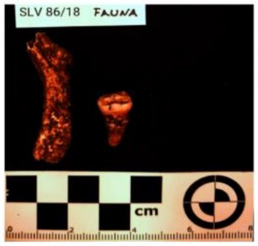
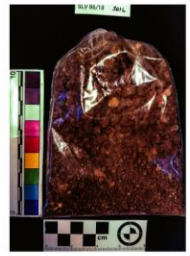
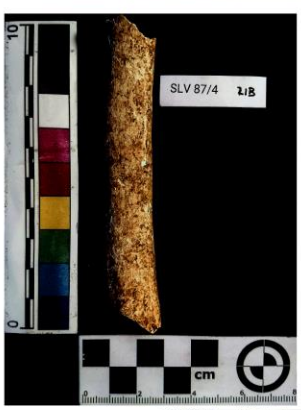
SLV 86/2

SLV 86/9



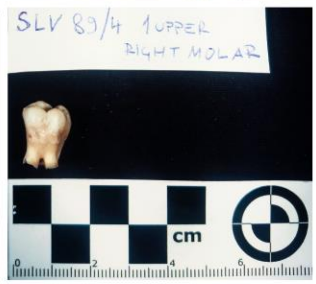


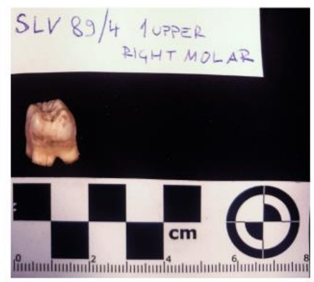
SLV 86/18



SLV 87/4

SLV 89/4

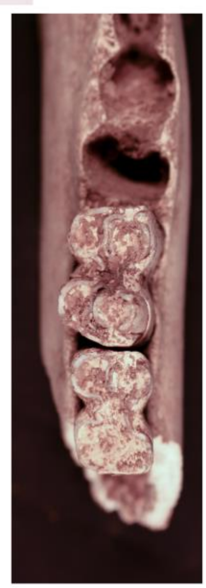




SLV 90/8

SLV 91/5

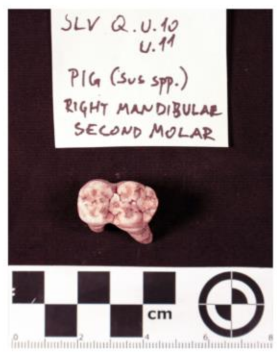
SLV Q.U. 10/11



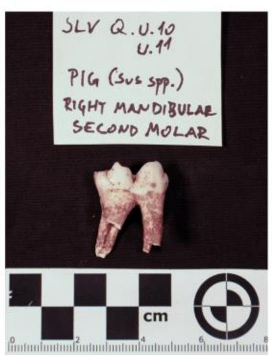
SLV Q.U. 10/11


SLV Q.U. 10
U. 11
Bovide (Bos t.)
LEFT MANDIBULAR
FIRST MOLAR
cm

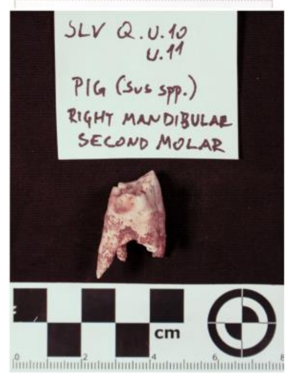

SLV Q.U. 10
U. 11
Bovide (Bos t.)
LEFT MANDIBULAR
FIRST MOLAR
cm


SLV Q.U.10
U.11
PIG (Sus spp.)
RIGHT MANDIBULAR
SECOND MOLAR
cm


SLV Q.U.10
U.11
PIG (Sus spp.)
RIGHT MANDIBULAR
SECOND MOLAR
cm


SLV Q.U.10
U.11
PIG (Sus spp.)
RIGHT MANDIBULAR
SECOND MOLAR
cm


SLV Q.U.10
U.11
PIG (Sus spp.)
RIGHT MANDIBULAR
SECOND MOLAR
cm


SLV Q.U.10
U.11
PIG (Sus spp.)
RIGHT MANDIBULAR
SECOND MOLAR
cm

Appendix II: Maps

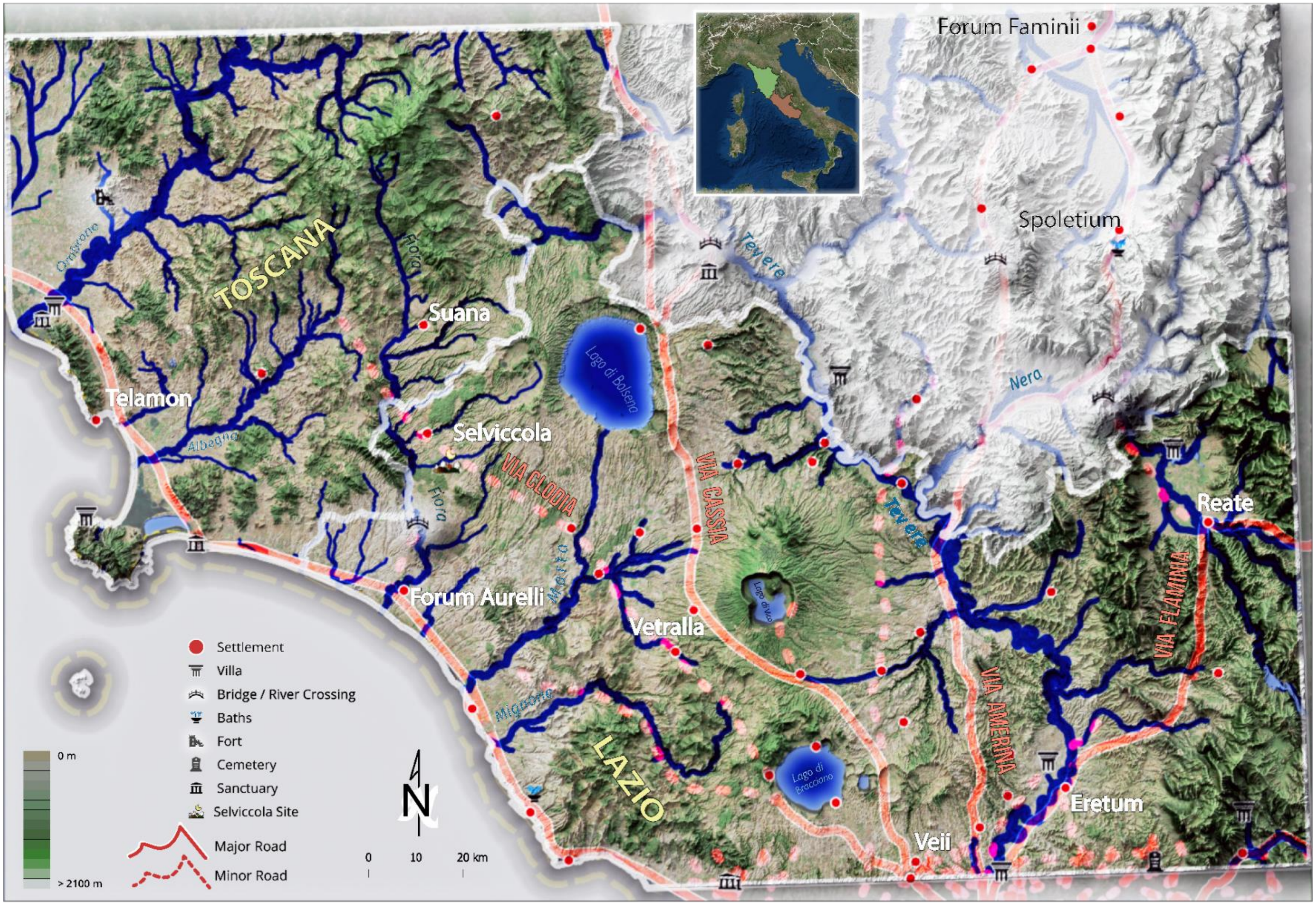


Figure 38. Relief Map with contemporaneous sites near Selvicciola

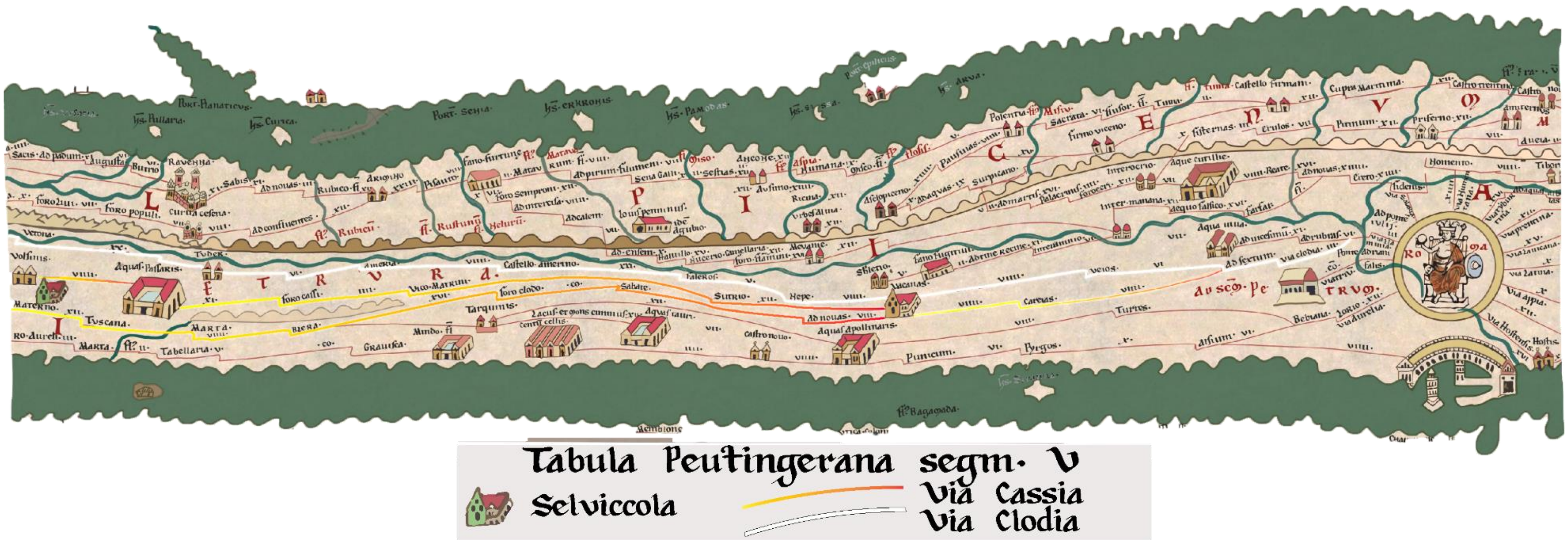
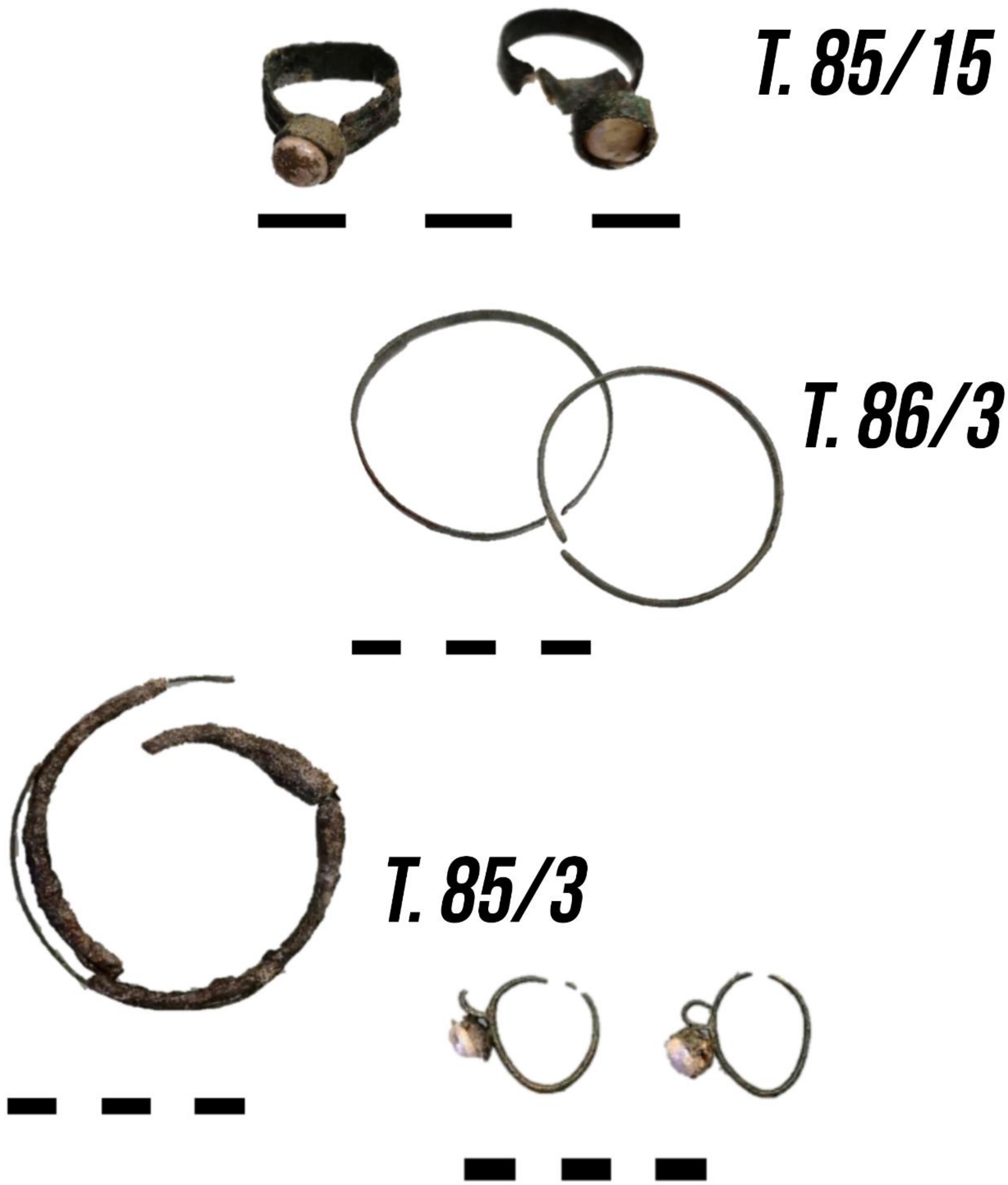


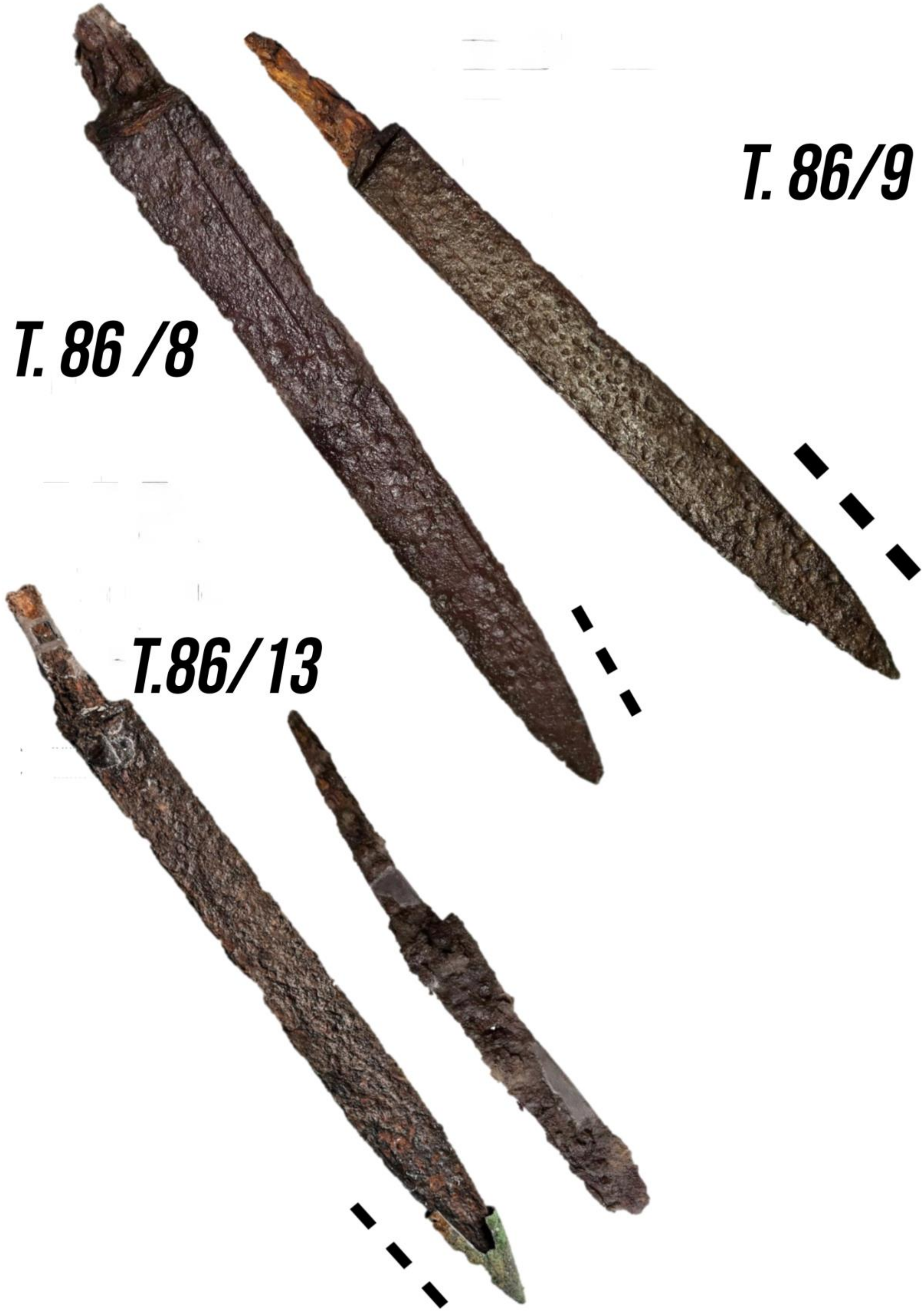
Figure 39. Tabula Peutingerana - Central Italy with roads passing near Selvicciola - (Adapted from www.tabula-peutingeriana.de).

Figure 40. Italy after arrival of Longobards in 6th century AD.

Figure 41. Italy at the end of Longobard Kingdom at the end of 8th century AD.

Appendix III: Grave Goods examples
Adapted from I. Micarelli, 2020.




T. 86/9
T. 86 /8
T.86/13

T. 86/3

T. 86/5

T. 86/8

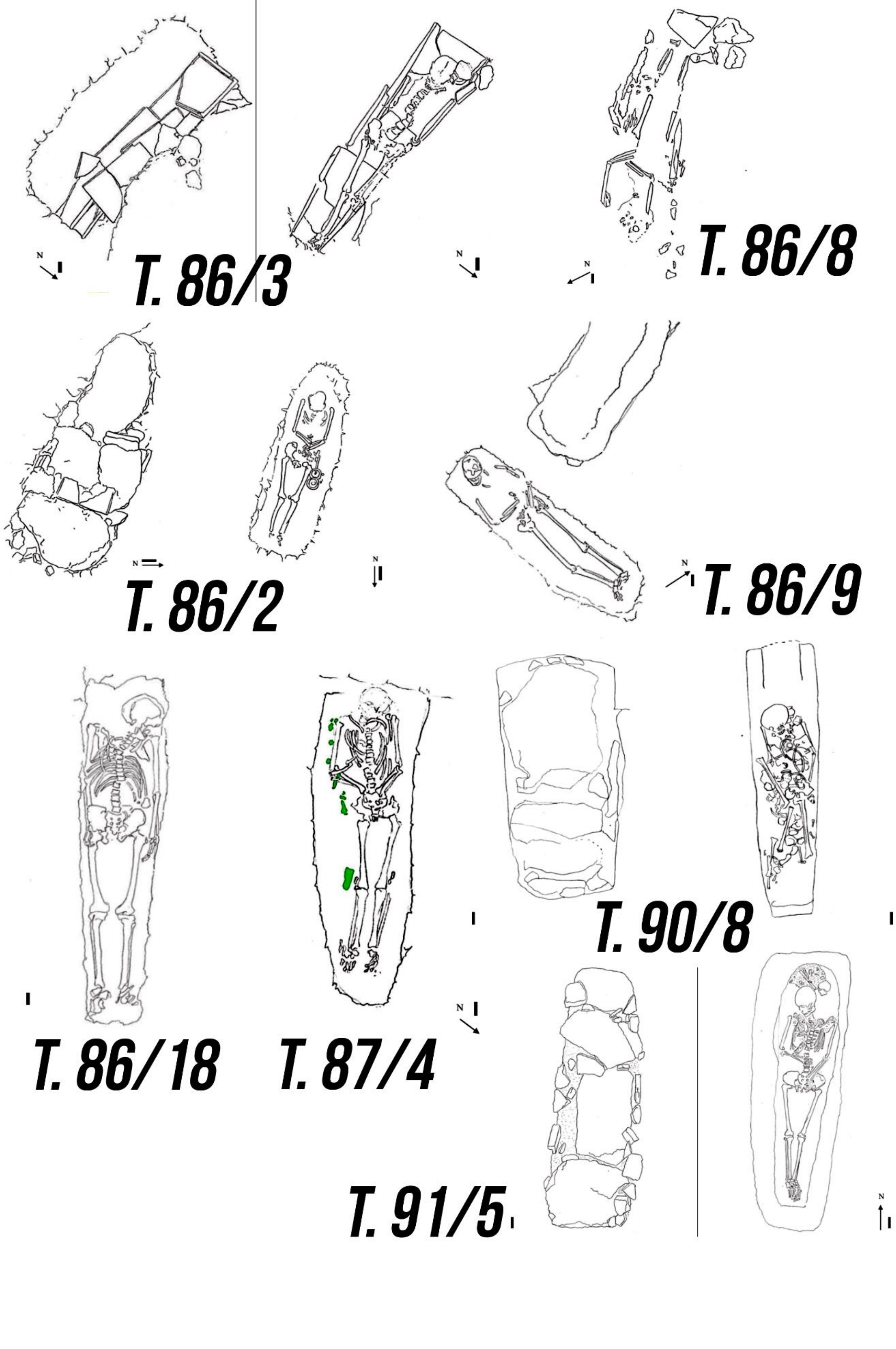
T. 86/13

T. 86/18

T. 87/4

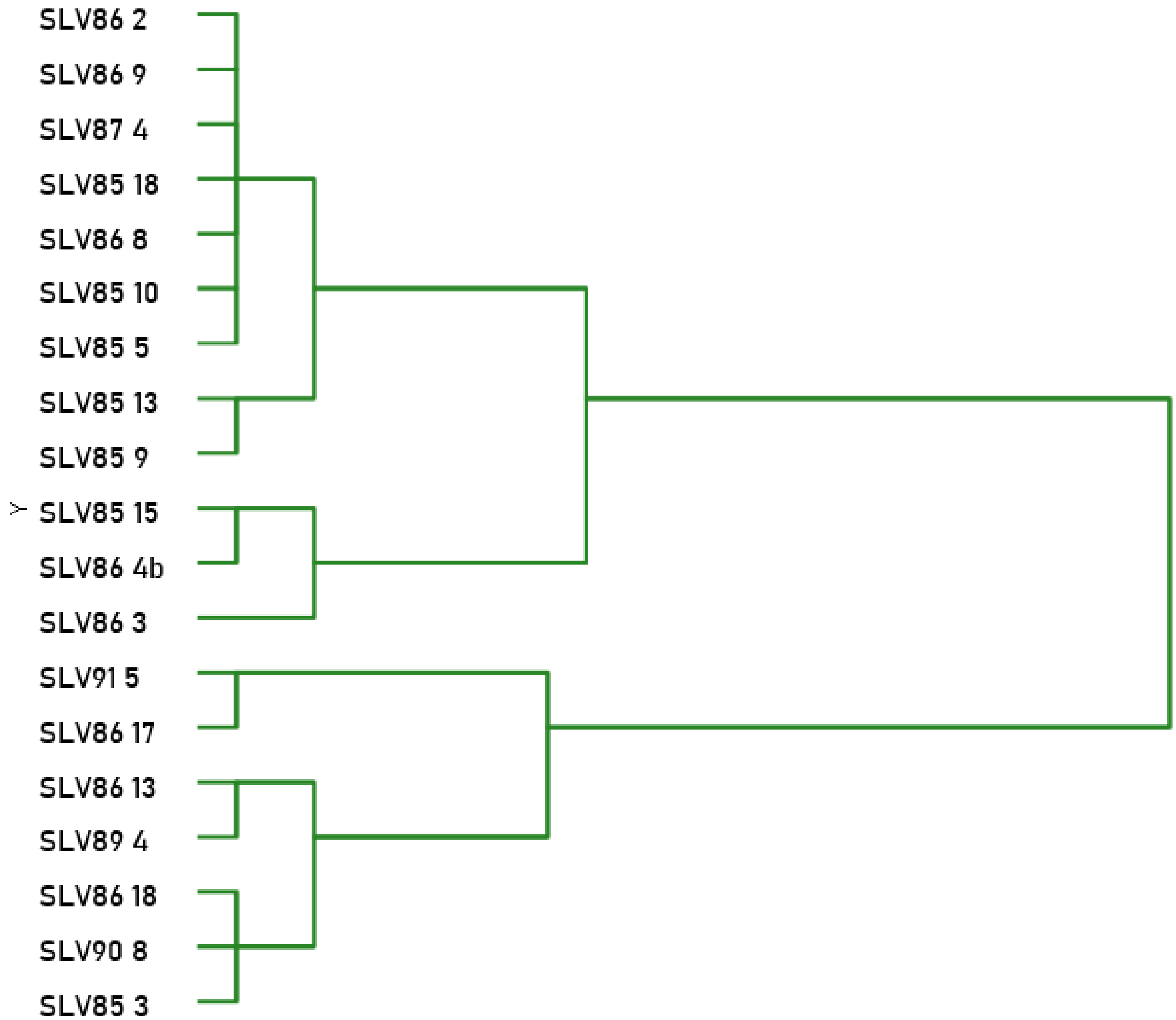
T. 86/17

Appendix IV: Burial typology



Appendix IV: Statistical Testing

Cluster analysis of $^{87}Sr/^{86}Sr$ measured in human dental enamel



T-Test - Human enamel against bones Sr ratios

Group Statistics

		N	Mean	Std. Deviation	Std. Error Mean
SrRatio	enamel	19	0.709318158	0.0003878068	0.0000889690
	bone	8	0.709046500	0.0003938818	0.0001392582

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
SrRatio	Equal variances assumed	0.539	0.469	1.655	25	0.110	0.000271658	0.000164167	-0.00006645	0.000609767
	Equal variances not assumed			1.644	13.036	0.124	0.000271658	0.000165252	-0.00008525	0.000628564

Mann-Whitney Test - Human enamel against bones Sr ratios

Ranks

		N	Mean Rank	Sum of Ranks
SrRatio	enamel	19	16.13	306.50
	bone	8	8.94	71.50
	Total	27		

Test Statistics[a]

	SrRatio
Mann-Whitney U	35.500
Wilcoxon W	71.500
Z	-2.151
Asymp. Sig. (2-tailed)	0.031
Exact Sig. [2*(1-tailed Sig.)]	0.029[b]

a. Grouping Variable: Bone or Enamel

b. Not corrected for ties.

Mann-Whitney Test - Roman against Longobard Sr ratios

Ranks

Sample		RorL	N	Mean Rank	Sum of Ranks
enamel	SrRatio	Roman	8	7.63	61.00
		Long	11	11.73	129.00
		Total	19		

Test Statistics[a]

Sample		SrRatio
enamel	Mann-Whitney U	25.000
	Wilcoxon W	61.000
	Z	-1.569
	Asymp. Sig. (2-tailed)	0.117
	Exact Sig. [2*(1-tailed Sig.)]	0.129[b]

a. Grouping Variable: RorL

b. Not corrected for ties.

Kolmogorov-Smirnov Test - Roman against Longobard Sr ratios

Tests of Normality

			Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Sample		RorL	Statistic	df	Sig.	Statistic	df	Sig.
enamel	SrRatio	Roman	0.110	8	0.200*	0.989	8	0.994
		Long	0.213	11	0.175	0.935	11	0.459

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction