Salt Production in Central Italy from the Bronze Age to Augustus

By

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Abstract:

Salt has played an important role in human history since our earliest days as a species. It is an essential nutrient for our survival (and that of all animals) and is appreciated beyond its culinary value in a variety of industries. In Central Italy, salt production first occurred on a major scale in the Early Bronze Age, via a technique known as briquetage. Technological advancements in hydraulic engineering would eventually lead to the region producing salt via solar salterns, a more efficient method that relied on more specific environmental conditions. This project analyzes both methods of salt production, but especially the transition from briquetage to salterns, using both archaeological evidence and ancient literary sources. The primary tool used for this is data visualization, which facilitates the examination of statistical data through graphs to emphasize key periods in Central Italian history. Overall, the transition between salt production methods seems to revolve around the area at the mouth of the Tiber River, a region contested by Rome and Veii early in the history of both states. At some point in the 9th or 10th centuries BCE, the sudden introduction of salt water into a nearby industrial area appears to have led to the foundation of solar salterns, inciting conflict between Rome and Veii surrounding control of the essential resource.

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Chapter 1: Introduction

Salt has always been an essential nutrient for human and animal life. As humans evolved and developed organized societies, our reliance on salt increased. In central Italy, the history of salt and its connection to human life is well illustrated in the archaeological record and in ancient literary sources. It played a key role in the culinary and preservation industries, the production of various luxury commodities, was applied in the medical field, and even saw use in religious rituals.

This project aims to summarize the primary methods of salt production in Central Italy from the early Bronze Age to the beginnings of the Roman Empire, outlining key trends in the relevant data and attempting to explain why these trends could have occurred. First, I will discuss the importance of salt in Italy and its value as a commodity. Next, I will discuss in detail the different types of salt production employed in Central Italy from the early Bronze Age to the Roman imperial Period. Then, I will compile data from archaeological reports, existing research, and primary literary sources to create data sets relating to the production of salt and the sites that produced it. I will then visualize this data in the form of bar graphs by using Microsoft Excel, assess the data, and attempt to highlight and explain trends through historical events, whether these are documented in the ancient literature or in the archaeological record. I will also attempt to use the visualized data as a tool for the identification of further historical events.

Overall, this research aims to answer the following question: can the analysis of salt production, its techniques, and the trends in its methods serve as a tool for the analysis of past events? Specifically, this project will attempt to answer this question through the use of data visualization, seeking an answer to the secondary question of whether this is an effective technique for the analysis of historical events.

Dates and Periodization:

The model used for periodization of Central Italian history in this study, outlined below, focuses on terms more similar to those used when describing the broader Greek Mediterranean and Italian archaeology, rather than the periodization of Roman History. This is a standard often used when discussing Central Italian history, as it allows for simpler comparisons to Greek colonies in Italy or Greek City States in the Aegean or Eastern Mediterranean. Table 1, below, outlines the dates assigned to each period that will be referenced in this work. Note also the abbreviations indicated in this table, which will be used at various times throughout the course of this project.

Period	**Begins**	**Ends**
Early Bronze Age (EBA)	2300 BCE	1700 BCE
Middle Bronze Age (MBA)	1700 BCE	1350 BCE
Recent Bronze Age (RBA)	1350 BCE	1150 BCE
Final Bronze Age (FBA)	1150 BCE	950 BCE
Early Iron Age (EIA)	950 BCE	750 BCE
Orientalizing Period (Ori.)	750 BCE	580 BCE
Archaic Period (Arch.)	580 BCE	490 BCE
Classical Period/Early Republican Period (Clas.)	490 BCE	323 BCE
Hellenistic Period/Middle-Late Republican Period (Hell.)	323 BCE	27 BCE
Imperial Period (Imp.)	27 BCE	476 CE

Table 1: Periodization of Central Italian History

Chapter 2: Evidence for the Study of Ancient Salt Production

Ancient Literary Evidence

The corpus of ancient literature on salt is far from scant – the substance receives mentions in Homeric works, scientific and philosophical texts, agricultural manuals, and a variety of literary genres. In Homer's *Iliad*, salt receives the epithet of "holy salt" (*ἁλὸς θείοιο*),[1] perhaps a reference to its role in the sacrificial rituals of the ancient Greek peoples.[2] In the *Odyssey*, salt is used as a device to portray the alienness of the Thrinacians, whom Odysseus must visit in his efforts to keep at bay Poseidon's wrath. The Thrinacians are described as "men that know naught of the sea and eat not of food mingled with salt."[3] This is deliberately sung in stark contrast with the Greeks of Ithaca, who had (at least in this story) just spent ten years fighting a war across the sea from their homeland, proving their maritime prowess, and who certainly did mix salt in their food. Though writing the better part of a millennium later, Plutarch gives us some insights into these references – in his *Quaestiones Convivales*, he both justifies Homer's epithet *ἁλὸς θείοιο*[4] and discusses the matter of seafood, especially fish, being essential in Italy and fetching a high price at Rome.[5] This depicts an implied contrast between the Italians of Plutarch's time and the Thrinacians of Homer's – if the latter are "less than" for their unsalted food and unfamiliarity with the sea, then the former must be at least "equal to" for their love of both salt and the sea.

[1] Homer, *Iliad* 9.214.

[2] J. N. Bremmer, "Greek Normative Animal Sacrifice." In D. Ogden (ed.), *A Companion to Greek Religion*. Blackwell, 2007, p. 136.

[3] Homer, *Odyssey*. 11.121-124. Tr. A. T. Murray, 1924.

[4] Plutarch, *Moralia* 5.10 (684e-685f).

[5] Plutarch, *Moralia* 4.4.2 (667e).

The ancient literature also presents a very clear picture of salt's importance in antiquity. Pliny the Elder and Cato the Elder both discuss the uses of salt and some of its production. Pliny, in his *Naturalis Historia*, devotes several chapters[6] to the substance, covering its production, its uses, its value, and its general qualities. This encyclopedic approach makes these chapters invaluable sources on the role of salt in ancient Italy.

First, Pliny briefly addresses the manner in which salt is extracted. He provides three primary methods by which this can occur – mining, desiccation, and condensation.[7] The mining of salt, in Pliny's account, consists of extracting large blocks of rock salt (as one would extract a block of stone from a quarry) to be broken down and processed into a more usable form. To this sort of salt, he assigns the term "native."[8] Pliny's "desiccation" most likely refers to the process of perfect evaporation – that is, evaporation in which all liquid is dried out and all that remains is a solid residue. "Condensation," as Pliny uses the term, probably refers to imperfect evaporation. This form of evaporation involves the reduction of a liquid's volume until either a liquid or solid precipitate form, but not all of the liquid is truly dried. Desiccation and condensation each correspond to a specific type of salt extraction, which will be addressed in this work. Pliny also makes a very brief reference to the production of brines by the leaching of reed or bullrush ashes, which seems to describe salt production by the burning of halophyte plants.

In Cato's work, *De Agricultura*, the discussion of salt is less direct and far briefer. No chapter in his work devotes itself to describing salt, but he discusses at different points remedies

[6] Pliny, *Naturalis Historia* 31.39-45.

[7] Pliny's "desiccation" and "condensation" are known by modern science to be the same process, evaporation.

[8] Pliny, *Naturalis Historia* 31.39. Pliny uses here the term *gignitur* – that is, "is produced/given birth," as opposed to other salts he says are *fit* (or "are made").

that use salt as an ingredient,[9] how to bleach or purify salt of poor quality,[10] how to make a pickling brine from salt, and how to make "Greek wine" with a salty flavour.[11] Columella, in his agricultural treatise *De Re Rustica*, also discusses the use of salt to encourage livestock to drink, marking a direct reflection of Aristotle's *Historia Animalum*.[12]

With the importance of salt understood, it is also crucial to examine the short- and long-distance trade routes along which such an essential resource may have been carried. Central Italian trade networks, including those of the Etruscans and Latins, stretched far beyond peninsular Italy. These connections are well documented in ancient literary sources and highlighted again by archaeological remains. Aristotle, in his *Politics*, makes note of trade connections between Etruria and Carthage,[13] which are also attested by archaeological research.[14] Other ancient literary references to the trade partners of the Etruscans are poorly documented. Where the ancient literature truly shines in this regard is in its detailing of Rome's trade connections. While these references are often made in passing and focus mostly on the period only towards the end of that examined by this project, they are still invaluable for understanding trade beyond Italian borders. Pliny, even in his chapters on salt, briefly mentions connections to India and their methods of salt mining (which are also passingly mentioned by Strabo).[15] Other sections of his work also make reference to trade with Gaul, including both Cisalpine and Transalpine Gaul. Strabo's *Geographica*

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[9] Cato, *De Agricultura*, 70; 156; 157.

[10] *ibid.* 88.

[11] *ibid.* 24; 105.

[12] Aristotle, *History of Animals* VIII.10.

[13] Aristotle, *Politics* 3.1280a.35-39.

[14] See e.g., J. M. Turfa, "Evidence for Etruscan-Punic relations," *American Journal of Archaeology* 81 no. 3 (1977): 373; Alessandro Naso, "North Africa." In A. Naso (ed.), *Etruscology*. De Gruyter, 2017, pp. 1695-1708.

[15] Pliny, *Naturalis Historia* 31.39; Strabo, *Geographica* 5.2.6.

highlights an essentially pan-Mediterranean network of trade, including modern Spain, France, Turkey, Syria, Lebanon, Palestine, and North Africa. A relatively obscure source, the *Periplus Maris Erythraei* (*PME*), also corroborates Pliny's reference to India – the anonymous work, dated to the first century CE, discusses trade routes East from Egypt along the coasts of Africa and Arabia Felix, as far as the west coast of modern India at the port of Barygaza (now Bharuch).[16] While Roman control of Egypt did not begin until around 30 BCE, it stands to reason that these trade routes would have existed and seen use by non-Roman people; further, an Italian-Egyptian trade connection is well-attested in the archaeological record.[17] Connections between Italy and Transalpine Gaul are addressed by, among others, Daphne Nash Briggs, who discusses the idea that metals and slaves were likely among the most common exports from Italy northwards,[18] and by Ewa Bugaj, who additionally discusses routes of communication beyond trade.[19] Shifting trade routes within central Italy are carefully examined by Francesca Fulminante and Luca Alessandri in their 2024 work "Salt production in Central Italy and Social Network Analysis Centrality Measures."[20] By using the modern analytical techniques of betweenness centrality and closeness centrality, the authors are able to highlight connections between salt-production sites and other settlements, describing changes in trade networks that appear to parallel changes in production

[16] *Periplus Maris Erythraei*, 41-44.

[17] J. Gran-Aymerich, J. M. Turfa, "Etruscan Goods in the Mediterranean World and Beyond," in J. M. Turfa (ed.), *The Etruscan World*. Routledge, 2013, p. 383.

[18] D. N. Briggs, "Metal, salt and slaves: economic links between Gaul and Italy from the eighth to the late sixth centuries BC," *Oxford Journal of Archaeology* 22 no. 3 (2003): 244-247.

[19] E. Bugaj, "Etruscan systems of goods exchange and communication routes including regions north of the Alps. Outline of the issue." In *Long Distance Trade in the Bronze Age and Early Iron Age*, edited by J. Baron and I. Lasak, 293-314. Wroclaw: Wydawnictwo Uniwersytetu Wroclawskiego, 2007.

[20] F. Fulminante and L. Alessandri, "Salt Production in Central Italy and Social Network Analysis Centrality Measures: An Exploratory Approach," *Open Archaeology* 10 (2024): 1-17.

techniques. All of Central Italy's trade partners could have represented either potential sources of salt in times of shortage or outlets for salt and salted products when a surplus existed.

The other important strength of the ancient literature lies in its discussion of salt as a resource of value not just to individuals but to entire states. Multiple sources highlight conflicts centred around the control of salt production facilities or make mention of state policies that exert control over salt production. By the account of Livy, salt-works were established at Ostia at the mouth of the Tiber by Ancus Marcius.[21] Many years later, tells the historian, when Rome was at war with Lars Porsenna and the Tarquin dynasty, the price of salt had been driven so high by a private market that the Roman government seized control of salt production,[22] presumably to better control its price in a time of turmoil and to prevent it from reaching the armies of allies-turned-enemies north of the Tiber. Plutarch, though further removed from the events of Rome's early history than Livy, provides another account of the state's control over the saltworks at the mouth of the Tiber. In his *Life of Romulus*, the biographer tells of the early Romans' war against the city of Veii over the alliance and control of the Fidenates, a Central Italian people. After being defeated in battle at the hands of Romulus' army, the Veientes were forced to surrender an area of land to Rome along the banks of the Tiber River, known as the "seven districts," which in Plutarch's account includes some saltworks.[23] The general episode is paralleled in both Dionysius of Halicarnassus[24] and Livy,[25] though Livy's passage portrays the same episode as a war against the Fidenates rather than over their allyship and lacks the explicit references to saltworks otherwise

[21] Livy, *Ab Urbe Condita,* 1.33.9.

[22] *ibid.* 2.9.6.

[23] Plutarch, *Romulus* 25.4.

[24] Dionysius of Halicarnassus, *Roman Antiquities* 2.55.5

[25] Livy, *Ab Urbe Condita,* 1.15.5.

featured in Dionysius' account. Regardless of whether the saltworks at the Tiber delta were constructed by Ancus Marcius, or by the Fidenates or Veientes before him, ancient accounts paint a clear picture of salt as a resource so essential that wars were worth fighting over the control of its production and the land best suited to the establishment of saltworks.

Archeological Evidence

The earliest non-domestic salt production in Central Italy likely made use of the briquetage technique. This technique involves evaporation of brine in clay vessels using the heat of a fire, followed by the shattering of the vessels to extract salt. Its simple *chaîne opératoire* made it a feasible method of production as early as the Neolithic period in some parts of Europe.[26] In Central Italy, the earliest evidenced salt production sites can be assigned a *terminus ante quem* of the Early or Middle Bronze Age, with some continuing their operations until well into the Roman Republican period. The earliest sites for which evidence of briquetage exists were located at Caprolace Settlement and Isola di Coltano.[27]

A well-organized study on Central Italian salt production sites was published in 2021 by Luca Alessandri, Clarissa Belardelli, Peter Attema, Francesca Cortese, Mario Rolfo, Jan Sevink,

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[26] Olivier Weller *et al*., "Première exploitation de sel en Europe. Techniques et gestion de l'exploitation de la source salée de Poiana Slatinei à Lunca," In O. Weller, A. Dufraisse, P. Petrequin (eds.), *Sel, eau, forêt. D'hier à aujourd'hui*. Presses universitaires de Franche-Comté, 2008. 205-230

[27] F. Bulian, L. Alessandri, P. Attema, J. Sevink, "Bronze Age to Roman period salt production in the coastal areas of peninsular Italy: Palaeoenvironments, production methods and archaeological evidence," *Quaternary Science Reviews* 244 (2024): 21.

and Wouter van Gorp.[28] This study aims not only to establish an initial catalogue of 43 sites devoted to salt production but also to provide a history of related research and discuss hypotheses related to salt production. Rather than attempting to find an "answer" to the questions that persist in the field, Alessandri expands on the theories of early scholars in salt research and proposes topics for further research. Another study, this one by Francesca Bulian, Luca Alessandri, Peter Attema, and Jan Sevink,[29] also provides an excellent (if general) overview of salt production in Italy. Her work introduces a catalogue of 49 salt-producing sites. While many of these overlap with Alessandri's catalogue, Bulian (with the advantage of writing three years later) presents the more thorough of the two. Another important aspect of the catalogues provided by both Alessandri and Bulian is their inclusion of the salt-producing sites' confirmed active dates (or date ranges). This information is essential for examining trends in salt production over time.

[28] Luca Alessandri *et al*. "Bronze and Iron Age salt production on the Italian Tyrrhenian coast." In M. Gnade and M. Lami (eds.), *Tracing Technology: Forty Years of Archaeological Research at Satricum, Rome*. Peeters, 2021, pp. 25-40.

[29] F. Bulian *et al*., pp. 1-28.

Works by (or including) Francesca Bulian, Luca Alessandri,[30]Christoph Reusser,[31] Clarissa Belardelli,[32] Felix-Adrian Tencariù,[33] and Paola Càssola Guida[34] all help to establish a clear archaeological fingerprint for sites at which briquetage is likely to have occurred. By far the most common identifying feature of these sites, discussed in virtually every relevant archaeological survey, is a large accumulation of reddish pottery shards. The shards of impasto pottery are generally crudely made,[35] brittle,[36] and in some cases bear traces of calcium carbonate (a residue of seawater with a lower solubility than common salt, sodium chloride) on their inner surfaces.[37] The most common interpretation of these shards is as fragments of shattered brine-boiling vessels, destroyed as part of the salt-extraction process, though other possible interpretations exist, such as

[30] L. Alessandri *et al.*, "Salt in late Iron Age Italy. A multidisciplinary Approach to the Exploration of Italy's Coastal Exploitation Sites: Piscina Torta (Ostia, Rome) Case Study," *Journal of Archaeological Science: Reports* 53 (2024); L. Alessandri, "Exploring territories: Bubble Model and Minimum Number of Contemporary Settlements," *Origini* 37 (2016): 173-197.

[31] Cristoph Reusser, "*Briquetage* in early Hellenistic Etruscan Spina (Ferrara, Italy)," *Quaternary Science Reviews* 331 (2024): 1-11.

[32] Clarissa Bellardelli, "Siti costieri villanoviani a nord di Roma (Italia): un paesaggio 'industriale' protostorico." *Cahiers D'Archéologie Romande* 120 (2011): 223-235.

[33] F. Tencariù, M. Alexianu, V. Cotiugă, V. Vasilache, I. Sandu, "Briquetage and salt cakes: an experimental approach of a prehistoric technique." *Journal of Archaeological Science* 59 (2015): 118-131.

[34] Paola Càssola Guida, "Il sale nella protostoria dell'Adriatico: una proposta di interpretazione per il deposito votivo di Cupra Marittima (Ascoli Piceno)." *West&East: Rivista della Scuola di Specializzazione in Beni Archeologici delle Università di Udine, Trieste, Venezia Ca' Foscari* 1 (2016): 38-63.

[35] C. Bellardelli, p. 223.

[36] A. Horiuchi, N. Ochiai, H. Kurozumi, Y. Miyata, "Detection of Chloride from Pottery as a Marker for Salt: A New Analytical Method Validated Using Simulated Salt-Making Pottery and Applied to Japanese Ceramics," *Journal of Archaeological Science* 38 no. 11 (2011): p. 2949.

[37] Luca Alesandri *et al.*, "A review of available analytical methods to detect ancient salt production," *Quaternary Science Reviews* 338 (2024): 7.

waste disposal sites or fish-processing sites.[38] The most clearly outlined archaeological footprint is that presented by Bulian, Alessandri, Attema and Sevink in their aforementioned study.[39] This fingerprint consists of four main features:

1. Layers or deposits of large amounts of reddish impasto pottery sherds, as a result of numerous shattered brine-boiling vessels. The reconstructed vessels typically have a slightly conical shape in order to facilitate efficient evaporation.
2. Supports for the brine boiling vessels, in the form of *piliers*, pedestals, or small bricks.
3. The presence of clay-lined pits, often with some residues of calcium carbonate,[40] and,
4. On occasion, kilns for heating brine.

This archaeological fingerprint is a reliable tool for identifying briquetage sites along the Tyrrhenian coast of Italy. Other sites with similar features exist in Slovenia and Croatia. Because of the near-identical fingerprints of these sites and the proximity of known Etruscan settlements,[41] they may be considered to have connections in some capacity to the Central Italian sites.

Where some briquetage sites differ from others is in the exact shape of the pottery vessels used. The shape of vessel most conducive to evaporation is conical, with a fairly open top – this

[38] Luca Alessandri *et al*., "Salt or fish (or salted fish)? The Bronze Age specialised sites along the Tyrrhenian coast of Central Italy: New insights from Caprolace settlement." *PLoS ONE* 14 no. 11 (2019): 1-41.

[39] F. Bulian *et al*., pp. 17-19.

[40] The exact function of these pits has not been determined. They may have served as natural evaporation ponds for the concentration of seawater into brine, as pools for the collection of brine that had been leached through salty sediments, as deposits of clay to be turned into disposable briquetage vessels, or as storage pits for finished salt prior to its packaging. Regardless of their exact function, they are a common feature of most briquetage sites and can be connected to salt production in some respect.

[41] Reusser *et al,* 1-11. Spina, an Etruscan settlement in northeastern Italy, for example, was connected with a specific briquetage site.

leaves no ridges to promote recondensation of steam and a large opening to allow as much evaporated liquid as possible to escape. Interestingly, based on the diagrams of several of the above-mentioned authors, the shapes of vessels do not always adhere to this "most efficient" design. At many sites, vessels are wide, round-bottomed, or have closed-shape tops. The variation in vessel styles may be reflective of differences in how the sites were operated, but could just as easily be a matter of local flavour or artisan ability. While in theory the shape of a vessel can impact the efficiency of the briquetage process, the realized difference in efficiency is minimal when working with early technologies that already face inefficiencies in their processes.

Valuable research was conducted by Tencariù, Alexianù, Cotiugă, Vasilache, and Sandu into the processes involved in briquetage. This research, published in 2015, consisted of archaeological experiments attempting to recreate saltcakes from brine using techniques attested in the archaeological record.[42] The experiment was conducted in the mountains of Romania and made use of brine from a saltwater spring to recreate a version of the technique likely used in a local context. One difference between the spring water and seawater was the salinity – the salt water from the springs was of a slightly different salinity than seawater, at about 3.68%, compared to the Mediterranean Sea's concentration of about 3.80%. However, this difference is minor enough that the impact on the experiments was likely very low. At some Central Italian sites, the concentrations of sodium and chlorine ions in briquetage pottery shards have been revealed by chemical analyses to be quite low.[43] However, Tencariù's experiments revealed that when an insulating layer is used to facilitate the separation of salt cakes from vessels, fewer ions are able to penetrate the pottery matrix. This could result in chemical analyses that do not necessarily reveal

[42] F. Tencariù *et al.*, pp. 118.131.

[43] L. Alessandri *et al.*, "A review of available analytical methods to detect ancient salt production," p. 7.

high concentrations of sodium or chloride ions, falsely indicating that the vessels were not in contact with high concentrations of salt.

The other common method of salt production in ancient Italy was the saltern (or solar saltern, more specifically). Salterns also rely on evaporation to crystallize salt from brine, but rather than relying on the heat of a fire, they use the heat of the sun. The presence of salterns at Ostia is attested in Livy,[44] and confirmed by archaeological excavations in the Tiber delta. What can make the identification of salterns especially difficult is the volatile nature of a coastal landscape. Often, the infrastructure of a salt pan involved no more than a series of shallow clay-lined pans separated by narrow channels with wooden sluice-gates.[45] On a wave-battered coast, soils and unfired clay can easily vanish as they are eroded by waves, and wood is prone to rot in a wet environment. Archaeological excavations along the coast of Northwestern Spain that have continued from the end of the 19th century to the present have revealed solar salterns paved with a combination of clay, flagstones, and Roman concrete – a much more permanent archaeological fingerprint.[46] While these sites date to a later period than those attested by Livy and feature more advanced materials than those used in early Central Italy, their organization and hydraulic engineering would certainly have been possible for the Etruscans and early Romans of Central Italy.

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[44] Livy, *Ab Urbe Condita*, 1.33.9.

[45] B. X. Currás Rejofos *et al.*, "The Roman saltworks of the Atlantic coast of Gallaecia: Traces and evidence of a large sea salt production complex," *Quaternary Science Reviews* 339 (2024): 2.

[46] B. X. Currás Rejofos *et al.*, "The *salinae* of O Areal (Vigo) and Roman salt production in NW Iberia," *Journal of Roman Archaeology* 30 (2017): 325-349.

Despite a very limited archaeological record of solar salterns, they are discussed in many ancient literary sources. Pliny,[47] Dionysius of Halicarnassus,[48] Plutarch[49] and Livy[50] all discuss salterns in the area of the Tiber River delta. While they do not explicitly name these salt works to be solar salterns, archaeological evidence to be presented in this project will explain why the interpretation of the ancient literary sources is best interpreted as referring to this kind of salt production. In other regions of Central Italy, salterns are attested at least in the imperial period by authors such as Rutilius Namatianus.[51] While references do seem to exist to briquetage in the ancient literature, they are far more rare and certainly less direct – two references that can possibly be connected to briquetage come from Pliny, who suggests there are at least two methods of salt production, and later refers to the addition of crushed reddish pottery to some salt products.

One solar saltern in particular is well preserved in the archaeological record and may also be referenced in ancient texts. This is the saltern located at the Stagno di Maccarese Lagoon at the mouth of the Tiber River, just west of Rome. The site would come to be known sometime in the Roman period as the *Campus Salinarum* for its role in the production of salt.[52] The existing hydraulic structures date to the first century CE, but the earlier[53] use of the site for other purposes is demonstrated by the archaeological record. It is unclear exactly what the activities were, but they seem to have been related to food production or preparation, an industry which certainly

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47 Pliny, *Naturalis Historia* 31.41.

48 Dionysius of Halicarnassus, *Roman Antiquities* 2.55.5.

49 Plutarch, *Romulus* 25.4.

50 Livy, *Ab Urbe* Condita 1.33.9

51 Rutilius Namatianus, *De Reditu Suo*, 470-484.

52 A. Marzano, "Marine salt production in the Roman world: The salinae and their ownership," *Quaternary Science Reviews* 336 (2024): 2.

53 Evidence of cooking surfaces, hearths, and other workstations shows the site was used in an industrial manner by earlier Etruscans of the Area.

would have benefitted from easy and direct access to salt. One convenient aspect of this site is that salt works there can be assigned a clear *terminus post quem* of sometime between the 10th and 9th centuries BCE. This is due to the fact that the site had limited or no access to salt water until a collapse of the local dune system at some point in that period.[54] While this is certainly a broad period of time, portions of it could potentially align with the proposed foundation dates for salt-works in the area, according to Dionysius.[55]

What is most clearly lacking in the ancient literature and modern analyses of archaeological evidence is a thorough discussion of the transition between salt production techniques. The ancient literature paints a clear picture of salt and its importance in the ancient world. It also provides a history of Central Italy with the role of salt at centre stage – it appears that the earliest major conflicts between Rome and her neighbours may have been fought over control of the substance's production. The ancient literature available seems to possibly focus on salt production via solar salterns, a method popular in the Roman Imperial Period and known around much of the world even in the modern era. The archaeological record, on the other hand, clearly demonstrates the presence of sites dedicated to the production technique known as briquetage, which involved the evaporation of brines in disposable clay vessels that would be shattered during the salt extraction process. The shattering of the vessels left a clear archaeological record that is the most essential feature in identifying such sites. Other key features used for identifying briquetage sites include pits, kilns and sediment deposits.

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[54] F. Di Rita *et al*. "Holocene Environmental Instability in the wetland North of the Tiber delta (Rome, Italy): Sea-lake-Man interaction," *Journal of Paleolimnology* 44 (2009): 51-67.

[55] Dionysius places the foundation of the salt works as being before the time of Romulus, meaning that they were founded before the middle of the 8th century BCE.

With both salt production methods thus well attested in the literature, there remains a significant lack of research into the transitional period between these two techniques. It is clear that briquetage was the first employed technique, with salterns following as the need for increased salt production arose. Fulminante and Alessandri also address shifting trade routes as a result of this transition, but fail to fully discuss the transition itself. Other sources indirectly refer to this transition period but again fail to analyze it in any capacity.

This project aims to address this issue by discussing the primary methods of salt production used in ancient Central Italy, condensing relevant data on the sites into tables and graphs, and visualizing this statistical data in order to analyze trends relating to the transition from briquetage to solar salterns in ancient Italy.

Chapter 3: The Role of Salt in Ancient Italy

"By Hercules! … The higher enjoyments of life could not exist without the use of salt; …indeed, so highly necessary is this substance to mankind…" (Pliny, *Hist. Nat.* 31.39).

Such are the words of Pliny the Elder on the simple yet essential good. Salt is a biological requirement for human and animal life. This was as much the case in antiquity as it is today. On average, a modern adult consumes about 3 kilograms of salt per year; by contrast, the body's biological need is much lower, being just over 1.5 kilograms per year.[56] In antiquity, an estimate by Cato the Elder suggests that one person needs a *modius* of salt[57] – that is, about 8.7L or about 19kg. This far exceeds the threshold for a healthy or even safe amount of salt to consume in a year.[58] Therefore, it is only reasonable to assume that Cato's estimate accounts for needs beyond the culinary. Indeed, Pliny's above statement seems far too dramatic to be a praise of a simple seasoning.

The immense importance of salt in the ancient world cannot be overstated. Pliny's *Historia Naturalis* provides an excellent catalogue on the uses of salt in antiquity.[59] Arguably, the most important use of salt in antiquity was for the preservation of foods. In the absence of modern preservation methods such as refrigeration or highly processed additives, salt was able to preserve

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[56] "Sodium Reduction," World Health Organization, Updated 2025. Retrieved from https://www.who.int/news-room/fact-sheets/detail/sodium-reduction.

[57] Cato, *De Agricultura* 58.

[58] World Health Organization, 2025. Above 5g of salt per day or over ~1.8kg per year can cause heightened risk of heart disease, osteoporosis, gastric cancers, and kidney failures. Above 10g per day or ~3.6kg per year, not an uncommon intake in the modern world, greatly increases these risks. The overconsumption of sodium is the direct cause of about 1.89 million deaths per year.

[59] Pliny, *Naturalis Historia*, 31.39-45.

food by acting as a desiccating agent, drawing away the water from meats and some vegetables and thus preventing the growth of many bacteria that could cause rot. A high enough salt concentration in brine was also enough to keep other bacteria out of pickled fruits, vegetables, or animal products. Salt could even aid in the preservation of dairy products (i.e., cheeses)[60] if appropriate additional steps were taken. Salt was also used for flavouring in antiquity as it is today, being added into stews and soups or rubbed on meats for seasoning.

As a non-culinary substance, salt also played a role in the maintenance of livestock herds. Aristotle, in his *Historia Animalum*, tells that a flock of a hundred sheep, if given one *medimnus/medimne* of salt every five days, will greatly increase their drinking and thus be healthier, especially during hot summers. The salt would have usually been mixed into the animals' grain or sprinkled over leafy greens fed to the flock.[61] Pliny agrees with Aristotle in his *Naturalis Historia*, stating that cattle, sheep, or beasts of burden all "are induced to graze all the better by giving them salt."[62] The practice of including salt in the food given to a herd or flock of livestock is recognized in the modern era as being essential for the animals' survival and is regularly practiced in agricultural communities. In the present day, as in antiquity, salt is fed mixed into grain or hay or is supplied via compressed blocks that can be licked directly by the animals. Pliny also suggests there is much medicinal value in salt, providing instances of simple rustic remedies that use either salt or seawater. Salt rubbed on the abdomen served as a liniment for women after childbirth; rubbed on the feet, it was considered a remedy for gout or warts; mixed with oils or

[60] Pliny, *Naturalis Historia*, 31.39. Tr. John Bostock, 1855. It is after mentioning that salt greatly improves the flavour of cheese that Pliny feels compelled to write his famous praise of the substance: "We may conclude, then – by Hercules! – that the higher enjoyments of life could not exist without the use of salt…"

[61] Aristotle, *History of Animals*, 8.10

[62] Pliny, *Naturalis Historia* 31.41.

vinegars, it was used to treat ulcers (though one must imagine this treatment was quite painful); mixed with grapes, it was believed to treat cancerous growths; it was used too in the treatment of leprosy, boils, and inflamed scabs.[63] Pliny also suggests the use of salt for erasing wrinkles or to bring colour to the skin, though these uses seem more cosmetic than medical.

Products heavy in salt such as “flower of salt” or the briny *salsugo* saw some medical use and were frequently used to induce sweating, vomiting, or diarrhea.[64] Another salted good that was used medicinally is *alex*, a natural byproduct of *garum* that was also often prepared on its own due its popularity. It was used as an ointment to cure scabs (especially on livestock), incisions or wounds in the skin, or serious burns – only effective, warns Pliny, if the patient should not be made aware that the remedy applied to their skin is made of the dregs of fermented, salted fish.[65] In cattle and beasts of burden, salt was used to treat sickness in the eyes.[66] Similar remedies appear in Cato the Elder’s *De Agricultura*[67] and Aristotle’s *Historia Animalum*.[68]

Another use of salt in ancient Italy was in religious rituals in the form of the *mola salsa* (“salt cake”), again detailed by Pliny.[69] The *mola salsa* was a mixture of grain and salt sprinkled over the head of an animal prior to sacrifice, likely in homage to the resources the animal would have been fed in its lifetime. This particular use of salt may be part of the reason for Homer’s use

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[63] *ibid.* 31.41-45.

[64] *ibid.* 31.42.

[65] *ibid.* 31.44

[66] *ibid.* 31.41.

[67] Cato, *De Agricultura*, 70; 156; 157.

[68] Aristotle, *History of Animals*, 8.26. An elephant’s insomnia is supposedly cured by the rubbing of salt on its shoulders.

[69] Pliny, *Naturalis Historia* 31.41.

of the term “holy salt.”[70] Salt was also used in different industries in Central Italy – it was a key ingredient in the production of a salted “Coan wine” or “Greek wine”,[71] fish sauce (*garum*, to the Romans) and its byproduct, *alex*,[72] perfume production,[73] and dyeing or fixing colour in cloth. It also saw much use in the culinary industries, especially those related to food preservation[74]. In addition to literary references to food preservation industries,[75] archaeological evidence supports the existence of large-scale fish farming and perhaps associated salting or processing stations.

Despite its immense usefulness and essential role in many ancient industries, salt is recorded in a number of ancient and modern sources as having had a low price in antiquity. According to the *Maximum Price Edict* of Diocletian, in that emperor’s time, a *modius* of salt would have cost 50 *denarii*[76] or roughly two days of pay for a manual labourer such as a farmhand, water carrier, or sewer cleaner, according to the same document. This is equal to the price for the same volume of wheat, millet, spelt, chick-peas, or dried beans, all of which were abundant during much of antiquity. Since, by Cato’s estimate, this much salt would account for a

[70] Homer, *Iliad*, 9.214.

[71] Cato, *De Agricultura,* 24; 105.

[72] Pliny, *Naturalis Historia*, 31.44

[73] *ibid.* 31.42. An oily substance gave some salts from Egypt a reddish hue, making them the most desirable for perfume-makers. Pliny also tells that the reddish hue is often applied to salts from other regions by the inclusion of crushed reddish pottery, creating a false colour that can be removed by rinsing the salt with water. The specific reference to reddish pottery shards may be connected to the salt production method, *briquetage*.

[74] Aristotle, *History of* Animals, 6.15. The fry, a small fish, is kept preserved by salting, which also allows it to be exported or traded over long distances when it would otherwise rapidly spoil. This revelation also helps the modern scholar to recognize that while salt may have had a low value on its own, salted or preserved goods were still exportable or valuable – non-maritime communities would still have had much use for fish products, which would have been inaccessible to them without the use of salt.

[75] Cato, *De Agricultura*, 162.

[76] Diocletian, *Edict on Maximum Prices* 3.1.8

year's supply, the proportion of most individuals' income that would need to have been devoted to the acquisition of salt is quite small. For a good produced *en masse*, it is easy to apply our modern standard of cheap salt to all salt that was available on ancient markets.

However, scholarship also exists to complicate the idea of salt having a consistently low price. Maria Cecilia D'Ercole presents arguments for a much higher price for salt in "Measures, Prices, and the Value of Salt in Ancient Societies." She argues that salt could only be produced *en masse* in specific areas of the Mediterranean and certainly was produced in immense quantities at many of these sites. The quantities of salt produced for example at Tyritaké on the Black Sea (~220 m^3 in one batch, or between 25 000 and 26 000 *modii*) in the early Roman Imperial period far exceeded the amounts that could have been used in the immediate region, and it must therefore have been exported as well.[77] However, a low price on salt would mean that the cost of transporting the good would cost more than the salt itself, and there would be no incentive for a facility with the output of Tyritaké to continue overproducing if the export of salt would in fact cost such a facility more than it could make. Based on the costs outlined in the *Maximum Price Edict*, a 1200 pound[78] wagonload of salt (or about 36 *modii*[79]) would have cost approximately 1800 *denarii*, equivalent to the cost to transport that same load just 60 miles (at a rate of 20 *denarii* per mile), not even accounting for the driver's wage.

[77] M. C. D'Ercole, "Measures, Prices, and the Value of Salt in Ancient Societies." *Annuario della Scuola Archeologica di Atene e delle Missioni Italiane in Oriente* 97 (2019): 312. Additionally, based on the estimates of Cato the Elder, this would be enough salt to provide for all of the dietary and preservation needs of over 25000 adults, or the equivalent of about 71% of the population under Rome's direct control in the sixth century BCE.

[78] That is, the Roman pound/*libra* of that period, about 327.45g.

[79] Based on the approximate weight of 33 Roman lbs. per *modius* (8.7L).

Another key argument by D'Ercole is that the price of salt in theory may not have been the same as its price in reality, making documents such as the *Maximum Price Edict* less reliable as a source of information on the value of salt. In 204 BCE, for example, the Roman government set a fixed price of one *sextans* for a specific (and undisclosed) quantity of salt, only for the price to be raised unofficially outside of the city itself due to a lack of policy enforcement.[80] Finally, D'Ercole brings up the idea that, especially prior to the development of efficient processes, salt was necessarily an expensive commodity as its production required many hours of labour, involving several specialized workers and consuming a large amount of other key resources. This process would not have allowed salt to have a low price, at least in early Central Italian productions, when briquetage was the primary or only production method. To corroborate D'Ercole's reasoning is a passage from Livy,[81] which asserts that the sale of salt was at some point taken into the control of the Roman government because of the substance's high price – a direct contrast to the recorded price in later periods.

It is also important to note that salt retained a certain value beyond its "face value" due to its usefulness and how common it was as an ingredient. As is highlighted by Cristina Carusi, even when salt was not exported on its own, it is well documented that salted fish and fish sauces were common exports and imports in the Mediterranean.[82] For regions such as Tyritaké, this could have meant that overproduction of salt was not an issue, as any excess could be used for the production of a large array of products, which were then worth exporting. Fish sauce or *garum* of the lowest quality, for example, is declared in the *Maximum Price Edicts* to have a

[80] D'Ercole, *ibid*., p. 314.

[81] Livy, *Ab Urbe Condita* 2.9.6.

[82] C. Carusi, "Salt and Fish Processing in the Ancient Mediterranean," *Journal of Maritime Archaeology* 13 no. 3 (2018): 481-490.

price of 12 *denarii* per *sextarius,* or 192 *denarii* per *modius*, nearly four times the value of the same volume of salt. Adding seasonings to common salt would also have increased its value from 50 *denarii* per *modius* to 128 *denarii* per *modius*.

Salt may indeed have initially been highly valued as a commodity, as is proposed by d'Ercole, as a result of the labour involved in its creation and the skill required to extract it, as well as the substance's usefulness. However, as techniques for the extraction of sea salt became more efficient, the amount of labour required to produce salt decreased dramatically, and new facilities' immense production capacities would easily have oversaturated a previously thriving market, leading to major price reductions. The transition between salt production techniques seems to have had a profound impact on the development of early states in Central Italy.

Chapter 4: Salt Production

Salt Production Techniques

In Central Italy, salt was produced or extracted using a variety of different techniques. Halophyte plant burning, mining, briquetage, and solar salterns are all attested at various times throughout the region's history.

Halophyte plants are plants that grow in salty or brackish water. These often include different varieties of reeds and marsh-grasses. Because of their salty environments, these plants often have high salt contents. In environments where salt water may exist in in soils or mud (i.e., salt marshes) but cannot be extracted in a clean enough form for evaporation and consumption, salt can be extracted in small batches from halophyte plants instead. In this process, saltwater reeds or bullrushes are harvested, dried, and burned until only ashes remain. The ashes are then rinsed with fresh water through a fine filter (usually cloth or woven baskets), allowing unwanted sediments to be removed while salts become dissolved in the water to form a brine. The brine can then be concentrated or boiled, creating a dried salt. This method is attested by Pliny,[83] though aside from this is rarely mentioned in ancient sources and is difficult or impossible to corroborate with archaeological evidence due to its general lack of preservable remains.

The mining of rock salt is also attested in Central Italy during some periods; however, this practice was very limited in its production based on how few sources of rock salt actually existed in Italy. One of the best attested through the Middle Ages, and the most prolific in the modern

[83] Pliny, *Naturalis Historia*, 31.40. Supposedly, this method of extracting salt from plant life was used by the Umbrii and other peoples of the same region.

era,[84] is located at Saline di Volterra at the Locatelli salt mine. As previously stated, the site was certainly active in the Middle Ages – it is well documented in medieval literary sources and was a source of moderate wealth for the region. Local tradition holds that the site was active as far back as the Etruscan period;[85] however, this cannot be verified with the archaeological and literary data available to current scholarship. The site was certainly active before 980 CE, as at that time, Holy Roman Emperor Otto II called on salters from Volterra to use their expertise in exploiting newly discovered salt deposits in Saxony.[86] In the modern era, the Locatelli Salt Mine is the highest-producing salt mine in Italy.[87]

The two methods of salt production which have seen the most consistent and most well-documented use throughout Central Italian history are briquetage and solar salterns. Briquetage involves the evaporation of salty brines using the heat of a fire, leaving a solid block or cake of salt ready for use or export. Solar salterns produce a less compacted salt, also ready to use or export, by evaporating brines in massive pools using the heat of the Sun. Both of these techniques were well attested in the history of Central Italy, with the use of solar salterns continuing from at least the later Iron Ages into the modern era.

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[84] P. Orlandi, *Siti di Interesse Minerario e Mineralogico del Territorio della Provincia di Pisa*. Provincia di Pisa, 2006, p. 252. The site produces about 100 000t of refined salt annually. "Già alla metà del X secolo è nota, da un documento dell'imperatore Ottone II, l'attività di salinatori di maestranze volterrane."

[85] E. Fani, "Saline di Volterra," *Itinerari Scientifici in Toscana*, Istituto e Museo di Storia della Scienza. Created 2008. Retrieved from https://brunelleschi.imss.fi.it/itinerari/luogo/SalineVolterra.html.

[86] P. Orlandi, p. 218.

[87] Saline di Volterra, "Headquarters: Saline of Volterra." Locatelli Saline di Volterra. Updated 2025. Retrieved from https://www.locatellisaline.it/en/headquarters/saline-of-volterra.

Salt Production – Briquetage

Beginning from the Middle Bronze Age in Italy, sites devoted to salt production by a method known as *briquetage* began to operate along the Tyrrhenian Coast of Central Italy. The process was centred around the boiling of brine in clay vessels, which would then be shattered to extract hardened cakes of dry salt. While the exact details of the *chaîne opératoire* may have varied from site to site, the general process was the same.

First, salty water was collected – in Central Italy, this was most often seawater, though in other areas of Europe water from salt-springs was certainly also used.[88] In order to minimize the amount of time for which a vessel of water would need to be heated the salt water would be concentrated into a stronger brine. There were multiple methods of achieving this. The method that was likely used at the site of Puntone Nuovo, for example, involved the leaching of seawater through salt-rich sediments collected from saline lagoons.[89] At other sites, clay-lined or stone-lined pits are preserved that may have been used for the partial evaporation of seawater into a stronger brine as well as for the settling of debris, detritus, and carbonates that would add, if not eliminated, a bitter flavour to produced salt.[90] These impurities are commonly referred to as "bitterns." The process of decantation is one of two ways that existed to "purify" salt, the other being a more

[88] F. Tencariù *et al.*, p. 119.

[89] Jan Sevink *et al.*, "Protohistoric briquetage at Puntone (Tuscany, Italy): principles and processes of an industry based on the leaching of saline lagoonal sediments," *Geoarchaeology* 36 (2021): 67. During the dry season, salt formed a crust at the edges of coastal lagoons that could be broken and collected for leaching. Pits excavated at the site were found to be rich in magnesium carbonate, formed by anoxic conditions such as those caused by prolonged and complete submersion in brine in the pit. That a sieve was used in the leaching process was confirmed by the total absence of large shell fragments in the pit, which were ubiquitous in other soils at the site.

[90] For clay-lined pits, see Sevink *et al.,* 2021; for stone-lined, see Belardelli, 2011.

complicated process of bleaching best outlined by Cato the Elder[91] and typically used on cheap, crude salts such as those collected "naturally." The decanted brine, now mostly free of bitterns, was allowed to concentrate further by evaporation for a period of time.

While the brine was prepared, clay vessels were produced that would be used for the evaporation process. Most often, these could be produced at the salt-production sites and were fabricated from easily accessible local clays. Vessels were formed, usually quickly and crudely, and then fired in simple kilns (usually shallow pits or hollows dug into the ground). After being formed, the vessels were probably covered by embers or coals in order to protect them from damaging thermal shocks. This firing and covering process caused an oxidation reaction, creating the recognizable reddish hue of the briquetage sherds and leading to their common epithet of *olle d'impasto rossicce* ("reddish impasto pots"). The vessels made this way were typically crude in design and quality, being most often of the class of non-depurated pottery called "impasto ware," though lightly decorated examples have been found at some Central Italian sites. The vessels varied greatly in size between sites – they could hold as little as one litre of brine, or as much as 20 litres.[92] The shape varies as well (Fig 1.a-c) – there seems to have been little regard at the salt production sites for the efficiency of certain vessel shapes in evaporating brine.[93] Many vessels also notably include a ridge not only around the top of the vessel, but also several centimeters

[91] Cato, *De Agricultura*, 88. This method is intended for an individual or family's supply/quantity of salt and would not have been efficient on a large or industrial scale.

[92] Volumes calculated by the author.

[93] C. Reusser, p. 5; C. Belardelli, p. 225. Vessels could be nearly spherical, completely conical, or even cubic/rectangular, with open or closed tops. Interestingly, where conic or rectangular vessels are more optimal for evaporation because of their high surface area to volume ratio, a sphere is, for this exact reason, the least efficient shape to use. Despite this, vessels with spherical components appear to be among the most popular shapes, perhaps for their general ease of fabrication.

below the top (Fig. 1.a,b.), the exact function of which has not been identified in any current scholarship. This sort of feature does not typically appear on household or artistic pottery in Central Italy and thus was probably a functional choice, especially given that the vessels would be broken by the end of the briquetage process. The ridges may have served to strengthen the vessels, preventing premature breakage during the firing process. Alternatively, they could have been used to facilitate the removal of the vessels from kilns after firing, allowing easier manipulation with tools.

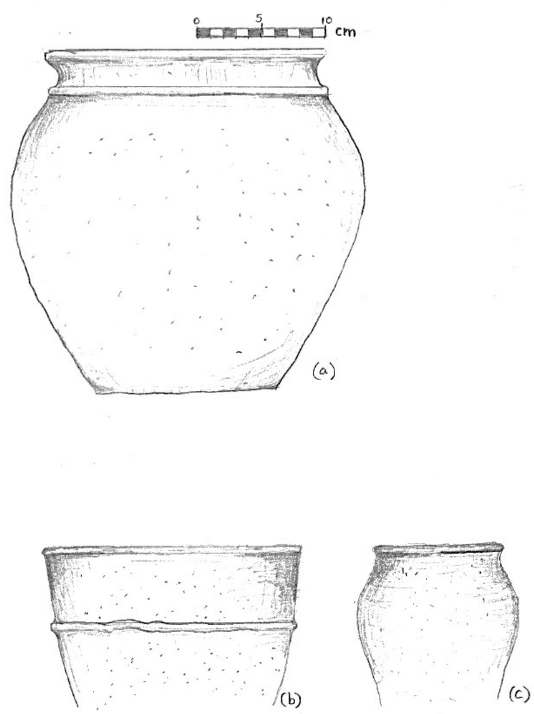

Fig. 1: Briquetage Vessel Shapes

(a): Vessel shape typical north of the Tiber (from Belardelli 2024, p. 225).

(b), (c): Open and closed vessel shapes, present at Caprolace Settlement (west of the Pontine Plain; from Alessandri *et al.*, "Salt or fish," 2019, pp.13-17).

Once the brine had reached a desired concentration, the clay vessels were propped up on ceramic stands[94] and filled with the prepared brine (see Figure 2 for examples of ceramic stands). The kilns would once again be fired, and this time would be stoked continuously until common salt began to precipitate. This stage of the process would likely have taken at least four hours.[95] As the volume of water on the vessels was slowly reduced, they may have been topped up with additional enriched brine. This would allow for a larger salt cake at the end of the process and would reduce the number of disposable vessels needed to create any given weight of salt. Eventually, with all liquid evaporated, the clay vessels would hold a solid cake of salt. Despite most bitterns being removed from the brine through the earlier decantation, some highly bitter and highly soluble compounds, especially including Mg^{2+} and K^{+} based salts, were not eliminated during the process. It is assumed that no additional steps were taken to remove these salts during the initial production phase, especially considering the process of salt "bleaching" provided by Cato the Elder, which seems to be designed specifically to remove these final bitterns.

[94] Cf. F. Bulian *et al.*, "Bronze Age to Roman Period Salt Production," p. 18.

[95] R. M. Salibay, M. Delos Santos, "Exploring the Pedagogy and Cultural Manifestations of Asin Tibuok," *International Journal of Education, Humanities and Social Science* 3 no. 2 (2020), pp. 111-122. In Bohol, in the Philippines, a method similar to briquetage is used in which salt is boiled in clay vessels known as salt-pots. These are typically very small, with capacities of no more than one or two litres. The shape of these vessels is roughly spherical, with a flanged neck creating an opening of about two-thirds of the vessel's width – a form similar to many Central Italian sites. In this process, it takes around four to six hours of continuous boiling, with new brine added throughout the process, to form a solid and dried salt cake in the pots. While there are differences between this method and Central Italian briquetage, the amount of time required for the boiling of brine is likely similar.
The experiments of Tencariù *et al.* are not helpful here, as for that experiment, large quantities of brine were pre-boiled to concentrate the brine into a sludge prior to being added to recreated briquetage vessels.

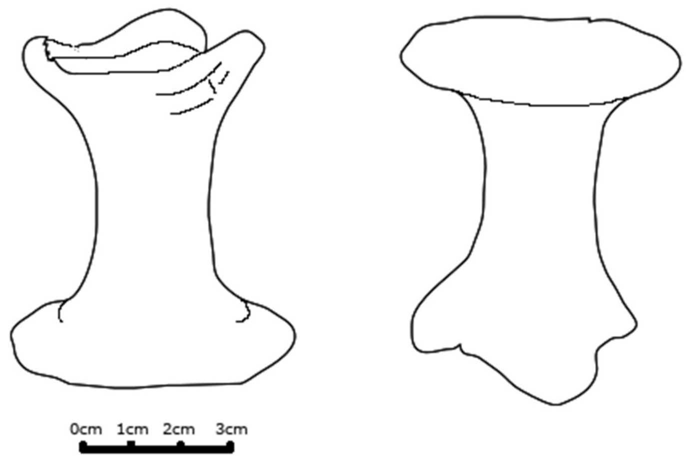

Figure 2: Ceramic Stand for the Support of Briquetage Vessels

This pedestal modelled after those depicted in Alessandri *et al,* 2019.

As one of the final stages in the *chaîne opératoire*, the salt cake needed to be extracted from the clay vessels. The hardened lumps of salt tended to stick to the sides of the ceramic containers, and the process of being in contact with boiling brine allowed ions of sodium and chlorine to infiltrate the impasto ware and expand its pottery matrix, weakening its structure and rendering it more brittle.[96] Thus, the most efficient method to extract a salt cake was typically to break the now-fragile clay vessel. These were not haphazardly smashed – excessive force could damage the salt cake or fill the salt with shards of clay, so some degree of caution was necessary. Experiments by Tencariù found that the most effective technique for preserving a salt cake during its extraction was to carefully split the clay vessels using cold water and a hammer while the

[96] A. Horiuchi *et al.,* p. 2949.

vessels were still hot.[97] Additionally, during the initial efforts to create salt cakes in these experiments, researchers were seldom able to extract an undamaged salt cake by breaking vessels, finding that clumps of salt would cling to the ceramics' interior surfaces and cause the final product to break apart. To mitigate this, they used different combinations of linings, including slip smoothed by a professional potter, large leaves from local flora, and animal fats. The most reliable insulating layers were composed of both leaves and animal fat in combination, although the professionally smoothed vessel also resulted in a relatively seamless extraction.[98] At Spina, an Etruscan settlement at the ancient mouth of the River Po, a Hellenistic Period building believed to be a briquetage salt production site was excavated, with many reddish impasto shards characteristic of briquetage sites were found. Traces of plant fibres appeared in tests performed on some of the pottery fragments, and on others, a smooth slip lining was evident.[99] This corroborates Tencariù's theory that a plant-based or slip lining could have been used to facilitate the process of extracting the finished salt cake.

An interesting note on the briquetage process comes from Pliny's *Historia Naturalis,* where the encyclopedic historian provides his readers with a description of two methods by which salt can be extracted when it is not mined – desiccation and condensation.[100] While modern science is able to recognize these two processes as essentially identical, being manifestations of complete and incomplete evaporation, respectively, Pliny lacked the understanding of the physical processes that make this the case. Imperfect evaporation (condensation, to Pliny) involves the evaporation of a liquid solvent just to the point where the solute begins to precipitate. At this point, the

[97] F. Tencariù *et al.*, p. 124.

[98] *ibid.*

[99] C. Reusser, p. 5.

[100] Pliny, *Naturalis Historia*, 31.39

precipitated solids can be extracted and dried. Perfect evaporation (or "desiccation," to Pliny) rather relies on the total evaporation of a solvent until the solute is fully dried, a process that neatly describes salt production by briquetage. As will be discussed later in this work, incomplete evaporation likewise describes another form of salt production.

The amount of energy required to evaporate pure seawater is immense, and hand-stoked fires even on a large scale are not close to producing heat nearly as sustainably or efficiently as the Sun. This makes the evaporation of pure seawater over a fire an inefficient process, something that Italians of the Bronze and Iron Ages certainly recognized. The process required large amounts of fuel, a variety of skilled and unskilled work, and massive amounts of manual labour. It was also limited to seasonal operation, as during wet seasons the salt concentrations in sea- and lagoon water were reduced, and salty sediments did not have the opportunity to form in coastal lagoons. However, briquetage was a method of salt production that was feasible in a broader range of geographical areas than other methods, making it the production method of choice from the Early Bronze Age until at least the Early Iron Age. The process would continue to see use, albeit in a greatly reduced capacity, until at least the 4th century BCE with solar salterns becoming the predominant source of salt from no later than the Orientalizing Period. The continued use of briquetage sites even in the presence of vastly more efficient extraction methods could be attributed to a number of factors, will which be discussed later in this work.

Geographically, most known briquetage sites were located within a very short distance (under a few kilometers) of a shoreline or a coastal lagoon. Some exceptions certainly did exist – the site of La Cotarda is one such example.[101] It is not entirely clear how these sites were able to

[101] L. Alessandri *et al.*, "Bronze and Iron Age Salt Production," p. 29.

access large amounts of brine. There is little or no evidence at the sites for salt springs, but the sites do lie on fluvial routes, meaning that transportation of brine by boat was a possibility. Some Andean people groups transport saltwater from springs to salt flats over long distances by using buckets and yokes, an activity still occurring in the 21st century CE. While this is an ethnographically different region of the world, this is still a testament to the fact that human labour could have allowed for the mass transportation of brines by hand. The site at La Cotarda also notably lacks leaching pits, kilns, hearths, or sediment deposits that could assist in the positive identification of this location as a briquetage site. Arguments have been put forward that, because of their distance from sources of saltwater and their lack of a "complete" briquetage fingerprint, the inland sites and some others were not for salt processing, but rather fish processing or fish sauce (*garum*) production.[102] However, what these arguments fail to properly explain is the presence of large quantities of characteristic reddish impasto sherds. While some such fragments would certainly be present due to the accidental breakage of clay vessels, larger deposits cannot be addressed by this theory alone. If these sites did not produce salt, it is perhaps possible that they imported salt for fish processing or other processes of any industry without the salt having been removed from its original evaporation vessels, choosing to break the vessels and extract salt cakes on arrival. This method would parallel the common modern manner of selling artisan salt in Bohol, in which evaporation pots are only partially broken and largely left attached to the salt cake.

Briquetage occurred at a large number of sites across Italy. A list of sites using briquetage to produce salt within and outside of Central Italy, which were considered in this project (based on lists from Bulian *et al.* and Alessandri *et al.*, and some other individual sites), can be found in Table 2, below. Briquetage also occurred at the sites of Portiglioni (near Puntone Nuovo), Poggio

[102] L. Alessandri *et al.*, "Salt or Fish," p. 5.

Carpineta (near the mouth of the Ombrone River), and Naples (near the present-day Duomo di Napoli). The site of La Cotarda has been included in this table despite a lack of definitive dating for its full range of operations due to its clear *terminus post quem* of the Orientalizing period.

Site	**Dates Active**
1. Chiavari	FBA
2. Isola di Coltano	EBA-FBA
3. Padule di Stagno	EIA-Arch.
4. Galafone	EIA-Ori.
5. Riva Degli Etruschi	FBA-EIA
6. Poggio Del Molino	LBA-FBA
7. La Torraccia	FBA-EIA
8. Baratti	FBA-EIA
9. Torre Mozza	FBA-Ori.
10. Puntone Nuovo - Groningen Excavation	EIA-Hell.
11. P. N. – Le Chiarine	FBA
12. P. N. – Campo da Gioco	EIA
13. P. N. – Meleta	LBA-Arch.
14. P. N. – Fiumara	MBA-EIA
15. P. N. – Fosso Del Fico	FBA-EIA
16. Portiglioni – C.G.	FBA-EIA
17. Tombolello	FBA-EIA
18. Casa San Giuseppe	EIA
19. Punta Degli Stretti	FBA-EIA
20. Poggio Pertuso	EIA-Arch.
21. Duna Feniglia	FBA-EIA
22. Fontanile delle Serpi	LBA
23. Le Saline di Tarquinia	EIA
24. Bagni Sant'Agostino	EIA
25. La Frasca	EIA
26. Acque Fresche	FBA-EIA
27. Torre Valdaliga	FBA-EIA
28. La Mattonara	EIA
29. Punta del Pecoraro	EIA
30. Malpasso	EIA
31. Marangone	EIA
32. Torre Chiaruccia	FBA-EIA
33. Colonia dei Calabresi	EIA
34. Quartaccia	FBA-EIA
35. Grottini	EIA
36. Greppa della Macchiozza	FBA
37. Piscina Torta	Ori.-Arch.
38. Cretarossa/Nettuno	Ori.
39. Le Grottacce	FBA
40. Pelliccione	FBA
41. Saracca	LBA
42. Area Stop 4	LBA-EIA
43. La Fibbia	EIA
44. Fosso Moscarello	FBA
45. Caprolace	MBA-LBA
46. Castelliere di Elleri	LBA
47. Spina	Hell.
48. Valle del Mezzano	MBA-EIA
49. Podere Boccagrande	LBA-EIA
50. Torre San Marco	FBA
51. La Cotarda	After Orientalizing, but unclear date.
52. Cupra Marittima**	Arch.

Table 2: Briquetage Sites Included in this Study

**This site is included, despite no evidence of briquetage salt production activities, on the basis of several ceramic and copper/bronze votive deposits that closely resemble briquetage equipment. This is considered by Càssola-Guida to be evidence for a nearby production site, which has not yet been discovered or precisely located (Càssola-Guida, 2016)

Figure 3, below, depicts the sites listed above on a map of Italy.

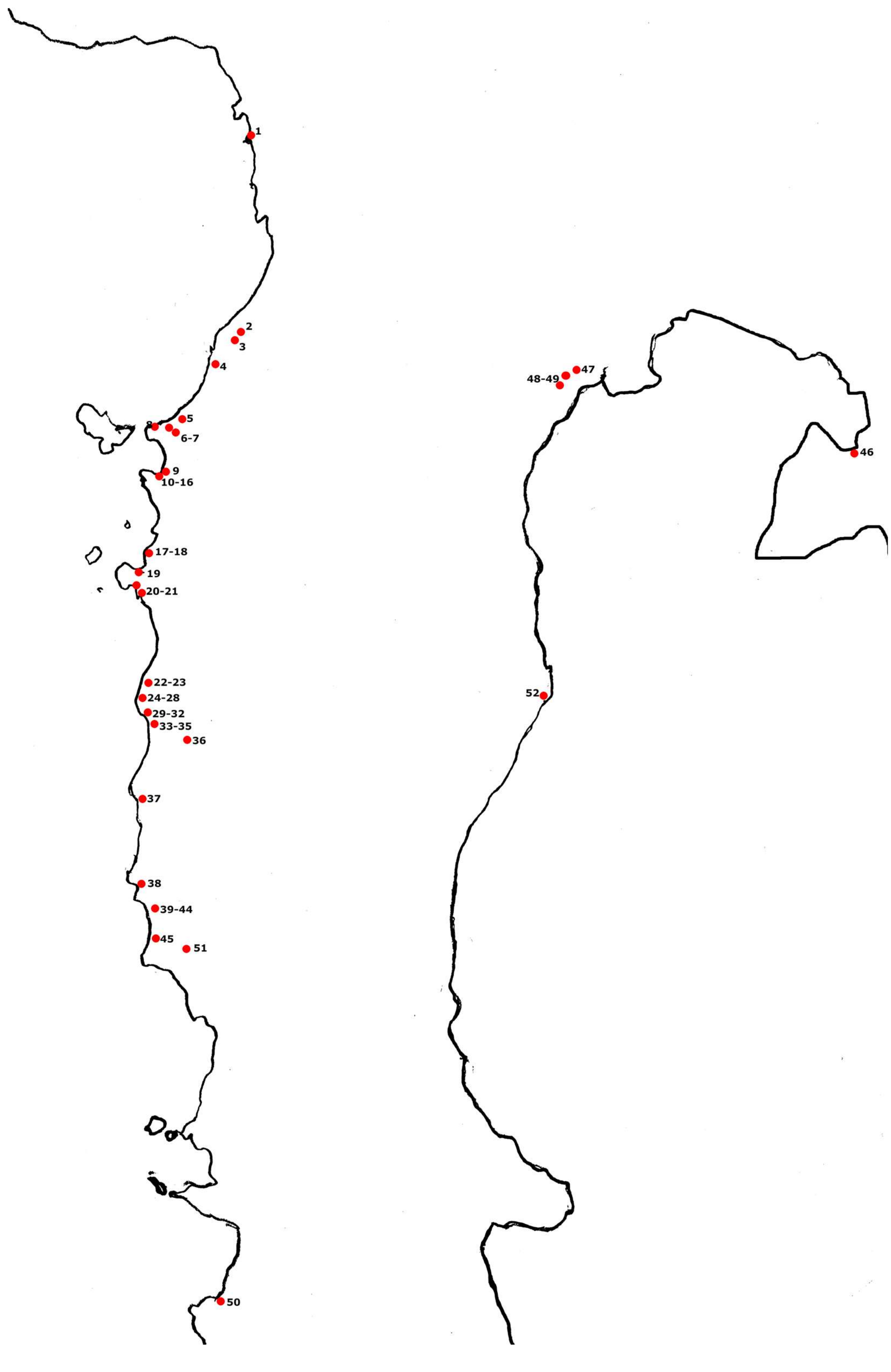

Figure 3: Sites from Table 2, Mapped

Salt Production – Salterns

If briquetage was a salt production method with limited production capacity but some flexibility in its environment and climatic conditions, solar salterns (or *salinae*) are just the opposite – production complexes that rely on specific climates and ideal landscapes, but that make up for this with their massive production capacities. Solar salterns rely on the power of the Sun to evaporate brine in large, shallow basins, gradually increasing its salinity until common salt can be extracted.

The earliest evidence for salinae of this kind in Central Italy is literary – a discussion of salt flats occurs in several ancient authors such as Pliny, Livy, Plutarch, and Dionysius of Halicarnassus. All of these authors mention salterns at the mouth of the Tiber. While in each case the authors are discussing these works centuries after their supposed construction, the fact that the salterns exist in so many ancient sources is a testament to the veracity of the authors' claims. The authors place the construction of these works in the Orientalizing or Archaic Periods, attributing them to Romulus, Ancus Marcius, or the Veientes.

Once again in direct contrast to briquetage, solar salterns (especially in the earliest phases of their development as a system of salt production) leave relatively little archaeological evidence to be discovered by modern excavations. This is due in large part to the volatile nature of coastal environments. A 2011 project by Vincenzo Amato, Pietro Aucelli, Simone Da Prato, and Luciano Farraro examined costal environments in the Poseidonia/Paestum archaeological area, aiming to describe the natural and anthropic history of the region's landscapes. The project found that over the course of even just a few decades, the nature of the local coastlines could change dramatically, as fluvial sediments fanned out from the Sele riverbed and enlarged the shore area while sea currents drove other sediments towards the shore.[103] Likewise, Federico Di Rita, Alessandra Celant, and Donatella Magri found that the Stagno di Maccarese lagoon at Ostia (a site with archaeological evidence for the foundation of salt works by no later than the early Roman Imperial Periods) did not even exist as a salt water lagoon until sometime between the tenth and ninth centuries BCE, when the nearby dune system collapsed and allowed the intrusion of seawater into what had previously been a freshwater marsh.[104] It is likely that this site was not a feasible location for a solar saltern until this major change to the landscape, which appears to have occurred naturally. The collapse of the dune systems at that location occurred at around the same time that briquetage sites began to decline in popularity in Central Italy. This environmental change could have been an inciting incident for the development of salterns at the mouth of the Tiber, and with this, the wars that ensued between early Rome and Veii. The idea of a volatile coastline is also noted by Strabo, who asserts that while the settlement of Spina had once been located by the seaside, it had moved a distance inland (the modern reader is left to assume that this is because of the deposition of fluvial sediments; one can only imagine how such an apparent migration of a whole settlement must have appeared to an ancient audience).[105] Finally, it is important to note that the sea level of the Mediterranean has increased by up to 80 centimetres since the dawn of the first millennium CE.[106] As the favoured landscapes for solar saltern development tended to be quite

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[103] Vincenzo Amato *et al.*, "Holocene Environmental evolution of the coastal sector in front of the *Poseidonia-Paestum* archaeological area (Sele plain, southern Italy)," *Rend. Fis. Acc. Lincei* (2012).

[104] F. Di Rita *et al.*, 51-67. This is generally interpreted as a natural event that sparked the exploitation of the area for salt. The idea has been suggested that the collapse of the dune system was a deliberate action to create a usable saltern; however, claims such as this have no basis in any archaeological or literary evidence.

[105] Strabo, *Geographica*, 5.1.7.

[106] P. Bellotti *et al.*, "The Tiber River delta plain (Central Italy): Coastal evolution and implications for the ancient Ostia Roman Settlement," *The Holocene* 21 no. 7 (2011): 1110.

flat, water level increases of this magnitude can completely cover such a site and obscure it with seaborne sediments, complicating its identification and excavation.

Where solar salterns excelled relative to briquetage sites was in their ability to output much higher quantities of salt in an operational season. During the briquetage process, many phases of the *chaîne opératoire* needed to take place in close proximity to one another – pottery had to be cheaply and quickly thrown/moulded and fired, brine needed to be leached over pits using sieves, empty vessels needed to be filled with brine, and filled vessels needed to be boiled and topped up. This resulted in any given area of land devoted to salt production being used relatively inefficiently, with only a small portion of the area actually producing salt. Salterns could make more efficient use of the same amount of space. Once the infrastructure of a saltern was in constructed, the entire surface area of the saltern could be devoted to the evaporation process, as fuel, kilns, pottery and leaching stations could be eliminated from the salt production process. This efficiency is also a contributing factor to the very limited archaeological fingerprint of these sites – in eliminating many processes related to salt production, salterns also eliminated the traces that these phases left behind, such as sediment deposits, leaching pits, pottery shards, and kilns.

Examples of late Republican Roman solar salterns do certainly survive in the archaeological record; these, however, rarely date to earlier than the second century BCE and are more commonly found outside of Italy.[107] Salterns from later periods in history can still provide invaluable insights into the operation of earlier sites. In modern Spain, salterns along the coast just

[107] J. Castro Carrera, "Architecture, construction system and functioning of the roman saltworks of O Areal (Vigo-Galicia-Spain). A reference in the investigation of salt production in the roman world," *Quaternary Science Reviews* 339 (2024): 1. While some salterns were certainly operated in Italy, others existed in Spain, Portugal, Croatia, France and Turkey.

north of the border with Portugal have been excavated that were lined with stone or concrete pavements, providing a more permanent archaeological record to analyze and helping scholars to reconstruct the salt production process. These salterns were constructed and operated during Roman imperial rule (likely around the 1^{st} to 3^{rd} centuries CE) and were possibly reiterations of or improvements on salterns that already existed in Italy or elsewhere in the Empire.

It is not unreasonable to assume that the hydraulic systems in use in Roman Spain would have paralleled those in use in Central Italy. A first-century CE saltern, probably constructed about the same time as the saltworks at O Areal, was excavated at the Stagno di Maccarese, with channels constructed from wood, clay, earth, and over 1400 cut amphorae.[108] While this site has marked differences to those excavated at O Areal/Vigo in terms of size and preferred construction materials, there are enough similarities to determine that the general functioning of the system was the same, and it likely produced a refined salt (see figure 4, below, for a general layout of the Stagno di Maccarese saltern and its functioning, based on drawings and descriptions by Grossi *et al*). The ~156-hectare site at the Stagno di Maccarese stands out among salterns for its use of about 1400 amphorae as the base of its berms or walkways, which would have been covered with earth to create watertight barriers for at least four major evaporation basins. Additional channels for the management of water flow indicate there were likely more basins, though the number of additional basins cannot be determined based on the completed excavations at the site. The suspected individual basins are also considerably larger than each basin at the O Areal saltworks, and feature silt or clay linings where O Areal features stone or pebble pavements.

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[108] M. Grossi *et al.*, "A complex relationship between human and natural landscape: a multidisciplinary approach to the study of the Roman saltworks in 'Le Vignole-Interporto' (Maccarese, Fiumicino-Roma)," in R. Brigand and O. Weller (eds.), *Archaeology of Salt: Approaching an Invisible Past*. Sidestone Press, 2015, pp. 83-101.

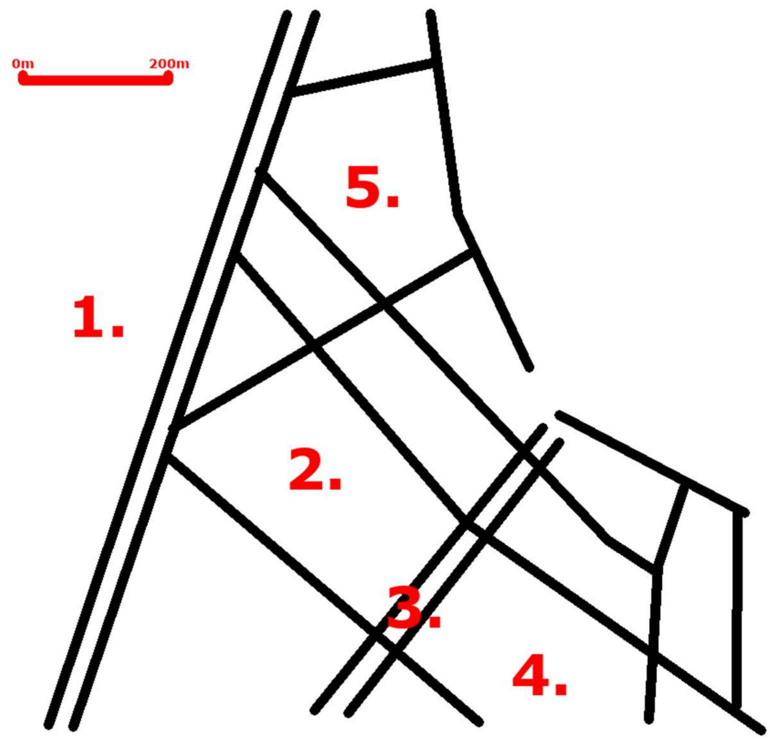

Figure 4: Layout and Functioning of the Stagno di Maccarese Saltern

(1) Amphorae wall/dam; (2) possible evaporation ponds; (3) possible channel for the inflow or decantation of brine; (4) possible additional evaporation ponds; (5) possible crystallization ponds.

It is likely that even prior to the introduction of stone linings or "permanent" features such as berms made from amphorae, environments with clay-rich soils were favoured for the construction of salterns as these soils were less conducive to the drainage of water from evaporating ponds. Salterns were also more likely to be constructed in coastal areas with ideal climactic conditions and flat landscapes that allowed for the (relatively) easy redirection of seawater into ponds. While massive workforces were able to transform landscapes during the Roman Imperial Period,[109] this kind of labour is never documented as having been applied to the

[109] Such as for the construction of Nero's *Domus Transitoria*.

flattening of coastal areas to construct salt pans. These exacting environmental conditions made the territory on which salterns could be built highly prized or valued, leading to their well-documented role as sites of contention for early Central Italian states.

Solar salterns, like briquetage, processed seawater in such a way that undesirable salts and carbonates were not included in the final product, which is a system well demonstrated at the Cabo de Gata Saltern in Spain, a site in use since Roman times that sees continued use in the present day as a salt-production site.[110] The first stages of a saltern's operation parallelled in this way the decantation stage of briquetage salt production but additionally combined this step with some evaporation or concentration of brine. In this first step, seawater was allowed to run into an initial set of evaporation pans. In these pans, the salinity of the seawater gradually increased over the course of several days, causing carbonates to precipitate. After sitting for a period of time, the brine was now somewhat more pure and much more concentrated, and sluice gates were opened which allowed it to flow through channels into another set of evaporating ponds in which the precipitated carbonates were allowed to dry before being swept from the first set of ponds. In the case of O Areal (Vigo), the stone pavement does not include any channels or sluice gates, which has led some scholars to believe that the water was moved manually, either by the use of buckets or a device such as an Archimedes' screw or waterwheel. Square or rectangular pits found in many salterns of the imperial period may have been used in this transportation process.[111] Archaeological remains do not yet allow for a definitive answer to this problem.

[110] For layouts and general diagrams, see E. López *et al.*, "Selection of ecological indicators for the conservation, management and monitoring of Mediterranean coastal salinas," *Environmental Monitoring and Assessment* 166 (2010): 241-256.

[111] J. C. Castro Carrera, p. 12. This work highlights multiple examples of these square or rectangular pits, each between 60 and 90 centimeters in both length and width, and between 20 and 30 centimeters in depth. The pits are

Now in a new set of evaporation ponds which would typically be slightly shallower than the previous ones in order to facilitate a more rapid evaporation, the brine was allowed to concentrate further until $MgSO_4$ began to precipitate. Once again, sluice gates were opened, water flowed from one set of ponds to the next via channels (or, again, could have been moved manually), and precipitates would have again been allowed to dry and subsequently removed from the saltern. This system of concentration and precipitation was most effective for the removal of salts such as sulfates (SO_4^{2-}) and carbonates (CO_3^{2-}) that have lower solubilities than common salt (NaCl). In order to remove salts with higher solubilities than common salt (especially those containing Cl^- and F^-), they must be removed while still dissolved in the brine.

With the lowest-solubility salts extracted from the brine, it would next be allowed to evaporate and concentrate until the precipitation of common salt began to occur. The salt could then be manually extracted using rakes and flat shovels while still wet. The extraction of the salt in this state would have allowed highly soluble bitterns to largely remain dissolved in the brine, creating a relatively "pure" salt that would not need to undergo a bleaching process like that presented by Cato. Once the common salt had been fully extracted, the bittern-rich brine could then be allowed to flow from the saltern back into the original source (i.e., the sea or a lagoon) or may have been allowed to evaporate fully in another set of ponds, with the precipitated salts swept away and disposed of as with the carbonates and sulfates. Piles of wet salt were either pushed onto berms between ponds to dry fully in the sun, or it would have been collected in wicker baskets and set aside in a sunny place for the same purpose.

made of stone slabs (typically schist), with pavements of clay and gravel nearly identical to those in many evaporation ponds. See also Currás Rejofos, 2017, p. 344.

The extraction of the common salt itself is a phase that may have varied either by location or by time period – some literary sources attest that in the final stages of salt production, the brine would be left in its evaporation ponds until all liquid had evaporated.[112] While this would have created a salt with bitterns still included, it would save some (though little) manual labour and would mean that a drain/channel system would not necessarily need to be installed in the last set of ponds, slightly reducing the amount of infrastructure (and thus, construction labour) required for the operation of the saltern. However, other literary sources also tell that the salt was extracted wet.[113] The extraction of salt in this (wet) form parallels Pliny's description of salt extraction by the condensation (i.e., imperfect/incomplete evaporation) of a brine. Pliny also tells that during the operation of a saltern, fresh water must be used as well as brine.[114] It is possible that fresh water was fed into the final evaporating ponds in order to rinse the remaining highly soluble bitterns from a nearly refined sea salt. In any case, the refined product produced by solar salterns, while identical in usefulness to that produced via briquetage, was certainly different in form and appearance as it would not have developed into hardened cakes.

Briquetage produced solid blocks, bars, or cakes of salt, with smoky or ashy residues often present as a result of the firing process.[115] These would have been relatively easy to transport, packed into crates or loaded directly into carts. The salt produced by solar salterns, however, was much more comparable to sea salt one might expect to find in a modern supermarket – piles of loose coarse or fine crystals, partially bleached by the sun. No smoky residues or major discolourations would have been present at most salterns. While this salt may have looked more

[112] Rutilius Namatianus, *De Reditu Suo*, 470-484.

[113] Pliny, *Naturalis Historia*, 31.39.

[114] Pliny, *Naturalis Historia*, 31.39.6.

[115] F. Tencariù *et al.*, p. 128.

appealing to many consumers, its transportation would have required the use of baskets, sacks, or barrels, mildly complicating the export of the substance.

Summary

The different methods of salt production employed in Central Italy from the Bronze Age onwards had different advantages and disadvantages, and different settings in which they could be employed most effectively. Table 3, below, is intended to serve as a summary of all the aforementioned methods of salt production known to have been employed in Central Italy and their benefits and drawbacks.

Production Method	**Halophyte Plant Burning**	**Mining**	**Briquetage**	**Solar Salterns**
Frequency of Use	Low	Low	High from MBA-EIA, otherwise moderate to low	High from the Orientalizing or Archaic Periods onwards
Environmental Requirements	Salty Soils (common in Central Italy)	Salt deposits (very rare in Central Italy)	Lagoons or Coastal sites	Hot weather, light breezes, dry seasons, clay-rich soils, flat landscapes
Infrastructure requirements (or cost)	None-low	Moderate-High	Moderate	High
Skilled Labour Requirements	Low	Low-Moderate	High	Low-moderate
Production Capacity	Very low	High	Low-moderate	Very high
Refined Product?	Sometimes	Sometimes	Yes (Partially)	Yes
Archaeological remains	None	Mining tools or mine shafts (not extant in central Italy)	Reddish pottery sherds, kilns, clay-lined pits, sediment deposits.	Channels, sluices, ponds, pavements; dependent on the environment and construction materials
Literary references	Yes	None in Central Italy; Yes elsewhere	Yes (likely)	Yes

Table 3: Overview of Salt Production Methods in Central Italy

Chapter 5: Analysis

Different methods of salt production were popular at different periods in time in Central Italy. In the Middle and Late Bronze Ages, briquetage was the most common method known to be used for the production of salt. By the Early Iron Age, at least 34 sites in Central Italy were actively producing salt via briquetage on a large enough scale to leave behind a significant archaeological record.[116]

Early in Central Italian history, communities, especially those located along the Tyrrhenian coast, may not have needed access to large amounts of processed and refined salt for survival. These communities consumed enough salt to meet their biological needs by relying on maritime diets rich in fish and seafood.[117] Small amounts of salt needed for seasoning or even for small batches of preserved meats or vegetables could be collected from naturally evaporated salt that crystallized along rocky sections of the coastline. This particular technique for the gathering of salt was employed by peasants in Crete until as late as the 19th century CE,[118] proving its viability for communities that lacked the need for large quantities of the substance. As communities grew, the demand for salt increased – higher populations meant larger herds of livestock (which needed salt for survival) and more consumption of prepared and preserved foods (which needed salt for their production). This increase in demand for salt is likely what led to the formation of specialized salt works. By the Final Bronze Age (c. 1150 BCE – 950 BCE), at least 27 sites along the Tyrrhenian coast employed briquetage for the production of salt. This

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[116] See Table 2 in Chapter 2.

[117] A. Varalli, J. Moggi-Cecchi, A. Moroni, G. Goude, "Dietary Variability During Bronze Age in Central Italy: First Results," *Int. J. Osteoarchaeology* 26 (2016): 439.

[118] C. Carusi, p. 483.

method was somewhat labour-intensive, but in areas with growing populations, there was also a growing supply of cheap labour to mitigate this.

Prior to the Bronze Age, Central Italian diets (while they certainly varied between regions) had largely consisted of seafood and meats, alongside small portions of vegetables and some grains.[119] By the Early or Middle Bronze Age, the introduction of hardier grains like millet to Central Italy led to an increase in the proportion of calories provided by plant products.[120] This continued to increase until, by the Roman Republican Period, between 70% and 80% of an average person's calorie intake was provided by bread or grains.[121] This may be due to the high yield and short growing season of millet, which thrives in hot climates and with less water than a comparable acreage of durum wheat, a grain which, based on Varro's descriptions, must have been already popular by the turn of the first century BCE.[122] While meats and fish already naturally contain a considerable amount of salt, grains and vegetables typically do not. Salt would instead be added to bread dough or to cooked grains for flavour, meaning that there had to be a ready supply of salt for the preparation of bread and meal. Beginning from at least the Neolithic, some Central Italian diets also included protein from cheeses, evidenced by the persistence of lactase in early genetics and the presence of milk processing tools.[123] The consumption of cheeses continued to increase through the Bronze Age. Just as salt was required

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[119] A. Varalli *et al.*, 442.

[120] *ibid.*

[121] N. Rosenstein, "Agriculture, Roman Republic," in R. Bagnall *et al* (eds.), *The Encyclopedia of Ancient History*. Blackwell Publishing Ltd.: 2013. 222-224.

[122] Varro, *De Re Rustica* 48.1-3.

[123] T. Di Fraia, "Colatoi, bollitoi e altri accessori fittili per la lavorazione del latte: possibiliinterpretazioni e relative implicazioni socioeconomiche e culturali" (paper presented at 50ª Riunione Scientifica dell'Istituto Italiano di Preistoria e Protostoria, Roma, Ottobre 2015), 503.

for the production of bread or grain-based foods, so too was it required for the production and preservation of cheeses.

As a result of population growth and major dietary changes, the number of known salt production sites using briquetage increased from just 4 in the Middle Bronze Age, to at least 11 by the Late Bronze Age, and at least 27 in the Final Bronze Age. As the Central Italian population continued to grow, the total number of active sites reached its peak in the Early Iron Age, with at least 34 sites active.[124] The total number of active briquetage sites active in Central Italy may have been higher than what is presented in this project as a result of unpreserved or unexcavated sites, but the overall trends in briquetage production by era would likely remain the same – increasing populations logically must have required increased quantities of salt.

The production capacity of an *atelier de briquetage* is not standard, and is affected by factors such as climate, length of production seasons, size of site, number of workers available, temperature of the fires, concentration of the brine, availability of fuel, and the degree of refinement each site sought to attain.[125] It is also difficult to accurately estimate the production capacity of any given briquetage site given the wide range of vessel sizes and shapes[126] and the possibility of firing virtually any number of batches of salt during the production season. Thus, the number of briquetage sites needed to produce salt for a specific population can also not yet be accurately estimated. Further archaeological experiments similar to those of Tencariù could prove invaluable here in combination with archaeological data to determine how many hours were required per batch of salt at any Central Italian site and how many batches could have been

[124] See Ch. 2, Tab. 2 for a list of sites.

[125] Tencariù *et al.*, pp. 129-130.

[126] See Ch. 2, Fig. 1 for vessel shapes.

produced in a season. This data would help to establish whether there is an explicit connection between briquetage sites and their closest settlements.

What is quite clear, however, even in the absence of this data, is that a well-constructed solar saltern must have had a significantly higher production capacity than a briquetage site, in addition to requiring less manual labour. The initial large evaporation ponds at the Stagno di Maccarese saltworks had a potential capacity of over 4 million litres, which could potentially evaporate to form up to 144,000 kg of solid salts.[127] Based on the experiments of Tencariù, individual salt cakes produced by briquetage may have been under a single kilogram each in many cases,[128] which would mean that a briquetage site would have had to craft, fire, fill, and shatter hundreds of thousands of clay vessels to achieve a similar production capacity – a feat that is certainly not recorded in any archaeological or literary source.

While the climatic and geographic conditions for a large solar saltern are certainly stricter, one well-managed solar saltern could replace many briquetage sites. This becomes evident in an analysis of salt production in the Orientalizing Period, when the first solar salterns in Central Italy may have been founded at the mouth of the Tiber River, coinciding with a decline in the frequency of briquetage sites. This decline would lead to the technique's disappearance by the Roman Imperial Period, along with the advent of other solar salterns at Valle del Mezzano and Cervia, likely among others.

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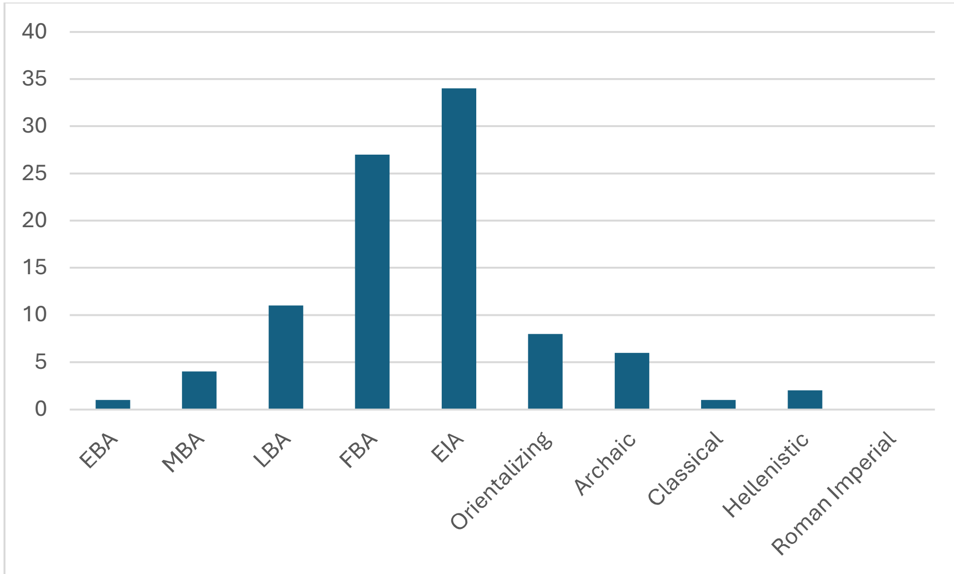
[127] Calculations based on the basin dimensions provided by Grossi *et al*.

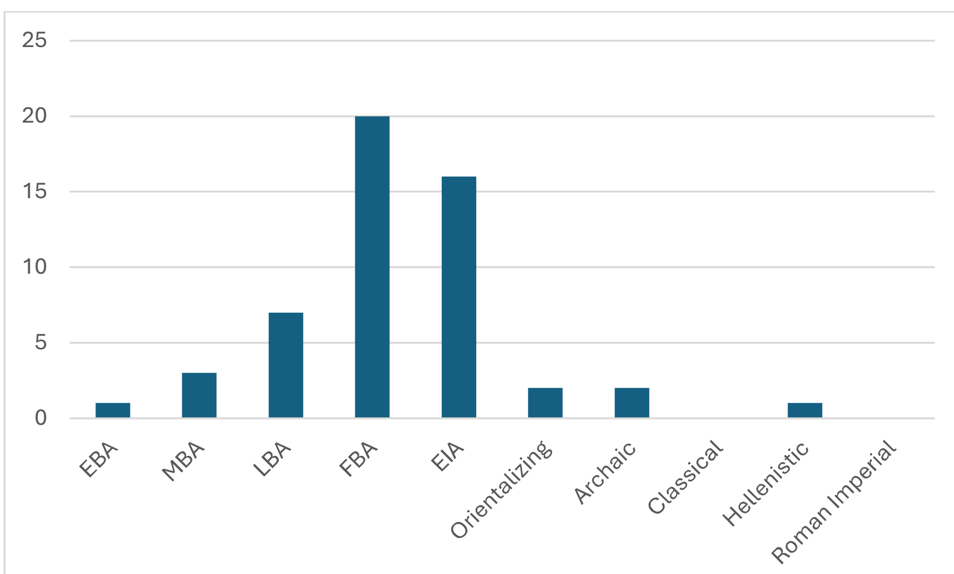
[128] F. Tencariù *et al.*, p. 125.

Data Visualization and Explanations

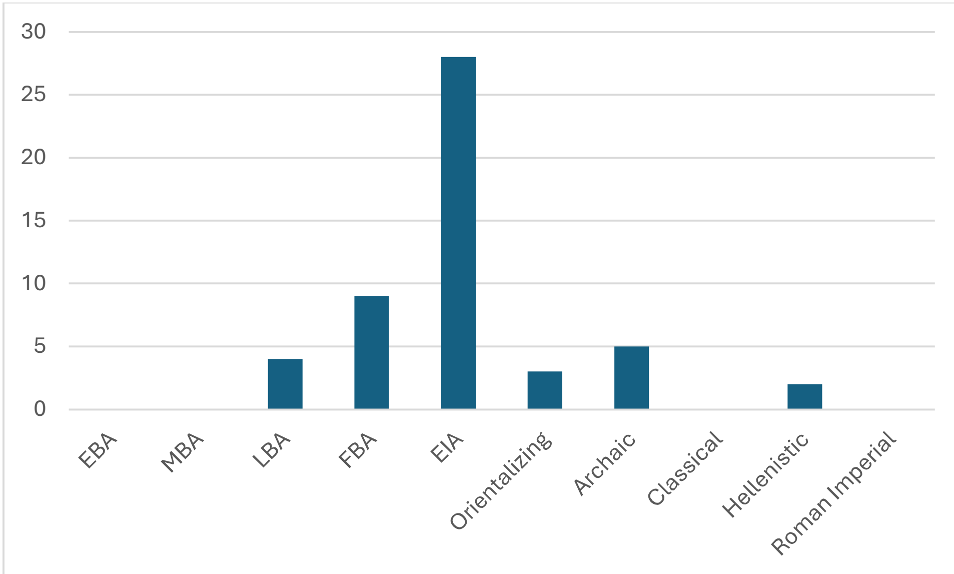
One method of reviewing data related to salt production sites that can help key information stand out is through data visualization. In this project, I have gathered and processed data from 55 briquetage sites, 51 of which were dateable, to include in a series of data visualizations. The dateable sites are all listed in Table 2 in Chapter 2 of this project. These visualizations will depict three representations relating to the operating dates of the briquetage sites. Graph 1 depicts the number of active briquetage sites (mostly in Central Italy) in each of the time periods outlined in the *Introduction* section of this work (Table 1). This provides a clear overview of the growth and decline of the briquetage method for producing salt in Central Italy. Graph 2 uses the same 51 sites and the same time periods as graph 1, but rather than depicting the total number of active sites in each time period depicts the number of sites to open in each period. Graph 3 similarly uses the same sites and time periods to show how many briquetage sites ceased their production after the depicted time period (i.e., the last period in which each site was active).



Graph 1: Total Active Briquetage Sites by Period



Graph 2: Sites Opened by Period



Graph 3: Sites Closed by Period

Each of the above graphs was made by compiling data largely from Bulian (2024) and Alessandri (2017), corroborated or adjusted by various additional works already cited in this project, for processing in Microsoft Excel. The site of La Cotarda was excluded from the visualizations due to unclear dating but is included in this analysis overall because of a number of unique features that will be addressed later in this chapter.

The overview of active briquetage sites in Graph 1 reveals a simple set of trends: from the Early Bronze Age until the Early Iron Age, the number of active briquetage sites in Central Italy continued to grow, from just a single identified site in the EBA to 34 active sites at the peak in the EIA. The increase appears to parallel a generic model for exponential population growth until the EIA, at which point the rate of growth slows somewhat. By the Orientalizing period, the number of identified active briquetage sites had decreased to just eight; by the Archaic Period, six; and by the Roman Imperial Period, down at last to zero. Graph 2 is an excellent demonstrator here of growth rates for the Central Italian briquetage industry as a whole. An increase in growth rate is shown here from the EBA (1 known briquetage site opened) to its peak in the FBA (20 known sites opened), and while the increase in the number of active sites in the EIA is still positive (16 known sites opened), it is markedly lower than the FBA. No new sites were opened in the Classical Period; one was opened in the Hellenistic Period (at Spina); and none were opened during the Roman Imperial Period.

Where Graph 1 is certainly the best overall indicator of the "health" of the Central Italian briquetage industry, perhaps the most revealing is Graph 3. Graph 3 clearly demonstrates the number of known briquetage sites to close in each historical period, illustrating this salt production method's decline. Operations were prone to move or close as they ran out of resources, changed owners, or lost their connections to major settlements. This sort of closure is likely what is depicted in the columns for the LBA and FBA on Graph 3, with ~35% of active sites in each of these periods closing in that period as well. This changes suddenly in the Early Iron Age, which marks the final period of production for 28 known briquetage sites that had been active up until that point. This is roughly an 82% closure rate – significantly higher than that demonstrated for the LBA and FBA. The mass closure of briquetage sites in this period must be addressed and will be covered later in this same section. Only eight briquetage sites remained active during the Orientalizing Period, with three of them closing by the end of this period; of the six still remaining by the Archaic, five ceased operations before the beginning of the Classical Period. Only the site at the Groningen University Excavation section of Puntone Nuovo appears to have remained active through the Classical period, and it stayed open until as late as the

Hellenistic period,[129] during which a second site opened and subsequently closed at Spina, an Etruscan site near the mouth of the Po.

Analyzing the data presented in Graphs 1, 2 and 3

The increase in the number of active briquetage sites from the EBA until the EIA likely reflects an increase in the population of Central Italy. During the Neolithic period, settlements tended to be temporary and focused on hunting, fishing and gathering, as well as the raising of livestock. Horticulture occurred only on a small scale in the form of small seasonal gardens and did not involve the mass clearing of land. Because of this lifestyle, communities were able to move from one site to the next with relative ease, staying only for as long as the area could support them with its natural resources. As populations naturally grew over time, the process of moving villages became more complex, and an area could support a community for a shorter time due to an increased strain on the area's resources. As such, larger-scale agriculture, including grain horticulture, became dominant during the Early Bronze Age or as late as the Middle Bronze Age. Larger fields and more agriculture meant a stronger commitment to a specific area and resulted in more permanent settlements. The advent of larger-scale agriculture in Central Italy also allowed farming operations to push beyond subsistence and start storing surplus harvests, which could then be exported to developing urban centres and allow some people to focus on crafts or trades other than agriculture.

With an increased Central Italian population and a concentration of people into larger population centres also came a need for increased salt consumption – no longer could

[129] J. Sevink *et al.*, "Protohistoric Briquetage at Puntone (Tuscany, Italy): principles and processes of an industry based on the leaching of saline lagoonal sediments," p. 68.

communities hunt, fish, and farm for themselves, but they now relied on agricultural imports into cities to sustain their populations. Food in cities could also not always be imported fresh, especially when those cities were further inland than other coastal settlements or lacked access to major waterways. This meant that preserved foods such as pickled vegetables, milled and unmilled grains, salted meats and fish, and fish sauce, which all had extended shelf lives compared to their "fresh" equivalents, were required for the sustenance of large populations. All of these products, except for grains, required salt for their production; grains, on the other hand, would be mixed with salt and seasonings when they were prepared for consumption (i.e., at a bakery or in the kitchen). This would have compounded the increased demand for salt that naturally followed a growing population, resulting in a very high demand for salt and thus an increase in the number of sites producing salt via briquetage.

While the exact production of a briquetage site has never yet been determined, it can be assumed that a specific number of active sites could serve a specific size of population, including their needs for preserved and salted goods, and that the relationship between population and salt production sites was linear. The archaeological fingerprint of a briquetage site remains fairly consistent from the EBA onwards, indicating that the technology changed little – if at all – during the centuries in which it saw use. The lack of change in briquetage technology is another indicator that the relationship between the number of active briquetage sites in an area and the population size in that area is a linear one. Because populations tend to grow exponentially, this linear relationship could explain the quasi-exponential growth in the number of active briquetage sites depicted in Graph 1 – if the population grew exponentially, then so should the number of active sites producing salt via briquetage. However, any apparent relationships between Central Italian populations and their salt-producing sites seem to disintegrate sometime in the Early Iron

Age. While there is no reason to suspect the population of Central Italy did not continue to grow exponentially, the growth in the number of known active briquetage sites fails to follow an exponential model in this period. It is apparent that some major change in populations, environments, or technologies occurred around this time that impacted the relationship between populations and briquetage sites.

Around the time this massive change in the number of briquetage sites occurred, another event, this time environmental, also occurred in Central Italy. Near a salt production site close to the mouth of the Tiber, the dune system separating the Stagno di Maccarese lagoon area from the Tyrrhenian sea collapsed, changing the lagoon's water from fresh to salty.[130] Archaeological evidence outlined in Chapter 2 shows that by no later than the first century CE, this site was in use as a solar saltern, though it may have seen earlier use.[131] Determining the period in which exploitation of the lagoon's salt water truly began is difficult, as little archaeological evidence prior to the Roman saltern is preserved. Remains of workstations from sometime in the Bronze Age show there was some degree of industrial activity in that period, which was most likely not connected to salt production, and sedimental and floral analyses reveal that at this time the area was a freshwater marsh with a small freshwater lagoon.[132] The dune collapse at Stagno di Maccarese occurred sometime after 910 BCE, and it is at this point that I propose the site began to first see use as a solar saltern, either by the Etruscans or Latins of the area.

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[130] C. Giraudi, "The sediments of the 'Stagno di Maccarese' marsh (Tiber River delta, central Italy): A late-Holocene record of natural and human-induced environmental changes," *The Holocene* 21 no. 8 (2011): 1237.

[131] M. Grossi *et al.*, pp. 83-98.

[132] F. Di Rita *et al.,* p. 64.

While there is not yet enough archaeological evidence alone to support this theory, the sudden availability of a new, shallow source of saltwater for evaporation, combined with a sudden seeming abandonment of the nearby briquetage saltworks, does suggest it is a strong possibility. As the site was previously used for some industrial or other non-domestic activity,[133] the development of the lagoon into an exploitable saltern would also not likely have displaced any permanent residents of the area. Some two centuries later, tell Livy,[134] Dionysius of Halicarnassus,[135] and Plutarch,[136] the Romans under the leadership of Romulus would defeat the Veientes and Fidenates and seize from them a portion of their territory north of the Tiber (the Stagno di Maccarese, notably, is just north of the Tiber). Dionysius and Plutarch record that the territory specifically included salt works near the mouth of the Tiber. It is not impossible that the literary references to "salt works" discuss sites at which briquetage occurred; however, given the relative commonality of these kinds of operations, the concession of them to the Romans would not have had any crippling effect on the Etruscans, who had been defeated. It stands to reason, then, that these salt works that were important to both Rome and Veii were rather solar salterns with high production capacities.

The combination of the literary evidence, the above analysis of briquetage site closures, and the environmental evidence of sudden connection to the sea all therefore point to the use of the area around the Stagno di Maccarese seeing use as a saltern sometime shortly after 910 BCE.

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[133] M. Grossi *et al.*, p. 90.

[134] Livy, *Ab Urbe Condita* 1.15.5.

[135] Dionysius of Halicarnassus, *Roman Antiquities* 2.55.5.

[136] Plutarch, *Romulus* 25.4.

With a new method of salt production seemingly available by the Early Iron Age, there would have been no reason for many briquetage sites to continue their operations. It is not likely that the Stagno di Maccarese saltern, which would become known to the Romans as the *Campus Salinarum*, was the only solar saltern active in this period in the area near the mouth of the Tiber. However, in the absence of adequate literary sources, environmental evidence, and completed analyses of other salt production methods, identifying and possibly dating such sites remains difficult or impossible.

The closure of briquetage sites further away from the *Campus Salinarum* may be an indicator of the development or expansion of a Central Italian salt trade. Fulminante and Alessandri address this concept in a 2024 article, highlighting that by no later than the Orientalizing Period, trade routes in Italy had shifted from coastal routes to those along the Tiber River Valley.[137] The authors write that this shift is likely representative of an increase in salt trade along the analyzed routes, and that it may be connected to the development of salterns at the mouth of the Tiber. This shift in trade routes is once again an indicator that even without much archaeological evidence, the salterns at the *Campus Salinarum* most likely were active by no later than this time. Trade networks both within and beyond Italy were very well established in Etruscan times and would only improve with the advent of Roman Republican and Imperial trade and communication networks.

The employment of briquetage to produce salt did still continue at some, though few, locations after the mass closures during the EIA and the introduction of new salterns. A small

[137] F. Fulminante, L. Alessandri, p. 13.

number of "outlier sites," including Nettuno/Cretarossa[138] and Piscina Torta[139] (both just south of the Tiber), La Cotarda[140] (southeast of the Pontine Plain) and Spina[141] (near Ferrara) did not even begin their operations until after this time. Both Nettuno and Piscina Torta were located in close proximity to the salterns at the *Campus Salinarum*, so their continued production was likely not intended to meet the needs of the early Latin or Roman populace. The opening of the sites at La Cotarda and Spina is easier to explain away if one assumes that they began salt production to meet the needs of local populations simply because of the distance between these sites and the *Campus Salinarum*. While this is an attractive possibility in isolation, it falls apart in the face of the existing evidence.

The site at Spina is unique among briquetage sites for a number of reasons. The first of these is its phase of occupation – the site opened by 300 BCE, and likely closed with the abandonment of the city in the mid-3rd century BCE.[142] Salterns in the same general region of Italy were in operation not long after this time, based on the research compilation of Bulian *et al.,* making it quite unlikely that this site's purpose was solely to provide salt to meet the basic needs of a local population. While many settlements in the same region of Italy were destroyed or abandoned with the arrival of the Celts during a large migration in the early 4th century BCE, Spina seems to have survived and may even have been a place of refuge for Etruscan peoples fleeing their own settlements.[143] Another unique aspect of Spina's briquetage site is its inclusion

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138 Bulian *et al.* p. 9.

139 Alessandri *et al.*, "Salt in Late Iron Age Italy," p. 9.

140 Alessandri *et al.*, "Bronze and Iron Age Salt Production," p.29.

141 Reusser, p. 1.

142 Strabo, *Geographica* 5.1.7.

143 Reusser, p. 1.

within the city limits. Where most briquetage sites were operated outside of, but nearby, major settlements, the site at Spina was constructed directly on top of the remains of a house that was deliberately and violently destroyed sometime in the third quarter of the 4th century BCE,[144] placing it clearly within the town's orthogonal street plan.

An additional element of Spina's briquetage that sets it apart from other sites is the shape of its vessels. Spina is the only known site at which evaporation vessels had a square or rectangular shape, similar to that of a trough. Rather than this pottery being coiled or thrown like at other sites,[145] the clay seems to have been flattened into five sheets, which were then attached to each other at the edges and bound with rope to keep the vessels intact until they were initially fired.[146] Impressions from this rope can be seen on a number of the briquetage shards excavated at the site. Like at other sites, the construction of the vessels was relatively crude, with finger impressions and variations in thickness notable on many vessels. The average size of the vessels from Spina has not been determined, as a non-curved fragment of pottery cannot reveal the size of its vessel in the same way as a curved fragment. It is likely, however, based on the large range of thicknesses for the pottery shards that they belonged to vessels in a range of sizes, and not uniform. The reason for the rectangular vessels may be connected to a loss of knowledge on the briquetage technique, as by the Hellenistic period, only one other known site made use of briquetage for the production of salt. This site is one of the subsections of the Puntone Nuovo

144 This destruction is evidenced by a layer of ash and burned material as well as a high concentration of terracotta sling bullets in portions of the house. The enemy that destroyed the house or the reason for its destruction have not been determined.

145 C. Belardelli, "Siti costieri villanoviani a nord di Roma (Italia): un paesaggio 'industriale' protostorico," *Cahiers d'Archéologie Romande* 120 (2011): 223-235.

146 Reusser, p. 5.

briquetage complex, which was the latest subsection of the operation to remain open.[147] The distance between it and Spina makes it unlikely that expertise in the art of briquetage crossed the Italian peninsula in a time when the technique's relevance had suffered a major decline.

The final feature that distinguishes Spina from other briquetage sites is the total absence of hearths, pits or kilns, which are otherwise fairly common across the majority of known briquetage salt production sites. Reusser *et al.* suggest that the site, rather than seeing use as Spina's primary salt source (especially since solar salterns are known in the area from the first or second centuries CE), may have instead been for the production of more valuable artisanal salt, which would have formed into hard rectangular bricks ready for trade as a result of its evaporation in rectangular vessels. Findings such as those by Alessandri *et al.* also present the notion that such a site could have also been used for fish processing rather than the production of salt. Reusser also notes that there may have been additional briquetage sites located at Spina, but cannot provide a date or much information on the sites based on the poor documentation of earlier excavations at the settlement. The role of a larger salt industry at Spina could be discussed with a more thorough understanding of the available evidence, though this role should fall on a separate project with a narrower focus and better access to research materials on the original excavations.

La Cotarda stands out among briquetage sites for its distance to any salt source – the nearest likely source of brine was the sea, located some 14km from the site.[148] The likelihood of

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[147] J. Sevink *et al.*, "The protohistoric briquetage at Puntone (Tuscany, Italy): A multidisciplinary attempt to unravel its age and role in the salt supply of Early States in Tyrrhenian Central Italy," *J. Arch. Sci.: Reports* 38 (2021): 17-18.

[148] Alessandri *et al.*, "Bronze and Iron Age Salt Production," pp. 35-36.

water being transported from the sea to this site manually (i.e., in tanks or vessels) seems low but not impossible. It is also possible that salt was imported to the site in the form of blocks or cakes still affixed to their original production vessels, and that the vessels were shattered at the site to extract salt cakes separately from the original site of production. This possibility stands out especially due to La Cotarda's lack of any identified pits, hearths, kilns, sediment deposits, or pedestals, all of which are considered evidence for the presence of briquetage sites in combination with accumulations of reddish potsherds. Analyses of this site are also complicated by the fact that while it is generally dated to after the orientalizing period, there is little consensus on during which periods the site was active. As little evidence is ever presented for the site's being active in the Orientalizing Period, Alessandri suggests an earlier set of operational dates, perhaps as early as the Final Bronze Age or Early Iron Age.[149] This dating would remove the site at La Cotarda from this discussion altogether, simplifying the research.

One final possibility that may describe the function of the outlier sites connects to a passing remark in Pliny's *Naturalis Historia*. Salt products from Egypt, Pliny asserts, were highly valued in the perfume industry for their reddish colour, which they gained from earthen impurities that became mixed in during the natural formation process. He tells also that these products can be distinguished from an artificial duplicate of the product by rinsing it with water – in the case of the true and rarer product, the nature of the pigment maintains the red colour of the salt when it is rinsed; in the case of an artificial and much more common product, the reddish colour becomes washed away because it would typically be dyed with crushed reddish pottery pieces. The specific language employed in the *Historia Naturalis*, "coloured red… with

[149] L. Alessandri, "Salt or Fish," p. 31.

powdered potsherds,"[150] evokes images of shattering reddish pottery along with salt, perhaps in the same style as briquetage. The same passage also claims that salt products coloured with potsherds were more common than the naturally occurring Egyptian product but also seems to suggest that even a duplicate of lower quality may have seen use in the creation of perfume. It is possible that the continued operation of briquetage sites in the era of the solar saltern was intended to meet the needs of the perfume industry for a dyed red salt, and made use of an existing technique (i.e., briquetage) that naturally included reddish pottery shards.

Regardless of the presence of these "outlier sites," it is clear that briquetage lost its status as the predominant method of salt production sometime after 910 BCE in the Early Iron Age.

Limited archaeological and literary evidence does not allow for an accurate description of the total number of solar salterns active in Central Italy after the EIA. However, it is nearly certain that a single solar saltern could outproduce a single briquetage site in terms of quantity.[151] Thus, probably only a few solar salterns replaced the large range of previously active briquetage sites.

Overall, based on environmental changes and technological advancements in salt production, briquetage declined in popularity from as early as the Early Iron Age, being replaced with more efficient yet less easily constructed solar salterns by sometime shortly after 910 BCE. The advent of solar salterns reduced the amount of labour and resources involved in the production of salt. However, the decreased number of active salt production sites in combination with their increased efficiency and capacity to support a population also increased the importance

[150] Pliny *Hist. Nat.* 31.42. tr. John Bostock, 1855.

[151] See earlier sections of this chapter for a discussion of the capacities of salt-producing sites.

of these individual sites to early Central Italian states. This made them points of contention or conflict, as outlined in the ancient literature on the early history of Rome.

Chapter 6: Conclusions

Understanding the role of salt in ancient Central Italy is essential for understanding the region's rich and complex history. The substance was a necessity for not only survival, but also for the operation of culinary, agricultural and luxury industries. It also saw use in medical remedies, personal cosmetics, and, as today, in the kitchen of virtually every household. Salt's role in the preservation of perishable foods, including meats, vegetables and dairy, made it essential also for the storage of surplus food that would be necessary for the development of larger communities or cities.

The ubiquity of salt in ancient Central Italian diets and industries made it a highly sought-after substance and meant that its production on a large scale was one of the most important industries for the continued survival of Central Italian populations. Salt production probably began in the earliest periods of the region's history, with the collection of naturally forming crusts or piles of salt in coastal lagoons or along the Tyrrhenian coast and quickly shifted to the more industrial process of briquetage by the Early or Middle Bronze Age as communities grew larger. Technologies such as solar salterns allowed for massively increased efficiency and production capacity in order to meet the needs of populations that continued to grow exponentially through the Orientalizing, Archaic, Hellenistic, and Imperial Periods.

This project successfully visualized the advent and decline of the briquetage technique in Central Italy by compiling data surrounding briquetage sites' operational dates and generating graphs to depict when the sites opened, closed, or were overall active. Through the visualized data, it was possible to see trends in salt production, especially in the employment of the briquetage technique. The first sites to produce salt in this manner opened in the Early and

Middle Bronze Age, and the method gained popularity as populations grew and their need for salt and preserved foods increased. The technique's growth was demonstrated to have slowed by the Early Iron Age. By the Orientalizing Period, briquetage began to decline rapidly in popularity, until its apparent total disappearance by the Roman Imperial Period. While archaeological remains for salterns in Central Italy cannot be dated to earlier than the 1^{st} century CE, the drastic decline in the use of the briquetage technique from the Orientalizing Period onwards, paired with evidence of a dune collapse at the mouth of the Tiber in the 10^{th} or 9^{th} century BCE that flooded a previously freshwater marsh with seawater, provide evidence that the first solar salterns may have been founded in Central Italy during the Early Iron Age. This theory is also supported by early literary sources, which place a great deal of importance on the area at the mouth of the Tiber, citing conflicts over the area between early Rome and her Etruscan neighbours. This is a clear demonstration of the effectiveness of data visualization as a tool for analyzing historical events, especially when paired with additional literary and archaeological sources.

A close analysis of trends in Central Italian salt production reveals an initial direct relationship with the region's population growth, which reflects the notion that salt was needed by every person living in the region. Other trends relate to the introduction of new salt production techniques. They additionally demonstrate a close relationship between salt production, environmental changes, and the development of centralized power in early Central Italian States such as Veii and Rome. The analysis of these trends and others proves to be an effective tool for the visualization of some key events in Central Italian history, especially those connected to population changes, technological advancements, and environmental changes. Overall, what this project has clearly revealed is that the role of salt in Central Italy was so important that an analysis of the substance itself manifests as an analysis of the region's broader history.

This method may also be applied to the production of commodities other than salt in an effort to better understand their role in or relationships to history. The analysis of salt, a substance necessary for virtually every member of Central Italy's population and greatly affected by developments in engineering, reveals trends related especially to population growth and technological advancement. Likewise, the analysis of other production trends may reveal patterns or information on the populations most affected by that commodity or the fields of research to which it is most strongly connected. A thorough understanding of trends in the production of various commodities will enhance the understanding of populations and major environmental events, as well as changes in technology.

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