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A Framework for the Analysis of Rewriting Practices, and Three Case Studies: Clay Tablets, Wax Tablets, and Erasable Coatings

Abstract: This study takes rewritability as a key lens for understanding writing habits, proposing a framework for investigating practices of erasing and rewriting in premodern manuscript cultures. It begins by exploring the intersections between rewritability and the concepts of erasable manuscripts and ephemeral writings. It then presents an analytical examination of the factors influencing rewriting practices and discusses how these can be compared to each other. Finally, it considers three exemplary types of rewritable manuscripts – clay tablets, wax tablets, and erasable coatings – discussing the material properties of the substances involved, the related techniques of (re)writing, and their historical significance.

1 Rewritability, erasable manuscripts, and ephemeral writings

The aim of this contribution is threefold: to provide a framework for exploring the role of the rewritability of writing supports in manuscript cultures; to offer an introduction to the contributions gathered in this volume; and to present three exemplary case studies of rewritable manuscripts, namely, clay and wax tablets, and erasable coatings.

The term *rewritability* refers to the capacity of a support to allow for the erasure of what has been written and its subsequent rewriting.[1] Framed in such general terms, the concept of rewritability can apply to a wide variety of materials, situations, and processes. Virtually any material – from stone to paper, parchment to sand – can serve as a writing surface from which the written text can be more or less completely obliterated so that the surface can be inscribed again. It is important here to distinguish between technical aspects – in particular, given a certain material and a certain writing technique applied to it, the extent to

1 The present study focuses on rewritability as related specifically to glottographic writing (henceforth simply 'writing'; see Hyman 2006).

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which, the ways in which, and under what conditions it can be obliterated (the material's *affordance*) – and the rationale behind the process of erasure and rewriting.[2] Thus, alongside cases where the process of erasure and rewriting has left no traces at all of the previous text, we also find instances in which the process intentionally leaves visible traces of the obliterated text, even when it would have been technically possible to erase it completely, as well as cases in which the intention is to erase the writing as thoroughly as possible, but this proves technically unfeasible.[3] Moreover, rewritability can concern only a small part of the written surface within a single artefact – as in the case of a patch of parchment bearing a word to be corrected, which the scribe scrapes off before reinscribing it – or the entire written surface of the artefact, as in the case of a slate covered with notes that is wiped clean with a cloth. Finally, the rewriting process may involve very different degrees of modification of the original artefact. Within this broad range of possibilities and situations, the focus of this volume is on a particular kind of inscribed artefact, namely, manuscripts, and a specific form of rewritability, namely, the practices developed to reuse a manuscript as many times and as easily as possible. This focus is further narrowed to selected historical contexts of premodern and traditional societies.

Consequently, the protagonists of this volume are what we may call *erasable* (or *rewritable*) *manuscripts*: those expressly designed to be easily and recursively reused. As will be seen, certain materials – particularly clay, wax, and wood – are especially well suited to this purpose. Importantly, there exists a special affinity between rewritable manuscripts and what may be termed *ephemeral writings*, that is, texts intended to be temporary. The supports used for ephemeral writings are necessarily destined either for disposal or reuse; where reuse is both easy and recursive, we are dealing with rewritable manuscripts. Conversely, the natural –

2 Text obliteration often has little to do with the will to suppress knowledge, and the commonly cited distinction between 'intentional' and 'unintentional' destruction of text is, on closer inspection, problematic (Giele 2019). On the concepts and methods involved in studying erasing and rewriting practices see also Crisci 2003.

3 See Östenberg 2018 on the so-called *damnatio memoriae* in ancient Rome, where the erased name often was deliberately left readable, underscoring and cautioning against the damned person; on the necessity of leaving corrections visible and recognisable as such in medieval documents, see Da Rold 2020, 99; on paper's erasability see also Section 2.1 below. The opposite scenario, where erasure is intended to be non-visible once executed but is not completely successful due to technical difficulties, is aptly exemplified by the difficulty of completely erasing iron-gall ink from parchment, leading to the possibility of recovering previous layers of text in palimpsests (Gippert, Maksimczuk and Sargsyan (eds) 2025).

though not exclusive – destined use for rewritable manuscripts, as defined above, is indeed ephemeral writing.

In addressing the topic of rewritability, as delineated above, this volume aims not at completeness or systematic coverage but rather at presenting a series of exemplary spotlights that highlight the deep impact of rewriting practices in literate societies, as well as the great potential that a comparative investigation of such practices holds for the study of manuscript cultures. The majority of the contributions collected here focus on those materials most eminently suited to serving as supports for rewritable manuscripts in the premodern world – namely, clay, wax, and wood – and on historical contexts in which these types of materials and manuscripts played a central role in the broader landscape of writing practices.

In line with this approach, the volume's first part gathers studies devoted to the materiality of clay as a writing support in the ancient Near East (Carmen Gütschow, Jon Taylor, Cécile Michel, Jamie Novotny) and to wax tablets in the classical and medieval periods (Anna Willi, Serena Ammirati, Georgios Boudalis, Thomas Wozniak). The second part then features studies of supports which, unlike clay and wax, are typically inscribed with ink and do not allow for an indefinitely repeatable reuse of the writing surface but rather permit only a limited number of iterations. These include papyrus in ancient Egypt (Elena Luise Hertel); parchment and papyrus manuscripts in Coptic Egypt (Paola Buzi); papyrus and paper in the Arabo-Islamic world (Sara Fani, Claudia Colini and colleagues); wood, sand, and metal in contemporary Nigeria (Andrea Brigaglia and Dahir Lawan Mu'az); and *mokkan* in Nara Japan (Antonio Manieri). The contributions are preceded by a reflection from Marilena Maniaci, who, considering the collected studies as a whole, invites us to reflect on how the study of rewritability contributes to our understanding of writing practices both past and present.

There is scarcely any need to stress just how partial and selective the picture painted by this volume is. To name only two major absences, the reader will find no contributions on ancient China or India, while the classical and medieval periods are treated in a selective and limited fashion. May this volume, then, serve as both stimulus and auspice for broader and more systematic research on the role of rewritability!

2 Materials, techniques, contexts: Framing rewriting practices

Given the wide range of phenomena associated with the concept of rewriting and the different perspectives from which it can be approached, a need arises to develop a framework for studying it in the most comprehensive and systematic possible way. In the following, a set of dedicated criteria are presented, which in turn serve as the foundation for a deeper exploration of the exemplary rewriting technologies discussed in Sections 3–5.

2.1 Materials and techniques

A comparative approach to rewriting practices requires a heuristic framework capable of accommodating a wide range of diverse factors across various historical settings. Such a framework should be designed to allow for meaningful comparisons of significantly divergent practices by situating them within a consistent grid of parameters, while also enabling detailed descriptions of the materials and processes involved.[4]

The framework I propose distinguishes two levels of analysis: one concerning technology, the other the historical context. At the technological level, rewriting practices are examined and described from a purely technical perspective, focusing on the materials interacting with each other, the conditions under which they

4 I am not aware of any systematic framework for analysing practices of erasure and rewriting. In the programmatic chapter on reuse ('*Wiederverwenden*'; see Bolle, Theis and Wilhelmi 2015) within the volume *Materiale Textkulturen: Konzepte – Materialien – Praktiken*, arising from the German Research Foundation Sonderforschungsbereich 933 'Materiale Textkulturen: Materialität und Präsenz des Geschriebenen in non-typographischen Gesellschaften', the authors refrain from providing such a framework, emphasising instead the vast variety of contexts and motivations in which the reuse of a written artefact can occur, and highlighting the difficulty of drawing clear boundaries and addressing the subject in a unified and coherent manner. The recent volume *Palimpsests and Related Phenomena across Languages and Cultures* (Gippert, Maksimczuk and Sargsyan (eds) 2025), originating from Jost Gippert's European Research Council project 'The Development of Literacy in the Caucasian Territories' (DeLiCaTe), offers a rich set of case studies on the phenomenon of palimpsests, with a particular focus on parchment. Gippert's introductory chapter provides an excellent overview, particularly of the concept of 'palimpsest' as traceable from classical sources to contemporary studies (Gippert 2025). Given the volume's scope and the nature of its case studies, this work, too, does not aim to develop a general model for rewriting practices.

operate, and their role in the rewriting process. This is schematically defined through the interaction of three fundamental parameters: (1) writing support; (2) writing process (including the writing substance); and (3) the process of textual obliteration. Each parameter is to be considered in terms of its temporal dynamics and the environmental conditions under which the process occurs: how the materials evolve over time, under what conditions of temperature, humidity, salinity, and so on, and how (re)writing and text obliteration take place.

This framework makes it possible to identify and characterise the core mechanisms underlying diverse historical practices of reusing writing surfaces. It also enables a basic yet meaningful comparison between them. For instance, it becomes immediately evident that certain materials have historically been used for such practices in far more varied ways than others. Most importantly, the framework accommodates a wide range of surface reuse practices beyond methods of 'erasure and rewriting' proper (e.g. paper recycling through repulping).

A basic list of key variables for the three primary parameters listed above includes:

1. Supports: inorganic (stone, sand, metals, clay, pottery); organic (papyrus, palm leaves, bamboo, birch bark, wood, textiles, leather, parchment); mixed (ivory, bone, chalk-based coatings, wax mixtures).[5]
2. Writing: displacement of the support material, subtraction of the support material, addition of a writing substance (inks, etc.), as well as the tools used in these processes.
3. Textual obliteration: reshaping of the support, removal of the writing substance while leaving the surface intact (e.g. by solvent application, adhesive substances) or while damaging the support (e.g. rubbing, scraping, chiselling); not rarely, a combination of multiple actions is involved.

Each material and each practice of writing and text obliteration can, of course, be further specified at various levels of detail.

The bewildering variety of practices adopted throughout history for text obliteration and rewriting stems from the many possible combinations of these

5 The distinction between writing supports made of organic, inorganic, and mixed materials is conventional and pragmatic. A concise yet information-rich overview of the writing supports used in Antiquity is provided in Capasso 2005, 45–63, which classifies materials within a broad bipartition between those readily available in nature and those specifically manufactured or substantially reworked to accommodate writing. Comprehensive discussions can be found in Breton-Gravereau and Thibault (eds) 1998 and in the 'Materialien' section of Meier, Ott and Sauer (eds) 2015. Useful online resources include <https://materialarchiv.ch/> and <https://www.csmc.uni-hamburg.de/profiling-guide.html> (all URLs cited in this contribution were last accessed on 18 April 2025).

three parameters, as well as from the ingenuity with which the *Homo (re)scribens* used the materials and knowledge available in different times and places for different and varying aims, in diverse socioeconomic and cultural settings.

Moist clay, wax mixtures, and erasable coatings applied to tablets or sheets, discussed in Sections 3, 4, and 5 respectively, are three important and widespread writing supports with a special affinity to erasability. But, as already said, all materials are rewritable up to a certain extent and under certain constraints. Stone and metal, which we instinctively associate with permanence, also have been widely used as erasable writing surfaces throughout history – think of slates inscribed with chalk or the lead sheets common in ancient Greece and Rome for letters, spells, and more, which were quite easy to smooth and reincise with a new text. In ancient China, bamboo and wooden slips and tablets, inscribed in ink, were widely used, with corrections performed by scraping with a knife and reuse by slicing off the entire surface.[6] Ink on papyrus can be washed out,[7] and several methods for reusing parchment are known from medieval and early modern manuscripts.[8] Paper is less amenable to erasure and rewriting, which famously led rulers around the globe to impose its use instead of parchment or wood for official documents that should never be altered. This is why methods for correcting mistakes in paper manuscripts mostly involve soaking the relevant signs in a reagent or covering them with a substance that can, in turn, be overwritten.[9] However, under certain conditions, ink on paper also can be obliterated – whether or not the author intended it – as Darya Ogorodnikova and Khaoula Trad's recent study aptly documents.[10]

Bone inscribed with ink, used throughout a number of manuscript cultures from ancient China to twentieth-century Ethiopia, can also be easily reused by washing out the written text.[11] In the Middle Ages, ivory notebooks written in ink or metalpoint were praised for their erasability – a technique already known in

6 Giele 2019, 218–220; Staack 2023, 39–46.

7 See Elena Hertel's contribution to this volume.

8 The topic of reusing parchment is closely related to palimpsest studies. For the technical aspects, see Bartl et al. (eds) 2005, 653–656; Agati 2009, 75–76; Quandt 2011, 83–88; Tchernetska and Wilson 2011, esp. 243–249, 257–259; Engel 2021.

9 For corrections and erasures on paper in the European Middle Ages, see Da Rold 2020, 114–115. In ancient China, an orpiment paste could be applied and then overwritten; see Drège 2024, 38. For the Islamicate world, see the methods discussed by Sara Fani and Claudia Colini and colleagues in their contributions to this volume.

10 Ogorodnikova and Trad 2025.

11 Bone, together with parchment scraps, has been the standard material for practising writing in the traditional Ethiopian manuscript culture; see Alehegne 2011, 149.

ancient Rome. Between the late seventeenth and nineteenth centuries, memorandum books with ivory sheets bound together like a fan were widespread on both sides of the Atlantic, used for taking quick notes while away from home or travelling, and even as dance cards (Fig. 1).[12] Sand and dust tablets used for writing – whether for exercises, calculations, or divination – represent yet another important category of erasable manuscript.[13]

Fig. 1: Ivory memorandum book with silver clasp, acquired by Katherine Bigelow in 1819, from England, 9 × 4.5 × 1.3 cm, Boston, MA, Museum of Fine Arts, accession no. 52.1306; reproduced with permission.

12 Stallybrass 2006, 555–558. For ancient Rome, see Martial's reference to ivory notebooks (*pugillares eborei*; *M. Valerii Martialis Epigrammaton libri*, §14.5, ed. Heraeus 1925).

13 On dust boards and blackened, erasable boards used in the Sanskrit mathematical tradition, see Keller 2024, 96–103, with important methodological considerations on pp. 100–101 with n. 64. As Agathe Keller notes, calculations could also be performed using seeds, grains, and cowrie shells placed on grids, with or without the support of boards. On the comparable situation of popular arithmetic in early modern Europe, which likewise involved both erasable tablets and tokens on grids, see Section 5.2. For sand tablets in the Islamic tradition, used for calculations, divination, and advanced teaching, see Fahd 1966, 196–204; Savage-Smith and Smith 1980; and Andrea Brigaglia and Dahir Lawan Mu'az's contribution to this volume. Writing on sand and dust is attested of course all around the globe, but only sand and dust tablets can be considered manuscripts proper. Importantly, writing on sand can be less ephemeral than one may assume; see the example of messages written in the sand by the Tuareg to communicate with each other, lasting several days (Cardona 1990, 146).

From a comparative perspective, practices of erasing and rewriting can be examined through multiple lenses. One lens concerns the extent to which a given writing support, in combination with a specific writing technique and method of text obliteration, lends itself to recursive reuse. Between immediate disposal and potentially infinite reuse, there exists a wide spectrum of intermediate possibilities. Clay and wax tablets (see Sections 3 and 4) can, in principle, be reused indefinitely without the need to add or remove any material. In contrast, wooden sticks and slips inscribed with ink, widely used for note-taking and learning to write in China and later also in Korea and Japan, played a fundamental role in the manuscript cultures of these regions. However, since their reuse involved shaving the surface with a knife, thinning them, they could be reused only a limited number of times (see Antonio Manieri's contribution to this volume on *mokkan* use in Nara Japan). Wood was also employed in other contexts, but with its surface treated such that inks could be washed off easily. A still different case is that of whitewashed or otherwise coated tablets or sheets, widespread from Antiquity to medieval and early modern Europe: they can in principle be reused indefinitely but require periodic renewal of their coating, typically based on chalk (see Section 5). Other writing supports arguably were developed primarily for long-lived texts, with obliteration and rewriting occurring only secondarily or in exceptional cases. This is the case of papyrus and parchment, as well as paper, which only in relatively recent times – thanks to the widespread availability of graphite pencils, and later also of erasers – has become one of the most common rewritable supports.

In evaluating the ease with which a given writing support, in combination with a specific writing technique and method of text obliteration, can be prepared and reused, it is crucial to avoid generalising assumptions that in fact hold true only under certain conditions and circumstances. On the one hand, it might seem straightforward to observe that some rewriting methods appear more economical than others: washing away an inscription from an ostracon may take only a few moments; scraping and rewriting a word on a wax tablet might require just a quick pass of the spatula typically found at the end of a stylus; an unbaked clay tablet can be erased simply by submerging it in water for a few minutes or, at most, a few hours. Conversely, scraping a word from parchment, or smoothing the surface of a lead sheet – let alone a harder metal – inscribed via engraving or punching appear to be more 'costly' processes, requiring greater effort and specialised tools. However, both cost-effectiveness and presumed ease of execution are vague categories prone to misinterpretation if applied in absolute terms without precisely defining their parameters. The cost of materials and tools can vary significantly from one place and time to another, as can the availability of resources, and whether a particular process is easy or difficult depends on specific

skills and acquired habits. Furthermore, the material cost of a given object is not the only factor influencing the inclination towards reuse; ideological and cultural considerations can play a greater role than monetary concerns, particularly in non-capitalist societies and non-utilitarian contexts. A good case in point is the reuse of papyrus, on which see Elena Hertel's contribution to this volume.

Assessing cost-effectiveness also requires considering not only the direct material aspects related to the reuse process itself but also any intangible costs (e.g. cognitive effort) and those associated with the initial preparation of the writing support and any necessary writing materials, as well as disposal costs if materials need to be discarded at the end of the process. This brings us back to the question of how long reuse is possible and whether it involves the subtraction or addition of substances. For example, a wax tablet represents a relatively sophisticated and 'expensive' technology, but, once available, it can, in principle, be reused indefinitely. In contrast, a potsherd inscribed by engraving or with ink may be effortlessly obtained in many contexts and essentially cost nothing, but, on the other hand, it must be smoothed down or supplied with fresh ink every time one wishes to write on it again.

Environmental and contextual conditions of use also play a decisive role. Temperature, humidity, salinity, and light conditions co-determine the suitability of certain technologies over others. This also applies to the broader context in which the act of writing occurs and the intended use of the manuscript: for example, whether one is writing while seated, standing, or on horseback; indoors or outdoors; on land or at sea, as well as whether the manuscript is meant to travel or remain in a library or archive. A clay tablet is typically cumbersome to transport and fragile to mechanical impact but can withstand fire remarkably well. Conversely, high atmospheric salinity has favoured the use of media such as wax tablets and notebooks with specially treated leaves to be inscribed using dedicated stone styluses, even in historical periods when paper was widely available and served as the standard medium under normal conditions.[14]

14 For the former case, see wax tablets still used in salt mines up to the early nineteenth century (see Section 4.2.4). For the latter, see the recent discovery of a previously unknown kind of erasable notebook, dating to the seventeenth century, among the Prize Papers of the National Archives in London, originally used in a naval context, now to be investigated by Marc Vermeulen and Katerina Williams (see a provisional insight by Peter Stallybrass at <https://www.youtube.com/watch?v=GGhHdfTFEOo>, minute 11).

2.2 Historical contexts

The conceptual framework developed within the Universität Hamburg's Centre for the Study of Manuscript Cultures for the comparative study of manuscripts from different cultures is a practical and well-tested tool for framing the historical contexts in which erasable manuscripts were produced and used. It considers four key factors: production, use, settings, and patterns.[15] This framework is conducive to examining fundamental aspects of rewriting technologies within their historical contexts, particularly: the function that the act of erasure and rewriting served for the individuals performing this operation at the time it occurred (bearing in mind that the function of the rewritten manuscript may vary subsequently and for different actors); the availability of materials involved in the rewriting process (raw or processed, locally sourced or imported, with all associated economic implications); the know-how required for the involved manufacture and procedures; and the role of tradition.

Particularly complex, and prone to partial evaluations and anachronisms, are attempts to reconstruct the rationale behind the adoption of specific practices of reuse in past cultures. This complexity arises because a wide variety of factors influence the historical outcomes we reconstruct today, based on evidence that is incomplete at best, and badly fragmented in most cases. Among these factors, the influence of tradition is frequently underestimated. In many cases, tradition plays a significant role in the – more or less unconscious, and not rarely irrational – continuation of established practices, also often leading to the creation of imaginary etiologies. Primo Levi's memorable short story 'Chromium', from *The Periodic Table*, provides an excellent illustration of this process.

2.3 Three case studies: Clay, wax, and erasable coatings

Before the general availability of paper and graphite pencils, widespread writing technologies for reusable manuscripts included inkless writing on clay, wax, and ink and metalpoint writing on erasable coatings. These techniques represent three key case studies for exploring rewritability's role in premodern manuscript cultures for three main reasons.

Firstly, inkless writing on clay and wax are the only two widely used writing practices that allow for potentially infinite recycling of the manuscript without

15 Wimmer et al. 2015.

needing to add or remove any material. Even today, they may well be considered the ultimate rewritable media, as well as among the most sustainable and eco-friendly writing technologies available. In addition to these, coated tablets and sheets specifically designed for erasure and reinscription allow for practically endless reuse with minimal effort, thanks to the wide availability of the coatings' basic ingredients.

Secondly, these technologies played crucial roles in the history of writing. The Mesopotamian civilisation, which primarily practised clay writing, is one of the oldest and most influential in terms of writing practices. Wax tablets have been fundamental in Western writing history, transferred and adapted uninterrupted across periods, areas, and cultures from the ancient Near East through the ancient Mediterranean world and into early modern Europe. In ancient Egypt, coated wooden tablets played the same role that clay and wax tablets did in the ancient Near East: serving as notebooks and school exercise boards. From there, having passed through the Hellenistic, Roman, and Coptic Periods, they were adopted in the Islamic world and thus spread across a vast region, becoming, in the context of Qur'anic education, a symbol of knowledge and the Qur'an itself – an uninterrupted tradition that remains alive today in some West African countries (see Andrea Brigaglia and Dahir Lawan Mu'az's contribution to this volume). Rewritable coatings applied to wooden tablets, as well as to sheets of parchment and, later, paper, were among the most significant media used for ephemeral texts in Antiquity and later in the Middle Ages and Early Modern Period in Europe.

The final reason clay, wax, and erasable coatings represent key case studies for understanding rewritability's role is because practices of erasure and rewriting used for such inherently erasable, highly widespread media coexisted with several others. These others practices were adapted for supports that were more intractable to recycling, such as papyrus, parchment, and paper, as documented both by close examination of extant manuscripts and indirectly through textual and iconographic sources. Therefore, they represent important case studies for exploring the relation between writing media in manuscript cultures.

As part of this initial contribution towards a systematic and in-depth investigation of the role of reusability in the history of manuscript cultures, the next three sections aim to provide insight into these three fundamental rewriting technologies, considered from the perspective of their material fundamentals.

3 Clay tablets

Clay is widely available across the globe, has plasticity when wet, and becomes permanently hardened when fired: it is no surprise that it has always been a fundamental material in many human activities, including writing. After briefly presenting the variables at play and the main historically attested forms of writing on clay, this section focuses on the one form constituting a particularly relevant kind of rewritable medium, namely, the clay tablet.

3.1 Writing on clay

Among the most significant script carriers in history, clay allows for diverse methods of inscription.[16] Key factors to consider include: (1) the chemical and mineral composition of the clay paste; (2) its physical state during inscription (in particular whether moist or dry); and (3) the writing techniques employed. The third factor, in turn, includes two crucial aspects: (1) whether writing techniques involve applying substances (such as ink, chalk, etc.) onto the surface, and (2) the biomechanics of the writing act, such as whether signs are scratched, impressed with a stylus, drawn or painted in ink, or created by impressing a matrix (as seen in seals and brick stamps).

Common occurrences of writing on supports made of clay include scratched and painted inscriptions on ceramic vessels, pottery sherds, and walls, found across multiple cultures. Two important concepts in this regard are *graffito*, which considers the writing technique as its point of reference (most often, graffiti are found on walls, rock surfaces, pottery sherds, and other surfaces not specifically prepared for writing), and *ostracon*, which instead refers to the type of support – ceramic sherds or stone fragments, often limestone – where the text is inscribed in ink using a reed pen or another tool, or incised by scratching (in which case it also qualifies as a graffito).[17] All these supports are rewritable to a certain extent – by smoothing in the case of graffiti, and by washing off the inscription in the case of ink writings. In the latter case, the ease of text obliteration depends on the porosity and composition of the surface as well as the type of ink used. Although the literature often emphasises that ostraca represented an almost unlimited and cost-free writing medium, numerous examples of palimpsest ostraca are known.

16 Balke et al. 2015; Faivre 2023b.

17 On graffiti and ostraca, see most recently Škrabal et al. (eds) 2023 and Caputo and Lougovaya (eds) 2021, respectively.

Considering that the more successful the erasure process, the harder it becomes to identify traces of the removed text without systematically applying advanced imaging techniques, it is reasonable to assume that the practice of reusing these supports was more common than generally thought.

Yet another technique of writing on clay offers even bigger opportunities for easy reuse of the script carrier, namely, writing without ink on moist, unbaked, and thus malleable, clay. This technique, enabling potentially infinite reuse without the need of adding or subtracting any material apart from the water needed to remoisten the manuscript, played a significant role in ancient societies, from the ancient Near East to Elam, the Bronze Age Aegean polities, and, to a much lesser extent, ancient Egypt.[18] To be sure, the typical scripts, manuscript formats, and other specifics varied across historical contexts and writing traditions. Likewise, the role of clay manuscripts within each tradition differed significantly: in the ancient Near East, they were so essential and intimately bound to writing from its very invention that they shaped the entire character and development of scribal practices, whereas in Egypt they represent an isolated exception, confined to the Dakhleh Oasis and limited to a few centuries between *c.* 2350 and 2000 BCE.[19]

In all these traditions, clay coexisted with other manuscript materials, including wooden boards (coated or not), wax tablets, papyrus, and leather scrolls. Here again, the situation varied. Despite being contemporaneous and well acquainted with each other's writing practices, pharaonic Egypt and the ancient Near East remained for millennia true to their respective customary usages: in the former, the primary manuscript materials were papyrus and wooden boards, while in the latter, clay and wax predominated, with leather gaining increasing importance in the first millennium BCE. Particularly debated is the situation in the Bronze Age

18 The practice of writing on moist clay by incising signs on a tablet is attested, of course, in several other traditions, but with a quite marginal role (for ancient Greece, see Faraguna 2020, 118, n. 26).

19 Compact, articulated insights into the materiality of writing in the above-mentioned contexts are Taylor 2011a (ancient Near East); Basello and Ascalone 2018 (Elam); Quack 2005 (pharaonic Egypt); Finlayson 2013 (Bronze Age Aegean polities, but see Salgarella 2020 for the debated relation between texts in Linear A and Linear B). In Egypt, the use of clay as writing support is confined to the 'archive' of Balat (Dakhleh Oasis, approx. 350 km west of Thebes), where the use of clay tablets was arguably due to the unavailability of papyrus (Pantalacci 2021), and the Late Bronze Age diplomatic correspondence between the pharaoh and the ancient Near Eastern polities (Amarna archive and arguably comparable ones; see Hagen 2018, 136). As far as inkless writing on moist clay is concerned, the cuneiform writing tradition stands out for its antiquity, relevance in the history of writing, and the vast and diachronic nature of the existing evidence; see Streck 2010. Schnitzlein 2022 offers an extensive study in the Mesopotamian scribal culture, focused on the first millennium BCE.

Aegean, where leather, wood, and possibly palm leaves also played a role alongside clay as script carriers.[20]

The quintessential format for clay manuscripts is the tablet. Thus, the clay tablet embodies the convergence of one of the oldest and most versatile forms of written artefact with one of the oldest and most versatile materials used by mankind, and as such it stands out as a pivotal manuscript technology. Within this category, various sub-formats exist, differentiated by shape, dimension, and orientation (from a few millimetres to over half a metre; rectangular, squared, rounded, globular, etc.; portrait, landscape), with some being characteristic of specific textual genres within a given tradition.[21] Alongside tablets, other common formats within this manuscript class include cones, prisms, and cylinders, primarily found in the cuneiform world.[22]

Within the broader category of inscribed clay objects, other crucial classes of inscribed artefacts, which, however, are not manuscripts, include clay sealings, bricks, and pottery bearing stamped inscriptions. Clay sealings, taking various shapes but most commonly the form of lumps used as stoppers, noduli, or cones suspended by cords, served as a fundamental means of communication, securing technology, and staple management in ancient societies. Whenever a seal impression (created by pressing on or rolling the seal, depending on its type) carries an inscription, the sealed object is to be considered an inscribed artefact. Similar considerations apply to mud bricks with stamped inscriptions, especially prevalent in the ancient Near East, and pottery with stamped potmarks.

3.2 Material, manufacture, inscription, and reuse of clay tablets

When speaking of clay tablets, the material should not be understood in the narrow sense given to it in the geosciences, where particle size is the main criterion for distinguishing clay from silt,[23] but as a generic reference to clayey mixtures, most often consisting of a matrix of clay and silt in varying proportions, mineral

20 Waal 2024.

21 For example, so-called lentil tablets, easily held in the palm, are characteristic of elementary exercises in the initial stages of scribal education in Mesopotamia. So-called palm-leaf tablets are characteristic of Linear B corpora, in addition to page-shaped tablets (Salgarella 2020, 178–209; for the possibility that this format may hark back to the practice of writing on perishable palm leaves, see Waal 2022).

22 Taylor 2011a.

23 But it should be noted that even here there is no full consensus among scholars. See Bergaya, Theng and Lagaly (eds) 2006; Thomas 2023.

inclusions, and frequently a tempering component of vegetable (e.g. straw) or animal (e.g. shell) origin.[24] Clay used in a particular tablet may have originated from a location far removed from where the tablet was discovered. Tablets were often transported over significant distances, and in some instances, the raw clay itself was moved from one place to another for processing. Therefore, one must exercise extreme caution when using material analysis results to draw implications about a tablet's place of origin. Petrographic and chemical analyses (see Section 3.3) highlight, on the one hand, the possibility of identifying regional clusters on the basis of specific compositional parameters, and, on the other, the variability in composition resulting from the natural variation of either clay deposits even within a limited geographical area or tablet preparation practices even in the same place and time.[25]

Ancient sources provide scarce information about the origins and manufacture of clay manuscripts.[26] Consequently, reconstructing these processes mainly relies on archaeological evidence, close inspection of original manuscripts, material analysis, and experimentation.[27] Several factors governed tablet preparation techniques: quality and quantity of available raw materials (in some instances, clay was transported from afar, while in most cases it was locally sourced, ranging from fresh to ancient alluvial deposits); available know-how and traditional preferences, also related to local ceramic-processing practices; and the artefact's intended use.[28] Administrative tablets and drafts, for example, display a lower-quality fabric than tablets meant for long-term preservation and of particular value (Fig. 2). It is reasonable to assume that, as a rule, the primary process for preparing clay after collecting the raw mass involved levigation in dedicated pits, but the evidence also points to exceptions.[29] Archaeological excavations have yielded several examples of what can plausibly be identified as basins and pits

24 Taylor 2011b; Cartwright and Taylor 2011. In the ancient Near East, gypsum is also attested as a material of cuneiform tablets, although to a very limited extent. It has been speculated that it may have been used at a very early stage within the development of cuneiform writing when 'experimenting' with various materials; see Reade 1992. However, it is also attested in, for example, the Old Babylonian Period; see for instance the literary tablet Philadelphia, Penn Museum, UM 55-21-303, <https://cdli.ucla.edu/P257245>.

25 Comentale 2023; Spataro, Taylor and O'Flynn 2023.

26 Some information is available in ancient Near Eastern sources. See Civil 1998; Taylor 2011b; Torri 2020; van Buylaere, Watanabe and Altaweel 2019.

27 For Linear B tablets, see Judson 2023; Hruby and Nakassis 2024. For the ancient Near East, Taylor 2011b. For Balat, Pantalacci 2021.

28 Taylor 2011b; Spataro, Taylor and O'Flynn 2023 with literature.

29 See Spataro, Taylor and O'Flynn 2023, 68.

used for preparing tablets – in some cases, this interpretation is confirmed by the discovery of 'blanks' or ripped-up tablets ready for recycling, either inside or in close proximity to these pits.[30] It is equally reasonable to assume that, as a rule, the clay used for tablets was essentially the same as that used locally for pottery. This, too, often can be demonstrated through material analysis.

Fig. 2: A Hittite tablet fragment from the genre of the so-called cult inventories, displaying comparatively raw clay and large stone inclusions both inside and on the surface, typical of administrative tablets of ephemeral nature. Ankara, Anadolu Medeniyetleri Müzesi, Bo 73/s; photograph by the author.

The primary criterion in choosing clay mixtures and processing them into manuscripts was likely the plasticity of the material and the legibility of the written text. This, in turn, depended not only on the sharpness of the sign contours but also on the colour and texture of the surface: a uniform-coloured surface enhances legibility compared to one dotted with mineral inclusions. Similar considerations applied to the choice of whether to add temper, and the type of temper used. Recent analyses, referenced above, show that various techniques were used in preparing the tablets, both with and without levigation, addition of temper materials, and polishing. The

30 See Taylor 2011b; Faivre 2023a, and the contributions by Cécile Michel and Jon Taylor to this volume. For an illuminating example from Tell Khaiber, see the section by Eleanor Robson in Campbell et al. 2017, 28–30.

modelling process also varied, with some artefacts having a uniform matrix, while others feature a finer clay 'skin' enveloping a coarser core.

Cuneiform was typically written with a reed stylus cut at a sharp angle, enabling wedge-shaped impressions into wet clay.[31] Our term 'cuneiform' follows the first modern description of this type of writing, which Thomas Hyde provided in 1700 in his work *Historia Religionis Veterum Persarum* in reference to Achaemenid monumental inscriptions: 'ductuli pyramidales seu cuneiformes' ('pyramidal or wedge-shaped marks').[32] The highly pronounced three-dimensionality of this script makes it a prime subject for quantitative palaeographic analysis based on the geometry of the impressions that form its fundamental elements[33] and has non-trivial implications for legibility (as anyone who has had to collate cuneiform tablets knows, they are best read with a light source coming obliquely from the upper left). The use of a reed stylus, arguably of the species *Arundo donax*, is typical of the core area of the ancient Near East, roughly corresponding to present-day Iraq and Syria. Remarkably, for over 3,000 years, the reed stylus was consistently impressed in such a way that the right face of the wedge was produced using the part of the stylus corresponding to the outer skin of the reed, giving it its characteristic curvature. In Hittite Anatolia, however, where the colder climate did not support the growth of giant reed, styluses were likely made of bone. As a result, the wedge faces on Hittite cuneiform tablets are all perfectly flat.

In contrast, linear scripts like Linear Elamite, Hieratic, Aramaic, and Aegean linear scripts, when on clay, required pointed-end styluses made of metal, wood, or bone.[34] Here as well, careful examination of the written traces can reveal significant information about writing tools – now almost entirely lost – and the way they were used to produce signs, particularly whether they were made by impression or by dragging the stylus along the surface.

Since clay gradually dries in the open air, the time available to the scribe to write on a moist clay tablet is limited, unless specific measures are taken to extend this period. This can be done by keeping the tablet wrapped in a damp cloth or remoistening sections that have become too dry to be inscribed. This phenomenon is precisely what is observed in original documents: variations in the appearance of strokes within different portions of the same manuscript that were arguably written

31 Cammarosano 2014; Devecchi, Müller and Mynářová (eds) 2015. For a quick overview, see <https://cuneiform.neocities.org/CWT/howtowritecuneiform>.

32 Hyde 1700, 526.

33 Cammarosano 2015.

34 See Pantalacci 2021 for the Hieratic tablets from Balat. See Steele 2020 and Steele and Boyes 2023 for the Aegean scripts.

at different times (with intervals ranging from hours to, depending on humidity and temperature, even minutes); signs of localised remoistening in larger manuscripts to facilitate the inscription of the final sections; and various techniques to update or modify the text once the tablet had already dried. Jon Taylor's contribution to this volume offers a systematic and in-depth study of all these aspects.

Fig. 3: A clay tablet from Balat, Dakhleh Oasis, Egypt, Old Kingdom, inscribed in Hieratic. Note the erased portion on the left, with traces of previous writing. Cairo, Egyptian Museum, Tablet IFAO no. 6163, NU_2006_1985; photo courtesy Laure Pantalacci / IFAO.

As long as the clay remains malleable, one of the defining characteristics of clay tablets – directly stemming from their being inscribed without ink and from the material's plasticity – is the remarkable ease with which corrections can be made. Existing signs can be effortlessly erased by simply smoothing the surface with a finger or another suitable tool, allowing immediate rewriting (Fig. 3). The extent to which erasures remain visible depends on how thoroughly the surface has been smoothed. In many cuneiform tablets, scribes often did not bother to flatten the surface at all, simply impressing new signs over the previous ones. It is generally assumed that any erasure leaves at least minimal traces due to the inevitable

compression of the clay mass in that area, though this has yet to be systematically investigated through experimental research. Regardless, the countless erasures observed in cuneiform tablet corpora – and in other writing traditions that used clay – constitute an invaluable source of information about scribal practices, conventions, and broader aspects of manuscript cultures, many of which remain to be systematically explored.[35]

Another open question that still awaits thorough investigation concerns the extent to which 'localised remoistening' may have been employed (see again Cécile Michel's contribution to this volume). A related but distinct issue, also tied to the reusable nature of clay tablets, is the complete recycling of a manuscript. This could be achieved by soaking the tablet in water until the surface became malleable again and thus could be smoothed, or by fully reworking the clay and reforming the manuscript from scratch. In the cuneiform world, we have both textual and archaeological evidence for these practices, which were likely particularly common in contexts of intensive ephemeral text production, such as scribal education. A Neo-Babylonian tablet, probably a model for school colophons (Baghdad, Iraq Museum, U.3018), instructs students to 'crumble' their completed exercise tablets into the 'tablet container': as noted by Enrique Jiménez, 'this practice would account for the fact that school tablets with colophons are relatively few, particularly considering that each scribe must have made several of them during his apprenticeship'.[36] Similarly, typical Old Babylonian school tablets often exhibit clear traces of repeated erasure and rewriting: while one column, containing the master text, was left intact, the column used for exercises was frequently erased and reinscribed (Fig. 4).[37] In some cases, when the clay had already dried, the exercise column was scraped rather than smoothed, resulting in its gradual thinning over time (see Jon Taylor's contribution to this volume, with literature), and, more generally, secondary inscriptions could be added after the clay had dried using various techniques, such as adding a scratched or painted inscription, or both.[38] But how widespread was the recycling of tablets? Scholarly opinions vary: some argue for a minimalist view, given the virtually inexhaustible availability of clay, particularly in the Mesopotamian alluvial plains, while others suggest that tablet recycling was a routine practice.[39]

35 Delnero 2024; Cécile Michel's contribution to this volume.

36 <https://www.ebl.lmu.de/fragmentarium/U.3018>.

37 Robson 2001; Veldhuis 2014.

38 Fales et al. 2005; Taylor 2011a.

39 See, respectively, Taylor 2011b and Faivre 2023a, both with extensive previous literature. For Linear B tablets, see Hruby and Nakassis 2024.

Fig. 4: Obverse of an Old Babylonian cuneiform clay tablet from Nippur, inscribed with school exercises. On the right side, one or two columns were (imperfectly) erased by the scribe when the surface was still moist, as was customary in order to practice there again. Chicago, IL, Institute for the Study of Ancient Cultures Museum, A30276; courtesy of the Institute for the Study of Ancient Cultures of the University of Chicago; photograph: Danielle Levy.

Firing the clay at high temperatures induced permanent changes in its physical and chemical properties, rendering it unable to become plastic again by adding water. Importantly, *fired* and *unfired* represented two ends of a continuum, dependent on temperature and firing method.[40] Some tablets were intentionally baked in ancient times to prevent modification, particularly copies of documents with legal value, while others were baked accidentally due to building conflagrations. Some were also baked at the time of discovery or later to prevent deterioration, although this end was not always achieved.[41] As already mentioned, fired clay – that is, ceramics – is highly suitable for use as a writing material, both with ink and by incising, with the added possibility of smoothing or washing the surface for reuse.

3.3 Material analysis of clay tablets

Several methods, both destructive and non-destructive, can be applied in studying clay written artefacts:

- Optical microscopy and reflectance transformation imaging (RTI) help in observing the texture and details of the artefact, and can be employed for enhancing legibility in the process of text edition.
- 3D (laser or structured-light) scanning enables precise measurement of the artefact's geometry, including sign components.
- Thermoluminescence dating can be used to determine the date of firing, but a larger sample is required.
- Several elemental and isotopic techniques can be used (including in combination) for determining the composition of the material and of pigments that may be present on the surface. Some of these techniques also can be used for the optical study of volumetry, morphological micro-structure, or micro-flora and micro-fauna that may be present, and X-ray computed tomography enables the reading of tablets enclosed in a clay envelope, without breaking the latter).[42]

40 Reade 2017.

41 See Reade 2017 and Gütschow 2012, as well as Carmen Gütschow's contribution to this volume.

42 Spataro, Taylor and O'Flynn 2023 with literature and discussion.

4 Wax tablets

Wax tablets represent one of the most impactful and long-lasting writing supports in history. This is due to the unique characteristics of their fundamental component, beeswax, particularly its chemically stable nature, its high plasticity at room temperature, and, at the same time, its considerably higher melting point compared to naturally available animal and vegetable fats.

After a brief overview of wax's role as a support for the written word, this section discusses the characteristics of wax-based mixtures in relation to their use as a writing support, outlines the history of the wax tablet as a rewritable medium, and finally presents the methods of investigation applicable to the study of preserved original specimens.

4.1 Writing on wax

The use of wax (mixtures) as a writing surface is first attested in the twenty-first century BCE through direct evidence in Middle Kingdom Egypt and around the same time through indirect evidence in southern Iraq (Ur III Period). In Egypt, the context is that of wax figurines, which were sometimes provided with inscriptions, inked either directly on the wax surface or on plaques then applied onto the object.[43] Inscribed wax objects are known from several other periods and cultures. In Mesopotamia, the context is the invention of wax tablets, which are dealt with in Section 4.2. The third major context for the use of wax as a writing surface is sealing practices. The earliest evidence of wax mixtures used as sealings – that is, as the recipient of seal impressions – dates from ancient Egypt (fifteenth/fourteenth-century BCE Egypt, eighteenth dynasty),[44] but became widespread only in Late Antiquity and the Middle Ages.[45] When wax sealings bear an inscription, they configure written artefacts, albeit not manuscripts.

Waxes are lipid materials characterised by esters of long-chain carboxylic acids, solidifying at room temperature and exhibiting high hydrophobicity. Natural waxes stem from animal (beeswax, Chinese wax, lanolin, spermaceti), vegetable (carnauba, candelilla wax, esparto wax, Japan wax), and fossil (paraffin wax, montan wax, ceresin) sources.[46] Throughout history, waxes have served various

43 Raven 1983.
44 Hayes 1990, 209.
45 Becchetti 2011; Kasso et al. 2023.
46 Colombini and Modugno 2009, 10–12.

purposes, including as sealants, coatings, polishes, balms, and cosmetics, as well as in lost-wax casting, candle production, encaustic painting, ceroplastic art, and writing tablets.[47] Beeswax, exploited since the early Neolithic,[48] stands out as the principal type of wax documented as a support for writing. Indeed, it constitutes the fundamental component of the wax paste in wax figurines, wax tablets, and wax sealings.[49]

An excretion from honeybee glands, beeswax forms as wax scales on the bee's abdomen, later shaped into honeycombs using their mandibles (Fig. 5). Wax colour can be affected by pollen and cuticula incorporation. Obtaining beeswax involves extracting honeycombs and separating wax from honey through heating and filtration. Chemically, beeswax is a mixture of monoesters, hydrocarbons, diesters, hydroxy polyesters, and a large variety of further compounds.[50] It melts between 62 and 65°C. Esters, mainly myricyl palmitate, dominate the composition (70 per cent).

Fig. 5: A construction bee taking wax scales from a nest mate with its mandibles. From Tautz and Heilmann 2007, 158, fig. 7.2; reproduced with permission.

47 Büll 1977.

48 Roffet-Salque et al. 2015.

49 Carnauba wax was occasionally used for producing sealings in the Modern Period; see Šoltys et al. 2019.

50 Hepburn et al. 2014, 16; Fröhlich 2000.

A wax paste suitable for writing needs to strike a delicate balance between softness (to enable inscription and erasure) and hardness (for text stability).[51] This optimal equilibrium is not fixed but hinges on the script's nature, specific text requirements, and environmental constraints. Mechanical properties rely on environmental temperature, beeswax quality, and added substances. Pure beeswax's stickiness and translucent colour deem it unfit as a writing surface, prompting the addition of other substances with a triple purpose: adjusting consistency and plasticity, influencing colour, and increasing cost-effectiveness through blending with more common materials. While numerous extant specimens of wax tablets and historically attested recipes involve multiple ingredients, a single substance, such as ochre or carbon, can achieve all these objectives.[52]

Philological sources and scientific analyses provide insights into the diverse substances incorporated into beeswax for inscribed figurines, writing tablets, and sealings throughout history. Evidence from ancient Egypt shows the addition of resins, oils, and pigments.[53] Ancient Near Eastern evidence is restricted to yellow ochre, arsenic sulfide (orpiment), possibly soot, and potentially (sesame) oil (see Section 4.2.2). In contrast, evidence from Antiquity and the Middle Ages and Early Modern Period reveals a more extensive list of additives in various proportions and combinations, including oils, resins, turpentine, dairy products, honey, ochre, charcoal, soot, copper acetates (verdigris), cinnabar, red lead (minium), azurite, and basic lead carbonate (white lead).[54] The colour of the resulting paste depends on the added ingredients, ranging from golden and ochre hues to black, red, green, and even blue. Textual evidence confirms that the wax paste's colour played an important role in determining the written text's legibility, which resulted from contrasting patterns of light and shadow within the wax layer.[55] The variable composition of both wax tablets and sealings testifies to complex patterns of knowledge transfer, intersections with other wax-related processes, and culturally conditioned preferences, which remain poorly understood.

The plasticity criteria for sealings differ from those for wax tablets, as the former are intended to remain stable over time once impressed, while the latter

51 Büll 1977, 785.

52 Cammarosano et al. 2019, 156–157.

53 Büll 1977, 808–814, concerning wax tablets from Roman Egypt; Serpico and White 2000, 420–422.

54 Büll 1977, 796–820; Oltrogge in Bartl et al. (eds) 2005, 658–662; Weirauch and Cammarosano 2021, 19–21.

55 Weirauch and Cammarosano 2021, 13–15 with literature. On the link between background colour, writing technique, and legibility see Section 4.2.3, regarding the case of Roman wax tablets.

as a rule aim for easy erasability. Therefore, individual examples of inscribed wax mixtures are unique and should be treated accordingly.

4.2 Wax tablets in manuscript cultures

4.2.1 The wax tablet as medium

Wax tablets, composed of one or more leaves typically made of ivory or wood, feature a framed recess housing a beeswax-based paste to be inscribed with a stylus, normally made of metal or bone.[56] The recesses are regularly scored with a criss-cross hatching to enhance the wax layer's grip, and the writing marks are impressed (in the case of cuneiform) or scratched (linear scripts) into the wax paste with the stylus. The stylus's tip is shaped according to the script to be produced: squared for cuneiform,[57] pointed for linear scripts.[58] Erasing is easily done with a spatula or globular tip, most often incorporated on the back end of the stylus, enabling immediate or delayed reinscription. Thanks to the chemical stability of beeswax, the wax paste in principle could be reused indefinitely. In practice, however, accumulated dust and impurities over time made it advisable to periodically renew the wax layer. Not infrequently, a too thin layer of wax or excessive pressure on the stylus caused it to cut into the wood, producing incised traces, which were subsequently hidden when a new layer of wax was added. As a consequence, in many instances multiple layers of written traces survive on top of each other, complicating decipherment.[59] This writing technology, providing an ink-free and highly portable surface, endured for nearly four millennia, crossing cultures and historical periods, and was still in use in nineteenth-century Europe. The earliest precursor to the modern book in codex form,[60] the wax tablet stands as one of the longest-lasting manuscript forms in history (Fig. 6).

56 Büll 1977, 785–894.
57 Cammarosano et al. 2019.
58 Gerlach 1965; Schaltenbrand-Obrecht 2012.
59 Mullen and Bowman 2021, 72–85.
60 Boudalis 2018, 21–34.

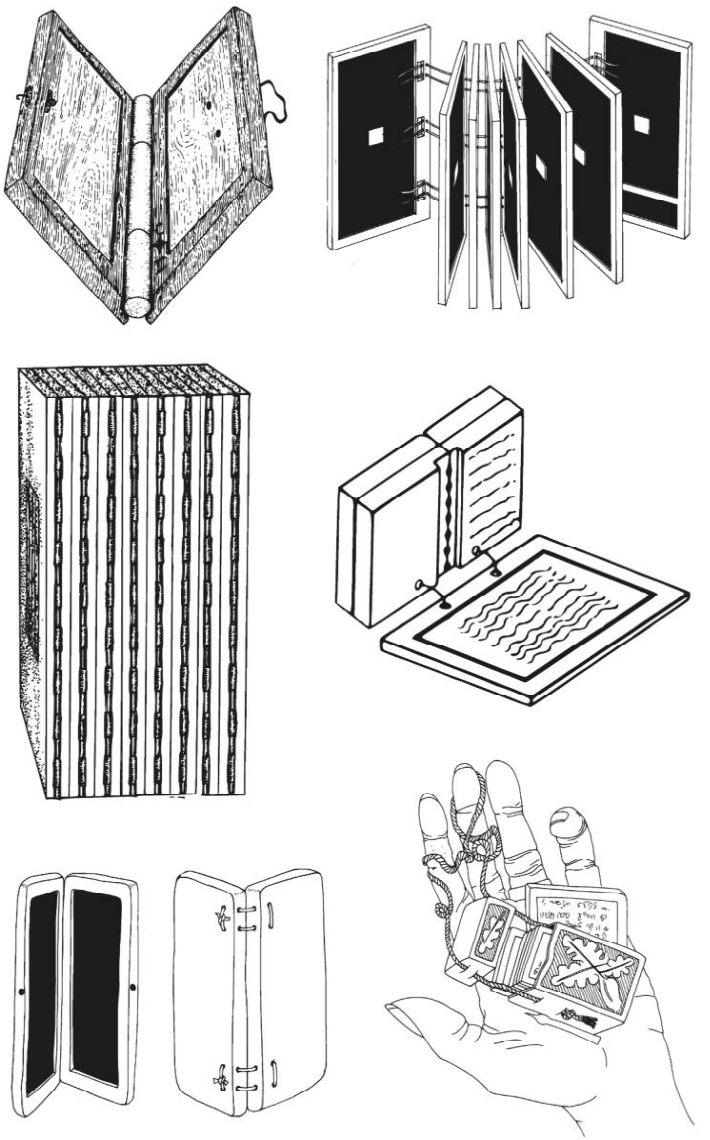

Fig. 6: Exemplary types of wax tablets (not to scale). From top to bottom and from left to right: reconstruction of the wooden diptych from Uluburun, 14th c. BCE (from Payton 1991, fig. 4); a Roman octoptych from Herculaneum, 1st c. CE (from Boudalis 2018, 25, fig. 11); reconstruction of the ivory polyptych from Nimrud, 8th c. BCE (adapted after Howard 1955, 17, fig. 9); the structure of Roman triptychs with legal text (from Camodeca 2022, 22, fig. 2); reconstruction of a method for connecting the two leaves of a diptych (from Boudalis 2018, 25, fig. 10); set of wax tablets in their leather pouch, from York, 14th c. CE (from O'Connor and Tweddle 1992, 322, fig. 11).

4.2.2 Wax tablets in the ancient Near East

The wax tablet as an invention must be credited to the cuneiform manuscript culture of ancient Mesopotamia (modern-day Iraq and Syria).[61] The earliest evidence of wax writing tablets dates back to the late third millennium BCE (the Ur III Period) and is found in cuneiform clay tablets from southern Iraq referring to the use of wax tablets in administrative procedures and bookkeeping. We have no information on the exact composition of the wax mixture used in this context, but it is reasonable to assume that the main ingredient was beeswax, as preliminary experiments and practical considerations suggest that possible substitutes – particularly tallow – do not yield satisfactory results for imprinting wedges. Given the climatic conditions of Lower Mesopotamia, the beeswax necessary for preparing these tablets, as well as for other documented uses in the same period – particularly the lost-wax casting technique – had to be imported from the mountainous regions to the east and north.[62]

As discussed in Section 3, at this time Mesopotamian scribal cultures already had a writing technology that was both readily available and highly suited to reusing the writing surface – namely, clay tablets. It is therefore not a trivial question as to why these same cultures felt the need to adopt wax, alongside clay, as a writing support. The answer likely lies in three distinctive features of wax tablets, which offer significant advantages over their clay counterparts:

1. The ability to correct and update the text over an indefinitely long period without any preliminary operation, unlike clay, which requires remoistening once dried. This makes wax tablets particularly suitable as a support for texts requiring periodic updating, as is often the case in bookkeeping.
2. Greater resistance to mechanical shock compared to clay, and a lower specific weight – both characteristics that make wax tablets easier to transport over long distances.
3. The possibility of binding multiple leaves together to create polyptychs capable of holding significantly longer texts within a single manuscript than possible on clay tablets (the polyptych from Nimrud constitutes a good example of this, discussed later in this subsection).

61 The following outline summarises the results presented in Cammarosano et al. 2019, with selected bibliographical notes. The most recent literature includes Molina and Steinkeller 2023 and Zimmermann 2023.

62 Recently, it has been hypothesised that the technology of wax tablets was originally developed further north, in northern Mesopotamia; see Reade 2024.

The available evidence, mostly indirect (textual and iconographic), becomes more abundant in the second millennium BCE, showing that wax tablets were used throughout the cuneiform world and for a range of different text genres, both documentary and literary (Fig. 7). Particularly significant in this period is the extensive evidence from Hittite Anatolia. In this context, in addition to a significant number of textual references – pointing, among other contexts of use, to wax tablets as aides-mémoire for the correct performance of festive rites – we also have more than thirty bronze styluses, found at multiple sites, featuring a pointed writing tip on one end and a spatula on the other, fully analogous to those known from the classical and medieval periods. These tips show that wax tablets were used not only for cuneiform but also for the indigenous linear script known as Anatolian hieroglyphs, and furthermore suggest that wax tablets may have been the primary medium for economic administration in the Hittite state – a hypothesis that could explain the striking absence of economic texts from the Hittite record.[63]

Fig. 7: Left: A portion of the preserved wax layer inscribed in cuneiform from the Nimrud ivory polyptych, London, British Museum, BM 131952. Right: Detail from the Neo-Assyrian wall panel BM 124955 (Nineveh, South West Palace, 7th c. BCE) showing two scribes recording booty, one writing arguably in Aramaic on leather, the other in cuneiform on a wax diptych; © The Trustees of the British Museum.

63 Cammarosano 2024, for the textual evidence; Cammarosano 2025, for the bronze styluses.

The oldest surviving examples of wax tablets – the well-known diptychs from the Uluburun shipwreck – date to the fifteenth century BCE (Fig. 6).[64] Since the wax layer has not survived, it is impossible to determine which script(s) were used on these specific examples, and the interpretation of the incised marks on their edges remains highly debated.[65]

Wax tablet use in the ancient Near East appears to have further increased in the first millennium BCE, particularly during the Neo-Assyrian and Neo-Babylonian Periods. A relief from the island of Qal'at 'Ana in the Middle Euphrates, dated to the eighth century BCE, suggests that this medium was also used for Aramaic, and numerous indirect sources document that a significant portion of entire libraries consisted of wax tablets, the most striking example being the library of Ashurbanipal. The eighth century BCE also saw the creation of the only other known surviving examples of ancient Near Eastern wax tablets: two sets of polyptychs from the palace of the Assyrian king Sennacherib at Nimrud (one in ivory and one in walnut wood – the ivory set featuring leaves 34 cm tall bound in concertina format; Figs 6–8), and two diptychs from another Assyrian capital, the city of Assur (two ivory diptychs with leaves 8.3 and 14.7 cm tall, respectively).[66]

Some fragments of the Nimrud polyptychs still preserve part of their wax coating, partially still inscribed with cuneiform signs. This is especially evident in the ivory set, which displays a paste of bright-yellow colour and contains a part of the astronomical omen series Enūma Anu Enlil. According to analyses performed in the 1950s, this paste is made of beeswax compounded with 25 per cent orpiment (As_2S_3, arsenic sulfide). A recent analysis conducted at the British Museum, London, confirms that a detached sample of wax paste, presumably originating from the ivory set, is composed of beeswax and orpiment, while traces of matter newly identified on fragments of the wooden set hint at the presence of a mixture of beeswax and soot, thus resembling a wax recipe that would later become standard in the classical world.[67] Finally, references to the supply of beeswax and yellow ochre (Akkadian: *kalû*) 'for the wax tablets', found in Neo-Babylonian economic receipts suggest that these were ingredients commonly used in that context and possibly more generally in ancient Mesopotamia for ordinary wax tablets,

64 In truth, only one of the two is well known – the better-preserved example, on display at the Bodrum Museum of Underwater Archaeology in Turkey; see Payton 1991, with additional information provided in Cammarosano et al. 2019, 148–150.

65 See most recently Waal and Dillo 2021.

66 See Howard 1955 and Cammarosano et al. 2019, 151 for Nimrud; Jendritzki, Streckfuß and Cammarosano 2019 for Assur.

67 Tamburini et al. 2025.

while the presence of orpiment in this Assyrian royal collection can be explained by a desire to imitate the colour of gold.[68]

Since wedges are produced simply by pressing a squared tip into a moist surface, the same stylus can be used to write cuneiform on both clay and wax. However, iconographic sources reveal a curious difference in the appearance and handling of styluses associated with wax boards compared to those used for clay tablets. While both are of rectangular or trapezoidal shape, styluses for wax boards display what appears to be a longitudinal line or groove, whereas styluses for clay tablets do not. Whether this feature is merely an iconographic convention or reflects a technical adaptation for writing cuneiform on wax remains an open question.[69]

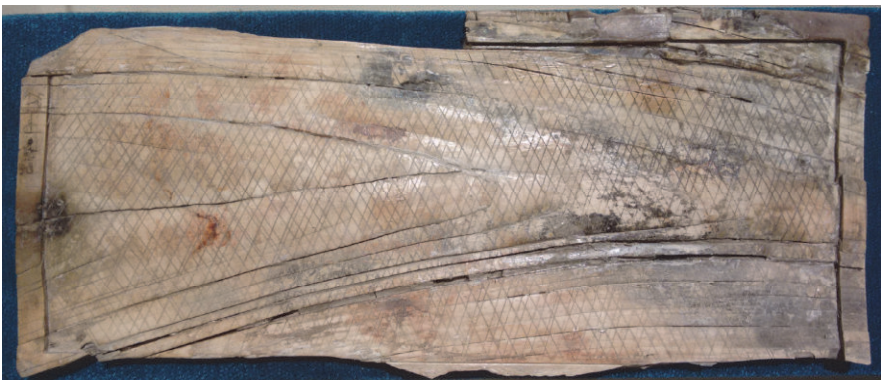

Fig. 8: One of the sixteen leaves of the ivory polyptych from Nimrud. Baghdad, Iraq Museum, IM 56967; photograph by the author.

4.2.3 Wax tablets in the classical world

Via the Levant, the technology of wax tablets spread from the Near East to the Mediterranean basin. As Laura Boffo and Michele Faraguna have recently reaffirmed,

> In the process of receiving and reworking the *phoinikeia grammata*, the Greeks did not simply learn a technique (or a 'technology') whose utility was perceived or intuitively understood

68 Cammarosano et al. 2019, 153–154, 162–166.
69 Cammarosano et al. 2019, 158–168.

> in the abstract. Instead, through close and prolonged contact with the 'Phoenicians' (a term that also includes Arameans and Levantines), they became familiar with a complex of social practices, of which writing was, in fact, only one element (though, in retrospective evaluation, certainly the most important one).[70]

It is therefore virtually certain that the Greeks encountered wax tablets at the same time as they came into contact with other writing materials used in the broadly defined 'Phoenician' world, including perishable ones such as papyrus, leather, and wood.[71] Indeed, the Greek word for wax tablet, δέλτος (*déltos*), has been argued to be a Semitic loanword ultimately deriving from Akkadian *daltu* ('door'), which was used metaphorically to refer to the leaf of a waxed board book.[72]

The large body of evidence available for wax tablets in the classical world includes texts, iconographic sources, and material culture, with approximately 2,600 known extant (fragments of) tablets and hundreds of styluses. However, their distribution is highly unequal. While textual and iconographic sources are available, albeit at different rates, for the entire span of time from archaic Greece to late imperial Rome,[73] surviving examples of wax and wooden tablets for the archaic and classical Greek periods are extremely rare (the wax tablets from Tomb II in Daphni, dated to the fifth century BCE, constitute an exceptional case; in Egypt, specimens written in Greek prior to the second century BCE are very rare). For the Hellenistic and Roman Periods, examples are mostly concentrated in a few well-defined contexts, in which particular environmental conditions allowed the conservation of wood: Hellenistic, Roman, and Coptic Egypt; the Vesuvian sites (Pompeii, Herculaneum, Puteoli, first century CE); and the corpora of Roman wax tablets from Dacia (second century CE), Vindonissa (first century CE), and Roman Britain (first/second centuries CE, mainly from London and Vindolanda; at the latter site, besides approximately 340 wax tablets we have around 1600 uncoated

70 Boffo and Faraguna 2023, 61 with n. 1 (my translation).

71 See again Boffo and Faraguna 2023, 63–68 for a clear and dense elaboration of the issue, with an updated and critically discussed bibliography. On pages 29–57, the authors offer an illuminating methodological discussion on the usefulness of comparing writing and archiving practices in the Greek world with those of the Near Eastern world.

72 Boffo and Faraguna 2023, 64–65, n. 21.

73 For terminology and contexts of use based on written sources, see Degni 1998; Ammirati 2013. For iconographic sources, Büll 1977, 821–829; Meyer 2009; Meyer 2023; Hartmann 2023. See furthermore the essays collected in Lalou (ed.) 1992b, 61–230. For a convenient overview, see Willi 2021, 49–55, 76–81.

wooden leaves – *tilia* – written in ink).[74] A particular case is that of the *Tablettes Albertini* from Djebel Mrata in south-eastern Algeria, dated to the fifth century CE during the Vandal reign, documenting the practice of reusing wooden tablets several times for writing in ink.[75] In addition to these main corpora of tablets, a considerable number of smaller corpora and isolated specimens come from the most varied areas of the Roman Empire.[76] Finally, there are the thousands of styluses for wax tablets, of metal but also of bone, and related accessories (spatulas, etc.).[77]

Fig. 9: Leaf from a Coptic wax book used in schooling, from Egypt, 5th c. CE (Würzburg, Martin von Wagner Museum, K1011, board 3); © Martin von Wagner Museum der Universität Würzburg; photograph: Christina Kiefer.

74 Major publications: Egypt: Brashear and Hoogendijk 1990; Pompeii: *CIL* IV Suppl.; Herculaneum: Camodeca 2017; Puteoli: Camodeca 1999; Dacia: *CIL* III/2; Vindonissa: Speidel 1996; Roman Britain: several, aptly listed and searchable at the Roman Inscriptions of Britain online database at <https://romaninscriptionsofbritain.org/>.

75 Courtois et al. 1952.

76 Useful catalogues are in Bartoletti and Pescini (eds) 1994; Hartmann 2015.

77 See recently Božič and Feugère 2004; Schaltenbrandt-Obrecht 2012; Willi 2021 with literature.

Wax tablets – commonly referred to in Greek as δέλτοι (*déltoi*) and in Latin as *tabulae ceratae*, *tabellae*, *cerae*, or *pugillares* – played a fundamental role in the writing practices of the Greco-Roman world, where they embodied the quintessential rewritable medium.[78] A symptom and consequence of this is their use as a metaphor for the human mind and memory – a metaphor attested as early as Aeschylus, and one that would persist in Western thought all the way to Sigmund Freud.[79] As is well known, wax tablets played a central role in the development of the parchment codex, thus having a decisive impact on a crucial aspect of the history of Western written culture.[80]

The ease with which wax tablets could be corrected and rewritten – by smoothing the surface with a spatula or another appropriate tool (Latin: *planare* ('to flatten'), on which see Serena Ammirati's contribution to this volume) – made them a privileged medium for taking notes and drafting compositions in progress. This, in turn, underscores their central role in literary composition processes.[81] For the same reason, they were widely used in educational contexts, especially in the Roman world, with important consequences for the development of individual handwriting that remain to be fully understood (Fig. 9).[82] Few palaeographers have reflected on the possible interaction between 'scratched' writing and ink writing in particular contexts.[83] Marc Smith has argued for wider-ranging, long-term effects of the technique, suggesting that the parameters of moving a stylus on wax contributed to the formation of Old Roman Cursive and that a partial shift from wax to papyrus in the second and third centuries CE helps explain the relatively sudden transition to the more fluent New Roman Cursive. Smith's hypothesis is based on experimental observations and on a parallel with the later and better documented transition, around 1300, from wax to paper, associated with comparable technical effects on cursive handwriting.[84]

78 Further kinds of 'erasable manuscripts' that were widely used in Antiquity were lead sheets (incised), coated wooden tablets (large and small, inscribed with ink or paint), and uncoated wooden tablets and sheets (the latter also known as *tilia*; either incised or written with ink or paint).

79 Sigmund Freud's well-known essay on human memory, 'Notiz über den „Wunderblock"' (1925), was inspired by a peculiar kind of wax tablet. On the wax tablet as metaphor for the human mind, see Small 1997; Julião et al. 2016; Agócs 2019.

80 Boudalis 2018, 21–34; see also his contribution to this volume.

81 Small 1997; Dorandi 2007; Pecere 2010; Del Corso 2016. The interaction between memorisation, orality and writing in textual composition is especially debated for archaic Greece; see Spelman 2019.

82 Cribiore 1996; Fioretti 2010.

83 Fioretti 2010, for Antiquity; Rouse and Rouse 1989b, 183–186, for the Middle Ages. See also Mullen and Bowman 2021, 41–42.

84 Smith 2003.

The ability to write without the need for ink and inkwell also gave wax tablets an advantage for writing outdoors and during travel. However, they were not used solely for drafting ephemeral texts. In the Roman Imperial Period, for example, they served up to the third century CE as the mandatory support for certain types of legal documents, such as contracts and testaments. The well-known *Senatus Consultum Neronianum* of 61/62 CE specifically prescribed special sealing and closure methods to prevent tampering and forgery of such documents.[85]

The different uses and contexts of wax tablets are reflected in the variety of their dimensions, their number of leaves, the techniques used to manufacture and join them, their closure and sealing mechanisms, and possible accessories, like the detachable stylus holders investigated by Georgios Boudalis in his contribution to this volume.[86] This diversity also extends to the materials, types, shapes, and sizes of the styluses that were the tablets' indispensable companions.[87] In many cases, wax tablets contained not only text inscribed with a stylus on the waxed surfaces but also inked writing on the outer pages (*scriptura exterior* or *ad atramentum*) or even along the edges, a fact that underscores their nature as a composite and complex manuscript form. Finally, a special type of wax tablet is the ivory consular diptych, widespread especially in Late Antiquity for ceremonial use.[88]

Greco-Roman wax tablets can be studied from multiple perspectives. While the fundamental task of reading and interpreting the traces of writing still present on them is primarily a palaeographic (or, if preferred, epigraphic) and philological endeavour, their study as artefacts requires a multidisciplinary approach. Ideally, this involves a combination of material analysis, codicological-technological examination, replication and experimentation, and consideration of available textual and iconographic sources. In this regard, it is worth emphasising that the critical editions and catalogues cited in the foregoing have been compiled from a philological perspective and therefore generally consider only those specimens that still bear traces of writing. In fact, no comprehensive repertory compiled from a material perspective has been published so far.[89]

85 Camodeca 2022.

86 Federici, Mita and Pezzano 1989 and Goodburn and Humphreys 2016 are among the few studies dealing with the techniques of manufacturing wooden wax tablets. Also see the ongoing project 'The Making of the Vindolanda Wooden Writing Tablets' at the British Museum, under the lead of Caroline Cartwright and Richard Hobbs (<https://www.britishmuseum.org/research/projects/making-vindolanda-tablets>).

87 Schaltenbrandt-Obrecht 2021; Willi 2021.

88 Büll 1977, 792–795; David (ed.) 2007; Cameron 2013, all with previous literature.

89 A database including the corpora from Vindolanda, London Bloomberg, Velsen I, Vechten, Valkenburg, Vindonissa, and Tasgetium has been compiled by Anna Willi in the frame of her

Similar considerations apply to the reconstruction of writing techniques. The composition of wax mixtures can be investigated through the analysis of preserved residues. Some specimens from Egypt have particularly well-preserved wax layers, as does the corpus of the *Tabulae Sulpiciorum*, though wax residues also appear in various other corpora in scattered specimens. Further insights can be drawn from textual sources and iconographic evidence, which are particularly useful for understanding the range of colours attested for wax mixtures. The standard base ingredient was consistently beeswax, most often mixed with soot or charcoal. Textual sources and archaeological reports also indicate the existence of tablets with a red-coloured wax layer, and special preparations are mentioned in textual sources.[90] The presence of resins, identified in analyses conducted in the 1970s by Reinhard Büll, still requires thorough investigation, as does the problematic case of the *Tabulae Sulpiciorum* from Puteoli near Pompeii, in which the mineralogist Selim Augusti has claimed shellac instead of beeswax was used – an assumption I consider impossible, if only for historical reasons (shellac arrived in Europe many centuries later), although a clear refutation based on hard data is still pending.[91]

The study of styluses is central to the reconstruction of writing techniques. A great number of examples survive, most made of metal and some of bone. Both the material and the shape of the writing tip play a crucial role, alongside the physico-chemical properties of the wax layer, in determining the execution and appearance of the incised strokes – one of the aspects most in need of further research.[92]

Finally, wax tablets also can be studied in their relationships and interactions with other types of media, both rewritable and non-rewritable. Given that wax tablets, coated wooden tablets, papyrus scraps, and ostraca were all, in principle, available, which type of manuscript was preferred, and based on what factors? In

project 'Tabulae Ceratae: An Object-Based Approach to Roman Stylus Tablets'. See her contribution to this volume, n. 8.

90 Consider, e.g., the term *maltha*, on which see Büll 1969; Büll 1977, 798–817.

91 See the provisional report by Fuchs, Ferreira and Cammarosano 2023. For the critical edition of the corpus, see Camodeca 1999.

92 A particularly illuminating and, in fact, unique study on this issue is provided by Gerlach 1965. Central to the reconstruction of the writing technique(s) used on wax tablets is the question of whether legibility was ensured by lighting contrast only (the strokes remaining within the wax layer without exposing the underlying wood), or, in some periods and contexts, 'by intentionally exposing the white surface of the wood below with the point of the stilus' (Collingwood and Wright 1992, 11, endorsed by Speidel 1996, 17; Tomlin 2016, 15–16). I plan to argue for the former hypothesis in a forthcoming paper.

a given context, what influenced the choice between writing down a preliminary, ephemeral draft versus a definitive and lasting version, and on which medium? These questions must be examined by distinguishing and specifying the roles of the various factors involved, ideally based on an interdisciplinary, careful analysis of available textual, iconographic, and material evidence.[93]

4.2.4 Wax tablets in the Middle Ages and Early Modern Period

The simultaneous use of various types of rewritable manuscripts observed for the classical world continued in Late Antiquity and medieval and early modern Europe, and wax tablets continued to play a fundamental role among them. Being produced in a bewildering variety of sizes, typologies, and specifics,[94] they continued to represent the medium of choice for the acquisition of writing, and therefore in school context, as a support for taking notes, especially in situations where the use of ink and inkwells was not ideal, such as working outdoors or while travelling, and in all contexts in which the written text required periodic corrections and updates, as with inventories and running accounts.[95] Some tablets have a composite writing surface, where one page (or part of a page) was made of (or provided with) a sheet of parchment or paper and the facing page (or another portion of the same page) was coated with wax. The former typically contained the 'stable' information, such as library book titles or the names of taxpayers, while the latter was meant to record corresponding temporary data to be updated regularly, such as loan and return dates or amounts paid and outstanding.[96] The impact of wax tablets as a writing medium extended to the field of science, as demonstrated by tablets' combination with sundials.[97]

Particularly notable is medieval authors' extensive use of wax tablets for the first drafts of literary compositions, taking advantage of the possibility to easily make corrections and thus revise the text until reaching the definitive version, which was then transferred to supports intended for long-term storage of the text (mostly parchment). This is what prompted Richard Rouse and Mary Rouse to

93 Extensive studies on this topic include Dorandi 2007 and Pecere 2010, with further references. For a concise but dense overview, see Del Corso 2016.

94 Büll 1977, 787–791, 838–853; Wozniak 2021.

95 Wattenbach 1896, 51–88; Gerlach 1965; Büll 1977, 785–894; Graßmann 1986; Rouse and Rouse 1989a; Rouse and Rouse 1989b; Lalou 1989; Lalou 1992a; Lalou (ed.) 1992b; Krüger 2003; Chartier 2007; Wozniak 2021.

96 Büll 1977, 790–791.

97 Schewe and Davis 2019.

state, 'The wax tablet, as a support for the written word, had a longer uninterrupted association with literate Western civilisation than either parchment or paper, and a more intimate relationship with literary creation'.[98] Both textual and visual sources provide compelling evidence of this role as a 'bridge' between thought or spoken word and writing intended for permanence. Examples range from the sermons that Bernardino of Siena held in 1427, preserved thanks to the shorthand notes – '*de verbo ad verbum*' ('word for word') – that a cloth-cutter named Benedetto di mastro Bartolomeo took on wax tablets while attending them, to famous depictions such as that of Pope Gregory the Great's *famulus*, poised to take notes on a *codex ansatus* (i.e. a wax-coated tablet with a handle) in the so-called *Gregorblatt*.[99] Another emblematic miniature, dated *c.* 1380, portrays the Flemish mystic Jan van Ruusbroec in two successive moments: first, outdoors, inspired by the Holy Spirit as he takes notes on a wax tablet analogous to that of Gregory's servant, and, later, indoors at his convent desk, transcribing his final text, based on his earlier notes, onto a parchment manuscript (Fig. 10).[100]

In both depictions, the wax is not black – as is typical in representations from Antiquity, the Middle Ages and the Early Modern Periods – but green. Some surviving medieval and early modern specimens also exhibit green wax. The preference for this colour is attested in written sources as well, the most notable being the poem the cleric Baldric of Dol (Baudri de Bourgueil, *c.* 1050 – 1130) dedicated to his own wax tablets ('Ad tabulas').[101] Baldric justifies his preference according to the aesthetic appeal and pleasantness of the green hue, as well as the significantly improved legibility of inscriptions on green wax compared to the more common black. This brings us back to the discussion in Sections 2.2 and 2.3 on the importance of the colour of the wax mixture. In the writing technique used for wax tablets, legibility depended uniquely on the interplay of light and shadow, making background colour, light intensity, and angle of illumination essential factors.[102]

98 Rouse and Rouse 1989a, 220.

99 Trier, Stadtbibliothek, Hs. 171/1626, tenth century CE.

100 Brussels, Koninklijke Bibliotheek van België, inv. no. 19.295–97, *c.* 1380 CE.

101 'As for the wax, it is old and black with grit, and this old wax disfigures your beauty. So you are less indulgent of the writer and resist his stylus as though you found it odious. Hence I am preparing green wax to replace the black, so as to make you more tolerant and friendly toward the scribe', translated and discussed in Chartier 2007, 3.

102 Cultural factors also played a role. On the importance of green in the context of early modern reading and writing practices, see Knight 2014, 28–30.

Fig. 10: The Flemish mystic Jan van Ruusbroec writing notes on a green-paste wax tablet in the woods, and copying them onto parchment upon his return to the monastery; Brussels, Koninklijke Bibliotheek van België, inv. no. 19.295–97, *c.* 1380.

The history of the wax tablet's decline is closely linked to the introduction and spread of paper in Europe, starting in the eleventh century. But the dynamic by which paper took over from wax tablets cannot be defined in terms of a simple one-to-one substitution: it was rather a complex process in which several factors had a role, including the availability of materials, balance between costs and benefits, established customs, and legal frameworks.[103] The issue of whether making corrections to the text already written would be necessary or not is also of importance: in some areas of use, paper substitutes wax tablets especially when combined with graphite pencil, which became widely available only from the seventeenth century on. Wax tablets therefore experienced different fortunes in different contexts. For example, in the German

103 See Thomas Wozniak's contribution to this volume.

area they remained in common use much longer than in Italy, broadly following the trajectory and spread of paper through the continent.[104]

Instances where wax tablet use persisted exceptionally long are linked to specific environmental conditions. In particular, their use in the administration of saltworks in cities where salt production played a significant economic role, such as Lüneburg, Schwäbisch Hall, and Halle (Saale), is documented as late as the nineteenth century (Fig. 11).[105] In Rouen, wax tablets remained in use for liturgical purposes until the eighteenth century and, remarkably, were still employed by the fish market superintendent as late as 1849.[106]

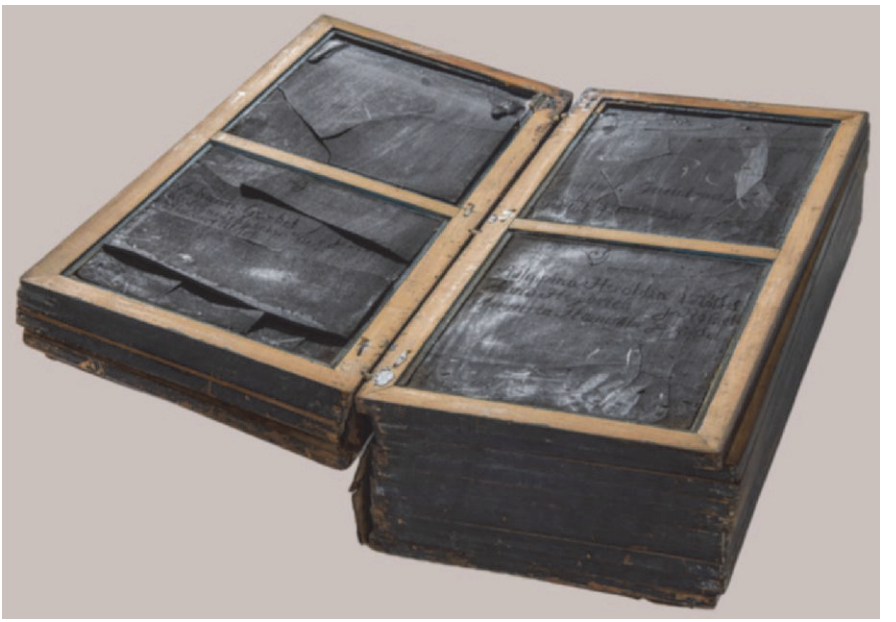

Fig. 11: A wax book from Halle (Saale), used for accounting purposes in a saltwork context, 17th c. CE, wood, wax mixture, and leather, 20 × 41 × 15 cm; photograph: Stadtarchiv Halle.

The specimens preserved for the Middle Ages and Early Modern Period are fewer than for Antiquity. Nevertheless, they are distributed over a wide chronological

104 Stallybrass et al. 2004, 385.
105 For Halle (Saale), see Büll 1977, 881–883; for Schwäbisch Hall, see Fehleisen 1919.
106 Büll 1977, 786, 845, figs 619–620.

and geographical span and show an extreme typological variety. Élisabeth Lalou published a useful inventory in 1992, now susceptible to updating.[107] Similar considerations apply to the styluses, which have come down to us in large numbers, made of bone and metal, and in exceptional cases also of wood, and with a great typological variety.[108] The number and density of the preserved evidence, both tablets and styluses, are highly uneven depending on time period and geographical area.

A holistic study of wax tablets in the Middle Ages and Early Modern Period should adopt the same interdisciplinary approach already discussed in relation to Antiquity. Many of the key issues requiring further investigation are similar to those identified for Antiquity, particularly the composition of wax mixtures and the factors influencing them, the manufacturing practices of different tablet types, the writing techniques employed, and the relationship between wax tablets and other media, especially ink writing on parchment and paper. Regarding the first of these aspects, it would be particularly interesting to explore the interactions and cross-influences between the mixtures used for writing tablets and those for other applications of beeswax, such as seals, ceroplastics, and encaustic painting. This could be done by examining the numerous preserved recipes – which rarely specify the described mixtures' intended applications – combined with material analysis of surviving specimens. While recent years have seen growing interest in the material study of medieval and early modern wax sealings, contemporary wax tablets have not received the same attention.[109] As a result, the campaign of material analysis conducted by Reinhard Büll in the 1960s and 1970s remains virtually the only source of archaeometric data for this class of manuscript.

The impact of wax writing on palaeographic development and individual handwriting styles also has been scarcely addressed, despite its potential relevance (see the considerations already made concerning Antiquity and Roman cursives, Section 4.2.3). Finally, much remains to be explored regarding the relationship between wax tablets and other types of reusable writing media in specific historical contexts. Various other rewritable supports were used alongside wax tablets, sometimes within the same settings. These include uncoated wooden tablets inscribed with carbon ink; slate tablets, whose use was concentrated in particular contexts;[110] and glass, though its application was limited.[111] Most notably,

107 Lalou 1992a.

108 Graßmann 1986; Merten 2009; Mårtensson 1962; Harjula et al. 2013–2015.

109 See, among others, Hahn 1995; Novotná and Dernovšková 2002; Bartl et al. (eds) 2015; Kasso et al. 2023.

110 Wozniak 2022.

important rewritable media were wooden tablets and parchment or paper sheets coated with a predominantly chalk-based layer, allowing inscriptions with carbon ink, chalk (and, in principle, also pastels and crayons), or metalpoint. It is precisely these 'erasable coatings' that are the focus of Section 5.

4.3 Material analysis of wax tablets

Several methods, both destructive and non-destructive, can be applied in studying wax mixtures in written artefacts:

- Optical microscopy and RTI help in observing the texture and details of artefacts, and can be employed for enhancing legibility in the process of text edition.
- 3D laser scanning microscopy can be used to precisely measure relevant features, such as shape and dimensions of written traces; optical and electronic scanning can be used for analysis of specific elements embedded in the wax mixture, such as hairs.[112]
- X-ray micro-radiography and micro-tomography can be used to inspect volumetry and morphological structures within the wax mixture,[113] and thus for accessing marks that may be present beneath the wax layer in wax tablets.
- A multi-analytical approach can be used for to characterise beeswax and added components, such as pigments, resins, and fats. This includes Fourier transform infrared spectroscopy (μ-FTIR), micro-Raman spectroscopy (μ-Raman), and scanning electron microscopy with energy dispersive spectroscopy (SEM-EDX) as well as mass spectrometry techniques, ideally used in combination.[114]
- Palynological analysis can be used to reveal traces of pollen and microorganisms nestled within wax blends. While the concept of genomic analysis holds promise for sequencing the DNA of honeybees and other organisms, the conventional techniques applied in extracting and processing beeswax normally result in a scarcity of genomic material of adequate quality.[115] Illumina high-throughput sequencing has proved useful for investigating microorganism

111 Wozniak 2024.

112 Charlier et al. 2016.

113 Karch et al. 2016.

114 See Hahn 1995; Regert, Langlois and Colinart 2005; Regert 2009; Serpico and White 2000; van den Berg et al. 2000; Ferreira et al. 2016; Tamburini et al. 2025.

115 Kasso et al. 2023.

and metabolite diversity in wax seals, and thus for better assessing biodeterioration processes.[116]

Ideally, the analysis should be able to distinguish the components originally present in the mixture from those that may have been added as a result of restoration and conservation processes (including resins and waxes, both natural and synthetic) and from possible breakdown products. In addition to the analytical methods listed above, compound specific radiocarbon analysis can be used for this purpose.

5 Erasable coatings

'Erasable coatings' encompass writing and drawing with materials such as carbon ink, chalks (including pastels and crayons), and metalpoint on surfaces coated for subsequent washing and rewriting. The coating, often chalk based, is the key element in the rewriting process, with the underlying surface, whether hard (wooden boards, pottery sherds) or soft (parchment, paper), playing a secondary role. While both coated and uncoated surfaces can be inscribed with the above-listed materials and then washed in order to be reinscribed, *ceteris paribus* the use of coated surfaces proves more effective.

The material aspects related to the use of erasable coatings for writing purposes are surprisingly under-researched. While metalpoint and related coatings have been a regular object of material analysis in art history and conservation studies in connection to drawing,[117] hardly any material analysis in relation to writing tablets is available,[118] and the same applies to replication and experimentation.[119]

116 Szulc et al. 2020.

117 See e.g. Duval et al. 2004; Burns 2012; Quintero Balbas et al. 2022.

118 But see Pietschmann 1898, 53–54 on ancient Egyptian boards: 'Traces of surface preparation can almost always be found on the wood, at least remnants of a light whitewash applied before writing. Not infrequently, the surface also consists of a gypsum or chalk base covered with a thin layer of linen, which is then coated again with a white pigment. This prepared surface, once smoothly polished, was often given an additional water-insoluble varnish to prevent the ink from spreading and to allow for easy washing. Over time, this varnish, similar to the one used on white-painted wooden or papier-mâché mummy cases produced in a similar manner, has often developed a yellowish tint' (my translation). See also the subsection by William Brashear in Brashear and Hoogendijk 1990, 24–25.

119 A partial exception is Stallybrass et al. 2004. Methods that can be employed for analysing these kinds of manuscripts include X-ray fluorescence (XRF) reflection, FTIR and Raman spectros-

5.1 Erasable coatings in ancient Egypt, the classical world, and the Qur'anic tradition

The practice of coating boards or sheets to enhance rewritability has ancient origins, notably in Old Kingdom Egypt, where coated tablets started to be extensively used in scribal schooling and note-taking (see, in Elena Hertel's contribution to this volume, Fig. 8).[120] As mentioned in Section 4.2, wax tablets were not used in Egypt before the Hellenistic Period, and it is no coincidence that the primary contexts of coated board use in Egypt are the same as for wax tablets in the Greco-Roman world, first and foremost the acquisition of writing in the school context, but also note-taking and as an aide-mémoire in performing rites.[121] Importantly, while up to around 1000 BCE tablets were regularly coated, from the Third Intermediate Period (starting 1070 BCE) onwards, their format became smaller and writing was normally applied directly to the wood.[122] The reasons for this change in practice are not known, but as a matter of fact in all subsequent periods we find both coated and uncoated writing tablets, often within the same contexts, as is still the case in the tradition of the Qur'anic school, which ultimately derives from the Egyptian use of this medium.

Coated wooden writing tablets are well documented in Greek and Roman contexts, with surviving examples primarily from Egypt[123] and evidence from literary sources for all areas.[124] Some of the terms used to refer to coated tablets explicitly point to a white-coloured coating (λευκώματα [*leukómata*], *tabulae dealbatae*, *alba*). One of the main contexts of use appears to have been the publication of notices, bills, and other texts of an intrinsically ephemeral nature, which were painted on large-format coated boards that were then washed and reused as appropriate.[125] Smaller-format tablets were also used and coexisted with other eminently rewritable media, first and foremost wax tablets and uncoated wooden tablets, but also, to some extent and with limitations, ostraca as well as papyrus

copy, ultraviolet and near infrared NIR reflectography, visible spectrophotometry, computer tomography, and laser scanning micro-profilometry. Additionally, vibrational spectroscopies are sensitive to both the chemistry and structure of the compounds of the coatings and of the writing substances (kindly pointed out by Claudia Colini and Stelios Aspiotis).

120 Pietschmann 1898; Vernus 1984; Brashear and Hoogendijk 1990, 21–33; Cenival 1992; Hagen 2013; Motte 2022.

121 For the last context of use, see Quack 2001, 305 with n.77.

122 Berkes et al. 2015, 384.

123 Brashear and Hoogendijk 1990.

124 Degni 1998.

125 Marichal 1992; Fioretti 2012, esp. 410–415. On the technique of writing with the brush, see also Donati 1998.

and parchment sheets. In Coptic Egypt, the simultaneous use of wooden tablets (both coated and uncoated) and wax tablets within the same monasteries and schools reflects the mingling of Egyptian and Greek traditions, and thanks to the favourable climate is witnessed in numerous extant manuscripts (Fig. 9).[126]

As mentioned above, wooden tablets as a tool for learning to write were adopted from Egyptian practice into the Islamic world, where it became inextricably linked with the Qur'anic school. The specific writing techniques used in Qur'anic schools across different countries and locations throughout the history of Arab-Islamic traditions vary, as do the types of wood employed. While some traditions have pupils write directly in ink on wood (as in the Qur'anic schools of northern Nigeria discussed in Andrea Brigaglia and Dahir Lawan Mu'az's contribution to this volume), others use tablets with a coating, which itself appears in numerous variations. In addition to plaster, similar to what is attested in ancient Egypt, Antiquity, and medieval Europe, late-nineteenth-century Mozambique provides evidence of a coating made from a dried and powdered marine plant.[127] A fascinating chapter in Geert Mommersteeg's *In the City of the Marabouts* describes the practice in Djenné, Mali, of coating tablets with a layer of mud, which, once dried, serves as the writing surface in the initial stages of Qur'anic education (Fig. 12). First, the teacher writes in ink the passages the pupil must memorise. Then, using a sharp wooden stylus, the teacher incises the text, creating grooves for the student to trace over in ink.[128] Finally, the student fill in the traces with ink directly on the dried-mud layer. Throughout these stages, each time a lesson is successfully completed, the tablet is washed, allowing the mixture of mud, ink, and water to drain into a special jar, the contents of which are later disposed of according to Qur'anic guidelines. The tablet is then ready to be coated with a fresh layer of mud and reused. Finally, a thirteenth-century technical treatise compiled by Abū Bakr Muḥammad b. Muḥammad al-Qalalūsī describes how to prepare clay crayons for teaching, arguably used on erasable Qur'anic tablets (but quite possibly on other surfaces as well).[129]

126 Pintaudi and Sijpesteijn (eds) 1989.

127 According to an account published in 1901 and quoted in Bonate 2016, 98: 'For writing, instead of paper they use a flattened rectangular wooden board, more or less half a meter of length, which is called *nimbao*; it is whitewashed with a type of lime made of some marine plant, which is sun-dried and reduced into powder in stoop; the ink is made of cinders dissolved in water. When *nimbao* is full of characters [i.e. writing], they wash it, and whitewash again. The pen (*m'tati*) is made of the stalk of a narrow corn [millet]'.

128 Such a method is attested in other traditions as well: Quintilian, for instance, describes a similar technique for teaching writing, though in his case, the grooves were incised directly into the wood; see Fioretti 2010, 7–8.

129 See Sara Fani's contribution to this volume, Section 2.

Fig. 12: Lessons at a Qur'anic school in Djenné, Mali, using mud-coated writing tablets. An advanced student scratches the Qur'anic text into the layer of mud, and a pupil will subsequently fill in the traces with ink. After a passage has been thoroughly learned, the tablets are ritually washed, and a new layer of mud can be applied (pupil on the left). From Mommersteeg 2012, 41–42.

5.2 Erasable coatings in the Middle Ages and Early Modern Period

Turning back to the Western tradition, the evidence for coated tablet use in Late Antiquity and the Early Middle Ages is very scarce, while it becomes abundant from the High Middle Ages onwards, encompassing textual and iconographic sources as well as several extant examples.[130] Importantly, coatings were now applied also to sheets (of parchment and paper) in addition to wooden tablets, and, alongside ink, paint, and chalk, they were also inscribed in metalpoint. The practice is famously described by Cennino Cennini in his *Il libro dell'arte*, where it is explained how to prepare a paste made of bone ash and saliva for spreading over a wooden tablet – preferably boxwood or figwood – on which one could draw using a silverpoint stylus.[131] Cennini further explains that with a stylus made of lead or a lead-tin alloy, one could also draw directly on wood, as well as on paper and parchment, and that the marks could be easily erased using a bit of fresh bread.[132] While Cennini addresses aspiring artists, we know from numerous written sources, including technical literature, that this technique was also widely used for writing and calculating.[133]

As far as the coating is concerned, many variants are attested, and the same applies to the metals and alloys used for drawing or writing. 'Recipes' for coating and metalpoint writing can be found in several manuscripts from the Middle Ages and Early Modern Period besides *Il libro dell'arte*. The relevant sources include miscellaneous texts, Edward Norgate's and Theodore de Mayerne's notorious art-technical treatises, and calligraphy handbooks of the seventeenth and eighteenth centuries.[134]

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130 Wattenbach 1896, 91–96; Rosenfeld 2002, 55–60.

131 Cennini, *Il libro dell'arte*, §§ 5–8, 10–12, ed. Ricotta 2019, 156–159.

132 Using bread as an eraser was widespread up to the twentieth century. Importantly, silverpoint is by no means easily erasable, differently than lead or lead-tin, which is why Leonardo recommended young artists sketch models in silverpoint in a notebook with gesso-coated pages (e.g. Chapman and Faietti (eds) 2010, 40; Leonardo da Vinci, *Trattato della pittura*, § 175, ed. Milanesi 1890, 73).

133 The fundamental literature on metalpoint includes Meder 1923, 72–100; Watrous 1957, 3–33; van de Wetering 1991; van de Wetering 1997, 46–73; Woudhuysen 2004; Stallybrass et al. 2004; Burns 2012.

134 See, for example, a recipe for producing parchment noteboards ('de tabulis ex pergameno') in the *Liber illuministarum* from Tegernsee (*c.* 1500), Munich, Bayerische Staatsbibliothek, Cgm 821, Bartl et al. (eds) 2005, with commentary to the recipe by Doris Oltrogge on pages 653–656; a recipe 'to make white tables to write in with the pointe of a wire, such as come out of Germanie' in the *Secrets of Alessio Piemontese* (1555, cited in Stallybrass 2006, 559, n. 22); recipes nos 55 and 57–59

Tablets and sheets with an erasable coating for writing in ink and metalpoint were often combined into pocket-sized notebooks. They were typically labelled with terms derived from Latin *tabula* – such as *tavolette*, *Schreib-Tafeln*, *Tafeletten*, *tables*, *tablets*, and *table-books*. They offered the advantage of easy erasability – particularly when using lead styluses – alongside an ink-free writing technique, making them highly portable and convenient, especially for outdoor use and even while riding. This explains their growing popularity, especially among merchants, professionals, and travellers, as well as anyone in need of a practical way to take notes without the inconvenience and mess of ink and inkwells. During the sixteenth century, erasable notebooks were mass-produced and circulated widely, especially in Northern Europe, with the Netherlands being one of the main production centres. They often included not only erasable pages but also calendars, almanacs, lists of fairs with their respective dates, exchange rate tables, and reproductions of coins – features particularly useful for merchants and travellers. In many cases, the metal stylus could be conveniently stored and secured within the notebook itself using dedicated loops and compartments, as evidenced by the few surviving examples and numerous iconographic sources. In a well-known article, Peter Stallybrass, Roger Chartier, J. Franklin Mowery, and Heather Wolfe 'rediscovered' what had been perfectly obvious to William Shakespeare's original audiences until the nineteenth century – namely, that Hamlet's reference to the 'table of my memory' (Act I, sc. v, l. 105) directly alludes to these erasable notebooks.[135] The earliest known example of this kind of notebook, identified by Peter Stallybrass, was made in Antwerp in 1527,[136] and the famous *Portrait of a Man, possibly Jan Snoeck* (*c.* 1530) by the Antwerp artist Jan Gossaert features an almost identical notebook, possibly bound by the same binder (Fig. 13).

in the De Mayerne manuscript (London, British Library, Sloane 2052), ed. Berger 1901, 152–154; and a recipe by Robert Hooke (British Library, Sloane 1039, fol. 117^{r}, cited in Yeo 2014, 20). Neither have such sources ever been collected and discussed systematically (see the 'appeal to interested young researchers' in van de Wetering 2016, 305), nor has this topic ever been addressed from the perspective of palaeography and manuscript studies. In his groundbreaking book *Rembrandt: The Painter at Work*, Ernst van de Wetering (1997) highlights the importance of metalpoint notebooks to art history, which has received growing attention in recent years. Their relevance for manuscript studies, by contrast, has never been thoroughly investigated.

135 Stallybrass et al. 2004; but also see the much earlier Hone 1827, 1.

136 According to the title page of the enclosed almanac, 'Item you may write here with a stylus of gold, silver, tin, copper, or brass, and you may erase [what you have written] with a wet finger. And when you have worn out [the erasable surface], so that you cannot write on it any more, you can get it repaired by Jan Severszoon, parchment maker, for a little money, and you can then write on it as if it was new. […] Item if you get grease on it by erasing with your finger, you should use a clay sponge [*cleyspongie*] with a little flour, and the grease will come off' (after Stallybrass 2006, 558).

Fig. 13: Erasable notebook, Antwerp, 1527, The New York Public Library, Spencer Collection, Neth. 1527 94-143. Jan Gossaert, *Portrait of a Man, possibly Jan Snoeck*, *c.* 1530, Washington DC, The National Gallery of Art, accession no. 1967.4.1.

In the late eighteenth and nineteenth centuries, this kind of surface was often called ‘asse’s skin’ and was made of paper or parchment coated with gesso mixed

with glue.[137] Sometimes, an additional layer of varnish was applied, making erasure with a damp sponge or cloth even easier and more effective – not only for metalpoint writing but also when writing with ink. In view of Richard Pietschmann's observations about ancient Egyptian coated wooden boards (see Section 5.1), comments by De Mayerne on 'recipes' nos 58 and 59 are particularly interesting. Commenting on an Italian recipe 'A far tacco la bianca per scriuer con stil d'ottone, come i libbrettj da conto che vengono d'Allamagna',[138] which describes the process for producing a coating made of gypsum, animal glue, and white lead, he notes:

> After adding oil, the material does not allow writing with the brass stylus, but it can be written on with ink. The ink should also be made from lamp black and gum, without vitriol, as it [i.e. iron-gall ink] adheres too strongly and is difficult to remove.[139]

Similarly, remarking upon an analogous recipe immediately after that, De Mayerne notes:

> On parchment, paper glued to a board, or canvas stretched on a frame, apply lead white and ochre ground with drying oil or half-thickened linseed oil using a large, soft brush. Do not let it dry completely. Then sprinkle burnt bones and finely ground eggshells over it, as is done with smalt. Let it dry thoroughly. You can then write on it with a copper, silver, or lead stylus and remove the writing by washing. However, for writing with a pen, apply a layer of varnish.[140]

This technology must now be painstakingly reconstructed through mostly indirect sources, since the once common manuscripts associated with it have largely disappeared due precisely to the ephemeral nature of the texts and drawings they contained. It holds significance not only for the history of writing and disciplines such as codicology and palaeography but also for various aspects of cultural and cognitive history. In his book *Notebooks, English Virtuosi, and Early Modern Science*, Richard Yeo shows how various kinds of erasable notebooks played an important role in the complex process of note-taking and knowledge management

137 Burns 2012, 144–147 with literature; Stallybrass 2006, 558–561; Yeo 2014, 20. For the results of a replication test, see Stallybrass et al. 2004, 382 with figs 3–8 and 388 with n. 36.

138 'To make the white (coating) more adhesive for writing with the brass stylus, like in the notebooks for counting that come from Germany' (my translation). See Berger 1901, 154–155.

139 Berger 1901, 154–155, my translation. The alleged difference in the erasability of carbon versus iron-gall ink is particularly intriguing, given experimental observations made by others (see Colini and colleagues' contribution to this volume), and prompts additional, systematic investigation.

140 Berger 1901, 154–155, my translation.

that led to the emergence of modern science in the scholarly circles of early modern England, citing various recipes for erasable paper coatings collected by Robert Hooke, John Locke, and other leading members of the Royal Society.[141] And in recent years, Ray Schrire has been investigating the crucial role of rewritable surfaces and their associated practices in the social history of early modern popular numeracy.[142]

Coated tablets and sheets of various formats coexisted with other types of rewritable manuscripts: the 'poorest' and most elementary type, the uncoated wooden tablet inscribed with ink; slates, whose use however is concentrated in specific contexts;[143] and ivory[144] and glass,[145] of limited use. A context in which the coexistence and interplay of all these techniques is exemplarily attested is that of musical drafts in the Middle Ages and Early Modern Period, explored by Randall A. Rosenfeld, expanding on work by Jessie Ann Owens and others.[146] Besides memory, composers used wax tablets, 'correctable' slates, coated tablets and sheets, and lead on uncoated parchment or paper as rewritable supports for sketches and drafts of their music, variably referred to with terms like *cartelle*, *tabelle*, *tabulae compositoriae*, and more. Rosenfeld's considerations in respect to music composition apply to the field of writing and note-taking as well, and may serve both as an apt conclusion for the present study and as encouragement for future ones:

> The relative frequency of use of the different sorts of correctable support, with respect to one another, has been poorly calculated. […] Basic research is still required on many aspects of these technologies, apart from any consideration of their use in the composition or transmission of music. […] Perhaps the most important questions arising out of this research are how these technologies may have affected composers' working methods, the teaching and *Überlieferungsgeschichte* of music, and even musical style. Eventual answers to those questions should not invoke a strict technological determinism except as a last resort, for without first taking into account the human element in these technologies (i.e. the level of

141 Yeo 2014, esp. 20–21, 104–105.

142 See Ray Schrire's blog post 'The Mystery of Humphrey Walcot's Grocery Bill and Early-Modern Popular Numeracy', Folger Shakespeare Library, 18 November 2021, <https://www.folger.edu/blogs/collation/humphrey-walcots-grocery-bill/>, and cf. the comparable and in many aspects analogous picture seen for Sanskrit mathematics recalled in Section 2.1 above.

143 Wozniak 2022.

144 Stallybrass 2006, 555–558.

145 Wozniak 2024.

146 Rosenfeld 2002.

skill that can be achieved by experts, and the degree of flexibility in the results they produce), the technologies cannot be said to have been fully understood.[147]

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147 Rosenfeld 2002, 58, 60.

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Abbreviations

CIL = *Corpus Inscriptionum Latinarum*, Berlin: Reimer / De Gruyter, 1862–.

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