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Late Hellenistic and Early Roman Invention and Innovation: The Case of Lead-Glazed Pottery

KEVIN GREENE

Abstract

The western production of lead-glazed pottery began in Asia Minor during the first century B.C.E. Examining this topic offers insights into invention and innovation in a period frequently dismissed as technologically stagnant and invites questions about why lead-glazed pottery did not come into general use in Europe until the Medieval period. The identification of this pottery with the *rhosica vasa* mentioned by Cicero and Athenaeus highlights difficulties in reconciling documentary sources with material culture. Lead-glazed pottery is discussed in terms of chronology, function, and production technology. Contemporaneous developments in glass and metalwork suggest cognitive synchronization among workers in different materials. The trajectory of invention, innovation, and diffusion of lead-glazed pottery is compared with that of other Greek and Roman technologies.*

INTRODUCTION

The production of lead-glazed pottery in Late Hellenistic and Early Roman Asia Minor in the first century B.C.E. was “an unprecedented experiment that broke from the 1,500-year-old tradition in the Near East of glazing ceramics with an alkaline flux.”¹ Firm evidence for the long-suspected manufacture of lead-glazed pottery at Tarsus was recovered from excavations at Gözlü Kule in the 1930s and prepared for publication by Frances Follin Jones.² Jones also wrote an article equating this glazed pottery with the *rhosica vasa* (Rhosic Ware) mentioned by Cicero,³ while scientific analyses confirmed that it had a high lead content similar to that of medieval and later pottery.⁴ This paper explores the “dialectical relationship between the microlevel

of research and the grand theories that provide its research context.”⁵ It places lead-glazed ceramics into a theoretical framework and relates the results to wider economic, technological, and cultural questions.⁶

CHARACTERISTICS OF EARLY LEAD-GLAZED POTTERY

The most common lead-glazed vessel made in Asia Minor in the first centuries B.C.E. and C.E. was the skyphos, a two-handled hemispherical bowl with a low footring (fig. 1). Skyphoi greatly outnumbered bowls with a pedestal foot and flared rim (kantharoi) and jugs (lagynoi) (fig. 2). The surfaces of these bowls are covered by a thick glaze, normally green on the outside and yellow on the inside. Like Hellenistic “Megarian” bowls and decorated Roman terra sigillata (figs. 3, 4), most bowls were formed in a concave clay mold whose inner surface had been impressed with stamped ornamentation.⁷ The mold was mounted on a potter’s wheel, and once plastic clay had been pressed firmly into the negative relief decoration, the interior could be smoothed and a rim formed by conventional wheel-throwing. After drying, the bowl was removed from the mold, and the handles and footring added before final drying and the first firing.⁸ The glaze mixture was applied to this “biscuit-fired” vessel, which was fired a second time using kiln equipment that prevented it from sticking to other vessels.⁹

The beginning of production is assigned to the first half of the first century B.C.E. on typological and documentary grounds. The earliest vessels from Tarsus have

* Marc Walton kindly sent me a copy of his unpublished D.Phil. thesis; Mark Jackson, Helen Loney, Paul Roberts, Susan Rotroff, Susan Sherratt, Glenn Storey, and Kathleen Warner Slane commented on early drafts of this paper. Julia Greene, T. Douglas Olson, Philip van der Eijk, Michael Vickers, and Jaap Wisse offered enlightening suggestions about the interpretation of extracts from Cicero and Athenaeus. Editor-in-Chief Naomi J. Norman and the *AJA*’s anonymous reviewers provided valuable suggestions for improvements. I am particularly grateful to the British Academy for supporting my research into aspects of the Roman economy. This paper is dedicated to the memory of Andrew Sherratt (1946–2006), who encouraged me to place Roman technology into a wider

cultural and chronological context.

¹Walton 2004 (abstract).

²Goldman 1950, 191–96.

³Jones 1945.

⁴Caley 1947.

⁵Woolf 2004, 422.

⁶As recommended in Greene 2005.

⁷Hochuli-Gysel 2002, 319, figs. 13, 14.

⁸A small number of figurines (Jeammet 2005, 196, figs. 526, 527) and vessels with particularly high relief decoration or asymmetrical shapes were made in two-piece molds.

⁹Hochuli-Gysel 2002, 313, figs. 1, 2.



Fig. 1. Roman fine wares: *left*, molded lead-glazed skyphos from Asia Minor, ht. 7 cm; *center front*, wheel-thrown thin-walled beakers from Italy and Spain; *center rear*, “Cnidian” Relief Ware wine container; *right*, lead-glazed askos from Italy (© The Trustees of the British Museum).

stylistic relationships to Megarian bowls, Pergamene Relief Ware, and molded Eastern Sigillata A current in the second and first centuries B.C.E.¹⁰ A single fragment of a Megarian bowl with a lead glaze from the Agora at Athens confirms that glazing had been introduced before these bowls went out of production (see fig. 4).¹¹ In Italy, Megarian bowls remained in production until about 50 B.C.E., and their makers occasionally added higher rims, narrow necks, and handles to the basic bowl form to create skyphoi and lagynoi of types familiar in lead-glazed ware.¹² If lead-glazed pottery is equated with the *rhosica vasa* mentioned by Cicero, then production must have been under way near Rhosus in Syria before 50 B.C.E.

However early production actually started, dating evidence for lead-glazed pottery is concentrated in the

Augustan period, whether on production sites (such as Tarsus or Perge) or on those to which it was distributed. Production spread from Asia Minor to Italy and Gaul, where lead-glazed pottery was manufactured in Lyon by ca. 20 B.C.E.¹³ Hochuli-Gysel’s comprehensive survey of early glazed pottery and its decoration included skyphoi and related vessels made in Italy as well as Asia Minor¹⁴ but did not pursue new forms and industries that continued and developed in Italy and Gaul in the first century C.E.¹⁵ Lead-glazed pottery fell out of use in Asia Minor and around most of the Mediterranean until the Early Medieval period, but it had a long and complicated history in the western provinces.¹⁶ Its production only became numerically significant in a small area along the upper and middle Danube in Late Roman times.¹⁷

¹⁰ Hochuli-Gysel 1977, 143–44. A wide range of Hellenistic and Early Roman relief wares is illustrated in Brusić 1999.

¹¹ I am indebted to Susan Rotroff for drawing my attention to this vessel.

¹² Puppo 1995, 30, pl. 5 (L7, L8).

¹³ Desbat 1986.

¹⁴ Hochuli-Gysel 1977, updated in 2002.

¹⁵ Greene 1979, 86–105; Hochuli-Gysel’s (1998) report on finds excavated at Winterthur in Switzerland is an exemplary account of Gallic products.

¹⁶ Maccabruni 1987.

¹⁷ *Acta Cretariae Romanae Fautorum* 34 (1995); Cvjetičanin 2006.

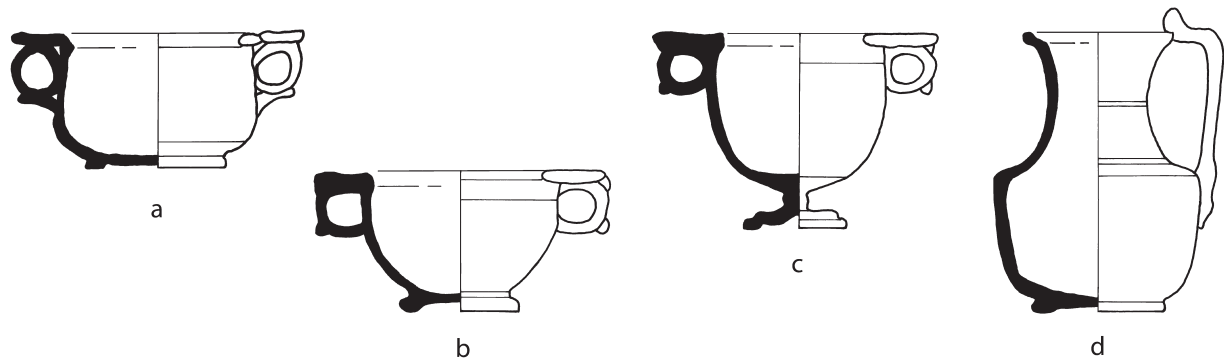


Fig. 2. Forms of early lead-glazed pottery manufactured in Asia Minor and Italy, ca. 50 B.C.E.–50 C.E. (scale ca. 1:4): *a, b*, skyphoi; *c*, kantharos; *d*, lagynos (drawing by S. Severn Newton; after Hochuli-Gysel 2002, fig. 3, nos. 1–3, 11).

TECHNOLOGICAL CHANGES IN HELLENISTIC AND EARLY ROMAN CERAMICS AND GLASS

Rostovtzeff believed that lead-glazed ceramics emerged in the first century B.C.E. because “improvements and discoveries were in the air and that the way had been prepared for them by a long series of experiments.”¹⁸ Ceramics and glass certainly did undergo interesting developments:

1. A new decorated bowl (traditionally described as “Megarian”) was being made in Athens by 200 B.C.E., in a new type of concave mold mounted on a potter’s wheel.¹⁹
2. By 100 B.C.E., production centers in Syria and/or Asia Minor were making tablewares with an oxidized red slip,²⁰ ending the long dominance of black tableware in Greece and its cultural outposts.²¹
3. At some point in the first century B.C.E., potters in Asia Minor began to add a thick, vitreous lead glaze to relief-molded and hand-decorated bowls and also to occasional molded figurines.²²
4. Glass vessels had been manufactured since the mid second millennium B.C.E. by coiling heat-softened strips over a clay core or by casting solid vessels and drilling out their interiors.²³ By Hellenistic times, bowls were being made by sagging a disc of hot glass either into a mold or over a form that could be rotated on a wheel for accurate shaping.²⁴ Around 50 B.C.E., in Syria,

Palestine, or an adjacent area, it was discovered that molten glass on the end of a tube could be distended by blowing.²⁵ Within a century, larger vessels were made in this way, and elaborate relief ornamentation was added to the exterior of some by blowing them into a multipiece mold.²⁶

The new ceramic techniques were soon transferred from Hellenistic Greece and Asia Minor to Italy and other centers and remained in use until late antiquity. Glassblowing spread throughout the Roman empire, transforming a previously labor-intensive handicraft into an industry that could turn out unprecedented numbers of drinking, serving, and storage vessels.²⁷

APPROACHES TO THE INTERPRETATION OF EARLY LEAD-GLAZED POTTERY

Documentary Sources

How should we explain the sudden appearance of a new ceramic technology? The experiments that led Böttger to create Meissen porcelain in 1708/1709 are well documented,²⁸ but ancient references to Greek and Roman technology are sparse, and none refers to the invention of lead-glazed pottery. Rotroff’s explanation of the invention of Megarian bowls shows how historical events exert power over silent material culture:

It is likely that vessels carried in honor of King Ptolemy III in Athens would have been imported from Alexan-

¹⁸ Rostovtzeff 1941, 1024.

¹⁹ Rotroff 1982.

²⁰ E.g., Meyer-Schlichtmann 1988; Lund 2005.

²¹ Sparkes and Talcott 1970. Although its surface is described as a “glaze” by Greek pottery specialists, it was formed by the reduction firing of an iron-rich slip, which fused but never formed a vitreous glaze. “Gloss” is a preferable term for fused slips because most dictionary definitions of glaze accen-

tuates transparency.

²² Walton 2004.

²³ Goldstein 1979, 26–9.

²⁴ Stern and Schlick-Nolte 1994, 71–81.

²⁵ Israeli 1991.

²⁶ Stern 1995.

²⁷ Stern 1999.

²⁸ Hoffmann 1985.



Fig. 3. Contrasting surface finishes on provincial Roman fine wares from sites in Austria, first to third centuries C.E.: *left*, molded terra sigillata bowl with red slip; *center*, wheel-thrown beaker with black slip and painted motifs, ht. 25.5 cm; *right*, wheel-thrown jug with molded details and lead glaze (© Kunsthistorisches Museum, Vienna).

dria, one of the foremost centers for the production of precious metalwork. They would have been seen by large numbers of Athenians and excited widespread admiration in the city. A shrewd and enterprising Athenian potter might well have recognized a market for cheap imitations of the magnificent gold and silver bowls. If this is so, we can date the first Athenian moldmade bowls in the year 224/3.²⁹

Surprisingly, documentary evidence that has possible relevance to lead-glazed pottery does exist.³⁰ An economic survey of Asia Minor published in 1938 suggested that archaeologists might pursue “the ware of Rhosus of Cilicia, a sample of which Atticus expected Cicero to send him.”³¹ Since the port of Rhosus lay across the Gulf of Iskenderun from Tarsus, Jones considered each kind of pottery recently excavated at Tarsus and Antioch. She concluded that glazed pottery was the only novelty current in the mid first century B.C.E. that could have caught the attention of Cicero or Atticus, and that “the glassiness of its texture and appearance” would have intrigued purchasers otherwise unimpressed by pottery.³² Her conclusion has been widely accepted, with the result that Cicero is

frequently cited as confirmation that lead-glazed ware was already in production by ca. 50 B.C.E.³³

Rhosica Vasa in Cicero Ad Atticum 6.1.13. While governor of Cilicia in 50/1 B.C.E., Cicero wrote to his friend Atticus in Rome, “I have ordered the Rhosian ware—but see here, what are you up to? You give us bits of cabbage for dinner on fern-pattern dishes and in magnificent baskets. What can I expect you to serve up on earthenware?”³⁴ The bald statement “*rhosica vasa mandavi*” does not tell us whether the vessels were ordered for Cicero himself or for Atticus, and gives no indication of the material from which they were made. After an informal “*sed heus tu! quid cogitas?*” Cicero describes Atticus’ serving vessels, again without naming the material. “Fern-pattern dishes” sound like vessels decorated with leaves in a familiar Hellenistic manner,³⁵ while “magnificent baskets” echo baskets made of gold in imitation of intertwined reeds used when dining in Italian style at the court of King Masinissa of Libya (Ath. 6.229d). The contrast between elaborate serving vessels and “bits of cabbage” refers to Atticus’ well-known habit of serving cheap food on expensive plates.³⁶ Most commentators have deduced that *rhosica vasa* were made from earthenware because of the reference to *vasis fictilibus*.

Athenaeus Deipnosophistae 6.229c. In 1987, Hans discussed another reference to *rhosica vasa* in Athenaeus’ *Deipnosophistae*, an account of a fictional dinner party during which guests discussed many questions about dining practices. Despite problems and ambiguities, Hans endorsed Jones’ identification of these vessels with the lead-glazed pottery excavated at Tarsus. Although the key passage was written ca. 200 C.E., it included a quotation from a lost work by Juba II, king of Mauritania (ca. 50 B.C.E.–23 C.E.):

Down to Macedonian times people at dinner were served from utensils of crockery, as my compatriot Juba says. But when the Romans shifted their mode of living in the direction of greater luxury, Cleopatra, who caused the downfall of the Egyptian monarchy, in imitation of the Romans gave up her mode of living. But not being able to change the name, she called a silver or gold vessel “crockery” pure and simple, and used to bestow such “crockery-ware” upon her guests at dinner to take home; and this ware was of the most

²⁹ Rotroff 1982, 13. This date is restated in Rotroff 2006, 357, 363.

³⁰ Full resolution of the problems and ambiguities of this documentary evidence is not essential to the analysis of the invention and subsequent history of lead-glazed pottery that follows.

³¹ Broughton 1938, 832.

³² Jones 1945, 47.

³³ Gabelmann 1974, 261; Atik 1995, 18.

³⁴ Cic. *Att.* 6.1.13 (Shackleton-Bailey 1968, 91): “*Rhosica vasa mandavi. sed heus tu! quid cogitas? in felicitatis lancibus et splendidissimis canistris holusculis nos soles pascere: quid te in vasis fictilibus appositurum putem?*”

³⁵ E.g., Strong 1966, pl. 31A, B.

³⁶ Shackleton-Bailey 1968, 247.

costly kind; for the Rhosic ware, which is the most gaily decorated of all, Cleopatra used to spend five minas every day.³⁷

Juba should have been well informed about the court of Cleopatra, as he was her son-in-law. Athenaeus had already quoted Socrates of Rhodes as evidence for the opulence of Cleopatra's precious metal tableware and for the lavishness of gifts bestowed on dinner guests (Ath. 4.147e–148b). Her generosity has been taken at face value by Thompson, who paraphrased the statement as “the gold and silver plates she gave them to take home she called plain crocks or *keramos*.”³⁸ The principal problem with considering Cleopatra's “crockery” and Rhosic Ware as pottery is that the passage is part of a discussion of the question, “[c]an we prove that the ancients used silverware at their dinners?” (Ath. 6.228c). The point of stating that Cleopatra “called a silver or gold vessel ‘crockery’” is that she did use metal plate. In book 11 (an extended study of the etymology of the names of table vessels), one of Athenaeus' diners states, “[w]e must beg to be excused from earthenware cups. For Ctesias says that ‘among the Persians any man who falls under the king's displeasure uses earthenware drinking-cups’” (Ath. 11.464a).³⁹ Athenaeus would therefore have been aware that a gift of pottery could be construed as an insult.

Was Rhosic Ware Made from Lead-Glazed Pottery?

Cicero and Athenaeus were separated by as much time as Shakespeare and Dickens, and wrote in different languages; Athenaeus does not appear to have known Cicero's letter to Atticus. Shackleton-Bailey's assertion in 1968 that *rhosica vasa* were “expensive, gaily decorated pottery”⁴⁰ was based solely on his knowledge of what Athenaeus wrote ca. 200 C.E., 250 years after Cicero. Likewise, Hans' statement in 1987 that Rhosic Ware was “very probably lead-glazed pottery”⁴¹ was based on Jones' 1945 article, not on what Athenaeus himself said. We should be careful to use the original sources rather than allow modern interpretations to prop each other up in a rather circular manner.

³⁷ Ath. 6.229c (Gulick 1929, 32–3): “μέχρι γὰρ τῶν Μακεδονικῶν χρόνων κεραμίοις σκεύεσιν οἱ δειπνοῦντες διηκονοῦντο, ὡς φησὶν ὁ ἐμὸς Ἰόβας. μεταβαλόντων δ' ἐπὶ τὸ πολυτελέστερον Ῥωμαίων τὴν διαίταν κατὰ μίμησιν ἐκδιαιτηθεῖσα Κλεοπάτρα ἢ τὴν Αἰγύπτου καταλύσασα βασιλείαν τοῦνομα οὐ δυναμένη ἀλλάξει ἀργυροῦν καὶ χρυσοῦν ἀπεκάλει κέραμον αὐτὸ κεραμᾶ τ' ἐπεδίδου τοιαῦτα ἀποφόρητα τοῖς δειπνοῦσι· καὶ τοῦτ' ἦν τὸ πολυτελέστατον· εἰς τε τὸν Ῥωσικὸν εὐανθέστατον ὄντα κέραμον πέντε μνᾶς ἡμερησίας ἀνήλισκεν ἡ Κλεοπάτρα.”

³⁸Thompson 2000, 83–4. I am grateful to T. Douglas Olson

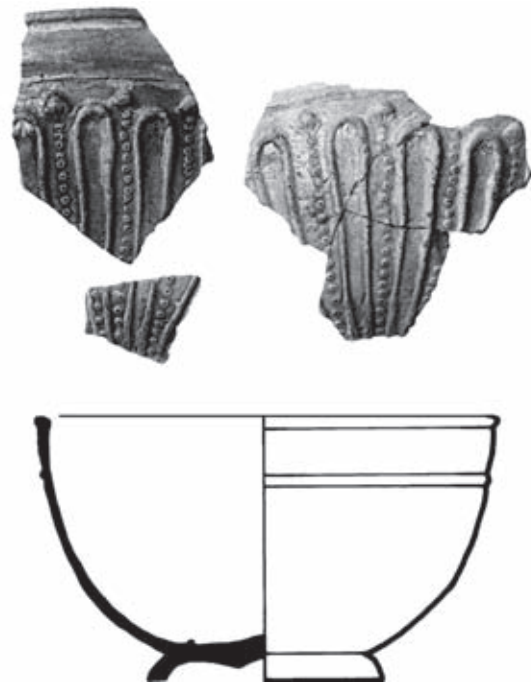


Fig. 4. Hellenistic moldmade “Megarian” relief bowl with lead glaze from the Agora excavations at Athens (scale of line drawing 1:2) (photograph © 1982 American School of Classical Studies at Athens, Agora Excavations; drawing by S. Severn Newton; adapted from Rotroff 1982, pl. 69, no. 409).

Evidence for lead-glazed pottery production has not yet been encountered as far east as Rhosus; all other known production sites in Asia Minor are west of Tarsus, from Perge to Lesbos.⁴² If lead-glazed pottery really was made in Syria, it is surprising that so little was found at Antioch.⁴³ Hans argues that the use of lead-glazed *rhosica vasa* along with precious metal vessels at the court of Cleopatra in Alexandria increased their popularity in Augustan times,⁴⁴ but they are extremely rare in Egypt. Courby knew of no examples in 1922, and Nenna and Seif el-Din found only 10 fragments when cataloguing more than 600 Graeco-Roman faience

for allowing me to see his new translation of this passage.

³⁹Gulick 1933, 23.

⁴⁰Shackleton-Bailey 1968, 247.

⁴¹Hans 1987, 121.

⁴²Hochuli-Gysel 2002, 318, fig. 10. Hierapolis is an additional candidate (Semeraro 2003, 85–6).

⁴³Waagé 1948, 82. Of 170 vessels attributable to a production center in Tarsus, Hochuli-Gysel (1977, fig. 31) recorded 37 examples from Syria, compared with 32 from Italy and the northwestern Roman provinces.

⁴⁴Hans 1987, 120.

vessels from Alexandria.⁴⁵ By the time of Athenaeus, lead-glazed pottery had been unknown in Egypt for at least 150 years.

Even if earthenware vessels had been molded and glazed, it is inconceivable that they would be considered “most costly” when compared with metalwork. The skyphoi made at Tarsus and elsewhere are no more elaborate than other Hellenistic relief wares, and contemporary Egyptian faience is more ornate than any of them.⁴⁶ Five minas would have purchased the labor of a skilled worker for 500 days in classical Greece, a price more appropriate for precious metal vessels than for earthenware.⁴⁷ It would not be surprising if elaborately decorated metal vessels were associated with Rhosus, a Syrian port that (briefly) lay within Cleopatra’s territory, for it was located in a region noted for skilled metalworkers.⁴⁸

Although Cicero described Atticus’ serving dishes and baskets, early lead-glazed ware is not a table service, as is terra sigillata; it comprises a small range of drinking cups, bowls, and a few jugs (see fig. 2). For this reason, some specialists in eastern Mediterranean ceramics prefer to equate *rhosica vasa* with Eastern Sigillata A, the first widely distributed table service with an oxidized slip.⁴⁹ Unfortunately, its range of predominantly undecorated vessels is impossible to reconcile either with Athenaeus’ assertion that it was “the most gaily decorated of all” or with Cicero’s reference to ornate plates and baskets.⁵⁰ Furthermore, the many complete vessels found in modern museums and additional examples that appear regularly in the commercial antiquities trade suggest that lead-glazed vessels may have been placed in graves as frequently as on dining tables.⁵¹

Nevertheless, despite problems and ambiguities, there is an attractive coincidence between the date of Cicero’s letter and the emergence of lead-glazed pottery. There is plentiful evidence in Cilicia and northern Syria for mining, and conjunctions between metalworkers and potters were therefore likely.⁵² Shackleton-Bailey’s translation of Cicero’s “*vasis fictilibus*” as “earthenware” is preferable to Winstedt’s

“porcelain,” but both (like Hans) were undoubtedly influenced by the tendency of archaeologists to equate ancient pottery with more valuable ceramics used at higher social levels in modern times simply because both are made from clay.⁵³ In light of Cicero’s preoccupation with opulent dining, and explicit references to metalwork in Athenaeus’ sources, it is possible that *rhosica vasa* were made from metal. If *rhosica vasa* really were made from earthenware, it is conceivable that the name was extended from silver or bronze vessels to early imitations. Their novel glazed surfaces might have misled early buyers (such as Atticus) into valuing glazed pottery as highly as semiprecious stone until its true nature was recognized.⁵⁴ Is this what Cicero was hinting at in his letter? Until decisive evidence emerges, it would be wise to concur with Maccabruni that Cicero’s order for lead-glazed pottery remains “*suggestiva ma indimostrabile*.”⁵⁵

East Meets West

Since neither the date nor the precise location of the earliest lead-glazed pottery production can be unambiguously correlated with documents, written sources cannot enlighten us about the circumstances of its invention. A historical understanding of its cultural context may still be helpful, however. Cilicia passed from (Eastern) Seleucid to (Western) Roman control in the first century B.C.E.; can an East–West narrative explain the timing of the invention of lead-glazed pottery? In Mesopotamia and Egypt, brightly colored quartz frit objects with a glossy vitreous surface (faience) had been familiar for thousands of years before glazed pottery or glass vessels began to be manufactured in the second millennium B.C.E.⁵⁶ If taste really had been orientalized, why did Hellenistic Greece and Early Rome not adopt the long-established alkaline-glazed ceramics of Mesopotamia (fig. 5) or the faience of Egypt (fig. 6)? The raw materials for glazes were the same as those used in making glass, and a small amount of faience had been produced in archaic Greece.⁵⁷ Even when Seleucid rule (305–64 B.C.E.) brought Mesopotamia together with Asia Minor, alkaline-

⁴⁵ Nenna and Seif el-Din 2000, 402–3.

⁴⁶ Spencer and Schofield 1997.

⁴⁷ Vickers 1998, 12–13.

⁴⁸ Gabelmann 1974, 261.

⁴⁹ Lund 2005, 237–38; Malfitana et al. 2005.

⁵⁰ Jones (1945, 45) made this point in her original discussion of *rhosica vasa*.

⁵¹ Atik 1995, 18. Molded lead-glazed pottery also served as a substitute for bronze and painted lacquer vessels in graves in Han-dynasty China (Kerr and Wood 2004, 115). Many complete Ptolemaic faience oinochoai have been recovered from graves in Egypt (Thompson 1973, 119).

⁵² I am grateful to Kathleen Warner Slane and an anonymous reviewer for stressing these points. Clay crucibles from Göltepe are discussed in Yener and Vandiver 1993.

⁵³ Winstedt 1912, 429; Shackleton-Bailey 1968, 91.

⁵⁴ For fluorspar vessels from Cilicia, see Loewental and Harden (1949), who also criticized attempts to equate valuable *vasa murrina* with glazed pottery (Loewental and Harden 1949, 33–4).

⁵⁵ Maccabruni 1987, 170.

⁵⁶ Spencer and Schofield 1997.

⁵⁷ Webb 1978; Caubet and Pierrat-Bonnefois 2005, 128–35.



Fig. 5. Alkaline-glazed pottery from Mesopotamia (two-handled amphora at rear, ht. 23 cm) (© The Trustees of the British Museum).



Fig. 6. Egyptian faience produced in the Roman period: utilitarian molded and wheel-thrown table vessels (plate, diam. 16.8 cm) (© Musée du Louvre/Georges Poncet).

glazed pottery (despite its strongly hellenized forms) did not spread to the West,⁵⁸ and it was not imported during the Roman period from the Parthian or Sasanian kingdoms.⁵⁹ Waagé encountered small quantities of Seleucid/Parthian alkaline-glazed pottery and Early Roman molded lead-glazed vessels at Antioch along with the usual Hellenistic and Roman fine wares current around the Aegean. In contrast, “[d]espite its proximity to Egypt and Mesopotamia, no glazed pottery at all was used in Antioch during the late Roman period down to the Muslim conquest of the VII century A.D.”⁶⁰ Thus, a simple attraction to oriental tastes is not a good explanation for the invention of lead-glazed pottery in Asia Minor in the first century B.C.E. The vessels have standard Graeco-Roman forms, and the use of a vitreous glaze with a high lead content has no precedent in western Asia or Egypt.⁶¹

East–West cultural narratives frequently involve geographical relativism and diffusionism.⁶² Many writers assumed that inspiration for lead-glazed pottery flowed from Mesopotamia to a place of invention in Syria,⁶³ incorporated Hellenistic and Egyptian styles and finishes in Asia Minor, and proliferated there before spreading to Italy by “a very natural and easy process.”⁶⁴ The spread of offshoots of the Italian industries across the Alps to Gaul follows a different (but equally familiar) narrative of the Romanization of the north-

western provinces. It was long believed that diffusion to the West was counterbalanced by technical impulses spreading eastward from Syria to China, sparking off the lead-glazed pottery of the Han dynasty⁶⁵—an elegant narrative contradicted by the chronological precedence of Chinese lead glazes.⁶⁶

Other writers omit Mesopotamia from their East–West narrative and, like Rotroff’s account of the invention of Megarian bowls, stress links with Egypt, where faience was adapted to Hellenistic forms, notably tall jugs decorated with appliqué representing Ptolemaic queens.⁶⁷ Both Courby and Jeammet consider the use of lead glazes in Asia Minor a local expedient aimed at reproducing the color, brilliance, and impermeability of imported Egyptian faience by potters unfamiliar with this material.⁶⁸ This derivation not only fails to explain the invention of lead glazing but also raises the question of why true faience-making was not introduced by the transfer of artisans.

Material Hierarchies

According to Vickers, Greek pottery with a black gloss imitated silverware darkened by corrosion, while the red finish of Hellenistic and Roman oxidized terra sigillata reflected the increasing use of gold services on the tables of the rich.⁶⁹ Does his principle of hierarchical imitation help in the interpretation of glazed

⁵⁸ Caubet and Pierrat-Bonnefois 2005, 182.

⁵⁹ Debevoise 1934; Simpson 1997.

⁶⁰ Waagé 1948, 82.

⁶¹ Walton 2004; Hill 2006.

⁶² Sherratt and Sherratt 1998, 329–30.

⁶³ E.g., Gabelmann 1974, 261.

⁶⁴ Jones 1945, 50.

⁶⁵ Jones (in Goldman 1950, 195); Charleston 1968, 43, 45.

⁶⁶ Kerr and Wood 2004, 486–88.

⁶⁷ Thompson 1973.

⁶⁸ Courby 1922, 527; Jeammet 2005, 191.

⁶⁹ Vickers et al. 1986; Vickers 1994; Vickers and Gill 1994.

pottery? Early Mesopotamian and Egyptian glazed pottery and faience artifacts have a striking blue or greenish-blue shiny finish inspired by lapis lazuli or other semiprecious stones. Contemporary glass also mimicked carved stone, especially variegated kinds such as serpentine or fluor spar. It is frequently suggested that the earliest Roman lead-glazed bowls copy both the form and appearance of silver skyphoi, especially when they bear an internal yellow glaze that may echo the practice of gilding the interior of silver vessels to protect them from corrosion.⁷⁰ Since the external glaze is normally green, others suggest imitation of patinated bronze vessels whose interiors retained their original color.⁷¹

Egyptian faience *oenochés des reines* were probably imitations of the metal vessels used in official cult ceremonies in honor of Ptolemaic sovereigns; the coarser vessels might have been presented to bystanders on state occasions.⁷² Courby's summary of the hierarchy of inspiration precisely matches that of Vickers and suggests that lead-glazed pottery would have occupied a similarly modest place in the Hellenistic and Early Roman periods.⁷³

Functional Explanations

Recent analytical work has reaffirmed the fundamental differences between the technology of Roman lead-glazed and western Asiatic alkaline-glazed pottery.⁷⁴ On a cultural level, Early Roman glazed vessels do not imitate the forms or surface color either of alkaline-glazed pottery or of Egyptian faience. Furthermore, the quantity of Early Roman glazed pottery is minute compared with Parthian, Sasanian, or Chinese wares, and it died out around the eastern Mediterranean and North Africa until the Islamic conquests. Lead-glazed Roman pottery did persist and proliferate in Italy and the northwestern provinces of the Roman empire, however. Can functional explanations shed any light on this development?

The history of technology is highly dependent on a paradigm of rational choice of materials and processes that offer functional advantages, especially in evolu-

tionary archaeology, where material factors operate in a selectionist manner.⁷⁵ Glazed pottery has many obvious advantages over unglazed earthenware, notably impermeability, which makes it ideal for vessels associated with serving and consuming food and drink. Slips were commonly used as surface finishes on ancient pottery (see fig. 3), but few achieved a shiny fused gloss like that found on Greek tableware. Lead glazes also have advantages over alkaline glazes at the production stage: lower firing temperatures, better fluidity, and a reduced tendency to crack on cooling.⁷⁶

Glazed pottery in China began before 1500 B.C.E. with the accidental effects of wood ash.⁷⁷ Increases in firing temperatures eventually brought out the special qualities of stoneware and porcelain clays. Before the manufacture of true porcelain became common during the Tang dynasty (after ca. 600 C.E.), lead glazes were in widespread use on earthenware and remained important for low-fired products such as roof tiles.⁷⁸ The sequence of discovery, invention, innovation, and proliferation in Chinese glazes and clay sources produced ceramics that were unrivaled elsewhere before the 18th century C.E.⁷⁹ Once medieval Europe had adopted glazed ceramics of Eastern inspiration, east Asian imports acted as models for emulation and, ultimately, for scientific experiments aimed at replicating porcelain. Chinese ceramics were the concern of royal, state, or religious administrators.⁸⁰ Some 18th-century European porcelain was also made in royal factories (Sèvres, Meissen) and graced the tables of royalty and the aristocracy. Anyone aware of this well-established technological narrative may wonder why the invention of Greek and Roman glazed ceramics did not follow a similarly progressive path.

The technology for making lead-glazed pottery was transferred (probably by the movement of craft workers) to Italy and the Rhône Valley by ca. 20 B.C.E., and glazing was extended to new forms of pottery, including nonmolded wheel-thrown vessels.⁸¹ The latter became increasingly common in the first century C.E. in Gaul. Although the use of a mold mounted on a potter's wheel to produce relief decoration died out

⁷⁰ Rotroff and Oliver 2003, 169.

⁷¹ Gabelmann 1974, 265; Vickers 1998, 20; Walton 2004, 10.

⁷² Thompson 1973, 117–22.

⁷³ Courby (1922, 512): "On doit bien plutôt croire qu'il s'agit tout simplement d'une vaisselle ordinaire, dont le décor remonte à quelque oeuvre célèbre, par l'intermédiaire de vases en métal précieux."

⁷⁴ Walton 2004; Hill 2006.

⁷⁵ Leonard 2001, 73–5.

⁷⁶ Tite et al. 1998; Hill 2006, 30–1.

⁷⁷ Kerr and Wood 2004, 455–56.

⁷⁸ Kerr and Wood 2004, 115–16.

⁷⁹ In this paper, the term "discovery" indicates the revealing of something that already existed but had not been recognized or conceptualized. "Invention" implies originality and a conscious act of implementing an idea in a new device or process that may well rely upon a prior discovery. Invention is an action (although it may require sustained effort) while "innovation" is the process whereby an invention is brought into use.

⁸⁰ Harrison-Hall 1997.

⁸¹ Desbat 1986; Hanut 2004, 192, fig. 17, nos. 8–10.

in the second century, individually molded appliqué motifs continued to be added, and figurines were made in two-piece molds, employing techniques found throughout the history of Greek and Roman ceramics. In addition, plates and bowls with decorated horizontal rims were made in static molds in Italy, again in a manner used widely for manufacturing other Roman ceramics.⁸² By the Late Roman period, the majority of glazed vessels were plain wheel-thrown forms made from earthenware that could be fired at a relatively low temperature with the glaze mixture already on its surface, rather than requiring a biscuit firing before being glazed.⁸³ A shift from luxury items to utilitarian forms is clearly visible in Italy, where there was a smooth transition to Early Medieval wares.⁸⁴ This increasingly utilitarian focus is particularly clear in the Danube provinces,⁸⁵ where jugs, bowls, and plates resembling those found in Italy (figs. 7, 8) are joined by large numbers of the classic Roman food preparation vessel, the mortarium (see fig. 8, bottom right).⁸⁶

In most regions where glazed pottery was produced (from northern Britain to the Black Sea), the quantities remained vanishingly small, and many areas did without it altogether. In contrast, the percentage of glazed pottery found on sites along the middle Danube reached double figures in the fourth century C.E.⁸⁷ The quantities and classes of vessels are broadly comparable to traditional alkaline-glazed pottery found on Parthian and Sasanian sites, notably Dura Europos and Seleucia,⁸⁸ possibly because some soldiers stationed on the Danube had become accustomed to using glazed pottery while serving on the eastern frontier.⁸⁹

Glazed pottery virtually disappeared from the eastern Roman provinces and North Africa, and even Palmyra received only a small amount from Parthia.⁹⁰ Mass-produced faience bowls and plates were in everyday use throughout Roman Egypt but were not exported; only a few elaborate relief-molded vessels reached Italy.⁹¹ As Waagé points out, “[t]he remarks one still finds occasionally about a growing use of glazed pottery during the late Roman empire are wholly erroneous so far as the Aegean cities and even the great eastern metropolis of Antioch are concerned.”⁹² Thus, we encounter a paradox if we attempt to apply a purely functional explanation to the history of Roman lead-

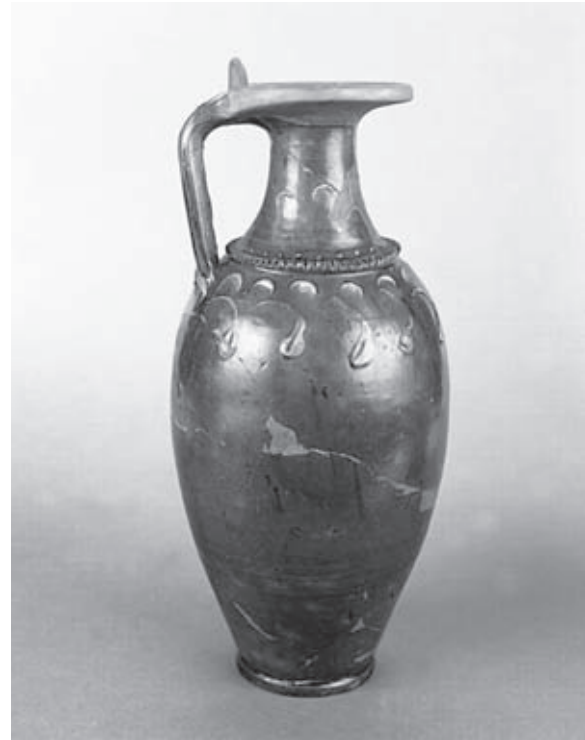


Fig. 7. Wheel-thrown lead-glazed jug from Kosmaj, Serbia, second century C.E., ht. to rim 31 cm (Cvjetičanin 2001, fig. 6; © 2001 National Museum, Belgrade).

glazed pottery: neither the early “luxury” products nor the later utilitarian vessels triggered widespread use, despite their superior impermeability. The glazed vessels of the middle Danube region do, however, show that production and consumption on a medieval scale was technically and economically possible.

The lesson of ethnoarchaeology and modern-world historical archaeology is that function is only part of the story; materials may act like texts, express identities and interact with knowledgeable actors,⁹³ but physical properties impose limitations on these roles. Loney has highlighted a division between American ceramic analysts, who favor approaches involving evolution and selection, and Europeans, who emphasize socio-cultural and contextual factors. She suggests a combined approach that acknowledges that technology

⁸² Hayes 1972, 49, pl. 1d.

⁸³ Cvjetičanin 2006, 15–19.

⁸⁴ Martin 1995; Porta et al. 1998.

⁸⁵ Cvjetičanin 2001; 2006, 115–16.

⁸⁶ Almost half of all glazed vessels found at Mautern-Favianis (Austria) were mortarium (Groh and Sedlmayer 2002, 303–7).

⁸⁷ Cvjetičanin 1995.

⁸⁸ Debevoise 1934; Toll 1943.

⁸⁹ Cvjetičanin (2006, 196–97) considers that pottery production was related to distributions of food rations to soldiers following the reorganization of the frontier armies by Diocletian and Constantine.

⁹⁰ Fellmann 1970, 71–9.

⁹¹ Di Gioia 2006.

⁹² Waagé 1948, 82.

⁹³ Cochran and Beaudry 2006.

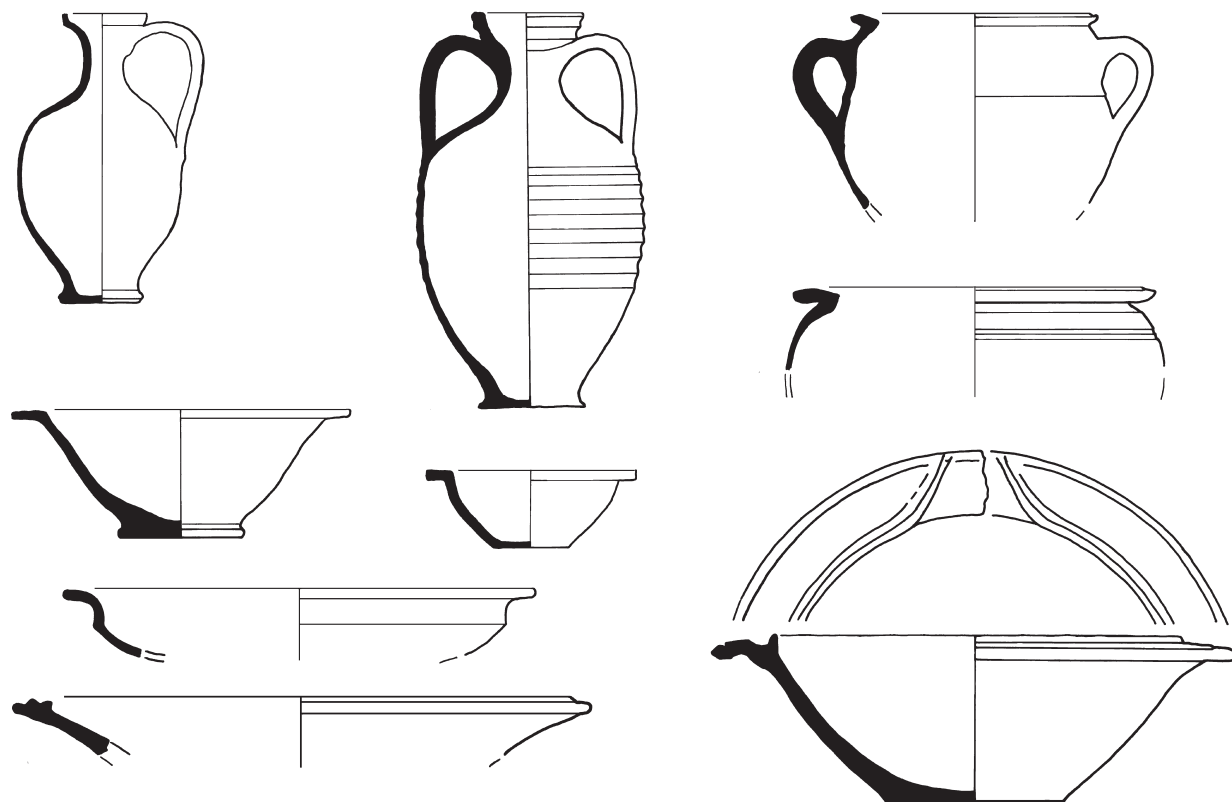


Fig. 8. Utilitarian lead-glazed vessels of Late Roman date from Singidunum, Belgrade, Serbia (scale ca. 1:4) (drawing by S. Severn Newton; after Bjelajac 1995, figs. 1–3).

is governed by culture but recognizes that technical efficiency and improvement frequently conflicts with cultural beliefs and desires: “It is a perspective which gives ceramic archaeologists a chance to enhance a frequently mechanistic view of pottery analysis with the cultural and personal motivations behind the production of material culture.”⁹⁴ We should therefore explore reasons for glazed pottery not becoming the standard tableware of the Roman world by looking widely at consumption, cultural behavior, technological choices, and competition from other materials.

Consumption: Novelty and Tradition

We have become so accustomed to mass communication and advertising that “early adopters” may now only be a few months ahead of general consumers of new technology. In early modern Britain, the technology associated with industrial revolution was directed toward ordinary items such as clothes rather than technologically complex products. The combination of

capitalism, marketing, and engineering behind Boulton’s Soho factory in Birmingham (opened in 1762) facilitated the production of cheap faceted-steel costume accessories that imitated sparkling jewelry.⁹⁵ This is entirely consistent with Berg’s emphasis on the role of consumer goods (and in particular the imitation of formerly luxurious imports) in promoting industrialization.⁹⁶ Lead glass pioneered in London was inspired by clear Venetian glass whose use had been promoted by the consumption of wine.⁹⁷ Likewise, 18th-century European ceramic production was stimulated by the desire to serve chocolate, coffee, and, especially, tea in fine china that resembled Chinese porcelain.⁹⁸ Communication was driven by advertising, shop displays, and highly visible social consumption in spas, assembly rooms, coffee houses, and domestic entertaining.⁹⁹ The virtuous circle of production and consumption was sustained by global access to raw materials that could be transformed into profitable goods for home and export markets. But where early modern long-distance

⁹⁴ Loney 2000, 662.

⁹⁵ Berg 1994, 129–30.

⁹⁶ Berg 2004.

⁹⁷ Macfarlane and Martin 2002, 117–18.

⁹⁸ Snodin and Styles 2001, 129, 252–53, fig. 18.

⁹⁹ Weatherill 1996.

trade and communications encouraged emulation of the exotic—whether Indian printed cotton, Chinese porcelain, or neoclassical interiors inspired by excavations at Pompeii—Roman material culture remained resolutely wedded to traditional forms.

Greek and Roman conservatism may explain the enduring influence of archaic and classical Greek ceramics (and, presumably, their models in more precious materials) whose forms persisted into Hellenistic and Roman times. Makers of the Megarian and other relief-molded vessels that replaced hand-painted vases in the third century B.C.E. still decorated some with ritual or mythological scenes. This practice continued when wheel-mounted molding technology was transferred to Italy and then to the provinces of the Roman empire. Even simple representations without narrative potential could allude to familiar stories or rituals by using figures in distinctive poses.¹⁰⁰ In this way, technical innovation was cloaked in traditional iconography.

Alongside this conservatism, the Greek and Roman world experienced population growth and economic expansion that accelerated the downward mobility of status objects and provided opportunities for innovation. Osborne emphasized the early date of this economic development in the context of Greek long-distance trade and colonization, and even earlier Mediterranean connectivity has been described by Sherratt.¹⁰¹ Field-survey projects have recorded intensification in agriculture and settlement, with notable peaks in the western and northern provinces of the Roman empire.¹⁰² Distinctive buildings such as villas extended Roman ways of living deep into the countryside to complement focal points (e.g., forts, towns). Although Romanization is complicated by postcolonial concepts of identity and resistance, everyday experience of metal, glass, and pottery brought the long traditions of classical and Hellenistic Greece into Roman living.¹⁰³

Thus, a comparative approach to consumption in the ancient and early modern worlds contrasts ancient conservatism with early modern love of novelty. Given that the only major technological changes in ceramics for the table between 700 B.C.E. and 700 C.E. were shifts from painting to molding and from black to red slips, should we be surprised that a new shiny green vitreous surface was not adopted into widespread use? Lest awareness of the success of glazed ceramics in later periods leads us to ask inappropriate behavioral questions about their “failure” in the

Roman period, we should examine production as well as consumption.

Cognitive Synchronization in Inventions

Renfrew’s phrase “engagement with the material world”¹⁰⁴ epitomizes the view that the interaction between people and things is not just functional: artifacts have stimulated physical and cognitive evolution, and the possession of material culture has promoted economic concepts of ownership and exchange. Taylor, however, warned against technological futurism when considering the cognitive implications of prehistoric metallurgy:

All of our preconceptions about metal, no matter whether they come directly from our modern industrial and scientific knowledge, or from our ethnographic knowledge of communities first brought into contact with fully fledged metals as part of the expansion of mercantile capitalism, are simply that—preconceptions. To throw away our knowledge does not seem a good way to begin to understand the inception of metallurgy. Yet, the people long ago started with none. Why should we not seek to think our way back to their position?¹⁰⁵

If we clear modern categorizations from our minds, we might see connections between molten materials and clay that facilitated technology transfer between makers of glass, metal, and pottery. Early glass vessels were formed over a removable clay core, as were many cast metal objects. This may have given rise to the idea of coating earthenware vessels with an alkaline slip that would fire to become a glaze. Making glass bowls by sagging a disc of hot glass became common in the Hellenistic period and, when combined with using a slowly rotating wheel for shaping them, may be related to the invention of wheel-mounted molds for making Megarian bowls from clay. Conceptualizing glass as a flexible material rather than a solid (such as rock crystal, which could only be worked by carving) would have opened a cognitive path to the invention of blowing. Once blowing had become established, the use of multi-piece molds with internal decoration (familiar from making bronze or terracotta statuettes) allowed mold-blown glass vessels to replicate the relief-decorated surfaces of molded or repoussé metalwork.

Cognitive linkages of this kind were important in the pioneering theoretical work of Usher.¹⁰⁶ He defined four steps in an invention: perception of the problem, setting the stage, the act of insight, and critical

¹⁰⁰ Talloen and Poblome 2005.

¹⁰¹ Osborne 1996; Sherratt 1999.

¹⁰² Greene 1986, 98–141.

¹⁰³ Malfitana et al. 2005, 204.

¹⁰⁴ Renfrew 2001, 127.

¹⁰⁵ Taylor 1999, 22.

¹⁰⁶ His approach incorporated Gestalt psychology (Ruttan 2001, 66–8).

revision. Usher described how a cumulative synthesis might be achieved:

Many may presume that the invention flows directly from the combination of a special problem with the highly individualized experience of the gifted inventor. . . . Close attention to the detailed accounts of particular inventions affords a clue to the general character of the circumstances that promote the achievement of a new configuration. It is well-nigh indispensable that certain data of experience should be presented to the mind of the inventor in such a fashion as to suggest their connection with the problem. All the elements essential to the accomplishment must be brought together sufficiently to facilitate their organization into a new circuit or configuration.¹⁰⁷

One “new circuit or configuration” was the use of clay molds mounted on a potter’s wheel, by which Hellenistic Megarian bowls could be given a rim and a smooth internal profile in a single operation. Its novelty has been understated because of art historical prejudice inspired by the Arts and Crafts Movement;¹⁰⁸ Walters attributed the disappearance of individually painted Greek vases to “the luxurious and artificial tendencies of the Hellenistic Age, when men were ever seeking for new artistic departures, and a new system of technique arose which finally substituted various forms of decoration in relief for painting.”¹⁰⁹ The originality and significance of wheel-mounted relief molding has also been overlooked because of its simplicity and its familiarity in later Western terra sigillata industries. Finley observed, with characteristic acerbity, that “[f]ourth-century Greeks were not Neanderthal men and we need not hail this particular step as a brilliant accomplishment.”¹¹⁰ Siebert put it rather differently: “L’invention des bols à reliefs, leur production en série et leur diffusion rapide correspondent-elles à un renouvellement fondamental des techniques?”¹¹¹

What could be described as “cognitive synchronization”¹¹² in technical changes in the manufacture of molded ceramics and sagged glass bowls also applies to the production of fine metalwork. Many Hellenistic and Roman drinking cups and bowls made from

metal had such prominent repoussé decoration that they required a separate lining, raised on a lathe.¹¹³ In other cases, the external decoration was cast, and the rim and interior surface were finished on a lathe.¹¹⁴ On a cognitive level, making bowls from pottery, glass, or metal required pliable raw material (a lump of soft clay or a disc of glass or metal). Each material underwent a transition (wet to dry, hot to cold, viscous to solid), and both glass and metal required careful heating and annealing to keep them in the right condition for shaping. Their manufacture also involved rotary motion, which is interesting in light of developments in agricultural processing technology during the Hellenistic period. Olynthine mills operated by side-to-side motion were replaced by new rotary millstones for grinding grain or crushing olives, and opened up the possibility of mechanized mills powered by animals or water. Lewis considers that the water mill driven by a horizontal wheel was invented in Asia Minor and adapted to its vertical (“Vitruvian”) form with 90° gearing in Alexandria in the third century B.C.E.¹¹⁵ Following Usher, knowledge of one kind of machinery could add to a cumulative synthesis that resulted in other inventions. The two contrasting kinds of waterwheels—one working horizontally, the other vertically—are mirrored by molds set on horizontal potters’ wheels and discs of metal set vertically on metalworkers’ lathes.

Do the lead-glazed molded pots invented in the first century B.C.E. reveal cognitive synchronization between different raw materials? Bronzsmiths worked closely with makers of ceramics such as the molded terracottas manufactured in Corinth.¹¹⁶ A metalworking context would provide plentiful opportunities for observing the vitrification of clay crucibles or furnaces and the glassy appearance of slag.¹¹⁷ Minds aware of accidental vitreous finishes, possibly enhanced by sightings of Parthian alkaline-glazed pottery and/or Egyptian faience,¹¹⁸ would require only a small conceptual step to add a glaze to Hellenistic pottery. Glass had to be heated in a high-temperature furnace to be sufficiently liquid for blowing rather than sagging, and clay debris produced during the melting process

¹⁰⁷ Usher 1929, 17.

¹⁰⁸ Greene 2005, 37–9.

¹⁰⁹ Walters 1905, 2:554–55.

¹¹⁰ Finley 1965, 31.

¹¹¹ Siebert 1980, 67. The technique is surprisingly rare in later periods and only made a brief appearance in China in the 10th century C.E. (Kerr and Wood 2004, 430). Similar molds from Aleppo in Syria dating to the 12th–13th century C.E. are displayed in the John Addis Gallery of Islamic Art (British Museum, London).

¹¹² This term, coined while writing this paper, is used in a similar manner in empirical software engineering to describe

“a shared representation of the to-be-evaluated object” (Détienne et al. 2003, 23).

¹¹³ Strong 1966, 114.

¹¹⁴ Oliver 1977, 42.

¹¹⁵ Lewis 2000, 644–45.

¹¹⁶ Merker 2003.

¹¹⁷ It does not require a “Eureka moment” like Pliny’s (*HN* 36.191) account of the invention of glass by sailors who accidentally melted sand while cooking on a beach.

¹¹⁸ Such as an Egyptian bowl excavated at Tarsus (Goldman 1950, 165–66, pl. 132).

would have drawn attention to its excellent coating properties.¹¹⁹ Walton's scientific analyses suggested similarities between recipes for glass, alkaline glazes, and the earliest lead glazes.¹²⁰

The idea of adding a lustrous surface coating to drinking vessels need not have come directly from metal or glass prototypes. Two obsidian skyphoi recovered from the Villa di San Marco at Stabiae, near Pompeii, draw attention to potential models in other exotic materials:

The bodies of the vessels . . . were formed from single pieces of obsidian. Framed by thin gold wire, the figural scenes were crafted by inlaying precious materials (coral, hard stones, and gold) into the exterior surface. . . . All the figural components, as well as the carved portions of the base and the swan-shaped handles at the rim, indicate the use of tools specifically intended for stone carving. Manufactured by Alexandrian artisans, the cups must have formed part of a larger group of prestigious vessels, as is suggested by the fragments of at least two other similar containers also found in the villa.¹²¹

While cognitive synchronization between craft workers presented opportunities for technology transfer between different materials, it could have confused the consumers of their finished products. Greek writers quoted by Athenaeus may have used the term *keramos* loosely to describe vessels made from gold and silver because of the prevalence of skeuomorphism.¹²² Several Roman writers related "urban myths" about unbreakable glass that probably arose from confusion about the properties of blown glass and hammered metal.¹²³

An Empire of Glass

Unusually intense economic activity is suggested by a peak in the bell curve of Mediterranean shipwrecks in the first centuries B.C.E. and C.E.¹²⁴ This period is characterized by inventiveness in glass, metalwork, and pottery. Lead-glazed pottery was rare, but terra sigillata and thin-walled wares proliferated (see fig. 3). The latter were a particularly diverse class of drinking vessels whose execution and decoration reveals skilled potters (even if inspired by metalwork or glassware) making the most of clay through expert wheel-throwing, plastic decoration, and colorful slips.¹²⁵ The extensive distri-

bution of well-made and standardized terra sigillata achieved in the first century C.E. has been described as a "tableware boom" taking place during "the only recognizable phase of empire-wide integration."¹²⁶ Thus, economic circumstances were opportune for new lead-glazed drinking vessels that complemented metals, semiprecious stone, or glass.

Why was the take up of early lead-glazed pottery so low? The technical quality was high and its appearance novel. Was it adversely affected by the expansion of glass production? New insights may be gained from Macfarlane and Martin's comparative study of the role of glass technology in the development of European, Islamic, and Chinese science. The authors (an anthropological scientist and a former glass industrialist) draw attention to differing technical and cultural trajectories for glass.¹²⁷ Their assessment of Roman glass is refreshingly positive from both a technical and a functional standpoint, concluding that "Roman civilisation was more glass-soaked than any other until the very recent past."¹²⁸ The impact of large-scale glass production by means of blowing in the Roman empire invited comparisons between the West and China.¹²⁹ A Jesuit from the late 17th century noted that the drinking of hot tea rather than cool wine produced a very different trajectory in east Asia:

They are almost as curious in China, with respect to Glasses and Crystals that come from Europe, as the Europeans are with regard to China-ware; and yet this has never induc'd the Chinese to cross the Seas in quest of it, because they find their own Ware more useful; for it will bear hot Liquor, and you may hold a Dish of boiling Tea without burning yourself, when you take it after their way, which you could not do even with a Silver Dish of the same Thickness and Figure; besides China-ware has its Luster as well as Glass, and if it is less transparent it is likewise less brittle.¹³⁰

Macfarlane and Martin underline the implications of this cultural difference:

Once the divergence had begun it was self-reinforcing. It became more and more difficult to change track. So if one asks why the Chinese did not develop clear glass, one should equally ask why the Romans did not make porcelain. It is only after the event that absences, paths that were not taken, seem so odd.¹³¹

¹¹⁹ Illustrated in color in Seeley and Drummond-Murray 2005, 147–55.

¹²⁰ Walton 2004, 148.

¹²¹ Ciarallo and De Carolis 1999, 162.

¹²² Vickers 1998.

¹²³ Stern 1999, 442; Greene 2000, 46–7.

¹²⁴ Gibbins 2001, 279, fig. 10.2.

¹²⁵ Greene 1979; Ricci 1985.

¹²⁶ Poblome et al. 2000, 282.

¹²⁷ Macfarlane and Martin 2002, 14.

¹²⁸ Macfarlane and Martin 2002, 15.

¹²⁹ Macfarlane and Martin 2002, 14.

¹³⁰ Du Halde, cited by Macfarlane and Martin 2002, 110–11.

¹³¹ Macfarlane and Martin 2002, 121. The study of "path-dependency"—the consequences of initial technological choices—is an important theme in the history of technology (Ruttan 2001, 112), although derived from evolutionary biology (Greene 2006, 276, 289–90).

Setting aside the absence of suitable clay sources for Roman porcelain production, one clear implication of Rome's extraordinarily successful glass industries is that they left no economic or cultural niche for elaborate lead-glazed vessels. Jeammet has noted the ambiguity of the appearance of early lead-glazed pottery: "cette production permettait ainsi aux plus modestes d'orner leurs tables d'objets qui, sans avoir le valeur de l'argent, en avaient l'allure."¹³² The hitherto unparalleled wealth of the Late Hellenistic and Early Roman world allowed people who actually wanted metal or precious stone drinking vessels to buy the real thing. The change from cast to blown glass increased the availability of imitations of expensive materials and left glazed pottery on the sidelines; even Egyptian faience disappeared by the third century C.E., possibly because of the superb plates and bowls available in glass by this date.¹³³ Modest households could equip their tables with newly fashionable terra sigillata and thin-walled drinking vessels if they could not afford metalwork and glass. Glazed Roman pottery only flourished along the Danube and in north Italy, where functional jugs, plates, and bowls resembling those of Parthia, Egypt, or medieval Europe were in use.¹³⁴ The lead-glazed skyphoi of Hellenistic Tarsus or Pergamon were neither sufficiently similar to metal or semiprecious stone to make them a successful substitute nor sufficiently superior to glass, faience, or Parthian alkaline-glazed pottery to generate the appeal of Chinese porcelain. It is impossible to imagine them becoming heirlooms like the 51 pieces of Chinese porcelain bequeathed by Lorenzo de Medici in 1492.¹³⁵

Innovation and Diffusion

In addition to being of great art historical and cultural interest, glazed pottery provides insights into ancient invention and the subsequent process of innovation. Edgerton's observation, that "[t]he histories of innovation and of technology-in-use are remarkably different, in terms of geography, chronology, and sociology,"¹³⁶ is derived from modern technology, but its implications can be related to Greece and Rome:

Technique typically takes a long time to diffuse. Steam power, held to be characteristic of the industrial revolution in Britain, was not only absolutely but relatively

more important in 1900 than in 1800. . . . Rapid innovation need not correspond to periods of rapid productivity growth; innovations will have the greatest impact on productivity growth at the time of the fastest diffusion, which typically takes place long after innovation. . . . Looking at the world as a whole the spatial and temporal dimensions of technology behave differently, depending whether we are thinking about adoption or the extent of use.¹³⁷

Heron's aeolipyle, a simple steam turbine, found limited application in antiquity¹³⁸ and made modest progress in early modern utilitarian contexts (Barker's mills, Hero engines), but in the very different socio-economic context of Victorian England, it helped Parsons to reconceptualize turbines in a manner that enabled them to power warships, ocean liners, and electricity-generating stations.¹³⁹ Likewise, the fastest diffusion of lead-glazed pottery occurred during the industrialization of early modern production by Wedgwood and others, long after its 500-year spread through Europe from Islamic sources (fig. 9).¹⁴⁰ Thus, the minimal impact of Early Roman lead-glazed wares, followed by the greater success of utilitarian forms in Italy and along the Danube, is not an example of the failure of innovation in the ancient world; rather, it is a good example of the long and uneven path that inventions normally take before they become technology-in-use.¹⁴¹

Many Greek and Roman inventions were useful to the state: coinage, water clocks and sundials, mechanical artillery, roofing systems and concrete vaulting for large temples and public buildings, water-lifting devices employed in irrigation and mining, mechanical presses and water mills for food processing, adjustable scales for weighing coins or merchandise, and codices (rather than scrolls) for law codes and religious texts.¹⁴² Consumer goods underwent little technical change, and small workshops remained the principal context for their production. Output normally increased because of a proliferation of workshops rather than a transition to anything resembling a modern factory.¹⁴³ Metalworking and stoneworking intensified in Greek and Roman times and employed techniques and materials already invented or discovered during later prehistory or in Mesopotamia and Egypt. The adoption of wheel-mounted relief molds for mass-producing

¹³² Jeammet 2005, 193.

¹³³ Harden 1936, 40; Nenna 2005, 189.

¹³⁴ Cvjetičanin 2006, 194, fig. 29.

¹³⁵ Poole 1997, 42.

¹³⁶ Edgerton 1999, 115.

¹³⁷ Edgerton 1999, 115.

¹³⁸ Keyser 1992.

¹³⁹ Parsons 1934, 107–8.

¹⁴⁰ Hill 2006, 1.

¹⁴¹ Rotroff (2006) makes effective use of modern innovation theory in her latest study of the invention of Hellenistic mold-made bowls.

¹⁴² Greene (forthcoming).

¹⁴³ Greene 1986, 142–68.

decorated pottery and the invention of blown glass and lead-glazed ceramics demonstrate that technical changes were innovated into use in the ancient world, and that production could be transferred quickly over long distances.

CONCLUSIONS

It is important to be wary of accounts of the invention of lead-glazed pottery that are internalized within culture-historical narratives, whether diffusionist or teleological, because they cast material culture in a supporting role. Likewise, East–West cultural “interbreeding” substitutes metaphor for explanation unless an overtly evolutionary approach is taken to functional characteristics. I envisage the invention of lead glazing taking place as a result of new interactions among potters, metalworkers, and glass makers, and made possible by the reconfiguration of the political and economic landscape in the first century B.C.E.¹⁴⁴ The Hellenistic kingdoms had provided a context for growing wealth and social display that stimulated the production and distribution of metalwork, glass, and pottery. Subsequent Roman involvement in the geopolitics of the eastern Mediterranean caused considerable disruption, including the conversion of kingdoms into Roman provinces and a civil war. The Augustan peace that followed is notable for the unprecedented diversity and extensive geographical dispersal of its ceramics.¹⁴⁵ Megarian bowls had achieved widespread distribution and diffusion of production after their genesis in Athens before 200 B.C.E.; 150 years later, red-slipped terra sigillata and blown glass emerged even more successfully from Hellenistic Asia Minor and the Levant into the expanding Early Roman world. Lead glazing was only one of many ways to decorate Augustan thin-walled fine drinking and serving vessels, and it did not make any more impact than other techniques.

The comparatively successful glazed pottery industries of Late Roman northern Italy and the Danube region are separate phenomena with few technical or functional connections to their Late Hellenistic forebears. They illustrate the Edgerton principle, that innovations may experience their greatest diffusion in very different contexts from those of their invention. Like the utilitarian glazed pottery and faience of Mesopotamia and Egypt, Late Roman glazed wares anticipate a future role for ceramics that only came about after another geopolitical reconfiguration had brought Chinese glazed earthenware, stoneware,



Fig. 9. Staffordshire creamware, a type of early modern lead-glazed earthenware. The teapot has molded decoration and a green and yellow glaze resembling early products from Asia Minor. The plate, vase, and ewer (ht. 27.2 cm) are Wedgwood products (© The Trustees of the British Museum).

and porcelain into Islamic western Asia, whence lead-glazed and tin-glazed pottery spread into Europe. Early Medieval Islamic lead-glazed pottery achieved take-off because it emerged within a society already accustomed to using alkaline-glazed pottery for everyday utilitarian purposes.¹⁴⁶ Stylistic impulses from China were important because its pottery was held in high regard; local pottery could emulate imported ceramics, not just expensive glass or metalwork. Because fewer people between the Roman period and early modern Europe could afford comprehensive metal table services, decorated glazed earthenware (whether Byzantine white ware, Islamic luster ware, Italian maiolica, Delft, or Staffordshire slipware) did find a place on “respectable” tables. The richer households could acquire true porcelain; an 18th-century Cleopatra or Atticus, having cleared away the silverware after the main course of a dinner, could serve dessert on Sèvres porcelain without evoking the humble status of earthenware. By the late 18th century in England, Boulton took advantage of expanding wealth and social mobility by making hand-crafted silver and ormolu tableware and costume accessories aimed at the aristocracy, and following them with cheaper mass-produced versions for ordinary customers. Likewise, Wedgwood created expensive porcelain and stoneware for aristocratic tables and cheaper earthenware for a growing mass-market (see fig. 9). This kind of emulation superficially resembles the copying of silverware to make Megarian bowls outlined by Rotroff, but Finley was right to

¹⁴⁴It may have happened more than once; different centers in Asia Minor used different glaze recipes (Walton 2004, 147–48).

¹⁴⁵Poblome et al. 2000.

¹⁴⁶Hill 2006.

emphasize that “the potters were themselves modest men, not even little Wedgwoods.”¹⁴⁷ Although a consumer perspective is helpful, we must avoid futurism; Hellenistic and Early Roman glazed pottery should be considered on its own terms, not as a point on a linear graph of progress from antiquity to modernity.

Roberts’ study of a relatively little-known class of south Italian lead-glazed pottery attempts to put it into a human context and takes us from the industrial world of Boulton and Wedgwood back to Roman craft workshops:

Sometime during the late first century B.C.E., somewhere in southern Italy, a potter admired his new line of green-glazed pots. He was quite pleased with the vessels themselves, as the forms were quite well made and some, such as the large askos, were undeniably handsome. But it was his first attempt at the new technique of glazing, and the glaze had not adhered well to many of the pieces, nor had the appliqué motifs of gambolling cupids always turned out as well as he had hoped. Nonetheless the pots would find a niche in the markets, on the tables (and in the graves?) of the prosperous and novelty-hungry middle classes. He could even try selling some pieces, via the markets at Taranto, to the merchants who passed through the port, on their way to Africa and the East. As a piece of pure whimsy he had placed grasshoppers on either side of the large askos.¹⁴⁸ He could almost hear them chirruping as the cupids drank, played their pipes and danced—a spirited tarantella, perhaps?¹⁴⁹

I would have painted a less idyllic picture: a bossy freedman trying to meet the tough terms of a lease for pottery-making on the estate of a cultured but cheese-paring landowner, threatening the health of a slave by trying out a newly acquired recipe for lead glazing. Adding a few clumsily cut appliqués of dancing cupids to the pots might help the humble, but aspiring customers feel better about burying their deceased relatives with pottery rather than metal grave goods. Whether the technological choices behind lead-glazed pottery were made by cheerful potters or bad-tempered managers, the act of thinking through such narratives reminds us that concatenations of individual actions lie behind fragments of material culture created in the past.

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¹⁴⁷ Finley 1973, 137.

¹⁴⁸ See fig. 1, far right.

¹⁴⁹ Roberts 2005, 32.

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