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Advent of The Pottery Wheel: Technological Innovation and Craft Specialization in Minoan Crete

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Advent of The Pottery Wheel: Technological Innovation and Craft Specialization in Minoan Crete

Katherine Carlyle Slaughter

"..they would run very lightly, as when a potter crouching makes trial of his wheel, holding it close in his hands to see if it will run smooth."
Homer, Iliad xviii 598-600[1]

Chapter I: Introduction

The aim of the present study is to introduce the adoption of the pottery wheel in Crete as not only an important technological advancement, but a key to understanding discrete cultural intricacies within Minoan Crete. The spread of the pottery wheel occurred over a period of about 800 years, between 2300 B.C.-1500 B.C., and its use throughout Crete was especially uniform, a point which will be discussed at length in the upcoming chapters.[2] At present, there is extensive research regarding socio-technical theory, and there exists an overwhelming amount of material on the subject of Minoan pottery. Additionally, while some experimental research exploring the use of the pottery wheel and the building methods associated with this period has been performed by Corbetta, Evely, Jeffra, Morrison, and Roux, the results are preliminary and must be incorporated into the oeuvre of research on the subject as a whole. Furthermore, the majority of experimental research would benefit through cooperation between Archaeologists and modern potters such as those at Thrapsanos in eastern Crete, as the current experimental results do not meet the quality of ceramic product needed for analysis. This study attempts to bridge the gap between research published by pottery experts such as Evely, Knappett, Rice, and Roux and the socio-technical experts such as Binford, Lemonnier, Pelegrin, Pfaffenberger, and Wenger by analyzing primary formation methods in ceramic production using the pottery wheel as evidence for gradually increasing technical elasticity in a culture which previously exhibits rigidity. The aim of the present study is not to address the physical appearance of the pottery wheel in Crete, for without the supporting data this task proves futile. Instead, the main aim of this paper is to answer the following questions: how this culture accepted the innovation, what they did to adapt to foreign techniques, how long this process took, and what this information can tell us about the culture.

Chapter I serves as an introduction and overview of the topic, relevant existing research, problems within the topic at hand, a chronology of the pottery wheel in Greece and Crete specifically, as well as the aim of this study. It is necessary to begin by discussing the phenomenon of innovation and adoption of technology from an anthropological as well as archaeological standpoint in Chapter II. Chapter III formally presents direct evidence from various palatial regions (Gournia, Hagia Triada, Phaistos, and Knossos), in addition to both macro and microscopic indirect evi-

[1] Translation by Richmond Lattimore

[2] Berg 2012, 19; Jeffra 2013, 13; Knappett 2004, 264

dence, and is concluded with a discussion of the adoption of the pottery wheel and preferred building techniques. For the intent of this paper, direct evidence includes physical pottery wheels which have been excavated and identified as such. Indirect evidence includes markings on the finished ceramic products which show traces of rotation and therefore production on a pottery wheel, including but not limited to markings made by hands and tools. Chapter IV outlines the sociological reciprocal impact and palatial involvement, and the innovation in regards to socio-technical elasticity and rigidity. Chapters IV and V present a thorough analysis and concluding remarks respectively. I aim to lay out the variability of construction methods utilizing both macro and microscopic evidence, which forms the basis for later analysis of the adoption of the pottery wheel within late Pre-Palatial and Protopalatial Crete, and what this means within the context of the socio-technological theory.

While much has been published on Minoan pottery in regards to its style, consumption, trade, and palatial connectivity, the introduction of the pottery wheel is often overlooked despite being an important technological advancement of the period. The introduction of the pottery wheel created everlasting morpho-stylistic changes within Minoan ceramic production; but more importantly, the ways in which the Minoan culture adopted, and adapted to, this technological innovation reveals information regarding societal structure, practical knowledge, mythological and religious structures, as well as discrete value and cultural symbol systems. Archaeologists traditionally utilize pottery as an instrument for dating stratigraphical information at excavations, or to understand the technical and organizational factors of craft production. After this utilitarian function comes the discerning of meaning, which has historically been analyzed through decoration in addition to use and find-context. This system is not entirely flawed, and provides a considerable amount of information. It does, however, fail to include the technology involved in pottery production as its own entity imbued with meaning as a social practice.[3] To illustrate the ways in which technology is itself a social practice as well as a point of interest on which social practices hinge, I endeavor to underscore the use of the wheel for pottery production, the learning process involved, and furthermore highlight the ways in which socio-technological theory applies in practice to the pottery wheel. The present study serves to examine the advent of the pottery wheel in Minoan Crete from its first appearance in Early Minoan III to Late Minoan I (EM III-LM I), 2300-1500 B.C.

The main temporal focus lies within the academically accepted period of skillful use, Middle Minoan I (MM I), 1900-1800 B.C., to Late Minoan IA (LM IA), 2100-1500 B.C., during which time there is a demonstrable increase in the use of the pottery wheel for production.[4] The first evidence of the pottery wheel in Greece is from Early Bronze Age (EBA II) at Lefkandi and most likely stems from an Anatolian pottery tradition visible at Troy, Liman Tepe, Bakla Tepe, Kulluoba, Aphrodisias, Tarsus, and Beycesultan which was then introduced to the coastline of the Greek mainland, Aigina, the Cyclades, Sporades, and the northern and eastern Aegean islands

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[3] Costin 1991, 1; de Moortel 2002, 189; van der Leeuw 1990, 1

[4] Berg 2012, 19

during the late EBA II.[5] This diffusion of the pottery wheel may have been due to an invasion or immigration of Eastern peoples to the Aegean, or the development of intricate and more widely spread trade networks and exchange routes between the Aegean and the Near East.[6] The spread of the pottery wheel in Crete occurred over a period of about 800 years, between 2300 B.C. - 1500 B.C., and its use throughout Crete was especially uniform, a major point which will be analyzed in the upcoming chapters.

The term *pottery wheel* for the purpose of this study describes a circular disc or plate mounted atop a fulcrum point on which it rotates, and is rotated manually. The use of the pottery wheel in MM I-LM IA Crete must be divided into two categories of techniques: wheel-fashioned, and wheel-thrown. Using macro and microscopic analysis of the ceramic products from the periods MM I-LM IA, Roux and Corbetta altered our understanding of pottery wheel usage by distinguishing these two categories: wheel-fashioning indicates the use of the wheel as a secondary tool to join coils, smooth, and shape the vessel, versus wheel-throwing, wherein the wheel is used as a primary formation tool to create a vessel in its entirety from a ball of clay or "off the hump".[7] Using the pottery wheel, the potter either spins or employs an assistant to spin the wheel, applying rotative kinetic energy to the object using one of the two aforementioned techniques (wheel-fashioning or wheel-thrown) to smooth, elongate, or shape the vessel.[8] This study includes vessels of all sizes, and the ceramic objects to be discussed include vessels for drinking, food preparation, food storage, and ritual use.

The Appearance of the Pottery Wheel in Ancient Greece

As previously mentioned, the Early Bronze Age marks a period of growth, reorganization, and innovation within the Aegean. Pottery was not exempt from this period of evolution, and there are visible morpho-stylistic changes which occur to differentiate this period from the established style of material culture which dominated the previous generation of ceramic production.[9] The provenance of the pottery wheel is yet to be determined in absolute terms, however, most agree it is of Anatolian, Egyptian, or broadly put, Levantine, or Near Eastern origin.[10] The pottery wheel first appears in mainland Greece at Lefkandi on Euboea and is known as the Lefkandi I assem-

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[5] Berg 2012, 19

[6] Betancourt 1985, 65

[7] Roux and Corbetta 1989

[8] All preceding research utilizes the term "rotative" in "rotative kinetic energy," and so I will utilize the term in keeping with established research, although rotational may be more grammatically correct.

[9] Choleva 2012, 345

[10] Berg 2012, Evely 1993, Choleva 2012, Jeffra 2013 Roux 1989

blage, or the Kastri group.[11] The pottery wheel can be traced from its origin point at Lefkandi, spreading throughout the northeastern Peloponnese, and from there to the rest of mainland Greece and the islands. The wheel appears at Lefkandi during late EB II, which seems to designate a transition period into EB III when many of the other origins of the wheel are found; however, there is a major onset of material culture during EB III and many of the sites of EB III are built upon destruction levels which indicates a sharp transition.[12]

The first evidence of wheelmade pottery from Lefkandi I during late EB II assemblage is made up of three techno-morphological assemblage types: the first, a new assortment of small and medium-sized vessels for drinking, eating, and pouring; the second type includes use of the wheel for plates and shallow bowls; and the third is a preference for burnishing and slip casting surfaces for most vessels.[13] The burnished and slip-cast category is further subdivided into two subcategories detailed below.[14]

The Fine Gray Burnished class appears in the northeastern Peloponnese during EB III and consists of the two-handled tankard, kantharos, and Bass bowl. These are produced using the wheel alongside vessels which are hand-built in the same workshops. The Fine Gray Burnished class is quite obviously burnished or wet-smoothed, contain decoration at the shoulder or lip, and has uniform gray surfaces, which demonstrates clay preparation and skilled firing, oxidation, and reduction methods. The Fine Gray Burnished class appears alongside the plain or red-slipped and burnished bowls of Magnesia, Euboia, and the Sporades throughout EB III.[15]

The plain or red-slipped and burnished bowls which originate from sites at Magnesia, Euboia, and the Sporades demonstrate an Anatolian influence and appear during the same period, EB III.[16] They consist of small open shapes such as convex bowls, bowls with inward curving profiles, and bowls with S-shaped rims.[17] This category also includes burnished or slipped surfaces, although they are infrequent.[18] The Lefkandi workshop incorporates this style during EB III

[11] Choleva 2012, 348

[12] Choleva 2012, 347

[13] Choleva 2012, 349

[14] Choleva 2012, 349

[15] Choleva 2012, 348

[16] Choleva 2012, 348

[17] Choleva 2012, 349

[18] Choleva 2012, 349

which indicates diffusion of technique and style as well as the tenacity of the pottery wheel in this region.[19]

Crete's Pottery Wheel

Early evidence of experimentation with rotating devices appears in EM III/MM IA Crete, however, the watershed moment which most scholars agree upon for wheel-fashioned pottery appears in MM IB.[20] This presents a possible gap of about 300 years in the chronology of its appearance in Crete, EM III, and its later rise in popular use during MM IB.

Because there is evidence of experimentation with rotation as early as EM III, many propose the pottery wheel is an internal development which sees more frequent and popularized use in MM IB.[21] In this case, we must ask: what happened between EM III-MM IB? It is imperative to explain the reason why an internal innovation lay almost completely dormant for about 300 years before experiencing an exponential rise in popularity. This will be revisited and further detailed in the concluding chapter. The pottery wheel in Crete follows the same trend as on mainland Greece, wherein evidence shows the introduction during EM III, a gap in use, or a lack of information, between EM III - MM IB, at which time (MM IB-LM IA) there is a significant increase in popularity and usage of the wheel, as well as a general coalescing toward one primary formation method.[22] In an effort to explain this sudden uptick in usage of the pottery wheel, some believe that the innovation was introduced from the Near East around the time of MM IB, as there is both artifactual and textual evidence of the pottery wheel in Egypt as early as 2323 B.C.[23] This theory ties in well with the established evidence of increased long-distance trading during the MM IB, or Protopalatial, period in Crete.

The need for more research in this area is clear and is integral in answering the questions of when and how the innovation appears in Crete. It goes without saying that a concrete origin story acts as a boon in any further research on the topic or its peripheral subjects. The aim of this study is not to address the physical appearance of the pottery wheel in Crete, for without the supporting data there is only room for speculation. Instead, the purpose of this paper is to answer the following questions: how this culture accepted the innovation, what they did to adapt to foreign techniques, how long this process took, and what all of this information can tell us about the culture. In order to answer these questions, I must adopt an *a posteriori* lens with which I examine the

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[19] Choleva 2012, 347

[20] Berg 2012, 19; Choleva 2012, 345

[21] Choleva, 2012; Jeffra 2013; Knappett and van der Leeuw 2014; Roux 2010

[22] Knappett and van der Leeuw 2014, 77

[23] Jeffra 2013, 14

direct evidence: the pottery wheels, and indirect evidence: traces left on pottery showing the use of rotation (i.e. the use of pottery wheels).

Chapter II: Technological Innovation

Technological Innovation and the Social Aspects of Technology

Technological innovation does not exist in a vacuum; however, it is directly related to survival, social networks, identity, and worldviews or mytho-religious understandings. This rather newly minted but now commonly accepted concept of technology has been formed in contrast to what Pfaffenberger references and renounces, the Standard View or the techno-functionalist view, which accredits technological invention and innovation as a response to environmentally driven necessities which develop in a forward trajectory over time.[24] The Standard View of technology, as Pfaffenberger details, cites necessity as the impetus for invention. Within the Standard View, form is dictated by function, and the material record of technological inventions is viewed as a linear progression of achievements necessitated by survival challenges.[25] The word "progression" is used specifically here, because within this Standard View, technology is seen as cumulative (i.e. the digging stick precedes the shovel which precedes the plough).[26] In the same way, technique within the Standard View is seen as progressing from "primitive" motor skills to advanced. Through an overview of current socio-technical theory, as well as the forthcoming analysis, the outdated nature of the Standard View will be underlined. We now agree that necessity is not always the mother of invention, technological advances may take a nonlinear track, and it is incorrect to classify technique on a primitive to advanced spectrum. Thus, for the purposes of discussing the introduction of the pottery wheel, it is necessary to provide current socio-technical theoretical context, discuss the aspects which lead to its advent, and finally the manner in which it was adopted and folded into existing traditions. In this way, the foundations are laid for future research to evaluate the effects of this innovation on social, economic, and political identity. Many archaeological studies focus mainly on the aftermath of innovation, solely based on extant material evidence, without looking closely at the reasons for its development, dissemination of information, and adoption of techniques.[27]

In order to discuss the introduction of the pottery wheel to Minoan Crete, as well as its diffusion and use throughout this historical production period, we must thoroughly address the theoretical and practical phenomenon of innovation in the broader sense. Technology is directly related to social interaction, belief systems, practical knowledge, and an understanding of the physical

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[24] Berg 2007, 235

[25] Pfaffenberger 1992, 494

[26] Pfaffenberger 1992, 494

[27] Leeuw and Torrence 1989, 300

world.[28] Furthermore, technology and its products, are inherently impacted *by* and have a tremendous impact *on* the social, political, economic, and symbolic spheres of a community. Three key components of the study of innovation will be presented here: *material culture, technique* (resources, tools, operational sequences and skills, verbal and nonverbal knowledge) and *socio-technical systems* (technological activity that stems from the link between technique and material culture and the social coordination of labor).[29]

Binford, Costin, Dobres, Hoffman, Leeuw, Lemonnier, and Pfaffenberger's scholarship account for an extensive bibliography regarding innovation and the social aspects of technology, and form the basis of the following section regarding the topic and its relation to the pottery wheel. Archaeology and anthropology must coexist in this chapter, for many archaeologists' focus is material culture, or artifacts, while anthropologists deal mainly with the social dynamics and practices which human beings employ for survival; the obvious overlapping of the two results in the study of technological phenomena which cannot necessarily be claimed by either discipline. Through physical interaction and symbolic communication, human beings create things, and these things in turn become the objects through which those people understand the world around them. Studying the social dimensions of technology does not indicate that the material aspects, or "hardware" of a phenomenon are negligible. It is necessary to observe the technological innovation of the pottery wheel through the anthropological lens to form a more complete comprehension of the technical features and processes involved in the introduction, use, and output of the pottery wheel. Binford wrote in 1965 that culture is an "extrasomatic means of adaptation" and furthermore that technology and material culture form the primary basis of a community's viability within the limits of their physical environment and sociocultural systems.[30] He also defines two characteristics of every artifact: the primary trait being the instrumental element related to its function, and the secondary trait being related to the object's social-symbolic meaning.[31] This binary definition informs the topic of the present study, in which I examine the interdependent nature of these two artifactual traits.

Technological invention is defined by a break in tradition or routine; it is the process or discovery of ideas and things previously unknown.[32] Invention requires the renunciation of other culturally accepted behaviors, or acknowledging that there may be a better or more efficient process available to a community.[33] While invention commonly involves the repurposing of existing elements or material culture to form a radical new item, *innovation* hinges on the repurposing or

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[28] Dobres and Hoffman 1994, 216

[29] Pffafenberger 1992, 497

[30] Binford 1960, 205

[31] Binford 1960, 206

[32] Dobres and Hoffman 1994; Lemonnier 1993

[33] Lemonnier 1993, 21

adaptation of the technological *processes* of a newly introduced invention by a foreign group. In short, innovation is defined more by technique than by the tool. Leeuw defines innovation as non-replicative behavior, which is then accepted and included in a group's replicative behavior.[34] Lemonnier's definition further clarifies the matter: innovation is technical borrowing, and adapting or dismissing the associated technical features of a foreign invention;[35] these two complementary definitions serve as the most apt and concise summary for the purpose of this study. Although there is evidence of experimentation with rotation in pottery production during EM III Crete before its agreed upon widespread introduction in MM IB, the pottery wheel is not yet proven to be a Minoan *invention*, rather most agree that is an adopted behavior through contact with other Near Eastern cultures[36]. As most scholars acknowledge, and Choleva details, a series of Anatolian characteristics appear in EB II-EB III pottery at Lefkandi. There is also evidence of pottery wheel technology in Egypt as there is both artifactual and textual evidence of the pottery wheel in Egypt as early as 2323 B.C..[37] Thus the introduction of the pottery wheel to Crete is best characterized as an *innovation*. The speed at which innovations are adopted is naturally subject to cultural conservatism or acceptance. Van der Leuw deftly states that "not nature but culture is the main constraint of technique."[38] The spread of the pottery wheel occurred over a period of about 800 years, between 2300 B.C-1500 B.C., and its use throughout Crete was especially uniform, which I will continue to unpack and discuss throughout the present study.[39]

Now, once an innovation is introduced to a social system and accepted, it is necessarily deciphered and given an interpretation.[40] The innovation may be similar to a preexisting item or system, and thus incorporated using adopted or preexisting techniques. Techniques are invariably intertwined in dynamic social practices, and material performance.[41] Lemonnier expertly states, "Any technique, in any society, be it a mere gesture or a simple artefact, is always the physical rendering of mental schemas learned through tradition and concerned with how things work, are to be made, and used."[42] Every element in a practice carries meaning from procuring raw material, to selecting tools, and human actors. Are these chosen actors men, women, children, the elderly, or lower class citizens? As these symbolically entangled elements come together to form the

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34 Van der Leeuw 1989, 302

35 Lemonnier 1993

36 Choleva 2012, 345

37 Jeffra 2013, 14

38 Lemonnier 1993, 23

39 Knappett and van der Leeuw 2014, 77

40 Lemonnier 1993, 13

41 Dobres and Hoffman 1994, 214

42 Lemonnier 1993, 3

technique and consequently the practice, its social and cultural symbolism and range in meaning becomes vast and far-reaching. In continuation, techniques and the numerous ways in which they may be borrowed, adapted, or copied, then, carry immense cultural meaning. For instance, a foreign technique may be considered masculine and result in the creation of a tangential yet related technique for the women who participate in said practice. So, while the selection of a technique may seem relatively arbitrary as a means to utilize a new tool upon introduction to a community, the technical elements of this adopted and altered technique are chosen in accordance with social strategies, symbol systems, worldviews, and with the physical goal in mind, the creation of material objects.[43]

Choices made regarding techniques within such cultures are classified as discrete, tacit decisions.[44] Not only is there no written record of such decision-making processes, this would prove to be an inefficient use of time to gather a community and discuss technique in theoretical terms; rather, the technique is built through physical practice and subconscious action and gesture within a society. Schaniel writes that while an artifact may be adopted by a society, it does not necessitate the adoption of the system of logic wherein that artifact was invented.[45] Schaniel later concludes, "the process of adopting and adapting technology does not imply that introduced technology does not lead to change, but the change is not preordained by the technology adapted. The process of technological adaptation is one where the introduced technology is adapted to the social processes of the adopting society, and not vice-versa."[46]

As an aside, it is important to mention that such technological and technical choices are not reflected in the shape or decoration of a pot, rather in the physical process of production, the markings of selected tools, and the cultural understanding of the item, its use, and significance.[47] In this way, it is possible to extrapolate an enormous amount of information about a prehistoric culture, their worldview, cultural values, and lifestyle, through examining the seemingly mundane *act* of producing a clay vessel on a wheel, rather than the product itself. On a much grander scale, the development of technique offers a unique lens with which to view how a group of people engages in an inherently creative act within the limits of the physical world, as they understand it. As Lemonnier notes, "The identification, location, and deciphering of technological choices correspond to a series of crucial questions regarding how, and in what respect, technologies are a mediation between inescapable universal physical laws and the unbound inventiveness of cultures."[48] At this junction, the goal of technological studies becomes clear: the objective at

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[43] Lemonnier 1993, 5

[44] Lemonnier 1993, 6

[45] Schaniel 1998, 493-98

[46] Schaniel 1998, 496-98

[47] Lemonnier 1993, 8

[48] Lemonnier 1993, 10

hand is not to simply define a group's activities but to understand the social processes, their implications, and the resulting bilateral cultural impact on both micro, and ultimately, macro levels.[49] Sahlins, citing Clifford Geertz further abridges this idea stating, "For the greater part of human history, labor has been more significant than tools, the intelligent efforts of the producer more decisive than his simple equipment. The entire history of labor until very recently has been a history of skilled labor."[50] So, while this study closely examines the pottery wheel as a significant innovation, the importance does not lie in the evidence of its arrival to Crete, but the ways in which Minoan societies navigated its arrival, and both had an impact on and were impacted by what is a seemingly mundane circular object which had already been in existence and was known to this society.

Following this brief survey of socio-technological theory, the three key components of the study of innovation are to be addressed: *material culture, technique* (resources, tools, operational sequences and skills, verbal and nonverbal knowledge) and *socio-technical systems* (technological activity that stems from the link between technique and material culture and the social coordination of labor).[51] Beginning with material culture, I have compiled both direct and indirect evidence which forms the basis of forthcoming discussion of technique and socio-technical systems and reciprocal impact.

Chapter III: Primary Evidence

Direct Evidence: Gournia, Hagia Triada, Phaistos, Knossos

The most decisive evidence signaling the introduction of the pottery wheel to Crete is the published record of extant pottery wheels, of which there are surprisingly few examples. Xanthoudides identified and published a useful canon of potters' wheels in 1927, which serves as direct evidence for the introduction of pottery wheels to Minoan Crete.[52] In this chapter I underscore the most commonly occurring traits of the potters' wheels, and briefly discuss the outliers of Xanthoudides' set as well.[53] Evely's classification of pottery wheels modernized the canon in 1993, and further classified the items into *bats* or *wheelheads*. However, direct evidence is lacking when compared to the copious amount of indirect evidence published to date. The detailed publishing of pottery wheels historically has served a different purpose than this study entirely-the reconstruction of the technology rather than the analysis of the culture's amenability. They

[49] Dobres and Hoffman 1994, 213

[50] Sahlins 1972, 81

[51] Pffafenberger 1992, 497

[52] Xanthoudides 1927, 111

[53] For research which requires additional detail of each individual disc, please refer to Xanthoudides' original publishing.

remain instrumental in discussing the advent of the pottery wheel. Not only do they serve as the singular direct evidence available, this data catalogues the range of sizes and variation of features in the development of the tool.

Potters' discs, the term which Xanthoudides uses, refers to the bat or wheelhead. The *bat* is the uppermost portion of the pottery wheel; the disc (made of clay, stone, or marble) is attached with raw clay to a fired clay, stone, or marble disc which makes up the wheelhead, both of which are fixed to a wooden axle for rotation.[54] Evely further clarifies that the terms *mat* and *turntable* refer to the non-freely moving variations of pottery wheels.[55] For the purpose of this study I have chosen select examples of wheelheads from each of Xanthoudides' sites, with additional information provided by Evely. These case studies present the primary evidence for pottery wheels of the Late Bronze Age at four locations: Gournia, Hagia Triada, Phaistos, and Knossos.[56] Although the pottery wheel predates the Late Bronze Age, this catalogue in addition to Evely's research, serves as the most detailed publishing of the wheels themselves. These pottery wheels were formerly identified as either sacred or secular tables, or as lids of pithoi when initially published in excavation reports, until Xanthoudides correctly identified the trove of pottery discs located at the Heraklion Archaeological Museum.[57] Xanthoudides proposed his theory to, and was confirmed by, M.L. Franchet.[58] Xanthoudides further corroborated the newly minted theory through his own careful study of the then contemporary potters at Thrapsanos, a group which still produces work to this day.[59]

54 Evely 1993; Xanthoudides 1927

55 Evely 1993, 270

56 Xanthoudides 1927, 111

57 Xanthoudides 1927

58 Xanthoudides 1927, 111

59 Boyd-Hawes 1908, 42; Xanthoudides 1927, 111

Fig. 1. Six of the published wheelheads. The upper sides of the wheelheads are shown here.
Xanthoudides, S. "Some Minoan Potter's-Wheel Discs"

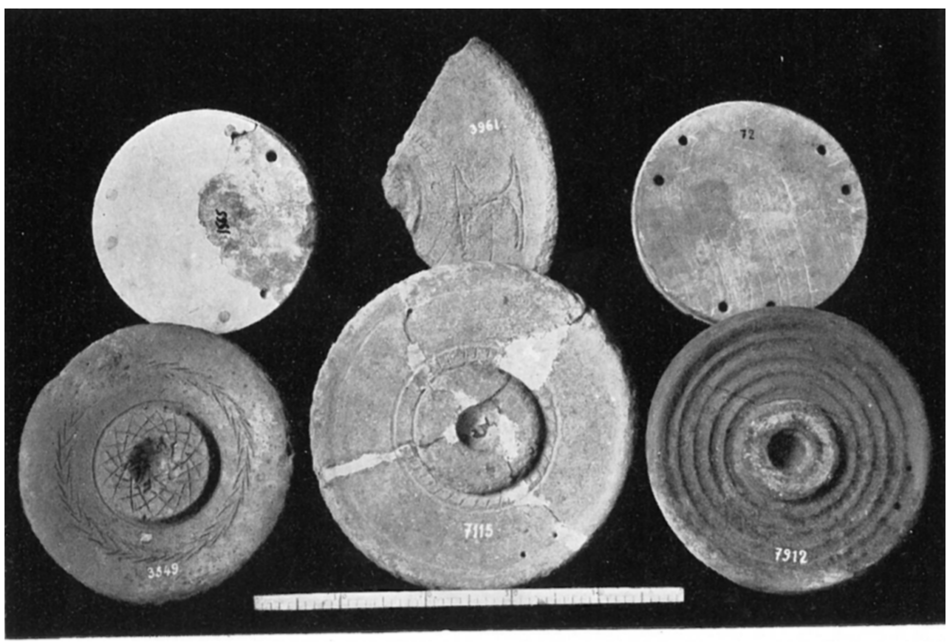

Fig. 2. Six wheelheads showing lower sides with collars, rims, and varying etching and grooves.
Xanthoudides, S. "Some Minoan Potter's-Wheel Discs"

Gournia

The five clay wheelheads described by Xanthoudides at Gournia are dated approximately to LMI-II. Four of the five wheelheads are made of red baked clay, the remaining wheelhead is white. All five have flat upper surfaces and have a characteristic hole on the underside, equidistant from each edge presumably to attach the wooden axle for rotation. A significant number of the wheelheads also have traces of clay on the upper or lower surfaces spread over incised concentric circles, which provides evidence for use of a binding clay to fasten the clay pottery disc to either the bat or wheelhead.[60] Due to the varying types of bats and wheelheads, some require further investigation to prove their identification as either a bat or wheelhead. For the purpose of this study, I have attempted to address only wheelheads.

No. 6738 published by Xanthoudides presents an archetypal wheelhead from this excavation at Grournia: The disc's upper surface is flat while the underside has a central hole, presumably for the wooden axle, and also has incised concentric circles with clay remaining to aid in binding the construction to the axle. Xanthoudides states that this disc is representative of the most characteristic and simplest type of wheelhead due to the fact that it is flat with only slight concavity on the lower side, and has no defining collar or rim.[61] An illustration of this wheelhead is shown below. This particular wheelhead is dated to MM III-LM I.[62]

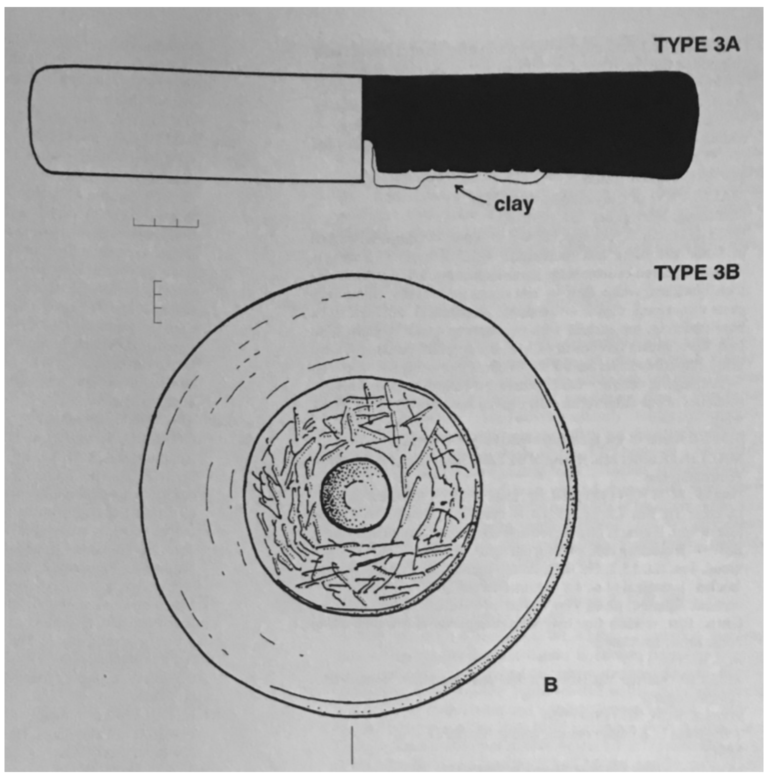

Fig. 3. Illustration of pottery disc No. 6738 with slight concavity on the bottom for axle and linear etching around collar.
Evely, D. "Minoan Crafts"

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[60] Xanthoudides 1927, 112

[61] Evely 1993, 273; Xanthoudides 1927, 112

[62] Evely 1993, 273

Hagia Triada

At Hagia Triada only one wheelhead was excavated (No. 7912), of which approximately three-fifths of the disc remain; the wheelhead has been restored in the photograph below. It is made of clay with white and purple grit mixed throughout.[63] The upper surface is flat apart from a deep groove at the rim. There is faint evidence of reddish-yellow wash applied to a small circular area at the center, and to a concentric circle at some distance from the center.[64] The rim is thick and protrudes above the surface on both the upper and lower sides.[65] The painted wash is seen infrequently and most likely caused confusion in identification, which is why the original excavation report lists this item as the surface of a table. This disc also contains two holes near the rim, presumably to hang the disc by a string, which is uncommon.[66]

Xanthoudides does not confidently attribute this wheelhead to any specific Minoan period though he states it is most likely older than LMI-II, maybe MM III period, due to the sand grit used to make the disc heavy and its similarity to those at Phaistos. The sand grit used may have been intended to add weight to the discs, but may also be useful in future microscopic analysis to date the discs to the precise time period from which they originate.

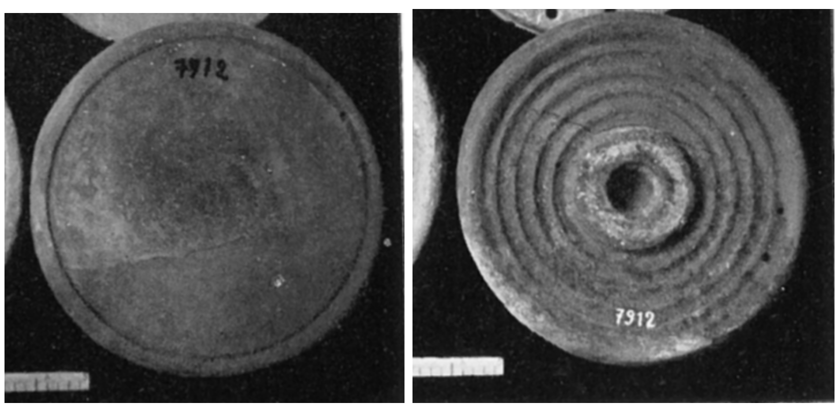

Fig. 4. Wheelhead No. 7912. Left: Upper side showing rim. Right: Lower side showing central collar with hole for axle, grooves, outer rim, and two holes on the lower right edge.
Xanthoudides, S. "Some Minoan Potter's-Wheel Discs"

Phaistos

Xanthoudides dates the wheelheads from Phaistos to the MM period due to their reddish color and the red glaze used. These also present as outliers to the general trends due to the intricate incisions made for the application of binding clay. The detail with which these discs are incised

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[63] Xanthoudides 1927, 115

[64] Xanthoudides 1927, 115

[65] Xanthoudides 1927, 116

[66] Xanthoudides 1927, 116

with geometric, linear, and symbolic patterns measures beyond the utilitarian binding purposes and may serve as evidence of individuality amongst potters and their tools at this site.

No. 3549 is preserved in its entirety and contains more incisions than any other: the wheelhead is made of red clay and shows traces of a red glaze on the upper flat surface.[67] There are three concentric grooves separated by ridges on the upper surface.[68] The rim is decorated with a twisting pattern formed by slanted grooves. The underside of this wheelhead contains a central hole around which is a raised flat surface with incised cross-hatches and perpendicular deeply cut nicks at the edge. The outer edge slopes down and inward toward the axel and is decorated with an incised wreath pattern about halfway between the center and the rim. The geometric incisions at the collar served to bind the disc and axle with the addition of raw clay.

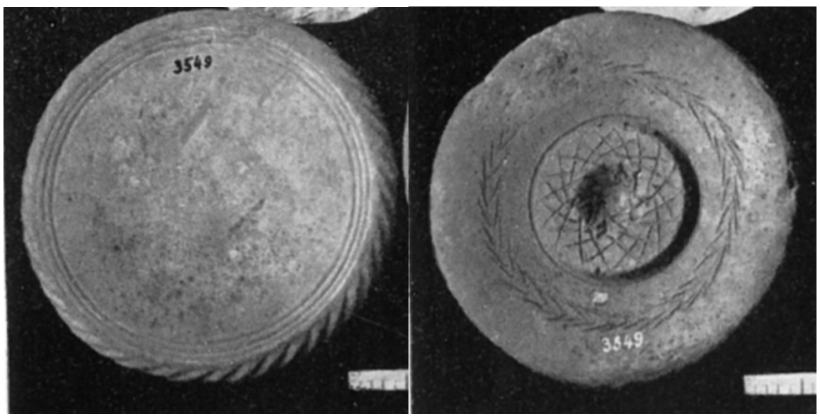

Fig. 5. Wheelhead No. 3549. Left: Upper side contains patterned edge and concentric circles. Right: Lower side shows the collar with geometric etching, and circular wreath.
Xanthoudides, S. “Some Minoan Potter’s-Wheel Discs”

No. 3961 is peculiar: One-third of this wheelhead remains and is made of reddish clay mixed with sand and grit.[69] The upper surface is flat as usual. The underside has a central hole, and three concentric circles - the outer two being connected by incised parallel lines.[70] Outside of the concentric circles is an incised double-axe with a shaft.[71] This mysterious decoration is of unknown significance though it may be sacred, a symbol for luck, or may have served as the potter’s mark or signature.[72]

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[67] Xanthoudides 1927, 116

[68] Xanthoudides 1927, 117

[69] Xanthoudides 1927, 115

[70] Xanthoudides 1927, 115

[71] Xanthoudides 1927, 115

[72] Xanthoudides 1927, 115

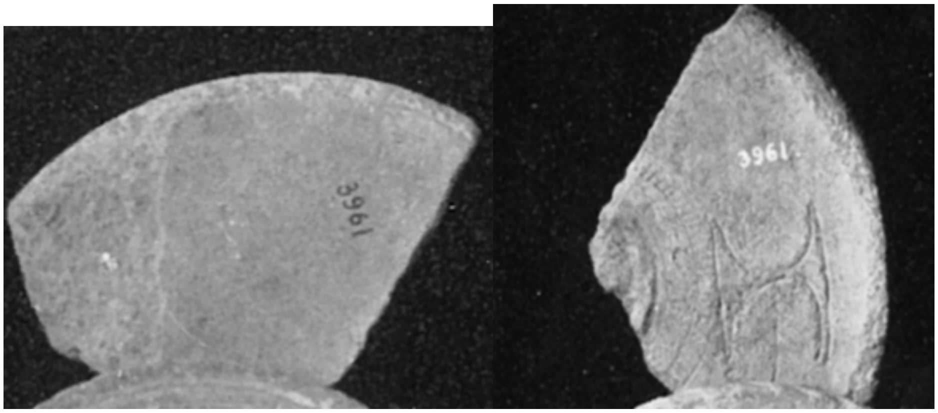

Fig. 6. Wheelhead No. 3961. Left: Upper side contains no unique features. Right: Lower side shows part of the collar, concentric grooves, and double-axe.
Xanthoudides, S. "Some Minoan Potter's-Wheel Discs"

Knossos

Xanthoudides published one white marble disc (No. 72) from Knossos but does not attribute it to any particular period apart from the general MM-LM period. The disc was discovered in Sir Arthur Evans' excavation at Knossos. There are three uniform holes near the edge, which may have been for fastening the bat to the wheelhead, or may indicate holes for bolts to attach legs - in which case this is the surface of a table.[73] Due to the fact that this is the sole example of a marble disc, it is impossible to establish the purpose of the holes with certainty. Xanthoudides also remarks that there are three equidistant grooves on the outer edge of the rim, which Franchet noted may indicate buffing from a cord used to turn the disc.[74] This would indicate a unique method for turning the wheel, and is an interesting concept worth investigating, however, it would be an outlier in an otherwise cohesive dataset.

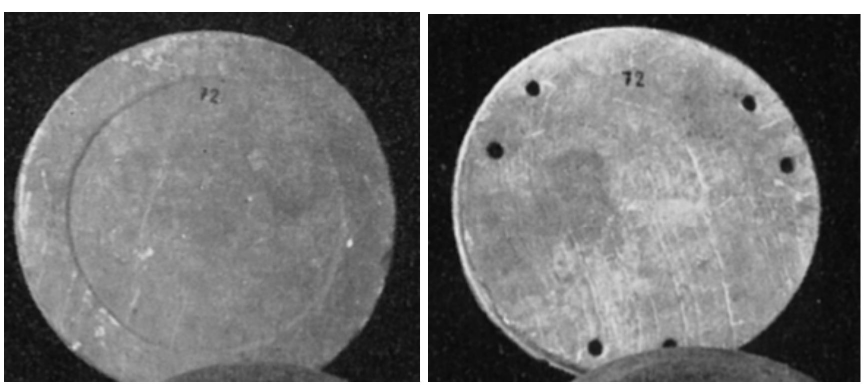

Fig. 7. Wheelhead No. 72. Left: Upper side showing slightly raised rim. Right: Lower side shows six holes which do not penetrate the disc fully.

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[73] Xanthoudides 1927, 117

[74] Xanthoudides 1927, 117

Xanthoudides, S. “Some Minoan Potter’s-Wheel Discs”

Xanthoudides builds upon Franchet’s affirmation of these discs as pottery wheels by studying the modern day Cretan pottery tradition which originates mainly from a group at Thrapsanos, situated southeast of Knossos. These potters at Thrapsanos utilize methods which originate from the ancient Minoan techniques; to this day, the potters use much of the vocabulary from the Classical period, further proving the tradition remains much the same. These potters work in a group of ten to twelve men, and travel throughout the island for approximately three months in the summer, stopping to work in places which provide quality clay, water, and wood for firing, as well as a settlement nearby to serve as a market for their products.[75] Presumably, they travel and work during the summer months due to the fact that the amount of precipitation during the rest of the year would make it challenging, if not impossible, to work outdoors with clay and to maintain a controlled firing process.

The modern potters of Thrapsanos utilize clay bats atop their wheels. These bats, which today they call a πλάκα, are in fact exactly the same as those bats (not wheelheads) described by Xanthoudides dated to MM-LM from Gournia, Hagia Triada, Phaistos, and Knossos, with one minor difference: the modern πλάκα is thinner, to accommodate for the potters traveling with a large stock of them for three months. The thinner width of the πλάκα is reconciled by the use of a larger amount of binding clay, which adds to the weight of the disc to maintain rotative kinetic energy. We might postulate that the thickness of the bats described from MM-LM indicates that they were not traveling wheels, however, further investigation is needed.

Identifying wheelheads and bats from multiple sites of varying sizes and differing levels of palatial involvement, such as these four, serves as evidence that while local sites may have developed the technology with slight differentiation, they demonstrate unification in adopting the pottery wheel during the same timeframe.

Indirect Evidence: The Macroscopic

Knossos and Palaikastro and Lerna

With such limited direct evidence, it is necessary for any study of the pottery wheel to include indirect evidence, namely the traces left on pottery that indicate use of the wheel. Jeffra, Roux and Choleva’s studies function as invaluable resources for indirect evidence of the pottery wheel: a survey of markings on pottery indicating the removal of the vessel from a wheel, or evidence of shaping the vessel via marks left on the vessel walls indicating rotative kinetic energy.[76] The indirect evidence described is from both Knossos and Palaikastro circa MM-LM (1900-1450 B.C.). However, the study by Jeffra and Roux does not provide visual analysis from individual vessels, instead describing general visual patterns. In order to provide visual references to illustrate the patterns, the corresponding visual resources I have presented are those from Choleva’s survey of

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[75] Xanthoudides 1927, 118

[76] Choleva 2012; Jeffra and Roux 2015; Roux and Corbetta 1989

pottery at Lerna, from the fourth occupation level (EB III). Due to the fact that the current scholarship on the topic is lacking, the direct evidence is traced to Knossos, Hagia Triada, Phaistos, and Gournia, while this chapter of indirect evidence will be sourced from Knossos, Palaikastro, and Lerna. Ideally, it would be possible to compare direct and indirect evidence from the same settlements; this is yet another opportunity for future research. I do not observe any significant detrimental effects that the inclusion of geographically diverse sources for formation technique might have on this study, because while Lerna is found on the Pelloponese, the visuals demonstrate the formation methods, which are congruous throughout Greece. In fact, including data from various sites throughout Crete, especially, highlight the potential *limited* influence the palaces had on this particular technological development.

The importance of examining forming techniques in tandem with the technical innovation itself rests in the variability which can be seen within the stages of production, or *chaîne opératoire,* and the resulting reflection of discrete social factors. This chaîne opératoire as it is related to pottery production includes stages such as procuring clay, adding temper, forming techniques, and firing.[77] Each of these stages possess the opportunity for choice, but not every stage is as favorable to adaptation.[78] As Knappett states, "flexibility of choice depends upon both technical and social factors."[79] In other words, if there is both technical elasticity and social amenability for change, the result is high variability in one or all components of a chaîne opératoire.

Gosselain identifies three categories of manufacturing stages within the chaîne opératoire based on their visibility to the consumer and the impact this social factor has on the producer. In the first category are techniques conspicuous in the final product such as decorative techniques, which are highly visible to the consumer, and whose reaction will have an impact on production choices. Techniques in the first category like decoration and firing tend to be highly malleable, and may change as does the consumers' preference with ease. The second category is comprised of techniques that are technically flexible, but not conspicuous in the final product such as selection and preparation of clay, and some firing techniques. Because these processes are invisible to the consumer, they have no impact on the producers' choices within this stage. The third category measures most relevant to this study. The parameters of this category include processes that are neither malleable *nor* visible in the final stage, which includes vessel formation techniques. Because formation techniques include specialized motor skills, they are particularly resistant to change. Gosselain states, "these gestures are 'motor habits' mastered through repeated practice during early learning and subsequently internalized."[80] He further details an essential point, explaining that pottery skills are often learned at a relatively young age from close relatives, making them inherently social traits reflecting "deeply rooted and enduring aspects of social identity,

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[77] Knappett 2004, 257

[78] Knappett 2004, 257

[79] Knappett 2004, 257

[80] Gosselain 2000, 192

such as kinship, language, gender, and class subdivisions."[81] As a result, we may analyze the socio-technical heritage of a group which shows trends of selecting similar technical processes. Vessel forming methods are therefore compulsory in the study of the pottery wheel and must first be outlined in this chapter, as they form the basis for the forthcoming analysis.

In agreement with the previously discussed socio-technological theories of the adoption of invention and adaptation of innovation, the pottery wheel was not immediately introduced and used to form vessels from a formless ball of clay as is done today (wheel-throwing). The wheel was first used in coordination with existing coil or hand-building techniques (wheel-fashioning), and later evolved over time toward complete wheel-throwing. Using macroscopic analysis, four methods of wheel-fashioning are identified and illustrated in the following table:

	Coil Forming	Coil Joining	Coil Thinning	Roughout Shaping
Method 1	non-RKE			RKE
Method 2	non-RKE		RKE	
Method 3	non-RKE	RKE		
Method 4	RKE			

Fig. 8. Description of differences between wheel-fashioning methods. Jeffra, Caroline and Roux Valentine. "The spreading of the potter's wheel in the ancient Mediterranean. A social context-dependent phenomenon."

Excavators are occasionally unable to reliably identify each method using macroscopic analysis, so in some cases a vessel may be identified as using Method 1/2, 2/3, 3/4, and so forth. In other cases, the method is in fact a combination of two techniques and will also be categorized as such. Microscopic x-radiography analysis is needed to resolve this issue and provide a more accurate method identification, and will be discussed shortly. Despite this problem in identification, it is usually quite easy to distinguish between hand-building, wheel-fashioning, and wheel-throwing, and whether coils are present at the very least. If Methods 1, 2, or 3, are used, the coils are usually visible on the interior wall of the vessel and show the circular ribbing made by the potter joining thinner or wetter areas between coils. Wheel-throwing creates a degree of symmetry which is more difficult to produce using hand-building techniques. Wheel-throwing also produces *rilling*, or markings on the interior wall (and exterior, if it is not smoothed with a tool) which show concentric circles made by the fingers when drawing the clay horizontally and vertically. Ultimately, upon removal of the vessel from the wheel, a taut string is used in conjunction with rotative kinetic energy to separate the finished vessel from the *bat, disc, or πλάκα* which creates circular grooves on the bottom of the vessel. When in doubt, this is often the most effective way to identify the use of rotation during some stage or stages of the primary forming phase. It is necessary to emphasize that the circular groove made in this removal step does not necessarily signify complete wheel-throwing, but simply shows that at some stage of production, the vessel was situated on a rotating device while *green* (i.e. the vessel has not been fired; greenware encompasses a range of stages from wet and extremely fragile to leatherhard). The following visuals taken

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81 Gosselain 2000, 192

from Choleva's study from Lerna demonstrate quintessential examples of the four methods, in order, as well as wheel-throwing and the string removal from the wheel.

Method 1:

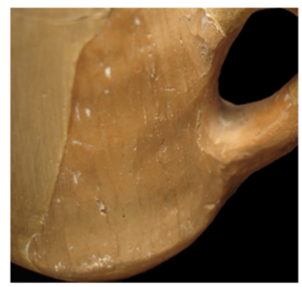
Feature	*Morphology*	*Method of Formation*	*Forming Operation*	*Example from Lerna IV*
Uneven wall thickness	Irregular surface relief and differentiated wall thickness	Application of continuous pressure unable to level and regularize the thickness of the wall due to the presence of coils of different thickness	Shaping the rough-out with RKE	 Tankard P206 (L.491)

Fig. 9. Table illustrating wheel-fashioning Method 1.
Maria Choleva. "The First Wheelmade Pottery at Lerna: Wheel-Thrown Or Wheel-Fashioned?"

This example of Method 1 demonstrates hand-building with coils, and later use of rotative kinetic energy to shape the vessel *after* completion of the form. The coils create an uneven wall thickness, which has not been successfully smoothed using rotation; This generally means that the coils have been created and joined prior to use of rotation.

Method 2:

Feature	*Morphology*	*Method of Formation*	*Forming Operation*	*Example from Lerna IV*
Miscellaneous linear anomalies between zones of coil joints	Various traces of joining of coils: deep rectilinear and nonrectilinear grooves, furrowed wavy grooves, oblique features, broken lines, beetling irregular features, fine fractures and fissures	Application of continuous or discontinuous pressure on coil joints to erase the traces of joining	Thinning and/or shaping the rough-out with RKE	 Bass bowl P1347 (L.789)  Bass bowl P1365

Fig. 10. Table illustrating wheel-fashioning Method 2.
Maria Choleva. "The First Wheelmade Pottery at Lerna: Wheel-Thrown Or Wheel-Fashioned?"

Method 2 demonstrates coil forming and joining without rotative kinetic energy, and later use of rotation for thinning and shaping. Due to the horizontal fissures on the exterior and undulations on the interior wall, it is clear that rotation is not present in joining the coils. Attempting to smooth and thin coils and coil-joints using rotation often causes horizontal fissures due to irregular drying; hand-building is slow in comparison to wheel-fashioning so the coils and joints begin to dry as the vessel is built. Then, it is placed upon a wheel, and water is added to smooth or thin the coils which creates a wet layer of clay on the surface and the appearance of a smooth wall. However, the surface is extremely wet in comparison with the interior of the clay, and ultimately this technique often leads to horizontal fissures at the joints due to water seeping into the joints while not fully penetrating the thicker, dehydrated coils.

Method 3:

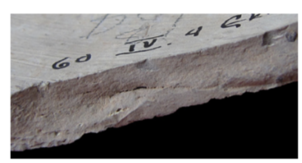
Feature	*Morphology*	*Method of Formation*	*Forming Operation*	*Example from Lerna IV*
Discontinuities and fractures on wall breaks	Horizontal, vertical, and oblique fractures and fissures cutting the continuous configuration of the section	Traces of coil joints visible in the break of the wall	Joining the coils with or without RKE	 Bass bowl P981

Fig. 11. Table illustrating wheel-fashioning Method 3.
Maria Choleva. "The First Wheelmade Pottery at Lerna: Wheel-Thrown Or Wheel-Fashioned?"

Method 3, used to create this bowl, presents joining, thinning, and shaping using rotation after forming the vessel with coils by hand. I postulate that the presence of long diagonal fissures in the cross-section of the bowl demonstrates very clearly that the coils have been rotated and clay has been moved across the surface *after* the initial coil-forming technique, but before creating and smoothing the joins. The method is more effective than Method 2, however, if the potter is inexperienced, the resulting vessel will show discontinuities and possibly horizontal fissures.

Method 4/Wheel-coiling:

Feature	*Morphology*	*Method of Formation*	*Forming Operation*	*Example from Lerna IV*
Undulations in the form of bands on the internal and/or external surface	Bands of different thicknesses and irregularly arranged, corresponding to the presence of coils	Application of continuous pressure to join and level the coils	Joining the coils and thinning the rough-out	 Bass bowl P806 (L.1354)

Fig. 12. Table illustrating wheel-fashioning Method 4.
Maria Choleva. "The First Wheelmade Pottery at Lerna: Wheel-Thrown Or Wheel-Fashioned?"

Method 4, or wheel-coiling, is illustrated here through the application of regular pressure to join and smooth the coils for a level surface, although this vessel certainly presents all traits necessary for Method 3 as well. Methods 3 and 4 are often difficult to distinguish solely based upon macroscopic analysis, and many vessels are often attributed to category 3/4 either because a combination technique was used *or* because the presenting characteristics are too subtle for differentiation. Of course, to prove beyond doubt each of the four methods, microscopic analysis is necessary and is discussed in the upcoming subchapter.

Wheel-throwing:

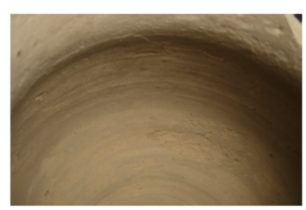
Feature	*Morphology*	*Method of Formation*	*Forming Operation*	*Example from Lerna IV*
Symmetry in wall thickness and profile on either side of vertical axis	Geometrical similarity and uniformity on either side of vertical axis	Application of continuous, symmetrical pressure	Shaping the rough-out with RKE	 Tankard P688 (L.90)
Stretched surface	Smooth surface	Vertical and upward strain of the clay under continuous pressure	Shaping with RKE	 Tankard P688 (L.90)

Fig. 13. Table illustrating wheel-throwing method.

Maria Choleva. "The First Wheelmade Pottery at Lerna: Wheel-Thrown Or Wheel-Fashioned?"

The two examples above show the most quintessential traits necessary to visually identify wheel-thrown vessels. In particular, symmetry, uniform thickness, continuous pressure, upward strain, and stretched surface are essential in identification.

Removing the Vessel:

Feature	*Morphology*	*Method of Formation*	*Forming Operation*	*Example from Lerna IV*
Concentric striation on the underside of the base	Spiral lines (string marks)	Cutting the vessel with a string while turning	Cutting operation with RKE	 Bass bowl P815 (L.488)

Fig. 14. Table illustrating marks of removal.
Maria Choleva. "The First Wheelmade Pottery at Lerna: Wheel-Thrown Or Wheel-Fashioned?"

The concentric grooves shown above near the center of the base is the clear mark of removal from a rotating device with a string. This mark does not certify wheel-throwing; it will be present on any vessel that has been rotated for shaping, thinning, joining, wheel-coiling, or even for decoration while *green* (i.e. the clay is still wet).

These four methods, in addition to wheel-throwing, demonstrate the wide variety of approaches possible when constructing a vessel, not to mention the additional hand-building techniques such as pinching, pulling, slab-building, and molds. In many cases, there will be more than one method put to use such as Methods 2/3 used for the body of a vessel, while the handles were most likely made using a pulling technique, while the spout and base of the vessel are better made by slab and hand-building processes. The use of multiple methods on one vessel also may indicate various potters working to complete the product, which also indicates a sophisticated production system as well as solidifying the general notion that the potter is a craftsman, not an artist, and the goal is to produce quickly and efficiently. Furthermore, the use of numerous wheel-shaping methods shows the variability in use of the tool, and demonstrates the potters' curious nature in approach to this new technology. A general understanding of these four methods in imperative in discussing the evolution of wheel-use as they illustrate how closely related each stage is, and how naturally one might progress from hand-building to wheel-fashioning. Concurrently, the methods also demonstrate very clearly the ways in which hand-building or coil-building, as the socially preferred and mastered technique, remains present throughout each stage of development. In this way, we see social rigidity alongside technical rigidity which becomes increasingly elastic over time, an observation that I will expand upon in the forthcoming analysis chapter.

Indirect Evidence: The Microscopic

Currently there is insufficient microscopic data published regarding primary formation techniques with the exception of Ina Berg, 2009, and O.S. Rye, 1977. Berg's results from her X-radiographic analysis of Knossian pottery serve as the most detailed indirect evidence of the pottery wheel in EM III through LM II fine, coarse, and semicoarse wares from the Stratigraphical Museum at Knossos.[82] Through x-radiography Berg is able to identify beyond doubt (with few exceptions) the four methods previously discussed; where macroscopic analysis may falter, this method proves invaluable. Because this data set covers such a large chronological span, this study is useful in corroborating initial experimentation with a rotating device in EM III, and developing trends in wheel-use and the ongoing adoption of the potter's wheel after the "formal" introduction in MM IB.

Berg's study produced cross-section and surface level identification characteristics on a microscopic scale for six subsets of primary forming techniques: pinching, drawing, coiling, slab-building, molding, and wheel throwing. This follows Rye's 1977 recognition that "the application of pressure to plastic clay causes mineral particles, voids, and organic fragments to take up a preferred orientation."[83] In order to understand the following analysis, the terms *inclusions* and *voids* must be defined. Inclusions refer to non-clay elements (sand, grit, glass, etc.) added to clay to increase strength, heating properties, or porosity. Typically, there are fewer inclusions present in wheel-thrown vessels due to damaging affects these small inclusions would have on the potters' hands. As a result of this friction between inclusions and potters' hands, the inclusions may stretch the clay unfavorably and potentially tear the vessel when using rotative kinetic energy, especially at high speeds.[84] Voids refer to fissures in the vessels and may be an indication of the amount of water added during the manufacturing process. The shape of fissures also aids in distinguishing between voids caused by ineffective coil building or by rotative kinetic energy.

It should be noted that Berg states numerous times that a wheel-thrown vessel shows greater wall diameter at the base of the vessel and gradually narrows toward the rim which is "natural and inevitable" because "the lower part needs to be stronger in order to support the upper part - equal wall thickness would most likely lead to the collapse of the vessel."[85] Unless she is referring to limitations specific to this period that no longer exist in our physical world (unlikely), this statement is incorrect and many expert potters would in fact corroborate my own experience which proves that with proficiency comes uniform wall thickness which is both achievable and desir-

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[82] Berg 2009, 137-146

[83] Rye 1977, 206

[84] As a note, I have personally worked with clay containing a high percentage of sand inclusions while wheel-throwing. Not only is this quite painful, the chances of catching an inclusion at an unfavorable angle and ripping the entire vessel are very high. The resulting vessels are unique, but take a high level of patience and skill, in addition to a tolerance for damage to the hands.

[85] Berg 2009, 143

able for less problematic firing. It is possible that the cases which produce this gradual thinning in her study are the result of novice potters at the wheel. In the present study, I disregard this alleged characteristic of wheel-thrown vessels as it is not further substantiated or clarified by Berg, and bears no real determination in distinguishing formation techniques. I do, however, agree that wall thickness and irregularity is a major determining factor in identifying other techniques of primary formation such as pinching, drawing, and coil building. However, there are generally *fewer* wall width irregularities in slab-building, molding, and wheel-throwing. The combination techniques, which will be discussed may also produce irregular wall thickness.

The details of pinching, drawing, slab-building, and molding do not fall within the parameters of this study and will not be considered here. For more information regarding the particle alignment of these methods, see Berg's X-radiographic study. Coiling produces no significant pattern in relation to the surface, but does present a horizontal orientation among inclusions as well as elongated and horizontal voids. Wheel-throwing results in inclusions that are aligned parallel to the surface with a diagonal orientation when viewed on the surface. Berg does not include images of the x-rays for publishing, which is unfortunate, nonetheless, the following illustration serves as a visual key for the six methods and their corresponding characteristics.

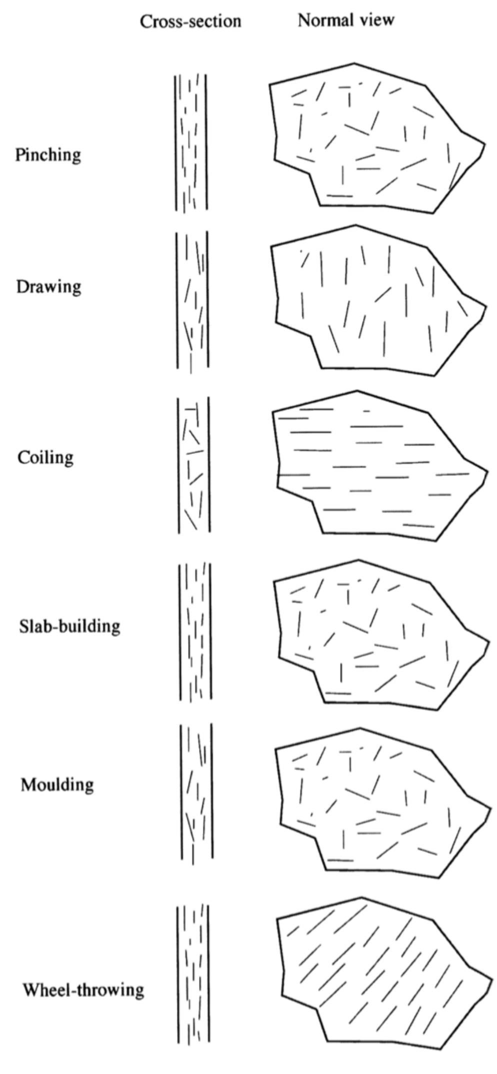

Fig. 15. Illustration of particle alignment in various techniques.
Berg, Ina. "X-Radiography of Knossian Bronze Age Vessels: Assessing Our Knowledge of Primary Forming Techniques."

Four representative cases of the ninety-five items studied are presented in detail: coil, wheel-coiled, wheel-thrown, and combination techniques. Here they are distilled for the purposes of this study.

First, a jug with cut-away spout (No. 18) formed using the coil method, shows many typical traits.[86] This jug presents a thin wall from base to shoulder, dramatically thick shoulder, and thin neck. The thick shoulder does not serve any obvious purpose, and may be the result of an intermediate potter navigating a difficult section of the form. We should not discount the possibility that more than one potter created this vessel, which may also account for differing wall thickness in the three sections (body, shoulder, neck) of the jug. The color variations in the X-ray indicate

86 Berg 2009, 144

uneven pressure applied to the wall.[87] Numerous voids are present, which demonstrates that the clay was not kneaded or *wedged* thoroughly - an indication of a novice or intermediate potter. Berg attributes the lack of wedging to the large inclusions, which is also plausible.[88] The voids range in size, the largest void present is medium in size, and demonstrate a lack of water added and limited working of the material by the potter during the formation of this pot.[89] Berg does not include the diameter of this (or any) void, leaving the reader to infer what these relative terms might indicate.

Wheel-coiled vessels (Method 4) such as No. 92 in Berg's radiographic analysis may appear to be wheel-thrown during macroscopic investigation. Wheel-coiled vessels (Method 4) not only present macroscopically as wheel-thrown, they also present the same traits as the coil-built (Method 3) vessel examined above. Wheel-coiling is especially misleading as the vessel is formed using the primary technique of coil-building, however, the joints are not formed by hand. The wheel is later used as a secondary forming method, using limited rotative kinetic energy to join the coils in addition to smoothing and thinning the walls. The wheel is not spun with great velocity and consequently, the diagonal alignment of inclusions is not present; this trait only appears when utilizing the full force of rotative kinetic energy.[90] *Rilling*, or the appearance of horizontal rippling on the surface, can be attributed to coiling, wheel-coiling, or novice wheel-throwing (rilling may appear as irregular pressure applied while throwing), thus the X-ray proves essential in this determination. The X-ray clearly illuminates the coil seams present in this vessel, sometimes gone undetected by macroscopic analysis.

Wheel-thrown vessels such as No. 16, a carinated cup, present distinct traits that only appear in strictly wheel-thrown forms. Berg notes the diminishing wall width toward the rim here, but as previously evinced this trait is not inherent in identification of wheel-throwing. There is, however, regular *rilling* on the vessel walls which is common for novice to intermediate throwing (but can also be seen in coil-built forms). There are also black gaps in the X-ray which indicates voids.[91] Voids in this vessel are a result of a few possibilities: inefficient kneading of the clay prior to throwing, an abundance of water added during throwing, or basic potter error while creating the form. The voids seen in this vessel No. 16 are elongated which Berg imputes to compression with both hands simultaneously, followed by drawing up on the walls.[92] This is of course the natural method for creating a form on the wheel, so it may not be the primary reason for the voids, but does explain their shape. It seems the voids must have been created by a com-

[87] Berg 2009, 144

[88] Berg 2009, 144

[89] Berg 2009, 144

[90] Berg 2009, 145

[91] Berg 2009, 143

[92] Berg 2009, 144

bination of incomplete kneading, and the addition of excess water. These flaws in preparation of the clay, when followed by correct throwing techniques would have elongated the existing voids. Accordingly, the X-ray shows the expected diagonal orientation of voids and inclusions as a result of the mechanics involved in lifting clay material as the wheel rotates. Berg notes that theoretically, the speed of the wheel could be determined through the angle of the voids, however, the manufacturing process proves too complex for an equation.[93] Through further experimentation, it may be possible to determine a range of potential speeds necessary to create similar voids; this is an experiment I aim to conduct in future research. Inclusions in this vessel are rounded and cannot provide additional information regarding the formation technique. In general, inclusions can act like voids and become elongated, providing information about rotational speed, pressure, and direction resulting in a clearer picture of the potter and the technique used for primary formation.[94]

Berg's X-radiography study also confirms the presence of multiple vessels (No. 1, 68, and possibly 13, 17, 59,67, and 76) formed using a combination technique, which encompass a wide variety of permutations of coil, wheel, and other primary forming methods but must include at least two primary methods. This also serves as evidence that not only are vessels sometimes made in different stages using different methods, but may also be completed by numerous potters with disparate skill-levels.[95] The evidence provided by this X-radiographic experiment is invaluable in corroborating macroscopic analysis and also provides additional information regarding combination methods, and the high variability in pottery technique at that time. This variability provides us with a glimpse of the curiosity of a Minoan potter, as well as the creativity with which this culture approached innovation within a preexisting crafting system. A fact which reminds us that, while the potter was part of a larger crafting industry, they were able to express their agency in experimentation, a vital step in negotiating social values and narratives as a part of the larger process of innovation.

Berg notes that shortly after the completion of this study, the X-ray was purchased by the INSTAP Study Center for East Crete, and will hopefully facilitate similar analysis for a larger range of samples from various sites in Crete. It is necessary to perform this analysis to provide conclusive results beyond macroscopic visual analysis to definitively prove primary pottery forming trends over time and across Crete. Secondary forming techniques do not surface in the X-radiographic study, rendering them irrelevant to microscopic study, and will remain under the purview of pottery experts at present.

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[93] Berg 2009, 144

[94] Berg 2009, 144

[95] Berg 2009, 145

Chapter IV: socio-technical Dynamics and Reciprocal Effects of Innovation

What follows is a brief summation of the chronology of the pottery wheel's introduction to Crete, followed by a discussion of the stages of adoption of the technology, and thereafter a discussion regarding why this succession took place as well as its significance within the framework of socio-technical theory.

Circa 1900 B.C. (MM IB), we have the first evidence of rotative kinetic energy as an informed technique applied to ceramic production in Crete.[96] Berg writes that there is evidence of experimentation with rotating devices as early as EM III, however, the majority of scholars agree that the spread of the pottery wheel and its "true" use for wheel-fashioning and later wheel-throwing occurs during the MM IB-IIB date range.[97] The origin of the pottery wheel in Crete still divides scholars. It is possible to consider a parallel (but later in time) correlation to the development of the pottery wheel in the Levant, in which, the wheel appears as early as the Chalcolithic period (c. 4000-3500 B.C.), disappearing with the start of the Early Bronze Age, and reappearing in EB II.[98] If this were the case, it is worth investigating the pottery wheel is an internal development during EM III, which only gains traction and popularity in MM IB. If this hypothesis is supported through research, the question remains: what happened between EM III-MM IB? Why would an innovation lay dormant for 300 years? Scholars such as Evely and Jeffra cite that the innovation was introduced from the Near East as there is both artifactual and textual evidence of the pottery wheel in Egypt circa 2323 B.C.[99] With this question yet unanswered, the focus remains on technique and use which develops during MM IB-LM I. It is interesting to note this innovation within the context of pottery occurs alongside the advent of administrative documentation, monumental architecture, increased trade including long-distance routes, and regionally-defined political organization or palatial trends.[100] So, we see an enormous boom in non-replicative, or innovative, behavior across many systems, which may account for the parallel introduction of foreign technology and uniform acceptance of the pottery wheel for wheel-fashioning, the incorporation of non-replicative behavior into replicative behavior across the entire production system. A further expansion of these innovations occurred during MM IIIA-LM IA, during which time ceramic styles became less regionally tied, political organization became more centralized, and the population grew.[101] It is also important to emphasize that the pottery wheel was not only

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[96] Jeffra and Roux 2019, 169

[97] Berg 2012, 25

[98] Kappett and Van der Leeuw 2014, 76

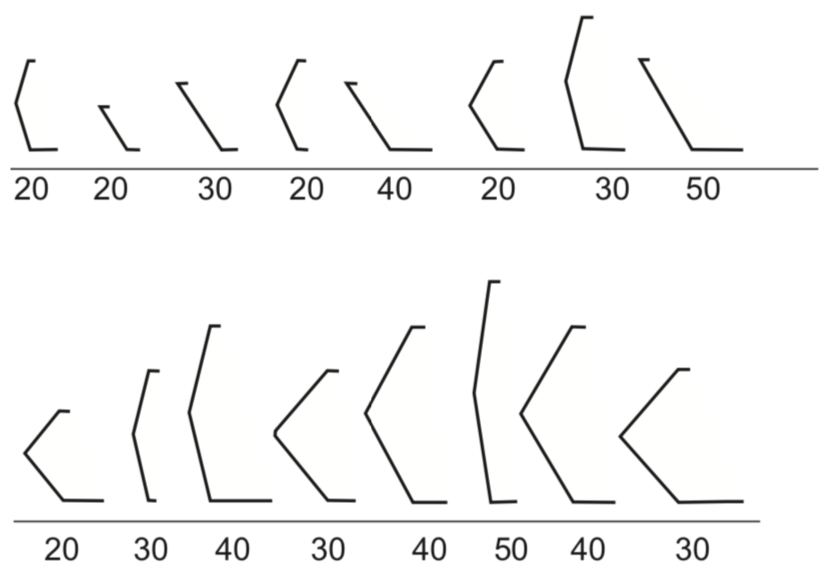
[99] Evely 1993; Jeffra 2013, 14

[100] Jeffra and Roux 2019, 169

[101] Jeffra and Roux 2019, 169

included in replicative behavior but it became the main production technique during this outlined period of time and the resulting skills were developed to apply to vessels of nearly all sizes.

The mastery of wheel-use is loosely correlated with the size of the vessel, which is one way that scholars such as Jeffra and Roux evaluate the progression of use; as the potter becomes more proficient with the wheel, the vessels produced increase in height. However, in some cases this correlation is irrelevant. The design of the pottery wheel during the early period of its introduction (MM I-LM I) limited its speed and capacity to maintain momentum and so would not accommodate throwing large forms (strictly wheel-thrown from a formless lump of clay) even if the skill of the potter allowed it, the exception being those vessels which were wheel-coiled (Methods 1-4) and thus circumvented the necessity for increased speed and sustained momentum.[102] That being given, size or height of the vessel can easily become a problematic method for analysis as it is not directly linked to skill and wheel-use during the period. Some, like Berg, have approached an alternative methodology and judged the level of proficiency through the ratio of base-body-lip diameters. In simplified terms, a master will form a variety of complex shapes with ease, while a beginner usually spends years perfecting simple wide-mouthed bowls or conical cups, usually with straight walls. This method is generally sound except in the regional styles that appreciate simple open forms over complex closed forms. This methodology also does not apply when assessing form over multiple types of wares (coarse versus fine wares for instance, or cooking and storage vessels versus ritual vessels which would necessarily be distinct in style and complexity of form). I find it necessary to add that proficiency may also be expressed by the width of the vessel wall in many cases; it requires greater skill and finesse to work with, and create a uniformly thin-walled vessel; this does not allow for broad enough parameters to engage with the overall regional mastery of the wheel and also skews toward evaluation of small fine wares. The following illustration demonstrates a sequence of vessel forms by increasing complexity.



102 Berg 2012, 25

Fig. 16. Forms illustrated by increasing complexity (after Roux - Corbetta 1989, 111). Difficulty increases left to right. Numbers indicate rim diameter. To scale.
Berg, Ina. "Potting Skill and Learning Networks in Bronze Age Crete"

Naturally, evidence from different sites show different local trajectories of practice throughout the Middle and early Late Bronze Age, due to differing economic needs based on settlement size, trade, and palatial involvement.[103] However, in general, there is widespread analogous evolution across Crete especially in the way that each of the four techniques is applied with astounding consistency to specific vessel shapes. All of this to say, the most compelling methodology for analyzing skill-level in pottery production and fully incorporated use of the wheel is by using the four primary formation methods which illustrate the evolution from hand-building and wheel-fashioning to complete wheel-throwing over time. Additionally, this set of formation methods serves as the best general guideline for stages of mastery among vessels of all wares, uses, sizes, and shapes.

As noted, the analysis of pottery across Bronze Age Crete shows uniform characteristics of forming practices, pointing to a high degree of communication and skill-sharing across the island, which resulted in this congruity.[104] Berg notes that this is likely due to social expectations of how a pot should look or feel, and the likely accepted "ways of doing."[105] As the four techniques for wheel-use spread, and information disseminated across the island and over the given period of time, Method 3 in which a basic shape is formed using coils without rotative kinetic energy, and then joined and finished on the wheel, becomes the most popular and accepted technique amongst all potters across the island and across most vessel sizes and wares, as will be demonstrated in the forthcoming datasets. This technique requires communication and teaching, but not complete mastery of the innovation, and does not make use of the wheel's full technological capabilities (i.e. complete wheel-throwing with self-sustained momentum of rotative kinetic energy). The popularity of this method indicates that pottery forming practices are not dictated by economic or technological factors, but were determined by sociological rules and belief systems at play.[106] Because pottery production includes numerous stages, each of which is learned through physical participation with a mentor, potters engage in shared social practice, "communities of practice," frequently. Wenger defines "communities of practice," as conventions united through shared social experience, and are usually created tacitly through community engagement; this is a reasonable explanation for the widespread homogeneity of pottery forming techniques across Crete.[107] Below is a chart showing the proportion of handmade and wheelmade vessels as relates to MM IB-LM IA. The column indicating wheelmade pottery includes vessels

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[103] Knappett and Van der Leeuw 2014, 77

[104] Berg 2012, 28

[105] Berg 2012, 28

[106] Berg 2012, 28

[107] Wenger 1999

built using any of the wheel-fashioning or wheel-throwing methods; more comprehensive data follows detailing a breakdown of the development and use of individual formation methods, however, this overview provides an initial glimpse at the near-total replacement of Crete's original hand-building technique.

Period	Wheelmade	Handmade
Middle Minoan IB	41 % (113)	59 % (164)
Middle Minoan II	88 % (1,436)	12 % (174)
Middle Minoan III	97 % (387)	3 % (4)
Late Minoan IA	99 % (133)	1 % (2)

Fig. 17. Proportion of wheelmade and handmade Minoan vessels by chronological period.
Jeffra, Caroline and Roux, Valentine. "The spreading of the potter's wheel in the ancient Mediterranean. A social context-dependent phenomenon."

Forming techniques are made up of both knowledge and skill, or *connaissance* and *savoiré-faire* according to Pelegrin.[108] Connaissance, being strictly intellectual, may be disseminated via verbal interaction only, whereas savoiré-faire indicates physical skill or prowess and must be learned through "hands on" experience.[109] Mauss developed the concept of *homme total* which describes the way that the human body is simultaneously developed as a tool itself through skeletal, muscular, and neurological changes. "Potters thus, literally create themselves through the act of potting."[110] In other words, the potter is a tool in the same way that the wheel is, and this bodily tool is "sharpened" through repetition and muscle memory. The inverse of this theory also applies in wheelmade pottery: a prolonged lapse in practice results in decreased potting skill, as muscle memory may fade. During this period, potters are craftsmen not artists, so while preliminary education and continuous practice play a role in skill-level, creativity is a largely irrelevant factor, the potters are "tools" by Mauss' definition. Due to the fact that potters must engage in verbal as well as physical training to develop an elaborate set of gestures, we find a rather homogenous network of potters or "tools" as it were, across the island. There are few extant records of the types of communication or transfer of knowledge which occurred amongst potters, but scholars such as Xanthoudides and Knappett speculate visits between potting communities either through teacher-apprenticeship networks or familial relations, traveling communities of seasonal potters, or movement due to marriage as the most likely avenues for dissemination of this type of connaissance and savoir-faire.[111] Xanthoudides, in studying the modern practices of the Thrapsanos potters, observed the potters working seasonally, and traveling extensively, which may be a practice derived from ancient traditions and would explain the rate at which this transfer of skill

[108] Pelegrin 1990, 116-125

[109] Pelegrin 1990, 116-125

[110] Budden, Sofaer 2009, 6

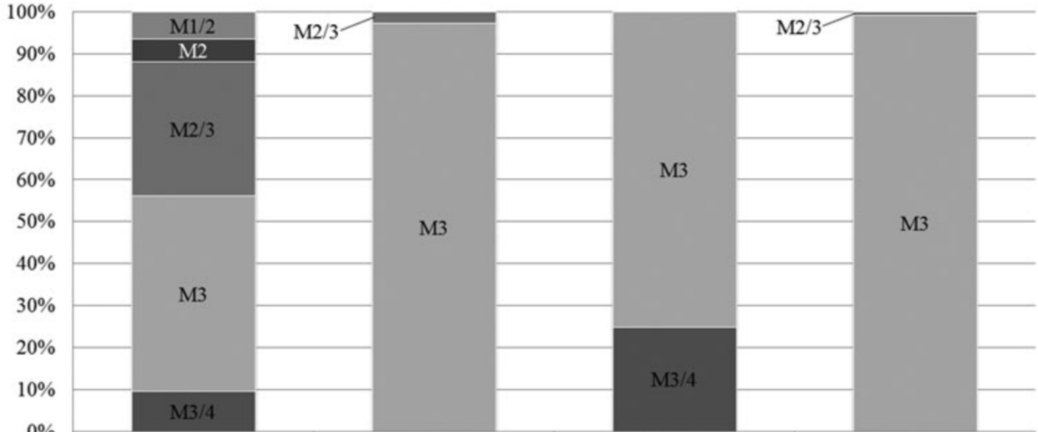
[111] Berg 2012, 29

occurred as well as the homogeneity of the resulting formation methods and pottery style across Crete.

Roux and Corbetta performed the most comprehensive research and experimental work detailing the learning process of wheel-fashioning and throwing. Berg elaborates on this in her 2012 contribution to the International Conference at the Austrian Archaeological Institute at Athens. It may seem superfluous to mention that different potting skills require different lengths of time to master, and each skill is built upon mastery of the last, but this may not be obvious to a non-potter. According to Roux, it takes anywhere from ten to fifteen years for an apprentice to become a master of the pottery wheel.[112] Hand-building techniques (pinching, drawing, slab-building, and molding) correlate with existing motor skills (such as baking) and as such are adopted in a relatively organic matter, whereas wheel-fashioning and later wheel-throwing skills take years of consistent practice and supervision by a master in order to acquire and perfect the techniques along with all of their intricacies. In socio-technical language, hand-building techniques are concurrently present in other replicative behavior systems, while wheel-fashioning or throwing presents itself as non-replicative behavior and must be accepted and incorporated into the system. As previously mentioned, this community of practice indicates a transition in behavior evidenced by pottery remains: social and technical rigidity at the outset of EM III, with development toward technical elasticity by the end of LM I.

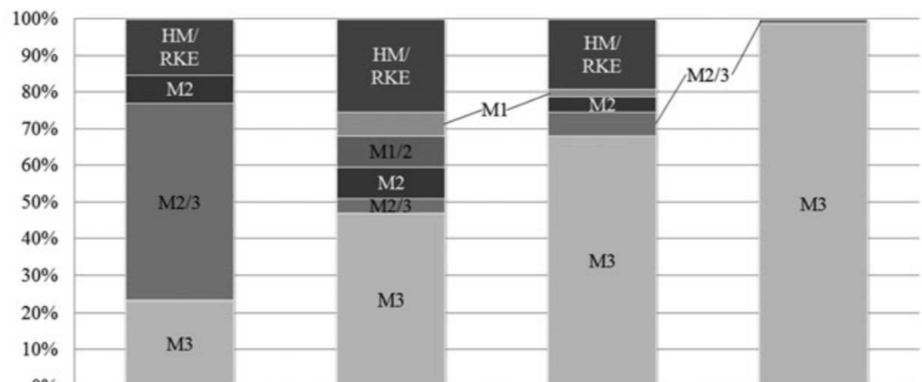
As discussed and visually presented, there are four distinct wheel-fashioning methods; in accord with one's natural presumption, the first method requires the least amount of skill and is most closely related to hand-building, while the fourth method requires the highest skill and most closely resembles wheel-throwing. What is most interesting in terms of socio-technical theory is the fact that the method which gained popularity and was used most regularly across Crete from MM I-LM I is neither Method 1 nor 4 lying on the extremities of this skill-development spectrum, but Method 3 is that which prevails in terms of popularity. Below are two charts mapping the use of each method in both small and medium to medium-large vessels, across three major sites: Palaikastro, Knossos, and Myrtos-Pyrgos. Again, I draw from studies that include numerous Minoan sites in this paper, each with varying levels of palatial involvement (Knossos being a large palatial center, Palaikastro is also large but a palace is yet to be excavated, and Myrtos-Pyrgos finally, is non-palatial) to demonstrate that the pottery forming techniques present similar developmental arcs within differing socio-economic contexts. Jeffra provides detailed charts of the development at each site, although for the purpose of this discussion, her consolidated data is sufficient. The following graphs provide the consolidated data from the three sites, showing the percentage of vessels constructed using each method in the infographic. The number of vessels are listed below the infographic, by method. This information is further organized by time periods MM IB-LM IA. M1, M2, M3, M4 refers to Methods 1-4, HM is handmade, RKE is the abbreviation for rotative kinetic energy.

[112] Roux, Corbetta 1989, 28



	MM IB	MM II	MM III	LM IA
M1/2	5			
M2	4			
M2/3	24	3		2
M3	35	105	116	196
M3/4	7		38	

Fig. 18. Consolidated RKE forming methods in small Minoan vessels, by period.
Jeffra, Caroline "Re-Examination of Early Wheel Potting in Crete"



	MM IB	MM II	MM III	LM IA
Handmade with slight RKE	2	12	9	
M1		3	1	
M1/2		4		
M2	1	4	2	
M2/3	7	2	3	1
M3	3	22	32	80

Fig. 19. Consolidated RKE forming methods in medium to medium-large Minoan vessels, by period.
Jeffra, Caroline "Re-Examination of Early Wheel Potting in Crete"

As is made clear through Jeffra's consolidated data, and underlined by Knappett's 2004 assessment of Knossian potters, early wheel-fashioning methods emerging during MM IB were not yet standardized and a relatively large range of experimentation with hand-building and the first three methods is evident in the data. This quite obviously substantiates my initial point, as well as all of the supporting socio-technical theory, in which the transition to use of the pottery wheel would not have been an orchestrated bilateral exchange or replacement, rather a gradual progression and adaptation through negotiation of social parameters such as mytho-religious, political, economic, and cultural symbol systems. Due to the physical difficulty involved, it is not unexpected that hand-building and Methods 1/2 maintain popularity longer among medium-large vessels than is seen with small vessels. In small vessels we see almost no lasting evidence of hand-building after MM I. This is significant because here we see where the physical challenges are fewer, innovation has overcome the historically accepted hand-building formation method.

During MM II we see less diversity and range of experimentation, especially among small vessels. MM II potters seem to favor Method 3 heavily, even as it relates to large vessel formation, a shift from the previous period which showed a considerable difference in techniques between small and large vessels. There are variations on this general trend within sites, especially smaller settlements, however, some of these differences may be due to smaller excavated sample sizes, inclusion of crudewares, differing economic demand for pottery overall, or diminished demand for pottery of specific sizes which also skews the data. Nevertheless, the preference for Method 3 during MM II is a trend which is upheld at each site.

MM III is a period which sees continued preference for Method 3, as well as increased experimentation with Method 3/4 (especially for small vessels). This, within the progression over MM IB - MM III, seems to reflect the natural tendency to master the preferred or learned method and subsequently experiment with the next stage of difficulty within the context of material that lends itself to beginners (i.e. small vessels are preferred for practicing increasingly difficult formation methods). There is little to no evidence showing large vessels formed using Method 3/4 during this period which supports this observation.

By LM IA, there is substantial preference shown for Method 3, a decline in experimentation with Method 4 (or 3/4), and minuscule evidence for Method 2. It is here within the data that we may infer that social values must outweigh an interest in "technological advances." What is shown in the data between MM IB-MM III is a rather steadily growing interest in maximizing the innovation's capability, by increased rates in more difficult formation methods over time ending at MM III in which we see rising numbers of vessels created through Method 4 (or a combination of Method 3/4). The departure from this progressive, linear, trend comes during LM IA with the noticeable decrease in Method 4 or 3/4. What can be said about this? First, it shows that both the connaissance (knowledge) and *s*avoiré-faire (know-how or skill) exist within the technological system to utilize Method 3/4 or 4. If both connaissance and savoiré-faire are present within the system, there must be a meaningful reason for choosing a method which requires less skill, does not use the innovation optimally, and may quite possibly be more time-consuming in terms of production purposes; considering the fact that the innovation requires both a potter and an assistant for rotation, and the fact that Method 3 is still significantly slower than wheel-throwing, this Method 3 is inefficient in terms of both labor force and production speed. As for the sociological reasons for selecting Method 3, it would take less time to teach and gain proficiency as it combines existing motor skills and gestures with the incorporation of only some foreign techniques in coordination with the wheel. Therefore, more potters at the same easily-achieved skill level would be able to produce products of similar quality. It is also important to consider that Method 3 may have been the most effective way to replicate specific shapes within the Minoan repertoire, or conversely, that the method is also very likely to have affected the vessel forms thereafter, a theory which Gandon covers in his 2011 study.[113] The most significant and remarkable find within this set of data and discussion is that a shift in primary forming method did in fact occur, albeit over a period of about 400 years. Knappett argues this is a slow transition (especially in his study of MM Knossian potters), and while measuring the speed of a culture's adaptation of a foreign innovation, the terms "fast" or "slow" become seemingly arbitrary when compared to the significance of the fact that an extremely inflexible and deeply socially rooted technical skill is indeed replaced entirely, a fact which is remarkable in a culture which exhibits social rigidity.

What we see in Crete from EM III-LM I, is the adoption of the pottery wheel through negotiation of social parameters, in conjunction with a unified development of technique which points to gradually increasing technical elasticity, but lingering preference for the historically accepted and socially rooted hand-building technique points to low social malleability. Knappett discusses the great length of time which potters at Knossos took to adopt wheel-fashioning and wheel-throwing.[114] It is not wholly surprising that a community within a large palatial setting, with more varied social identities (as he states), would not accept the technology as rapidly as a more unified community or smaller group of craftsmen, who assign greater social value in coherence both as a group and in the output of their products.[115] Roux and Corbetta demonstrate that cultural differences shape the social aspects of apprenticeship, however, this does not have a major impact on the length of the apprenticeship. This further corroborates the aforementioned idea that a loosely aligned group may take much longer to complete the repetitions necessary for mastery due to more complex and varying social systems in terms of kinship, in comparison to smaller crafting communities.

Chapter V: Conclusions and Final Remarks

In studying the formation methods as indicators for sociological implications, I concede that my study takes on an *a posteriori* lens. From such a lens it is easy to infer and draw conclusions regarding a cultural coalescence toward the prevalent primary formation Method number 3. For this reason, I found it particularly compelling to include Xanthoudides' canon of pottery discs, as well as the X-radiographic evidence from Berg's study to synthesize the various types of evidence for preference of Method 3, and illustrate how these studies work to answer the same questions regarding initial variability leading to cohesion in both tool and technique. A more comprehensive survey of all existing evidence is needed to advance this particular field of inquiry. As it stands, many of the individual studies that I have cited were designed to address dif-

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[113] Gandon 2011

[114] Knappett 2004

[115] Knappett 2004, 258

fering subtopics within the realm of Minoan pottery. Other scholars such as Knappett, who assume the same *a posteriori* lens as I have, take their conclusions one step further and go on to infer cultural implications regarding palatial involvement in pottery production based on technique. Because the rise of the palaces occurred contemporaneously with the introduction and use of the pottery wheel, this is a tempting conclusion to draw. While the island does display a convergence on the same primary formation method during a time of increased political unity, I do not find enough evidence to support palatial influence. In fact, there is nearly an equal amount of evidence supporting the opposite conclusion. For instance, Mytros-Pyrgos is non-palatial and features heavily in my analysis alongside an enormous palatial center like Knossos. It is for this particular reason that I selected studies which include a range of sites with varying degrees of palatial influence. Of course, this can be seen as a bias toward finding generalizations or toward island-wide centralism in craft activity. That being said, the trend is visible within the data, and speaks to a significant occurrence during the period.

I believe, however, that in lieu of palatial involvement or overly-simplified island-wide cooperation, there is enough evidence to justify more research of potting communities, interconnected through travel, marriage, or otherwise. The nature by which the entire island seems to learn, advance, and then concomitantly select a preferred formation method underlines the possibility for small groups with a high level of communication, disseminating the information (both connaissance and savior-fairé) through interwoven crafting networks. It appears that potters of Minoan Crete worked within a community of practice which heavily prioritized cohesion as a community, and aesthetic commonality in their output of ceramic vessels. Whether this value was expressed tacitly or otherwise, remains unknown, but the result of this emphasis on group homogeneity is made clear by excavated pottery remains, the preference for a singular technique proven macroscopically and microscopically, and through the unified acceptance and use of a singular foreign tool: the pottery wheel. This theory of an interconnected network of potters would also serve to explain the similarities between palatial and non-palatial communities of practice. Modern day potters at Thrapsanos, studied by Xanthoudides, still function in this way, as a seasonal traveling group, and may prove to be an invaluable contemporary resource for a deeper understanding of these communities of practice, and the dissemination of both savoiré-faire and connaissance. Not only should future research include a careful examination of modern Cretan potters' techniques, it would benefit the research greatly to include a more extensive search for any additional pottery wheels which might have been initially identified as tables or pithoi lids. X-radiographic research should also be conducted on a wider sample of vessels, as it seems will be done with the acquisition of Berg's X-ray by INSTAP. Images of these X-rays would prove useful to scholars, and should be published along with analysis. Under these circumstances, a more thorough analysis of the advent of the pottery wheel may be completed without bias toward the *a posteriori* lens.

The significance of this research does not apply solely to ceramic production. Underlying social values are what give directionality to advances in technology, and are important to understanding many key elements of a society. What is especially unique about the study of technology is that as previously stated, through physical interaction and symbolic communication, human beings create things, and these things in turn become the objects through which those people understand the world around them. So, while technology helps people to understand the world, it also has a subsequent reciprocal impact on those people and their own environment. This offers us as researchers a unique lens through which to observe the behavior of a particular group. Within technological study, technique plays a nuanced role. The technical elements and required motor skills of an adopted and altered technique are chosen in accordance with social strategies, symbol systems, worldviews, and with the physical goal in mind, the creation of material objects.[116] Through technology, it is possible to observe or infer social interaction, belief systems, practical knowledge, and an understanding of the limitations of the physical world.[117] Beyond the physical realm, technology and its products, are inherently impacted *by* and have a tremendous impact *on* the social, political, economic, and symbolic spheres of a community, which means that this type of research may have far-reaching impact within Minoan studies.

[116] Lemonnier 1993, 5

[117] Dobres and Hoffman 1994, 216

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