Chapter

Technopoiesis in the Southern Levantine Metallurgy and Its Implications on the Rise and Fall of the Ghassulian Society

Nissim Amzallag

Abstract

The impact of mental shifts on societal transformations in antiquity is frequently minimized due to the difficulty of evaluating them. However, even in the absence of written sources, some of these changes are traceable in the material culture, through a special type of implements produced for revealing the technique bringing them forth. Defined as processual artifacts, they inform us about the 'juvenile phase' of complex techniques with strong cosmological dimension (technopoiesis), their evolution, and their societal influences. This paper exposes the heuristic power of this approach through the analysis of the early metallurgy in the Southern Levant. It shows how the evolution of this craft and its cosmological resonances contribute to clarify the singularity of the Ghassulian culture and its disappearance during the transition to the Early Bronze Age.

Keywords: technopraxis, technopoiesis, processual artifacts, cultural metallurgy, Ghassulian culture, Southern Levant, Early Bronze Age

1. Introduction

Our representation of ancient history depends on the data available and the tools and concepts used for their investigation. Concerning prewriting societies, the material culture remains the primary source used to understand ancient history and lifestyles, but it poorly informs us about the mental universe of the past's inhabitants and its transformations. The shifts affecting ancient cultures are therefore generally accounted for by deterministic factors, such as climatic changes, ecological crisis, plagues, famines, invasions, and breakdown of communication networks. Though no one excludes that 'intrinsic' factors, such as the beliefs, rituals, and mode of social organization, may potentially drive societal changes, our inability to characterize them through the material remains renders this type of explanation speculative. This methodological bias overemphasizes the weight of the deterministic factors, as they are the only ones where variations may be accurately measured.

This situation is not always easy to accredit. For example, the process of plant domestication in the ancient Near East, the driving force of the Neolithic Revolution, extended for so long a time interval (12,000–8300 BCE) that its representation as a response to climatic changes, famines, and overpopulation becomes difficult to argue [1]. This timeline may explain why researchers have assumed that mental changes (materialized by the revolution of symbols, rituals, and architecture) might be the driving force of plant domestication and its societal consequences ([2], pp. 3, 9; [3, 4]). Nevertheless, the theories about plant domestication that rank mental changes before survival considerations remain marginal today. Models advocating a neutral process of protracted domestication [5] are preferred, even though they are discrepant with the data [6]. A methodological problem is the source of this bias. It is revealed by Jacques Cauvin, who advocates the prevalence of mental changes to explain plant domestication but acknowledges that "*this invention is scarcely accessible to our present analytical tools. We see only the consequences, at a stage where the phenomenon, already well established, has substantially reshaped the mass of quantifiable information that we can get hold of*." ([3], p. 60).

This situation is not necessarily a fatality. The intrinsic (endogenous) factors that are perceived only through their consequences, after their influence vanishes, might result from the lack of appropriate conceptual tools to reveal their expression and track their evolution. This paper aims to show that a new conceptual tool, *technopoiesis*, may uncover the contribution of some intrinsic factors to societal transformations and illuminate some decisive steps in their evolution. Examination of the rise and demise of the Ghassulian society in the Southern Levant (late Chalcolithic period, 4500–3900 BC) will here illustrate the heuristic power of this approach.

2. The concept of technopoiesis

The analysis of the material culture enables us to reconstitute the techniques used to generate it. Nevertheless, the societal importance of these techniques is generally considered secondary to the impact of the end products. The reason for this bias is simple: we generally approach techniques as processes teleologically oriented toward producing the desired artifacts ([7], p. 20). Through this perspective, the crafts systematically integrate the classical approach of technology (also defined as *technopraxis*) in modern societies, a concept defined as the collection of techniques, skills, methods, and processes recruited to attain an objective and/or the creation of an end product. By extension, the material universe as a whole becomes oriented by the considerations of survival and their societal extensions, the perspectives of increase of wealth and concentration of power.

Nevertheless, technical developments may have other motivations. For complex techniques requiring generations to mature the end product and to explore the benefits of its use, the practical perspectives of the outcomes remain necessarily evasive to the first proponents. In these cases, the first stages of emergence are mainly fueled by discovering a new intriguing reality, the wish to reproduce it and to explore its implications. These latter may be of cosmological nature, and consequently, they may interfere with the universe of beliefs. The early developments of gunpowder and electricity, stimulated by cosmological considerations rather than by any practical perspective, are recent examples of such motivations ([8], pp. 32–33; [9]). They testify that the origins of some complex techniques do not necessarily integrate the technopraxis framework fueled by perspectives of practical applications. An

alternative framework, *technopoiesis*, was recently introduced in order to account for situations of importance of a technical process, irrespective of the potential of practical exploitation of its outcome [10].

In technopoiesis, the primary function of the end product is not practical (tools, ornaments, and prestige artifacts). Instead, the items become the material expression of the technical process that brought them forth. Defined as *processual artifacts*, these objects may carry symbols and serve ritual functions that reflect the cosmological dimension attached to the techniques involved. Identifying processual artifacts in the material culture and investigating their evolution may therefore illuminate the mental changes accompanying the juvenile phase of the development of a technique (technopoiesis) and those accompanying the transition to the 'mature phase' (technopraxis) focused on practical applications. Few points characterize this duality:

1. *Unidirectional trend:* The replacement of the production of processual artifacts (technopoiesis) by their utilitarian or prestige counterpart (technopraxis) is a spontaneous evolution from the juvenile to the mature phase of the development of a technique. However, the opposite trend, the transition from technopraxis to technopoiesis, is not observed.

2. *Facultative character*: Technopoiesis is a facultative stage of development. In relatively simple techniques, such as the production of elementary ceramic artifacts, technopoiesis is attested in some homelands but not in others in which a utilitarian dimension is visible from the very beginning [10].

3. *Uniqueness*: The cosmological connotations attached to technopoiesis interfere with the cultural universe of the people developing the technique. This local character of the motivations contrasts with the universal principles of efficiency guiding the production of the desired issues in the technopraxis framework.

4. *Cosmological dimension*: In technopoiesis, the cosmological resonance of the process overlooks the practical perspectives attached to the end products. This characteristic is generally minimized or even evanesces after the transition to technopraxis.

5. *Religious changes*: Through their cosmological dimension, the principles guiding the technopoietic development of a craft may influence the whole universe of beliefs. The transition to technopraxis introduces a deconsecration of the technique.

Introducing the concept of technopoiesis opens a new horizon of investigation. It explains some characteristics attached to the early development of some techniques and may enable us to track its impact on societal changes. The technopoietic dimension of metallurgy in the Ghassulian society (4500–3800 BCE, Southern Levant, Chalcolithic period) illustrates this reality.

3. The question of origin of the South Levantine metallurgy

Attested from the Ghassulian period, metallurgy reached in the Southern Levant a level of technical development unmatched in the other contemporaneous homelands.

It comprises the mastering of the furnace technique of copper production, the making of complex copper alloys, and the development of the lost-wax technique of casting ([11], 245–253); ([12, 13], p. 41). The high level of standardization of the techniques even suggests the differentiation of a corporation of specialized Ghassulian metalworkers developing this craft ([13][13], p. 46; [14], p. 390).

Metallurgy emerged in the Southern Levant many centuries after the first attestations of metalworking in the neighboring areas (Balkans, Anatolia, Upper Euphrates, Caucasus, and the Iranian plateau). Some authors deny that metallurgy was introduced in the Southern Levant from one of these homelands, because we find no sign of external influence on the early development of the Ghassulian metallurgy ([15], p. 562) and because the earliest use of furnaces for copper production is attested in the Southern Levant [12]. On the other hand, the rapid development of techniques of smelting and metalworking in the Southern Levant is easy to justify by the introduction of mature technical knowledge from another homeland [16]. The discovery of a small artifact of native copper dated from the sixth millennium BCE in the Southern Levant and originating from the Northern Euphrates/Caucasus copper area renders this assumption plausible [17]. The use by the Ghassulian metalworkers of arsenic- and antimony-rich ores coming from afar (Caucasus and Upper Euphrates) might also reflect an ascendancy of these homelands in regard to the one identified in the Southern Levant [18]. The reference to technopoiesis enables us to clarify this question.

4. Technopoiesis in the Southern Levant homeland

The Ghassulian metallurgy is atypical by the produced items. Utilitarian artifacts (hooks, axes, and chisels) and personal ornaments are rarely encountered ([19], p. 21). Concerning the Nahal Mishmar hoard [20] even the artifacts shaped as tools (axes, chisels, and adzes) do not show traces of use, and their abnormal dimension even challenges utilitarian purposes ([21], pp. 294–295). Most items from this hoard, especially the complex ones, are approached as 'prestige artifacts' [20]. However, these complex items are encountered neither in burial contexts nor in any other circumstance attesting to social stratification, and the low level of differentiation of the Ghassulian society reduces considerably the potential demand for such 'prestige artifacts' ([13], p. 68). Finally, the reduced importance of the trade of copper items (seals, stamps, bullae, and tokens are extremely rare in the Southern Levant at this time) undermines the prominence of a mercantile dimension of the Ghassulian metallurgy.

These observations challenge the interpretation of the complex metallic items (such as those discovered in Nahal Mishmar) produced by this culture as prestige artifacts. These objects might have been conceived for rituals ([22], p. 124; [23]). If their metallic nature, shape, symbolism, and even their mode of production (lost-wax casting) was of significance, these objects should be interpreted as processual instead of prestige artifacts ([24], p. 273; [25]).

The rise of metallurgy in the Southern Levant coincides with the emergence of religious and symbolic novelties of the Ghassulian culture, suggesting that both are interrelated. This premise is supported by the similar symbolism identified on these metallic artifacts and other nonmetallic ones (ossuaries, incense burners, and ritual vessel). It suggests an interference between metallurgy and the Ghassulian beliefs about death, afterlife, and regeneration ([25, 26], pp. 72–73). Milena Gošić and Itzhak

Gilead even conclude that "*The Ghassulian metallurgy introduced a new ritual behavior, starting with metal-smelting, through shaping of the artefacts, to the use of the finished artefacts in rituals. Its transformational quality demonstrated the unprecedented control of smiths over the material world and suggests they were most influential members in their communities.*" ([23], p. 171). All these observations suggest a technopoietic dimension of this craft and its impact on the beliefs of the Ghassulian society.

5. Metallurgy in the surrounding homelands

Extractive metallurgy (the production of metal from ore) is attested from the late sixth millennium BCE in Iran [27], the early fifth millennium BC in the Balkans [28], and the mid-fifth millennium in Anatolia, Upper Euphrates [29], and the Caucasus [30]. Though these homelands probably emerged independently from each other, they share a similar mode of copper production by co-smelting sulfide and oxide ores in a crucible ([31][32], p. 195; [33]). The type of produced artifacts is similar too. In all them, most of the implements are tools (chisels, awls, hooks, knives, adzes, and flat axes), weapons (projectile points, and daggers), and ornaments (rings, beads, and pendants), all shaped by simple production processes (hammering or casting in open or bivalve molds) [34–37].

Though copper was probably considered a precious, powerful, and even outstanding material, its mode of production does not show any substantial cultural importance in these homelands. The rise of extractive metallurgy is accompanied neither by a cultural discontinuity nor by a metamorphosis of the rituals and symbols. Instead, a mercantile dimension of copper production is rapidly visible in all them, evidenced by the networks of trade and exchange centered on the areas of metal production in the Upper Euphrates area, area ([38], pp. 37, 43), the Caucasus [30, 35, 39], the Iranian plateau [32], and especially the Balkans ([28, 40], p. 117). In these cultures, the development of extractive metallurgy did not modify the universe of beliefs, symbolism, and rituals. Rather, the mercantile perspective and the many practical uses of copper advanced the integration of early metallurgy, in all these homelands, into the framework of technopraxis.

While the approach of a technique evolves spontaneously from technopoiesis to technopraxis, the opposite trend is unexpected (see above). The technopoietic dimension of the early copper metallurgy in the Southern Levant is therefore unlikely to have emerged from the introduction in this area of the technopraxis approach attested in all the neighbor homelands. The concept of technopoiesis invites us to conclude that metallurgy in the Southern Levant emerged independent of all the other homelands.

6. Early metallurgy and the fundaments of technopoiesis

Extractive metallurgy followed the work of native copper in Anatolia/Upper Euphrates ([38], pp. 19–22), Caucasus [35], Iran [40], and the Balkans [42]. In these homelands, the early mode of smelting in crucibles extends their use for purifying native copper and casting it. Also, the artifacts made of smelt copper are inspired by the repertoire of tools and ornaments produced from native copper. This continuity reveals that copper remained apparently approached before the rise of extractive metallurgy as a powerful material of precious value, with mechanical properties allowing

the production of ornaments and utilitarian and prestige items. It seems, therefore, that extractive metallurgy was teleologically oriented from its very origin toward the production of raw copper, the preexisting desired issue. This motivation positions extractive metallurgy, from its very beginning, within the technopraxis framework in these homelands. At best, the rise of extractive metallurgy affected the societies by increasing the amount of metal available, then enhancing the network of exchanges and social stratification.

Unlike all these homelands, the Southern Levant one is devoid of native copper [21]. It means that the development of the smelting process, in this area, antedates the potential uses of raw copper, its final issue. This singularity is compatible with the main characteristic of technopoiesis: the prevalence of considerations about the process on the perspectives of exploitation of its issue.

Furthermore, extractive metallurgy extends in all the neighbor homelands the separation of native copper from its mineral gangue in crucibles. It means that the symbolism of extraction extends there from the production of native copper to that of smelt metal. In the Southern Levant, where native copper is absent, the smelting of green sandstone devoid of metallic characteristics to produce a metal becomes an act of the creation of matter of cosmological consequences. And the furnace, where copper ore is mixed with coals for performing the smelting process (from the very beginning of metallurgy in this area [11], pp. 244–252; [12, 16]), becomes the site of expression of these demiurgic powers. The religious dimension attached to this technopoietic dimension of early metallurgy is closely related to the singular mode of emergence of metallurgy in the Southern Levant.

7. The transition to the Early Bronze Age in the Southern Levant

7.1 The dislocation of the Ghassulian culture

The Ghassulian culture disappeared at the early fourth millennium BCE. Many settlements became deserted, and those surviving were of reduced size ([43, 44], p. 41; [45]). In parallel, the mode of habitat and crafts (especially pottery and metallurgy) simplified ([13, 46, 47], pp. 69–70; [48]), and the production of the Ghassulian ritual artifacts ceased ([49], pp. 24–26). However, a new culture did not immediately replace the Ghassulian one. Instead, the beginning of the Early Bronze Age (3800–3500 BCE, EBA1 period) looks like a 'dark age', in which the Ghassulian cultural unity merely dislocates [50].

The causes of this erosion are unclear today, mainly because the deterministic factors traditionally drawn on to account for societal collapse are not applicable here. An invasion replacing most of the local population was typically invoked in the past ([51], pp. 64–65; [52], p. 101). However, no foreign influence is visible in the early fourth millennium BCE in the Southern Levant, nor is there any evidence for genocide of the Ghassulian people [53]. Alternatively, the disaggregation of the Ghassulian society became approached as the unavoidable consequence of the degradation of the conditions of subsistence consecutive to a transient phase of drought [45]. However, the analyses of oxygen isotope ratios in the Southern Levant and the evolution of the Dead Sea level suggest an opposite trend [54, 55]. They aim for a transient period of wet climate from the beginning of the fourth millennium BCE (including in the semiarid areas). Plagues are another factor potentially explaining the degradation of the Ghassulian society, but in the absence of positive evidence and parallel collapses

in neighboring areas, such a hypothesis remains speculative. Warfare and internal conflicts are also taken in consideration, but whether or not violence escalated at the end of the period remains a matter of speculation ([53, 56], p. 90). Social disorders are also among the possible causes of collapse, potentially revealed by the disruption of the production of prestige items, especially the metallic ones ([13], pp. 70–71). This assumption depends, however, on the interpretation of the precious copper items as prestige artifacts and their use as markers of the social stratification of the Ghassulian society ([56], p. 241). However, out of this perspective (here challenged), nothing attests that social disorders prompted the disappearance of this culture.

The inability to account for the collapse of the Ghassulian society through deterministic factors calls for an alternative approach. In light of the central importance of metallurgy in the Ghassulian society and religion, this craft and its cultural impact might have been the intrinsic factor whose transformation stimulated the collapse of this society.

7.2 The transition to technopraxis

The cessation of the production of complex metallic items, at the end of the Ghassulian period, is significant. The concomitant demise of the symbols, rituals, and burial traditions reveals that this cessation does not merely result from problems in supplying the exotic ores necessary for producing the alloys. Rather, Alex Joffe concludes, "*These symbolic endings were doubly significant: they represent the abandonment of both symbols themselves and highly skilled craft production (and resource procurement) patterns. If nothing else, this represents a dramatic manifestation of ritual failure*" ([53], p. 100).

Since metallurgy was a central component of the Ghassulian religion, the 'ritual failure' characterizing the end of the Ghassulian period might reflect the disappearance of the technopoietic dimension of this craft and the religious dimension attached to it. In such a case, we may expect the replacement, toward the Early Bronze Age, of the processual artifacts by ornaments and utilitarian and prestige items. Such a transition is attested in the Southern Levant at the early fourth millennium BCE. Instead of highly complex artifacts cast through the lost-wax technique, the techniques of alloying and casting simplify, and this activity reorganizes around the production of tools (awls, flat axes, and adzes), weapons (crescentic axes, daggers, and spearheads) and prestige items [53, 57, 58]. In parallel, the metal production shows drastic changes. The Chalcolithic metallurgy lacked specialization and division of labor: the ores were transported to small workshops, mainly located in the northern Negev, where the metal was produced, alloyed, purified, and cast to produce implements [59]. This mode of organization (cottage industry) fits a technopoietic context in which the mode of production is inseparable from its end products.

From the early fourth millennium BCE, new centers specializing in copper production emerged in the mining areas from the Arabah valley [57, 58]. Besides these sites devoted to the production of copper ingots, other centers positioned at the nexus of networks of trade and distribution became specialized in transforming this raw material into implements [60].This division of labor fits a reorientation of this activity toward the criteria of efficiency rather than the cosmological considerations.

In the Early Bronze Age, the division of labor became visible even within the workshops specializing in copper production [61, 62]. This evolution suggests that standardization and efficiency in producing the desired issue (raw metal or finished implements) now conditioned the development of this activity. It corroborates the

assumption that metallurgy overcame an abrupt transition from technopoiesis to technopraxis at the same time as the Ghassulian culture collapsed [63].

Once gathered, the cosmological importance of the Ghassulian metallurgy, the switch to technopraxis at the early fourth millennium BCE, and the absence of deterministic factors accounting for the collapse of the Ghassulian culture promote a new interpretation: the transition of metallurgy from technopoiesis to technopraxis might be involved in the collapse of the Ghassulian culture and the transition to a 'dark age' period in the Southern Levant.

8. Conclusion

The over-importance devoted to deterministic factors in the transformations affecting the ancient societies reflects a methodological bias rooted in the inability to evaluate the contribution of intrinsic factors. However, this inability also emanates from the exclusive approach of the techniques forging the material culture through the perspective of technopraxis. Ignoring the cultural dimension of the juvenile phase of development (technopoiesis), this premise prevents us from accounting for the changes in cosmological conceptions by analyzing ancient techniques, their mode of organization, and their use.

Identifying the processual artifacts and their symbolism enables us to apprehend this reality, the cosmological resonance of a technique, and its involvement in shaping the religious universe. By extension, it enables us to appreciate the contribution of these beliefs in the transformation of ancient cultures, even though their exact nature remains ignored. This approach allowed us to identify the indigenous origin of the Ghassulian metallurgy and its importance in the religious universe of this culture. It also clarifies the origin of the singular combination between the high inventiveness of the Ghassulian metallurgy and its disconnection from any utilitarian perspective, trade, and exchange. Introducing technopoiesis also illuminates its singular combination of a lack of specialization and division of labor with an outstanding level of mastery of this craft. It also accounts for the contrasting reality of the high level of specialization and the low level of technical complexity and inventiveness of the subsequent technopraxis phase of the development of the metallurgy at the Early Bronze Age.

The example of the Southern Levant reveals that the concept of technopoiesis may illuminate some processes inherent of the evolution of ancient societies that are generally overlooked or considered inaccessible. It stresses how the motivations driving the early development of complex techniques may be far more diversified than the universal pragmatism guiding the technopraxis development of crafts. But technopoiesis is a facultative reality, whose expression remains generally limited. It is why the driving force of the development of the Ghassulian metallurgy, once identified, cannot be extended to other crafts or other homelands of metallurgy. While technopraxis is the domain of general theories and considerations, technopoiesis remains mainly a local and transient reality. Nevertheless, this dual approach opens new perspectives of investigation of ancient history, out of the general principles and theories currently conditioning its investigation.

Author details

Nissim Amzallag
Department of Bible, Archaeology and Ancient Near Eastern Studies, Ben Gurion University of the Negev, Beer Sheba, Israel

*Address all correspondence to: nissamz@post.bgu.ac.il

IntechOpen

References

[1] Abbo S, Gopher A. Near eastern plant domestication: A history of thought. Trends in Plant Science. 2017;**22**:491-511

[2] Wilson PJ. The Domestication of the Human Species. New Haven: The Yale University Press; 1988

[3] Cauvin J. The Birth of the Gods and the Origins of Agriculture. Cambridge: Cambridge University Press; 2000

[4] Watkins T. Building houses, framing concepts, constructing worlds. Paléorient. 2004;**30**:5-23

[5] Fuller DQ, Allaby RG, Stevens C. Domestication as innovation: The entanglement of techniques, technology and chance in the domestication of cereal crops. World Archaeology. 2010;**42**:13-28

[6] Heun M, Abbo S, Lev-Yadun S, Gopher A. A critical review of the protracted domestication model for near eastern founder crops: Linear regression, long-distance gene flow, archaeological and Archaeobotanical evidence. Journal of Experimental Botany. 2012;**63**:4333-4341

[7] Li-Hua R. Definitions of technology. In: Olsen JKB, Pedersen SA, Hendricks VF, editors. A Companion to the Philosophy of Technology. Wiley-Blackwell: Chichester (UK); 2009. pp. 18-22

[8] Lorge PA. The Asian Military Revolution – From Gunpowder to the Bomb. Cambridge: Cambridge University Press; 2008

[9] Morus IR. Frankenstein's Children: Electricity, Exhibition and Experiment in Early-Nineteenth-Century London. New Jersey: Princeton University Press; 1998

[10] Amzallag N. Technopoiesis – The forgotten dimension of early technique development. Philosophy & Technology. 2021;**34**:785-809. DOI: 10.1007/s13347-020-00433-4

[11] Shugar AN. Archaeometallurgical Investigations of the Chalcolithic Site of Abu Matar, Israel: A Reassessment of Technology and its Implications of the Ghassulian Culture. London: University of London; 2000

[12] Amzallag N. From metallurgy to bronze age civilizations: The synthetic theory. American Journal of Archaeology. 2009;**113**:497-519

[13] Rowan YM, Golden J. The chalcolithic period of the southern Levant: A synthetic view. Journal of World Prehistory. 2009;**22**:1-92

[14] Goren Y. The location of specialized copper production by the lost-wax technique in the chalcolithic southern Levant. Geoarchaeology. 2008;**23**:374-397

[15] Golden J. Who Dunnit? New clues concerning the development of chalcolithic metal Technology in the Southern Levant. In: Roberts B, Thornton CP, editors. Archaeometallurgy in Global Perspective. New York: Springer; 2014. pp. 559-578

[16] Ackerfeld D, Abadi-Reiss Y, Yagel O, Harlavan Y, Abulafia T, Yegorov D, et al. Firing up the furnace: New insights on metallurgical practices in the chalcolithic southern Levant from a recently discovered copper-smelting workshop at Horvat beter (Israel). Journal of Archaeological Science: Reports. 2020;**33**:1-14

[17] Garfinkel Y, Klimscha F, Shalev S, Rosenberg D. The beginning of metallurgy in the southern Levant: A late 6th millennium Cal BC copper awl from Tel Tsaf, Israel. PLoS One. 2014;**9**:e92591

[18] Gandulla B, Jaruf P. Otherness and interaction in copper metallurgy in the chalcolithic of the southern Levant: The Transcaucasian connection. Claroscuro. 2017;**16**:1-22

[19] Bourke SJ. The origins of social complexity in the southern Levant: New evidence from Teleilat Ghassul, Jordan. Palestine Exploration Quarterly. 2002;**134**:2-27

[20] Bar Adon P. The Cave of the Treasure – The Finds from the Caves in Nahal Mishmar. Jerusalem: The Israel Exploration Society; 1980

[21] Golden J. New light on the development of chalcolithic metal Technology in the Southern Levant. Journal of World Prehistory. 2009;**22**:283-300

[22] Klimscha F. What makes the world go round? Silenced consequences of the introduction of metallurgy. In: Burmeister S, Bernbeck R, editors. The Interplay of People and Technologies. Archaeological Case Studies on Innovations. Berlin: Editions Topoi; 2017. pp. 105-139

[23] Gosic M, Gilead I. Casting the sacred: Chalcolithic metallurgy and ritual in the southern Levant. In: Laneri N, editor. Defining the Sacred – Approaches to the Archaeology of Religion in the Near East. Oxford: Oxbow Books; 2015. pp. 161-175

[24] Gosic M. Metallurgy, Magic and Social Identities in the Ghassulian Culture of the Southern Levant (ca. 4500-4000 BC). Beer Sheva (Israel): Ben Gurion University; 2013

[25] Amzallag N. Visual code in Nahal Mishmar: The earliest case of proto-writing? Antiguo Oriente. 2018;**16**:45-92

[26] Ilan D, Rowan YM. Deconstructing and recomposing the narrative of spiritual life in the chalcolithic of the southern Levant (4500-3600 B.C.E.). Archaeological Papers of the American Anthropological Association. 2012;**21**:89-113

[27] Pigott VC. The development of metal production on the Iranian plateau. In: Pigott VC, editor. The Archaeometallurgy of the Asian Old World. Philadelphia: University of Pennsylvania Press; 1999. pp. 73-106

[28] Roberts BW, Radivojevic M. Invention as process: Pyrotechnologies in early societies. Cambridge Archaeological Journal. 2015;**25**:299-306

[29] Lehner JW, Yener KA. Organization and specialization of early mining and metal Technologies in Anatolia. In: Roberts BW, Thornton CP, editors. Archaeometallurgy in Global Perspective. New York: Springer; 2014. pp. 529-557

[30] Bobokhian A, Meliksetian K, Gasparyan B, Avetisyan P, Chataigner C, Pernicka E. Transition to extractive metallurgy and social transformation in Armenia at the end of the stone age. In: Gasparyan B, Arimura M, editors. Stone Age of Armenia. A Guide-Book to Stone Age Archaeology in the Republic of Armenia. Kanazawa (Japan): Center for Cultural Resource Studies; 2014. pp. 283-314

[31] Bourgarit, D. 2007. Chalcolithic copper smelting. In: Metals and Mines: Studies in Archaeometallurgy; S. La Niece; D.R. Hook and P. Craddock (eds.). London: Archetype Publications, pp. 3-14.

[32] Frame LD. Reconstructing ancient technologies: Chalcolithic, crucible

smelting at Tal-i-Iblis, Iran. In: Jett P, McCarthy B, Douglas JG, editors. Scientific Research on Ancient Asian Metallurgy: Proceedings of the Fifth Forbes Symposium at the Freer Gallery of art. London: Archetype; 2012. pp. 183-204

[33] Mehofer M. Metallurgy during the chalcolithic and the beginning of the early bronze age in Western Anatolia. In: Horejs B, Mehofer M, editors. Western Anatolia before Troy – Proto-Urbanism in the 4th Millennium BC? Vienna: Austrian Academy of Sciences Press; 2014. pp. 463-490

[34] Antonovic D. Copper processing in Vinča. New contributions to the thesis about metallurgical character of the Vinča culture. The Star. 2002;**52**:27-45

[35] Courcier A. Ancient metallurgy in the Caucasus from the sixth to the third millennium BCE. In: Roberts BW, Thornton CP, editors. Archaeometallurgy in Global Perspective. New York: Springer; 2014. pp. 579-664

[36] Frame L. Technological Change in Southwestern Asia: Metallurgical Production Styles and Social Values during the Chalcolithic and Early Bronze Age. Arizona: The University of Arizona; 2009

[37] Kashani P, Sodaei B, Zishk RY, Hamivand M. Arsenial copper production in the late-chalcolithic period, central plateau, Iran. Case study: Copper-based artefacts in Meymanatabad. Interdisciplinaria Archaeologica. 2013;**4**:207-210

[38] Yener KA. The Domestication of Metals – The Rise of Complex Metal Industries in Anatolia. Leiden: Brill; 2000. p. 2000

[39] Lyonnet B. Introduction. In: Lyonnet B, editor. Les cultures du Caucase (VI-IIIe millénaires avant notre ère. Leur relation avec le Proche-Orient). Paris: CNRS Éditions; 2007. pp. 11-19

[40] Chernykh EN. Nomadic Cultures in the Mega-Structure of the Eurasian World. Boston: Academic Studies Press; 2017

[41] Weeks L. Iranian metallurgy of the fourth millennium BC in its wider technological and cultural contexts. In: Petrie CA, editor. Ancient Iran and its Neighbours: Local Developments and Long-Range Interactions in the Fourth Millennium BC. Oxford: Oxbow; 2013. pp. 277-291

[42] Kienlin TL. Aspects of metalworking and society from the Black Sea to the Baltic Sea from the fifth to the second millennium BC. In: Roberts BW, Thornton CP, editors. Archaeometallurgy in Global Perspective. New York: Springer; 2014. pp. 447-472

[43] Gophna R, Portugali J. Settlement and demographic processes in Israel's coastal plain from the chalcolithic to the middle bronze age. Bulletin of the American Schools of Oriental Research. 1988;**269**:11-28

[44] Joffe AH. Settlement and Society in the Early Bronze age I and II Southern Levant. Sheffield: Sheffield Academic Press; 1993

[45] Lovell J. Shifting Subsistance patterns: Some ideas about the end of the chalcolithic in the southern Levant. Paléorient. 2002;**28**:89-102

[46] Roux V, Courty MA. Les bols élaborés au tour d'Abu Hamid : Rupture technique au 4e millénaire avant J.C. dans le Levant-Sud. Paléorient. 1998;**23**:24-43

[47] Yekutieli Y. The early bronze age 1A of Southwestern Canaan. In: Wolff SR,

editor. Studies in the Archaeology of Israel and Neighboring Lands in Memory of Douglass L. Esse. Chicago: The Oriental Institute of the University of Chicago; 2001. pp. 659-688

[48] Vardi J, Gilead I. Chalcolithic – Early bronze age I transition in the southern Levant: The lithic perspective. Paléorient. 2013;**39**:111-123

[49] Braun E. Cultural Diversity and Change in the Early Bronze I of Israel and Jordan: Towards an Understanding of the Chronological Progression and Patterns of Regionalism in Early Bronze I Society. Tel Aviv: Tel Aviv University; 1996

[50] Braun E. The transition from the Chalcolithic to the Early bronze Age I in Northern Israel and Transjordan: Is There a Missing Link? In : L'urbanisation de la Palestine à l'Âge du Bronze Ancien, Bilan et Perspectives des recherches actuelles; P. de Miroschedji, (ed.); Oxford : BAR International Series 1989;**527**; pp. 7-27.

[51] Kenyon KM. Archaeology of the Holy Land. 4th ed. London: Norton; 1979

[52] Issar AS, Zohar M. Climate Change. Environment and History of the Near East. 2nd ed. Berlin: Springer; 2007

[53] Joffe A. New models for the end of the chalcolithic in the southern Levant. In: Adams MJ, Roux V, editors. Transitions during the early bronze age in the Levant: Methodological problems and interpretative perspectives. Münster: Zaphon; 2021. pp. 81-115

[54] Bar-Matthews M, Ayalon A, Kaufman A. Late quaternary paleoclimate in the eastern Mediterranean region from stable isotope analysis of Speleotherms at Soreq cave, Israel. Quaternary Research. 1997;**47**:155-168

[55] Enzel Y, Bookman R, Sharon D, Gvirtzman H, Dayan U, Ziv B, et al. Late Holocene climates of the near east deduced from Dead Sea level variations and modern regional winter rainfall. Quaternary Research. 2003;**60**:263-273

[56] Levy TE. Cult, metallurgy and rank society – Chalcolithic period (ca 4500-3500 BCE). In: Levy TE, editor. The Archaeology of Society in the Holy Land. Leicester University Press; 1995. pp. 226-244

[57] Genz H. The Organization of Early Bronze age Metalworking in the southern Levant. Paléorient. 2000;**26**:55-65

[58] Golani A. Ashqelon during the EBI period – A Centre for Copper Processing and Trade. In: Maczynska A, editor. The Nile Delta as a Centre of Cultural Interactions between Upper Egypt and the southern Levant in the 4th millennium BC. Poznan: Poznan Archaeological Museum; 2014. pp. 119-138

[59] MacDonald B. The chalcolithic period (c. 4900-3800/3700 BCE): In the southern Transjordan plateau, the southern Ghors, the northeast Arabah, and the Faynan region. Akkadica Supplementum. 2014;**12**:27-41

[60] Segal I, Halicz L, Kamenski A. The metallurgical remains from Ashqelon Afridar – Areas E, G and H. Atiqot. 2004;**45**:311-330

[61] Ben-Yosef E, Gidding A, Tauxe L, Davidovich U, Najjar M, Levy TE. Early bronze age copper production Systems in the Northern Arabah Valley: New insights from Archaeomagnetic study of slag deposits in Jordan and Israel. Journal of Archaeological Science. 2016;**72**:71-84

[62] Levy TE, Adams RB, Hauptmann A, Prange M, Schmitt-Strecker S, Najjar M.

Early bronze age metallurgy: A newly discovered copper manufactory in southern Jordan. Antiquity. 2002;**76**:425-437

[63] Amzallag N. Cultural metallurgy – A key factor in the transition from the chalcolithic to bronze age in the southern Levant. Cambridge Archaeological Journal. 2022;**32**:445-465. DOI: 10.1017/S0959774321000524