Lithic networks in Iran and the Caucasus

By Judith Thomalsky

Schlagwörter: ####, #####, #############, ##########, #########, #########, #######, ###, ###, ####, ####

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Ключевые слова: ####, #####, #############, ##########, #########, #########, #######, ###, ###, ####, #####

Lithic networks are to be regarded as socio-technological interactions or bilateral influences that can be documented by particular *chaîné opératoires* in lithic tool production and utilization. These were established by specific socio-technological behaviour of the community, evolved through every-day life production. Continuous repetition and gestures in tool production leads to a common outline of the products, including artefacts of waste. Also attributes of consumption and discard are shaped by the communal habitus. In this sense, we can speak of technological styles which are directly related with and constituted by the producing community. Therefore, technological styles can be regarded as being established by the social entity. Any supplementary change of either technological attributes or of the standardized production and consumption scheme can be defined as innovative impulses which are either internal or come from "outside". It obviously remains problematic to identify the "core area" of such developments, but it is "easier" to trace such changes in the technological habits: different technological attributes converge to new ideas and were distributed by different modes of socio-technological transfer into other regions/or networks.

The most dominant lithic traditions during the Neolithic Period In the Zagros are the microlithic industries of the Epipalaeolithic late Zarzian and Neolithic Mlefatian (and partly the Nemrikian). These are technologically constituted by pressure flaking that produces microblades/bladelets and leaves so-called "bullet cores" which are microlithic cores, exhausted until these show a very distinctive shape of a bullet. This microlithic tradition considerably differs from the naviforme large blade core industry of the PPN world of the Western fertile crescent, not only in the size but also in regard to the flaking method. The naviforme core industry produced large blades by direct hammer technique **(Fig. 1)**. For the Southern Caucasus, the so-called Trialetian[1] was regarded as a contemporary lithic complex which spread from the greater Transcaucasia region including Hallan Çemi in SE-Anatolia along the Southern Caspian seashore to the (fairly younger) Dzheitunian in the Turkmenian Kopet Dağ area **(Fig. 2)**.[2] These technological complexes were defined by a distinctive composition of director fossils or tool types that share a distinctive primary industry (e.g. micro blades versus large blades) or tool types (e.g. "geometrics"; "asymmetric points"). However, one must admit that the director fossils assemble unspecified blade tools and cannot generally be regarded as technologically parameters, as will be discussed further on. In addition, the basic references for the definition of these so-called technological complexes broadly differ in our study area. The best-documented region in concern of Epipalaeolithic and Neolithic inventories is the Iranian Zagros and adjacent areas including Khuzestan and the Fars Province in the course of the developing "bullet core technology". In contrast, the *Trialetian complex* is defined by approximately ten find spots in SE-Anatolia, Georgia, and North-East Iran which cover a data range from the ninth millennium until 6000 BC. This picture leads to methodical difficulties in a technological and chronological view, primarily caused by the quite different level of documentation and contextual assignments. Another critical point is the very different handling of the documentation of lithic inventories from site to site. Often, only major elements of an inventory are accessible, such as a generalized description of raw materials (that remain very suggestive when material groups are directly related to the described inventory but not set into the wider region), type lists or tool group counts; or even the original amount of lithic artefacts is not presented in the statistical analyses. Further to consider is the conceptual confusion about what exactly is meant by results in an impairment of the

1 Aurenche et al. 2004; Aurenche/Kozlowski 2005; Kozlowski 1996.
2 Gebel/Kozlowski 1994.

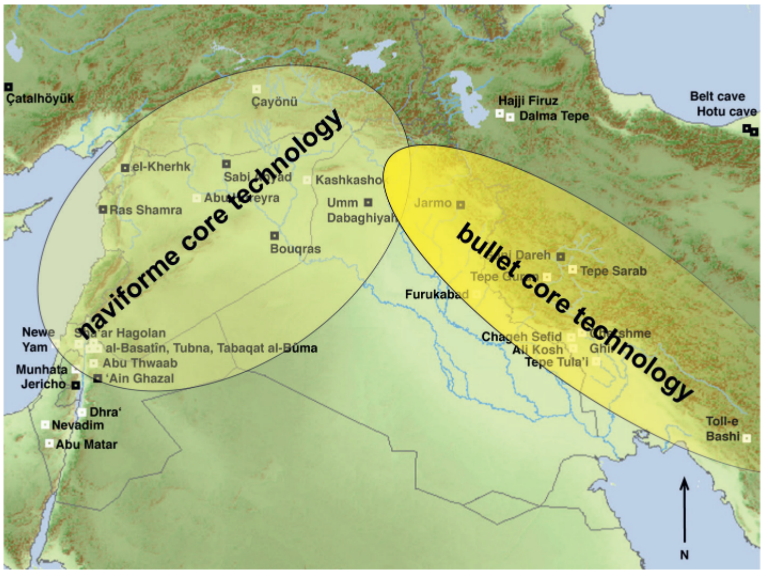

Fig. 1.
Schematic map of microlithic bullet core industry and the naviforme large core industry of the Early Neolithic (Thomalsky)

socio-cultural significance of lithic assemblages. This is at best to demonstrate by phrases such as "lithic complexes", lithic "tradition", or "lithic industry", which are mostly based on a generalized classification of single types or tool kits and their distribution patterns.

To shorten this introduction: a lithic network can generally be described by the following three major aspects: 1) The circulation of specific raw materials such as the obsidian trade network, by 2) social groups that shared basic-technologies of production and consumption or 3) the circulation of tool types with distinctive technological attributes that reflect the same production process and application range(s). On the other hand, a lithic network can comprise different modes of production and function. This means that any aspect of the lithic *chaîne opératoire* should be considered as generated by distinctive patterns of subsistence

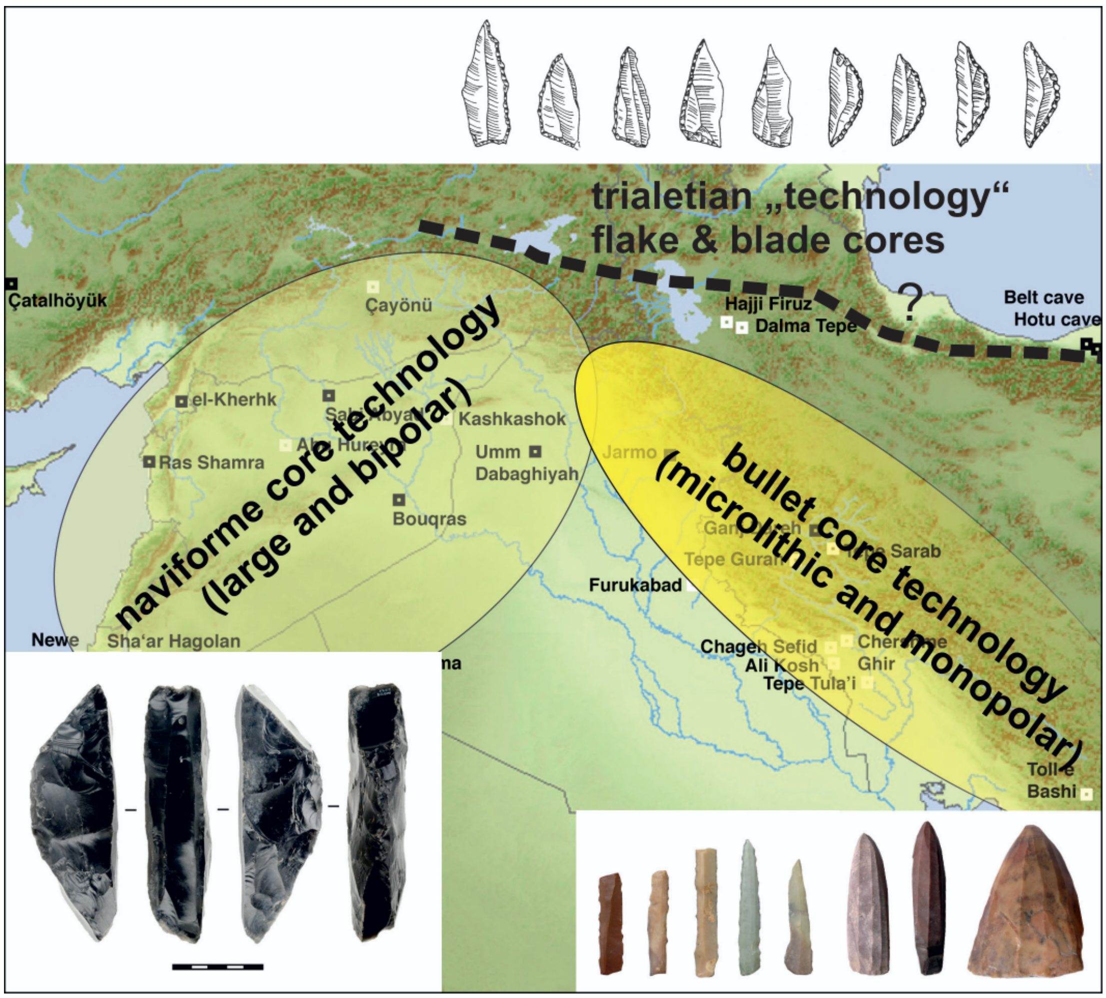

Fig. 2.
The Western and the Eastern Fringe "technological borders", with the so-called Trialetian in the North (after Aurenche et al. 2004).

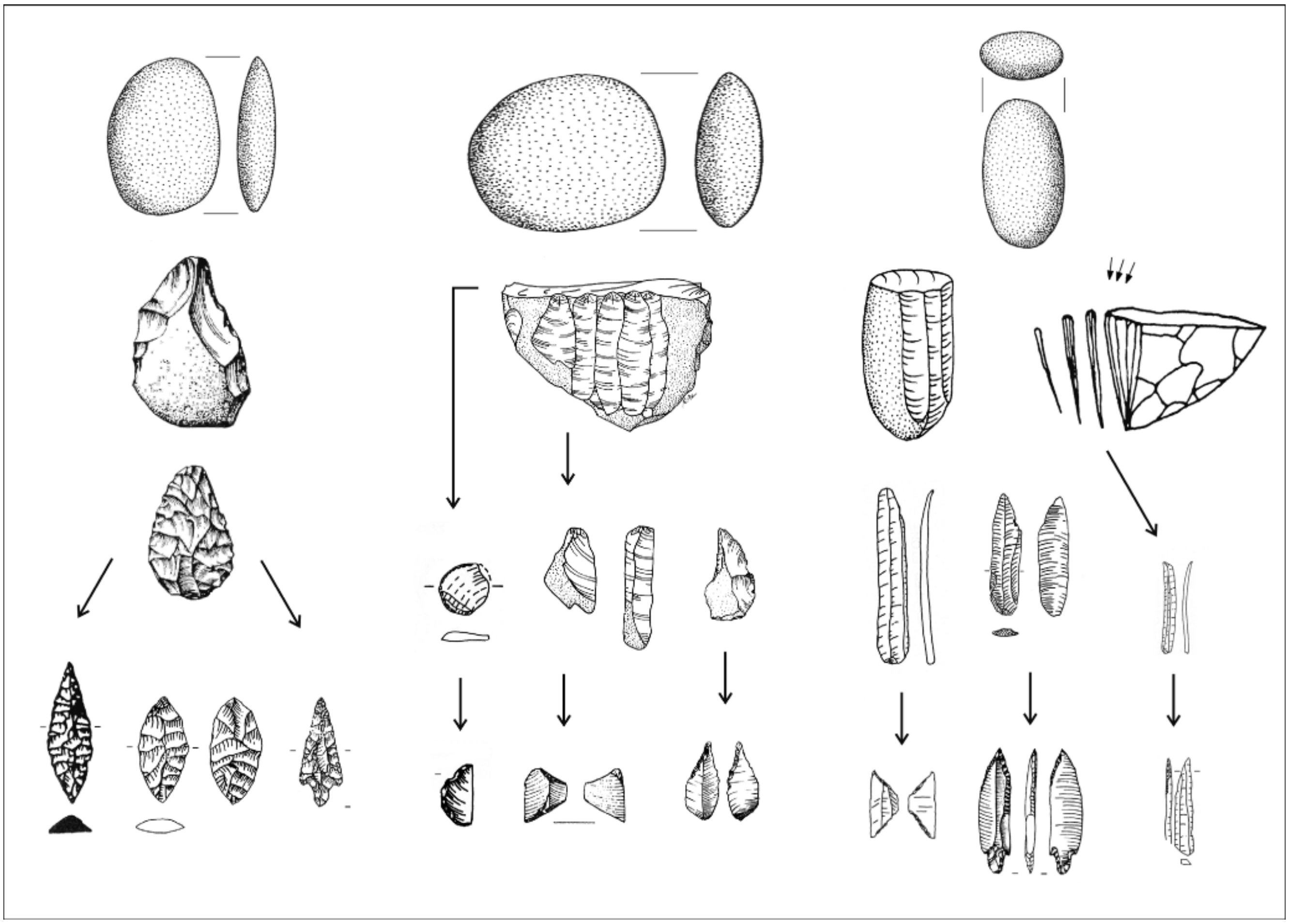

Fig. 3.
Schematic description of technological styles and technological grammar (Thomalsky

and social organisation. However, not all aspects of possible interaction are necessarily involved, but only few attributes that can tell us about the degree of linkage between the interacting networks or in other words, techno-social entities.

No clear framework exists for objective distinctions of lithic networks so far. In the area under study, the major debate concerning lithic industries is dealing with the identification of cultural-technological complexes in the greater Zagros area, the Levante and Southern Caucasus, the latter possibly linked via the Southern Caspian Coast to Turkmenistan (see below). This debate is obviously undercut by the very different state of research and publication. Only a window-like insight can be given for lithic inventories in SE-Anatolia, while the determination of lithic industries in the South Caucasus does not rely on systematic excavations. Hence, the paper addresses the following major aspects: The characterisation of tool-manufacture in the Western Zagros and adjacent areas, particularly Iran, in comparison to the lithic industries of the Southern Caucasus is outlined and discussed within the methodical framework of the definition of socio-technological habitus in lithic industries. The resulting schemata – or technological styles – can be determined as socio-technological interactions or networks.

Technological parameters or how to describe lithic networks

Since many and complex irregularities in lithic documentation and analysis do exist, what can we say about their value of comparability? Additionally to consider are the wide range of technological parameters and social aspects of stone tool manufacture and utilization. The concept of the lithic *chaîne opératoire* itself provides an excellent equipment for the differentiation of “lithic tradition” and “lithic industry”.[3]

[3] Thomalsky 2012, 5–8.

Table 1.
The lithic *chaîne opératoire* with corresponding steps in socio-technological choice.

Stages of the lithic *chaîne opératoire*		Activities	Social and technological aspects of work organization
Extraction	1	raw material procurement testing and collecting nodules	selection of raw material (properties) transport system
Reduction	2	material block/ core preparation initial stage of bifacial tool production	variability in flaking methods place of activity
Production	3	bifacial flaking tool blank production (flakes and blades) from core / nodule	variability of flaking methods intensity of core exploitation place of activity
Transformation	4	tool finishing	degree of "flaking effort" place of activity
	5	tool consumption: using, modifying, re-sharpening, repairing secondary utilization/ recycling	tool kit (functional diversity) degree of utilization (curation)
	6	disposal, final refuse post-depositional processes	place of tool disposal contextual features (refuse pits)

To develop the *chaîne opératoire* of a lithic inventory, the systematic study of the technological attributes of a lithic inventory or selected artefact groups – up to the single object – is necessary **(Tab. 1)**. Significant parameters are the selection of the tool blank (blade, flake or any other debris category) and the further tool modification (shaping of working-edges, etc.) in respect of differences in tool-manufacture. A single technological gesture can differ from another though leading to the same tool form. This aspect becomes clearer if we are discussing raw material usage, since the selection depends on external parameters. Moreover, the processing of material pieces, core or blank, leads to a sequence of irreversible physical modifications and in consequence guides the knapper's decision. The resultant sum of technological attributes defines the technological grammar of a tool.[4] Distinctive attributes can be described by the distinguished flaking technology – flake versus blade and succeeding modification in form of segmentation or edge retouch patterns. For example, a sickle element can be manufactured either from a blade or from a flake, and both can be modified into similar shape by further retouching. That means, the same result can be produced by different technologies, flaking strategies and tool finishing (= surface and edge retouches). The choice of the distinguished tool production steps can be here described as "technological grammar". A regular and permanent repetition of this specific production cycle can be then identified as a technological style of the specific workshop and/or social group (see below; and **Fig. 3**).

[4] Thomalsky 2012, 41.

Chaîne opératoire

To start with a "lithic terminology", there are several levels of socio-technological parameters to consider. While the term lithic tradition comprises a specific core reduction technique, which leaves distinctive core shapes and blanks, the term lithic industry describes the predominating blank production that was used for further tool manufacture. Whether this is a flake based or blade based industry, both often comprise a distinctive core/reduction technology that was chosen in the preceding step of the lithic *chaîne opératoire*. In fact, the larger amount of a complete lithic inventory should mainly be composed on chipping debris which includes core preparation, flakes and even splinters of cores. Also, the place of production and place of consumption can differ in space and time. Nevertheless, the remainder artefacts in context help to understand how a community was producing, distributing, and handling tools. Particularly tools – or on a more comprehensive level, the archaeological artefact – are the result of a distinctive series of technological gestures which comprise the exploration of resources, the modification of raw material into a tool (by a possible specific technological grammar), the utilization of tools. The complete chaîne opératoire from the initial steps, raw material acquisition, production and final discard of an artefact, reflects the techno-economical behaviour of a social unit. In other words, every single human-produced artefact is to be regarded as a technological object, with a distinctive object biography. Its specific manufacturing process as well as its utilization is equivalent to a cultural marker. This constitutes an excellent indicator for technological innovations, transfer and modifications. Such incidents take place within a network which is primarily defined as a social organisation structurally differed in its degree of linkages between the (individual) agents.[5] Consequently, a network can basically be defined as an open communication structure of diverse agents of any kind, whether they are single artefacts or objects (lithic tools), individuals or a group of humans.

In this sense, a lithic network describes a technological habitus, achieved by a commonly evolved socio-technological history, altered to common knowledge and accomplished in an indirect implicit way. The single member of that community or network is not necessarily able to perform the complete *chaîne opératoire*, but is rather accustomed to it. Such a broad regional study, as is presented in this paper, consequently experiences a large range of technological parameters of lithic tool production and variability. On the other hand, the close look onto the individual character of a single lithic inventory and – finally- to the individual elements of a tool – the "tool anatomy" can provide useful information about the generated technological habitus of a community. This approach can thus achieve a comprehensive picture of tool production-and-utilizing communities though single inventories remain fragmentary or incomplete, aside from the investigation by more generalized statistical analyses.

Technological style

One can assume that a collective technological knowledge and thus a pool of technological possibilities existed at any time in prehistory. However, it is not only the decision of the lithic knapper – whether expert or not – what kind of method of tool-manufacture is selected. The result of this process of decision-making and selections can be called a technological style of a social unit.[6] It reflects a distinctive gesture of artefact modification that comprises technological choices which are caused by the reductive character of stone-tool manufacture and by the social habitus that is established over a longer period. Both factors come as one institutionalized lithic tradition (or "technological complex" after Aurenche[7], as they provide the dimension in which technological innovations are proceeded and transferred through social networking. The social network linked to this is reflected by a distinctive character of a tool-manufacture and thus "technological style" can be visualized in various distribution and diffusion patterns.

Technological grammar

Assuming, a large range of technological parameters of lithic tool production is subordinated to the technological habitus of a community; which results in the experienced replicating of tool types. To develop a comprehensive framework that focuses on the technological habitus of tool production and its social context, respectively the lithic network, it is necessary to widen the archaeologists view onto the technological structure of a single artefact. The technological grammar of a tool is developed by a series of decision-making and the remaining technological possibilities after an artefact's modification (see. Fig. 3). This can also become a decoder in a reverse way. In other words, a tool's morphology is the result of a series of selections during the manufacturing process and is adopted from a pool of technological variables; such as raw material, knapping method and further tool modification patterns like segmentation, or distinctive patterns of retouch. Typological analyses should thus comprise not only the general outline of tool types but the basic type of blank, differences in tool modification pattern (facial versus bifacial; inverse versus edge retouches) and intensity of use wear.

Lithic networks are technological networks

"Lithic networks" that are embodied in the concept of communal shared technologies offer a significant insight in the mechanisms of communication and thus technological innovation and diffusion in prehistory. In particular stone tools play a substantial role in prehistoric daily life. Tool manufacture, utilization and consumption are liable to distinctive rules of technological gestures which can be described by the *chaîne opératoire* that also consider specific social-technological habits of the community. Coherent with the concept of socio-technological behaviour is the implemented network of the community which assures the exploration of required resources within a related catchment area. Furthermore, a certain "openness" and socialness of the operating community for new innovative inputs and technological transfer can provide the degree of advancement of a cultural entity. In this sense, technological parameters of lithic tool production are subordinated to the technological habitus of a community. Experienced

[5] See Thomalsky 2012, 11, 53–54 for the definition and discussion of "socio-technological networks".
[6] Thomalsky 2012, 34–37.
[7] Aurenche et al. 2004.

replicating of certain steps in tool production finally lead to a specific tool's morphology (= tool type) which actually comprise a series of selections during the manufacturing process adopted from a pool of technological variables:

1) Accessibility and properties of raw materials,
2) established core technology and method of blank reduction,
3) tool-finishing like segmentation, edge modification or the degree of facial retouching

Therefore, a *lithic network* can be described along specific patterns of the above described shared technological parameters on different levels: exploitation of the same raw material sources for the tool production, tool manufacture technique (bifacial technology or blade industry; hafting methods) and retouch patterns for the final tool modification. Again, their examination on various scales can determine routes of technological transfer, but also can help to identify and differentiate the technological style of social groups in our archaeological contexts, to the point of on-site knapping activities, tool repairing and discard (keyword: re-fitting analyses).

One can observe the circulation of raw materials (keyword: obsidian provenience studies), or the exchange and distribution area (of the consumption) of distinct tool groups or types. Here, on a microscale of examination, the individual "tool anatomy" can be described along its specific technological grammar. This can be reflected by a shared primary industry (core reduction method and blank production) and, on a microscale, the tool grammar which is describing once more the group-related way of how to modify a tool into its final form. In other words: different techniques of flaking, different choices of blanks (whether flake or blade, or blade segments) and different retouch patterns can still configure the same tool layout. The group/the fintknappers is choosing from a pool of possible ways. Thus, one can determine, along the technical attributes a lithic tool is exhibiting, a group-specific technical style. Nevertheless, the individual dimensions of these lithic networks, whether based on flaking method or tool type, should be interpreted within a reliable range in order to consider other aspects of functional or social value.

Lithic traditions in W-Asia and in the Southern Caucasus

From the 9th millennium BC onwards, two major reduction methods draw a prominent technological border in the area under study, respectively the pressure flaking technology with regular bladelet cores (up to their remaining bullet cores) in the Neolithic Zagros, and the naviforme core technology of the so-called PPNB sphere,[8] a large blade industry, performed by direct hammer technique. Especially the bullet core technology comprises roughly the local Zagros lithic groups (Ml'efatian, Nemrikian), while the naviforme technique can be seen as equal to the PPNB industry or *Big Arrowhead Industries* (BAI) after Kozlowski (1994). The latter shows an equally large distribution area, from SW-Anatolia and Upper Mesopotamia through the Levantine corridor to the Southern Levantine coast. Both core technologies are still present in the later Neolithic period, the 6th millennium BCE, though already reduced in their importance by the emergence of the larger blade and flake industries. Altogether we can determine, that these two core technologies seem to draw a technological frontier along the western Zagros fringe. For the Caucasus, the already mentioned "Trialetian" appears to be contemporary with the other two "technological complexes".

What makes the significant difference is that the "Trialetian" is neither described by a specific core technology nor determined by any specific flaking method such as of primary blank production for the tool manufactory, but by a specific tool group: large geometrics, made on rather irregular blades or flakes and formed into shape by retouching the edges. A look into the referred assemblages that were labelled as "Trialetian", the "other" artefacts represent a heterogeneous mixture of different assemblages of different age, respectively different technological styles. One can observe equally obsidian and/or chert industries, microlithic or larger blade industries as well as flake dominated or blade dominated inventories. It therefore seems more likely that the presumed lithic coiné (or "Trialetian complex") shows strong differences in its contextual and chronological dimensions.

However, these aspects require consequently an overall view onto the suggested technological frontiers in the area under study which were established by the differentiation of "lithic groups" in the Zagros, Northern Mesopotamia and in the Caucasus. The emergence of such "lithic groups" or better, their exact technological definition, must further be

8 Asouti 2006.

	Blank production	Core preparation schema	Reduction technique	Reduction schema	Ideal Core Shape	By-products
(large) Naviforme Core Technology	Large regular blades	facial modification (backs) core tablet initial crests (=crested blades)	Hard/direct hammer	Bipolar alternating; unifacial to semi circumferential	Boat-shaped;	bladelets
(microlithic) Bullet Core Technology	Micro-bladelets	facial modification (backs) core tablet initial crests (crested bladelets)	Pressure flaking	Unipolar, semi to circumferential	Conical – pyramidal; Bullets as residues	burin spalls

Table 2. Comparison of core reduction schemata of the naviforme core technology and the bullet core technology.

considered from a lithic point of view. This means the application of the above given terminology of “lithic tradition”, “technological style” and “lithic network”.

Transition(s) in lithic technology: Natufian-PPNA and Zarzian-Protoneolithic

Natufian hunter-gatherer communities of the Western Fertile Crescent as well as the roughly contemporary Zarzian epipalaeolithic groups of the Eastern Fertile crescent both appear to have been directed at the dawn of the Younger Dryas cooling event towards more sedentary or territorial behaviour in form of more regular and repetitive mobile cycles in their specific habitats. This important climatic change may have led to cultural transformation processes which can be seen as possible adaptions and changes in subsistence strategies, which are also visible in lithic technologies. We can further find particular technological parameters that “brigde” the Western and the Eastern Fertile crescent in this specific transition era from the Natufian-Epipaelolithic to the Early Neolithic (12.000 – 10.000/9.000 cal BCE).

The Natufian lithic inventories are characterized by a dominating microlithic component of a small-bladelet industry with geometrics (hunting tools) and a considerable presence of blades with “sickle gloss”[9] which spread throughout the western part of SE-Anatolia and Northern Mesopotamia with a diffusion through the Levantine Corridor into the Southern Levant. From PPNA-times onwards, this Natufian microlithic technology was gradually replaced by a larger blade core industry in general and the naviforme core-technology in particular. The latter finally represents the newly generated lithic tradition of the ensuing PPNB phase. Along with this shift in lithic technology, the PPN world of the Western Fertile Crescent is marked by increasing sedentarism, plant cultivation and intensive animal husbandry. The long blades were used for both, large reaping knives and big arrowheads (respectively the Big Arrowhead Industries). The naviforme cores are boat-shaped, with opposed striking platforms, the blades were struck off from the core by direct percussion.[10] The first advantage was the rapid supply of a large number of straight and regular blades for tool blanks, in a predictable fashion that needed no further or very little modification. Therefore, the naviforme core technique of the PPN already shows specific aspects of craft standardisation and specialisation.

The so-called Epipalaeolithic period or “Zarzian” (only determined for the Zagros area so far) of the Eastern Fertile Crescent lasted from 22.000 to 12.000 BP (respectively 20.000 – 10.000 BC) and is thus of a considerable long-time span. It also forms the bridge to the beginning of earliest sedentism in the Zagros. There is common agreement that the Zarzian can be differentiated into an older and younger period by the introduction of a distinctive tool group – the geometric microliths – in the younger phase. Another important aspect is, that the older phase Is only known in the Zagros region while the younger period, from around 12.000 BCE onwards, is further represented in sequences located along the Caspian Sea shore in North-Eastern Iran (Ali, Belt and Hotu cave). These places became apparently habitable as the Caspian Sea retreated about 10 km toward the present shoreline. Interestingly, the lithic inventories differ significantly from site to site, though radiocarbon data sequences imply a contemporaneous development.

A stratigraphic analysis of the Zarzian core technology at Warwasi cave (Kermanshah, Iran. Zagros) firstly shows a clear development from rather irregular multiplatform flaking towards a two-platform/alternating (= bipolar) reduction schema which leaves roughly naviforme-shaped

9 Wilke/Qintero 1995, 18.

10 Wilke/Quintero 1995, 22.

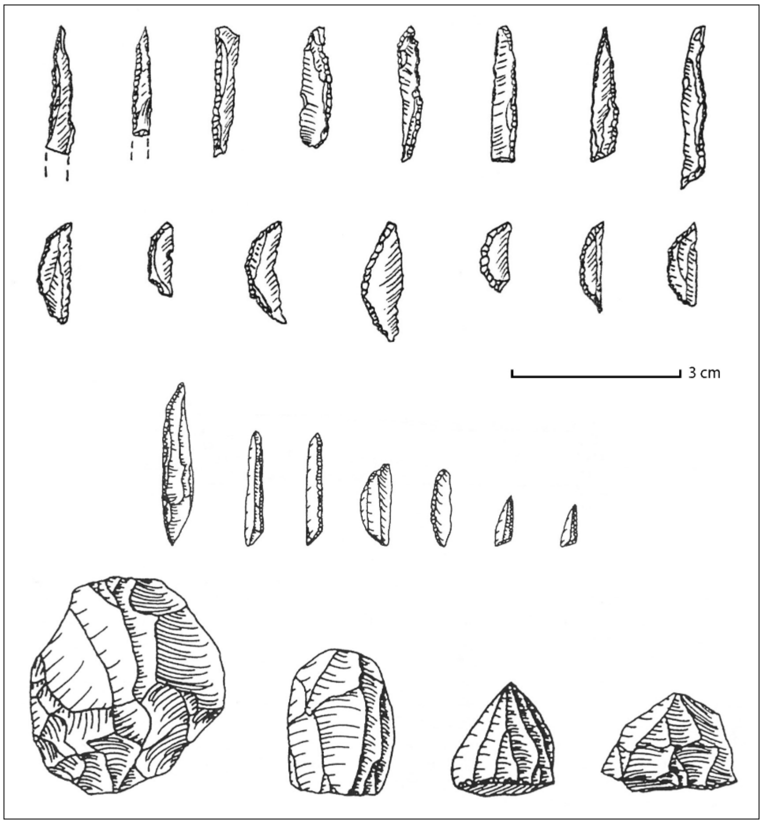

Fig. 4. Lithic inventory of the (Late) Zarzian microlithic complex; microliths from Zarzi (Iraq) and cores from Warwasi cave (Iran) (after Kozlwoski 1996 fig. 1 and Olszweski 1996, fig. 1).

microlithic blade cores **(Fig. 4)**. In the succeeding layers, this gradual change in blade production strategy ended-up in the dominance of small pyramidal blade cores, which means the blades were flaked from one platform in an uni-directional (= unipolar) schema. The step towards the succeeding Neolithic bullet core technology then can be "simply" regarded as an improvement to circumferential flaking and increasing output of the blade number per core, leaving a fully exhausted core lump.

The Zarzian micro-bladelet cores are accompanied by backed and nibbled bladelets, but equally common are flake tools.[11] As a possible transitional site, Zawi Chemi Shanidar in the Iraqi Zagros yields a "standardized" geometric component with backed pieces, backed and truncated pieces and crescent-shaped convex pieces.[12] After Kozlowski, the hereafter following Ml'efatian industry then is marked by the disappearance of the geometric crescents (= hunting component), while the number of backed bladelets increases. Furthermore, the Ml'efatian complex is actually determined as the representative industry of the bullet core technology in Neolithic Iran. Not discussed by Kozlowski (and others) is the actual range of core morphology which rather reflects various reduction techniques than a homogeneous standardized one, as is implied. In fact, the very end of the Zarzian is marked by the introduction and distribution of the pressure flaking method. This change in technology, actually an advancement in technological methods, was used as a marker for a transitional phase, the "Protoneolithic" in Iran (see below). More interestingly, microlithic geometrics and in particular the crescents, are again present in the pottery Neolithic Mushki phase In Fars Province, a fact emphasized by Abe, which can be associated with the recurrence of hunting in this region during the later Neolithic.[13] Also, a decrease of crescents is not to demonstrate for the Neolithic sites of the Iranian Zagros but were instead used as sickle inlays (see below).

Moreover, we can determine specific trends in the lithic industries in both geographical parts of the fertile crescents that rely firstly on the technological concept of a microlithic tradition, and, secondly, on the gradual change towards a standardized flaking pattern in the blade core technology – respectively the alternating blade reduction schema that later on dominates the naviforme blade core technique of the PPNA in the "West" as well as the circumferential and highly-productive blade reduction pattern of the bullet core technology in the "East".

The Diffusion of the pressure flaking technique in the area under study

The subsequent development towards the characteristic bullet cores of the Neolithic in Iran can be regarded as a technological consequence of the microlithic tradition, which is present in form of the Zarzian in the Zagros group in the later Epipalaeolithic (12^{th}–9^{th} millennium BCE).[14] This transitional phase of Epipalaeolithic/Neolithic in Iran is equally named as the "Proto-Neolithic" phase,[15] primarily defined by the appearance of geometric tools, mostly oblong trapezoid tools that are made on bladelets with sharpened asymmetric short ends. From the mid-9^{th} millennium BCE onwards, bullet cores are established in the Zagros and Iranian Fars province, including Northern Iraq sites such as Jarmo, Tell Shimshara and Magzalia, as well as those are known from Hassuna and Halaf contexts (Yarim Tepe, Khirbet Derak). In the so-called transitional Proto-Neolithic period, the importance

11 Kozlowksi 1994, 143, 149.
12 Kozlowski 1999, 61.
13 Abe 2011.
14 For the definition of the „Zagros group", see Hole 1987.
15 Olszewski 1993; Olszewski 1994; Olszewski 2012; Solecki 1981; Thomalsky 2016.

of blades and bladelets as blanks for tool manufacture even increases, and approximately half of the cores belong to this industry. However, the most significant technological innovation is the introduction of the pressure flaking method in the 9th millennium BC. Earliest evidences came from the sequence of Cave TB75 in the Bolaghi valley in Fars province, from rockshelters/cave sites along the Arsanjan and Seymareh rivers and around Lake Zaribar and the Izeh valley in the Zagros **(Fig. 5)**.[16] As concerns NE Iran, the introduction of pressure flaking is still undefinable. For Ali Tappe, it remains uncertain whether pressure flaking was already introduced. The earlier levels contain a microlithic bladelet industry, but are rather linked with the Epipalaeolithic Zarzian Zagros tradition in hard hammer technique. According to the current state of research, the earliest evidence of pressure flaking in NE Iran comes from the Neolithic Sang-e Chakmak which is dated around 6300 BC,[17] while Belt cave layers 10–8 exhibit attributes of pressure flaking dated slightly later around 6000 BC. However, very recently, new investigations in the caves of the Iranian South Caspian coast present a long-scale and possibly local evolution in lithic technology, from the Mesolithic/Epipalaeolithic to the Neolithic period, independent from the Zagros developments though similar in the major technological steps that lead to the standardized bullet core industry in the 9th mill. cal BCE.[18] After these layers, we still have a temporal gap in our archaeological context – which covers the transition of occupation from the caves towards the plain, respectively the Eastern fringes of the Alborz and the desert fringes. Here, earliest farming communities are dated into the late 7th/early 6th mill. BC, and were broadly associated with the Sang-e Chakmak culture and the "Dzheitunian" in the later Neolithic (late 6th/early 5th mill. BC). The lithic industry is then already dominated by a larger blade-flake production that is not of the microlithic bullet core character anymore which was, indeed, most likely not very established in this region. At least, the vast material sources of the Beshar flint limestones, along which the cave sites like Hotu, Belt and Ali Tappe were located, provided rich and large nodules for flint knappers; a wealth in raw material that may have led to different opportunities in terms of size, dimension and blade technology in contrast to the Zagros traditions.

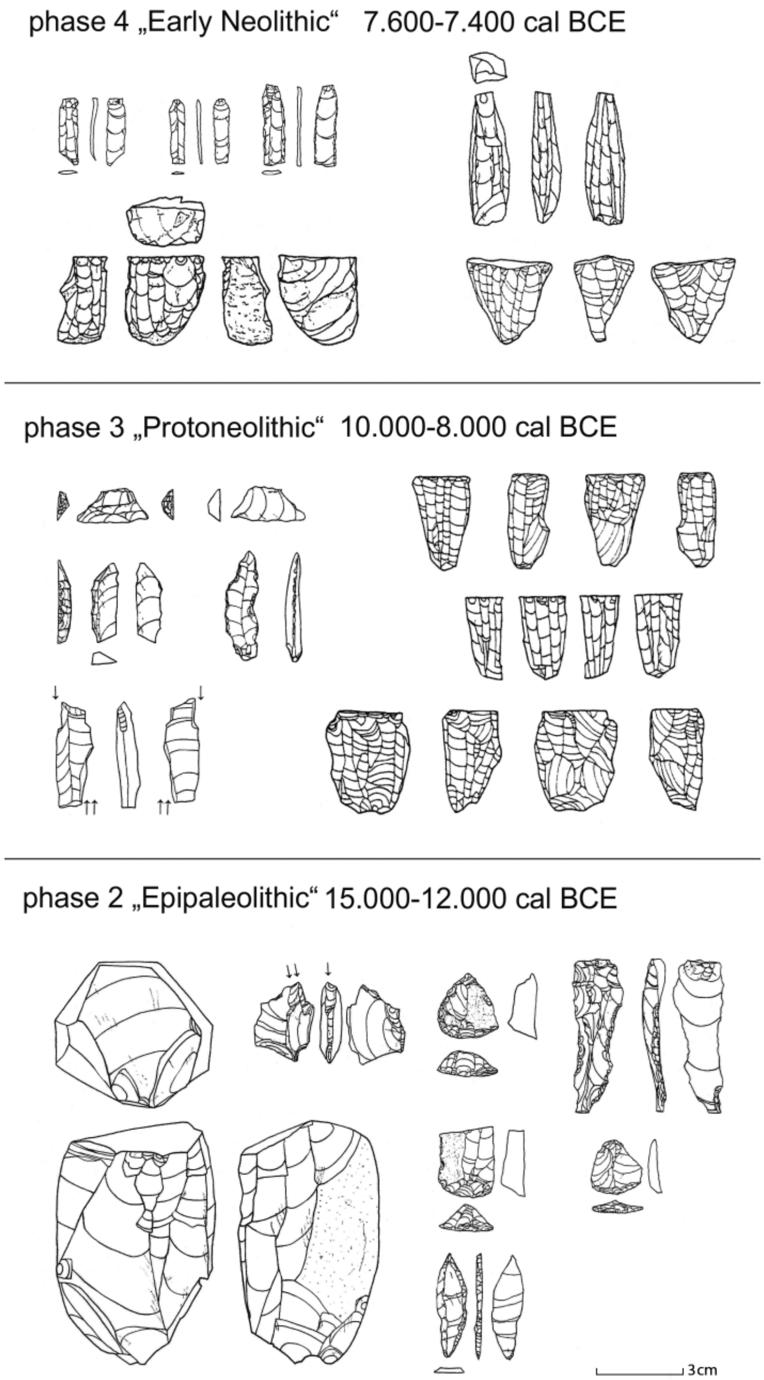

Fig. 5.
The Bolaghi lithic sequence (after Ohnuma 2008 fig. 5).

Again further northwest, the group of so-called "pencil cores" from possible Neolithic contexts in the Caucasus were sometimes compared as technologically similar to the bullet core technology of the Zagros Early Neolithic. More reasonable is to argue, that pencil cores can be regarded as a remnant of the earlier Mesolithic microlithic industry,[19] rather than as an indicator of a technological

16 Niknami et al. 2009; Ohnuma 2008; Tsuneki 2013.
17 Masuda 2013; Thornton 2013.
18 Vahdati Nasab et al. 2011; Fazeli, pers. comm.
19 Rostunov et al. 2009.

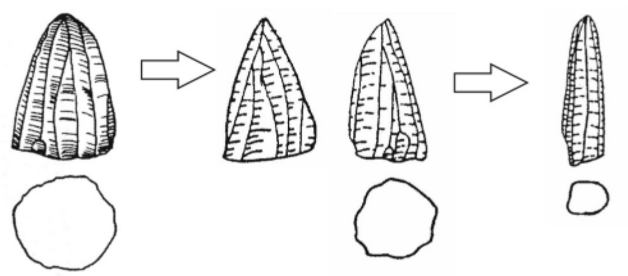

Fig. 6. Stages of consumption of the Neolithic bladelet cores (Thomalsky)

network linked with the Zagros Transitional Neolithic. Instead, the arising Neolithic is marked by the diffusion of the indirect punch technique, which produces larger flint blades in the west – and obsidian blades in the East of the Caucasus. A microlithic industry and related tools are non-existent. Instead, a microlithic prismatic core technology performed by pressure flaking with exhausted cores of bullet-shape is well presented in Western Anatolia (e.g. in Çatal Höyük and Haliçar) and is also present in several assemblages in the NW Black Sea, dated into the 7th-6th millennium BC.[20] Moreover, we can find evidence of the diffusion of this specific technology further north via Moldavia and the Bulgarian Black Sea (Dikilitas) as far as the Crimean peninsula. These industries produced bladelets with steep retouch (= backing) along one or two edges and transversal oblique truncations at the narrower blade ends. Several geometric microliths such as trapezes and segments can be compared with characteristic tool types of the Neolithic Zagros group, though the latter is apparently earlier in date. Microliths furthermore remain common in the late Epipalaeolithic and Aceramic Neolithic sites of Abu Hureyra I and Mureybit in Northern Syria. Interestingly, in Mureybit, naviforme and bullet cores have been found side by side in the same archaeological context. Again, single platform bladelet cores and alternating two-platform (thus naviforme in shape) bladelet cores together with a dominating bladelet/blade inventory are reported from Qermez Dere and Nemrik 9.[21] Associated radiocarbon data fall into two main occupation phases, the late Younger Dryas between 10050–9650 cal BCE, and a later phase between 9260–8840 cal BCE. In fact, the horizon of the Nemrikian industry can be regarded contemporary to the diffusion of pressure flaking technology throughout the Zagros foothills and adjacent regions. In sum, there is evidence of a similar technological development during the Epipalaeolithic (respectively Natufian/Zarzian) that lead to a more homogeneous core reduction schema first, with a succeeding change from a bipolar to a monopolar reduction technology. Therefore, a significant and large-scaled technological change took place not only in the microlithic technologies of the Eastern Fertile, but is also to be observed in the large-blade industries in the West; a technological process that started during the Younger Dryas.

Other technological groups (or lithic complexes) comparable to the Zagros tradition can be seen in the pressure flaked bladelet industry of the Neolithic Kelteminarian industry of Uzbekistan and Kazakhstan, or the microblade industry in Southern Tajikistan, dating to the end of the 9th/begin of the 8th millennium BCE. However, apart from the flimsy evidence from the Southeastern Caspian See, respectively the Mesolithic cave sites (Komishan, Hotu, Belt and Ali Tappeh), we still lack adequate data that provide convincing technological bridges (in terms of lithic inventories and absolute data) between the lithic industries of NE-Iran and Central Asia. Apparently later, pressure flaking occurs in Neolithic Pakistan (Mergarh) and the Indus valley. The related archaeological dating covers the 7th to early 4th millennium BC, and is thus contemporary in date with the Neolithic Dzheitun culture that developed along the Kopet Dağ fringes. Lamellar bladelet tools, including geometrics (triangles and crescents) used as projectile points, dominate these late inventories. In a supra-regional view, pressure flaking techniques along with microblade industries appeared in North China-Mongolia and Eastern Sibiria from 28.000 BP onwards, and seem to spread both eastwards and westwards to Kazakhstan and possibly Tajikistan. This is why several scholars suggested a convincing model of an East-to-West diffusion of this technology,[22] from South-Asia towards the SE edge of the Caspian Sea, here represented by the assemblages of Hotu, Komishani and Belt cave. However, these earliest traditions lack the microlithic tools, especially geometrics, but still yields a high amount of irregular bladelet cores, including wedge-shaped and naviforme two-platform cores which in fact resemble a similar technological evolution from bipolar reduction to the monopolar reduction method; while the later Kelteminarian indeed provides characteristic bullet core assemblages.[23]

Returning to Iran, the archaeological data suggests an initial occurrence of “pressure flaking” already during the Later Epipalaeolithic, respectively during

[20] Gatsov/Özdogan 1994; Gatsov 2005.
[21] Betts et al. 1989; Kozlowski 2002.
[22] E.g. Larichev et al. 1962. A more detailed discussion about the Eastern extension of the “microlithic industries” is given by Rafifar 1996 and Szymczak 2002; and recently Brunet, in Desrosiers (ed.) 2012.
[23] Szymczak/Khudzhanazarov 2006.

or slightly after the End of the Younger Dryas event, somewhere between 10.000 and 9000 BCE. Indeed, this horizon is not only marked by a change in lithic technology, but also marked by a gradual change in patterns of social mobility and occupation, as was demonstrated for the Zagros[24] and the Marv Dasht plain in Fars Province in particular.[25] Here, single but larger sites seem to have been established in the sense of base-camps instead of the former pattern of open site clusters, in addition to a significant increase of occupation density. The earliest beginnings of innovative food-production strategies and domestication in the Zagros can be associated to this horizon, contemporary to the first occurrence of pressure flaking. At the eastern fringe of the Iranian Plateau, pressure flaked blades appear as a part of the neolithic package of the Dzheitun culture which reflects in fact a proper late (ceramic) Neolithic development of the 6th mill. BCE; so far, we cannot describe the dispersion of this innovation, whether it comes from Central Asia or from the Zagros.[26] Recent data obtained from a cave stratigraphy in the Bolaghi valley (Fars Province) places the introduction of the new technology during the 11th mill. BCE while the first true bullet cores appear during the 9th mill. BCE **(Fig. 5)**.[27] Similar to the early process of domestication, an explicit effect of the pressure flaking can in fact not be demonstrated before the developed (prepottery) Early Neolithic, then dominated by the typical bladelet industry with single-platform bladelet cores, exhausted to their little slender bullet shapes **(Fig. 6)**.

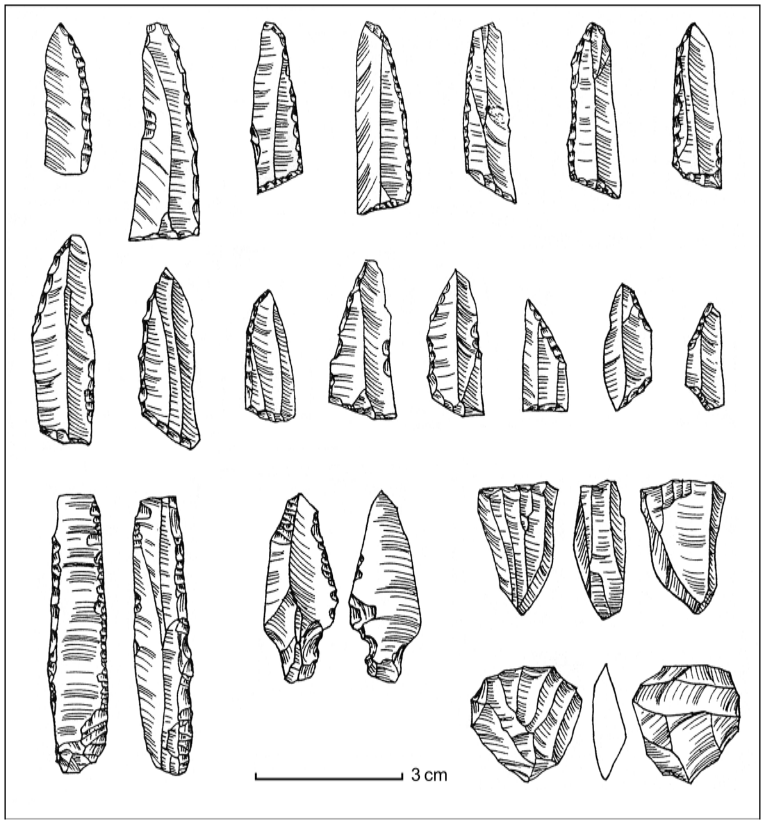

Fig. 7a. Lithic tool set of the Trialetian, from Edzani cave (after Kozlowski 1996 fig. 2).1996 fig. 1).

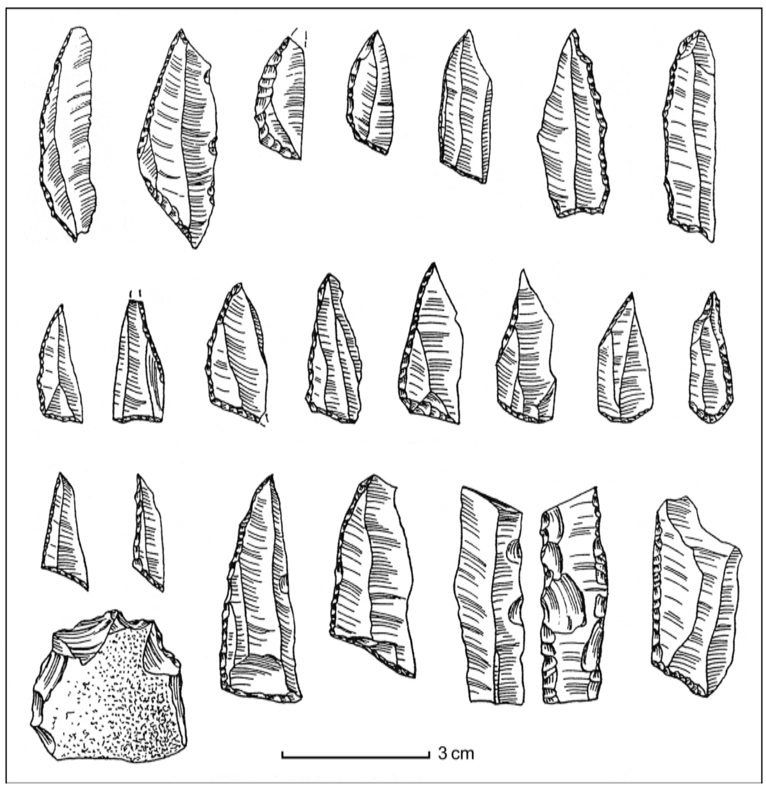

Fig. 7b Lithic tool set of the Trialetian, from Hallan Çemi (after Kozlowski 1996 fig. 1).

Lithic industries of the S-Caucasus: technological grammar and typological misunderstanding

I come to a third regional lithic complex in the area under study which was determined on the basis of a specific tool type rather than technological attributes such as flaking method or blank production schema. The *Trialetian* was firstly described as a Mesolithic culture of the Southern Caucasus, but also includes a few assemblages in SE-Anatolia at a considerable distance of the core-area. *Director fossil* of the Trialetian industry is the „large microlith" tool, mostly in form of symmetrical and asymmetrical trapezes, and short scalene triangles, both with short truncated ends. The tool inventories of Hallan Çemi in SE-Anatolia and the rock shelter Edzani in Georgia served as references **(Fig. 7a-b)**.[28]

[24] Mortensen 1972; Niknami et al. 2009.
[25] Rosenberg 2003.
[26] Harris 1997.
[27] Tsuneki 2013.
[28] Kozlowski 1999, 139.

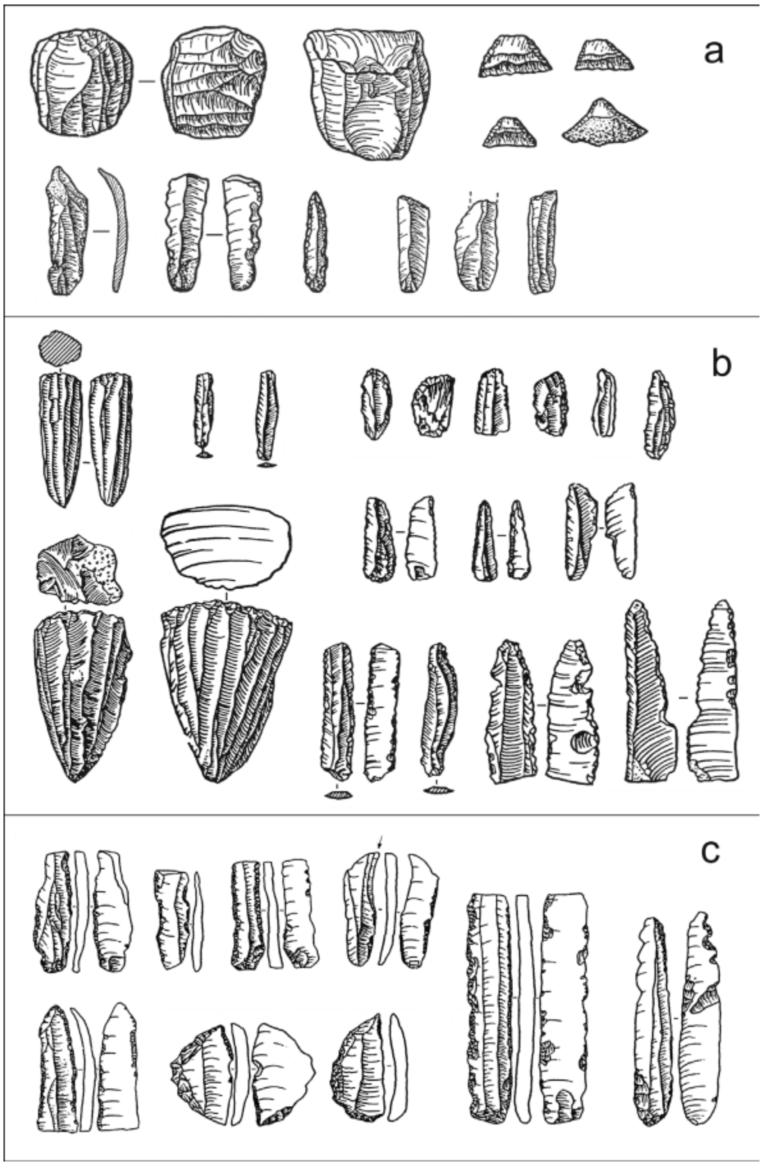

Fig. 8. Lithic inventories of the Shomutepe-Shulaveri group (after Korobkova 1996 fig. 9, 11–12). A: artefacts from Ginchi; b: artefacts from Shulaveris-Gora; c: artefacts from various sites.

Both inventories consist of approximately 50–60 % obsidian, the other half is made of flint. Significant are high amounts of end scrapers, denticulated pieces and side scrapers which were produced on large broad flakes or irregular blades. The most important component is the group of geometric tools and backed pieces, respectively the "large geometrics" after Kozlowski,[29] again mainly produced on irregular blades, sometimes segmented, or flakes. New data come from Kotias Klde in Western Georgia, where a karstic cave yielded an occupation sequence from the late Upper Palaeolithic (Layer C), Mesolithic (Layer B) to the Neolithic horizon (Layer A1–A2).[30] The lithic industry comprises a flint/radiolarite and obsidian inventory, and is characterized by backed bladelets and geometrics such as scalenes and isosceles triangles made from bladelet blanks with truncated and oblique ends. Both, flint and obsidian were used, but flint is clearly dominating. The radiocarbon data from the Neolithic horizon falls into the range between 10.500 to 9.100 cal. BC and can thus be placed at the very beginning of the site clusters under discussion in this paper. For the lithic material it seems obvious that the "geometrics" are hunting tools, most likely in function of arrow tips but also used as inserts into the arrow shaft for aerodynamic reasons.

The succeeding lithic development in the Southern Caucasus can be illustrated with the lithics of the Shulaveri-Shomutepe group in Eastern Georgia and West-Azerbaijan, which date from late 7th to second half of the 6th millennium BCE. While for a presumed older phase any secure lithic inventories are not available, the blade industry of the younger phase of the 6th mill. BC appear rather low standardized in terms of technological schema and output of production **(Fig. 8)**.[31] Larger obsidian blades with irregular edges replace the earlier (microlithic) bladelet industry, and consequently reflect the introduction and spread of a new core and blade technology. Huge amounts of core preparation flakes and debris characterize the lithic collections that indicate an intensive chipping activity before the cores can be used for the blade production. That in other words means a rather underdeveloped core preparation strategy, which produces a large amount of waste but provides a low amount of "output", in form of the number of blade blanks per core. Additionally, the blades are of irregular shapes with roughly modified edges emphasizing our impression of a rather non-specialized blade industry. Cores show a broader spectrum, of multipolar flake-blade cores, prismatic blade cores with one platform and bullet cores. It seems obvious that at least the illustrated and published assemblages need a re-evaluation in terms of context, dating, and general determination.

The Trialetian complex was not restricted to its "classic geographical region but appears to have developed several regional variants.[32] In Northern Dagestan, the so-called Chokh group is regarded as a local variant of the Trialetian. The Mesolithic layers 6–3 comprises broad geometrics, made on

[29] Kozlowski 1996.

[30] Meshveliani et al. 2007.
[31] Chataigner 1995, 153.
[32] Meshveliani et al. 2007.

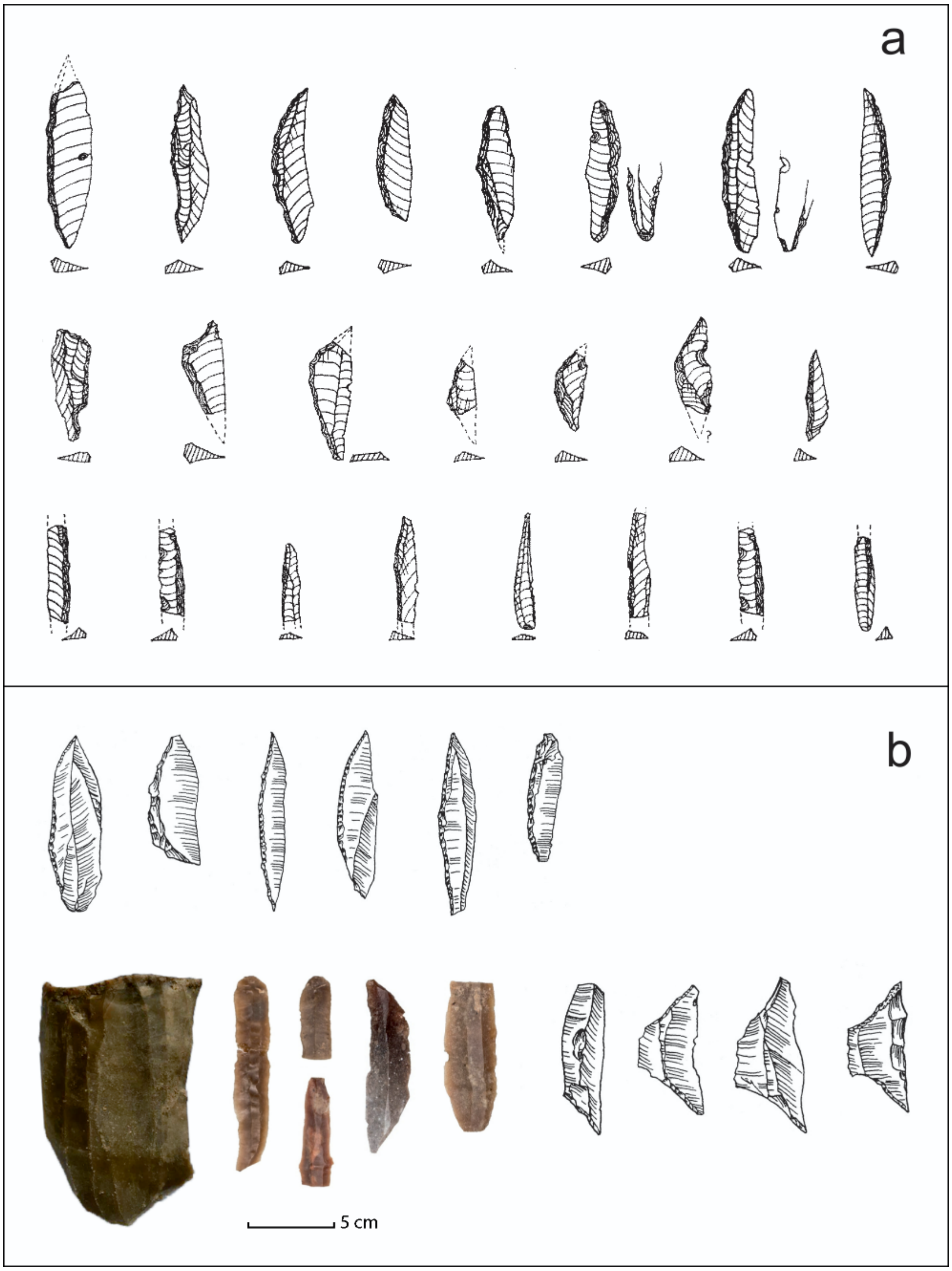

Fig. 9.
Lithic tools from a: Ali Tepe (10th-9th mill.) and b: Belt Cave, Beshar district, NE-Iran (after McBurney 1968 fig. 7, Kozlowski 1996 fig. 4, and photographs from H. Fazeli Nashli, 2020).

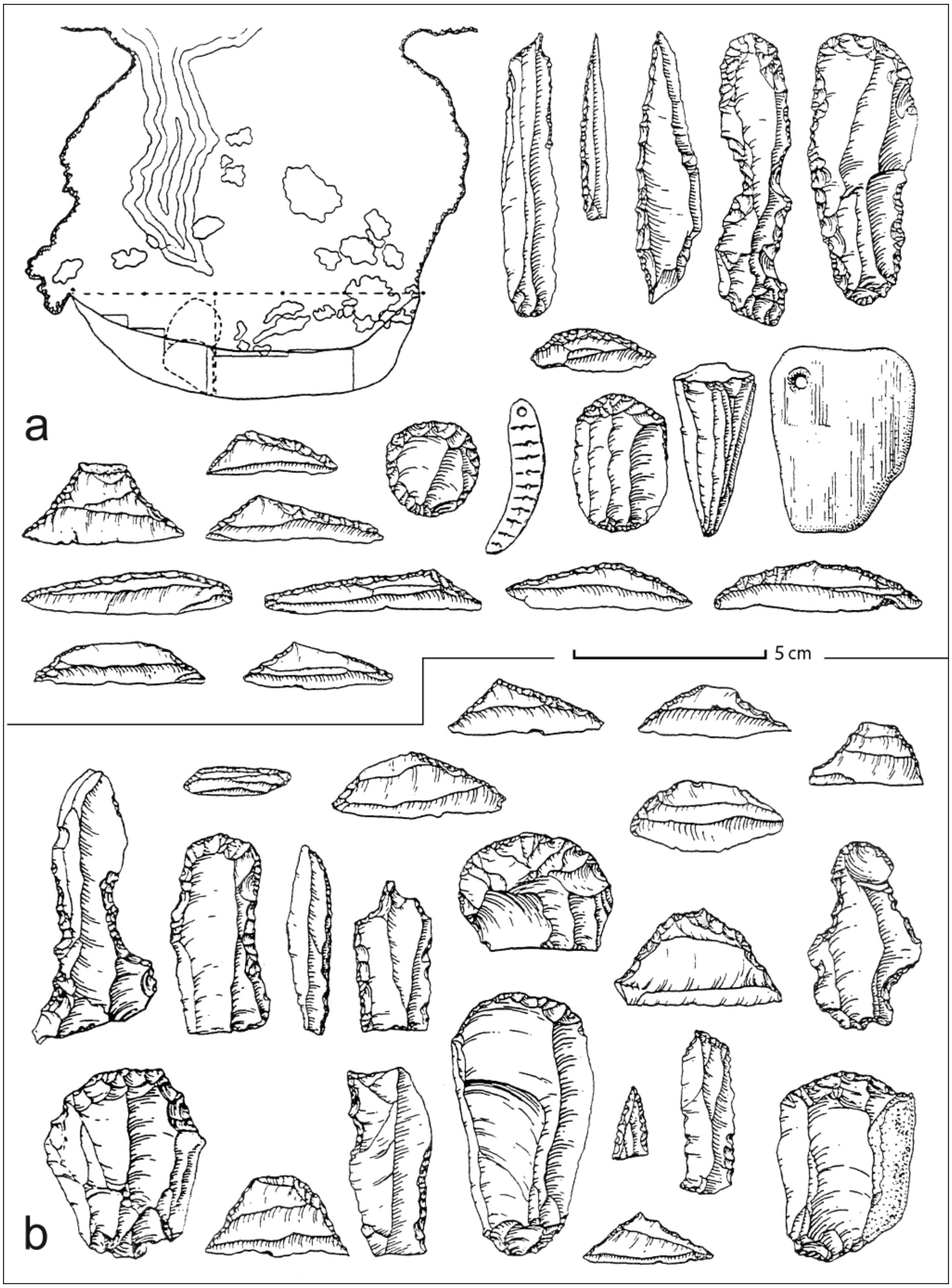

Fig. 10.
Lithic sequence from Dam Dam Cheshmeh, Turkmenistan. A: from upper horizon (layer 4) and B: from lower horizon (layer 7) (after Masson 1996 fig. 3).

broader flakes (long asymmetrical triangles, high trapezes) as well as a blade/bladelet industry with discoid cores which were reduced in a unidirectional circumferential schema. The succeeding layer 2 shows an increase with a total amount of 27 % of bladelets including pencil cores (respectively bullet cores) that coincides with the impact of neolithisation in lithic technology. The geometric tools show both an increase of diversity and standardization:[33] Elongated triangles, wide trapezes and trapeze truncations, produced from bladelet segments with further steep backing along the edges. Crescent-shaped lunates are present as well, though in low numbers.

A similar composition of a microlithic bladelet component and roughly produced, broad flake-blade tools is known from the Kolchis region in Western Caucasia.[34] In contrast to the Classic Trialetian core region, the assemblages are clearly dominated by flint. The few known older assemblages of the 8th millennium BCE, such as Sorusko cave or Firuz I–II, exhibit a microlithic industry with pencil cores and bladelets as well as larger geometric segments on blades. The younger material of Anaseuli 1 and Darkveti cave is already characterized by an advanced blade industry, but still exhibits a small microblade component while in the fully neolithized material known from Tetramitsa, Odishi and Ginchi the microlithic technology has completely disappeared.

Further East, along the southern Caspian coastline, several cave sites with Epipalaeolithic and subsequent Neolithic occupation layers are known, but the vast bulk of the excavated material is only insufficient unpublished. As already mentioned above, several of the South-Caspian Mesolithic assemblages in NE-Iran (Ali Tepe, Belt cave, Hotu cave, Kamarband) and in Turkmenistan (Dam Dam Cheshmeh) were regarded to carry so-called Trialetian attributes, in form of the "large geometrics" **(Fig. 9–10)**. By zooming into the lithic collection, Ali Tepe with its microlithic backed bladelets and triangles can rather be assigned a Zarzian character, while the material of Belt cave indeed shows geometrics made on irregular blanks similar to the Mesolithic Trialetian group. In fact, only Dam Dam Cheshmeh yielded a convenient sequence that demonstrates a basic technological change from an earlier flake industry to the possible younger geometric tools made on blade segments. Blades are then characteristic for the Dzheitun industry. The reference site Dzheitun is located in the Kopet Dağ Eastern foot hills in Turkmenistan, and is regarded as the first Neolithic agropastoral culture of West-Central Asia with cultivated cereals, herded sheep/goats and pottery production.[35] Several radiocarbon dates suggest the beginning in the late 7th/early 6th millennium BCE,[36] but the larger number of the related sites are dated into the developed 6th millennium BCE. The lithic industry is clearly dominated by a regular and standardized blade production, on which approximately 90 % of the tools were manufactured.[37] This is also true for the geometric tools which were made on blade segments and then steeply retouched at the ends (backing retouch) **(Fig. 11)**. A considerable part of the lithic chaîne opératoire – the primary industry in form of chipping debris, core preparation flakes etc. – is missing in the assemblage, and therefore presumably took place outside the settlements. In fact, any flake component is rather underrepresented in particular in the NE-Iranian Dzheitunian sites; a pattern which originally led G. Korobkova[38] to the differentiation a Western and an Eastern group: the latter is characterized by the presence of a flake industry (up to 30 % of total artefacts). However, according to

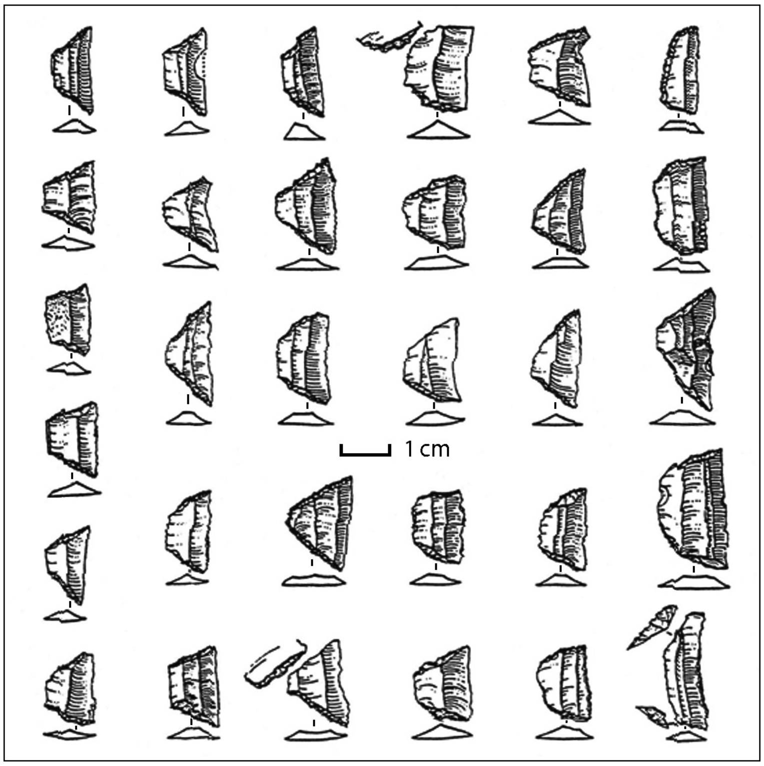

Fig. 11. Dzheitun (6th mill.): so-called large geometrics from Dzheitun in Turkmenistan made of blade segments (Korobkova 1996 fig. 31).

[33] Korobkova 1996, 68 fig. 7.
[34] Chataigner 1995.
[35] Harris et al. 1996; Harris 1997; Harris 2010, 201; Harris 2012.
[36] Harris 2010, 218.
[37] Korobkova 1996.
[38] Korobkova 1996, 46.

the above highlighted replacement of flakes that ended in a standardized blade industry in the 6th millennium BCE, one could describe Korobkova's observation as a rather temporal trend associated with the Neolithization process. This is supported by the fact that the "western sites" also exhibit an increase of a flake industry as well as a generally higher diversity in flaking technology as seen by the larger range of core-forms, and an increase of re-sharpening retouch during a later stage of the Dzheitunian industry.

Summarizing, the general comparison of the lithic material of the Caucasus, including the Trialetian, can be described as follows: In an earlier period, the lithic technology consists of a blade and flake industry reduced by indirect percussion. The conical/sub-conical blade cores can exhibit double platforms and were thus reduced in a bi-directional schema. Reduced blanks were short and broad, especially in comparison to the narrow and regular "microlithic Zagros industry". The broad blades or flakes were used for the production of the geometrics that actually exclusively describe the "Trialetian group" since the general tool production is dominated by a flake industry. In fact, this earlier phase of the Trialetian (or Mesolithic) in the Caucasus is not yet confirmed with radiocarbon data, but only by comparison with the data from the NE-Iran cave sequences. Up to now, this Mesolithic industry with a strong flake component appears quite similar in its technological character to the Epipalaeolithic inventories of Iranian Zagros and Fars. In a later phase, at least from the 8th millennium BCE onwards, a microlithic bladelet industry inclusing pencil or "bullet cores" occurs in the Transcaucasian sites, a new core technology which can be well-related to the Iranian Neolithic tradition. However, it is not yet understood, whether these inventories can be seen as a result of a possible input from the Iranian Zagros (since it is almost coincident with the largest outspread of the bullet core technology) or as remnants from the older Mesolithic traditions, developed from local technological substratum.

Returning to the Trialetian geometric complex, one can state that the earliest "inventory" stems from Hallan Çemi, dated between 8500–7500 BCE.[39] Similar dating came from the Caspian Belt cave.[40] This places the "Trialetian complex" beside the PPNA world west of the Zagros and the Proto-Neolithic of Iran. It becomes clear, that in the Caucasian region a microlithic tradition was successively replaced by the arising larger blade industry. Obviously, the Trialetian comprises both, a defined technological (lithic) entity, as well as a socio-economical entity of Mesolithic hunters-and-foragers, who lived in the forested mountain valleys of Transcaucasia and Elburz. In this presumption, the "Trialetian Complex" suggests a broad Mesolithic interaction sphere that spread from Transcaucasia along the southern Caspian Sea shore to the Dzheitunian complex in the East; from the 9th until the 6th millennium BCE. If so, we may suggest that the forested region was one refugium of hunter-gatherer communities in co-existence to early sedentary and farming communities.

The material linkages are found in particular in the lithic tool group of the "large geometrics", mostly made on flake blanks or larger irregular blade segments that possibly reflect a chronological depth in technological evolution. However, Trialetian geometrics clearly differ technologically from those of the Zarzian (bladelet) industry, though in some inventories more regular blades served as blanks for geometric tools. A major problem is the insufficient contextual and chronological information, in addition to the general lack of any systematical investigation of the lithic inventories within the scope of the chaîne opératoire: no statistic numbers, nor the complete lithic tool set is available in the published data.

Nevertheless, despite weak evidence for the existence of a "Trialetian complex", one can demonstrate a rather consistent evolution of the lithic industries in the Trans-Caucasus, in contrast to obvious differences in the lithic technological grammar of the sites of the S-Caspian Sea and abroad. In this respect, one can recapitulate the difficulties to define a "Trialetian complex" from the Caucasus to the SE Caspian Sea as follows:

– Firstly, the material from Mesolithic Chokh contains not only "large geometrics" but also a strong component of a bladelet industry that can obviously be compared to the Zagros Zarzian tradition **(Fig. 12)**. Several other inventories can be added to this horizon (e.g. Kotias Klde, Odishy, or Ali Tappe in NE-Iran), though their actual percentage cannot be verified yet.
– The "typical" Trialetian geometrics are made on larger segments of flakes or irregular blades, and can be regarded as hunting implements. Similar items are also common in the Mesolithic/Epipalaeolithic inventories of the Southern Caspian Sea sites, but can be seen very likely as the technologically predecessor

[39] Özdoğan 1999; Kozlowski 1996.
[40] Aurenche et al. 1987; Aurenche et al. 2001; Kozlowski 1996, 162.

of the more regular geometrics of the later horizons dominated by the blade-industry. We even can suggest the gradual development towards the Neolithic bladelet industry with the introduction of pressure flaking similar to the evidence of the Zagros Sequence. Therefore, one may suggest, though the local sequence from the Mesolithic/Epipalaeolithic to the Early Neolithic Period Is highly insecure,[41] that the so-called Trialetian inventories of NE-Iran are originally older than the Trialetian of the S-Caucasus and predate the local late Epipalaeolithic.

– The overall-cited assemblage of Hallan Çemi, with its large obsidian blades and geometrics, is rather different in its technological properties. As long as other contemporary lithic assemblages from SE-Anatolia are not available, it is more convincing to allocate Hallan Çemi to the typical PPNA transitional assemblage as discussed above.[42] This presumption can be supported by the fact that a so-called variant of the Big Arrowhead Industry was assimilated in this area by the end of the 8th millennium BC.
– Finally, somewhere between the late 7th and beginning 6th millennium BC, a gradual but considerable technological change in lithic production took place. The replacement of the microlithic tradition by a considerable progressive blade-industry occurred, including the introduction of harvesting knifes and sickle elements. The geometrics were equally worked on larger blade segments but no longer on flakes. Particularly Odishy and Anaseuli II exhibit a strong progressive character and can be placed at the latest stage of this process. On the other hand, the published bifacial tanged projectile points obviously do not belong to a "Neolithic phase" or to the 5th or 4th millennium BC assemblages but are most likely assigned to an Early Bronze Age level.

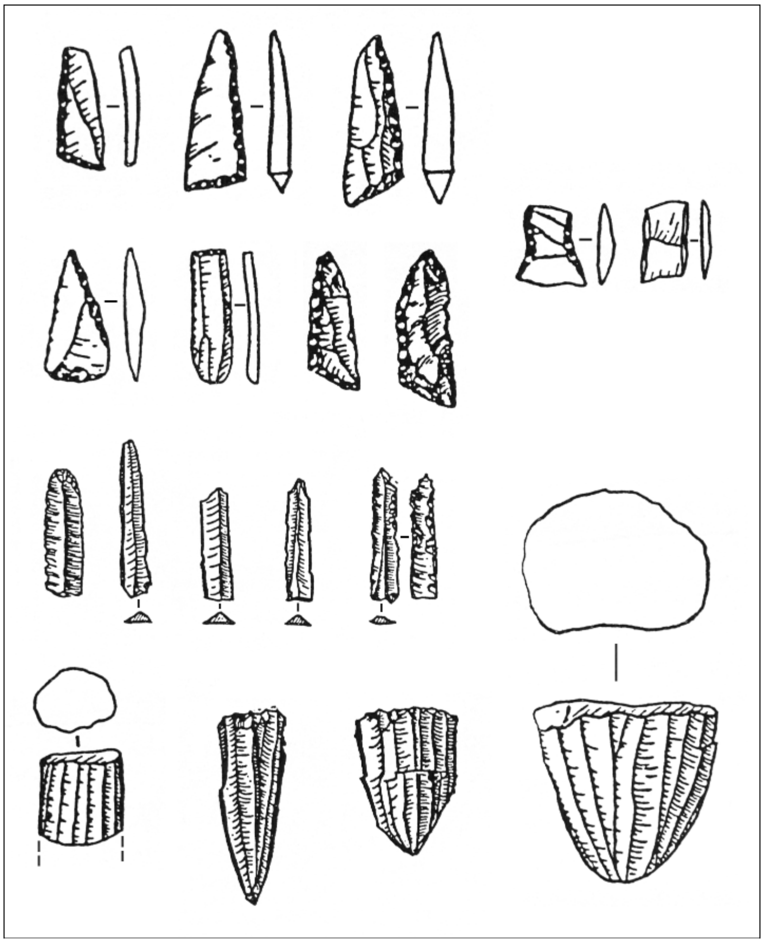

Fig. 12.
Large geometrics and a microlithic group from Chokh (after Korobkova 1996).

Visualising Lithic networks

If we want to describe technological networks such as shared lithic grammar(s) in stone tool production, we have to distinguish various patterns of diffusion which are related to technological attributes in tool production. These can be structured on different levels in terms of raw material usage (e.g. obsidian circulation), artefact classes or tool types; or of any other technological grammar that provides a special *chaîne opératoire* as tool of manufacture. It is not important whether these attributes are artifacts of regular exchange or of trinket trade, since "network" per definition describe social interaction on different degrees of linkage between participating agents.[43] Any kind of communication can result in the occurrence of new or modified or "foreign" artefacts, objects or technological methods – like the establishment of pressure flaking in the Zagros area and beyond. Here, a considerable technological border[44] between the naviforme core/large blade industry and the bullet core/ microlithic industry passes through the Zagros. The associated tool types on both sides (e.g. Big Arrowheads on the one side and microlithic bladelet points and geometrics on the other) equally display

[41] E.g. the material from Belt cave is under restudy and waits for its publication Masuda 2013; Thornton 2013.
[42] This further would fit to the linkages to the Zarzian culture as already noted by Peasnall et al. 1998.
[43] Thomalsky 2012.
[44] Quintero 1998.

the differentiation of such technological networks since we can demonstrate different tool typologies which are not directly dependent of the chosen core-and-blade technique. Moreover, there are several find spots where we can find characteristic artifact industry outside their associated technological complex. This can be highlighted as example for several microlithic bullet cores of the Ml'efatian industry found in more western PPNA sites, but also distinctive obsidian tools of the later PPNB world appear in the Iranian Zagros and vicinity, such as Cayönü tools, side-blow flakes, baked knifes or thumbnail scrapers (see below).

Contrastive or comparative? Networks and technological transfer

The apparently major difference between the two techno-cultural entities in the West (SE-Anatolia, N-Mesopotamia & Levant) and the East (Zagros – NE-Caspian coast) is the considerable break in socio-cultural-technological lifestyle in most sites of the "Western fertile crescent" at the transition of the Younger Dryas, while the occupation of the Zagros and the lithic tradition of the Zarzian shows a technological continuation into the Neolithic, though here we also have a considerable lack of occupation data between 12.000 and 10.000 BC. In contrast, the shift from a microlithic Natufian to the PPN lithic industry with new prominent dimensions obviously comprises far-reaching socio-technological consequences in tool manufacture (exploitation of new raw material, new flaking techniques for large-blade production, change from small-sized projectile points to Big Arrowheads), which appears at first glance more intense and radical than the contemporary development in the Eastern neighbourhood. On the other hand, one can demonstrate a technological progression also for the late Natufian to PPN industries which indicates continuity in technological behaviour and, moreover, also shows important similarities with its Eastern neighbour, the Zarzian and following Ml'efatian industry. The parameters are evaluated in the following passages.

As a possible initial stage towards the development to a bullet core industry, a gradual shift in both technological steps, the core preparation and core reduction, is demonstrated for the lithic inventories of the Zagros groups. This shift comprises the introduction of the pressure flaking somehow during the 10th millennium BC, albeit the related technological attributes (such as overworked cores; snapped edges) are often not to be identified securely in the recorded collections and literature. It was E. A. Hildebrandt, who firstly recognized a gradual development to a more regular and standardized flaking technique in the Epipalaeolithic sequence of the Zagros[45]: Bladelet cores with multiple platforms or two alternating platforms were gradually replaced by unipolar and unidirectional cores with one straight striking platform.[46] That means the reduction scheme changed from multi- or bi-directional to unidirectional which in fact again lead to technological consequences: The bladelets were flaked in semicircular to circumferential chipping pattern, and the cores finally ended up as narrow conical shapes **(Fig. 13)**.[47] This observation is well supported by the results of a recently conducted re-evaluation of Neolithic core inventories of Iran.[48] The Early Neolithic core pieces from Ganj Dareh exhibit opposed platforms and more or less regular boat-shaped outlines which suggest an internal older dating. Two platforms opposite to each other from which the blades were flaked in an alternating schema consequently led to a boat-shaped outline of the core. This means, a distinctive flaking schema in shape of the alternating blade-reduction is responsible for the naviforme core outline, but not for the actual dimension of the end-products. In addition, both blade-reduction techniques use the crested blade method for core preparation.

In other words, the boat-shaped two-platform bladelet cores from Ganj Dareh do not differ essentially in the technological grammar from the naviforme (large blade) cores of the Western Fertile Crescent. Through time, a change from the bipolar reduction schema (with two-platform cores) to unipolar leads to conical and/or pyramidal core shapes with single-platform. This technological change gained a more rapid development with the introduction of the pressure flaking method and finally lead to the characteristic bullet core technology of the Iranian Early Neolithic. Furthermore, these little lumps (or bullets, or pencils) of bladelet cores are the best indicator for the intensive knapping activity performed in a permanent working sequence. Obviously, this permanency required fully established lithic knappers who were active for a considerable time-period on the same place, a working behaviour which rather reflects a sedentary life style than that of mobile communities.

A similar socio-technological development towards permanent and specialized knapping activity can be

[45] Hildebrandt 1996 in particular the Warwasi cave sequence, Kermanshah Province
[46] Hildebrandt 1996.
[47] A similar development was already observed in the Syrian Mureybit sequence. Calley 1986.
[48] Thomalsky 2014.

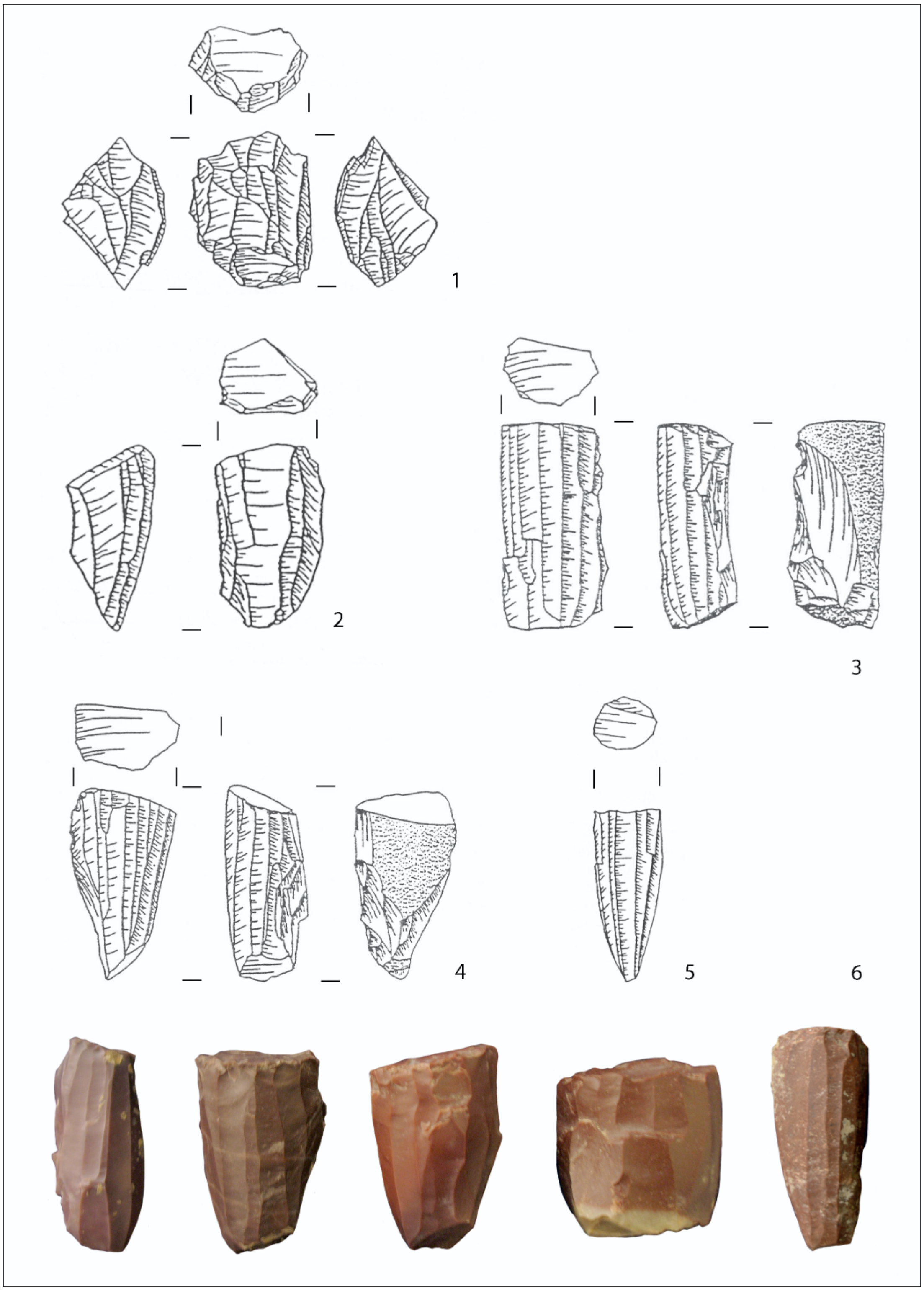

Fig. 13. Sketch of the epipaleolithic -neolithic "core evolution" in the Iranian Zagros. 1: irregular bipolar core, 2, 4: naviforme (bipoliar) microlithic core; 3: rectangular (bipolar) microlithic core; 5: bullet core with circumferential reduction schema; 6: cores from Ganj Dareh (photos and drawings: Thomalsky).

demonstrated for contemporary lithic industries in the Western Fertile Crescent: The earlier Natufian industry exhibits a large range of variable core shapes, while the ensuing PPN naviforme core technology is of a clearly more standardized level. The typical naviforme blade cores represent a bi-directional reduction schema. Prototypes of larger blade cores with bidirectional, opposed platforms are already known from Upper Palaeolithic and Natufian contexts.[49] As further micro-bladelets can be generated as by-products of the naviforme core technology, the value of documented micro-bladelets is to be discussed unless they were not modified into tools (as an indicator of explicit bladelet production).

Finally, the picture of lithic traditions in the third area under discussion, the Caucasus, cannot be regarded as homogeneous as stated in the published record. One prominent point is the overall later date of the assemblages and the fact that often only one or two reference inventories defined one local "variant". Nevertheless, a technological evolution in a broader sense similar to the Iranian picture can be seen with the arising bladelet/blade industries, including the increase of pencil cores (respectively bullet cores) in Dagestan and the Colchis from the 8th millennium BC onwards.

Summarizing the major points in this chapter: During the later Epipalaeolithic lithic tradition, respectively the microlithic Zarzian, a new flaking technology was introduced which perpetuated the Neolithic bullet core technology. Apart from the introduction of a new technological category in strictu sensu, the high degree of exhausted cores documents increasing permanency and intensity of blade production and output which can be related to increasing sedentary conditions. In other words, the observed technical development can be regarded as one indicator of standardization and specialisation in tool manufacture at the dawn of Neolithization.

Besides that, the PPN lithic industry is characterized by a similar technological development towards standardization and specialisation which indeed indicates no radical breaks in the socio-technological organisation – as is in contrast implied by the change in the occupation pattern.

To conclude, during the Younger Dryas period and throughout the Epipalaeolithic groups of the Western and the Eastern Fertile Crescent, new chipping techniques were introduced together with which new core types appeared. The differentiation of the large naviforme cores with direct hammer technique and the bullet cores with pressure flaking describe a distinctive technological border which runs through the western Zagros fringes. However, both industries underwent a similar technological evolution towards a standardization and specialisation in blade production. Until the 9th millennium BC the bi-directional reduction schema dominates and results in boat-shaped outlines of both, the microlithic cores in the East and the large blade cores in the West. The overall most significant attribute is the quickly performed reduction of high-qualitative blades blanks in large quantities. A similar pattern is to be drawn for the Caucasus. The available lithic sequences demonstrate a gradual standardization particularly in the core technology and the replacement of the microlithic industry by the larger blade industry from mid-9th to 6th millennium BC. It is therefore highly possible, that the inhomogeneous pattern of lithic technology of the Caucasus is firstly caused by the as yet insufficient archaeological record and the lack of secure stratigraphical data.

Large-scaled networks versus small-scaled networks

The circulation of distinctive raw materials or tool types can be interpreted as patches of a mobile community or as general shared preferences for certain raw materials. The latter case is easy to illustrate by mapping obsidian artefacts of the 9th to 6th millennium BC. In general, a very progressive circulation of obsidian of the South Eastern Anatolian sources can be observed from the 9th millennium BC onwards. This marks a broad exchange network or interaction sphere which covers the obsidian sources from SE-Anatolia and Armenia, and brought obsidian into NW-Iran and the Zagros flanks towards the Iranian Highland, and through the Levantine corridor towards the Southern Levant and adjacent regions. Diffusion, procurement and consumption of obsidian took place under differing conditions. While one can observe the exploitation and processing of large raw material blocks at one site, nothing can be found in the contemporary neighbouring places. Other sites "only" received obsidian items as imported finished tools. Another site can again be engaged with the production of bladelets from obsidian cores. From an overall view, it seems that from the 8th millennium BC onwards, the obsidian trade apparently increased in the Zagros during the developed Early Neolithic manifested in larger settlement mounds. This appears as the main criteria for the presence of obsidian in the archaeological data – outside the source regions.

[49] Wilke/Quintero 1995.

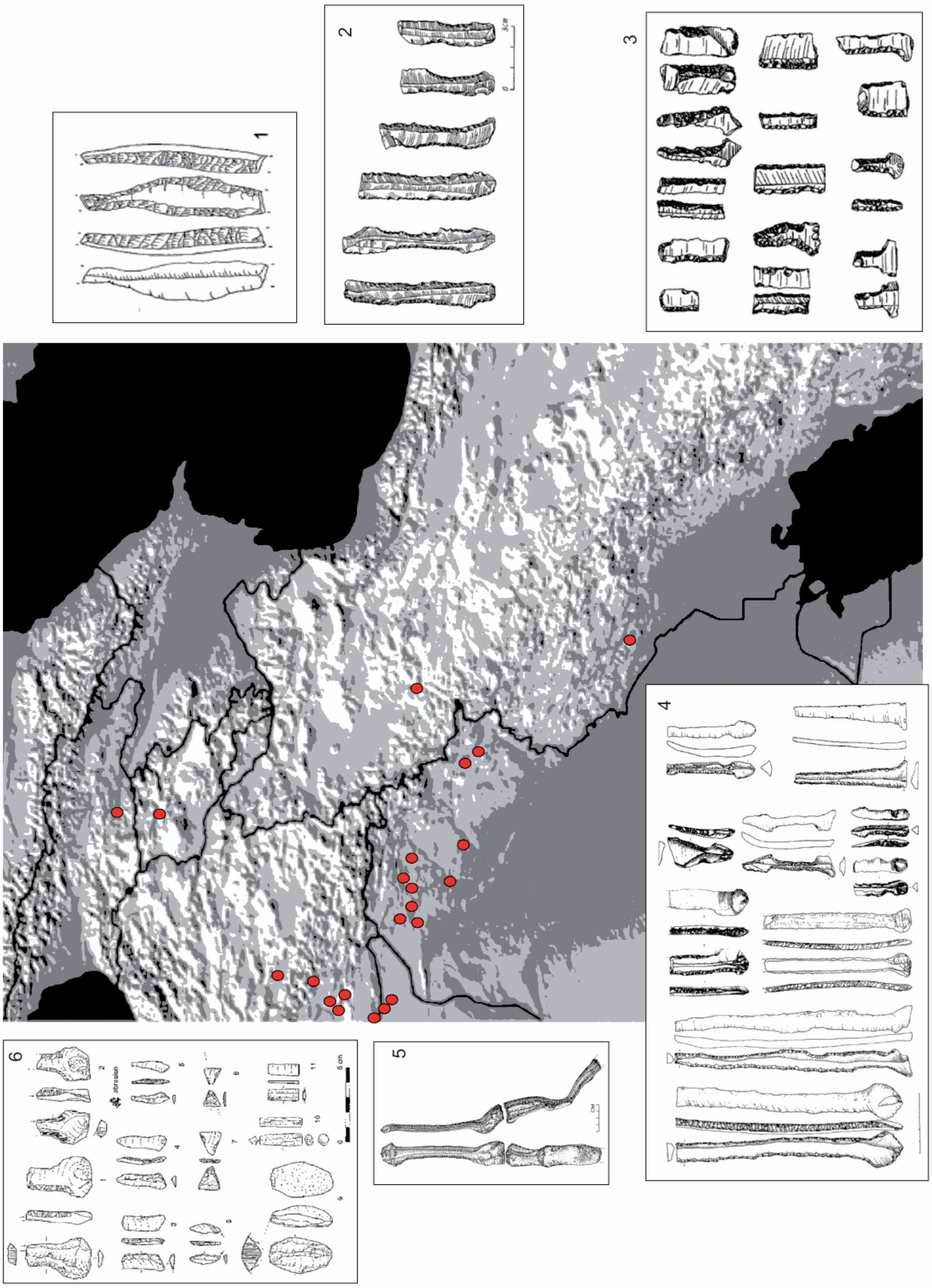

Fig. 14. Distribution and morphological range of Cayönü tools 1: Aruchlo (Hansen et al. 2009 fig. 51); 2: Djeitun (Masson 1971 pl. 12 and Rokitta 2005 fig. 83); 3: Jarmo (Rokitta 2005 fig. 60); 4: Cayönü (Rokitta 2005 fig, 41); 5: Shimshara (after Rokitta 2005 fig. 15); 6: Kmlo 2 (Arimura et al. 2009 fig. 3).

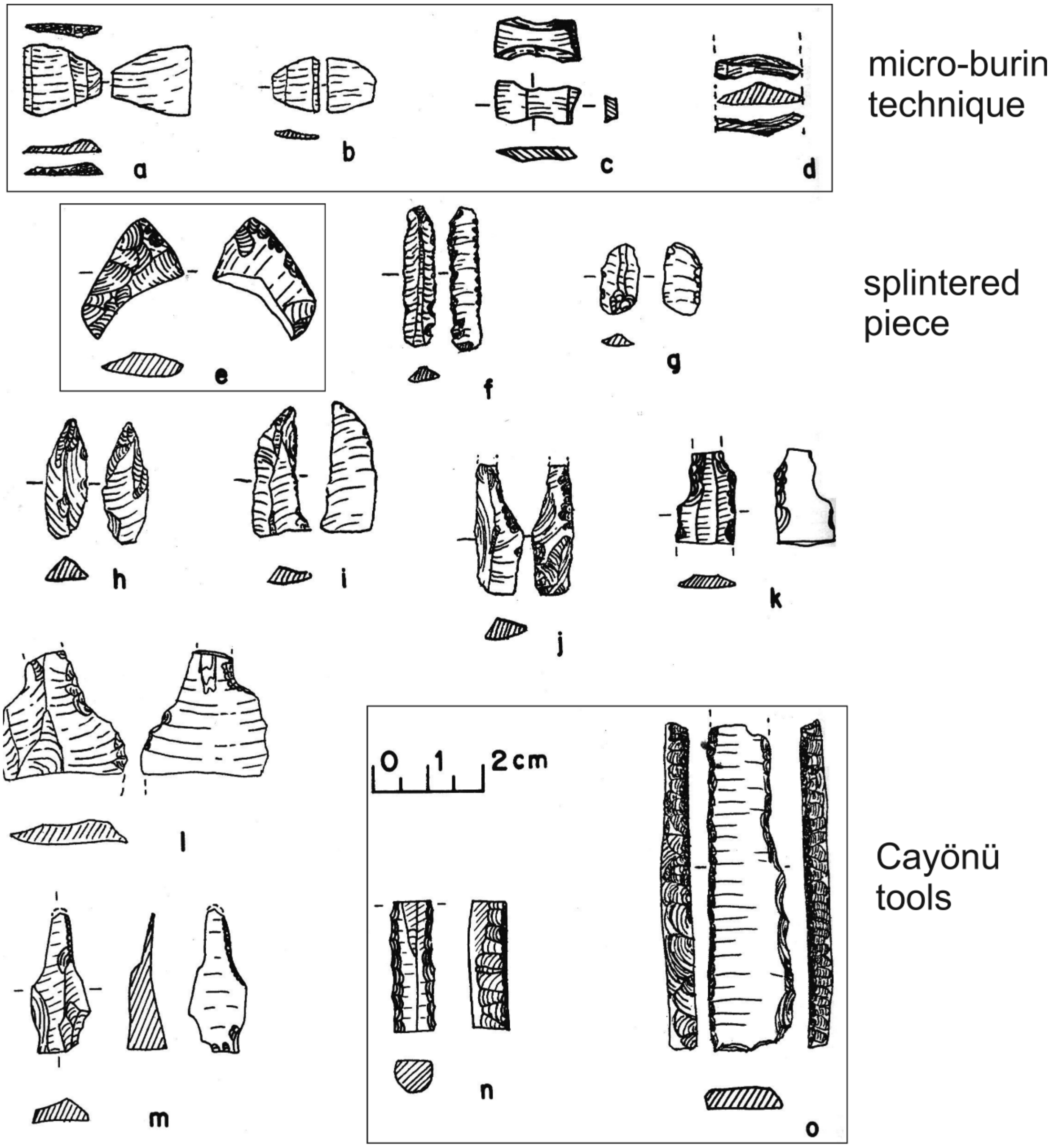

Fig. 15. The Hajji Firuz obsidian inventory, with fragments of Cayönu tools, splintered pieces and corner-thinned pieces (modified after Voigt 1983 figs. 110–111).

According to the given references, we can differentiate two "raw material zones" for the S-Caucasus, with a dominance of flint industries in the western region and an obsidian industry in the East, the latter obviously mirroring the proximity of the sites to the local obsidian sources in Georgia and Armenia. Local preferences draw possible different regional networks for different reasons.[50]

[50] Badalyan 2010; Chataigner/Barge 2010.

Coming to a case study: The obsidian circulation in SE-Anatolia is strongly associated with a distinctive tool type of the PPNB in Northern Mesopotamia: the so-called Çayönü Tools. Though determined as a typological class, one can observe a certain degree of morphological variability, which is rather the result of utilisation than of explicit tool-shaping. Highly interesting is their association with obsidian coming from the SE-Anatolian sources (Bingöl and Nemrut Dağ), due to the results of provenance analyses. Further, recent use wear analyses show that Çayönü Tools played a role in the stone object production and can be functionally assigned to the processing of stone artefacts, such as polishing, decoration or engraving of stone rings and/or stone vessels, as the material "obsidian" is suitable for such functions.[51]

Major evidence stems from Çayönü, Tell Magzalia, and Shimshara in the Upper-Middle Euphrates where the Çayönü tools were commonly worked on long blades of the naviforme technology while the lateral modifications were performed by deliberate pressure technique. Their distribution pattern indicates a first innovative core in the Upper Euphrates and a temporal distribution from West to East **(Fig. 14)**. The earliest pieces appear during the 9th millennium BC in Çayönü, Nevali Çori and Gritille, clustering south of the SE-Anatolian obsidian sources. From the late 8th millennenium BC onwards, Çayönü Tools diffuse along the major river systems to the southeast into the Zagros and Khuzestan. The finds in Ali Kosh probably belong to an earlier diffusion stage, while the pieces from Hajji Firuz in NW-Iran (Urmia) represents the latest phase, the second half of the 7th millennium BC. Worth mentioning is that almost all analysed pieces match the Nemrut Dağ/Lake Van sources in SE-Anatolia. As rapid as the introduction and diffusion of Cayönü tools in the PPN world was, so their decrease coincidences with the emergence of pottery production. Recently finds from Kmlo in NW-Armenia, Kotias Klde, Aruchlo and Anaseuli 1 in Western-Georgia complete the distribution pattern.[52]

In addition, fragments of blade tools with steep lateral edges from Dzheitunian assemblages in the NE of Iran and W-Turkmenistan – here made on flint – may have fulfilled a similar function.

Apart from the Çayönü Tools, several other lithic artifact types can be associated within this distinctive obsidian diffusion: 1) obsidian bladelet industries; 2) corner-thinned blades and 3) side-blow flakes; all found east of the Zagros. While the first two categories can be regarded as "true" items of the Neolithic tool set, side-blow flakes are in fact remnants of the debris and are to be identified as waste products of blade segmentation processes (step of tool-finishing according to the *chaîne opératoire*). They represent the snapped parts of blades but show no use traces.[53] Such artefacts are also known from Hajji Firuz at the Urmia lake, NW Iran **(Fig. 15)**. While corner-thinned blades appear as a local innovation in the Jezirah/Upper Mesopotamia for the production of harvesting tools,[54] obsidian bladelets (and much more rarely obsidian bladelet cores) show a broad geographical distribution from Upper Mesopotamia, the Zagros fringes and towards the West into the Southern Levante and Lower Egypt which suggests a special but common role of function. It is noteworthy, that the obsidian bladelets were all performed by pressure flaking.

Networks of technological style: the geometrics

Since the geometrics of the Epipalaeolithic/Neolithic Zagros and Caucasus were highlighted as a possible chronological marker, most scholars had focused on their sub-classification in terms of typological variants and their implication. This concerns particularly the Mesolithic/Neolithic tools of the Caucasus and the question about origin and typological linkages. In comparison, geometrics of the Epipalaeolithic Zarzian groups of the Zagros consist of small and narrow triangles or lunates, all produced from small bladelets with oblique steep retouches. Some specimens remind of Trialetian types made on irregular flakes, as in Jarmo.[55] During the 9th millennium BC, geometrics were virtually absent from the early Neolithic assemblages, e.g. in Ganj Dareh, East Chia Sabz or Chogha Golan[56], apart from singular specimen (e.g. Ali Kosh Phase In the Deh Luran).[57] Instead, a considerable amount of nibbled and backed bladelets with asymmetrical

[51] Rokitta 2005.

[52] See Chataigner/Gasparyan/Arimura. in this volume.

[53] Nishiaki 1996; Vardi/Gilead 2011. While most scholars have identified them as tools, others have suggested that they are really waste products of a blade segmentation processes. Recently, the newly discovered Ghassulian workshop at Beit Eshel in Beer Sheva, northern Negev, yielded thousands of SBBFs as well as numerous partially modified and complete sickle blades. The study of the lithic assemblage from Beit Eshel suggests that the SBBF are all waste products and we suggest that they had the same role in the northern Levantine sites; see Vardi/Gilead 2011.

[54] Nishiaki 1990.

[55] Hole 1983.

[56] Darabi et al. 2013; Thomalsky 2014; Zeidi/Conard 2013.

[57] Hole et al. 1969 Fig. 24.

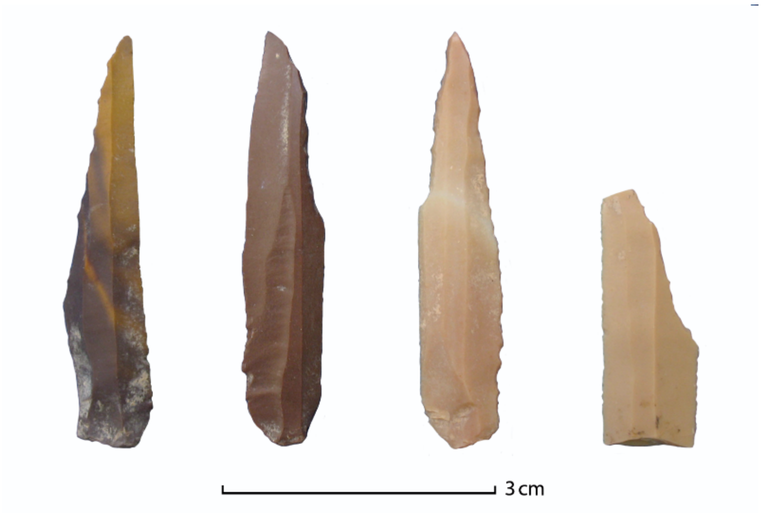

Fig. 16. Ganj Dareh points (nibbled oblique bladelets) (photo: Thomalsky).

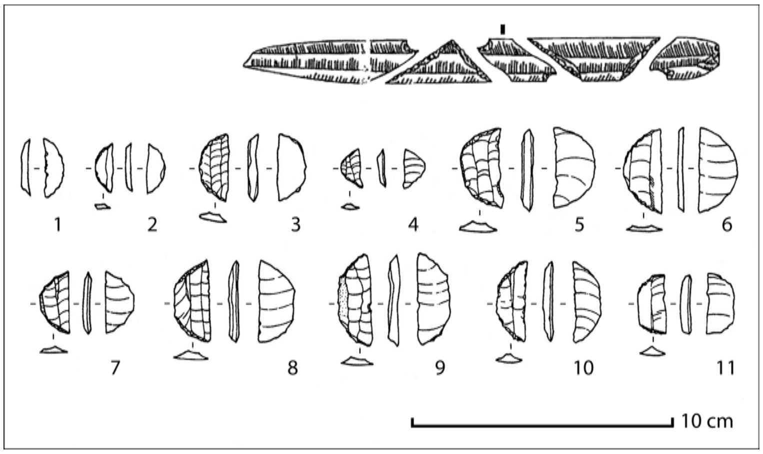

Fig. 17. The Mushki geometrics, produced on regular blade segments (late 7th to 6th millennium BCE) (modified after Abe 2011 fig. 2).

ends replaced the earlier geometric types in their function as hunting tools **(Fig. 16)**. Interestingly, the disappearance of the geometric types can be observed throughout the area under study, including the PPNB world.[58].

After a gap of approximately 1000 years, geometric microliths reappear in the shape of trapezes and lunates. In terms of technological grammar, they differ clearly from the older (Zarzian) geometrics as can be illustrated with the inventory of Tappe Mushki in Fars province **(Fig. 17)**[59] almost exclusively made on segmented bladelets which need no further modification such as edge retouches, this specific type was manufactured in a highly-specialized and time-saving procedure. Recently, M. Abe attributed the later geometric types to distinctive parts of the arrow, respectively the trapezes as inserts for the arrow shaft while the lunates served as arrow tip.[60] Overall, this study comprises a significant re-occurrence or even increase of the hunting component in subsistence economy (at least in Fars) associated with a prominent change in the bow-and-arrow technology and related technological style.

Concerning the question of an existent lithic network along the Southern Caspian coast, our discussion should start with the geometric inventory of Ali Tape in NE Iran. The tool inventory is dominated by backed bladelets similar to the Zagros points and microlithic triangles which were probably made on bladelets and also on core-tablets. As in the neighboring Belt cave no regular blade industry had taken place, the geometric triangles and trapezes were produced on irregular flakes. Hotu Cave contains amorphous flakes and pebble tools, but again lacks microliths. The Dam Dam Cheshmeh sequence indicates the appearance of geometrics in the 7th millennium BC at latest since the cave was abandoned in the course of the 6th millennium BC. The pieces were flaked from irregular cores and finished through oblique-transversal retouches. In fact, they can be placed technologically similar to the Trialetian geometrics (see below). Finally, the geometrics of the Dzheitunian, were made on regular short blade segments, where the dominant form is the trapeze. In fact, the geometrics of the Dzheitun sites do not differ typo-technologically from the Late Neolithic pieces of Fars or Khuzestan province.

By analyzing the geometric tools that were broadly described under the term “Trialetian”, it becomes clear that there are significant differences in terms of technological grammar, and function, as already discussed above. Typical for the “Mesolithic” inventories are triangles or scalenes made from broader flakes and/or short irregular blades. Nevertheless, a comparable number is produced on regular blade segments which appear in younger contexts of the “Classic Trialetian” (Georgia, Aserbaijan) and in the western and northern neighboring areas. The typological variety in the Caucasus can be chronologically ordered. Long asymmetric triangles and trapezes and backed pieces (e.g. Chokh) can be placed at the beginning of the technological development, while symmetric outlines are later shapes. Geometrics disappear during the Early Neolithic (around 6000 BC, see

58 Bar-Yosef/Belfer-Cohen 1989.
59 Fukaii et al. 1973.
60 Abe 2011; Abe/Azizi Kharanagi 2014.

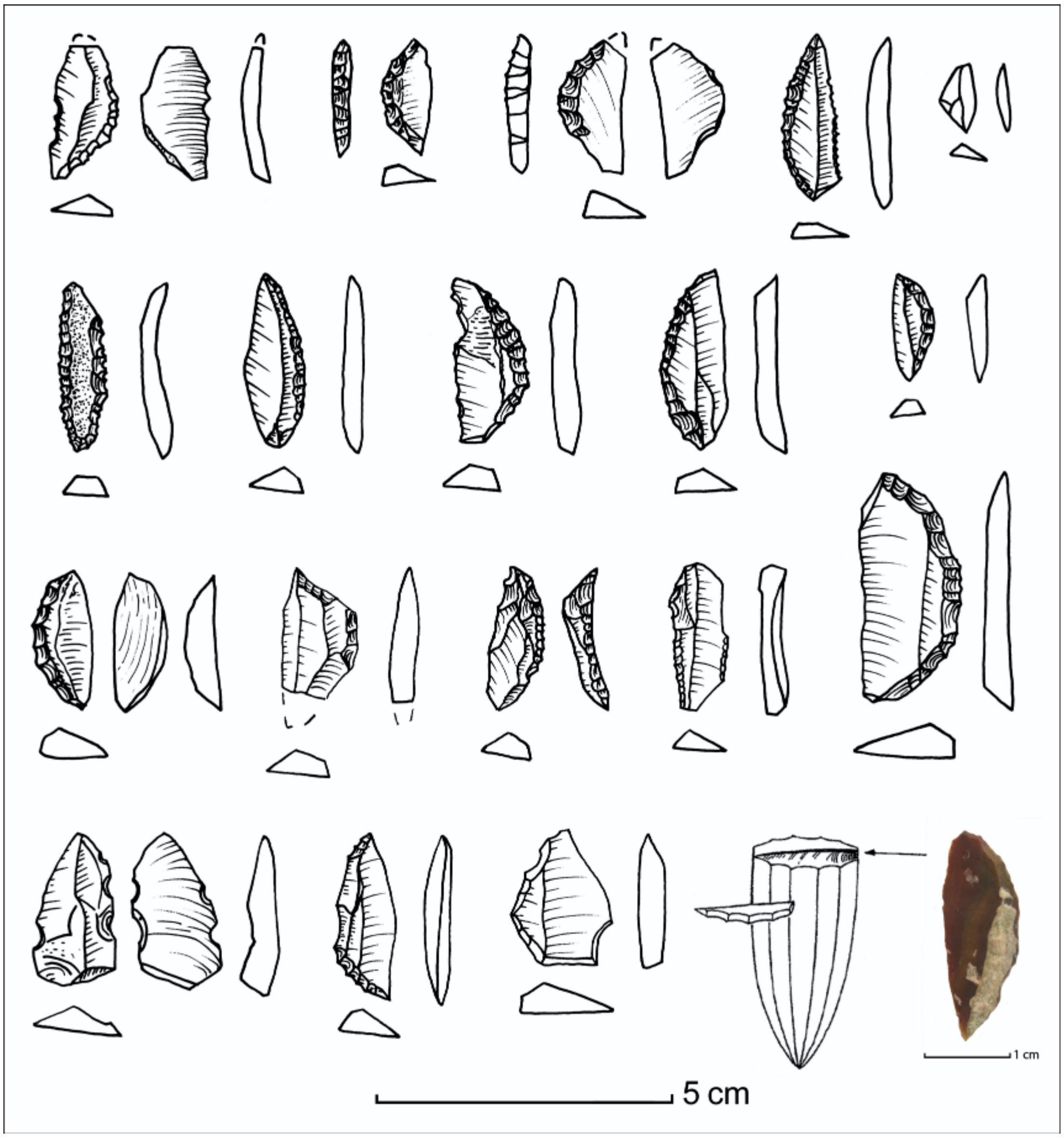

Fig. 18. Sialk geometrics, produced from flaking debris (core tablets) (photo & drawings: Thomalsky).

the Anaseuli or Odishi, inventories for example). Small bladelets with nibbled or backed laterals are still present and particularly characteristic for the assemblages of the W-Caucasus/Black Sea area,[61] or experience an increase in the northern regions (Abrasia, Imeretia). However, in some places (for instance in Firuz, W-Georgia) symmetric trapezes are present until Late Neolithic/Early Chalcolithic times. Since the available published record is still insufficient, the question remains if this pattern is valid or accidentally biased. Interestingly, there is a comparable pattern demonstrated for the Iranian Neolithic which lacks geometrics for a considerably span of time of approximately 1000 years, between the mid-8th to mid-7th millennium BC. A similar development is actually observed for the contemporary assemblages in NE-Iran and Turkmenistan. The assemblage known from Belt cave shows strong analogies to the Hallan Cemi material which belongs to the older Epipalaeolithic/Neolithic tradition. One can assign the geometric tools of the Dzheitunian

[61] Chataigner 1995.

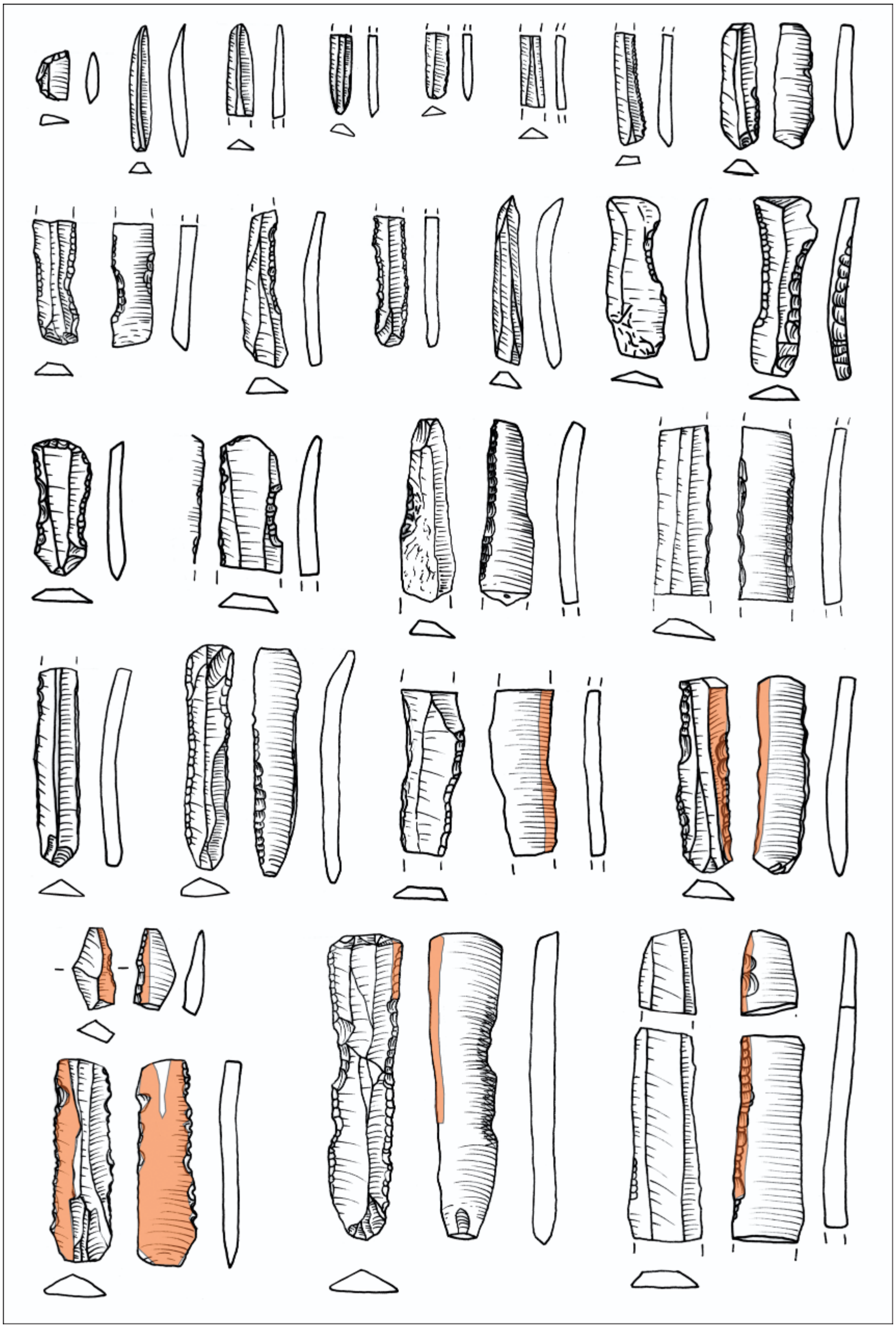

Fig. 19. Lithic artefacts of the 6th millennium site Ghabrestan Noushabad, Kashan plain (photo & drawings: Thomalsky).

to the younger group, since they exhibit the same technological attributes, mostly in the use of segmented blades/bladelets, which indicates a same manufacturing process as is the case in the 7th millennium BC Mushki inventory.

Similar to the Caucasus, the Iranian Central Plateau lacks an aceramic Neolithic and seems to have been occupied by fully neolithisized farming groups around 6200/6000 BC.[62] Recent investigations at one of the key sites, Tappe Sialk in the Kashan plain, places the Neolithic settlement (Period I and II) between 6000 and 5600 BC cal. Related lithic material is characterized by the bladelet industry but with a less significant number of blade/bladelet tools. The group of geometrics should be highlighted, out of which a certain amount exhibits glossy edges which runs obliquely across one end **(Fig. 18)**. In terms of technological grammar, it is highly evident that these geometrics were almost without exception manufactured from semi-core tablets, most possibly reduced from exhausted bladelet cores, instead of blade segments as it was mainly common in other geometric inventories. This distinctive exploitation of bladelet cores, by even using the remained broad core parts for obtaining crescent flakes as blanks for the required geometric tools illustrates a very opportunistic management of resources. In the neighbouring settlement of Ghabrestan Nourabad (12 km north of Sialk) which is equally dated into the early 6th millennium BC, the lithic inventory is comparably dominated by a blade-bladelet industry including pieces with glossy edges which have served as sickles **(Fig. 19)**. Geometrics are – with few exceptions – lacking. On the one hand, the industry shows strong links to the advanced bladelet industries of the Zagros, but in addition exhibits a rather advanced sickle manufacture which is possibly slightly younger in date than Sialk I. Assuming that, the crescents of Sialk I-II on the Iranian plateau are of a different *chaîne opératoire* than the other known geometrics of the Late Neolithic. All major groups of geometrics under discussion here – (1) Zagros/Fars and possibly NE-Caspian shoreline, (2) Trialetian, (3) Iranian Plateau and (4) Dzheitun – considerably differ from each other in manufacturing method (bladelet segment versus core tablet) and utilisation (projectile point versus sickle element). In a large-scale perspective, one can find even more technological differences which most possibly depended on cultural aspects of technological choice and not on technological potentials of the group. Another example can be given by a rough view of the harvesting and hunting tools of Neolithic sites of the Zagros/Fars and adjacent Khuzestan ("the Zagros fringes" after R. Braidwood). Here, harvesting tools were manufactured from bladelet blanks (e.g. Ganj Dareh) while geometric forms were used as inserts of projectile implements. Both groups stand within the microlithic tradition of Western Iran by using either the end products or the relicts of the bullet core technology. This picture also gives indirect evidence that lithic technology of the Northern Central Plateau originated technologically from the Zagros tradition, but developed either further, leading technological attributes, or transformed and re-generated to a new set of technological grammar which can be determined as a local technological style or habitus.

Summary and Conclusion

From a supra-regional view, the two lithic complexes of the Early Neolithic, the bullet core technology of the Eastern Fertile crescent and the large naviforme core technology of the Western Fertile Crescent, seem to reflect a technological borderline running through the Zagros flanks. In regard of lithic technological concepts, one can suggest that the microlithic complex of the earlier Zarzian industry of the Zagros served as the technological substratum of the later bullet core technology. When evaluating Natufian industries, one can find contemporary microlithic components. In an interregional perspective, one can observe a gradual technological change towards standardized blade cores and a high-opportunistic blade technology with an intensive output at the dawn of Neolithization. The suceeding technological development experiences considerable impulses by the diffusion of the pressure flaking technique: along the Western Zagros flanks during the mid-9th millennium BC. The derived most characteristic lithic artefact – the bullet core – thus reflects the new (Neolithic) lifestyle with more permanent and standardized working sequences. For the Caucasus, the microlithic tradition equally continues; until the 6th millennium BC, but appear to gradually be replaced by a larger blade industry. There are several indicators that the larger blade technology was first introduced on obsidian.[63] This blade industry has nothing in common with the PPNB technology, but again seems to be linked with the development in Iran. This is further underlined by the distribution of the pressure flaking technique into the Caucasus during that period. As an overall aspect, the so-called

[62] Fazeli Nashli et al. 2013.

[63] Thomalsky 2017.

Trialetian can be regarded as contemporaneous in its latest phase to the PPNA in Northern Mesopotamia and the Epipalaeolithic/Early Neolithic groups of the Western Zagros. It further is equally affected by major innovations in lithic technology such as the introduction of pressure flaking or the rise of new geometric types. This may explain why the Trialetian appears to link lithic production from the W-Caucasus to the SE-Caspian. Several open points remain for future investigations, for instance our question about the first introduction and distribution pattern of pressure flaking, or the more precise dating of our "Trialetian" and "Neolithic" sequences in the S-Caucasus. Additionally, a future look on what happened in the lithic production of SE-Anatolia may help to understand the Caucasian technological development.

The second part of the paper focused on the possibilities for the detection of technological networks, with some case studies from the "lithic" perspective. A "technological grammar" of a tool can help to distinguish specific technological styles which may be associated with exchange networks, specific functions, or social groups, as shown for the obsidian distribution and in particular for the Çayönü tools. For the latter, it is crucial that a specific application (for stone vessel/decoration) is directly connected with a specific raw material – obsidian-, though there are possible local adaptions in flint.

In the case of the Neolithic geometric tools, one can describe different technological attributes on a chronological, technological and functional level, as shown for the geometrics of the so-called Trialetian, the Mushki inventory or Sialk I.

Bibliographie

Abe 2011
Masashi Abe, Geometrics from the Neolithic settlement of Tall i Mushki, south-west Iran. In: Elisabeth Healey/ Stuart Campbell/Osamu Maeda (ed.), The State of the Stone Terminologies, Continuities and Contexts in Near Eastern Lithics. Proceedings of the Sixth PPN Conference on Chipped and Ground Stone Artefacts in the Near East, Manchester, 3rd–5th March 2008. Studies in Early Near Eastern Production, Subsistence, and Environment (Berlin 2011) 163–170.

Abe/Azizi Kharanagi 2014
Masashi Abe/Hossein Azizi Kharanagi, A Study on the Early Pottery Neolithic Chipped Stone Assemblage from Rahamatabad. In: Hossein Azizi Kharanagi/ Morteza Khanipour/Ramin Naseri (ed.), Proceedings of the International Congress on the Archaeology of the Ancient Near East (Tehran 2014) 27–40.

Arimura et al. 2010
Makoto Arimura/Ruben Badalyan/Boris Gasparyan/ Christine Chataigner, Current Neolithic research in Armenia. Field reports. Neo Lithics 2010, No. 1, 77–85.

Asouti 2006
Elena Asouti, Beyond the Pre-Pottery Neolithic B interaction sphere. Journal of World Prehistory 20, 2006, 87–126.

Aurenche et al. 1987
Olivier Aurenche/Jacques Èvin/Janine Gasco, Une séquence chronologique dans le Proche Orient de 12000 à 3700 BC et sa relation avec les données du radiocarbone. In: Olivier Aurenche/Jaques Èvin/ Francis Hours (ed.), Chronologies du Proche Orient. British Archaeological Reports, International Series 379 (Oxford 1987) 21–37.

Aurenche et al. 2001
Olivier Aurenche/Philippe Galet/Jaques Èvin, Proto-Neolithic and neolithic cultures in the Middle East – The Birth of Agriculture, Livestock Raising, and Ceramics: A calibrated ^{14}C Chronology 12,500–5500 cal BC. Radiocarbon 43, 2001, No. 3, 1191–1202.

Aurenche et al. 2004
Olivier Aurenche/Stephan K. Kozlowski/Marie Le Miére, La notion de frontière dans le Protonéolithique et le Néolithique du Proche-Orient. In: Olivier Aurenche/ Marie Le Miere/ Paul Sanlaville (ed.), From the River to the Sea: The Paleolithic and the Neolithic on the Euphrates and the Northern Levant. Studies in Honour of Loraine Copeland. British Archaeological Reports, International Series 1263 (2004) 355–366.

Aurenche/Kozlowski 2005
Olivier Aurenche/Stephan K. Kozlowski, Territories, Boundaries and Cultures in the Neolithic Near East. British Archaeological Reports, International Series 1362 (Oxford, Lyon 2005).

Badalyan 2010
Ruben S. Badalyan, Obsidian of the South Caucasus: The use of raw materials in the Neolithic to Early Iron Age. In: Svend Hansen/Ingo Motzenbäcker/Andreas Hauptmann/Ernst Pernicka (eds.), Von Majkop bis Trialeti. Gewinnung und Verbreitung von Metallen und Obsidian im Kaukasus im 4.–2. Jt. v. Chr. Beiträge des Internationalen Symposiums in Berlin vom 1.–3. Juni 2006 (Bonn 2010) 27–38.

Bar-Yosef/Belfer-Cohen 1989
Ofer Bar-Yosef/A. Belfer-Cohen, The Levantine "PPNB" Interaction Sphere. In: Israel Hershkovitz (ed.), People and Culture in Change. Proceedings of the Second Symposium on Upper Palaeolithic, Mesolithic and Neolithic Populations of Europe and the Mediterranean Basin. British Archaeological Reports International Series 508 (Oxford 1989) 59–72.

Betts et al. 1989
Alison Betts/Douglas Baird/Thomas Watkins, Qermez Dere and the Early Aceramic Neolithic of N. Iraq. Paléorient 51, 1989, No. 1, 19–24.

Calley 1986
Sylvie Calley, Technologie du débitage à Mureybet, Syrie. British Archaeological Report International Series 312 (Oxford 1986).

Chataigner 1995
Christine Chataigner, La Transcaucasie au Néolithique et au Chalcolithique (Oxford 1995).
Chataigner/Barge 2010
Christine Chataigner/Olivier Barge, GIS (Geographic Information System) and obsidian procurement analysis: pathway modelistaion in space and time. In: S. Hansen/A. Hauptmann/I. Motzenbäcker/E. Pernicka (eds.), Von Majkop bis Trialeti. Gewinnung und Verbreitung von MEtallen und Obsidian in Kaukasien im 4.-2. Jt. v. Chr. Beiträge des Internationalen Symposiums in Berlin vom 1.–3. Juni 2006 (Bonn 2010) 1–14.
Darabi et al. 2013
Hojjat Darabi/Hassan Fazeli Nashli/Ramin Naseri/Simone Riehl/Ruth Young, The neolithisation process in the Seimarreh Valley: excavations at east Chia Sabz, Central Zagros. In: Roger J. Matthews/Hassan Fazeli Nashli (eds.), The Neolithisation of Iran: the formation of new societies. Themes from the ancient Near East BANEA publication series 3 (Oxford, Oakville 2013) 55–76.
Desrosiers 2012
Pierre M. Desrosiers (ed.), The Emergence of Pressure Blade Making. From Origin to Modern Experimentation (New York 2012).
Fazeli Nashli et al. 2013
Hassan Fazeli Nashli/Robin Coningham/A. Marghussian/M. Manuel/Hossein Azizi Kharanaghi/M. Pollard, Mapping the neolithic occupation of the Kashan, Tehran and Qazvin plains. In: Roger J. Matthews/Hassan Fazeli Nashli (eds.), The Neolithisation of Iran: the formation of new societies. Themes from the ancient Near East BANEA publication series 3 (Oxford, Oakville 2013) 124–146.
Fukaii et al. 1973
Shinji Fukaii/Kiyoharu Horiuchi/Toshio Matsutani, Marv-Dasht 3: The Excavation at Tall-i Mushki, 1965 (Tokyo 1973).
Gatsov 2005
Ian Gatsov, Some Observation about Bullet Core Technique during $7^{th}/6^{th}$ Millennium BC. In: C. Lichter (ed.), How Did Farming Reach Europe? Anatolian-European Relations from the Second Half of the 7^{th} though the First Half of the 6^{th} Millennium cal. BC. BYZAS 2 (Istanbul 2005) 213–220.
Gatsov/Özdogan 1994
Ian Gatsov/Mehmet Özdoğan, Some Epi-Paleolithic Sites from NW Turkey: Ağaçlı, Domalı and Gümüşdere. Anatolica 20, 1994, 97–120.
Gebel/Kozlowski 1994
Hans Georg K. Gebel/Stephan K. Kozlowski (eds.), Neolithic Chipped Stone Industries of the Fertile Crescent. Proceedings of the First Workshop on PPN Chipped Lithic Industries. Seminar für Vorderasiatische Altertumskunde, Free University of Berlin, 29^{th} March–2^{nd} April, 1993. Studies in Early Near Eastern Production, Subsistence and Environment 1 (Berlin 1994).
Hansen et al. 2007
Svend Hansen/Guram Mirtskhulava/ Katrin Bastert-Lamprichs/Jochen Görsdorf/ Daniel Neumann/ Michael Ullrich/Ivan Gatsov/ Petranka Nedelcheva, Bericht über die Ausgrabungen in dem neolithischen Siedlungshügel Aruchlo I im Sommer 2007, Archäologische Mitteilungen aus Iran und Turan 39, 2007, 1–34.
Harris 1997
David R. Harris, Jeitun and the transition to agriculture in Central Asia. Archaeology International 1, 1997, 28–31.
Harris 2010
David R. Harris (ed.), Origins of Agriculture in Western Central Asia. An Environmental-Archaeological Study (Philadelphia 2010).
Harris 2012
David R. Harris, Jeitun and the transition to agriculture in Central Asia. Archaeology International 1, 2012.
Harris et al. 1996
David R. Harris/C. Gosden/M. P. Charles, Jeitun: recent excavations at an early neolithic site in southern Turkmenistan. Proceedings of the Prehistoric Society 62, 1996, 423–442.
Hildebrandt 1996
Elisabeth Hildebrandt, Changes in Methods and Techniques of Blade Production during the Epipaleolithic and Early Neolithic in the Eastern Fertile Crescent. In: Stephan K. Kozlowski/Hans Georg K. Gebel (eds.), Neolithic chipped stone industries of the Fertile Crescent, and Their Contemporaries in Adjacent Regions., vol. 3. Studies in Early Near Eastern Production, Subsistence and Environment (Berlin 1996) 193–207.
Hole 1983
Frank Hole, The Jarmo chipped stone. In: Linda S. Braidwood/Robert J. Braidwood/Bruce Howe/Charles Reed/Patty J. Watson (eds.), Prehistoric Archaeology along the Zagros flanks, vol. 105. Oriental Institute Publications (Chicago 1983) 233–284.
Hole 1987
Frank Hole, Archaeology of the Village Period, in: F. Hole (ed.), Archaeology of Western Iran, Settlement and Society from Prehistory to the Islamic Conquest (Washington D. C. 1987) 29–78.
Hole et al. 1969
Frank Hole/Kent V. Flannery/James A. Neely, Prehistory and Human Ecology on the Deh Luran Plain. Memoirs of the Museum of Anthropology, No 1 (Ann Arbor 1969).
Korobkova 1996
Galina F. Korobkova, The Djeitunian Industry, Southern Turkmenistan. In: Stephan K. Kozlowski/Hans Georg K. Gebel (eds.), Neolithic chipped stone industries of the Fertile Crescent, and Their Contemporaries in Adjacent Regions., vol. 3. Studies in Early Near Eastern Production, Subsistence and Environment (Berlin 1996) 37–55.
Kozlowski 1996
Stephan K. Kozlowski, The Trialetian "Mesolithic" Industry of the Caucasus, Transcaspia, Eastern Anatolia, and the Iranian Plateau. In: Stephan K. Kozlowski/Hans Georg K. Gebel (eds.), Neolithic chipped stone industries of the Fertile Crescent, and Their Contemporaries in Adjacent Regions, vol. 3. Studies in Early Near Eastern Production, Subsistence and Environment (Berlin 1996) 161–174.
Kozlowski 1999
Stephan K. Kozlowski, The Nemrikian PPN Lithic Industry in Iraq and Syria. In: Erwin Ciesla/ Thomas

Kerstin/Stefan Pratsch (eds.), Den Bogen spannen ..., Festschrift für Bernhard Gramsch, Teil 2 (Weissbach 1999) 313–326.

Kozlowski 2002
Stephan K. Kozlowski, Nemrik. An aceramic village in Northern Iraq. Swiatowit Supplement Series P: Prehistory and Middle Ages Vol. 3 (Warsaw 2002).

Larichev et al. 1962
Vladimir Larichev/Barbara L. Pforr/Chester S. Chard, The Microlithic Character of Neolithic Cultures in Central Asia, Trans-Baikal, and Manchuria. American Antiquity, 27(3), 1962, 315–322.

Masuda 2013
Seiichi I. Masuda, Tappe Sang-e Chakhmaq: investigations of a neolithic site in northeastern Iran. In: Roger J. Matthews/Hassan Fazeli Nashli (eds.), The Neolithisation of Iran: the formation of new societies. Themes from the ancient Near East BANEA publication series 3 (Oxford, Oakville 2013) 201–240.

Meshveliani et al. 2007
Tengiz Meshveliani/Guy Bar-Oz/Ofer Bar-Yosef/Anna Belfer-Cohen/Elisabetta Boaretto/Nino Jakeli/Irakli Koridze/Zinovi Matskevich, Mesolithic Hunters at Kotias Klde, Western Georgia: Preliminary Results. Paléorient 33, 2007, No. 2, 47–58.

Mortensen 1972
Peder Mortensen, Seasonal camps and Early Villages in the Zagros. In: Peter J. Ucko/Ruth Tringham/Geoffrey William Dimbleby (eds.), Man, Settlement and Urbanism (London 1972) 293–297.

Niknami et al. 2009
Kamal A. Niknami/Mozghan Jayez/Aliasgar Salahshour, New Epipaleolithic-Protoneolithic sites on the Izeh Plain, south-western Iran. Antiquity 83, 2009, No. 321, Project gallery.

Nishiaki 1990
Yoshihiro Nishiaki, Corner-Thinned Blades: A New Obsidian Tool Type from a Pottery Neolithic Mound in the Khabur Basin, Syria. Bulletin of the American Schools of Oriental Research 280, 1990, 5–14.

Nishiaki 1996
Yoshihiro Nishiaki, Side-Blow Blade-Flakes from Tell Kashkashok II, Syria: a Technological Study. In: Stephan K. Kozlowski/Hans Georg K. Gebel (eds.), Neolithic chipped stone industries of the Fertile Crescent, vol. 3. Studies in Early Near Eastern Production, Subsistence and Environment (Berlin 1996) 311–325.

Ohnuma 2008
Katsuhiko Ohnuma, Lithic Assemblages from TB75 and TB130. In: Akira Tsuneki/Mohsen Zeidi (eds.), Tang-e Bolaghi, The Iran-Japan Archaeological Project for the Sivand Dam Salvage Area. AL-SHARK 3 (Tsukuba 2008) 87–120.

Olszewski 1993
Deborah I. Olszewski, The Zarzian Occupation at Warwasi Rockshelter, Iran. In: Deborah I. Olszewski/Harold L. Dibble (eds.), The Paleolithic Prehistory of the Zagros-Taurus. University Museum Symposium Series Volume 5. University Museum Monographs 83(Philadelphia 1993) 207–236.

Olszewski 1994
Deborah I. Olszewski, The late epipaleolithic chipped stone "Heritage" in early aceramic Neolithic assemblages in the northern Fertile Crescent. In: Stephan K. Kozlowski/Hans Georg K. Gebel (eds.), Neolithic chipped stone industries of the Fertile Crescent, vol. 1. Studies in Early Near Eastern Production, Subsistence, and Environment (Berlin 1994) 83–90.

Olszewski 2012
Deborah I. Olszewski, The Zarzian in the Context of the Epipaleolithic Middle East. International Journal of Humanities 19, 2012, No. 3, 1–20.

Özdoğan 1999
Mehmet Özdoğan, Çayönü. In: M. Özdoğan/N. Basgelen (eds.), Neolithic in Turkey – The cradle of civilisation. New discoveries. Ancient Anatolian civilizations series 3 (Istanbul 1999) 35–63.

Peasnall et al. 1998
Brian L. Peasnall/Richard W. Redding/R. Marc Nesbitt/Michael Rosenberg, Hallan Çemi, pig husbandry, and post-Pleistocene adaptations along the Taurus-Zagros Arc (Turkey). Paléorient 24, 1998, No. 1, 25–41.

Quintero 1998
Leslie A. Quintero, Evolution of Lithic Economies in the Levantine Neolithic: Development and Demise of Naviform Core Technology, as Seen at 'Ain Ghazal. 'Ain Ghazal Excavation Reports Volume 2. Bibliotheca neolithica Asiae meridionalis et occidentalis (Berlin 1998).

Rafifar 1996
Jalal Rafifar, Remarques sur l'industrie lithique Néolithique de l'Iran (10.000–6.000 av. J.-C.). In Stephan K. Kozlowski and Hans-Georg K. Gebel (eds.), Neolithic Chipped Stone Industries of the Fertile Crescent, and Their Contemporaries in Adjacent Regions (Berlin 1996) 405–419.

Rokitta 2005
Dörte Rokitta, Obsidiangeräte im Vorderasiatischen Neolithikum. Die Çayönü Tools (Berlin 2005). Unpubl. MA thesis.

Rosenberg 2003
Michael Rosenberg, The Epipaleolithic in the Marvdasht. In: Naomi F. Miller/Kamyar Abdi (eds.), Yeki Bud, Yeki Naboud: Essays on the Archaeology of Iran in Honor of William M. Sumner (2003) 98–108.

Rostunov et al. 2009
Vjačeslav L. Rostunov/ Sergej Ljachov/Sabine Reinhold, Cmi – Eine Freilandfundstelle des Spätmesolithikums und Frühneolithikums in Nordossetien (Nordkaukasus). Archäologische Mitteilungen aus Iran und Turan 41, 2009, 47–73.

Solecki 1981
Rose S. Solecki, An Early Village Site at Zawi Chemi Shanidar. Bibliotheca Mesopotamica (Malibu, California 1981).

Szymczak 2002
Karol Szymczak, A problem of the bullet shaped cores: A global perspective, Światowit 6 (46), fasc. B, 2002, 229–241.

Szymczak/Khudzhanazarov 2006
Karol Szymczak/Mukhiddin Khudzhanazarov, Bullet-shaped core reduction in Kelteminar culture (Neolithic of Central Asia). In: Andrzej Wisniewski/Tomasz Plonka/Jan-Michael Burdukiewicz (eds.), The Stone: Technique and Technology. SKAM Stowarzyszenie Krzemieniarskie (Wroclaw 2006) 191–198.

Thomalsky 2012
Judith Thomalsky, Lithische Industrien im Vorderasiatischen und Ägyptischen Raum. Untersuchungen zur Organisation lithischer Produktion vom späten 6. bis zum ausgehenden 4. Jahrtausend v. Chr. PhD thesis, University Tübingen (Tübingen 2012).
Thomalsky 2014
Judith Thomalsky, Ganj Dareh: New emphasis on an old-fashioned "villagers site". In: Kamal A. Niknami/Hossein Azizi Kharanagi/Morteza Khanipur/Reza Naseri (eds.), Proceedings of the International Congress on the Archaeology of the Ancient Near East. Archaeological Scientific Association, School of Literature and Humanities, University of Tehran, Iran (Tehran 2014) 7–26.
Thomalsky 2016
Judith Thomalsky, The development of lithic industries in Iran in the light of the processes of Neolithisation. In: Marjan Mashkour/Feridoun Biglari/Mohammad Kourosh (eds.), Neolithisation in Iran (Berlin 2016) 169– 181.
Thomalsky 2017
Judith Thomalsky, Large Blade Technologies in the Southern Caucasus and in Northern Mesopotamia in the 6^{th}–4^{th} millennia BC. In: Elena Rova/Monika Tonussi (eds.): At the Northern Frontier of Near Eastern Archaeology. Recent Research on Caucasia and Anatolia in the Bronze Age. Proceedings of the international Humboldt-Kolleg Venice, January 9^{th}–12^{th} 2013, Subartu 38 (Venezia 2017) 79–90.
Thornton 2013
Christopher P. Thornton, Tappeh Sang-e Chakhmaq: a new look. In: Roger J. Matthews/Hassan Fazeli Nashli (eds.), The Neolithisation of Iran: the formation of new societies. Themes from the ancient Near East BANEA publication series 3 (Oxford, Oakville 2013) 241–255.
Tsuneki 2013
Akito Tsuneki, Proto-neolithic caves and neolithisation in the Southern Zagros. In: Roger J. Matthews/Hassan Fazeli Nashli (eds.), The Neolithisation of Iran: the formation of new societies. Themes from the ancient Near East BANEA publication series 3 (Oxford, Oakville 2013) 84–96.
Vahdati Nasab et al. 2011
Mozghan Jayez, Alireza Nobari, and Hamid Vahdati Nasab, Komishan Cave, Mazandaran, Iran: an Epipalaeolithic and later site on the southern Caspian Sea. Antiquity 85:328, 2011, Project Gallery.
Vardi/Gilead 2011
Jacob Vardi/Isaak Gilead, Side-blow blade-flakes from the Ghassulian sickle blade workshop of Beit Eshel. In: Elisabeth Healey/Stuart Campbell/Osamu Maeda (eds), The State of the Stone Terminologies, Continuities and Contexts in Near Eastern Lithics. Studies in Early Near Eastern Production, Subsistence, and Environment 13 (Berlin 2011) 343–356.
Voigt 1983
Mary M. Voigt, Hajji Firuz Tepe, Iran — The Neolithic Settlement. University Museum Monograph, Band 50 (Philadelphia 1983).
Wilke/Quintero 1995
Philip J. Wilke/Leslie A. Quintero, Evolution and Economic Significance of Naviform Core-a-Blade Technology in the Southern Levant. Paléorient 21, 1995, No. 1, 17–33.
Zeidi/Conard 2013
Mohsen Zeidi/Nicolas Conard, Chipped lithic assemblage from Chogha Golan, a PPN site in the foothills of the Zagros Mountains, Ilam Province, Iran. In: Ferran Borrell/Juan José (ed), Stone Tools in Transition: From Hunter-Gatherers to Farming Societies in the Near East. 7^{th} Conference on PPN Chipped and Ground Stone Industries in Barcelona, from February, 14^{th} to 17^{th}, 2012. Universitat Autònoma de Barcelona (Bellaterra 2013) 315–326.

Summary

The paper presents a tool set of technological attributes of lithic stone tool production that enables to circumscribe technological networks, using the example of the Neolithic industries of the Zagros, the S-Caucasus, Northern Mesopotamia and the Iranian Plateau. Specific parameters determined by the lithic *chaîne opératoire* distinguish differences and similarities in the general evolution of lithic stone tool production but also in terms of technological style and modes of cultural choice. We can define technological links which can be regarded as technological consequences of a Neolithic lifestyle; and we can furthermore bridge two major and very distinctive lithic industries of the so-called Western and Eastern fertile crescent. This contribution further re-evaluates older concepts established by Stefan Kozlowski and others, in particular in the question of the distribution pattern of distinctive geometric tools and postulated techno-cultural correlations as it is the case for the so-called *Trialetian*. In fact, this term requires a critical revision in terms of chronology, technology, and classification, since such forms of "lithic complexes" cannot be reliably described, at least with regard to recent investigations (and thus more finds of lithic inventories from better documented contexts) and socio-technological concepts. Lithic networks indeed can be described on different levels that derive from different steps of the *chaîne opératoire*, within the scope of raw material distribution (e.g. obsidian), flaking technique, and tool finishing/tool sets. Several case studies presented in this paper demonstrate such lithic networks within considerable areas of interaction and exchange on a broader scale. Equally, one can circumscribe distinguished technical styles which represent different local habits in tool production.

Zusammenfassung

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