Modes of chipped stone tool production: the early farming societies in the North-Western Pontic region

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Abstract:

The chipped stone assemblages of early farmers in the south of the Eastern Europe take several forms. 1) They can have a developed laminar component, with production wastes underrepresented, with a high percentage of retouched items (mostly blades with lateral retouch and endscrapers on blades), an exploitation of a high-quality long-distance imported raw material. These assemblages usually are numerically small. 2) Others demonstrate a "simplified" technical set (wide use of hard-hammer), many wastes of production, relatively low percentage of formal tools, most retouched tools on flakes (mostly retouched flakes and endscrapers on flakes), an exploitation of medium quality local chert. These assemblages are relatively larger in numbers. The latter complexes are often explained via the interaction with a local hunter-gatherer population.

An alternative explanation can be sought via the notion of social organisation of flintworking. The early farmers were able to develop a complex system of flintworking based on intra- and inter-communal specialization and constant exchange of blanks and tools. The complexes of the first type result from an inclusion of a settlement into its exchange network. The complexes of the second type represent domestic production of households, satisfying its needs on its own, being excluded from its exchange network. So, early farmers' flintknapping existed in two modes: "domestic" and "exchange". "Exchange" mode is a common way of chipped stone tools production in early farming societies. "Domestic" mode is common in "borderline situation" under conditions of on-going Neolithisation of new terrain. Every early farming lithic assemblage can be treated as composed of products of these two modes to varying degree.

Keywords: Neolithic; Criş; Linear Pottery Culture; Trypillia B1; flintknapping; social organisation

1. Introduction and background

1.1. The Research Question

In Neolithic studies, a common and repeated observation is that groups united by a similar ceramic style can differ in terms of chipped stone tool production. Quite often, there is a clear divide between two types of sites: 1. sites that yield low amounts of lithic finds, with high percentages of blades and formal tools, but almost (but never completely) devoid of debris from on-site knapping; 2. sites that yield large quantities of lithics, often numerous flakes and tools produced from flakes, with abundant evidence of on-site flint-working.

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In particular, in their report on the site of Tiszaszőlős-Domaháza-puszta (First Temperate Neolithic, Hungary), Laszlo Domboroczki, Malgozhata Kacanowska and Janusz Kozlowski (2010) made a number of observations regarding its lithic assemblage. They defined two models of lithic industry. On the one hand, the so-called "normal" model was observed on the sites of Endrőd 6, Endrőd 35, Endrőd 39, Endrőd 119 as well on sites dating to the very beginning of the Balkan First Temperate Neolithic (FTN). It is characterized by a) the macroblade technique; b) off-site production; c) low discard at sites evidenced by the presence of several to several dozens of artefacts, debitage and cores with most tools being "curated"; d) a predominance of blades with lateral retouch and, in some assemblages, of endscrapers among the tools; e) exploitation of "Balkan" or "Banat" flint. On the other hand, the site of Tiszaszőlős-Domaháza-puszta and a number of others belong to another model characterized by: a) the occurrence of three metric standards for blades; b) the use of two methods of blade detachment, namely direct percussion and punch technique; c) on-site treatment of some raw materials; d) the less prevalent occurrence of retouched tools (there are truncations and microliths); e) the use of local raw material. The authors of the report stated that "the shifting of production to the level of household clusters, the vanishing of specialized workshops" will result in tools losing their "curated status" in favour of "expedient status". And, *vice versa*, the presence of extensive exchange networks will make multiple flakes unavailable for re-use as expedient tools (Domboroczki *et al.* 2010).

This observation does not exhaust the variability of early farming lithic complexes. However, this dichotomy re-appears so systematically that it would be interesting to look into it in detail. As a case study I will take the region I am familiar with - the North-Western Pontic region.

1.2. Region of study and state of the art

The chosen study area is the North-Western Pontic region (S-W Ukraine and Republic of Moldova), at present mostly a steppe and forest-steppe landscape close to the north-western shore of the Black Sea. The first truly sedentary inhabitants of the region were the bearers of the Criș culture (around 5600-5400 BCE; Dergaciov & Larina 2015: 342). The next agricultural colonization of the region was part of the expansion of the Linear Pottery culture (LPC), and specifically the musical note phase of this culture (5250-5050 BCE; Kotova 2003: 42-43; Saile *et al.* 2016). The Trypillia-Precucuteni-Cucuteni (TPC) groups expanded in the hilly forested northern parts of the region in the second quarter of the fifth millennium BCE and remained there for almost two thousand years (Rassamakin 2012; Videiko 2004).

Flint mines and primary processing sites of the Trypillia culture were discovered in Volhynia, the Dniester River valley and Central Ukraine (Bibikov 1966; Cynkalowski 1969; Skakun 2012; Tsvek *et al.* 2012). S. Bibikov, N. Skakun, and O. Tsvek have shown that flint acquired from these primary production sites is present in Trypillia culture settlements, and suggested that it was procured via some type of logistic network. Similar networks have been described for the Balkans (Biagi & Starnini 2011; Gurova & Bonsall 2014; Hansen *et al.* 2012; Manolakakis 2004; 2005: 29-36). Geological characterization of a number of outcrops has been carried out in Bulgaria (Andreeva *et al.* 2014; Gurova *et al.* 2016; Nachev 2009; Nachev *et al.* 1981), and Romania (Crandell 2013; Crandell *et al.* 2013; Crandell & Vornicu 2015; Moreau *et al.* 2019), and similar studies have been initiated in the Ukraine (Petrougne 1995; Ryzhov *et al.* 2005).

The raw material supply networks of early farmers have been defined for some important regions of Central Europe (Gronenborn 1997: 105-118; Mateiciucova 2008: 44-56; Zimmermann 1995: 109-124), France (Allard & Denis 2015) and the Hungarian Plain

(Domboroczki *et al.* 2010). Recently, promising results were obtained from the Balkans (Crandell & Vornicu 2015; Gurova *et al.* 2016).

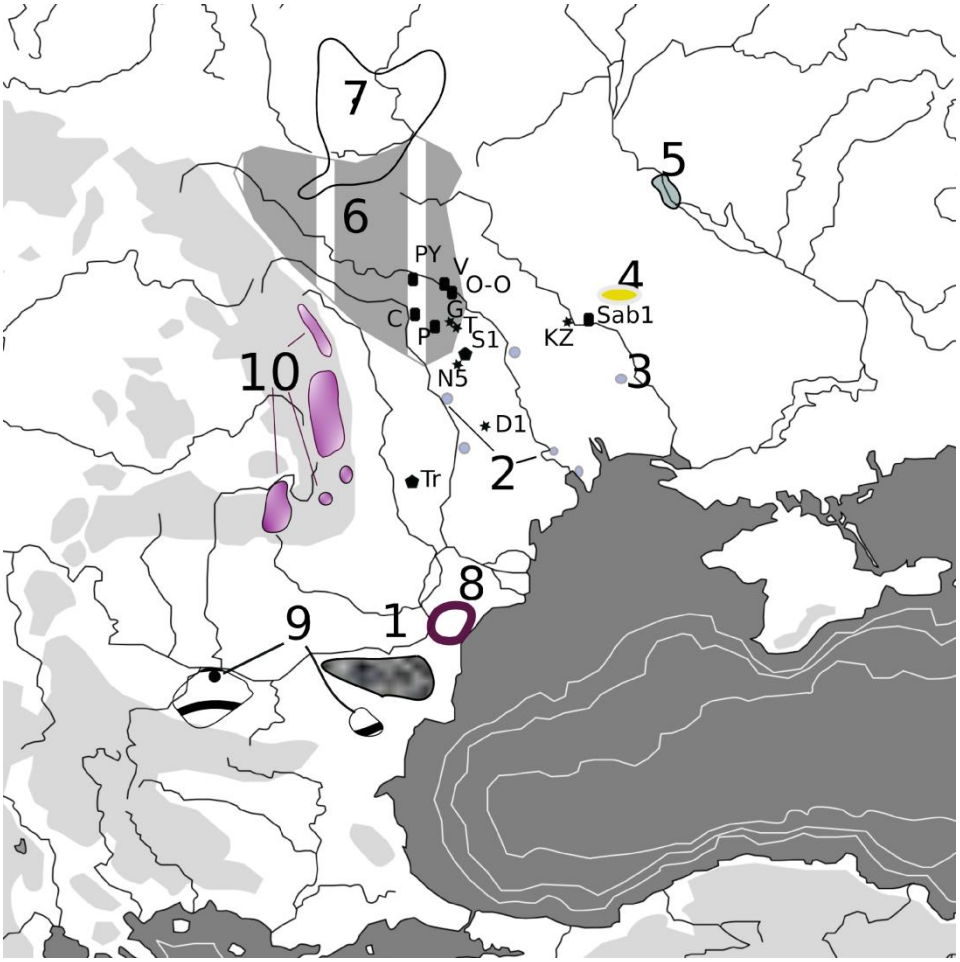

Figure 1. Region of study and relevant silicite outcrops. Silicite outcrops: 1 - Dobrogean flint; 2 - alluvial silicites of Siret, Prut and Dniester; 3 - Bakshala chert; 4 - flint of Ukrainian shield; 5 - silicites of Kaniv dislocations; 6 - Prut - Dniester silicites; 7 - Volhynian-Podolian flint; 8 - Murfatlar silicite; 9 - Moesian flint of pre-Balkan platform. Pentagons - Criș sites; stars - LPC sites; rectangles - Trypillia B1 sites. Tr - Trestiana, D1 - Dănceni 1, N5 - Nicolaevca 5, S1 - Sîngerei 1, T - Țâra 2, G - Gura Camencii 6, P - Putinești 2 and 3, C - Cuconești Vechi 1, PY - Polyvaniv Yar, V - Vasylivka, O-O - Ozheve-Ostriv, KZ - Kamyane-Zavallia, Sab1 - Sabatynivka 1. (After: Andreeva et al. 2014; Biagi & Starnini 2011; Crandell 2013; Crandell & Vornicu 2015; Crandell et al. 2013; Gurova & Bonsall 2014; Gurova & Nachev 2008; Konoplia 1982; Moreau et al. 2019; Nachev 2009; Petrougne 1971; 1995).

Figure 1. Région d'étude et principaux gites de silicites. 1 - Silex de Dobrogea; 2 - Silicites alluviales de Siret, Prut et Dniestr; 3 - Silex de Bakshala; 4 - Silex de la ceinture ukrainienne; 5 - Silicite des dislocations de Kaniv; 6 - Silicite de Prut et Dniestr; 7 - Silex de Volhynia et Podolia; 8 - Silicite de Murfatlar; 9 - Silex moesien du plateau pré-balkanique. Pentagones: Sites de Criș, étoiles: sites LPC, rectangles: Sites de Trypilia B1. Tr - Trestiana, D1 - Dănceni 1, N5 - Nicolaevca 5, S1 - Sîngerei 1, T - Țâra 2, G - Gura Camencii 6, P - Putinești 2 and 3, C - Cuconești Vechi 1, PY - Polyvaniv Yar, V - Vasylivka, O-O - Ozheve-Ostriv, KZ - Kamyane-Zavallia, Sab1 - Sabatynivka 1. (D'après Andreeva et al. 2014; Biagi & Starnini 2011; Crandell 2013; Crandell & Vornicu 2015; Crandell et al. 2013; Gurova & Bonsall 2014; Gurova & Nachev 2008; Konoplia 1982; Moreau et al. 2019; Nachev 2009; Petrougne 1971; 1995).

Logistic networks supplied raw material and helped prehistoric groups establish and systematically re-establish social ties in the course of constant exchanges of raw material and semi-finished products. The widely discussed presence of the aforementioned networks

implies the existence of craft specialization and other factors affecting craft specialization (Kiosak 2019: 9). The social sphere of early farmers of the north-western Pontic area in the 6th-5th millennium BCE has so far received relatively little attention from archaeologists. Moreover, lithic studies have rarely been employed to discuss the social organization of these groups.

Table 1. Basic characteristics of relevant lithic collections
Tableau 1. Caractéristiques de base des collections lithiques étudiées.

Site	Culture	Lithic count	Petrography	14C	Use-wear	Plan	Reference
Trestiana	Criş	1763	-	+	-	+	Ţurcanu 2009
Sacarovca 1	Criş	13999	-	+	+	+	Dergaciov, Larina 2015
Selişte 1	Criş	>2000	-	+	+	+	Dergaciov, Larina 2015
Suceava-Parcul-Cetatea	Criş	518	-	-	-	+	Ţurcanu 2009
Dănceni 1	LPC	283	-	-	+	+	Larina 1999
Ţâra 1	LPC	185	-	-	+	+	Kiosak *et al*. 2021a
Nicolaevca 5	LPC	265	-	-	-	+	Kiosak *et al*. 2021a
Kamyane-Zavallia	LPC	688	+	+	-	+	Kiosak 2019
Gura-Camencii 6	LPC	124	-	-	-	-	Larina 1999
Sângerei 1	LPC	43	-	-	-	-	Larina 1999
Ozheve-Ostriv	Trypillia B1	10102	-	+	-	+	Radmoskyi 2015
Vasylivka	Trypillia B1	226	-	-	-	+	Radmoskyi 2015
Polyvaniv Yar III1	Trypillia B1	3547	-	+	+	+	Popova 2003
Putineşti 2	Trypillia B1	521	-	-	+	+	Sorochin 2002
Putineşti 3	Trypillia B1	849	-	-	+	+	Sorochin 2002
Cuconeşti Vechi	Trypillia B1	2472	-	-	+	+	Sorochin 2002
Sabatynivka I	Trypillia B1	690	-	+	-	+	Kiosak 2019

2. Methods

Technological investigations of an assemblage involve subdividing it into basic compositional categories: cores, core maintenance flakes, flakes, blades and tools. Tools are defined as pieces bearing retouch, burin blow negatives or trimming (Stanko & Kiosak 2010). Technological flakes include flakes that served to prepare, maintain, rejuvenate or re-orientate knapping platforms and surfaces. Obviously, these are pieces whose characteristic morphology enables us to define their particular position in the operational chain; however, a great many other pieces, which served similar purposes, cannot be singled out with certainty among other flakes (Inizian *et al.* 1999: 60). Moreover, the development of technological methods broadened this category over time and pieces routinely defined today as technological were often treated as ordinary flakes several decades ago. Luckily, we can base our numerical estimates on the major efforts undertaken by Dmytro Telegin, Galina Korobkova and Alexandru Păunescu to create a unified terminology.

A. Păunescu adopted a modified type-list by Rozoy and the G.E.E.M. (*Le groupe d'étude de l'Epipaléolithique*) and his approach was followed by subsequent generations of Romanian archaeologists (Păunescu 1970: 90-100; Ţurcanu 2009: 31-42; Vornicu 2015).

Dmytro Telegin developed a type-list for Ukrainian Neolithic collections, which has been widely applied in Ukraine ever since (Telegin 1976). Galina Korobkova proposed a dynamic approach to lithic collections based on use-wear analysis, but also on the classification of the

main typological and technological groups (Korobkova 1987: 11-17). Her numerous students have systematically applied this approach to over 30 sites in Ukraine and Moldova (Larina 1999: 47; Sorochin 1991; 2002: 67-80; Sorokine 1990).

So, while narrow groupings of items, defined according to their typological variability (types and variants), do not necessarily correspond between these three dominant approaches, the larger groupings are in reasonable agreement and can be used for a meaningful comparison. This study includes well-published lithic collections, some of which were studied personally by the author. Table 1 summarizes the basic characteristics of these assemblages.

Having gathered information about the main structural groups of well-published collections, we ran a cluster analysis as implemented in the PAST (Paleontological Statistical Tools) software (Hammer *et al.* 2001), using a classical method of clustering. The formal results were compared with the existing qualitative data on the collections.

3. Data results

3.1. Lithic assemblages of Criş culture in the NW Pontic region

Can the pattern described by L. Domboroczki and his coauthors (2010) be observed in the study region? Here, the First Temperate Neolithic is represented by over 10 sites attributed to phases III-IV of the Criş culture (Dergaciov & Larina 2015: fig. 240). While their number is evidently not enough for a quantitative analysis, qualitative comparison suggests that similar variability also existed on the eastern side of the Carpathian Mountains.

Most of the tools in the Criş culture settlements east of the Carpathians were made from raw materials originating from within the study region (Dergaciov & Larina 2015: 65-66). The use of "Middle Dniester" and "Prut" silicites has been recorded. Deposits of the former were sometimes located very close to well-studied sites (18 km from Sacarovca 1), while the high-quality Turonian flint seems to have been supplied to settlements in virtually the entire region via a regional exchange network (Ţurcanu 2009: 91-144). Although it occurs in small quantities, it is constantly present at sites, even those quite distant from outcrops. It is likely that it was the subject of intercommunal exchange, along with the "Balkan" lithic group (Gurova & Nachev 2008; Gurova *et al.* 2016) and Carpathian obsidian (Ţurcanu 2009: 126).

Two outstanding lithic collections from the study region have been published: from Sacarovca 1 (Moldova, Figure 1: S) and Trestiana (Romania, Figure 1: Tr). Sacarovca 1 (dated to 5600-5350 BCE, (Kiosak *et al.* 2023) yielded over 40 structures and some 14,000 chipped stone artefacts (Dergaciov & Larina 2015: 65). In fact, in every fairly large Sacarovca 1 feature (containing more than 20-30 lithics) we encounter cores, fragments of cores, technical flakes and tools for knapping (hammerstones and retouchers). Thus, flint was knapped in the Sacarovca 1 features, where chipped stone artefacts were found. The cores from Sacarovca 1 often show the serial removal of lamellar blanks (Dergaciov & Larina 2015: figs. 35-36). The site of Selişte 1 has yielded a similar assemblage (Dergaciov & Larina 2015: 323-333).

Trestiana, which was dated to 5630-5230 BCE (Mantu 1998; Figure 1: Tr) yielded some 1700 lithics (Ţurcanu 2009: 117-136). Here, high percentages of tools are characteristic of all structures. Some assemblages lack nuclei, although the number of chipped stone artefacts present can reach 30-50. In assemblages of more than fifty artefacts, nuclei are present, but often they are not numerous enough to explain the entire array of blade blanks and tools made on them. Only Complex B/L.4 contained nodule decortication debris in sufficient quantities (Ţurcanu 2009: 119) to suggest that knapping took place "on site" or close to it. Nevertheless, it has yielded 25 blades and 38 tools for the two nuclei identified, which is definitely too many. Small flint assemblages from several other settlements in Moldova and Romania also demonstrate a structure similar to most of the Trestiana complexes: Suceava-Parcul-Cetatea,

Poeneşti in Târla, Viişoara I and II, etc. (Dergaciov & Larina 2015: 323-338; Ţurcanu 2009: 91-143).

This difference is more evident when comparing Sacarovca 1 and Trestiana (Figure 2). In the former, the proportion of nuclei is almost twice as low, while the percentage of blades and tools is higher. Therefore, we can assume that some of the blanks and tools came to Trestiana in finished form. The settlement of Trestiana, located closer to the deposits of Moesian raw materials south of the Danube, also yielded a distinct blade component associated with the importation of finished blanks. The remote "frontier" site of Sacarovca 1 mainly reflects the maximum development of the "home-made" industry with a heavy emphasis on knapping of local raw materials.

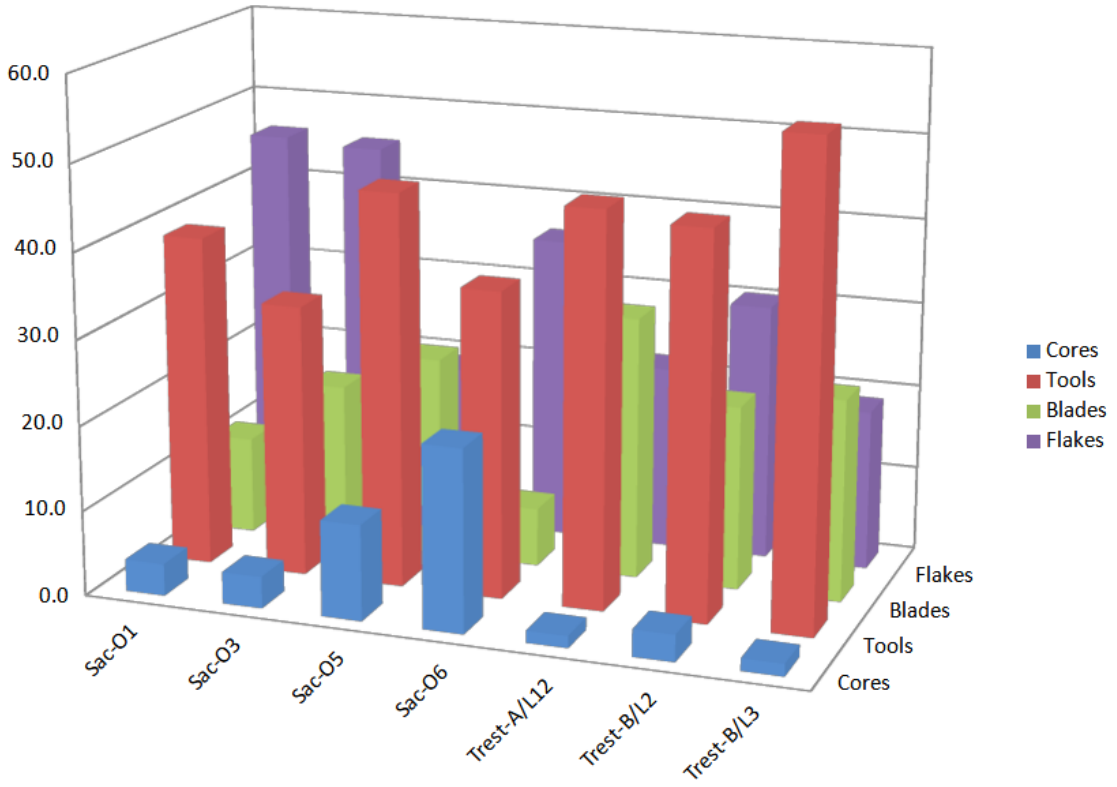

Figure 2. The composition of relevant (numerically sufficient) lithic assemblages from Sacarovca 1 (Sac) and Trestiana (Trest). Suffixes: O1 to B/L3 are denominations of respective features. (After Dergaciov & Larina 2015; Ţurcanu 2009).

Figure 2. Composition des principaux assemblages lithique (numériquement suffisant) de Sacarovca 1 (Sac) et Trestiana (Trest). Les suffixes O1 à B/L3 sont des denominations de structure. (D'après Dergaciov & Larina 2015; Ţurcanu 2009).

3.2. Lithic assemblages of LPC in the NW Pontic region

Many LPC settlements are located in close proximity to outcrops of medium-quality flint of the "Middle Dniester" variety, which actually lines the bottom of the Răut River (Larina 1999: 47; Passek & Chernysh 1963: 29). However, the numerous LPC assemblages also include items made of translucent flint, which Romanian and Moldovan researchers define as "Prut" flint and associate with deposits that occur near the villages of Miorcani and Lopatnik (Crandell 2013; Moreau *et al.* 2019). It should be noted that this flint is very similar in macroscopic characteristics to Volhynian-Dniester flint from secondary alluvial deposits of the Dniester, for example, deposits from near the town of Khotyn (according to H. Wehren, see Kiosak 2019: 52).

Structural analysis of the LPC complexes (Figures 3 and 4) has allowed us to identify several groups of settlements: 1) sites with a predominance of flake knapping techniques reflected in the composition of tools, the set of technologies used and the actual sample of blanks (the reference site is Nicolaevca 5; similar proportions were attested in the lithic collection from the site of Sîngerei 1); 2) sites with clear evidence of blade production, but with a lack of finished products in the collection (Ţâra 2); 3) sites with an excess of blade products, compared to the second group (Dănceni 1, Gura-Camencii 6). The site of Kamyane-Zavallia (dated to 5310-4945 BCE (Moskal-del-Hoyo *et al.* 2023) stands apart as it shows evidence of both on-site production and developed exchange of chipped stone tools (Kiosak 2019: 212-223).

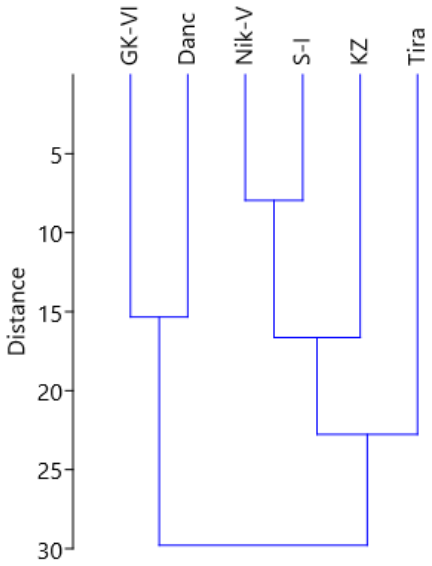

Figure 3. Cluster analysis of LPC complexes. GK-VI - Gura Camencii 6; Danc - Dănceni 1; Nik-V - Nicolaevca 5; S-I - Sîngerei 1; KZ - Kamyane-Zavallia, Tira - Ţâra 1. Done in PAST software. (Raw counts after Larina 1999; Kiosak 2019; Kiosak *et al.* 2021a).
Fig. 3. Classification ascendante hierarchique des complexes LPC. GK-VI - Gura Camencii 6; Danc - Dănceni 1; Nik-V - Nicolaevca 5; S-I - Sîngerei 1; KZ - Kamyane-Zavallia, Tira - Ţâra 1. Réalisée avec le logiciel PAST (décomptes issus de Larina 1999; Kiosak 2019; Kiosak *et al.* 2021a).

The settlement of Nicolaevca 5, dated to 5300-4950 BCE (Moskal-del-Hoyo *et al.* 2023; Figure 1: N; Figure 5A) was investigated under the supervision of S. Ţerna in 2019, with the participation of M. Dębec and T. Saile (Kiosak *et al.* 2021a; Saile 2020). Nicolaevca 5 is located on an unnamed tributary of the Ciuluc River at approximately the same distance of 35-45 km from the Răut and Prut valleys and related outcrops of silicites. The flint assemblage (264 units) consists of two parts: items found during the excavation of the 'long house' and a dense accumulation of prenuclei, nuclei and flakes (the 'hoard'). The assemblage contains nuclei and tools for knapping (hammerstones). Most of the nuclei are exhausted. For the most part, the blades were poorly prepared. Only one nucleus was used for serial knapping of lamellar pieces of regular shape. In general, the industry was oriented towards the production of flakes in an opportunistic manner. There were very few unretouched blades (10%), while flakes accounted for almost half of the production (45%). Tools accounted for 18.5%. Such high proportions are characteristic of consumer settlements (compare to Ţâra 2).

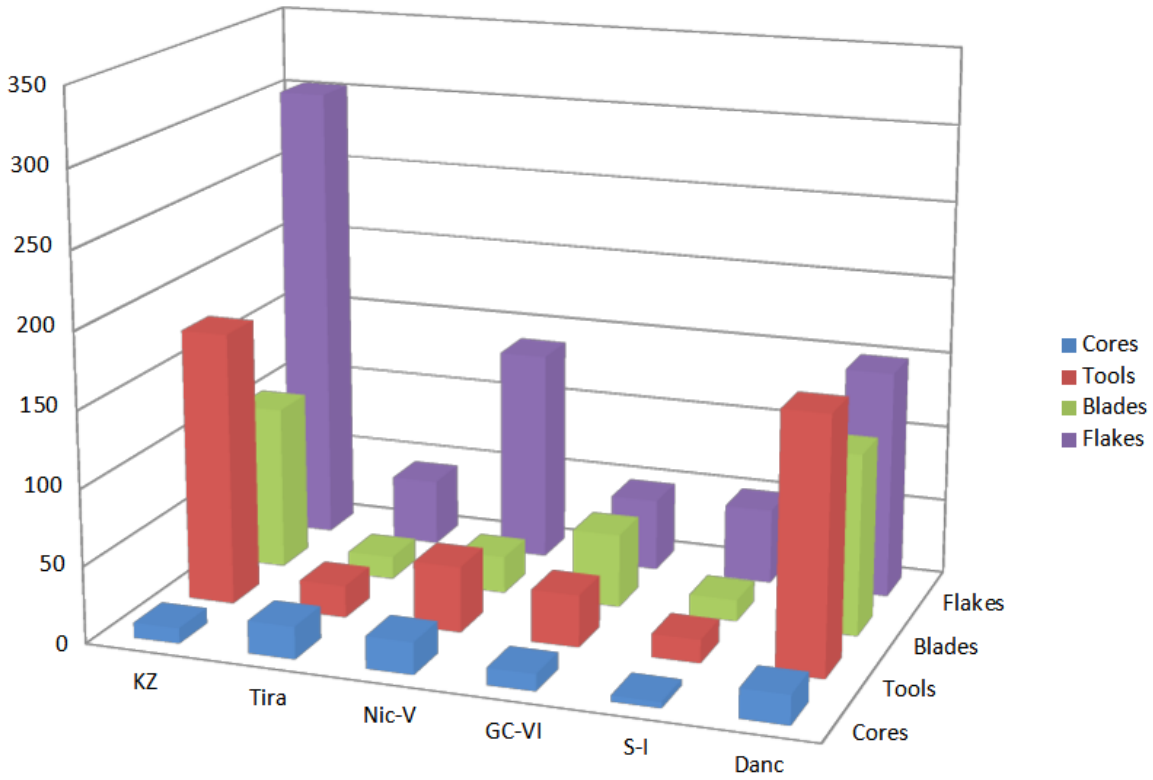

Figure 4. The composition of LPC lithic assemblages from the NW Pontic region. GC-VI - Gura Camencii 6; Danc - Dănceni 1; Nic-V - Nicolaevca 5; S-I - Sîngerei 1; KZ - Kamyane-Zavallia, Tira - Târa 1. (Raw counts after Kiosak 2019; Kiosak *et al.* 2021a; Larina 1999).
Figure 4. Composition des assemblages lithiques LPC du Nord-Ouest de la région pontique. GC-VI - Gura Camencii 6; Danc - Dănceni 1; Nic-V - Nicolaevca 5; S-I - Sîngerei 1; KZ - Kamyane-Zavallia, Tira - Târa 1. (Décomptes issus de Larina 1999; Kiosak 2019; Kiosak *et al.* 2021a).

Ţâra 2 (Figure 1: T) lies directly on the rich outcrop of alluvial medium-quality ‘Răut’ chert (Kiosak *et al.* 2021a). It yielded an elevated percentage of cores and core maintenance flakes. From the point of view of a technological approach to the flint industry, the first feature of note is the extensive nature of the flint processing— most of the flakes have cortex remains on the back, and there are a significant number of primary and semi-primary flakes and pieces of raw material. A weight comparison with the finished tools from the site is even more revealing. Together, the categories of products related to the preparation of raw materials for knapping weigh about 4 kg, ten times the weight of the final products (tools and blades).

In addition, all the products are quite large. The assemblage contains no unfragmented objects that might be classified as microlithic. Assuming that the microlithicisation of the flint complex of an "ordinary" LPC settlement is the result of the reduction of blanks in the process of adjustment and reuse (Nash 1996), we can conclude that the Ţâra complex was at the very beginning of the operational chain, spanning from the production of blanks to their use in the settlement by the end user.

While the pre-core and core stage of the chain is aimed at the production of lamellar blanks, the disproportionately small number of blades, especially their medial parts, may indicate that most of them were removed from the site in the past for further use. The tools present in the collection are mostly rather crude "expedient" tools made on site from directly available chert knapping waste - flakes and core maintenance flakes - in sharp contrast to the generally lamellar complexes known from other settlements throughout the LPC (Allard 2004: 54-55; Kaczanowska 1980; Larina 1999: 47-48; Mateiciucova 2008: 65-67).

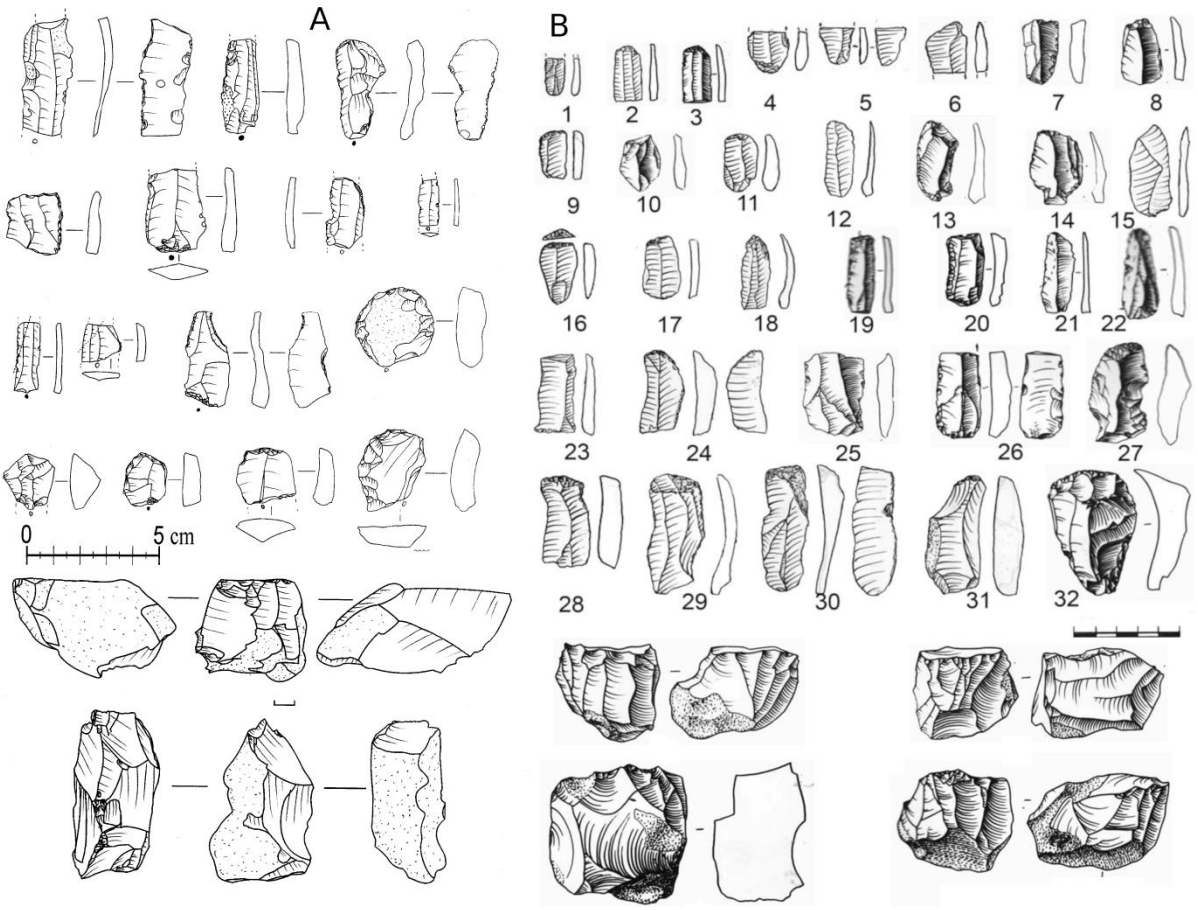

Figure 5. Modes of the LPC lithic industry in NW Pontic region by examples. A: the site of Nicolaevca 5; B: the site of Gura-Camencii 6 (after Kiosak *et al.* 2021; Larina 1999: fig. 36).
Figure 5. Exemples d'industries lithiques LPC du Nord-Ouest de la région pontique. A : site de Nicolaevca 5; B: site de Gura-Camencii 6 (d'après Kiosak *et al.* 2021; Larina 1999: fig. 36).

Thus, the lithic assemblage from the Ţâra 2 site most likely represents the remains of a flintworking "workshop" for the production of blades from local raw materials of medium quality. The term "workshop" is used here conventionally, without any suggestion of specialization on the part of the flint knappers (Pelegrin 1994). In addition, the presence of a small number of tools in the collection (also defined by use-wear analysis by G.F. Korobkova: endscrapers, sickle inserts and knives, Korobkova 1987: 260) indicates that ordinary subsistence activities were carried out along with flintworking.

The assemblage from the settlement of Dănceni 1 is typical of settlements that consumed finished products (322 items, Figure 1: D1; Larina & Dergaciov 2017: 226). The site is situated a considerable distance from silicite outcrops (at least 100 km). Nevertheless, the settlement has all the typical types of raw material for the region: "Middle Dniester" flint, "Prut" flint, and even obsidian. The nuclei are prismatic and conical, mostly with lamellar negatives, and are relatively few in number (5.1% of the assemblage). Blades are more numerous than flakes. There is a very high percentage of tools - over 50% of the lithic finds are retouched. A similar composition characterizes the site of Gura-Camencii 6 (Figure 1: G), situated in close proximity to the alluvial chert pebble beds (Larina & Dergaciov 2017: 161-163).

Another case is represented by the site of Kamyane-Zavallia (Kiosak 2014; 2017). It is situated at a certain distance from local silicite outcrops (Figure 1: KZ). However, in the

assemblage from the site the most common silicite type is an excellent quality Turonian flint, imported from a distance of at least 265 km (according to petrographic analysis by H. Wehren, see Kiosak 2019: 51-52). Structurally, the Kamyane-Zavallia collection represents all the main technical and typological groups (Figures 3 and 4), suggesting that some production occurred directly at the site, although no distinct knapping places were identified during excavations. Virtually all stages of the operational chain are represented, the purpose of which was to produce small blades and (to a lesser extent) blades with irregular outlines, wavy edges and the negatives of previous removals on the dorsal sides. The percentage of tools is elevated and most production occurred using the raw material imported over a long distance. Thus, it is likely that pre-cores, cores, blanks and tools were transported to the site (Kiosak 2019: 223).

The LPC sites have shown that interpreting variability in the lithic assemblages of early farmers is far from straightforward. There are blade-producing sites that lack blades and there are consumer sites that are rich in blades; however, there are also sites with flake-oriented industry as well as sites where on-site production was carried out using imported raw material.

3.3 Lithic assemblages of Trypillia B1 in the NW Pontic region

After the tumultuous and poorly understood Early Trypillia period (Bodean 2001: 3; Popovici & Drașovean 2020; Ursu 2016; Zbenovich 1996: 9-11), the cultural and historical situation stabilized with the beginning of the Middle Trypillia - Trypillia B1 (around 4400-4100 BCE, Kiosak *et al.* 2021b), known as Cucuteni A3 in the Romanian literature (Mantu 1998).

Structural analysis reveals marked differences between sites (Figures 6 and 7). The clustering comprises: 1. a group with high percentages of retouched tools (Sabatynivka 1 and Vasylivka); 2. a group of producer sites with notable percentages of cores and flakes (up to 75% of lithic assemblages; Ozheve-Ostriv, Putineşti 3); 3. a group where knapping evidently occurred on-site, but where there are high percentages of blades and blade-oriented production in general (Cuconești Vechi, Putinești 2, Polyvaniv Yar I).

The first group is best exemplified by the lithic assemblage from the site of Sabatynivka 1 (Kiosak 2009). The Sabatynivka 1 settlement (Figure 1: Sab1) is located directly on the Southern Buh River, relatively distant from the closest outcrops of silicites suitable for knapping. The chipped raw materials are represented by "local" silicites of poorer quality (probably from alluvial beds of the Southern Buh and other rivers) and "imported" smoky transparent flint. The latter is used almost exclusively to make tools. Only one nucleus of this type of flint has been found; the nucleus in question is small with regular micro-blade negatives all around its perimeter. The nuclei made from ‘local’ silicites are amorphous and prismatic. Blades are half as numerous as flakes and medium-wide blades with regular dorsal patterns prevail. Endscrapers are the most prominent group of tools. They are mainly produced from flakes and have scraper fronts on sides and sometimes on an end and a side. The series also includes endscrapers produced on blades. Several of these products are made of "imported" raw material, with retouch on both sides and trimming of the ventral part of the blade near the impact point. There are numerous retouched blades and flakes, burins, and perforators produced on flakes. The collection also includes symmetrical perforators made on blades, often of "imported" raw materials (Kiosak 2009).

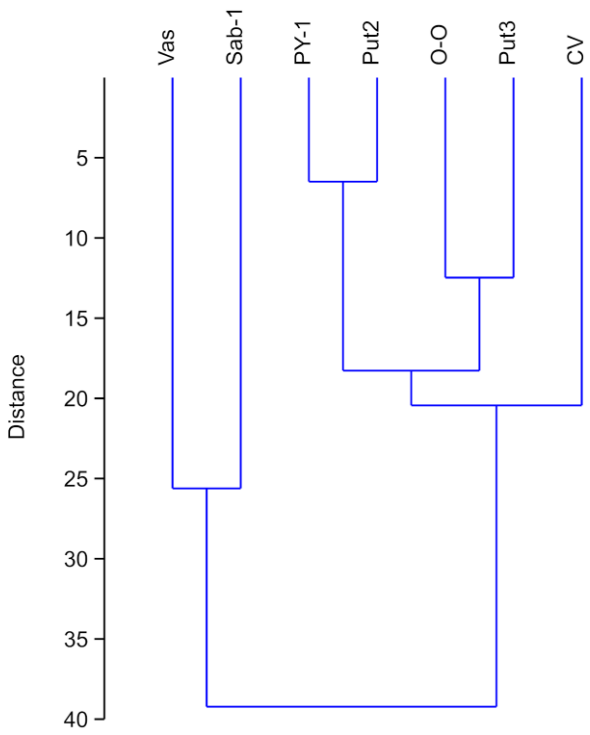

Figure 6. Cluster analysis of Cucuteni A3-Trypillia B1 complexes. Put 3 - Putineşti 3; Sab-1 - Sabatynivka 1; CV - Cuconeşti Vechi; Vas - Vasylivka; PY-1 - Polyvaniv Yar 1; Put 2 - Putineşti 2, O-O - Ozheve-Ostriv. Carried out in PAST software. (After Kiosak 2009; Popova 2003; Radomskyi 2017; Sorochin 2002).
Figure 6. Classification ascendante hierarchique des complexes Cucuteni A3 et Trypillia B1. Put 3 - Putineşti 3; Sab-1 - Sabatynivka 1; CV - Cuconeşti Vechi; Vas - Vasylivka; PY-1 - Polyvaniv Yar 1; Put 2 - Putineşti 2, O-O - Ozheve-Ostriv. Réalisée grace au logiciel PAST. (D'après Kiosak 2009; Popova 2003; Radomskyi 2017; Sorochin 2002).

Thus, the industry consists of artefacts from two raw material groups, to which different techniques and processing methods were applied. The "imported" raw materials are represented by the refined set of tools, mostly on blades, with a clear morphology. They were most likely made using techniques recorded on the sites of the Dniester region. The group of objects made from "local" raw materials (numerically predominant) gives the industry an archaic appearance, reminiscent of the Early Trypillian complexes of the region. Apparently, the flint inventory of a settlement site consisted of two components - a portion obtained through the exchange system and a portion that was produced locally (Kiosak 2009).

The lithic assemblage from the site of Vasylivka (Dniester basin, Figure 1: V) has a similar composition with tools comprising almost a third of the assemblage. The site is situated nearby outcrops of silicites of the "Middle Dniester" variety (Chernovol & Radomskyi 2015; Radomskyi 2017), so we would expect a large proportion of flint knapping remains, but it is not the case.

The second group is exemplified by the settlement of Ozheve-Ostriv (Figure 1: O-O; Figure 8A). It has been studied under the direction of D.V. Chernovol since 2009 (Chernovol & Radomskyi 2015; Radomskyi 2017). The site lies on the Dniester River in direct proximity to an abundant chert outcrop. The number of flakes significantly exceeds the number of blades. Of the flakes, a little less than a seventh are primary flakes. In addition to a small number of bladelets, blades 12-20 mm wide and blades wider than 20 mm are found in approximately equal proportions (39-40% of all laminar detachments). The length of the complete blades reaches some 14 cm. The butts of the blades are smooth and faceted. The nuclei are dominated by non-systemic (amorphous) cores (85%), with a small series of

prismatic, pyramidal and conical cores. The most common category of tools is retouched flakes. Endscrapers on flakes and blades are represented in approximately equal proportions. There are also many retouched blades. A significant group within the assemblage is made up of thin bifacial points made on flakes by means of two-sided flat retouching.

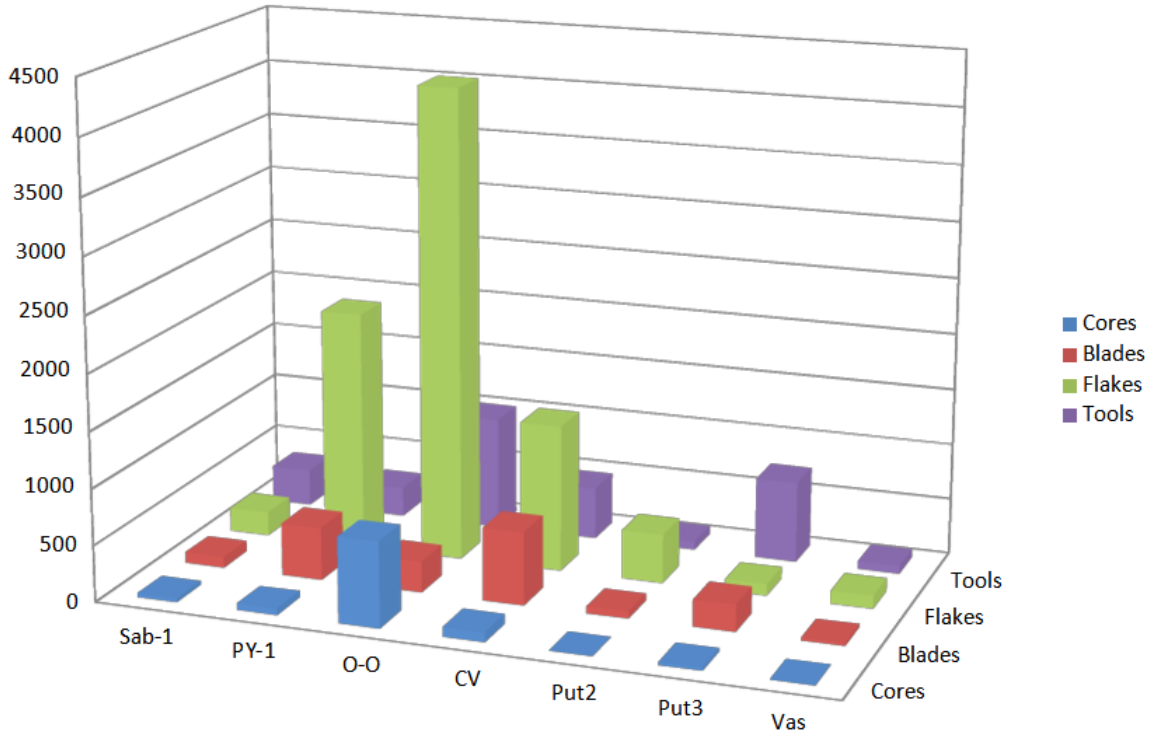

Figure 7. The composition of Trypillia B1 lithic assemblages from the NW Pontic region. Abbreviations are explained in the captions to the Figure 6.
Figure 7. Composition des assemblages lithiques de Trypillia B1 issus du Nord-Ouest de la région pontiques. Les abréviations sont explicitées dans en légende de la figure 6.

In general, the nature of the industry seems to be determined by the extensive mode of knapping due to the availability of raw materials of lower-than-average quality nearby (Radomskyi 2017). This explains the large number of flakes and nuclei with flake negatives, and the slightly higher percentage of tools made from flakes than on other synchronous sites. Similar proportions are attested in the assemblage from Putineşti 3 in Moldova (Sorochin 2002).

The site of Polyvaniv Yar (Figure 1: PY; Figure 7 and 8B) lies on the outcrop of high-quality silicites. It also yielded one of the oldest "knapper's dwellings" so far described for the Trypillia culture (Popova 2003: 20-21). In the first building horizon of the lower layer of the settlement, dwelling 1 stood out due to its size and the richness of its finds (20x10-12 m). The building consisted of two chambers with three ovens. The finds were made up of 14 chert pieces (tested), 58 nuclei in various stages of exploitation, spherical chert nodules (used as hammerstones), chunks (606 pieces), flakes (2127 pieces), and blades (470 pieces). Some of the nuclei were re-utilised as hammerstones. Chipped stone pieces were found in all parts of the dwelling, but especially frequently near its western wall. Here, a 12 m^2 flint working area was reconstructed, alongside a kiln equipped with a supporting clay pavement measuring about 1 m^2 (Popova 2003: 21-22).

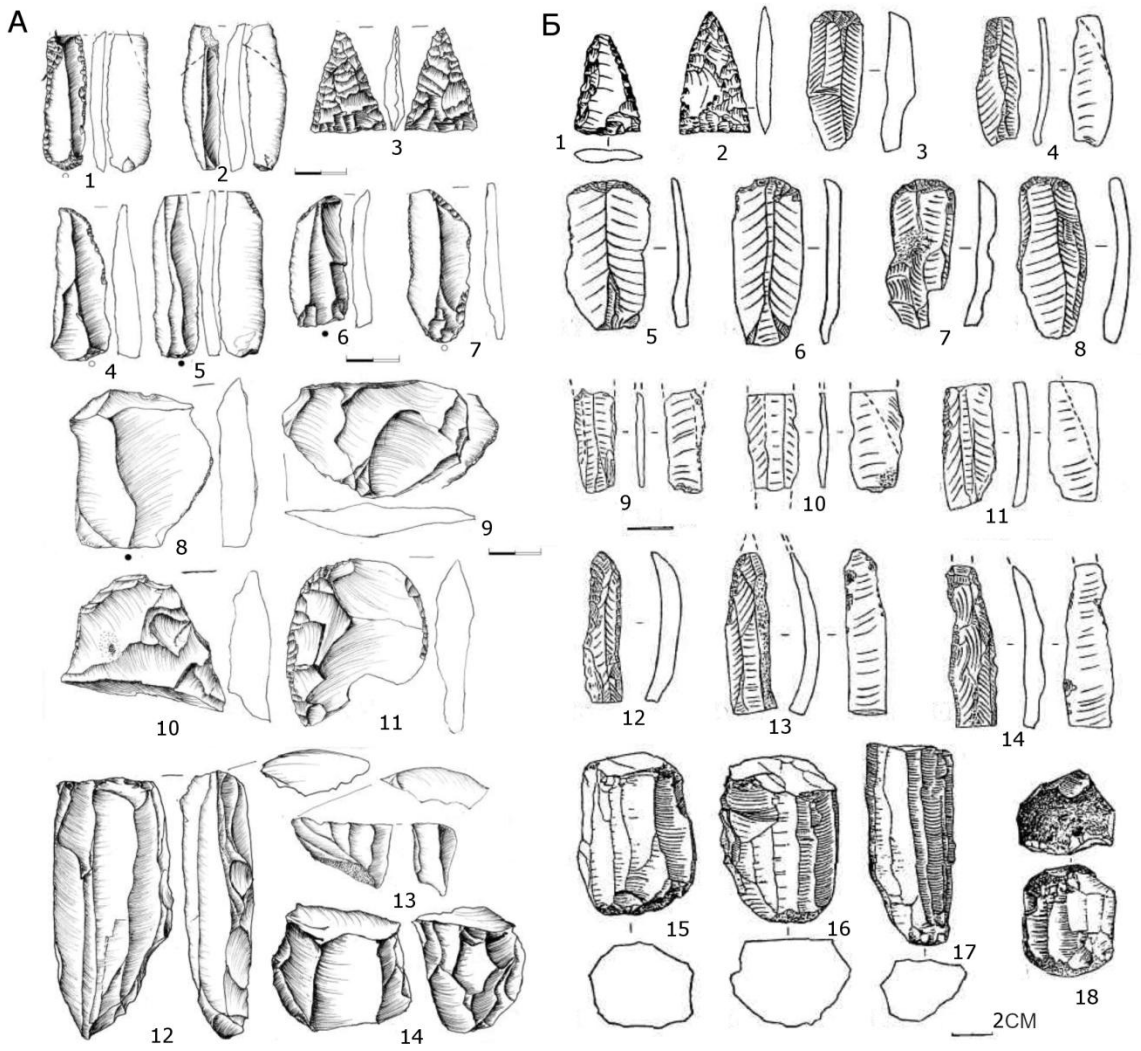

Figure 8. Modes of Trypillia B1 lithic industry by examples. A: the site of Ozheve-Ostriv 5; B: the site of Polyvaniv Yar. (After Popova 2003; Radomskyi 2015).
Figure 8. Exemples d'industries lithiques de Trypillia B1. A: site de Ozheve-Ostriv 5; B: site de Polyvaniv Yar (d'après Popova 2003; Radomskyi 2015).

The industry of the site is clearly blade-oriented, with most formal tools produced on blades, while non-retouched flakes out-number non-retouched blades. The assemblage from the site can be treated as a combination of extensive expedient knapping for immediate needs, production of serial blades, as well as exchange of some blades and tools.

The full cycle of knapping (Dibble 1987; Jelinek 1976; 1988) evidently took place at the settlements of Cuconeşti Vechi (Figure 1: CV and P; Figure 7) and Putineşti 2 (Sorochin 2002: 67). For example, at the settlement of Cuconeşti Vechi I, a large number of nuclei (86) and fragments of nuclei (more than 400) were found, as well as unprocessed flint nodules. Sites of primary processing were recorded in Putineşti 2 (Sorochin 2002: 68). The nuclei are represented by prismatic, conical and amorphous forms, with the first form predominating. A permanent component of the assemblages are spherical hammerstones and nuclei reused as hammerstones. Blades never outnumber flakes, but occur in varying proportions, making up from an eighth to a quarter of the collections. Most are wide and medium-wide blades (1.5-2.5 cm wide).

In this group, most of the tools were made on blades, while in the second group, in contrast, they were made on flakes (Figure 7 and 8). Since endscrapers predominate among

the tools, the question of the blade/flake industry largely comes down to which type of endscraper is more common - endscrapers on blades (Cuconesti Vechi I), or end/side scrapers on flakes (Ozheve-Ostriv, see Chernovol & Radomskyi 2015; Sorochin 2002: 67-69).

The proportion of endscrapers on flakes, as well as the high index of flakes at a particular site, were probably closely related to the presence of local raw material outcrops near the settlement and to its quality. However, some settlements (like Vasylivka and Sabatynivka 1, as well as some others yielding numerically insufficient collections) largely depended on the supply of finished blades and tools through the exchange system, regardless of the availability of local raw materials nearby.

4. Interpretations of the data

Thus, the dual pattern observed by L. Domboroczki and co-authors (2010) holds true for the three temporal horizons of neolithisation in the North-Western Pontic region. As described above, there are two types of sites among the sites of the Criş, LPC and Cucuteni A3 - Trypillia B1 in the region of study. Moreover, there are several other types of sites: blade-producing sites (like Ţâra and Polyvaniv Yar) and sites with both developed knapping on-site and notable shares of imported tools and blanks (similar to Kamyane-Zavallia).

Nevertheless, most lithic assemblages still fall within one of two main categories.

The first mode is characterized by the following features: 1. There is evidence of on-site knapping of low- and medium-quality raw material; 2. Debitage is oriented towards flakes, with detachment of some bladelets and small blades (up to 17 mm wide), and is carried out mainly by direct knapping, and less commonly probably with the aid of a punch or using chest pressure; 3. Flakes significantly out-number blades; 4. There was a high level of discard of flint-knapping debris on site; 5. Tools are not very numerous (up to 18-20%); 6. There is an elevated percentage of non-formal expedient tools: blades and flakes with irregular retouch; 7. Endscrapers, of side and end-side varieties, made from flakes dominate the toolkit; 8. Projectile points can take a geometric or geometric-like shape; 9. There is evidence of different utilisation of low- and medium-quality local silicites and high-quality imported raw materials, when these are present.

The second mode is characterized by the following features: 1. A notable part of the assemblage is made from high-quality imported raw material; 2. The aim of the knapping is the production of medium-wide and large blades (over 17 mm wide), with microblades and bladelets occurring in the assemblage, but in significantly lower proportions; 3. Blades constitute a significant share (20-40%) of assemblages; 4. There was a low rate of discard on site, so some parts of the assemblage were produced elsewhere; 5. The serial production of blades was mainly carried out using the punch technique; 6. The formal curated tools (perforators on blades and ‘long’ endscrapers, mostly) are represented by numerically significant series; 7. End scrapers on blades are the most common formal type of tools; 8. Projectile points are rare; 9. Some flake-based components produced using poor quality silicites are present. However, they were treated in a completely different way, similar to the technological set of mode 1. The blade-producing sites that lack blades constitute a systemic counter-part for consumer sites with an excess of blades in the framework of mode 2.

A number of standard explanations for variability of Stone Age lithic assemblages have been put forward, starting with the famous Bordes - Binford discussion (Bordes 1953; Binford & Binford 1966; Dibble 1987; Jelinek 1988). Namely, they are: 1. Availability of raw material; 2. Cultural differences between tool-makers; 3. Different economic functions of the compared assemblages. We will now consider each of these explanations in turn.

The difference between extensive and intensive modes of production (Rolland & Dibble 1990), depending on the availability of the raw material, immediately comes to mind when

dealing with modal differences in the Neolithic. However, it is not so easy to apply it in early farming contexts. First of all, early farmers had a supply network bringing the best possible silicites to their sites from hundreds of kilometers away (Zimmermann 1995). The existence of such a system largely smoothed the effects of raw material scarcity.

There are cases where imported flint was preferred over local raw materials despite the immediate availability of the latter. The site of Kamyane-Zavallia, described above, can be mentioned to exemplify this point (Kiosak 2019: 223-225), as well as the sites belonging to the Gumelniţa culture, east of the Prut River (Govedarica *et al.* 2017). These Gumelniţa local groups exploited mostly Dobrugean raw material not the local silicites from the alluvial beds of the Prut and Dniester. These examples indicate that, due to the existence of extensive logistic networks, Neolithic groups did not need to live in direct proximity to an outcrop. There are mode 2 sites situated in direct proximity to an outcrop (like this site of Vasylivka with its laminar industry in the Dniester valley). And *vice versa*, there are mode 1 sites situated at some distance from the closest outcrop - like the site of Nicolaevca 5. So, raw material availability alone does not explain the whole range of the observed variability.

The "unusual" Neolithic assemblages are often explained in terms of the incorporation of indigenous hunter-gatherers into Neolithic societies (Gronenborn 1997: 130-132; Mateiciucova 2008: 160-161; Nikitin *et al.* 2019). And in fact, it is quite often borderline sites that yield mode 1 lithic assemblages. However, the expected 'Mesolithic heritage' is often poorly defined: the similar products can result from different technologies and be included in different technological contexts. For example, Trypillian conical cores are very different technologically from pencil-like cores of the North Pontic Mesolithic (Gaskevych 2003).

If we consider only the final Mesolithic complexes, the range of possible parallels is significantly limited (Marchand & Perrin 2017). The preservation of Mesolithic cultural remnants is traditionally assumed for Neolithic cultures of Moldova and Ukraine on the basis of finds of regularly faceted (including pencil-shaped) nuclei for blades and microblades and trapezoidal geometric microliths (Dergachev & Dolukhanov 2007; Telegin *et al.* 2003; Zaliznyak 1998: 213-214 and 2020). At the same time, both types of artefacts are widely known in almost every Neolithic culture, and in each of them they are considered evidence of Mesolithic influence (Păunescu 1970; Țurcanu 2009). Both the pressure-flaking technique and geometric microliths are known in the Middle East, the distant origin point of most of the Neolithic cultures of south-eastern Europe, and they could have been brought to the Balkans as part of the "Neolithic package" (Binder 2008; Connolly 1999; Tringham 1971: 38-39; Zaliznyak 2006). Undoubtedly, they were part of the technological repertoire of the Criș-Starčevo, Dudeşti, Boian and LPC cultures. At least in the Carpathian-Dniester region there is no reason to suppose a new contact with the Mesolithic people in any of the Neolithic cultures with trapezes (Kiosak 2016). It is possible that the knowledge to produce geometric microliths came from the preceding Neolithic communities, rather than from surviving hunter-gatherer groups. Thus, simply put: LPC trapezes can be explained by trapezes of FTN, Trypillian trapezes by trapezes of LPC - and so on (Kiosak 2016; Kiosak *et al*. 2022).

Differences in the economic functions of the sites probably contributed to variations in their lithic industries (Binford & Binford 1966). The sites of the first mode often contain an elevated percentage of wild animal bones (Korobkova 1987: 192-193), thus indicating a somewhat different set of subsistence activities. However, it is unclear why the greater importance of hunting should entail an increase in the number of expedient tools, a high discard rate and differential use of raw material?

The nature of differences between modes is more structural and quantitative than qualitative. In general, the same types of products manufactured by the same set of techniques are found in different percentages. The phenomenon can be interpreted in many ways and, probably, no single explanation is enough for the multiplicity of historical conditions, under

which similar situations had developed. Here, we propose a concept of the complex social organization of knapping as an explanatory tool for the observed phenomenon. Chipped stone industry may have been organized in a variety of ways in the Neolithic: from supracommunal production in the exchange network to domestic household-level production, thus reflecting communities of practice of variable scale (Manolakakis 2005: 277-279; Perles 2001: 208-210; Roux & Pelegrin 1990). The synchronous or asynchronous changes in the inclusion of a given community within an exchange network could be responsible for a visible 'modular' variability between the lithic assemblages of the sites.

Ethnoarchaeological observations tend to attribute expedient, core-and-flake industries to sedentary groups (McCall 2012). Sedentism was proposed as an explanation for the expedient simplistic nature of ethnographic farmers' knapping (Parry & Kelly 1987). The sedentary way of life favored caching and re-use of the debris of previous knapping efforts. However, the early farmers of European Neolithic usually produced much more complex lithic industries. They were able to export knappable silicites and items made from them over hundreds of kilometres. New networks for the exchange of raw materials were established in the course of the further spread of early agricultural societies across Europe. For example, in the Adriatic Sea basin a high-quality flint mine on the Gargano Peninsula (Defensola) started operating almost simultaneously with the establishment of the first agricultural settlements nearby (Di Lernia *et al.* n.d.; Whitehouse 2014). And the carriers of the Impressed ware culture on the opposite side of the sea - in Dalmatia - made items from Gargano flint (Kačar 2019). The First Temperate Neolithic (FTN) spread overland through the interior of the Balkans. Its early phases are associated with flint complexes with a developed lamellar component, made from the same type of high-quality raw materials - the so-called "Balkan" flint (Gurova & Bonsall 2014; Gurova *et al.* 2016; 2022; Kozlowski 1989; Kozlowski & Nowak 2008). Similar observations were put forward regarding the LPC and Cucuteni-Trypillia.

Therefore, as a hypothesis, a social explanation for the changes can be assumed. The first mode corresponds to the use of local raw materials individually, for making tools within the household. The second mode can be interpreted as evidence of a more complex social organization of flint-working. The raw material arrives at the settlement already in tested form and possibly prepared for further work. Standard flint blanks are produced in series and then delivered to the consumer of the implements. It is characteristic that the production of other objects, which were widely manufactured and exchanged in the Neolithic-Eneolithic area of the Balkans and Central Europe, bifacial arrow- and dart- heads and flint axes with partial polishing (Klimscha 2007; 2010), is also documented. Thus, the second mode is the result of the fact that some flint-working was developed outside the household, and was related to a supracommunal exchange network.

This interpretational model is able to incorporate other proposed interpretations. And, in fact, technologies similar to the technological set of mobile hunter-gatherers should be expected in the framework of the mode 1 - and should be very rare in the mode 2 framework. Mode 1 knappers depended on personal expeditions to acquire raw material, which is why local varieties were actively exploited, while mode 2 sites were supplied with prepared items made of the best possible silicites. Hunting evidently played a more important role in 'frontier' situations within the freshly colonized landscape. This is why it is associated with mode 1 industries.

So, the mode of production depended on the inclusion of the knapper and his household within larger social structures, namely exchange networks. When this inclusion was limited ('frontier' situation, collapse of logistic networks, personal relation reasons, low position in network) it resulted in the development of mode 1 industries, while mode 2 is a result of the inclusion of the given household within a wider supply network. Thus, the sites of mode 2 require the existence of production sites lacking blades but rich in evidence of blade-

production. Such is the case for LPC (Ţâra 2). In Trypillia B1, the production loci are attested in some sites (Polyvaniv Yar 1, Cuconeşti Vechi 1; Popova 2003: 21-23; Sorochin 2002: 68) with the above-mentioned differences on the inter-site level.

5. Conclusions

The lithic industries of early farming communities existed in several "modes" - distinct technological expressions - in the North-Western Pontic region and, probably in some other regions of their distribution (Great Hungarian Plain, Lower Danube region etc.). Every early farming lithic assemblage can be treated as being composed of the products of these modes to varying degrees, depending on the current social organization of the lithic industry in the society in question. Mode 1 is an expression of domestic, expedient technology, employed by households attempting to satisfy their own needs. Mode 2 is an expression of extra-communal exchange of "curated" tools and blanks - and thus, it reflects the inclusion of a given community within an exchange network. When understood in this way, the lithic technology becomes a barometer of social change: phases of social integration are marked by laminar complexes made of "imported" raw material, while social disintegration results in flake/lamellar industries based on "local" raw materials.

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Data accessibility statement

The data that support the findings of this study will be available in Zenodo at DOI: 10.5281/zenodo.8151965

List of supplementary files

Supplementary file 1
"Kiosak - supplementary file 1 - fig2.xls"
The data for figure 2.

Supplementary file 2
"Kiosak - supplementary file 2 - fig3-4.xls"
The data for figures 3-4.

Supplementary file 3
"Kiosak - supplementary file 3 - fig6-7.xls"
The data for figures 6-7

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Modes de production des outils en pierre taillée : les premières sociétés agricoles de la région du Nord-Ouest de la Mer Noire

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Résumé:

Les assemblages de pierres taillées des premiers agriculteurs du sud de l'Europe de l'Est se présentent sous plusieurs formes. 1) Ils peuvent avoir une composante laminaire développée, avec des déchets de production sous-représentés et un pourcentage élevé d'objets retouchés (principalement des lames avec des retouches latérales et des grattoirs d'extrémité de lames), l'exploitation de matière première de bonne qualité, importée sur de longues distances. Ces assemblages sont généralement peu nombreux. 2) D'autres témoignent d'un ensemble technique dit « simplifié », marqué par l'importance des percuteurs durs, de nombreux déchets de production, et un pourcentage relativement faible d'outils, avec une majorité d'outils retouchés sur éclats (principalement des éclats retouchés et des grattoirs sur éclats), et enfin d'une exploitation d'un silex local de qualité moyenne. Ces assemblages sont relativement plus nombreux. Ces derniers, sont souvent expliqués par l'interaction avec une population locale de chasseurs-cueilleurs.

Une autre explication peut être recherchée dans la notion d'organisation sociale du travail de taille de la pierre. Les premiers agriculteurs ont pu développer un système complexe de travail du silex basé sur la spécialisation intra- et inter- communautaire et l'échange constant des lames et d'outils. Les complexes du premier type résultent de l'intégration d'un établissement dans un réseau d'échange. Les complexes du second type représentent la production domestique des ménages, qui satisfont à leurs besoins par eux-mêmes, de manière déconnectée du réseau d'échange. Ainsi, la taille du silex des premiers agriculteurs a existé selon deux modes : 1. le mode « domestique » et 2. le mode « d'échange ». Les sites du mode 2 nécessitent l'existence de sites de production dépourvus de lames mais riches en indices de production de lames. Le mode « échange » est un mode courant de production d'outils en pierre taillée dans les premières sociétés agricoles. Le mode « domestique » est courant dans les « situations de frontière », dans des conditions de néolithisation continue de nouveaux terrains. Chaque assemblage lithique des premières sociétés agricoles peut être considéré comme composé de produits de ces deux modes à des degrés divers.

Ce modèle est capable d'intégrer d'autres interprétations. En effet, des technologies similaires à celles des chasseurs-cueilleurs mobiles devraient être attendues dans le cadre du mode 1 - et devraient être très rares dans le cadre du mode 2. Les tailleurs du mode 1 dépendaient d'expéditions personnelles pour acquérir la matière première, ce qui explique pourquoi les variétés locales étaient activement exploitées, tandis que les sites du mode 2 étaient approvisionnés en produits préparés à partir des meilleures silicites possibles. La chasse a manifestement joué un rôle plus important dans les « situations de frontières » au

sein du paysage fraîchement colonisé. C'est pourquoi elle est associée aux industries du mode 1.

Ce modèle théorique est appliqué et affiné aux assemblages des trois horizons chronologiques du néolithique dans la région étudiée : Criş (5600-5400 BCE), la culture rubanée (5250-5050 BCE), et Trypillia B1 (4400-4100 BCE). Elle est mise en œuvre de manière différente dans chacun des cas étudiés, reflétant les particularités de l'organisation sociale des sociétés étudiées.

Mots clés: Néolithique; Criş ; Culture rubanée ; Trypillia B1 ; industrie lithique ; organisation sociale.