

Research Article

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A Glimpse at Raw Material Economy and Production of Chipped Stones at the Neolithic (Starčevo) Site of Svinjarička Čuka, South Serbia

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Abstract: In this contribution, we present new data from the multi-layered Starčevo site of Svinjarička Čuka in southern Serbia, highlighting its key role in reconstructing processes involved in the dispersal of the Neolithic way of life from Anatolia into Central Europe from the perspective of the chipped stone assemblage. This case study explores factors such as deliberate choices of raw material procurement and the occasional resilience to innovations shaped by local traditions resulting from the ease of access to specific resources versus openness to interconnectivity on a local, regional, and supra-regional scale. In-depth raw material and technological analyses of the chipped stone assemblage from Svinjarička Čuka, which were recovered from three out of altogether six Starčevo occupation phases dating to the middle of the sixth millennium calBC, provide insights into the development of early Neolithic resource management and socio-cultural and economic behavior. The results of our study can be regarded as a reflection of key mechanisms involved in the Neolithization of the central Balkans.

Keywords: Svinjarička Čuka, Neolithization, central Balkans, lithic raw materials, lithic technology, resource management

1 Introduction

This study was conducted within the framework of a collaborative effort between the Austrian Archaeological Institute of the Austrian Academy of Sciences (Vienna) and the independent Institute of Archaeology (Belgrade), striving to investigate all aspects relating to Neolithization processes within the central Balkans, the NEOTECH project. The Neolithization process commenced approximately between 6200 and 6000 BC in the Balkan region (e.g. Gronenborn et al., 2021; Haak et al., 2015; Hofmanová et al., 2016; Krauß et al., 2017; Marchi et al., 2022; Shennan, 2018; Stefanović et al., 2020; Whittle et al., 2002), marked by distinct regional patterns observed at notable sites such as Starčevo, Karanovo, and Amzabegovo (Garašanin, 1979; Gimbutas, 1976; Horejs et al., 2022, p. 257; Manson, 2008; Milošević, 1950; Naumov, 2015; Nikolov, 2007; Pavúk, 2014; Perić, 2001; Porčić et al., 2020a). Although ancient DNA and archaeological research have provided overarching insights into the general trajectories of Neolithization, our comprehension of the intricate social, cultural, and economic processes guiding these developments is still in its incipient stage (e.g., Mathieson et al., 2018; Porčić et al., 2020b; Vitezović, 2023).

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Figure 1: Location of Svinjarička Čuka in relation to other Early Neolithic settlements in the south Balkan region. Graphic: M. Börner, OeAI/OeAW.

Strategically located along one of the primary communication routes following the Axios–Vardar–Morava Rivers connecting the Aegean and Central Europe at a location rich in siliceous raw materials useful for chipped stone production, the site of Svinjarička Čuka in southern Serbia has been the focus of this endeavor and has been under excavation since 2018 (Figure 1). This multi-layered Neolithic site holds particular importance due to the wealth of archaeological data that has been collected thus far, shedding light on the complex socio-economic dynamics that shaped this transformative period during which important changes took place (Dietrich *et al.*, 2022; Horejs *et al.*, 2019, 2022, 2025).

The present study offers an initial overview of the lithic assemblage from Svinjarička Čuka, focusing on identifying broader trends in lithic raw material economy rather than offering a comprehensive technological analysis. Its primary objective is to explore the relationship between chipped stone production and the lithic raw materials employed by the Neolithic community. A more detailed technological study is currently in preparation and will follow in due course. Given this scope, the analytical framework and recording system (Figure 4) have been adapted to address specific questions concerning raw material procurement and use strategies.

Phase	Dates from Svinjarička Čuka	Trench S1	Trench N1
		Context	Context
NEO 1	ca. 5500 calBC	<i>no archaeological features present</i>	Using Horizons of the "Starčevo hut" (part of complex 1)
			Using Horizons associated with complex 1
			Layers outside of complex 1
NEO 2	ca. 5500 calBC	<i>no archaeological features present</i>	Floors beneath a large pit (complex 1)
NEO 3	ca. 5600 calBC	Using Horizons of the "Starčevo house" (complex 4)	Activity Zone (complex 3)
		Layers below the "Starčevo house"	Activity/using layers with depositions

Figure 2: Secured Neolithic archaeological contexts at Svinjarička Cuka from the different occupation phases NEO 1/NEO 2 and NEO 3 selected for detailed lithic analyses. Graphic: M. Brandl, OeAI/OeAW.

The scope of this paper is not to document all technological attributes in full detail but to contextualize and place lithic production within broader patterns of resource management. This investigation concentrates on a relatively brief yet informative segment of the site's overall occupation sequence, more precisely, the most recent part of the Starčevo horizon. Although temporally limited, this phase yields valuable insights into economic behavior related to lithic raw material exploitation. The findings presented here are considered preliminary and will serve as a foundation for comparative analysis once the full excavation sequence is completed. For the present study, two occupation phases were selected for detailed examination due to the availability of the most robust datasets. Earlier Starčevo occupation phases remain only partially excavated and are expected to provide additional information as the project progresses.

At Svinjarička Čuka, 5,379 chipped stone tools, with a total weight of just over 72 kg, have so far been recorded from six occupation phases dating between 6100 and 5500 cal BC. (Horejs et al., 2025, p. 1). Excavations were conducted using a systematic grid and unit system, and all excavated sediment was subjected to dry sieving. Additionally, flotation samples were taken from every unit, with complete flotation of all sediment from closed contexts and subsequent sorting of the heavy fraction (Horejs et al., 2019, p. 179). Archaeological features such as hearth installations and stone and burnt daub accumulations were defined as "complexes" when it became apparent that they structurally belonged together (e.g., house structures; Horejs et al., 2025, p. 5, Figure 4). The majority of all lithics was recovered from filling and leveling horizons, also containing chronologically mixed materials in the upper levels. Only those coming from secured archaeological contexts, attributed to the latest Starčevo phases from the site, NEO 1-3, dating to the middle of the 6th millennium cal. BCE, were used for this study. Secured contexts are defined as using horizons (UH) and stratigraphic units (SU) undisturbed by later intrusions, allowing for unambiguous assessments regarding the material culture. Based on these criteria, 2,189 lithics were selected for in-depth analyses from six stratigraphically distinct occupation phases dating to the Starčevo period identified at the end of the 2023 fieldwork season from two excavation trenches, S1 and N1, of which selected features of the phases NEO 1, NEO 2, and NEO 3 will be discussed in detail, which have already been published with their stratigraphy, styles of depositions, and radiocarbon dates (Horejs et al., 2022, pp. 266 Table 1 and 267, Figure 10).

From the most recent Neolithic phase, NEO 1 (for the dates, refer to Figure 2), a domestic structure comprising stamped clay floors associated with a rich accumulation of various artifacts (pottery, bones,

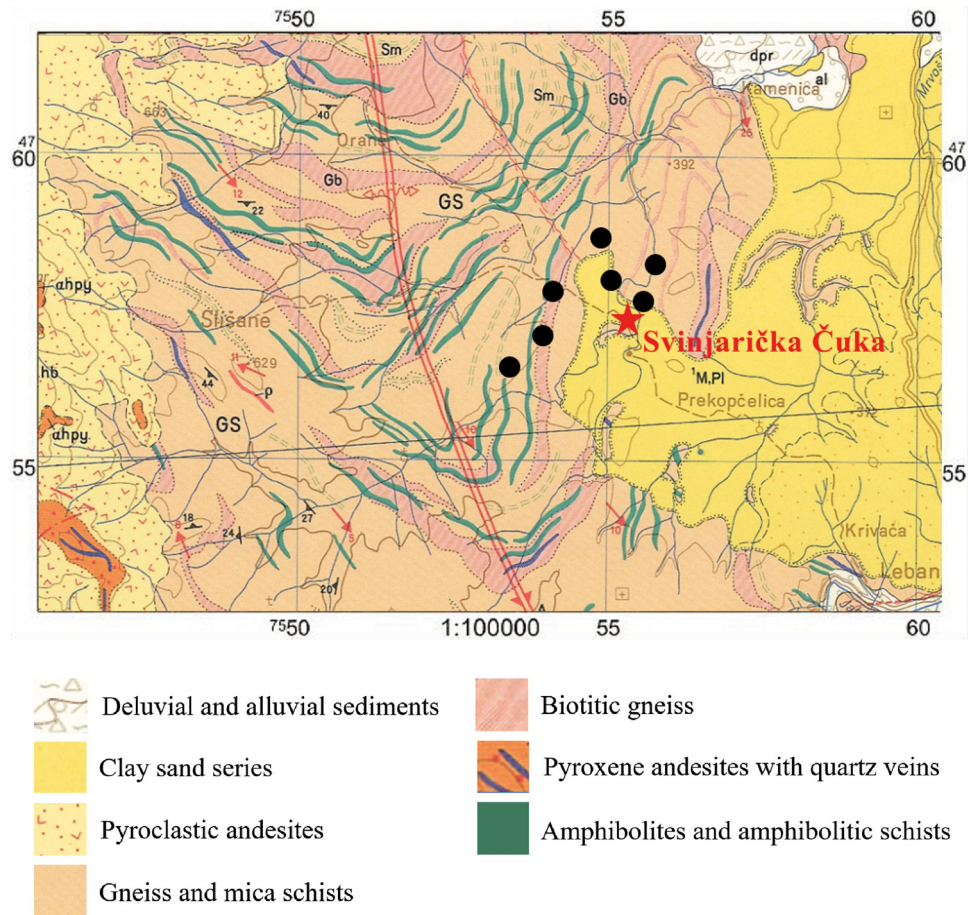


Figure 3: Secondary and residual deposits (black dots) of lithic raw materials for chipped stone production in the vicinity of S. Čuka. Adapted from the Geological Institute Beograd 1969, Leskovac 1:100.000. Graphic: M. Brandl, OeAI/OeAW.

and lithics) was identified and interpreted as a collapsed building best described as a hut. Several using horizons are associated with this “Starčevo hut,” which covers an inside space of ca. 2 m × 3 m. These using horizons extend also outside of the building. Radiocarbon data revealed an age of approximately 5500 cal BC for these late Starčevo features (Figure 2). NEO 2 is a large pit close to the hut feature at the bottom of which two using horizons (“floors”) were discovered, which are also included in this discussion. Chronologically, it is situated very close to the phase NEO 1, which is why we generally refer to the two main phases under discussion for the current study; however, we display the lithic assemblages individually for a better overview.

The occupation phase NEO 3 yielded radiocarbon dates calibrated to 5600 cal BC (Horejs *et al.*, 2022, pp. 26–268) and produced lithic artifacts suitable for further technological and raw material analyses. The archaeological features represent an extensively utilized domestic structure approximately covering an area of at least 7.50 m by 4.30 m and interpreted as the remains of a “Starčevo house,” revealing several using horizons with particular installations such as a hearth, a platform, and storage pits, and evidence of repeated phases of restoration (Horejs *et al.*, 2022) (Figure 2).

2 Materials and Methods

The dominating raw material type found within the chipped stone assemblage from Svinjarička Čuka is Neogene chert formed under lacustrine (i.e., freshwater) conditions.

Raw material	Provenance	Fire influence	% nat. surface remains	weight in g	Technological categories	
					raw/ unworked	core types - mod. tool types
					tested	
					tested - cores	flake core
						blade core
						flake + blade core
						bipolar core
						burin style core
						core on flake
						core on debris
						core fragment
					debitage	blade/let used
						blade/let unret sickle gloss
						blade/let ret sickle gloss
						blade/let ret tool
						flake used
						flake unret sickle gloss
						flake ret sickle gloss
						flake ret tool
						flake burin
						flake piece esquillee
					chipping debris	debris used
					fire debris	debris ret tool
					minideb >15 mm	

Figure 4: Recording system for assessing the main categories of the lithic assemblage. Graphic: M. Brandl, OeAI/OeAW.

Technology		Raw material provenance								
Debitage	Used / ret. tools	LOCAL			NON LOCAL			INDET	INDET BURNT	
		Chert local (NLS)	Jasper	Quartz	"Balkan Flint"	Obsidian	Clear quartz	Other chert varieties	Chert	Raw material indet
raw/ unworked		10	1	0	0	0	0	0	0	0
tested		62	3	2	0	0	0	2	0	0
pre-prep / precore		9	1	0	0	0	0	0	0	0
core		191	7	11	1	0	1	33	0	1
blade unused/unret		142	2	7	3	0	0	20	1	4
	blade tool	142	1	0	30	0	2	41	3	8
bladelet unused/unret		7	0	1	0	2	0	3	0	0
	bladelet tool	5	0	0	0	0	0	1	0	0
flake unused/unret		1763	18	152	3	1	4	131	14	14
	flake tool	190	3	10	1	0	1	34	0	2
debris unused/unret		2069	51	7	0	0	0	14	6	8
	debris tool	15	2	0	0	0	0	0	0	0
minideb >15 mm		95	0	1	0	1	0	9	0	0
ALL lithics count		4700	89	191	38	4	8	288	24	37
wgt in g		64447.63	2199.73	2697.63	111.54	0.43	12.55	2619.16	101.11	132.41

Figure 5: Raw materials and technology within the overall lithic assemblage from Neolithic Svinjarička Čuka. Graphic: M. Brandl, OeAI/OeAW.

Phase	NEO 1			NEO 2			NEO 3		
Raw Materials	No. Lithics	% in assemblage	Weight in g	No. Lithics	% in assemblage	Weight in g	No. Lithics	% in assemblage	Weight in g
Neogene chert local	611	92	5714.67	127	93	992.3	1227	89	15111.97
Jasper local	3	0.4	110.6	1	0.7	2.3	15	1	327.4
Quartz local	26	4	332.49	5	4	13.1	65	5	909.78
Neogene chert prov. indet.	14	2	87.27	2	1	4.35	52	4	369
Clear quartz prov. indet.	2	0.2	3.59	0	0	0	3	0.2	6.86
"Balkan Flint"	2	0.2	3.86	1	0.7	1.45	6	0.4	14.5
Other chert indet.	1	0.1	4.2	0	0	0	4	0.2	40.3
Obsidian	0	0	0	1	0.7	0.2	2	0.1	0.17
Neogene chert burnt prov. indet.	5	1	12.74	0	0	0	2	0.1	8.84
Indet. burnt	2	0.1	11.6	0	0	0	11	0.6	36.34
ALL	667	100	6281.02	137	100	1013.7	1387	100	16825.16

Figure 6: All lithic raw materials from Starčevo phases NEO 1 – NEO 3 determined within the assemblage. Graphic: M. Brandl, OeAI/OeAW.

The site and geological study area are located within the Neogene Niš-Dobrič and Leskovac Basin complexes and positioned between the Carpatho–Balkanides to the east and the Serbo-Macedonian Massif to the west and south. These basins, shaped by complex Neoalpine tectonics, were sites of significant subsidence from the Oligocene–Carpathian through the Late Pleistocene. During the Early to Middle Miocene, the Serbian Lake System developed across this region, initiating lacustrine sedimentation. Within this setting, prolonged volcanic and hydrothermal activity in the broader catchment led to the silicification of freshwater limestones, resulting in the formation of Neogene Lacustrine Silicites (NLS; Brandl & Hauzenberger, 2018, p. 59). These cryptocrystalline silica deposits, including hydrothermally formed chalcedonies and jaspers, are found in residual deposits along basin margins and within alluvial fills (Dimitrijević, 1997; Obradović & Goričan, 1988; Pavlović *et al.*, 2012, pp. 349–350; Sant *et al.*, 2017). Based on this geological information, we systematically surveyed the catchment area of the site for suitable lithic raw material deposits (Figure 3).

The terminology employed in our study adheres to the classification system introduced by Brandl (2014) and Brandl and Hauzenberger (2018). However, different definitions for these raw material varieties exist in the archaeological literature, especially in Eastern European countries, where terms like “limnic quartzite” or

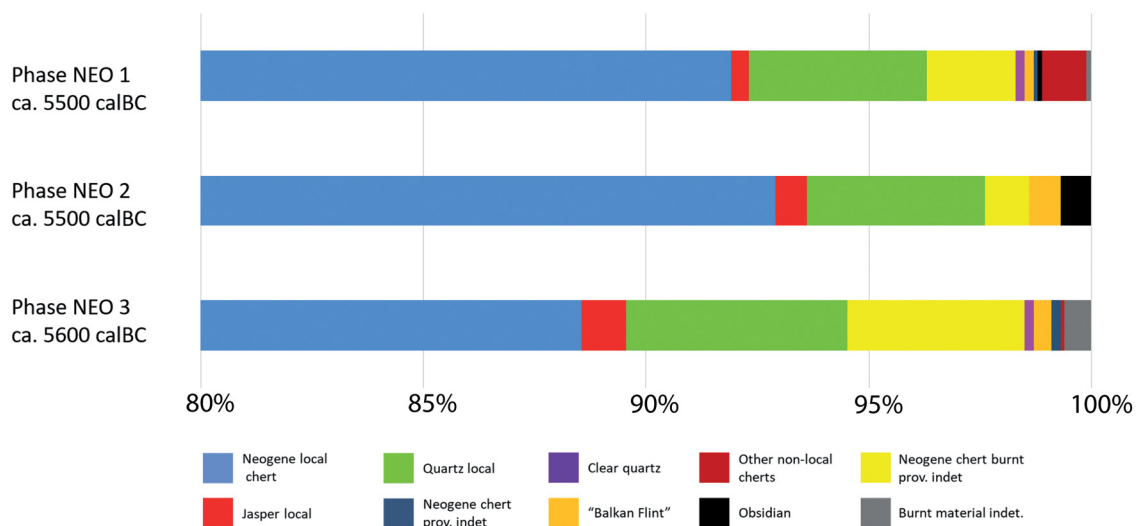


Figure 7: Diachronic overview of the lithic raw material distribution in the analyzed Starčevo contexts. Graphic: M. Brandl, OeAI/OeAW.

(a)

Phase	NEO 1 ca. 5500 calBC						NEO 2 ca. 5500 cal BC	
Context	Using Horizons of the "Starčevo hut" (part of complex 1)		Using Horizons associated with complex 1		Layers outside of complex 1		Floors under large pit (complex 1)	
Raw Materials	No. Lithics	Weight in g	No. Lithics	Weight in g	No. Lithics	Weight in g	No. Lithics	Weight in g
Neogene chert local	187	1581.75	378	3693.07	46	439.85	127	992.3
Jasper local			3	110.6			1	2.3
Quartz local	13	256.65	10	48.94	3	26.9	5	13.1
Neogene chert prov indet								
Clear quartz prov indet			1	0.7	1	2.89		
"Balkan Flint"	1	3.4			1	0.46	1	1.45
Other chert indet	2	9.1	6	13.29	7	69.08	2	4.35
Obsidian							1	0.2
Neogene chert burnt prov indet					5	12.74		
Indet burnt	2	11.6						
TOTAL	205	1862.5	398	3866.6	63	551.92	137	1013.7

(b)

Phase	NEO 3 ca. 5600 cal BC							
Context	Using Horizons of the "Starčevo house" (complex 4)		Activity Zone complex 3		Layers below the "Starčevo house"		Activity/using layers with depositions	
Raw Materials	No. Lithics	Weight in g	No. Lithics	Weight in g	No. Lithics	Weight in g	No. Lithics	Weight in g
Neogene chert local	812	9372.7	270	3797.04	35	966.78	110	975.45
Jasper local	12	240.45	2	84.85			1	2.1
Quartz local	35	442.49	22	322.99	1	46.9	7	97.4
Neogene chert prov indet	13	24.62	32	268.05	1	63.28	6	13.05
Clear quartz prov indet	2	5.4	1	1.46				
"Balkan Flint"	4	10.2	1	1.2			1	3.1
Other chert indet	2	0.3	2	32				
Obsidian	2	0.17						
Neogene chert burnt prov indet					1	6.89	1	1.95
Indet burnt	5	8.94	5	24.7			1	2.7
TOTAL	887	10105.27	335	4532.29	38	1083.85	127	1095.75

Figure 8: (a) Detailed analytical results from phases NEO 1 and NEO 2. Graphic: M. Brandl, OeAI/OeAW. (b) Detailed analytical results from phase NEO 3. Graphic: M. Brandl, OeAI/OeAW.

(a)

NEO 1 ca. 5500 calBC	Technology		Raw material provenance								
	Debitage	Used / ret. tools	LOCAL			NON LOCAL			INDET	INDET BURNT	
			Chert	Jasper	Quartz	"Balkan Flint"	Obsidian	Clear quartz	Other chert varieties	Chert	Raw material indet
	raw/ unworked		1								
	tested		5		1						
	pre-prep / precore		1								
	core		28		3				2		
	blade unused/unret		13		1				1		
		blade tool	13	1		2			3		
	bladelet unused/unret		3						1		
		bladelet tool	2								
	flake unused/unret		164		19			1	8	3	1
	flake tool	19		1			1				
debris unused/unret		341	2	1					2	1	
	debris tool	2									
minideb >15 mm		19									
ALL lithics count		611	3	26	2		2	15	5	2	
wgt in g		5714.67	110.6	332.49	3.86		3.59	91.47	12.74	11.6	

(b)

NEO 2 ca. 5500 cal BC	Technology		Raw material provenance								
	Debitage	Used / ret. tools	LOCAL			NON LOCAL			INDET	INDET BURNT	
			Chert	Jasper	Quartz	"Balkan Flint"	Obsidian	Clear quartz	Other chert varieties	Chert	Raw material indet
	raw/ unworked										
	tested										
	pre-prep / precore										
	core		5								
	blade unused/unret		4								
		blade tool	4			1		2			
	bladelet unused/unret						1				
	bladelet tool										
flake unused/unret		44	1	2							
	flake tool	5									
debris unused/unret		62		3							
	debris tool										
minideb >15 mm		3									
ALL lithics count		127	1	5	1	1		2			
wgt in g		992.3	2.3	13.1	1.45	0.2		4.35			

(c)

NEO 3 ca. 5600 cal BC	Technology		Raw material provenance								
	Debitage	Used / ret. tools	LOCAL			NON LOCAL			INDET	INDET BURNT	
			Chert	Jasper	Quartz	"Balkan Flint"	Obsidian	Clear quartz	Other chert varieties	Chert	Raw material indet
	raw/ unworked		4								
	tested		10		1				1		
	pre-prep / precore		2	1							
	core		46	3	4			1	4		
	blade unused/unret		47	1	2	1			6		1
		blade tool	37			3		1	8	1	1
	bladelet unused/unret		2				2				
		bladelet tool	1								
	flake unused/unret		410	2	51	2		1	18	1	5
	flake tool	50		4				8		1	
debris unused/unret		588	8	3				4		3	
	debris tool	3									
minideb >15 mm		27						7			
ALL lithics count		1227	15	65	6	2	3	56	2	11	
wgt in g		15111.97	327.4	909.78	14.5	0.17	6.86	409.3	8.84	36.34	

Figure 9: (a) The relationship between raw materials and techno-typological categories in NEO 1. Graphic: M. Brandl, OeAI/OeAW. (b) The relationship between raw materials and techno-typological categories in NEO 2. Graphic: M. Brandl, OeAI/OeAW. (c) The relationship between raw materials and techno-typological categories in NEO 3. Graphic: M. Brandl, OeAI/OeAW.

Tool type	Raw material	NEO 1				NEO 2				NEO 3			
		blank type				blank type				blank type			
		blade	bladelet	flake	debris	blade	bladelet	flake	debris	blade	bladelet	flake	debris
lateral retouch	chert local	2		6	2	2		2		7		14	
	quartz local											1	
	chert prov. indet.	1				1				3			
	clear quartz prov. indet.									1			
	indet. burnt									1		1	
unretouched used	chert local	3	2	6		1		2		15	1	11	
	jasper local	1											
	Balkan Flint	2								1			
	chert prov. indet.	2								2		7	
retouched with gloss	chert local	2				1				5		4	
	chert prov. indet.									2			
	Balkan Flint					1				1			
unret. with gloss	chert local	1								4			
	Balkan Flint									1			
	chert prov. indet.									1			
endscraper	chert local			1				1		2		9	3
	Balkan Flint					1							
truncated	chert local	3		2								4	
	chert prov. indet.											1	
	clear quartz prov. indet.			1									
notched tool	chert local			1								3	
	quartz local											2	
drill	chert local	2								3		2	
	quartz local			1									
pointed tool	chert local			1						1			
	quartz local											1	
microscraper	chert local			1								1	
burin	chert burnt prov. indet.									1		1	
ret. minidebitage	chert local			1								1	
TOTAL No. lithics		19	2	21	2	7		5		51	1	63	3

Figure 10: Tool types in relation to raw materials, comparing contexts NEO 1, 2, and 3. Graphic: M. Brandl, OeAI/OeAW.

“hydroquartzite” are used, implying an origin from freshwater environments (i.e., limnic/lacustrine). However, this terminology can be misleading, as the term “quartzite” traditionally applies exclusively to clastic (ortho-) or metamorphic (metaquartzite) rocks. A more neutral classification suggestion is to use the term “perivolcanic limnic silcrete” (silcrete being silica-cemented sediment). Given that this specific sedimentary siliceous rock type frequently contains microfossil inclusions, it can also be classified as “silicite.” To encompass these materials, particularly of Neogene age, the proposed inclusive term is “Neogene Lacustrine Silicites” (NLS). They can be further subdivided into clearly fossiliferous types and NLS with heavily dissolved fossil inclusions or entirely lacking fossils (e.g., Biró 2010; Brandl & Hauzenberger 2018, pp. 56–57; Přichystal 2010, p. 178; Ullyott et al., 2004).

For lithic raw material analysis, stereomicroscopic microfacies analysis was employed. This is a versatile technique applicable to all organogenic lithic materials, focusing on identifying characteristics such as microstructure – comprising size, shape, and spatial arrangement of rock-building components – and bioclasts as well as inorganic inclusions. Combined, the results of the microscopic examination reveal crucial information regarding specific formation environments, i.e., the microfacies, of siliceous rocks. Using this information helps narrow down the potential source region of the materials.

The main goal of the study was a clear identification and preliminary assessment of the potential origin of particular elements within Svinjarička Čuka’s lithic assemblage. At this stage of the project, it was sufficient to investigate every individual lithic find via stereomicroscopic microfacies analysis to identify the main raw material types and achieve a differentiation between local and non-local resources for litho-economic considerations.

Once the geological origin (i.e., in this case, local versus non-local) of the raw materials used for chipped stone production was established, technological analyses were performed as the second component of the investigation of the lithic economy. Technological investigations follow the chaîne opératoire concept to capture the full sequence of production stages from the raw, unworked nodule to the finished (and discarded) end products. The entire assemblage was recorded using a standardized system specifically designed for the lithic assemblage under investigation, as illustrated in Figure 4.

Beyond the general technological classification applied to the entire assemblage (as presented in the figure above) primarily used in this paper, a more detailed technological characterization was conducted on a

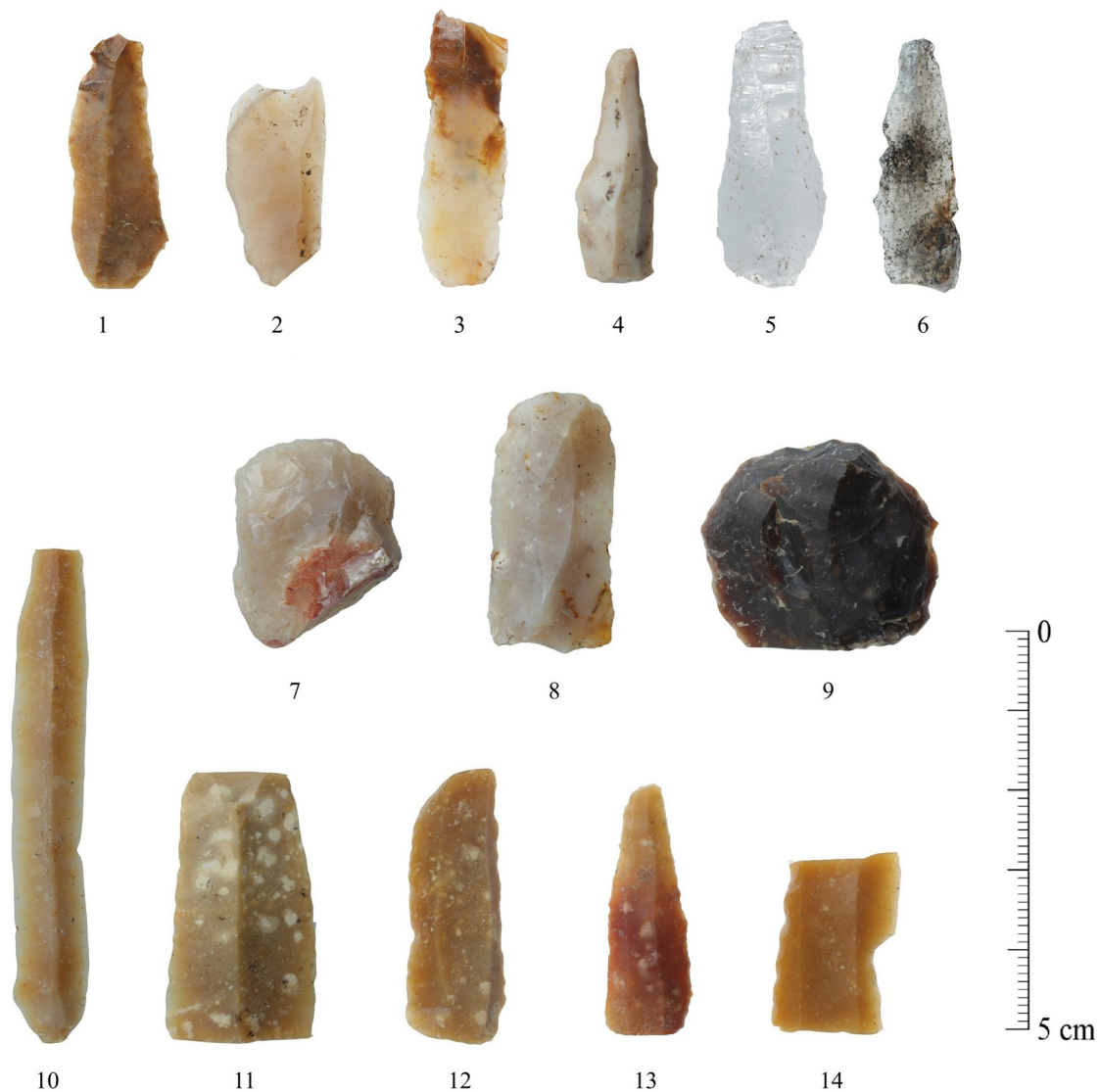


Figure 11: Tool type and raw material variety selection (retouched and used blanks) from the phases NEO 1 (artifacts nos. 2 and 4), NEO 2 (nos. 6, 9, 10, 13, and 14), and NEO 3 (nos. 1, 3, 5, 7, 8, 11, and 12). 1-Glossed (sickle) bladelet (NLS local); 2-laterally retouched (backed) blade (NLS local); 3-glossed (sickle) bladelet (NLS local); 4-drill (NLS prov. indet.); 5-used blade (clear quartz); 6-glossed (sickle) bladelet (NLS prov. indet.); 7-endscraper on flake (NLS local); 8-endscraper on blade (NLS local); 9-end/round-scraper (NLS local); 10-used bladelet (Balkan Flint); 11-aterally retouched blade (Balkan Flint); 12-laterally retouched blade (Balkan Flint); 13-endscraper on blade (laterally retouched) (Balkan Flint); 14-glossed (sickle) blade (Balkan Flint). Photos: F. Ostmann – B. Milić, OeAI/OeAW.

selected sample, focusing on five main categories within the core reduction sequence: cores, core preparation and rejuvenation elements, blades,¹ flakes,² and debris³ (mainly used from the methodology developed in Milić, 2018). Characteristic features on cores and blanks (flakes and blades) were used to assess

1 Defined by parallel or nearly parallel sides and at least double the length of the width. Blades with a width of less than 10 mm were defined as bladelets.

2 Every kind of debitage displaying clear knapping features and with clearly identifiable platforms and dorsal scar patterns (i.e. the piece can be clearly placed into the core reduction sequence with known proximal – distal and dorsal – ventral orientation) except blades (see above) were defined as “flakes.”

3 “Debris” defines all products of the reduction sequence which are undiagnostic debitage (e.g. shatter and waste) not attributed to the specific reduction stages.

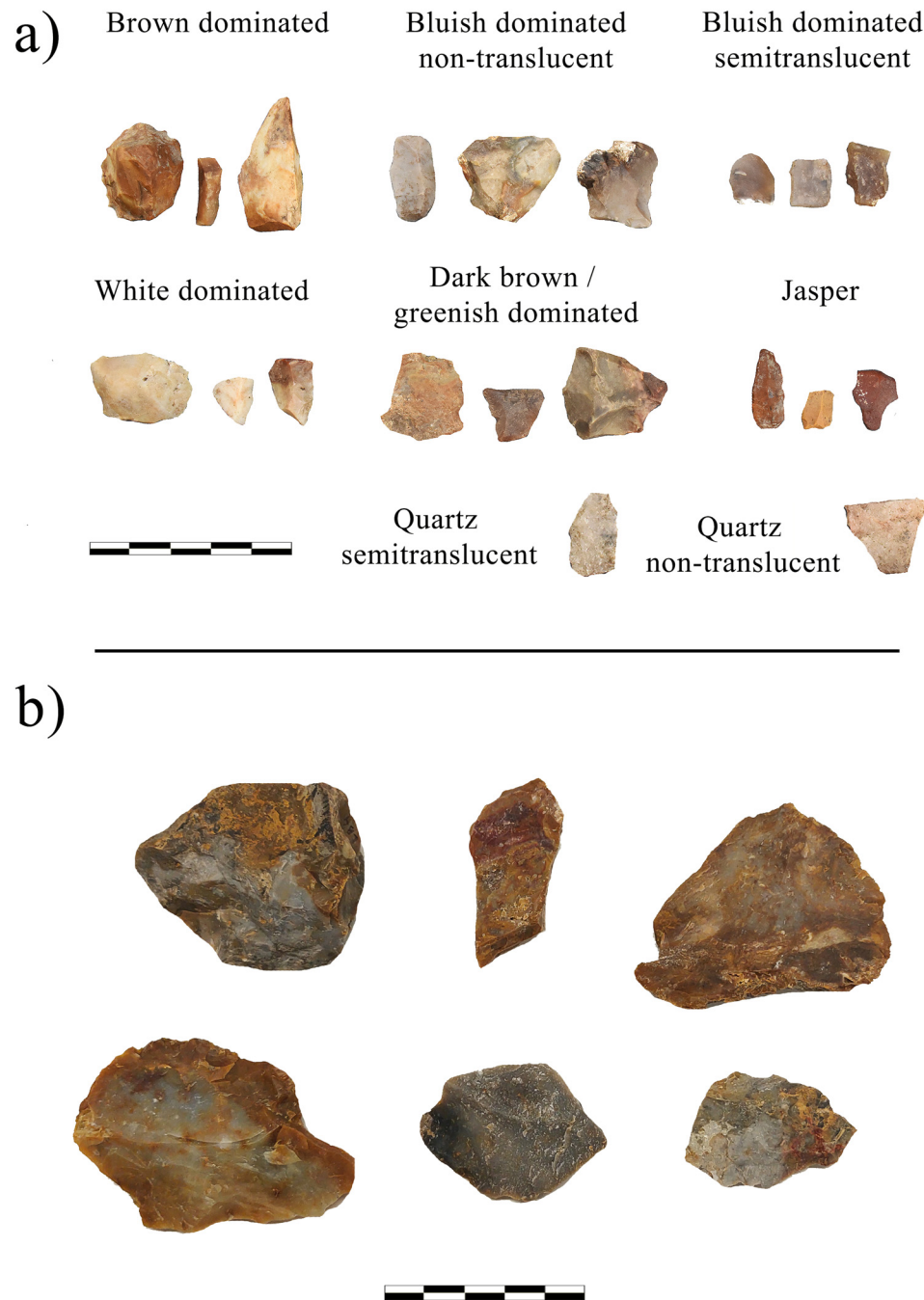


Figure 12: (a) Local raw material varieties from the lithic assemblage of Svinjarička Čuka; (b) lithic raw materials (NLS) from the deposit S. Čuka is situated on. Photos: F. Ostmann – M. Brandl, OeAI/OeAW.

particular knapping techniques, such as direct hard or soft percussion, indirect percussion or punch technique, and finally pressure flaking. The examination of secondary modifications of blanks involves a comprehensive exploration of retouch patterns, including their position and type, and traces of use, studied at both macroscopic and microscopic levels. Targeted analysis in this paper therefore aimed to highlight principal technological tendencies within specific phases and was not intended to represent the full assemblage. A broader, statistically supported technological study will be addressed in a separate publication.



Figure 13: NLS Specimen from the lithic raw material deposit at S. Čuka with macroscopically visible remains (i.e. stems) of charophyta (freshwater algae). Photo: M. Brandl, OeAI/OeAW.

3 Results

Based on systematic geo-archaeological surveys and a geochemical pilot study (Brandl & Hauzenberger, 2018), it was possible to securely identify the local components of the lithic assemblage and distinguish it from the certainly non-local elements. In this regard, we will discuss the results of our study through two analytical lenses: a general overviewing perspective and the viewpoint of in-depth investigations using only specific components, which allow for further interpretations.

3.1 The Complete Assemblage – An Overview

Although we will only use selected elements of the assemblage from Svinjarička Čuka for detailed raw material and technological assessments, all lithics from the site pre-dating the Bronze Age, regardless of the specific context, were recorded. A brief overview is provided here to demonstrate the overall composition of the lithic industry, especially signifying the relation between particular raw material types with different origins and tool categories.

As shown in Figure 5, the assemblage is dominated by local materials, above all chert (NLS), which is available directly at the archaeological site and the immediate catchment area (Figures 3 and 12–14). In fact, the site is located on a river terrace containing abundant chert cobbles. This favorable situation might have been one of the reasons for the choice of the settlement location, besides the availability of water and arable land. Quartz and jasper are the next most common materials. Both are also locally available from gravels of the Svinjarica River, on which the site is located, as well as from surface deposits in the close vicinity (within a distance between 100 m and 5 km). While quartz may have been deliberately selected to perform specific tasks due to its durability (mainly the production of flakes), the local jasper varieties are of minor quality and were probably collected in the course of the procurement of NLS. The fact that both lithic material types can be found within the same secondary and residual deposits in the close catchment area of Svinjarička Čuka also speaks in favor of this interpretation.

Non-local raw materials are predominantly represented by various types of “Balkan Flint,” which include the Kriva Reka and other not yet identified varieties,⁴ and are characterized by a high degree of standardization of the implements. Clear quartz is also evident in very low numbers. Obsidian was also identified in the assemblage, so far only in the later phases of the occupation. It is represented by one bladelet proximal fragment, two micro-blades, and a mini debitage. Based on color and translucency, a Carpathian source is likely, although this still requires confirmation through pXRF analysis. Furthermore, less common chert varieties of yet undetermined origin, which are not part of the local chert types found in the deposits within a radius of ca. 20 km around the site, are also present. Indeterminable pieces, mainly due to heavy fire influence,⁵ do occur; however, they are not very frequent.

The dominant knapping technique in the assemblage is hard direct percussion, applied to cores with minimal or no platform preparation. Hard stone percussion is also evident from the typical features observed on the ventral sides of blanks, both flakes and blades. However, based on the technological attributes observed in the blade and bladelet assemblage from various early to late Starčevo occupation phases, it is clear that multiple techniques were employed, including soft direct percussion and indirect percussion (punch technique). Pressure blade making may also have been used, although its presence and origin, whether local or introduced, remain to be confirmed. Overall, the assemblage reflects a predominantly flake-based technology; however, although the number of blades seems disproportionately low, the ratio of modified blades and flakes appears to be roughly equivalent (Figure 5). This trend, however, applies only to the general comparison and differs significantly across particular raw material categories. For example, Balkan Flint is almost exclusively used for blades. These include glossed pieces, the majority of which are sickle implements used in cereal harvesting, as well as laterally retouched blades, often showing signs of resharpening, and occasional end-scrapers on blades. In contrast, the high amount of local raw materials, for which all stages of the reduction process from decortification flakes to finished and discarded products are present, clearly attests to chipped stone tool production on-site. Many blanks, especially flakes, seem to have been used in a highly opportunistic manner, while the number of retouched tools such as endscrapers, truncated pieces, or pieces with a regular lateral are relatively scarce (Figure 5).

3.2 The Later Starčevo Assemblage (5600–5500 cal BC)

As initially outlined, altogether six Neolithic occupation phases were recognized at Svinjarička Čuka, spanning a sequence between 6100 and 5500 cal BC and representing different subphases associated with Starčevo horizons, which were stratigraphically analyzed and radiocarbon dated. However, only the phases NEO 1 and NEO 3 are fully excavated and analyzed, which is the reason why our in-depth lithic analysis will only focus on the assemblages from these two contexts and discuss the findings based on this chronological division from a diachronic perspective.

An overview of all lithic raw materials determined within Starčevo phases NEO 1/NEO 2 and NEO 3 is provided in Figure 6. As indicated in the general overview at the beginning of this section, local Neogene chert (NLS) remains the predominant identified raw material type. The other two local elements – quartz and jasper – follow the same pattern as observed for the overall collection. A clear difference when compared to the full assemblage is the significantly lower number of Balkan Flint artifacts. This is the result of the nature of the selected archaeological contexts we analyzed, since most BF specimens are contained in mixed layers. The number of burnt lithics is also very low (Figure 6).

⁴ While most of the BF materials in the assemblage resemble the Kriva Reka type, a detailed typological and technological analysis is beyond the scope of the present study and will be addressed in future research. The current focus lies in distinguishing between locally sourced and non-local components within the lithic assemblage.

⁵ Mainly color change, cracks and sometimes thermoclastic detachments.

The proportional distribution of all raw materials from the selected contexts of NEO 1/NEO 2 and NEO 3 is visualized in Figure 7 and normalized to 100%.

Delving deeper into the individual contexts we investigated (i.e., only using horizons and undisturbed stratigraphic units), it becomes apparent that the feature interpreted as a hut dating to the late Starčevo phase NEO 1 (ca. 5500 cal BC) produced 666 lithic artifacts, while the Starčevo house of phase NEO 3 belonging to an older occupation stage (ca. 5600 cal BC) contained over 800 specimens (Figure 8a and b). This, however, is simply an effect of the size of these buildings and their intensity of use and does not indicate a change in the lithic economic behavior of the inhabitants. The distribution pattern of all raw material varieties in both phases follows the general trends that are visible from these domestic as well as outside (open space) areas.

Combining the lithic raw material data with the technological information, the diachronic comparison between the NEO 1/NEO 2 and NEO 3 Starčevo contexts shows a homogeneous picture of raw material use for specific tool types, indicating no major changes in raw material procurement and production (Figure 9a–c). There are, however, certain subtle but noteworthy differences.

The NEO 3 Starčevo assemblage, depicted in Figure 9c, yielded three obsidian pieces, two in the form of mini-debitage (smaller than 10 mm in length), and one micro-blade from the Starčevo house context. They were most likely linked to on-site activities and may reflect the full or supplementary reduction of introduced blanks or cores originating from long-distance exchange networks. Six Balkan flints come from the same context, with three pieces representing blade tools (two of which are shown on Figure 11: no. 11, 12), one unretouched blade, and two flakes. This indicates the potential working of rare exogenous materials within the domestic space of the site itself. While it remains to be clarified whether Balkan Flint was additionally knapped on-site beyond tool maintenance, the frequent reparation and resharpening of blades made from this material strongly suggests repeated cycles of use and reuse within the settlement after the introduction of blade blanks or initially retouched blade tools. This is visible both macroscopically and microscopically, as seen in edge modifications and the type and position of retouch, pointing to potentially specialized activities and undoubtedly the value of the material. The NEO 3 Starčevo assemblage reveals a higher diversity of chert varieties compared to the later phase (NEO 1 and NEO 2). Caution is warranted, however, as this pattern may partly reflect the overall higher number of lithics in the earlier phase.

From a technological viewpoint, no major differences were observed throughout all the assemblages retrieved from the investigated phases. The primary technological strategy of the late Starčevo assemblage of NEO 1/NEO 2 relates to the production of flakes, mainly from uncurated uni- and multidirectional cores. Hard hammer percussion is the dominating production method within this assemblage. Some cores show both blade and flake negatives, likely reflecting the final stages of blade core exploitation, where remaining volumes were used to produce small flakes – particularly when the raw material was of suitable quality. Additionally, the presence of burin-style cores, bipolar anvil cores, and some cores on flakes indicates that high-quality raw materials, which are not very common amongst the local raw material spectrum, were heavily exploited, and old pieces were recycled. This is well observed in NEO 2, for instance, particularly in the context of the Neolithic house. Blade production predominantly relies on the high-quality end of the local raw material spectrum, Balkan Flint, and yet unprovenanced non-local high-quality chert types. The few bladelets (altogether 5) were predominantly made from local chert (Figure 9c).

Both flakes and blades were modified, while bladelets show use in two cases but no retouching. The proportion of retouched blades in relation to flakes is exceedingly higher, with 52% modified tools of blades and 10% of flakes. In the late Starčevo NEO 1/NEO 2 assemblage, 56 modified tools were documented (Figure 8). Of those, lateral retouching is most commonly observed at both blade and flake blanks, only surpassed by pieces that show use traces (macroscopic edge scaling different from damage) without being previously retouched. Within the laterally retouched and used pieces, only a few display gloss (Figure 10) from use as sickle implements. This is also in line with the observation that, except for one, all of the sickle elements are blades (i.e., segmented pieces). Other retouched tool types are scarce in the assemblage and comprise only a few endscrapers, truncated and notched pieces, and rare drills.

Technological traits of the NEO 3 Starčevo assemblage illustrate a basic core reduction strategy, mainly aiming at the production of flakes varying in size and shape from uni- and multidirectional cores. For this technological string, predominantly local materials, mainly NLS, were employed. Regular blade production is

attested to a far lesser degree from either mixed flake-blade cores or more carefully curated and maintained small cores of high-quality raw materials of either local origin or from “Balkan Flint” *sensu lato*, also one particular white non-translucent chert of yet unknown origin. Both flakes and blades were targeted products, as indicated by the frequency of retouched tools from both categories. Within this generally expedient technology, hard hammer percussion represents the most common production technique, with some indications of soft hammer percussion suggested by the flake scar patterns on cores and features on the debitage.

Recycling is also attested by a number of exhausted cores ($n = 15$) that had often undergone rejuvenation and adjustments, despite a minimal initial preparation and the frequent occurrence of bipolar anvil cores ($N = 17$), often on previously used flakes and sometimes blades. Notably, in the NEO 3 house context, a range of core types has already been documented – including bladelet, mixed blade-flake, and bipolar-on-anvil cores – from both the inner and exterior areas of the house structure (Horejs et al., 2022, p. 279, Figure 27).

In the NEO 3 Starčevo horizon, 46% of all blades and 11% of all flakes were modified or used (i.e., retouched and/or display clear use-wear). Of the three bladelets, one shows traces of use, however, without retouch. Altogether, 118 used and/or modified tools are present (Figure 10). As in the later phase NEO 1, laterally retouched and unmodified used tools make up the majority of this category. Interestingly, more blade blanks were used in an unmodified state, whereas more flakes were laterally retouched. Retouched pieces bearing sickle gloss are found amongst both blades and flakes; however, only blades show gloss without being retouched before use. It appears that most were hafted obliquely; however, a few pieces also display parallel sickle gloss along one or both entire lateral edges.

The tool variety in phase NEO 3 appears more diverse than in the late Starčevo assemblages of NEO 1 and NEO 2, which again might rather be related to the type of the analyzed contexts, reflecting a larger variety of activities than those recorded in the later phase. This could also explain the larger number of lithics in NEO 3 (Figure 6). This difference is also observed in the use of local and non-local raw materials across all tool types (Figure 11). Ongoing use-wear and technological analyses are expected to further clarify these patterns and contribute to a more comprehensive understanding of technological strategies across the phases.

4 Discussion and Conclusion

The results of our study show that the lithic raw material economy at Svinjarička Čuka predominantly relied on locally available resources for chipped stone tool production. This observation can be made in the overall assemblage and is equally reflected in the assemblages from selected contexts from the two chronologically distinct Starčevo occupation phases, NEO 1/NEO 2 (c. 5500 cal BC) and NEO 3 (c. 5600 cal BC; Horejs et al., 2022, p. 267). This is due to the fact that the site is situated directly on a Neogene chert outcrop with accompanying materials such as jasper and quartz, and in close proximity to further deposits carrying these raw material types. This understanding was informed by systematic geoarchaeological surveys covering an area of approximately 50 km around the site, allowing us to define the local supply zone for lithic materials. Based on previous studies, we assume that each Neolithic settlement was surrounded by a local supply zone – an area habitually exploited by its inhabitants. Drawing on site catchment analysis (Roper, 1979; Vita-Finzi et al., 1970), this zone is defined as the territory accessible for daily use. Amongst sedentary farming and herding societies, a 10-km radius, or a 2–3-h walk, depending on the terrain, has been established as a likely local exploitation zone (Allard & Denis 2021, pp. 8–10; Dubouloz et al., 2012; Jarman et al., 1982, p. 32). Resources obtained from within this area are considered “local.”

Additionally, a geochemical pilot study (Brandl & Hauzenberger, 2018) and the stereomicroscopic examination of nearly 6,000 lithic artifacts enable us to characterize the materials contained within the lithic assemblage and determine the provenance of the majority of them. This allowed a differentiation within the assemblage in “local” and “non-local” types, which is a necessary precondition for litho-economic considerations, especially regarding raw material procurement strategies. In the current contribution, our aim was to achieve the first step towards this larger goal, to present the primary dataset and first results of combined raw material and technological investigations.

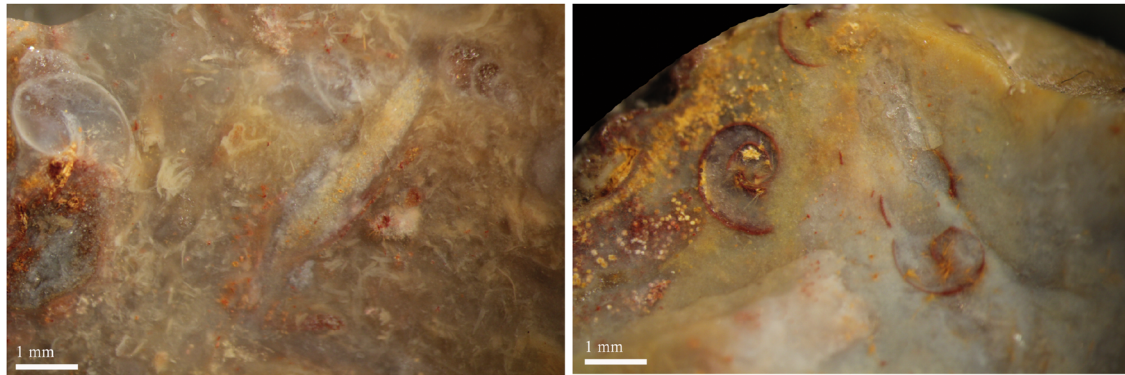


Figure 14: Microphotographs of lacustrine bioclasts in NLS from the catchment area of S. Čuka. Photos: M. Brandl, OeAI/OeAW.

Within the Neolithic assemblages analyzed, several clearly non-local chert varieties occur alongside the local raw material spectrum. Some of these varieties are of very high quality and were used exclusively for blade production. They were most likely brought to the site in a finished state, as suggested by the absence of cores and the near-complete lack of knapping debris. Among them is a white, non-translucent, high-quality chert variety of yet unknown origin. Balkan Flint also belongs to this category, for which, based on current knowledge, the most likely sources are found in northern Bulgaria (e.g., Gurova, 2008, 2012, 2016; Gurova & Nachev, 2008; Gurova *et al.*, 2016). Of particular interest is the presence of a few pieces of obsidian, visually attributed to Carpathian sources (most likely type I). Rather than appearing as imported finished tools or blade blanks – which might be expected given the rarity of the material – these consist of a small bladelet fragment (NEO 2), micro-blades (NEO 1 and NEO 3), and a mini debitage (NEO 3). Currently, these obsidian finds can be best interpreted as potential by-products of blank recycling and waste materials (perhaps from reshaping older implements). The small size and morphology of the fragments suggest they were likely produced on site, supporting the interpretation that obsidian was a curated material, introduced in limited quantities, and worked as needed. Both obsidian and Balkan flint are widely recognized as markers of long-distance networks involved in the spread of the Neolithic way of life in the Balkans, and their presence in the Svinjarička Cuka assemblage corresponds with patterns documented in other Starčevo lithic assemblages. This is also in line with broader interpretations of obsidian and Balkan flint as indicators of long-distance exchange and identity of Neolithic societies (Barfield, 2006; Biagi & Starnini, 2010, 2013). This was also exemplified by Milić and Brandl (2024) through the analysis of a small Early Neolithic chipped stone assemblage from Bucova Pusta IV in Romania, which attests to the circulation of extra-local raw materials, including “Balkan Flint.”

Technologically, two on-site core reduction strategies can be identified within the lithic assemblage of Svinjarička Cuka, largely determined by raw material quality. Within the local raw material spectrum (Figures 12–14), two core reduction strategies appear to be present. Medium – low quality materials were typically knapped by hard direct percussion using hammerstones to reduce multi- and unidirectional flake or mixed flake-blade cores. They rarely show platform preparation, and debitage was often detached directly from the natural surface of the raw pieces, e.g., nodules. This is also evidenced by characteristic knapping features on flakes, such as wide, long, flat platforms and pronounced flake scars. Recycled old cores were often used as hammer stones. Within this category, many tested nodules, which were discarded due to the low quality of the material, occur, and the complete exhaustion of cores of low- to medium-grade local raw material is very rare. Additionally, bipolar cores knapped on an anvil occur frequently, which indicates the attempts and efforts of the local community to fully exploit flakes or knapping debris of slightly better quality.

High-quality raw materials of local origin, which only occur rarely in the deposits near the site (most of the material is of medium to poor quality), are typically worked more carefully, also into multi- and unidirectional flake or mixed flake-blade cores. However, in contrast to those of medium-low raw material quality, they display prepared knapping platforms achieved through rubbing, chipping, rejuvenation, and surface corrections. They were likely exploited using a combination of hard hammer and soft direct or indirect percussion

using antler billets, as suggested by characteristic features on cores (e.g., striking angle, type of flake scars) and debitage (striking platform remains, bulbs of percussion, and ripples). Such cores were exploited to a high degree and discarded in a much smaller state than those of medium–low quality. At present, there is no secure evidence for the local production of the pressure technique for blade making. Moreover, further investigations are needed to clarify the role of indirect percussion in blade production at Svinjarička Čuka, particularly in comparison to the predominant use of direct percussion. Although flakes make up the vast majority of all lithics in the assemblage, modified tools are generally scarce, and the tool variety appears to be limited. The most frequent types are laterally retouched flakes and blades as well as endscrapers, representing the most frequent types. Sickle implements are present as both blades and flakes, sometimes retouched and in some cases used as simple unmodified blanks.

Non-local materials appear to have been brought to the site primarily as finished or half-finished products, as evidenced by the absence of cores and significant quantities of waste material from, for example, Balkan flint or obsidian. There is, however, evidence of reworking of these materials as noted above. Other chert types of yet unknown provenance are in most cases too uncharacteristic (i.e., simple flakes and rarely unretouched blade products) and too scarce to allow secure technological assessments (Figure 10).

Published data enable the contextualization of our results within the broader framework of the Starčevo phenomenon. The ^{14}C results obtained from the analyzed contexts (Horejs et al., 2022, p. 267) indicate that the lithic assemblage from Svinjarička Čuka is best comparable to sites dating to advanced phases of the Starčevo horizon, among which are Blagotin, Šalitrena pećina, and Donja Branjevina (Starčevo II), as well as Ušće Kameničkog potoka and Knjepište (Starčevo III) (Bogosavljević Petrović & Starović, 2016; Šarić, 2005, 2006, 2014).

From a diachronic perspective of the entire Starčevo horizon, i.e., between ca. 6100 and 5500 BC (Horejs et al., 2025, p. 1), lithic studies unveil a discernible trend. From the earliest to the latest phases, there is a general decrease in unretouched flakes, accompanied by a corresponding increase in diverse retouched tool types. Although the quality of tool manufacture appears to improve, the fundamental characteristics of debitage production remain relatively constant throughout the various stages of the Starčevo horizon. According to Šarić, “typical” Starčevo chipped stone tool assemblages are characterized by blades that were sometimes retouched and sometimes used as simple blanks, geometric microliths, and other tool types like scrapers, sidescrapers, perforators, and burin-like tools. A distinctive feature of Starčevo lithic industries is the presence of long, regular blades, predominantly produced using the pressure technique (Šarić, 2014, pp. 184–186). This has been interpreted as an indication of advanced developments in agricultural practices, particularly the increased demand for standardized sickle blades (Šarić, 2014, p. 186). However, not all Starčevo assemblages are blade-dominated. Examples such as Ušće Kameničkog potoka and Knjepište, both assigned to a late phase of this cultural horizon according to Šarić (2005, 2006, 2014), diverge from this pattern. Such local variations have been interpreted based on the idea that certain sites may not have prioritized agriculture to the same extent as others (e.g., Blagotin). This could be attributed to specialization in specific goods production or an unfavorable settlement location (Šarić, 2006, p. 18; 2014, p. 186).

The Starčevo chipped stone assemblage from Svinjarička Čuka is clearly dominated by a flake-based technology (44% of the entire assemblage) with a smaller emphasis on blade and bladelet production (8% of the assemblage), mainly relying on locally available resources. Exogenous materials such as Balkan Flint, however, demonstrate the targeted procurement of specific implements, predominantly blade products, through the wider networks the site was integrated into. The relative scarcity of sickle blades – 52 retouched and unretouched specimens in the overall assemblage and 13 in the contexts selected for in-depth analysis – together with the general paucity of modified tool types, appears to contrast with published results from other comparable sites. However, it has to be considered that Svinjarička Čuka is located directly on a rich source of lithic raw materials, which could be extensively worked in a more opportunistic manner than at sites without direct raw material access. If access to raw materials was uncertain and procurement difficult, communities were compelled to apply more rigorous criteria in selecting materials, which had to be obtained either directly from more distant sources or through social networks. This circumstance, on the other hand, may have resulted in what appears to be resilient behavior at Svinjarička Čuka regarding the local raw material economy. However, the community was at the same time well integrated into the wider procurement

networks, providing “prestigious” materials such as Balkan flint and obsidian, which demonstrates that Svinjarička Čuka’s inhabitants were not that entirely resistant to innovation in the lithic economy as it may appear, but open to interconnectivity despite their obvious ability to self-supply with resources technologically satisfying all their needs. This, again, places the site well into the overall idea of the Starčevo phenomenon.

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Conflict of interest: The authors declare no conflicts of interest.

Data availability statement: The data supporting this study are available from the corresponding author upon reasonable request.

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