Knapping before and after polishing: Technological evidence in the Neolithic polished stone tools from Hungary

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Abstract:

The authors present the evidence gathered during the interdisciplinary study of several polished stone tools from some Neolithic sites in Hungary. In particular, the cutting-edged tool production (axes, adzes, chisels) involves knapping at several stages of the operational-chain within an artefact's '*life cycle*' - from raw material procurement, its manufacture, use, and discard. Some specific fine-grained and non-siliceous raw materials, among which are mainly hornfels, "white stones" and a few greenstones, show evidence of being worked by knapping as shown by the recovery of rough-outs, flaked similarly to biface artefacts, reworked pieces during retooling attempts, and several flakes detached before and after polishing the artefact surfaces. These latter demonstrate that re-sharpening and re-working polished cutting-edged tools was a common practice within the settlements during the whole Neolithic period. These small flakes, that sometimes look like true bladelets, have been often confused with, and published as, chipped stone tools. Therefore, it is important to get a holistic view of the whole stone industry during the study of the lithic assemblages. As in the case for chert and flint in N Europe, which have been intensively exploited for the production of polished axes and adzes, some other lithic raw materials could be easily worked by knapping for the production of polished tools, especially micro-crystalline rocks that have technical response and physical properties very similar to true flint and chert. Moreover, there are indeed implications regarding social organization among Neolithic communities, not only from the point of view of raw material procurement. Notably, the technical capability of producing and maintaining in efficiency the polished stone tools had to be acquired by individuals belonging to each household within the community, since stone axe-adzes were polyfunctional tools for mundane and multiple tasks. Therefore, as an important means for survival, the production of stone tools, both chipped and polished, was a knowledge certainly transmitted from generation to generation, although we still have to understand the modes and social implications of the transfer in details.

Keywords: polished stone cutting edge tools; knapping; production technology; microcrystalline rocks; Neolithic; Hungary

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1. Introduction

The evidence gathered during the interdisciplinary study of several polished stone tools retrieved from some Neolithic sites in Hungary (Figure 1) shows that the cutting-edged tool production (axes, adzes, chisels) involves knapping at several stages of the operational sequence within the artefact's "life cycle" from raw material procurement, its manufacture, use, and discard (Inizan *et al.* 1992: 11-14).

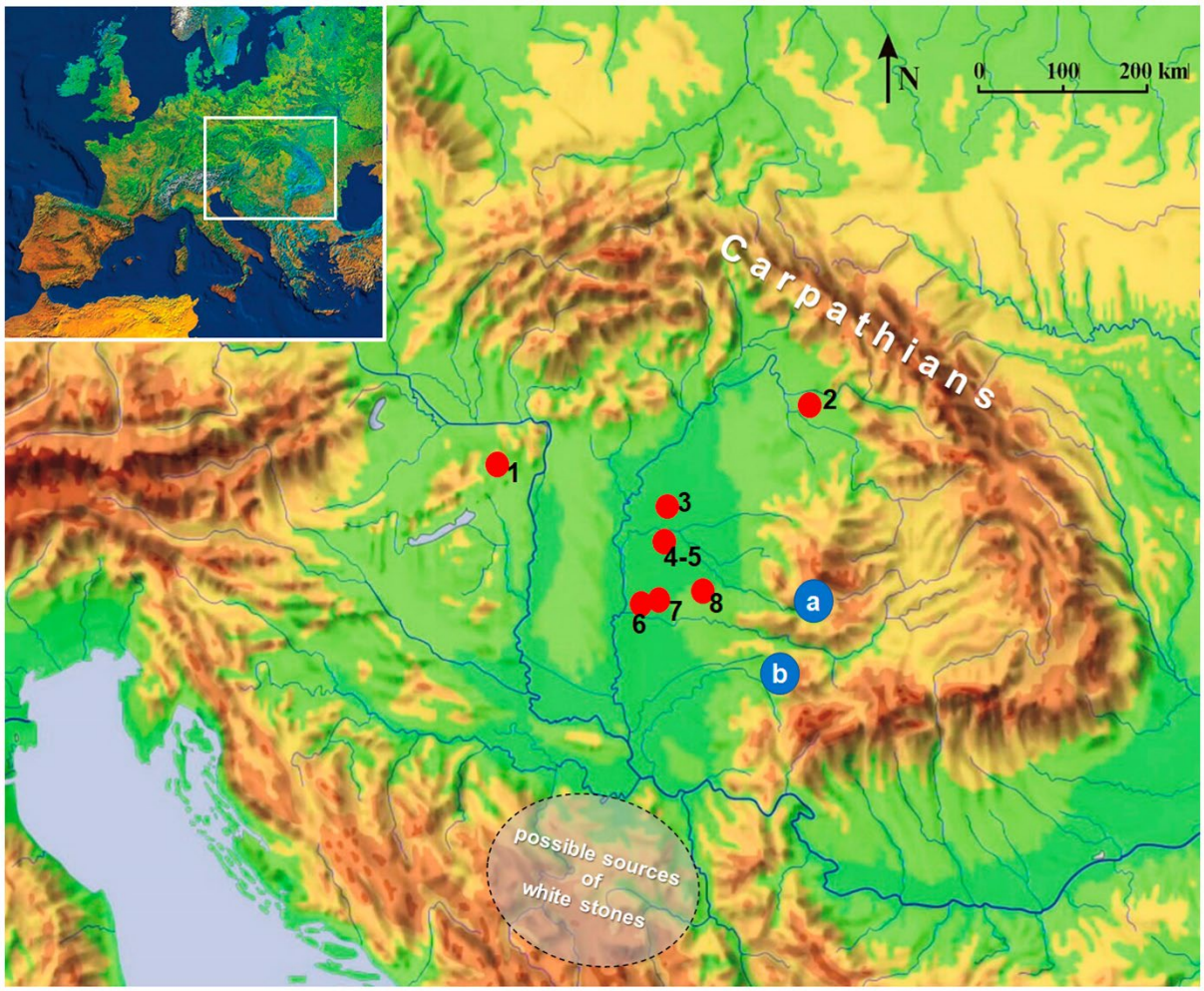

Figure 1. Map of the Carpathian Basin with the archaeological and geological localities mentioned in the text: 1: Bicske-Galagonyás; 2: Méhtelek-Nádas; 3: Ecsegfalva 23; 4-5: Szarvas and Endrőd; 6: Tápé-Lebő; 7: Hódmezővásárhely-Gorzsa; 8: Pitvaros; a (Rusca Mts.) and b (S-Apuseni Mts.): identified sources of hornfels. The possible source area of the so called "white stones" (magnesite bearing siliceous rocks and others) is marked according to the map from Antonović (1997: fig.1).

The chronology of the sampled artefacts spans from the early Neolithic (Méhtelek, Pitvaros, Ecsegfalva, Szarvas and Endrőd), the middle Neolithic (Bicske-Galagonyás), to the late Neolithic (Hódmezővásárhely-Gorzsa, Tápé-Lebő).

1.1. Sites and materials

Polished stone tools from the studied sites comprise adzes, axes and chisels commonly with a plano-convex, or biconvex cross section and complexly polished surfaces from sites dated to the early, middle and late Neolithic. Therefore, it is possible to observe continuity or changes in the technology of polished stone tools production and maintenance throughout the whole Neolithic period.

Several pieces from Méhtelek-Nádas, an early Neolithic site in N-E Hungary (Figure 1: 2) show re-sharpening attempts by flaking after accidental breaking of the tool (Starnini 1994: 70, figs. 39, 47-48). In one case it was possible to refit a flake to the piece (Starnini 1994: fig. 39: 6). One specimen is particularly interesting since it was discarded after being bifacially flaked (Figure 2: A), probably due to the irregular thickness of its cross-section (Starnini 1994: fig. 48: B, 1). Moreover, the site yielded several flakes from re-sharpening or reworking of polished stone tools (Figure 2: B). A small collection of polished stone tools from Ecsegfalva 23 (Figures 1 and 3), another early Neolithic Körös Culture settlement, shows that artefacts were worked and re-worked or re-shaped by flaking, as demonstrated by the presence of flakes bearing one polished side (Starnini *et al*. 2007: fig. 30:1).

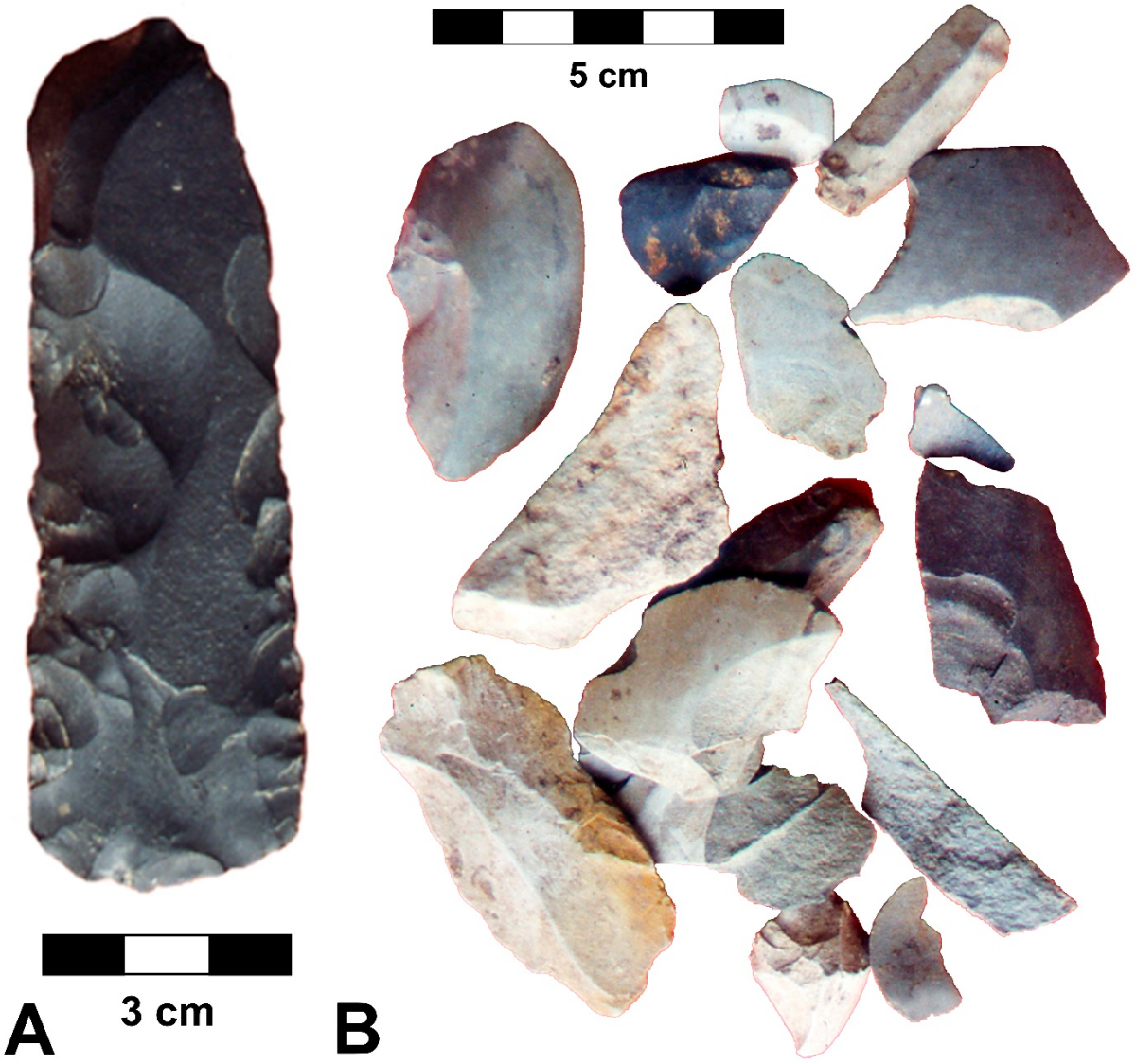

Figure 2. Méhtelek-Nádas, early Neolithic, Körös Culture: reworked polished stone tool by bifacial flaking (A); flakes from reworking polished stone tools; (B), scale in cm.

Figure 3. Hódmezővásárhely-Gorzsa, late Neolithic, Tisza Culture. A: adze blade knapped before polishing, hornfels (GOR-489); B: polished axe blade knapped after polishing and trace of "*débitage par sciage*" (Nougier & Romain 1953), reworking attempt, hornfels (GOR-606).

Other studied polished tool collections are those from the early Neolithic sites of the Szarvas and Endrőd region (Figure 1: 4-5) (Starnini & Szakmány 2000). Several pieces of microcrystalline rocks show reworking and retooling attempts by knapping the surfaces and the fractures (Starnini & Szakmány 2000: fig. 24: 1), whilst others bear scars of knapping before polishing (Starnini & Szakmány 2000: fig. 5, 4). Similar manufacture technology has been observed during the study of middle Neolithic, Linear Pottery assemblages from Bicske-Galagonyás (Figure 1: 1), in Transdanubia (Starnini 1996: figs. 119, 120).

Recently, other polished stone collections have been studied from Pitvaros, dating to the early Neolithic, and to the late Neolithic, Tisza Culture sites of Tápé-Lebő and Hódmezővásárhely-Gorzsa (Figure 1: 6-7). The present paper will examine the evidence gathered during the interdisciplinary study of these last collections.

2. Raw materials and methods

Among the polished stone tool assemblages from several Hungarian Neolithic sites some specific fine-grained non-siliceous rocks show evidence of being worked by knapping before and after polishing (Figures 3 and 4 and Table 1). A similar technology and operational sequence have been documented in the Vinča Culture (Antonović 2014; Prinz 1988).

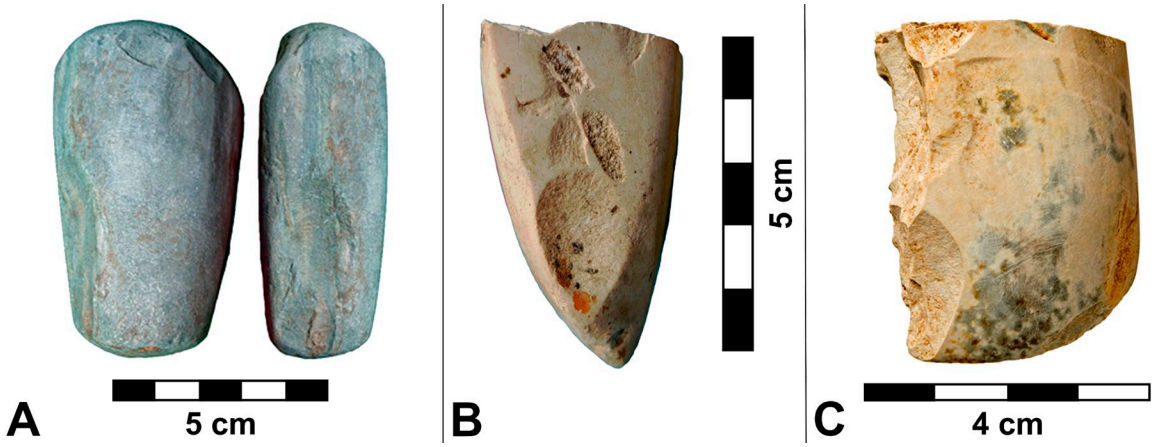

Figure 4. A: adze reused as hammerstone knapped before polishing, greenstone (PIV-5, from Pitvaros); B: adze blade fragment knapped before polishing, "white stone" (GOR-901, from Gorzsa); C: adze blade fragment knapped after polishing, "white stone" (PIV-10, from Pitvaros).

Table 1. List of unpublished polished stone artefacts showing scars of flaking technology from Hódmezővásárhely-Gorzsa (GOR-), Tápé-Lebő (TL-) and Pitvaros (PIV-) (EN for early Neolithic; LN for late Neolithic).

Sample	Date	Raw material	Short description	Figure
GOR-4	LN	hornfels	reworking flake after polishing	5
GOR-94	LN	hornfels	reworking flake after polishing	5
GOR-140	LN	hornfels	fragment of flat plano-convex adze. Knapped before polishing	-
GOR-146	LN	white stone	fragment of plano-convex adze on flake. Knapped after polishing	-
GOR-156	LN	hornfels	flake of polished stone tools. Knapped before and after polishing	-
GOR-226	LN	hornfels	plano-convex adze. Knapped before and after polishing	-
GOR-227	LN	hornfels	complete plano-convex adze. Knapped before polishing	-
GOR-233	LN	hornfels	small adze. Knapped before polishing.	-
GOR-241	LN	hornfels	fragment of reworking flake. Knapped after polishing	6, A and B
GOR-404	LN	white stone	plano-convex adze. Knapped before and after polishing	-
GOR-431	LN	hornfels	reworking bladelet after polishing	5
GOR-439	LN	hornfels	reworking flake after polishing	5 and 6
GOR-488	LN	white stone	small complete shoe last chisel. Knapped before polishing	-
GOR-489	LN	hornfels	complete polished adze. It shows chipping before polishing (polishing covers the chipping scars)	3, A
GOR-491	LN	hornfels	fragment of shoe last chisel. Knapped before and after polishing	-
GOR-494	LN	hornfels(?)	complete polished adze. Knapped before and after (old damaged?) polishing	-
GOR-501	LN	hornfels	reworking flake after polishing	-
GOR-506	LN	white stone	fragment of flat axe on flake. Knapped bifacially before polishing. Rough out?	-
GOR-509	LN	hornfels	shoe-last chisel pre-form. Knapped before polishing	-
GOR-523	LN	hornfels	plano-convex adze. Knapped before and after polishing	-
GOR-598	LN	white stone	fragment of flat axe on flake. Chipped before and after polishing	-
GOR-606	LN	hornfels	polished stone tools in reworking. Knapped after polishing. Groove cut in the middle	3, B
GOR-636	LN	white stone	fragmentary plano-convex adze. Knapped before and after polishing	-
GOR-645	LN	amphibolite	reused flake as chisel. It is polished after flaking	-
GOR-646	LN	white stone	fragment of shoe last chisel. Knapped before and after polishing	-
GOR-715	LN	white stone	small axe on flake. Chipped after polishing	-
GOR-719	LN	hornfels	fragment of plano-convex adze. Knapped before and after polishing	-
GOR-796	LN	hornfels	broken plano-convex adze. Knapped after polishing	-
GOR-823	LN	white stone	complete plano-convex adze. Chipped before and after polishing	-

Sample	Date	Raw material	Short description	Figure
GOR-834	LN	white stone	small plano-convex adze. It was chipped before polishing	-
GOR-844	LN	hornfels	reworking flake after polishing	5
GOR-846	LN	hornfels	reworking flake after polishing	5
GOR-900	LN	white stone	cutting edge fragment of an axe. Chipped after polishing	-
GOR-901	LN	white stone	fragment of shoe last chisel. Knapped before polishing	4, B
GOR-902	LN	hornfels	reworking flake after polishing	5
GOR-925	LN	hornfels	fragment of plano-convex adze cutting edge. Knapped before polishing	-
GOR-938 (GO-13)	LN	hornfels	fragment of shoe last chisel. Knapped before and after polishing	-
GOR-1013	LN	hornfels	reworking flake after polishing (82.1.8)	5
GOR-1019	LN	hornfels	fragment of plano-convex adze. Knapped after polishing	-
GOR-1027	LN	hornfels	reworking flake after polishing	5
GOR-1029	LN	hornfels	reworking flake after polishing	5
GOR-1030	LN	white stone	reworking flake after polishing	-
GOR-1034	LN	hornfels	chisel Knapped before polish	-
GOR-1036	LN	hornfels	reworking flake before polishing	5
GOR-1038	LN	hornfels	reworking flake after polishing	5
GOR-1041	LN	Mecsek radiolarite	reworking flake after polishing	-
GOR-1042	LN	hornfels	reworking flake before polishing	-
TL-5	LN	hornfels	complete polished adze. It shows chipping before polishing (polishing covers chipping scars). Damaged	-
PIV-5	EN	greenstone	adze reused as hammerstone. Knapped before polishing	4, A, and 8
PIV-10	EN	white stone	adze blade fragment. Knapped after polishing	4, C

This technological evidence is shown by the recovery of rough-outs, flaked similarly to bifacial artefacts, reworked pieces during retooling attempts, and the presence of several flakes detached before and after polishing the artefact surfaces with marked percussion bulbs due to intentional, controlled hard hammering (Figure 5). Therefore, it is possible to distinguish between accidental breaks and intentional flaking.

These latter demonstrate that re-sharpening and re-working polished cutting-edged tools was a common practice within the settlements during the whole Neolithic. These knapped byproducts, that sometimes look like true blades and flakes, may cause problems in recognition and classification (Prinz 1988: 257). Therefore, they might have been often confused with, and published as, chipped stone artefacts (Kaczanowska & Kozłowski 1987: fig. 3, 1).

Raw materials of some artefacts knapped before and after polishing have been determined by means of petroarchaeometry (petrographic analysis from thin section, electron-microscopic analysis by Scanning Electron Microscopy-Energy Dispersive Using X-Ray (SEM-EDX), chemical analysis by Prompt gamma-ray activation analysis (PGAA).

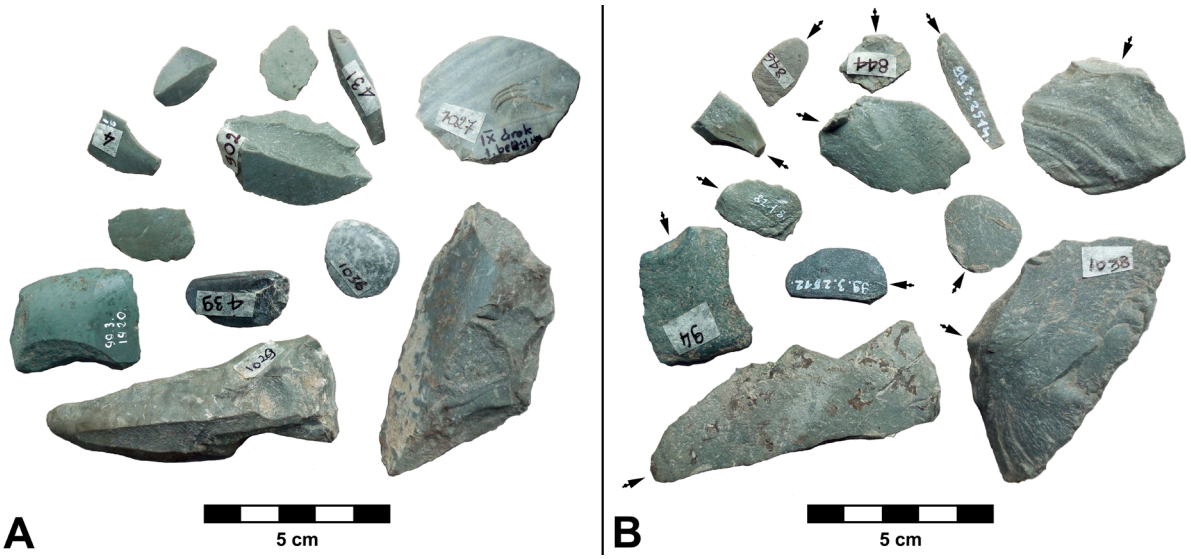

Figure 5. Hódmezővásárhely-Gorzsa, late Neolithic, Tisza Culture: knapped flakes and bladelets with bulb of percussion (black arrows), dorsal (A) and ventral (B) views, from hornfels polished stone tools.

Identified raw materials are all fine-grained rocks, among which especially represented are hornfels (Figure 6), "white stones" (Antonović 1997; Antonović *et al*. 2005) and more rarely greenstones (greenschists and amphibolites) and others (radiolarite, siliceous siltstone (Szakmány 1994)) that show evidence of being worked by knapping.

The hornfels is a very fine-grained, hard and tenacious, homogeneous greenish-grey, greyish-green or pale-grey rock, consisting of diopside, feldspar (K-feldspar or Ca-rich plagioclase), and occasionally less biotite, and scapolite (Figure 6). Accessory constituents are highly variable, the most common are sphene, apatite, allanite, zircon, titanite and pyrrhotite (Szakmány *et al*. 2016).

The "white stone" rock, which is petrologically a magnesitic silicite, consists of predominantly microcrystalline quartz with small holes filled by magnesite, and occasionally calcite. As accessories few rutile and zircon occur (Figure 7).

The raw material of the greenstone artefact from PIV-5 is a greenschist-(low grade amphibolite) rock, consisting of: epidote, actinolite, Na-rich plagioclase, quartz, small amount of fine grained titanite and few zircon crystals (Figure 8).

The provenances localities of the hornfels have been recognized in the Rusca Mts. and the S-Apuseni Mts (Figure 1: a-b) (Starnini *et al.* 2015; Szakmány *et al.* 2016), whilst the provenance area of "white stone" rocks is located in a larger territory to the South of the Carpathian Basin (Figure 1), in present Serbia (Antonović 1997: fig. 1), the core area of the Vinča Culture. A possible provenance of the greenstones is the Apuseni Mts., but the precise location of the possible outcrop has not been established until now.

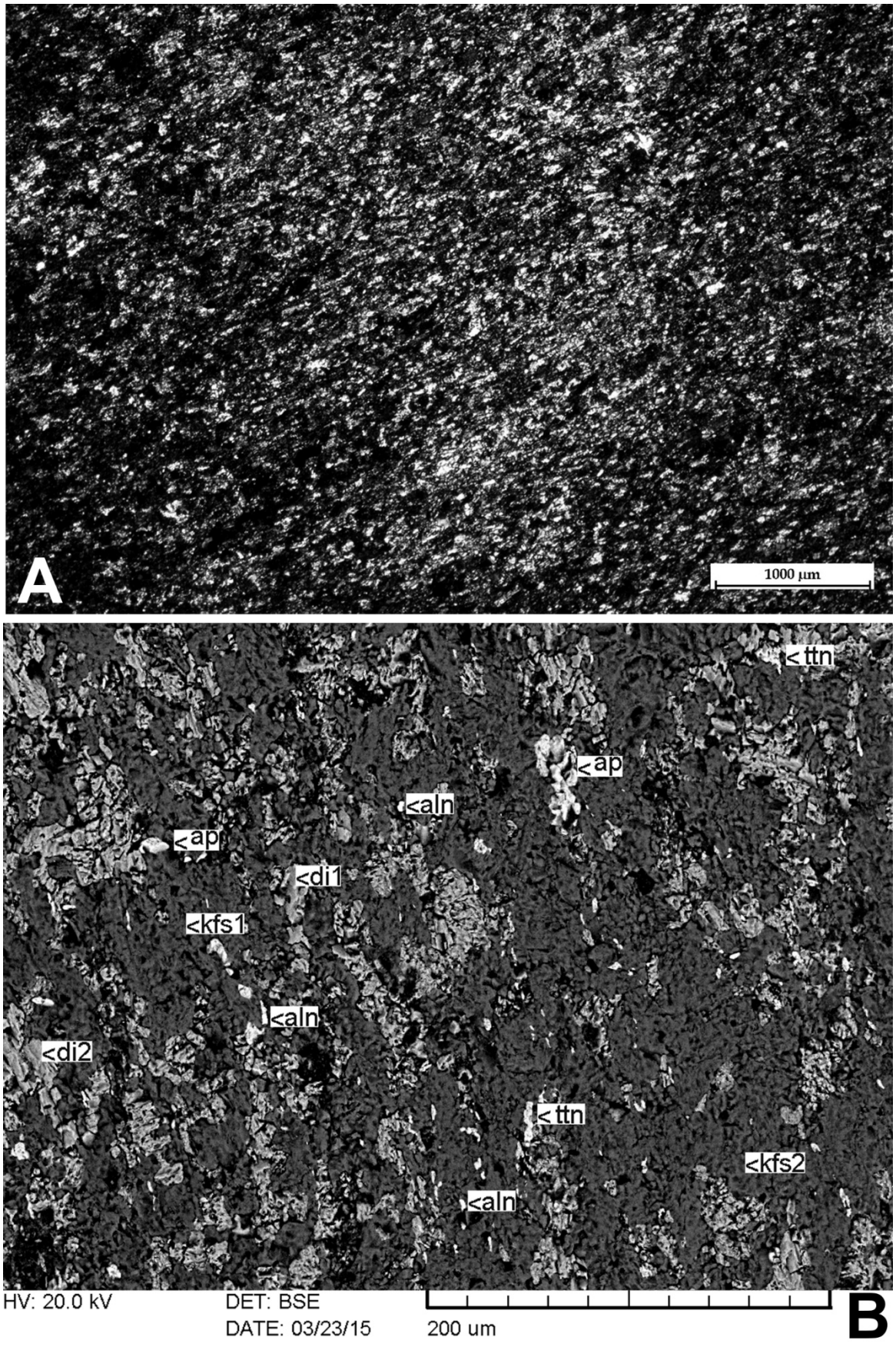

Figure 6. Late Neolithic hornfels polished stone tool (GOR-241, Gorzsa tell): A, thin section microphotographs (modified from Szakmány *et al*. (2016)); B, Back-Scattered Electron (BSE) image of the same sample: aln = allanite, ap = apatite, di1 & di2 = diopside, kfs1 & kfs2 = K-feldspar, ttn = titanite.

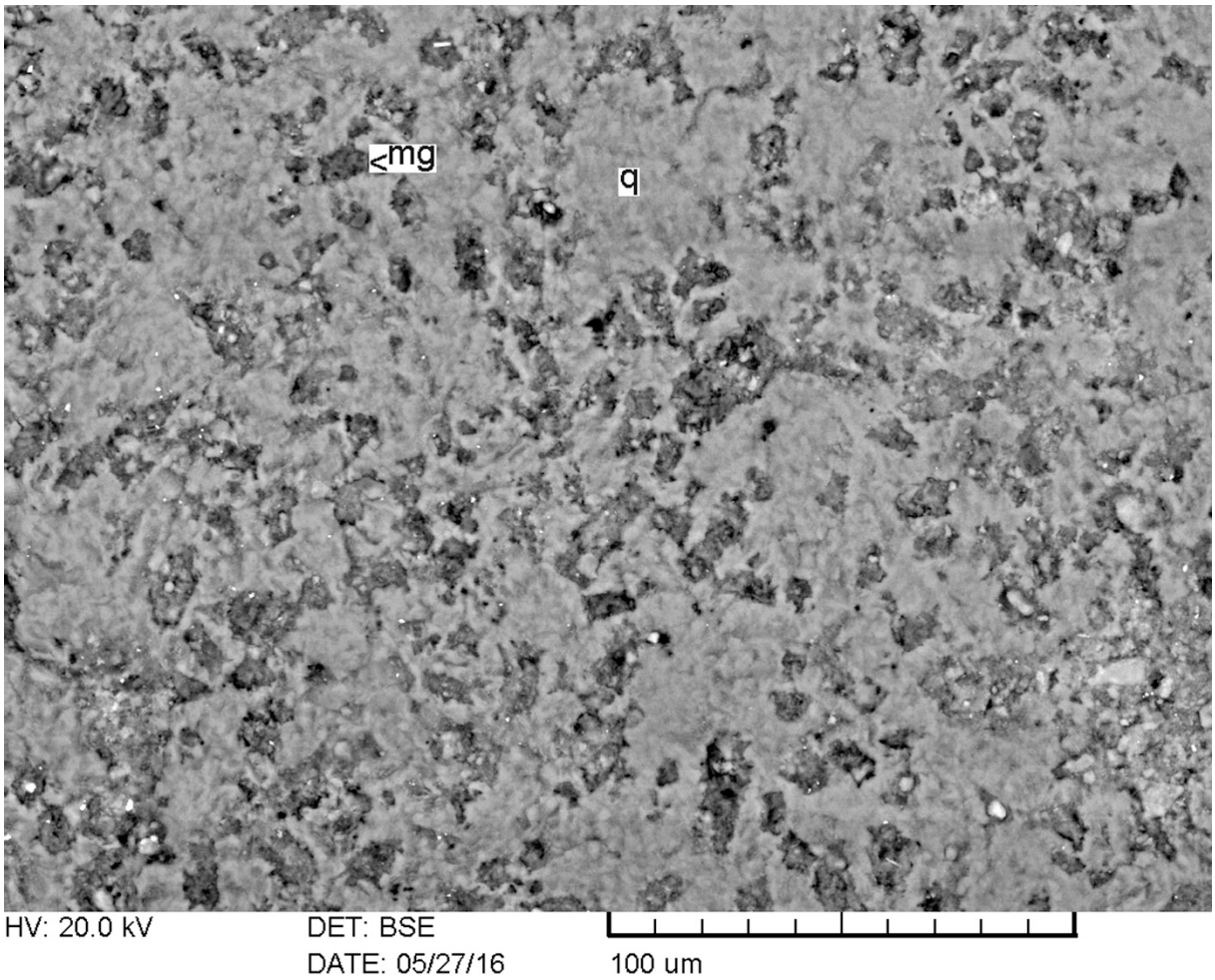

Figure 7. BSE image of Neolithic white stone polished tool (GOR-293, Gorzsa tell): q for quartz, Mg for magnesite.

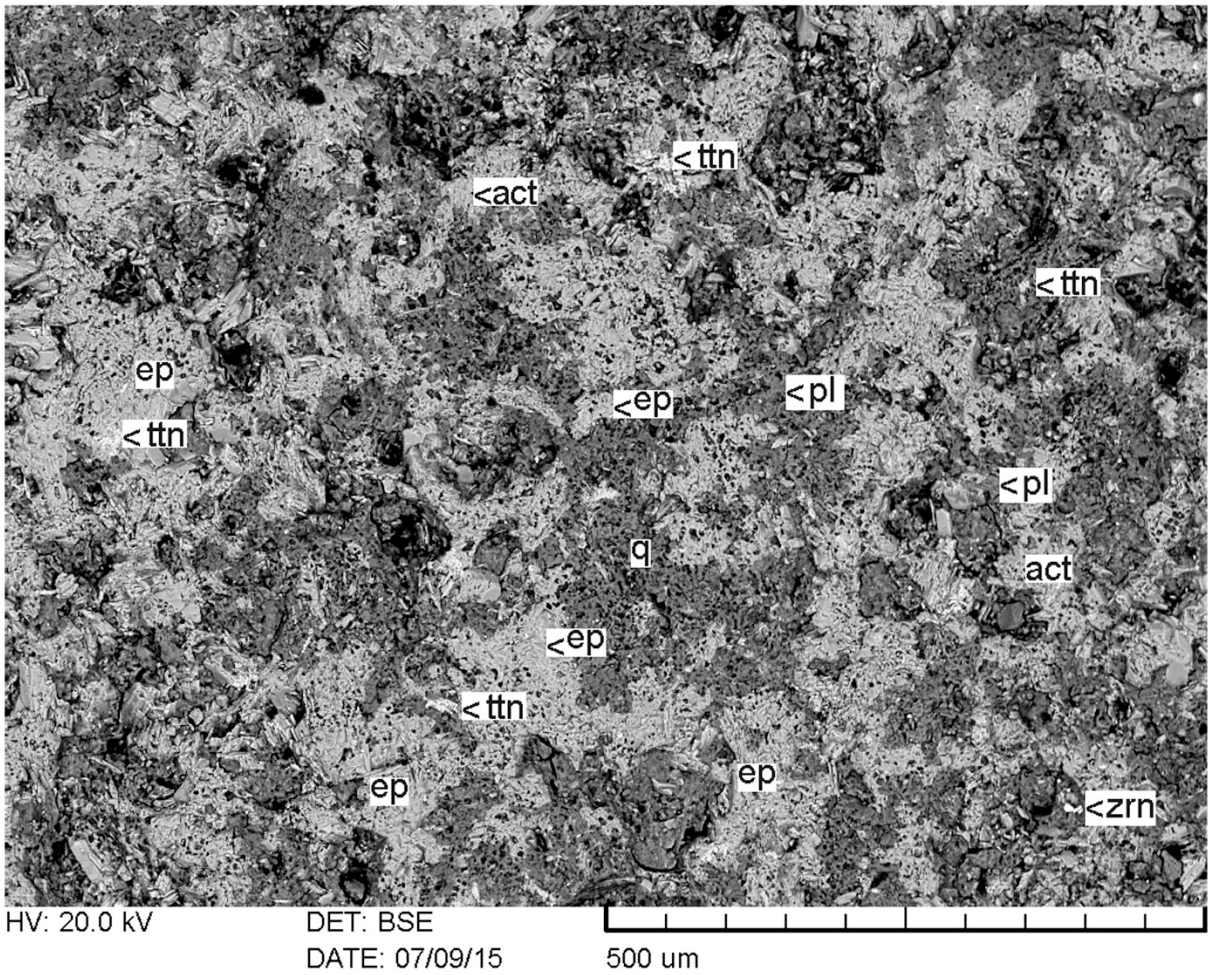

Figure 8. BSE image of an early Neolithic greenstone polished tool (PIV-5, Pitvaros): act for actinolite, ep for epidote, pl for plagioclase, q for quartz, ttn for titanite, zrn for zircon.

3. Interpretations of the data

Our data gathered during several years of analysis of polished stone tools from different Neolithic sites of the Carpathian Basin in Hungary show that this craftsmanship is quite a conservative one, both in terms of technology of tool production and maintenance, and raw material choice. Since the early Neolithic, cutting-edged tools employed in wood working have been obtained shaping the rough-outs by knapping different micro-crystalline rocks, first of all hornfels and "white stones". After this step, the operative chain employed grinding and polishing with abrasive media on the whole surfaces of the tools. Some authors, taking into account the operative chain used by lapidary artisans for gemstones, suggest to employ the term "polishing" only for those cases when surfaces are brought to a high shining gloss (Prinz 1988: 257). However, the general term "polished stone tools" is usually employed in archaeological literature to distinguish the peculiar surface finish of wood working, cutting-edged tools (axes, adzes, chisels) from that of other macro-lithic tools such as grinding stones, hammerstones, hand-stones *etc*. (Adams *et al*. 2009). In Europe there are indeed cases of stone axe-heads with whole polished surfaces to a glassy, high sheen, but they are always considered as "prestige" items, most probably embedding personal status or symbolic meanings (Pétrequin *et al*. 2012: 17-22; 2017a: 14-23; 2017b).

Other working techniques have been seldom observed in our assemblages, namely the *débitage par sciage* (Nougier & Romain 1953) for cutting and splitting the pieces, starting from the early Neolithic (Endrőd 119) (Starnini & Szakmány 1998: fig. 8: 1-3) until the late

Neolithic (Figure 3: B). This technique, involving sawing to produce a straight groove along which the piece is then snapped off into two pieces was also used at Divostin, a Neolithic site in central Serbia with a cultural sequence spanning from Starčevo to Vinča periods (Prinz 1988: 257).

This production technology is quite different from the western European tradition that employs pecking technique after shaping the rough-outs by knapping and usually finishes only the cutting-edge part with polishing (D'Amico & Starnini 2012). This different tradition may be conditioned by the technical response of the raw materials employed, namely Alpine High-Pressure meta-ophiolites (Váczi *et al*. 2019), certainly harder and tougher to work than hornfels and the other micro-crystalline rocks employed in S-E Europe. In the Carpathian Basin, the same knapping technology employed before and after polishing the surfaces for the production and maintenance of adze and axe heads during the early Neolithic is observed also during the middle and late Neolithic.

Therefore, it might be considered a quite conservative tradition, most probably representing the optimal technology for processing the commonest S-E European stone raw materials employed in the polished stone tool production.

4. Conclusions, significance, opinions

This research shows that it is important to get a holistic view of the whole stone industry during the study of the lithic assemblages. As is the case for chert and flint in N Europe, which have been intensively exploited for the production of polished axes and adzes, some other lithic raw materials could be easily worked by knapping for the production of polished tools too, especially some micro-crystalline non-siliceous rocks that have technical response and physical properties very similar to true flint and chert.

Moreover, there are indeed implications regarding social organization among Neolithic communities, not only from the point of view of raw material procurement.

Notably, the technical capability of producing and maintaining in efficiency the polished stone tools had to be acquired by individuals belonging to each household within the community, since stone axe-adzes were polyfunctional tools for mundane and multiple tasks.

Therefore, as an important means for survival, the technology for the production of both chipped and polished stone tools was a know-how certainly transmitted from generation to generation, although we still have to understand in full details the modes and social implications of its transfer.

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Data accessibility statement

The data used here are from the ownership of the authors, and the others are cited. The data presented in this study are available on request from the authors.

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