

Greenstone chisel-like adzes for carpentry were components of the »Neolithic Package« in Anatolia and the Balkans

Laura Dietrich, Mario Börner, Michael Brandl, and Barbara Horejs

Zusammenfassung

Meißelartige Grünsteindechseln für Zimmerhandwerk als Bestandteile des »neolithischen Pakets« in Anatolien und auf dem Balkan

Beile als unverzichtbare Werkzeuge der Landgewinnung und des Bauwesens werden seit langem als integraler Bestandteil des so genannten neolithischen Pakets im südwestasiatischen und europäischen Neolithikum angesehen. Aufgrund des uneinheitlichen Forschungsstandes, der Terminologie und der fehlenden Funktionsanalyse dieser amorphen Kategorie von Schneidwerkzeugen wird diese Annahme jedoch grundsätzlich pauschal als archäologische Fundkategorie – undifferenziert nach der tatsächlichen Verwendung dieser Werkzeuge – getroffen. In der vorliegenden Arbeit werden meißelartige Dechseln als neuer, eigenständiger Bestandteil des »neolithischen Pakets« technologischer Innovationen in Anatolien und auf dem Balkan vorgestellt – zwei der Regionen, die in den Veröffentlichungen von Beilfunden einen niedrigen Stand aufweisen. Meißelartige Beile, die, wie wir in dieser Arbeit gezeigt haben, ein besonderes Design haben, tauchen im Kerngebiet der Neolithisierung in der Levante auf, höchstwahrscheinlich im Anschluss an bedeutende Veränderungen in der Hausarchitektur – wie der Einführung von rechteckigem Holz und Holzverbindungen im Spätneolithikum. Obwohl die Erhaltung von Hausbauelementen aus organischen Materialien in den archäologischen Kontexten dürftig ist, kommen wir aufgrund von Form- und Gebrauchsspurenanalysen sowie laufenden Experimenten zu dem Schluss, dass wir es mit hochspezialisierten Zimmermannswerkzeugen zu tun haben, die in Anatolien und auf dem Balkan zusammen mit anderen Elementen des neolithischen Pakets nach Westen übertragen werden. Wir präsentieren eingehende funktionale, experimentell gestützte Analysen der Beile vom Çukuriçi Höyük, einer Pioniersiedlung an der westanatolischen Küste (ab ca. 6700 cal v. Chr.), und von Svinjarička Čuka auf dem Zentralbalkan (ab ca. 6000 cal v. Chr.), um die Besonderheit meißelartiger Beile innerhalb des Gerätespektrums und die Idee der Aufspaltung des Konzepts des »Neolithischen Pakets« in verschiedene Technologien zu sichern. Die beiden hier vorgestellten Fallstudien, die eine reiche Ansammlung meißelartiger Beile enthalten – zusammen mit wenigen anderen Beispielen an anderen Fundorten – weisen auf eine frühe Übernahme von architektonischen Elementen und Tischlerwerkzeugen in Westanatolien und auf dem Balkan als Schlüsselkonzepte des Wohnens während der Neolithisierung hin. Eine weitere – symbolische – Bedeutung spiegelt sich in den aufstrebenden Netzwerken des Austauschs von »Grünsteinen« in diesen Regionen als Rohmaterial für die Herstellung der spezialisierten Werkzeuge wider.

Summary

Axes, as essential tools for land clearance and construction, have long been considered an integral part of the so-called Neolithic package in the Southwest Asian and European Neolithic processes. However, due to the uneven state of research, terminology, and the lack of functional analysis of this amorphous category of cutting tools, this assumption is basically made as a whole, as an archaeological find category, and is undifferentiated according to the actual use of these tools. In the present paper we are introducing chisel-like adzes as a distinct component of the 'Neolithic Package' of technological innovations in Anatolia and the Balkans, two of the regions with a low state of the art in the publication of axe-assemblages. Chisel-like adzes which, as we have shown in this paper, have a particular design, emerge in the core area of the Neolithisation in the Levant most likely following significant changes in house architecture, like the introduction of rectangular timber and timber joints in the Late Neolithic. Although the preservation of house construction elements made of organic materials is poor in the archaeological contexts, we conclude, based on shape and use-wear analyses as well as on ongoing experiments, that we are dealing with highly specialised carpenter tools, which are transmitted towards the West, in Anatolia and the Balkans, together with other elements of the Neolithic package. We present in-depth functional, experimentally supported analyses of the axe assemblages of Çukuriçi Höyük, as a pioneer settlement on the West Anatolian coast (from c. 6700 cal BC), and of Svinjarička Čuka in the Central Balkans (from c. 6000 cal BC), in order to secure the distinctiveness of chisel-like axes within the axe assemblages and the idea of splitting the concept of 'Neolithic package' into distinct technologies. The two case studies presented here, including a rich assemblage of chisel-like adzes, together with fewer other analogues among other sites, indicate an early adoption of architectural elements and carpentry tools in Western Anatolia and the Balkans as key concepts of home during Neolithisation. Another – symbolic – meaning is mirrored in the raising networks of »greenstone« exchange in these regions as raw materials for the production of the specialised carpenter tools.

Keywords Neolithic Package, chisel-like adzes, carpentry, Anatolia, Southeastern Europe

Schlagwörter Neolithisches Paket, meißelartige Dechseln, Zimmerhandwerk, Anatolien, Südosteuropa

Axes, adzes and chisels

Axes have long been seen as an integral component of the so-called Neolithic package – a sum of technological innovations enabling Neolithisation, like pottery, figurines, ‘offering tables,’ M-shaped amulets, bracelets made of marble and stone, beads, bowls of ‘greenstone’ and phalli, grooved stones, chipped discs as well as polishers, belt hooks and bone *spatulae* (Özdoğan 2010; Özdoğan 2016; Çilingiroğlu 2005, 4 Tab. 1; Horejs 2019, 74 Fig. 2). Axes, adzes, and chisels, in the following labelled as Hitting and Cutting Tools (HCTs), are highly effective tools of a relatively simple and conservative, but efficient design, which undergo multiple changes in their use and meaning during the Neolithisation of different regions. Axes have a symmetrical shape, while adzes have one straight and one curved broadside, which is usually interpreted as indicating a difference in hafting (parallel with the shaft or perpendicular). Chisels are defined by their rectangular profile.

Axes (and adzes as well as chisels) are the main tools of the Neolithisation process. They are necessary for land clearance and the construction of houses and villages, and thus for the implementation of agriculture and settled life. Axes, adzes, and chisels are an early innovation of the core areas of the Neolithisation in Southwest Asia¹, being transferred from there to Anatolia² and on to Europe³.

The new research presented here proposes a more detailed look at the other two components of the HCTs, the adzes and chisels, through analyses of the technologies of their production and use and through the identification of regional trajectories in connection with the Neolithisation process.

HCTs in the Levant and Upper Mesopotamia

The technological principle of the Neolithic axe is first attested in Southwest Asia, where at first small unpolished flint tools appear during the Pre-Pottery Neolithic A (PPNA), followed by larger polished ground stone axes in the Early PPNB (ca 9600–8000 BC), which acquire a shaft, successively transforming them into powerful hitting and cutting tools (Barkai 2005). During the Middle Neolithic (MPPNB/PPNC; c. 8000–7000/6900 BC) and the Late Neolithic (Pottery Neolithic: 7000/6400–5300 BC), large axes made from different lithic raw materials were already in wide use in the Levant (Barkai 2005; Dietrich 2018), Upper Mesopotamia (Davis 1982; Roodenberg 1986; Mazurowski 1997), and Central Anatolia (Wright et al. 2013)⁴.

In a wider region throughout the core area of the Neolithisation, a general development from small to trapezoidal or oval large heavy polished cutting and hitting tools is evident between the PPNA and the PPNB. However, there is a

major research bias between the Southern Levant, where axes have been the object of intense studies and are published extensively (Barkai 2005; Barkai 2008), and Upper Mesopotamia and Anatolia, where only selected assemblages of a few sites have been analysed so far (Fig. 1)⁵.

A second phase in the evolution of HCTs is marked by the »adze«, an innovation of the Pottery Neolithic. Following their appearance in site assemblages mostly after 7000 BC, adzes (and, in smaller numbers, chisels) will gradually replace axes until the Chalcolithic in the Southern Levant (Barkai 2005; Barkai 2011). A few published assemblages from Upper Mesopotamia – for example, from Tell Sabi Abyad, Rakkah governorate, Syria (Huigens 2010), Bouqras, Deir ez-Zor governorate, Syria (Roodenberg 1983; Roodenberg 1986) and Shir, Hama governorate, Syria (Dietrich 2018) – with axes, adzes, and chisels may suggest a similar development. Thus, during the time coinciding with the Neolithic migration westwards, adzes are included in the innovation package of the Neolithisation in its core areas.

Terminological specifications on the types of »adze«

However, there are some terminological issues to be clarified here. Tools that have been labelled as »adzes« at Shir (Dietrich 2018, Pl. 1–2), »celts« at Sabi Abyad (Huigens 2010, Fig. 6–7; Huigens et al. 2014, 157, Fig. 6,5/60–63), or »herminettes« at Bouqras (Roodenberg 1983, Fig. 1,3,4,7)⁶ have certainly few commonalities with the Central European »Schuhleistenkeile« or »Flachbeile« of the LBK (e.g., Willms 2012, Fig. 7; Elburg et al. 2015, Fig. 5), or the relatively large triangular or oval tools of the Southeastern European Neolithic (e.g., Antonović/Dimić 2021, 423–424 Fig. 4–5), to give just some examples – except for the hafting with the blade-transverse to the shaft.

The largest group of adzes at Sabi Abyad is composed of small tools with a length of up to 5 cm, but also a group of larger adzes is attested (Huigens 2010, Fig. 8–9). The small tools have one curved and one straight broadside with a rectangular or, more rarely, a triangular facet. The facet falls obliquely at a ca 45° wide angle on the blade, which seems to be a standardised pattern. Most of the adzes from Sabi Abyad are made from non-local, very hard rocks: dolerite at Sabi Abyad (Huigens 2010) and »greenstone« at Shir (Dietrich 2018). Tools that have been labelled as »adzes« in the Southern Levant (Barkai 2005) are made of flint and are slightly larger than those in the Northern Levant, with a facet on their straight side, which can be rectangular, triangular, or irregularly shaped. Chisels have facets similar to adzes.

At the moment of the Neolithic dispersal westwards, the toolkit of HCTs in the core area of this process was not only composed of axes, but also of (increasingly important) small adzes and chisels, following a presumed

1 Davis 1982; Wright 1994; Barkai 2005; Yerkes et al. 2012; Rosenberg/Gluhak 2016; Dietrich 2018.

2 Wright et al. 2013.

3 For example: Antonović 2003; Stroulia 2003; Tsoraki 2008; Nowak 2009; Müller-Beck et al. 2010; Weiner 1997; Weiner 2012; Ram-

mingier/Šida 2012; Willms 2012; Elburg et al. 2015; Bernardini 2018; Masclans et al. 2021; Moník et al. 2021.

4 See also the comprehensive overviews on the material culture of the Neolithic in its core area: Kozłowski et al. 2006, 25 Map 2.2.5.4; Shea 2013, 233–238; 262–263 Fig. 7,21.

5 Davis 1982; Roodenberg 1986; Mazurowski 1997; Dietrich 2018.

6 See also type 6 of »herminettes« as well as some smaller exemplars of type 13 by Kozłowski et al. 2006.

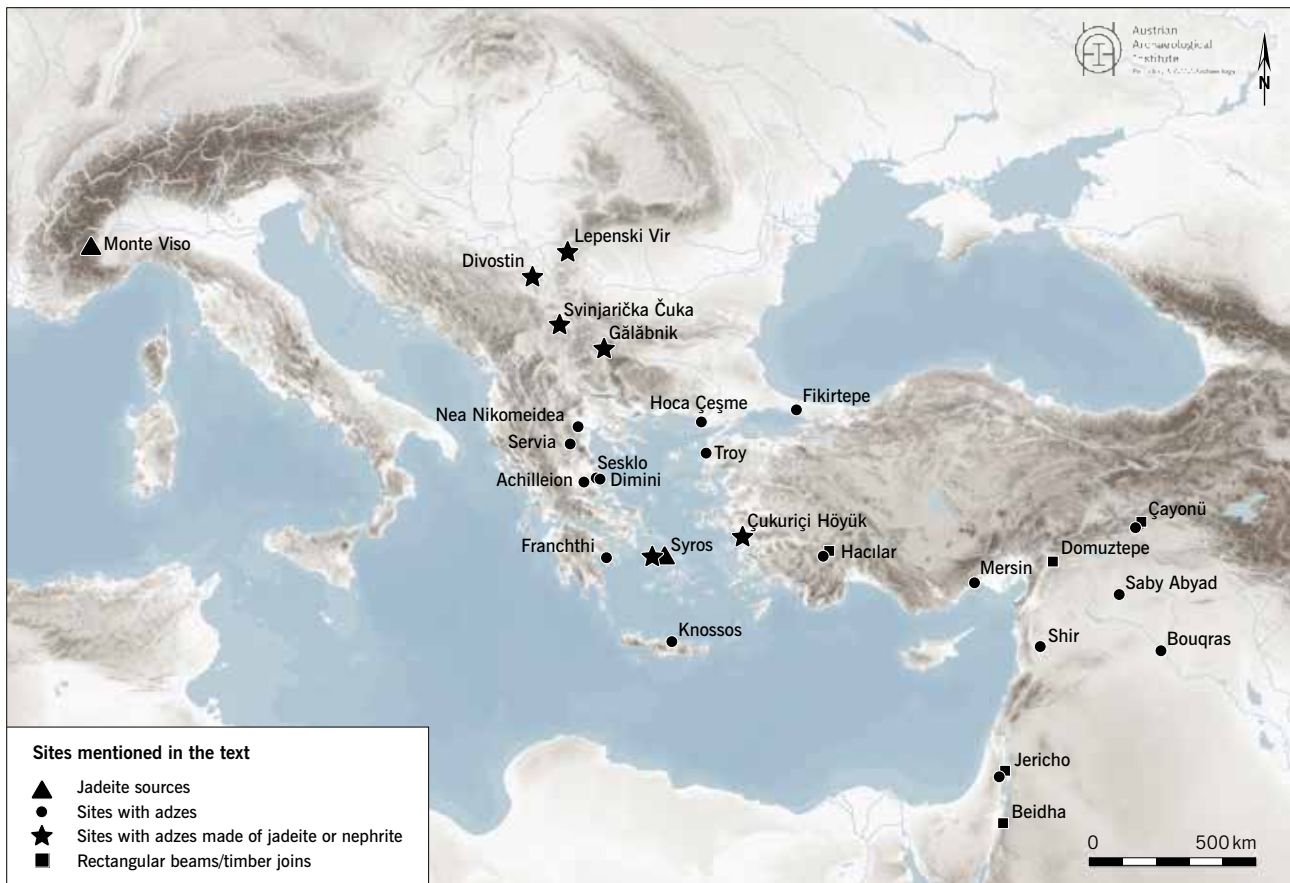


Fig. 1 Map with the location of the sites and finds discussed.

Abb. 1 Karte mit den besprochenen Funden und -orten.

change in woodworking practices as suggested by R. Barkai (2005, Barkai 2008). Barkai's interpretation of the »adze« innovation is mainly based on its versatility as a tool in comparison to the axes, as adzes are suitable for shaping or smoothing wooden planks, for the chopping and preparation of wooden utensils, and for other tasks in carpentry, in addition to tree-felling. Functional studies or reconstructions of hafting and handling are still missing for this category of tools, which probably explains their absence in the discourse on Neolithic technological innovations. However, adzes are transmitted with the Neolithic dispersion westwards and are, together with the axes, obviously common parts of site assemblages of the Neolithic pioneers in Western Anatolia and Southeastern Europe. One of these pioneer sites is Çukuriçi Höyük near Izmir in Western Anatolia, Türkiye.

HCTs in Western Anatolia: The Neolithic site of Çukuriçi Höyük

The Early Neolithic site Çukuriçi Höyük (Fig. 2–3), excavated between 2006 and 2014⁷, is one of the earliest Neolithic sites in Western Anatolia and the Aegean (Horejs

2019). The tell settlement, which originally was situated in a shallow coastal inlet characterised by lagoons and swamps, was most probably founded by pioneer farmers coming up over the sea in an optimal micro-habitat for settling, farming, and herding (Horejs et al. 2015). The earliest domestic features, ¹⁴C-dated to between 6680–6500 BC (ÇuHö XIII–XII), display an architecture composed of mud walls with massive post holes and plastered floors, whereas the successive Late Neolithic architecture (between 6500–5970 BC, ÇuHö XI–VIII) is built on stone wall foundations (cf. Fig. 3). Large houses with activity areas inside and outside, which stand on solid stone walls and are built of thick wooden posts, probably with wooden roofs and mud walls, have been reconstructed (Fig. 4; Brami et al. 2016; Lužnik-Jancsary et al. 2020). Thus, a rich wooden architecture can be reconstructed for Çukuriçi Höyük. The raw material came from the surrounding woods of deciduous oaks (Stock et al. 2013; Kayan 2014; Stock et al. 2015), which must have been exploited using HCTs. In fact, more than half (59 of 104) axes found at the site come from the Neolithic layers (Bochatz 2019). The rest of the finds belong to the later Chalcolithic and Bronze Age settlements that follow at Çukuriçi Höyük after a settlement hiatus or come from the mixed surface layer.

⁷ The excavation works were led by B. Horejs (Austrian Archaeological Institute, Vienna).



Fig. 2 Çukuriçi Höyük: View on the site during the excavations.

Abb. 2 Çukuriçi Höyük: Fundort während der Ausgrabungen.



Fig. 3 Çukuriçi Höyük: Examples of Late Neolithic house structures built on solid stone wall foundations – with mud walls and their activity areas.

Abb. 3 Çukuriçi Höyük: Beispiele der spätneolithischen Hausstrukturen, welche auf soliden Steinmauerfundamenten errichtet wurden – mit den Lehmwänden und ihren Aktivitätsbereichen.

The distribution pattern of Neolithic HCTs shows a dominance of the axes (symmetric section, 25 finds) in comparison with the adzes (one straight and one curved face, 12 finds). In addition, 2 chisels (narrow rectangular implements) and one pick-like implement have been observed. 9

fragments are probably from large axes but their attribution is not secured.

Following a traditional typological approach, a broad variety of shapes, ranging from oval to trapezoidal-elongate and trapezoidal-squat, rectangular-elongate and -squat, tri-

Fig. 4 Çukuriçi Höyük: Reconstruction of Late Neolithic house structures based on the interpretation of the archaeological contexts.

Abb. 4 Çukuriçi Höyük: Rekonstruktion spät-neolithischer Hausstrukturen auf der Grundlage der Interpretation der archäologischen Kontexte.



angular or irregular, in a variety of sizes, would have to be defined. However, this image is a result of the various deformation processes a tool can undergo between design, production, use, and recycling. A more reliable concept used in this study was to identify patterns of technological trajectories by analysing the complete *chaîne opératoire* of production, use, and maintenance of HCTs with special focus on the comparison between adzes and axes.

Rocks and »greenstones« at the site

There is a broad spectrum of rocks used to produce HCTs at Çukuriçi Höyük, which have been geologically and petrographically analysed in several studies (Wolf 2017; Sørensen et al. 2017; Schwall et al. 2020) and are the subject of current experimental projects for the determination of their mechanical properties related to their use as hitting and cutting tools.

Most of the Neolithic HCTs at the site (38 % = 29 finds) are made of locally available peridotite, which is a hard blackish rock and can be exploited in the near vicinity (Wolf 2017). Peridotite can be considered a good choice for the production of HCTs, as it is a dense and hard rock that

can be transformed into sharp and heavy axes (for example, for tree-felling). Through the geological process of serpentinisation, parts of naturally occurring peridotite, an ultramafic rock, were hydrated and transformed into serpentinite, which, at Çukuriçi Höyük, has also been exploited for the production of HCTs. Serpentinite is considerably softer and not as resistant to breakage or pressure as peridotite, but it can also be more easily shaped and ground into axes or adzes. 13 % of the HCTs (10 tools) were produced of this medium-soft local rock. Other local rocks used in the production of HCTs are emery stones, which are very hard and abrasive; in the Neolithic settlement, they were used predominantly for the production of chisels. Emery stone was used to an almost similar extent as serpentinite (14 % = 11 tools). Amphibolite and basalt are only occasional choices (seven and three tools, respectively).

Surprisingly, almost a quarter (22 % = 17 tools) of the HCTs, mostly adzes, are produced from non-local rocks tentatively identified as jadeite through reflectance spectroscopy (Wolf 2017; Sørensen 2019; Schwall et al. 2020). This deep green rock is not only significantly harder than other lithic materials, but is also more resistant to breakage, fracture, and compression. Also, polished green HCTs made of jadeite have high aesthetic qualities, at least from a today's perspective.

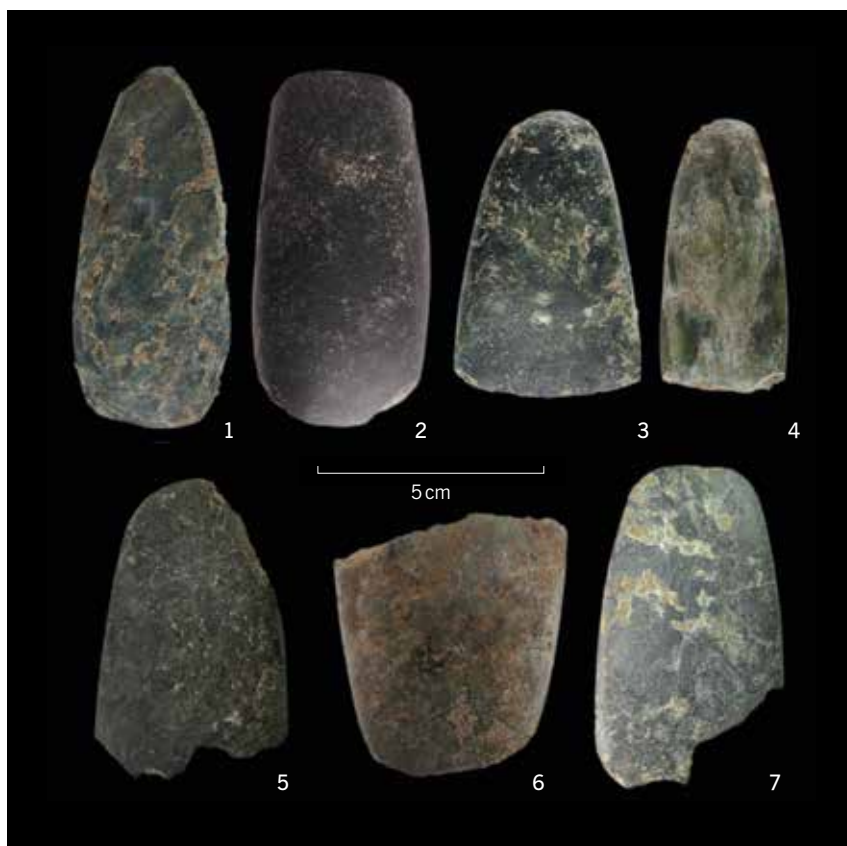


Fig. 5 Çukuriçi Höyük: The *chaîne opératoire* of production, use, maintenance, and recycling: model 1. 1–4 used axes made of peridotite, serpentinised peridotite, and emery stone; 5–7 broken, unrecycled fragments.

Abb. 5 Çukuriçi Höyük: die *Chaîne opératoire* von Herstellung, Gebrauch, Instandhaltung und Wiederverwertung: Modell 1. 1–4 benutzte Beile aus Peridotit, serpentinisiertem Peridotit und Schmirgel; 5–7 zerbrochene, nicht wiederverwertete Fragmente.

Our current projects follow the complex trajectories related to the exploitation, use, and exchange of »green-stone« in the Eastern Mediterranean⁸. One of the tasks is to investigate the exploitation of jadeite in terms of use, frequency, affordance, and availability at the site. As has been previously observed (Schwall et al. 2020), Neolithic to Bronze Age Çukuriçi Höyük was embedded in a large network of exchange reaching up to almost 300 km in distance and including materials and products such as obsidian, volcanic rocks, and greenstone. At least some of the jadeite was transported from Syros, Southern Aegean, Greece, as previous analyses have shown (Sørensen et al. 2017). For other jadeite artefacts, local resources and networks are assumed⁹.

Modelling the chaîne opératoire of use and usefulness

The *chaîne opératoire* of production, use, and maintenance of the HCTs can be roughly divided into three models, which show divergent patterns for local and non-local materials but also for rocks of different qualities.

Model 1 is a pattern of production for hard, large (9–10 cm) and middle-sized (7 cm) axes from local rocks, mostly peridotite and emery stone (Fig. 5). Most probably, large- to middle-sized blanks already suitable for the desired tool were chosen from the vicinity of the site, flaked, and pecked into shape, as indicated by their production markers. They were used for different tasks and eventually dis-

carded without any, or with only minimal, resharpening and recycling (cf. Fig. 5,5; Fig. 6–7). Their fragmentation pattern shows a relatively equal distribution of blades, body, or butt fragments.

The completely preserved axes have sharp blades and cutting edges. One use pattern of the large axes, observed on most tools, is characterised by regularly blunted blades covered with V-shaped fractures in the centre of the cutting edge and on its corners (cf. Fig. 6), as well as by asymmetrically rounded corners. The cutting edge also displays perpendicular and slightly oblique deep scratches and irregularly distributed medium reflective spots. Similar patterns have been observed on axes used for tree-felling (Fig. 7; Roy 2020, Fig. 8; 10). Wear markers on middle-sized axes are blades which are blunt and covered with either V-shaped or irregular fractures as well as oblique scratches and irregularly distributed spots which are medium to high reflective. The most frequent wear patterns observed on the analysed middle-sized axes are similar to the patterns on large axes, indicating their use as tree-felling tools. For all other middle-sized axes with divergent wear patterns, multifunctionality may be assumed. Work for house construction, for the procurement of fuel material, and for butchery was most probably performed with these tools. A large quantity of bones with deep large cut marks most likely produced by axes (Fig. 8; Galik 2019) comes from the Neolithic layers. Generally, archaeozoological research has reconstructed a diverse and extensive animal diet for the Neolithic inhabit-

8 Ongoing project led by L. Sørensen.

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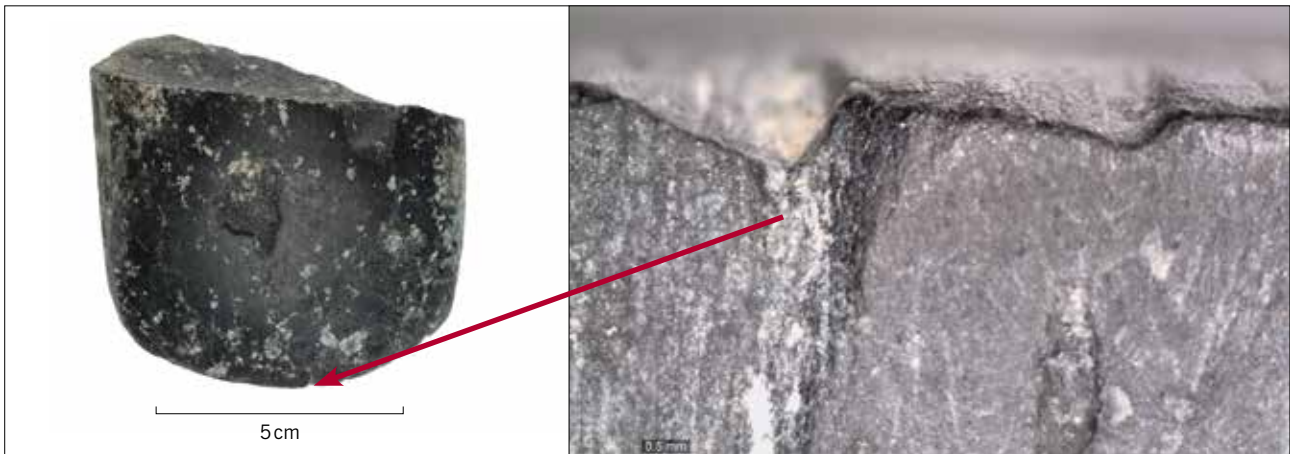


Fig. 6 Çukuriçi Höyük: Example of use-wear markers on massive axes: blunt bit with V-shaped fractures in the centre of the cutting edge.

Abb. 6 Çukuriçi Höyük: Gebrauchsspuren an großen Beilen: [...] mit V-förmigen Brüchen in der Mitte der Schneidkante.

ants of the site (Galik 2019), mainly based on domestic animals such as pigs, sheep, goats, and cattle, thus large animals for which butchery tools are required.

Our current experiments confirm the suitability of these kinds of axes for butchery on middle-sized animals (Fig. 9). In addition, axes can be effectively used to clean animal skins. Guided by the archaeological traces on bones, we used a toolkit composed of axes and flint blades to butcher a piglet weighing 15 kg. The use of axes makes the cracking of ribs and long bones easy; but axes are also much more suitable for cleaning animal skins of fat, a task that is nearly invisible in the archaeological record. However, the cleaning of one single pig skin, performed in 2023, did not leave enough significant evidence of wear to identify this use on the original tools.

Model 2 is a pattern of recycling larger jadeite or nephrite HCTs to be used as chisel-like adzes and chisels (Fig. 10). Most tools with this specific pattern are preserved as small green adzes with lengths between 2 and 4.5 cm. All adzes show multiple facets resulting from the recycling from larger tools and resharpening, such as sawing of their lateral sides, older grinding facets, and rudiments of older blades (Fig. 11).

These tools are made in a similar way and consist of an oval blade with a rectangular facet, inclined in a similar angle for all preserved tools. Striations on the facets, oriented parallelly and oblique to the cutting edge, and multiple small facets at their base indicate their manufacture and resharpening through grinding, until the desired edge shape was reached. In addition, one object¹⁰ shows chipping as a manufacturing technique for the rectangular facets. The construc-



Fig. 7 Tree-felling experiments with axe replicas. In photo: Michael Brandl.

Abb. 7 Experimentelles Bäumefällen mit Beilrepliken. Im Bild: Michael Brandl.

¹⁰ Artefact No. 13_1722_03_002, cf. database of the project.



Fig. 8 Example of bone with cut marks found at Çukuriçi Höyük.

Abb. 8 Beispiel eines Knochens mit Schnittspuren, gefunden in Çukuriçi Höyük.



Fig. 9 Butchering of a pig. Experiments with axe replicas.

Abb. 9 Schlachten eines Schweins. Experimente mit Beilrepliken.

tion principles show similarities with the Northern Levantine adzes from Sabi Abyad discussed above.

On the pieces from Çukuriçi Höyük, multiple cycles of resharpening and realigning of the angle of the rectangular facet can be observed (cf. Fig. 10,2–5; Fig. 12). The homogenic design and systematic resharpening indicate that we are dealing with highly standardised Neolithic tools for specific purposes. The use-wear observed on six completely preserved pieces is uniform: it consists of lines of regular U-shaped micro notches on the entire cutting edge, as well as of polish and perpendicular striations on the notches (cf. Fig. 12,5–6). Most probably, this pattern indicates a standardised use as a chisel-like tool, as has been observed in our (ongoing) experiments¹¹. Both design and wear indicate a smoother handling than for axes. Most probably, as also suggested by their small size, chisel-like adzes were hafted in wood platelets or organic sleeves and used in a similar way to modern carpentry chisels of metal. These are manoeuvred through pushing the tool by hand into wood or using a soft hammer for precise cutting, trimming, or finishing, either of furniture, of planks (for wider tools) or of timber joints, which have to be cut precisely. This specific element of the house construction process is invisible in the archaeological record but must be considered in the functional interpretation of these tools.

Chisels, which are rectangular tools with blade designs similar to adzes, also including rectangular facets¹² and pen-like tools¹³, which belong to the same recycling model, are rare. Both tools have considerably thinner blades than the adzes and hint at the probable existence of carpentry toolkits designed for high precision work.

The reasons for the choice of non-local jadeite to produce these specific tools cannot be easily investigated. Originally, in their first use life, most of the tools were likely either larger adzes or axes (cf. Fig. 11,1). Fragments of these tools are – in comparison with model 1 – only rarely preserved. This specific fragmentation pattern and the above-mentioned recycling traces on the smaller adzes are clear indicators of the recycling processes. Possibly, the specific hardness of jadeite, which is 7 on the scale of Mohs (e.g., Bradt et al. 1973, 727), and its resistance to breakage together with the possibility to produce sharp tools due to the high density and the fine-grained rock matrix could be the reason for recycling it into high-precision tools, a process that can also be observed in Sabi Abyad (Huigens 2010).

Model 3 refers to a model of production of small adzes or axes from local soft-green coloured stones (serpentine) without or with only small traces of recycling, such as resharpening. Most likely, they were produced from water-

11 Project »WEAR« led by L. Dietrich/
M. Brandl, forthcoming.

12 Artefact No. 14_2137_03_0009.

13 Artefact No. 13_1809_003_0001.



Fig. 10 Çukuriçi Höyük: The *chaîne opératoire* of production, use, maintenance, and recycling: model 2. 1 Adze; 2–5 adzes with traces of recycling and use; 6 adze with traces of recycling.

Abb. 10 Çukuriçi Höyük: Die *Chaîne opératoire* von Herstellung, Gebrauch, Instandhaltung und Wiederverwertung, Modell 2. 1 Dechsel; 2–5 Dechseln mit Spuren von Wiederverwertung und Gebrauch; 6 Dechsel mit Spuren der Wiederverwertung.

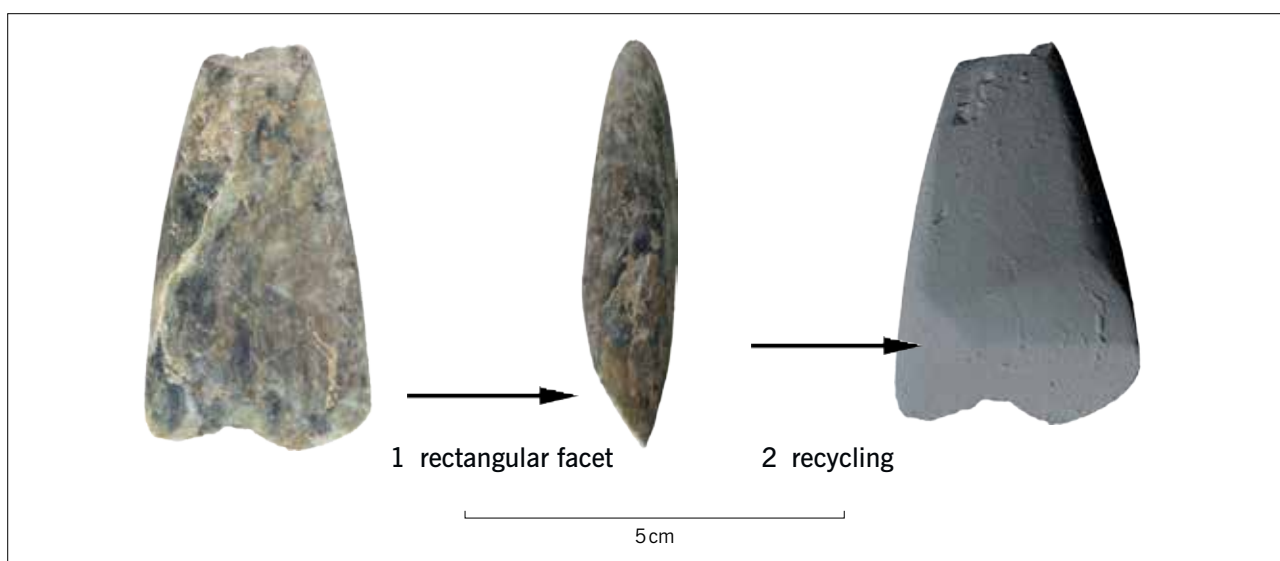


Fig. 11 Çukuriçi Höyük: Adze made of jadeite, example of production, recycling, and use-wear traces.

Abb. 11 Çukuriçi Höyük: Dechsel aus Jadeit. Beispiel für Spuren von Herstellung, Wiederverwertung und Gebrauch.

worn, serpentinised pebbles and cobbles. For example, one artefact¹⁴ still bears waterworn natural surface remains, which were left untreated. This kind of production for small axes and adzes was also employed in the Early Neolithic Franchthi Cave (Stroulia 2003). In assemblage from this site, the numerous small greenstone adzes with rectangular facets display similar patterns of use. Whether these tools were recycled (with strong arguments in favour of this

hypothesis) has been the subject of prolonged discussion (Stroulia 2003). These small, possibly recycled, greenstone tools dominate the assemblage and may indicate Neolithic architecture based on the use of carpentry tools outside the cave, where small Neolithic domestic structures are known (Jacobsen 1981). It also shows the transmission of this tradition from Western Anatolia to Greece already in the Early Neolithic.

14 Artefact No. 14_2360_3-1.

Bringing the carpentry toolkit to the Eastern Mediterranean and the Balkans

Green, small, hard chisel-like adzes with rectangular facets of the »Çukuriçi Höyük type« spread in the Neolithic of the Eastern Mediterranean from Greece to Italy (see for example the HCTs in Sørensen 2019). They are not only made of jadeite, but also of serpentinite, and other until now unidentified/unanalysed greenish stones. Aside from the already mentioned tools from the Early Neolithic Franchthi Cave (Stroulia 2003), chisel-like adzes have been found at Early Neolithic Knossos (Strasser 2004) and Syros (Sørensen et al. 2017), as well as at the Early to Late Neolithic settlements of Nea Nikomeidea, Central Macedonia; Sesklo, Dimini, Achilleion, Tsangli, all Thessaly; Servia, Western Macedonia, as shown by C. Sugaya (2012, 67, Fig. 1). Chisel-like adzes are also attested in the Early Neolithic layers at Fikir Tepe in North-western Anatolia (Özdoğan 2023, 221 B2, B4, B9, B13, possibly B6) and in Western Anatolia. The Neolithic tradition of the production of chisel-like adzes, largely made of hard and greenish stone, was most probably continued in the Chalcolithic and Bronze Age, both in Greece and in Western Anatolia, where they are known from several sites (Sugaya 2012).

Thus, we can clearly identify chisel-like adzes made of greenish stones (of the Çukuriçi Höyük type) originating in the core area of the Neolithisation in the Northern Levant as an integral component of the Neolithic package in Western Anatolia and Greece and the Western Mediterranean during the »initial wave« (as proposed by Özdoğan 2019), in the Early Neolithic pioneer sites (Horejs 2019), but also later in the course of the establishment of settled life. From here, defined as a new core region of the Neolithisation in some models (Özdoğan 2019), chisel-like adzes of the Çukuriçi Höyük type were transmitted through different channels further north to the Balkans. They are attested at Early Neolithic Gălăbnik (Bakamska et al. 2018), where they are made of jadeite-omphacite and bear clear traces of recycling (Bakamska et al. 2018, 53 Fig. 3) to smaller tools; at Divostin, Šumadija district, Serbia (Antonović 2003, 91 Tab. 5; 94, Fig. 59,3–7), where they are presumably made of jadeite; at Early Neolithic Lepenski Vir, Serbia, where they are made of nephrite and serpentinite (Antonović 2003, 108 Fig. 68,3–5; 9; 12; 109 Fig. 69, 9–13; 104 Tab. 9; 106 Tab. 10); and at Early to Middle Neolithic Svinjarička Čuka, Lebane District, Serbia, where they are made of nephrite. Particularly the last site, which has been intensively investigated in recent years (Horejs 2019; Horejs et al. 2022), gives valuable insights into the process of transmission and local adaption of the Çukuriçi Höyük type of chisel-like adzes.

The case of Svinjarička Čuka (Serbia)

According to the latest ¹⁴C dates (Horejs et al. in print), Svinjarička Čuka was already founded before or around 6000 BC, thus being one of the earliest pioneer sites in the Central Balkans. The archaeological site is situated on the elevated Svinjarička River terrace north-east of the famous Caričin Grad in the Lebane District of Southern Serbia, and

it is currently being investigated by an international and interdisciplinary research team within the framework of an Austrian-Serbian collaboration. A very important outcome of the research is the presence of solidly built architecture dating to the Neolithic Starčevo period (6000–5400 BC), representing the first agricultural communities along the Morava River connecting the Mediterranean cultures with the Danube region. The architectural structures are large rectangular houses attested through flat stones interpreted as sub-constructions of wooden poles and pit installations, stamped clay floors, and an oven in the interior. Consequently, the massive use of wooden constructional elements can be presumed, and the analyses of botanical taxa clearly supports this archaeological reconstruction (Schroedter in Horejs et al. 2022).

65 HCTs from the Neolithic, Chalcolithic, and the Bronze Age layers were found at the site. As has recently been observed (cf. the petrographic analyses in Brandl et al. in prep.), most of these tools were produced using locally available rocks, such as gneiss, quartz, quartzite, serpentinite, schist, and silicified siltstone. Clearly, most HCTs had been heavily used, especially in tasks implying hard impact on wood, such as tree-felling or woodcutting. The preliminary results of the use-wear analyses concur with the architectural reconstruction on the site. In addition, six HCTs were made of non-local nephrite and other non-determined green rocks.

There are clear differences in the *chaîne opératoire* of production, use, and discard of these HCTs compared to those of Çukuriçi Höyük, probably attesting to the adaptation to local environmental conditions. At Svinjarička Čuka, re-using and recycling was practiced in regard to the HCTs made of both local and non-local rock. Larger tree-felling axes made of local rocks as well middle-sized trapezoidal axes can be either repaired, recycled, transformed into smaller axes or discarded after breaking, while axes made of nephrite and green rocks can be recycled into hammers or adzes. However, the making of greenstone chisel-like adzes follows patterns similar to those in Çukuriçi Höyük, corroborating their affiliation to the spread of the Neolithic package described above: the pieces discovered until now are recycled from larger HCTs, are hard and small, and have similarly prepared rectangular facets (Fig. 12). Use-wear analyses indicate their use both for lighter tasks in carpentry, bearing similar wear markers as at Çukuriçi Höyük, and for heavier work, or for harder materials. Two of the analysed greenstone chisel-like adzes from the Early Neolithic layers display large breakages in the centre of the cutting edge, indicating impacts with high power, which would probably not correspond with light carpentry. To answer this question, future experiments are planned.

Greenstone chisel-like adzes continue to be present in the later Starčevo-Neolithic occupation at the site (5800–5500 cal. BC) and in the layers of the Metal Ages. Their distribution coincides with the picture drawn by R. Kostov (2005) for artefacts made of nephrite in Neolithic and Chalcolithic Bulgaria. Obviously, this specific rock with qualities similar to the Aegean jadeite was used primarily for small adzes and chisel, and only secondarily for other artefacts.

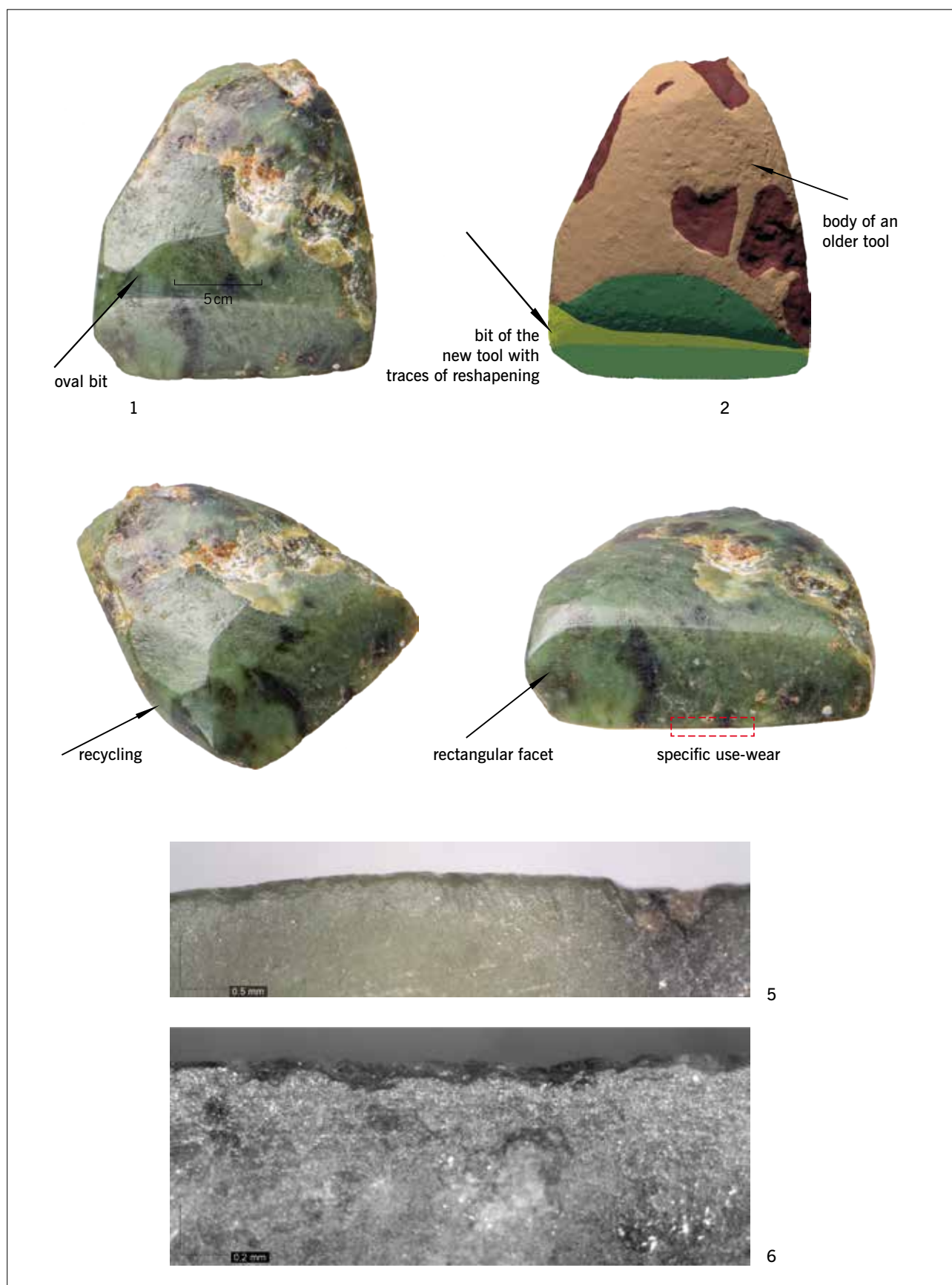


Fig. 12 Svinjarička Čuka: Adze made of nephrite with rectangular facet and traces of recycling.

Abb. 12 Svinjarička Čuka: Dechsel aus Nephrit mit rechteckiger Facette und Spuren der Wiederverwertung.

Current knowledge on the rising of Neolithic networks of jadeite, nephrite, and serpentinite

Jadeite

Until recently, the prevailing belief was that the sole prehistorically utilised jadeite deposits were confined to the Piedmontese Alps, specifically the Monte Viso source as detailed in studies by P. Pétrequin et al. (2012; Pétrequin et al. 2013). However, recent archaeological findings challenge this notion, shedding light on the existence of an additional jadeite source situated in the Eastern Mediterranean, on the Cycladic island of Syros (Pétrequin et al. 2017; Sørensen et al. 2017). An origin of two jadeite axeheads within Çukuriçi Höyük's stone axe assemblage from Syros has been proposed by Sørensen et al. (2017, 502; 506–507), whereas the provenance of the remaining axes remains elusive except one specimen, which potentially could originate from a source in the Monte Viso region (Sørensen et al. 2017, 507). This assumption, however, was solely based on macroscopic examination and requires further instrumental testing, which is planned for the near future.

Nephrite

For the Balkan region, specifically Bulgaria, Kostov (2013, 14–15) established at least two distinct varieties of nephrite used for the production of axes and adzes, based on petrographic investigations. He also proposed the likelihood of two different source regions for the two macroscopically and microscopically differing types; however, to date they have not been located. This may be due to the fact that the deposits were entirely exploited already during prehistoric times, or that they may not be accessible anymore for various reasons, or that they have simply not yet been found (Kostov 2013; Kostov 2018). One particularly intriguing question concerns the predominant use of nephrite in the Balkan region compared to a dominance of jadeite in the Eastern Mediterranean, including Western Anatolia: an issue that requires further detailed studies. An ongoing project with Bulgarian collaborators focusing on central and eastern Balkan nephrite is expected to shed new light on the potential nephrite sources in the wider region¹⁵.

Serpentinite

Regarding serpentinite distribution and use, and specifically the early stages of the underlying networks, research is still in its incipient stages. It is therefore not possible to draw any conclusions, and we are only beginning to understand the significance of materials visually corresponding to what we term »green stone axes« in the context of the processes of Neolithisation.

Chisel-like adzes, carpentry, house construction, and exchange networks of green stones: New components of the »Neolithic package«?

This research puts the spotlight on three entangled phenomena emerging during the processes of Neolithisation, which must be approached in forthcoming investigations¹⁶:

- 1) The most important outcome of this study is the potential for the inclusion of adzes into the Neolithic package as a distinct component next to polished axes.

Following their invention in the Pottery Neolithic, beginning approximately in 7000 BC in the core area of the Neolithisation, adzes were regularly included in the Neolithic toolkit; from here, this specific tool was then transmitted with the Neolithic dispersal to Western Anatolia together with other components of the Neolithic Package.

In some regions of the core area of the Neolithisation, adzes and chisel-like adzes seem to gradually replace axes in the Pottery Neolithic of the 7th millennium BC (Barkai 2005; Barkai 2011), but the state of research does not allow for a clearer picture at this moment. Chisel-like adzes are attested in Western Anatolia at the earliest around 6700 BC at Çukuriçi Höyük and continued to be used in the Late Neolithic layers of the site (6500–6000 cal BC). They are also attested at Early Neolithic Fikir Tepe (Özdoğan 2023) and at the later phases in Hacilar, Mersin, and Troy (Sugaya 2012), suggesting a widespread technological tradition in Southwest Asia.

Possibly through different pathways, via the Aegean and through North-western Anatolia (Özbek 2011; Reingruber 2011), the technological innovation was transmitted to Southern Europe (to Crete, coastal Greece, Bulgaria, and Serbia, starting around 6700–6000 BC), where it is attested during the Early Neolithic, and later in the Middle and Late Neolithic up to the Chalcolithic, where adzes are well-represented in the toolkit (Antonović 2014). Here, a combined contextual and diachronic study of tool assemblages with use-wear analyses could provide more insights into the social and economic role of these tools in the Southeastern European Neolithic. Most probably, Europe's first specialised carpenters can be located in the Neolithic of Southeastern Europe.

- 2) The introduction of this specific tool was probably related to changes in Late (Pottery) Neolithic house construction. Although both experiments and use-wear are only indicative for the functional interpretation as carpentry tools, there is some evidence of their development in relation with the use of timber joints in house construction. Already some PPNA–PPNB Neolithic sites have evidence of impressions of rectangular beams with worked surfaces, such as Çayönü, Diyarbakır province, Türkiye

15 For further information on the research project »Crossing the Neolithic Balkans. New approaches to green amulets«: <<https://www.oeaw.ac.at/oeai/forschung/praehistorie-wa->

na-archaeologie/prehistoric-phenomena/crossing-the-neolithic-balkans» (02.08.2024).

16 Ongoing project led by L. Dietrich.

Fig. 13 Vessel with depiction of houses from Domuztepein Domuztepe, Kahramanmaraş province, Türkiye.

Abb. 13 Gefäß aus Domuztepe mit Darstellung von Häusern, Provinz Kahramanmaraş, Türkei.

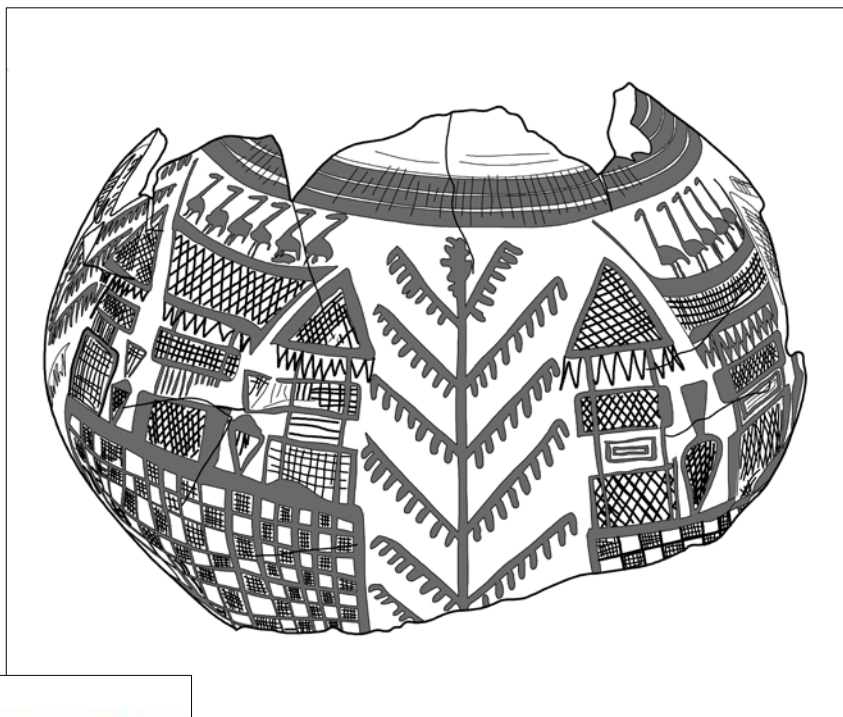


Fig. 14 Possible reconstruction of a chisel-like adze and its handling.

Abb. 14 Mögliche Rekonstruktion eines meißel-artigen Beils mit dazugehörigem Schaft.



(Bıçakçı 2003, 390 Footnote 8), Jericho, Jericho governorate, Palestine (Kenyon 1981, 225), Beidha, Ma'an governorate, Jordan (Kirkbride 1984, 10), and Hacilar, Kayseri province, Türkiye (Mellaart 1970, 17 House P.1; Pl. 9/9; Pl. 58/7), which could be early evidence for timber joints using rectangular beams (especially at Beidha, where two rectangular beams have been found lying across each other: Kirkbride 1968, 92), or at least for the idea of working levelled surfaces on beams as elements for house construction. Possibly, the large-scale introduction of the chisel-like adzes during the Late Neolithic is an indication

of the large-scale change to more stable timber joints in house architecture. The representation of houses on a Late Neolithic (Halaf Culture, c. 5800–5000 BC) vessel from Domuztepe, Kahramanmaraş province, Türkiye where such elements are clearly depicted (Fig. 13; Carter 2012, 112 Fig. 10a–b), could be considered clear evidence in spite of the otherwise poor preservation of the archaeological record.

Following this line of thought, we could ask ourselves to what extent the transmission of technologies and related practices in house construction were integrated into the local communities in Western Anatolia, the Mediterranean, and Southeastern Europe as a key concept of the Neolithic home and of household societies.

3) The development of regional and supra-regional exchange networks of particular raw rock materials related to the production of HCTs and chisel-like adzes. The emerging evidence indicates a more complex jadeite and nephrite distribution network than previously assumed, involving more than one »master source« and, consequently, a more interconnected web of highly mobile agents in this socioeconomic framework (Horejs 2024). It is conceivable that materials with particular properties such as enhanced durability when compared to other rocks and with additional aesthetic characteristics gained importance beyond their primary utilitarian function. Implements manufactured from such special materials as jadeite and nephrite may thus have gained symbolic value and been symbolically charged (e.g., Skeates 2002). This might also explain why they were heavily reworked and recycled into other types and tools, sometimes at the lowermost limits of usability, rather than using such tools made from other types of rock.

Our future research¹⁷ will focus on these topics. We are planning to carry out functional research on axes and adzes in several more Neolithic assemblages in the two regions, in addition to our focus on the experimental production (Fig. 14) and use of greenstone adzes in light of their role in Neolithic architecture and technologies. Our second research question is linked to the geological determination of the so-called greenstone in the archaeological assemblages of the Balkans and Western Anatolia, a question with large potential.

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Authors contributions:

Laura Dietrich: direction and development of the study, conception and writing of the manuscript and conception of the figures, design of the documentation methods and

documentation, functional analyses and the conducting of the experiments.

Barbara Horejs: direction of the excavation projects from Çukuriçi Höyük and Svinjarička Čuka, organisation of the data repository, creation of stratigraphy, dating and contexts, and comments on the text.

Mario Börner: documentation of the finds, comments on the text, design of the map with Laura Dietrich.

Michael Brandl: participation in the experiments, writing on the exchange networks, comments on the text and English proofs.

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Source of Figures

- 1 after Horejs 2017, Fig. 1,2;
photo: N. Gail, OeAI-OeAW
- 2 N. Gail, OeAI-OeAW
- 3 <<https://defc.acdh.oeaw.ac.at/cukurici-movie/>> (28.06.2024);
Lužnik-Jancsary et al. 2020, 68 Fig. 3.
- 4 photos: N. Gail, OeAI-OeAW; compilation: L. Dietrich
- 5 photo: left N. Gail, OeAI-OeAW
left and right L. Dietrich
- 6 photo: D. Hirako, OeAI-OeAW
- 7 photo: A. Galik, OeAI-OeAW
- 8 photo: above D. Hirako, OeAI-OeAW; below A. Haro, OeAI-OeAW
- 9 photos: N. Gail, OeAI-OeAW; compilation: L. Dietrich
- 10 photos: L. Dietrich, and D. Wieser, OeAI-OeAW; compilation: L. Dietrich
- 11 photos and compilation: L. Dietrich
- 12 Çiğdem Atakuman, METU Ankara
- 13 L. Dietrich; M. Börner, OeAI-OeAW; B. Horejs, OeAI-OeAW;
- base map: Jarvis A., H. I. Reuter, A. Nelson, E. Guevara, 2008, Hole-filled seamless SRTM data V4, International Centre for Tropical Agriculture (CIAT), available from <<https://srtm.csi.cgiar.org/>> (29.07.2024)
- 14 photos: 1, 2 and left L. Baunack, MLU Halle-Wittenberg; 3, below L. Dietrich

Addresses

Laura Dietrich
Martin-Luther-University Halle-Wittenberg
Emil-Abderhalden-Str. 26–27
06108 Halle (Saale)
Germany
ORCID: 0000-0002-7570-0576
laura.dietrich@praehist.uni-halle.de

Mario Börner,
Austrian Archaeological Institute
Austrian Academy of Sciences
Dr. Ignaz-Seipel-Platz 2
1010 Vienna
Austria
ORCID: 0000-0002-7601-3487
mario.boerner@oeaw.ac.at

Michael Brandl
Austrian Archaeological Institute
Austrian Academy of Sciences
Dr. Ignaz-Seipel-Platz 2
1010 Vienna
Austria
ORCID: 0000-0002-0214-8231
michael.brandl@oeaw.ac.at

Barbara Horejs
Austrian Archaeological Institute
Austrian Academy of Sciences and HEAS/UHA
University of Vienna
Dr. Ignaz-Seipel-Platz 2
1010 Viennay
Austria
ORCID: 0000-0002-4818-6268
barbara.horejs@oeaw.ac.at