Dolsko – Spodnje Škovce and a new insight into the settlement, chronology, ceramic style(s), and subsistence strategies of the Late Neolithic Sava group in Slovenia

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ABSTRACT - *Radiocarbon dates, analysis of ceramic finds, animal bones, fruits/seeds and wood (charcoal) from settlement features of the Sava group of the Lengyel Culture at the site of Dolsko – Spodnje Škovce in central Slovenia are presented and discussed in this paper. The aim of the study was to place the excavated material culture in its regional and supra-regional context in order to improve the understanding of Late Neolithic settlement features, chronology, pottery style(s) and subsistence strategies in settlements throughout the area of distribution of the Sava group. This is the first synthesis of archaeobotanical and archaeozoological data from the 5th millennium cal BC sites in Slovenia, including the evaluation and comparison of plant macro-remains and animal bones, and the first synthesis of data on technological and typological aspects of pottery production in the settlements obtained using the same analytical approach. Uncertainties regarding the chronology of different variations of a pottery style and subsistence strategies are emphasized.*

KEY WORDS – *Slovenia; Late Neolithic settlement; Sava group of the Lengyel Culture; radiocarbon dating; pottery analysis; archaeobotany; archaeozoology*

Dolsko – Spodnje Škovce in nov vpogled v poselitev, kronologijo, keramični stil ter strategije preživljanja v času poznoneolitske savske skupine v Sloveniji

IZVLEČEK – *V prispevku so predstavljeni in obravnavani radiokarbonski datumi, analiza keramičnih najdb, živalskih kosti, plodov/semen in lesa (oglja) iz naselbinskih struktur savske skupine lengyelske kulture na najdišču Dolsko – Spodnje Škovce v osrednji Sloveniji. Namen študije je umestiti materialno kulturo v njen regionalni in nadregionalni kontekst, da bi izboljšali naše poznavanje poznoneolitskih naselbinskih struktur, kronologije, keramičnega stila in strategij preživljanja na naselbinah na območju celotne razprostranjenosti savske skupine. Gre za prvo sintezo arheobotaničnih in arheozooloških podatkov z najdišč iz 5. tisočletja pr. n. št. v Sloveniji, v katero je vključeno vrednotenje in primerjava rastlinskih makroostankov in živalskih kosti, ter prvo sintezo podatkov o tehnoloških in tipoloških vidikih poznoneolitskega lončarstva na naselbinah, ki so bili pridobljeni z uporabo enakega analitičnega pristopa. Izpostavljene so negotovosti glede kronologije različnih variacij keramičnega stila in glede strategij preživljanja.*

KLJUČNE BESEDE – *Slovenija; poznoneolitska naselbina; savska skupina lengyelske kulture; radiokarbonsko datiranje; analiza keramike; arheobotanika; arheozoologija*

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Introduction

The Late Neolithic in the south-eastern Alpine region has many similarities with the contemporaneous settlement in the Pannonian Basin, but the subsistence strategies, ceramic style(s), households and chronology are comparatively poorly known. This study brings new analyses of ceramic finds, animal bones and plant remains, as well as six radiocarbon dates from two pits of the Sava group of the Lengyel Culture at the site of Dolsko – Spodnje Škovce in central Slovenia. The samples of cattle teeth and charcoal are dated and provide a basis for discussing the uncovered material culture in the context of regional and supra-regional development. The possible use of large, irregularly shaped pits is discussed on the basis of the excavation results, the distribution and composition of the finds, and comparisons with contemporaneous and culturally related settlements. The technological and typological aspects of ceramic production were compared with those reported previous studies and the results evaluated. We also evaluated new radiocarbon measurements in the context of 5th millennium cal BC ceramic sequences in central Slovenia, while archaeozoological and archaeobotanical analyses were used to discuss subsistence strategies and environmental conditions in settlements located in different micro-regions.

Late Neolithic in the south-eastern Alpine region

The material cultures of the south-eastern Alpine Late Neolithic and the Early Copper Age have long been regarded as a single chronological phase, probably because the Late Neolithic pottery here has many similarities with the later Lasinja Culture pottery, and because finds from both periods have often been found mixed together (*e.g., Korošec 1956; 1960; 1964; 1965; 1975; Pahič 1976*). The fact that the oldest settlement dates to the first half of the 5th millennium BC was finally recognized in the 1980s with the research carried out at Moverna vas (*e.g., Budja 1992; 1994; 1995*) and at Gradec near Mirna (*Dular* et al. *1991.84–90; 2001*). At both sites, several Neolithic and Copper Age occupation layers were uncovered in a vertically stratified position. The earliest settlement was dated to the Late Neolithic, associated with the Lengyel Culture and the following to the Early Eneolithic/Copper Age and associated with the Lasinja Culture. Both sites were excavated during research projects, the results of which clearly showed that lowland river terraces and the hills were settled, with at least some of the hilltops surrounded by stone walls.

In 2002, on the occasion of the newly discovered settlements Čatež – Sredno polje and Dragomelj, the Sava group of the Lengyel Culture was introduced as "*a cultural phenomenon that was spread in the Sava River basin between Kranj (NW Slovenia) and Karlovac (NE Croatia)*" (*Guštin 2002; 2005; Guštin, Bekić 2002*). All Late Neolithic sites in the south-eastern Alpine region around the river Sava were included in the newly established group, but not the settlements in NE Slovenia and the Bela krajina region (Fig. 1). It was argued that the pottery at the Sava group sites was mostly made of medium-grained fabrics, rarely coated with coloured clay slip, and most often decorated with impressions, the rest with appliqués and incised decoration (*Guštin 2005.9–12*). In contrast, it was emphasized that the pottery from NE Slovenia is mostly decorated with appliqués, and the pottery from Bela krajina with incised decoration or in a combination of incised decoration and impressions, and most often made of fine- and very fine-grained fabrics, but more often coated with a coloured clay slip. Furthermore, it has been suggested that large pits represent traces of pit-houses or places of residence, and based on the radiocarbon measurements the settlement has been chronologically correlated with the Lengyel II phase in Transdanubia (*Guštin 2005.13; Guštin* et al. *2005.104*).

Twenty years after the recognition of the Late Neolithic Sava group, possible earlier Neolithic settlements (from the Early or Middle Neolithic) in the area of distribution of the Sava group are still unknown. Traces of above-ground, timber-framed houses are known only from two Late Neolithic sites in the wetlands of Ljubljansko barje (*Korošec 1964; Velušček 2006; Velušček* et al. *2023*) and large irregular pits at other sites are assumed to represent the remains of pit-huts (*e.g., Ravnik, Tica 2018.39; Tomaž 2022.25–27; Turk* et al. *2022.332*). Subsistence strategies in the Late Neolithic are also poorly known. Archaeobotanical and archaeozoological data are available from only a few Late Neolithic settlements, mostly with a small number of identified plant and animal remains (*e.g., Culiberg* et al. *1992; Toškan 2018; 2022; Tolar 2021.109–110; Hincak 2022; Kramberger* et al. *2023.69–71*). Moreover, the chronology of the Late Neolithic in Slovenia is less well established. According to one theory, the Sava group was contemporaneous with the Lengyel II (*Guštin 2005*) or even Lengyel I (*Tomaž 2022.105*) phase in Transdanubia, while others proposed that the sites are younger, contemporary with the Lengyel III phase (*Velušček 2006; 2011*), according to the Hungarian chronology of Nandor Kalicz (*1969; 1976*) and Pal Ra-

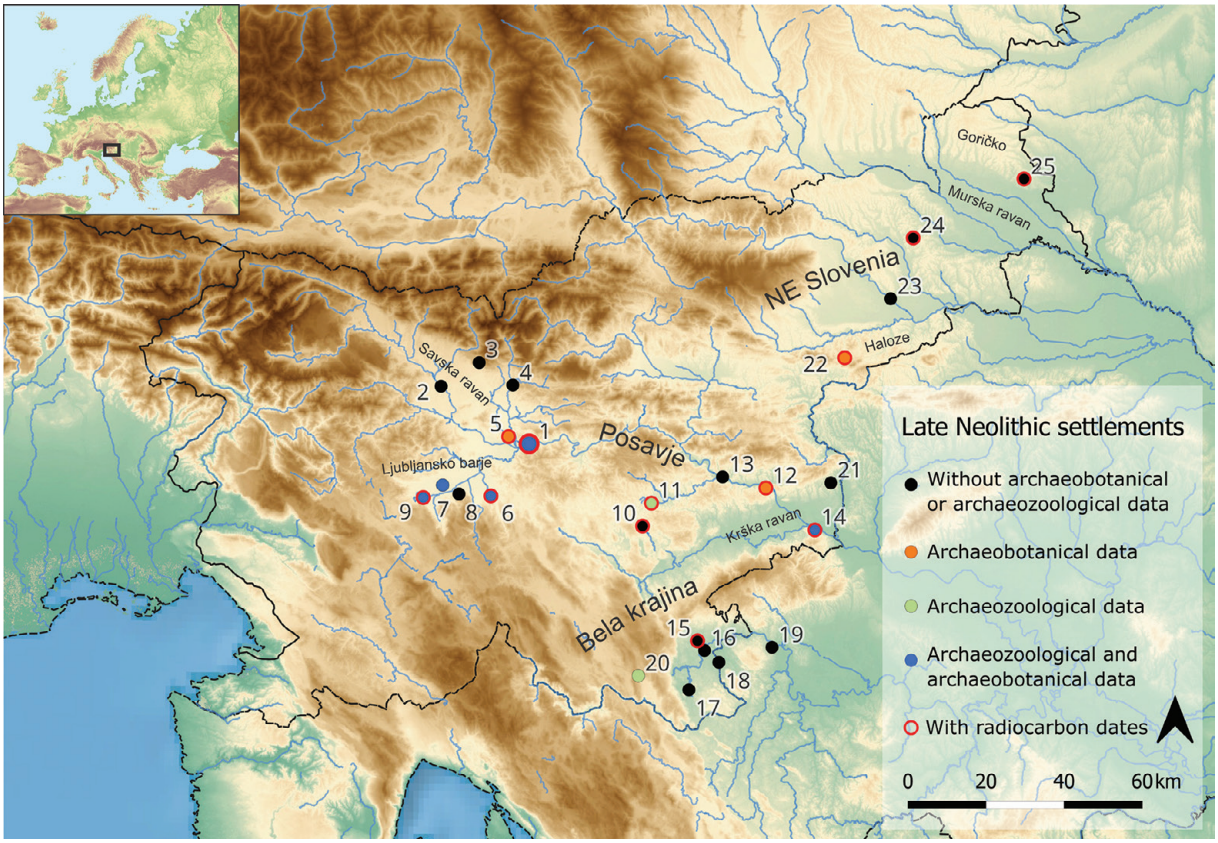

Fig. 1. Most important sites of the Sava group and Late Lengyel Culture in Slovenia and near Karlovac:* 1 *Dolsko – Spodnje Škovce,* 2 *Drulovka near Kranj,* 3 *Gradišče near Stiška vas,* 4 *Kamnik – Mali grad,* 5 *Dragomelj,* 6 *Resnikov prekop,* 7 *Zamedvedica near Plešivica,* 8 *Sv. Lovrenc,* 9 *Verd,* 10 *Ponikve near Trebnje,* 11 *Gradec near Mirna,* 12 *Dolenji Leskovec,* 13 *Sevnica,* 14 *Čatež – Sredno polje,* 15 *Moverna vas,* 16 *Gradac – Grajski park,* 17 *Pusti gradec,* 18 *Griblje,* 19 *Ozalj – Stari grad,* 20 *Spaha,* 21 *Podgorje near Pišece,* 22 *Stoperce,* 23 *Ptujski grad and Ptuj – Šolski center,* 24 *Andrenci,* 25 *Bukovnica.

czky (*1974*), which is mainly based on Pavúk's classification (*Pavúk 2007;* see also *Osztás* et al. *2016.197*). The main problem for chronological research on the Ljubljansko barje is the small number of piles from the 5th millennium cal BC and the use of timber taxa (*e.g., Alnus, Salix*), which are not suitable for dating with the help of the *Quercus/Fraxinus* reference (dendro) chronology, which has so far been established mainly for sites from the 3rd and 4th millennium cal BC (Fig. 1.6,9) (*Čufar* et al. *2010; 2022*), while in the case of other studies the research approaches used had their own risks and weaknesses. One of these studies was a typological analysis of ceramics and an attempt to correlate them with the Lengyel Culture sites (*Veluščekk 2006; 2011*), while other studies drew conclusions based on a comparison of radiocarbon dates with the same culture (*Guštin 2005; Sraka 2012.369–370; Tomaž 2022.105*). The first approach is not ideal, because the sites of the Sava group have a specific material culture, which does not correspond entirely to the Lengyel pottery (*e.g.,* no painting). On the other hand, the comparison of radiocarbon dates is also less than ideal, because radiocarbon dating can provide only a limited time resolution, and because dating in Slovenia is based on long-lived material (charcoal) and on dates from charred organic residues on the pottery, *i.e.* samples that have given unexpected results, probably also due to issues such as the 'old wood effect', the 'marine reservoir affect' and the 'hard water effect' (*Mlekuž* et al. *2013.132–133; Hlad 2015.13–14; Kramberger* et al. *2023, 55–68; cf. Oross* et al. *2010.392–398; Nowak* et al. *2017.189*).

Some attempts to comprehensively compare and evaluate the variability of the pottery at the Sava group sites were published in 2014 and 2020 (*Kramberger 2014; 2020*). Three groups of sites could be identified based on the similarities and differences in ceramics (Sava group Ia-b, II). However, due to the limited number of samples from short-lived materials, it was not possible to fully explain the pottery variability. The research conducted at the Dolsko site yielded new ^{14}C

AMS dates and a rich pottery assemblage, animal remains and some plant macro-remains from stratigraphically well-documented contexts. These data enabled us to conduct archaeobotanical and archaeozoological analyses, to analyse ceramics and to evaluate results in the context of the aforementioned research problems in Slovenian Late Neolithic Archaeology.

Dolsko – Spodnje Škovce: excavation, Late Neolithic settlement features

The archaeological site is located 5.56km southeast of the Late Neolithic settlement of Dragomelj (Fig. 1.5), at the edge of a second river terrace of Sava, which is between 2 and 3m high. It is located close to the Mlinščica stream (Figs. 1.1 and 2.1,2), and it is a known site of the Sava group of the Lengyel Culture, Middle Copper Age, Bronze Age and Early Medieval period, documented with several short reports (*Žorž Matjašič 2009; Žorž 2009; Žorž, Nadbath 2010*). Meanwhile, a monograph of the site is in progress, which includes the finds from all periods, including the stone tools and implements from the Late Neolithic and Copper Age (*Kramberger in preparation*). These finds are not the subject of the following study.

Nearby, 1.62km southwest of the site, there is a confluence of three major rivers. The Sava River flows from the northwest, the Ljubljanica River flows into it from the southwest, and the Kamniška Bistrica from the north (Fig. 1.1). Based on the results of archaeological excavations, both the Sava River and smaller streams shifted their beds throughout history until they were artificially regulated at the end of the 18th and in the 19th centuries, partly for economic reasons and partly for safety reasons due to frequent flooding. In both excavation areas (areas 1 and 2), several paleochannels were found, which flowed in different periods in a northwest-southeast direction and are not shown on the first or later military maps of the Habsburg Empire from the 18th and 19th centuries, each with a sequence of alluvial deposits, often containing archaeological finds from various periods (Fig. 2.3,4).

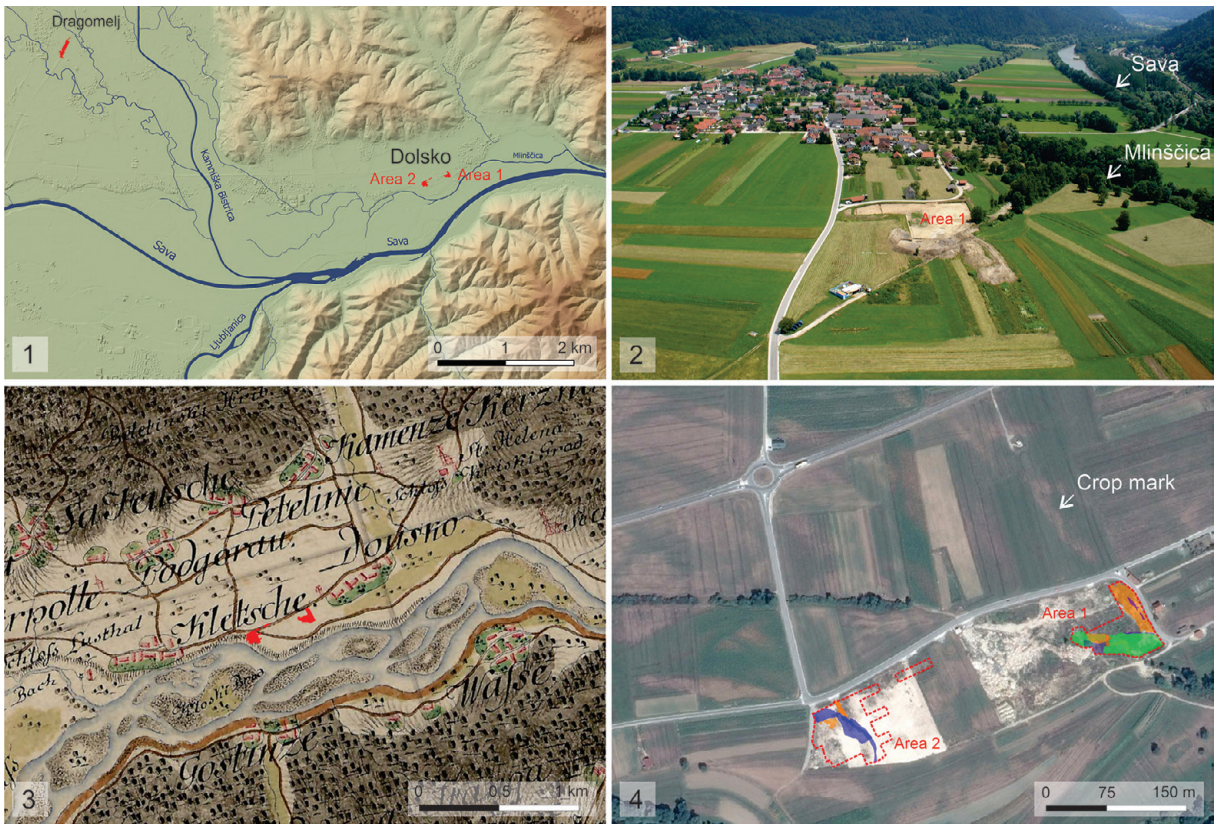

Fig. 2. Dolsko – Spodnje Škovce.* 1 *Location of the excavated areas (sources: ARSO, Lidar 2014; GURS, Hidrografija 2020; GURS, REZI 2019);* 2 *view on Area 1 from the west during excavation, with the Sava River in the background and Mlinščica stream in the foreground (photo: Matija Lukić);* 3 *the area on the map of Maria Theresa's "*First Military Survey*", 1784–1785 (source: Arcanum);* 4 *satellite map with paleochannels, alluvial deposits (blue, orange) and a large alluvial depression (green) discovered during the excavation (*Google Maps*).

From the shape of the Sava gravel discovered at the bottom of a large depression below the uncovered former edge of the river terrace, it can be concluded that the Sava River flowed close to the settlement in the Late Neolithic (see also *Žorž, Nadbath 2010*). During this period, a layer was deposited on the edge of a terrace, probably a buried soil, as evidenced by its consistency, colour and the finds discovered (Fig. 3. 1026, 1020,1013). In later periods the Sava and smaller watercourses deposited younger sediments along the edge of the Sava terrace and the river gradually moved southwards, with this process, based on the finds, being most intensive in the Late Bronze Age. Finally, in the 19th century, the river moved to the southern edge of the valley and soon after the Mlinščica stream was artificially diverted from the nearby Kamniška Bistrica River into the former dead arm of the Sava for use by watermills and later power plants (Fig. 2.1,2; *cf.* Fig. 2.3).

Two larger Late Neolithic pits and 12 smaller Late Neolithic pits ranging in size between 0.74x0.74m and 4.02x1.10m were found during the rescue excavations in 2008, most of them in Area 1 (Fig. 3). Traces of Late Neolithic posts in ground structures were not discovered, although several post holes were found, all but one of which proved to be later based on finds and their stratigraphic positions.

The most interesting Late Neolithic features are two large pits (1 and 2), interpreted in the first publications as the sunken floors of buildings, which yielded most of the pottery from the site. They were connected by a thin layer of darker soil, with a linear layout, interpreted as a path between houses (Figs. 3.202,75 and 4) (*Žorž Matjašič 2009; Žorž, Nadbath 2010*). However, this layer could also have been formed naturally by the erosion and deposition of material from the northwest. This is suggested by the ground plan and orientation of the layer, which matches the orientation of another layer, yellowish-brown alluvial deposit (SU 21), found beneath it (Figs. 3.21 and 4). The latter may be associated with the clearly visible crop mark to the north of the site (Fig. 2.4), and one of the paleochannels documented in the section of trial trench at the north-eastern edge of Area 1. The fragments of a single pot were found scattered in both large pits (SUs 200, 148), suggesting that the pits were partially filled with the same material (Fig. 3).

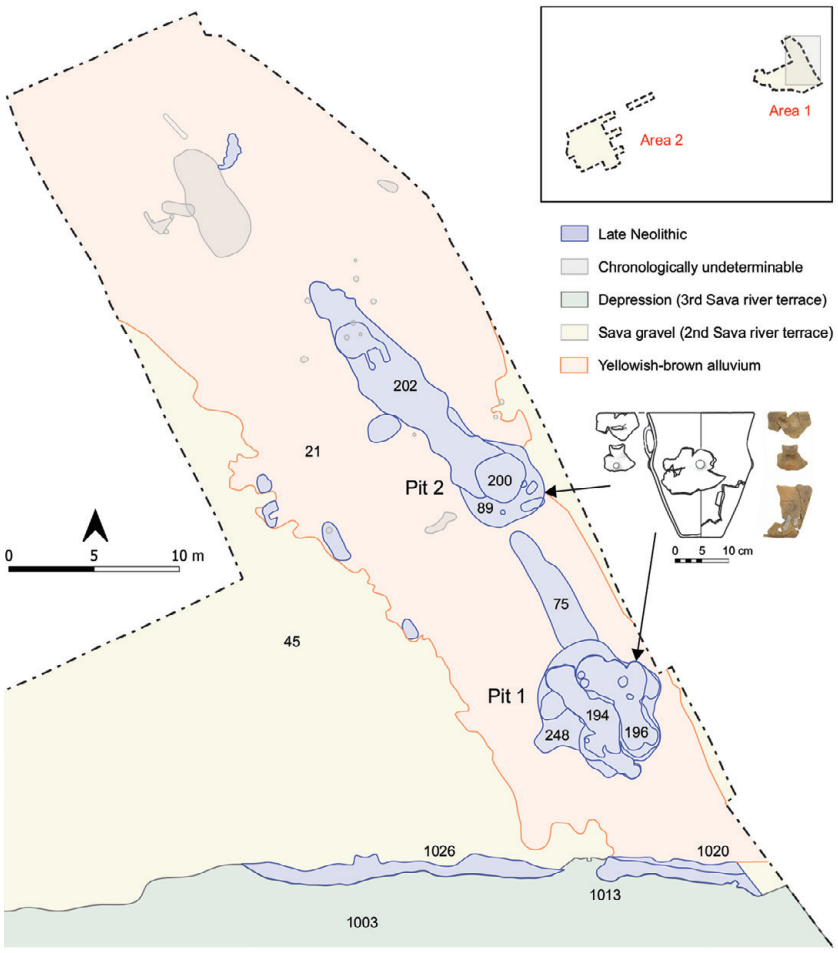

Fig. 3. Dolsko – Spodnje Škovce. General plan of the eastern part of Area 1 with the Late Neolithic pits and alluviums.

Late Neolithic pits 1 and 2 were found below the topsoil (SUs 1, 34) and were dug into the above mentioned light yellowish-brown alluvium, soft and malleable silty clay (Fig. 3.21), deposited in the Holocene over the older alluvium, the Sava gravel (Figs. 3.45 and 4), of either Late Pleistocene or Early Holocene age. The larger of the two features, pit 1 (SU 248 = a cut feature), measured 11x7m in size and yielded 6282 pottery fragments, or almost 40% of the total prehistoric pottery recovered at the site. It was irregular in shape (in plan and sections) and appeared as a complex of several smaller pits filled with three layers (SUs 113, 148, 194 = 196), each containing pottery frag-

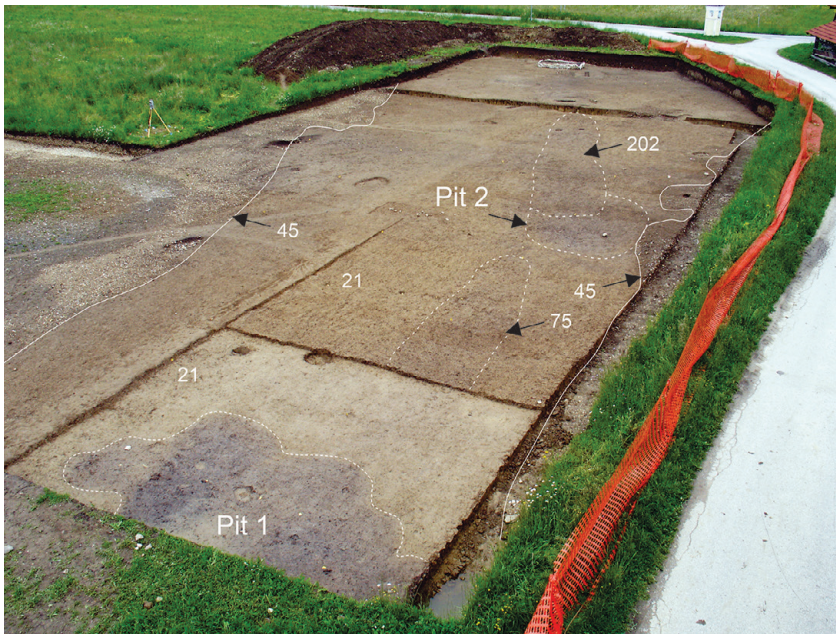

Fig. 4. Photo from the south-east on the pits 1, 2 and alluviums in the Area 1 during excavation.

ments, stone tools, flakes, animal remains, burnt clay and charcoal. Small concentrations of charcoal (SU 192, size 0.4x0.1m; SU 244, size 0.49x0.37m, 0.02m thick), possibly the remains of hearths, were also found (Figs. 5–6).

The pottery was fragmented and it can be observed that parts of individual vessels were scattered across layers in different stratigraphic positions (see Figs. 5–6). Fragments of two pots (G33, G34) were found in two different pits excavated at the bottom of the large pit and in the layer above (SUs 148, 194, 196). Fragments of two dishes (G11, G15), two pots (G37, G161) and a ladle (G58) were found in layers SU 194 and SU 148 above it. Parts of another pot (G171) and a dish (G149) were discovered in layers SUs 113 and 148. In addition to these cases, fragments of several other individual vessels were found scattered, but within the same layer (*e.g.,* G13, G29, G38, G57, G77, G81), some uncovered up to 4.5m apart (G26, G34; Fig. 6).

Pit 2 (SU 90) was discovered to the north of pit 1. It was oval in ground plan, and smaller (3.5m long). Shallow pits were found on its bottom, and a small pit of circular ground plan, probably the only Late Neolithic posthole at this site, was found close to its edge. Stone flakes, stone tools, fragments of burnt clay, animal remains and charcoal were discovered in two different fills of the pit, as well as 627 ceramic fragments: 170 in SU 200/201, which covered only the deepest part of the pit and 457 in SU 89/90 above it (Fig. 3.89,200).

Ceramic finds

A total of 6923 pottery fragments were found in pits 1 and 2, which places it among medium-sized Late Neolithic pottery assemblages from Slovenia. More pottery is only known from Čatež – Sredno polje (more than 57 000 fragments; *Tomaž 2022.34*). At the nearby Dragomelj 4256 ceramic fragments were found (*Turk, Svetličič 2022.36*), 3612 at Ponikve near Trebnje (*Ravnik, Tica 2018.59*), 1186 in SU 128 in Stoperce (*Kramberger* et al. *2023. 93*) and at Dolenji Leskovec 5379 in the only studied pit so far (*Hlad 2015.15; cf. Klasinc* et al. *2010; Jovanović* et al. *2012*). At Moverna vas and Resnikov prekop many pottery fragments were also found, and 3173 from the total assemblage at Moverna vas (*Tomaž 1997.116*) and 951 from Resnikov prekop were analysed (*Tomaž, Velušček 2005.89*). At other sites, pottery finds are fewer or the data on the quantity of ceramic fragments are not available (*e.g., Korošec 1960*).

After assembling the fragments, 215 typologically characteristic pieces of Late Neolithic ceramics from Dolsko were selected for publication (*Kramberger in press*). The typological classification was based on the author's own typology (*Kramberger 2014*; *2020*), while the pottery production methods were described using macroscopic standards (after *Horvat 1999*) and the results are presented here for the first time. Only the most relevant findings are shown graphically in the continuation of this text, labels mentioned (*e.g.,* G33, G34, G36) are from the catalogue included in the monographic publication of the site (*Kramberger in press*, G1–G511) and consequently do not follow each other sequentially. Technological macroscopic analysis was conducted on all Late Neolithic typologically characteristic ceramic fragments (No. 215), while the percentages of decoration techniques are calculated based on typologically characteristic fragments with decoration (No. 104).

It can be established that the Late Neolithic pottery contained quartz, mica and iron oxides, which are common inclusions in ceramic bodies in the region

and beyond. However, there are obvious differences in the size and frequency of the quartz grains, which are thought to have been added to the clay as an additive (sand tempering). In most cases, Late Neolithic pottery consisted of very fine-grained (43% – no temper) and fine-grained (36% – less temper) fabrics, followed by medium-grained (20%) and coarse-grained fabrics (1%) (Fig. 7.1).

The surfaces of the vessels are matte and smooth and they were sponged before firing to remove irregularities. In some cases, thin parallel smooth lines are noticeable, indicating the use of a harder tool for surface treatment. 27% of the vessels were additionally coated with a coloured clay slip of red, brown, pink or yellowish red colour (Fig. 7.2).

Approximately 50% of typological significant pottery fragments show decoration: most often applied decoration (62%), followed by impressions (23%), combinations of applied decoration-impressions (8%), applied decoration-impressions-incised decoration (4%),

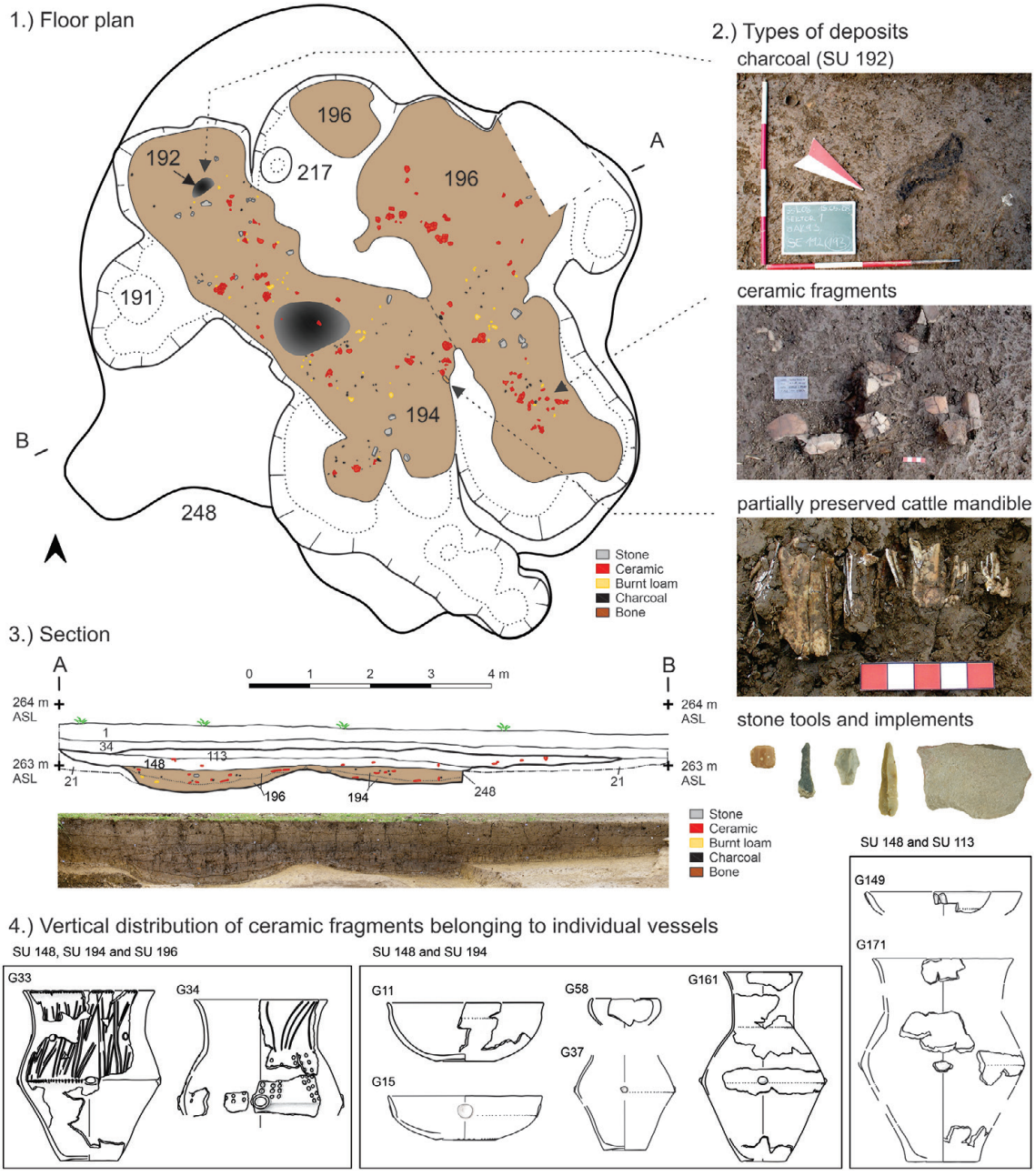

Fig. 5. Pit 1 (SU 248 = a cut feature). 1 Floor plan, 2 types of the deposits, 3 section, and 4 vertical distribution of pottery fragments belonging to individual vessels. Labels for the finds (e.g., G33…) are taken from the monographic publication of the site (Kramberger in press, G1–G511).

impressions-incised decoration (2%) and incised decoration (1%) (Fig. 7.3). Four pots, two pedestals and a small vessel with a grip attachment were decorated with incisions, other vessel types were in most cases only decorated with appliqués and/or impressions.

The firing atmosphere was fairly standardized. Pottery was generally fired under incomplete oxidizing conditions (93%), and a small amount in oxidizing (3%), reducing (3%) or oxidizing conditions with a reducing atmosphere at the end (1%).

The pottery assemblage includes pots, bottle-like vessel, pitchers, thin-walled vessels, pedestal dishes, dishes, bowls, ladles, a vessel with a grip attachment, vessels with zoomorphic/anthropomorphic grip, ceramic beads and a fired clay coil. The most common are pots (29.23%; Fig. 8.A), followed by dishes (13.51%; Fig. 8.F) and pedestal dishes (14.29%; Fig. 8.E). Just under a quarter (24.44%) are dishes or pedestal dishes (Fig. 8.G). Fragments of thin-walled vessels are also common (12.75%; Fig. 8.D), and pitchers could be reconstructed in two cases (1.20%; Fig. 8.C). Ladles are present in significant numbers (12.00%; Fig. 8.I), other types were rarer: bowls (2.44%; Fig. 8.H), a bottle-like vessels (0.59%; Fig. 8.B), ceramic beads (Fig. 8.G47–G52), a vessel with an attachment for a (wooden?) grip (Fig. 8.G57), fragments of vessels with anthropomorphic/zoomorphic grips (Fig. 8.G23, G118, G117), and a fired clay coil (Fig. 8.G123) (altogether 7.69%; Fig. 8.J). Vessels made of very fine and fine-grained fabrics (mostly dishes, pedestal dishes, pitchers, thin-walled

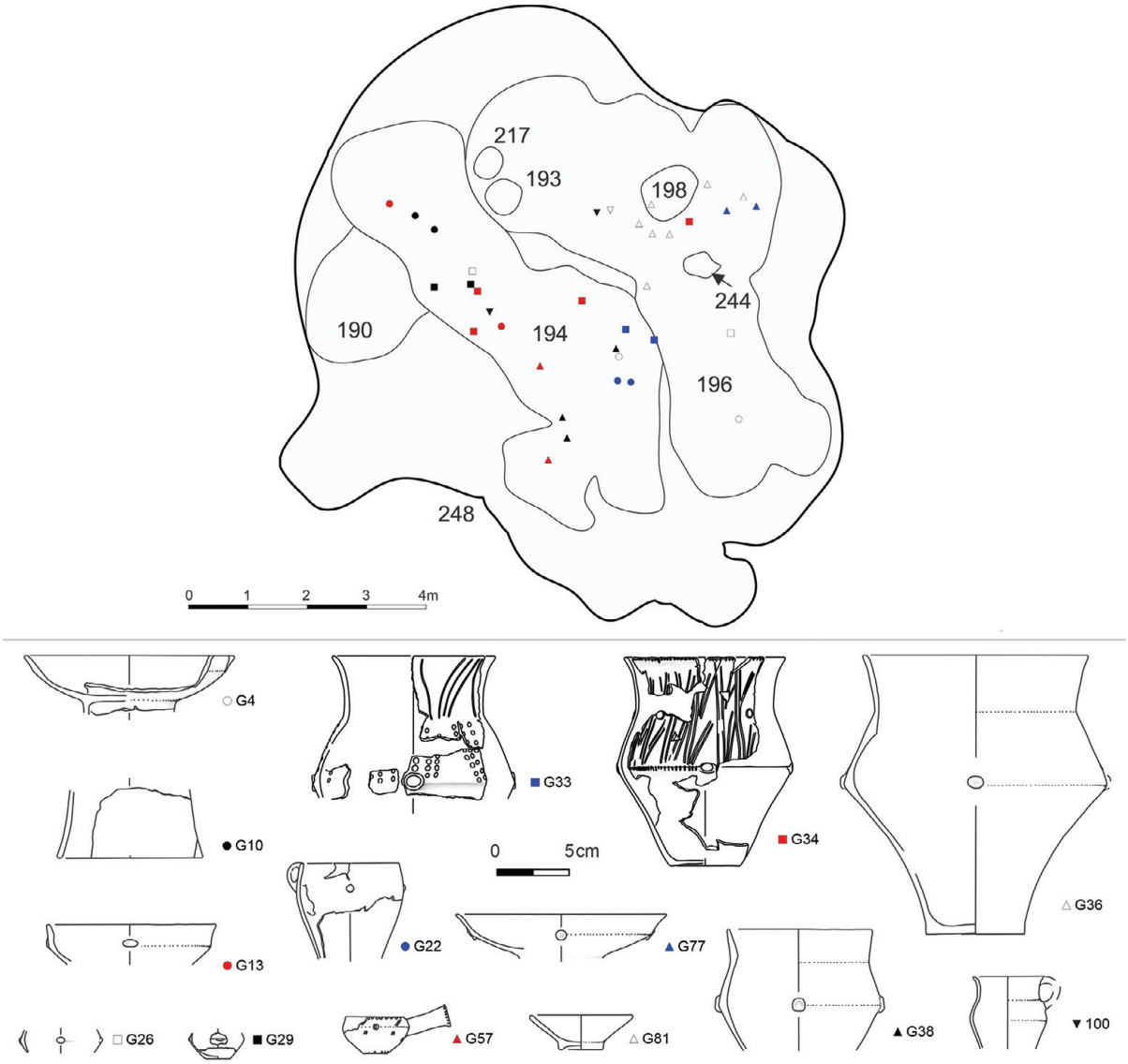

Fig. 6. Pit 1 (SU 248 = a cut feature). Horizontal distribution of ceramic fragments belonging to individual vessels. Labels for the finds (e.g., G4...) are taken from the monographic publication of the site (Kramberger in press, G1–G511).

vessels, and some bowls) usually have a surface of a uniform brownish or reddish colour, often coated with a colour clay slip. Most of the pottery with a significant amount of sand tempering (most pots and ladles) has no clay slip.

The pottery from Dolsko was typologically compared with pottery from other Late Neolithic sites and it was concluded that the pottery from Resnikov prekop, Dolenji Leskovec, Gradec near Mirna (phase 1), Moverna vas (phase 2) and Stoperce (SU 128), which are located in different parts of Slovenia, are the most similar (*Kramberger in press*; see also *Kramberger* et al. *2023*). The most chronologically relevant finds are pots with an everted neck of approximately the same length as the shoulder (Fig. 6.G33, G34, G36, G38; Fig. 8.G170, G38). They may have handles connecting the neck and the shoulder, or they may be without them As a rule, they were decorated with appliqués on the largest circumference, which is also typical for the pottery from Čatež – Sredno polje, nearby Dragomelj and Resnikov prekop (*Korošec 1964; Harej 1975; Velušček 2006; Tomaž 2022; Turk* et al. *2022*). The decoration can be complemented with impressions on the largest circumference and/or on the lip and with incisions spread over the neck and shoulder, and in the case of a pot from Dolenji Leskovec, extending into the lower part of the vessel (Fig. 9.Pot, type L7, Motif). Pots with ellipsoidal necks were found at the sites of Resnikov prekop, Dolenji Leskovec (see *Jovanović* et al. *2012.Tab. 5.5a, Tab. 22.22b*), Moverna vas (phase 2), Stoperce (SU 128) (Fig. 9.Pot, type L15/2) and others. Dishes and pedestal dishes with everted rims (Fig. 8.G1, G15, G80, G150) are decorated with appliqués (Fig. 9.Pedestal dish). In contrast, dishes with everted rim at Čatež – Sredno polje and Dragomelj are often decorated with appliqués and impressions on the transition to the rim and/or on the lip (*Tomaž 2022; Turk* et al. *2022*). Dishes with an everted rim decorated with impressions occur only occasionally at other sites: two at Dolsko (*Kramberger in press, finds 18 and 19*), one in the phase 2 at Moverna vas (*Tomaž 1999.Pl. 3.1*), one at Podgorje near Pišece (*Ciglenečki 1979.Fig. 3.1*) and one at Ptuj Castle (*Tomanič Jevremov* et al. *2006.find no. 2*).

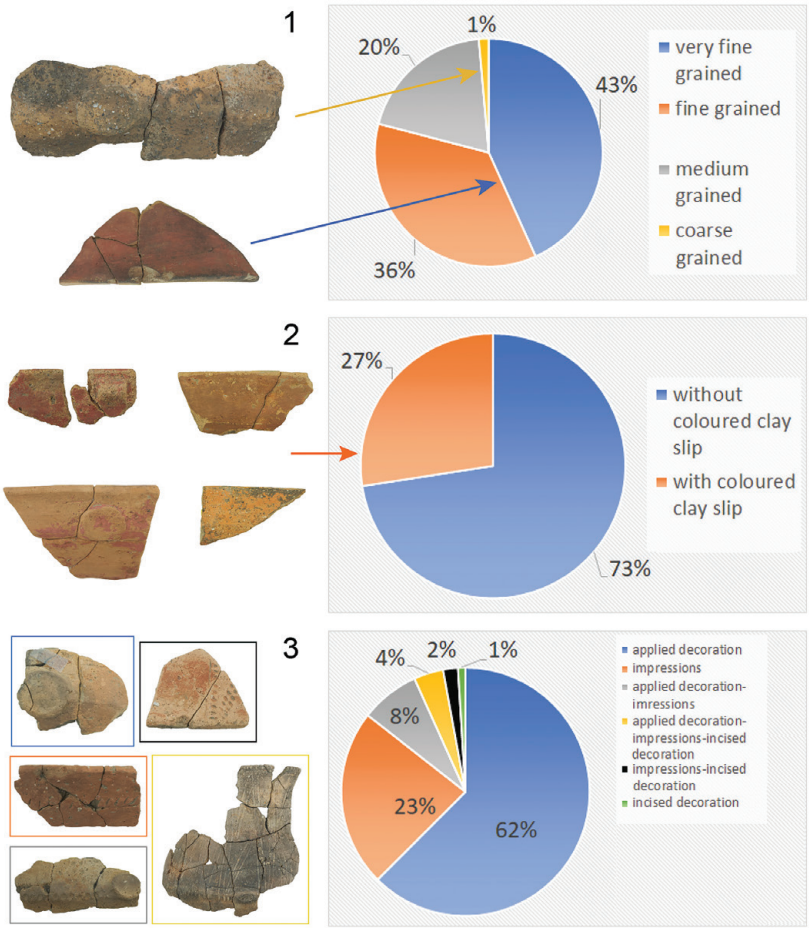

Fig. 7. Late Neolithic pottery from Dolsko – Spodnje Škovce.* 1 *Percentage of different granularity groups,* 2 *colour clay slip and* 3 *decoration techniques. Percentages of granularity groups and of colour clay slip are calculated on all Late Neolithic typologically characteristic ceramic fragments (No. 215), the percentages of decoration techniques on all typologically characteristic fragments with decoration (No. 104).

In addition, dishes and bowls with an inverted rim are found at Dolsko – Spodnje Škovce (Fig. 8.G92, G87) and Resnikov prekop, Dolenji Leskovec, Gradec near Mirna (phase 1), Moverna vas (phase 2) and Stoperce – SU 128, although in much smaller numbers (Fig. 9.Dish). These vessels are mostly decorated with small round appliqués on the maximum circumference. The ceramic assemblages at these sites are completed by pitchers, smaller vessels with a handle, which are also decorated with a round appliqué on the largest circumference and often coated with coloured clay slip (Fig. 9.Pitcher).

The pottery from Drulovka near Kranj (Fig. 1.2; *Korošec 1960*), Ponikve near Trebnje (Fig. 1.10; *Rav-*

nik, Tica 2018) and phases 4 and 5 at Moverna vas (Fig. 1.15; *Budja 1995; Tomaž 1999*) was found to be pronouncedly different (see *Kramberger 2014; 2020; Kramberger* et al. *2023*). Pots with short necks, usually cylindrical, rarely everted, predominate. Dishes and pedestal dishes with everted rim are present, but never decorated with appliqués, which is also characteristic of similar dishes at Col 1 near Podgračeno (*Horvat 2005; 2020*), Ajdovska jama (*Korošec 1975*) and Kranj – pit at Trubarjev trg (*Dolinar 2016*), where typical pottery of Lasinja Culture appears together with this Lengyel type (*e.g., Velušček 2006; 2011; Kramberger*

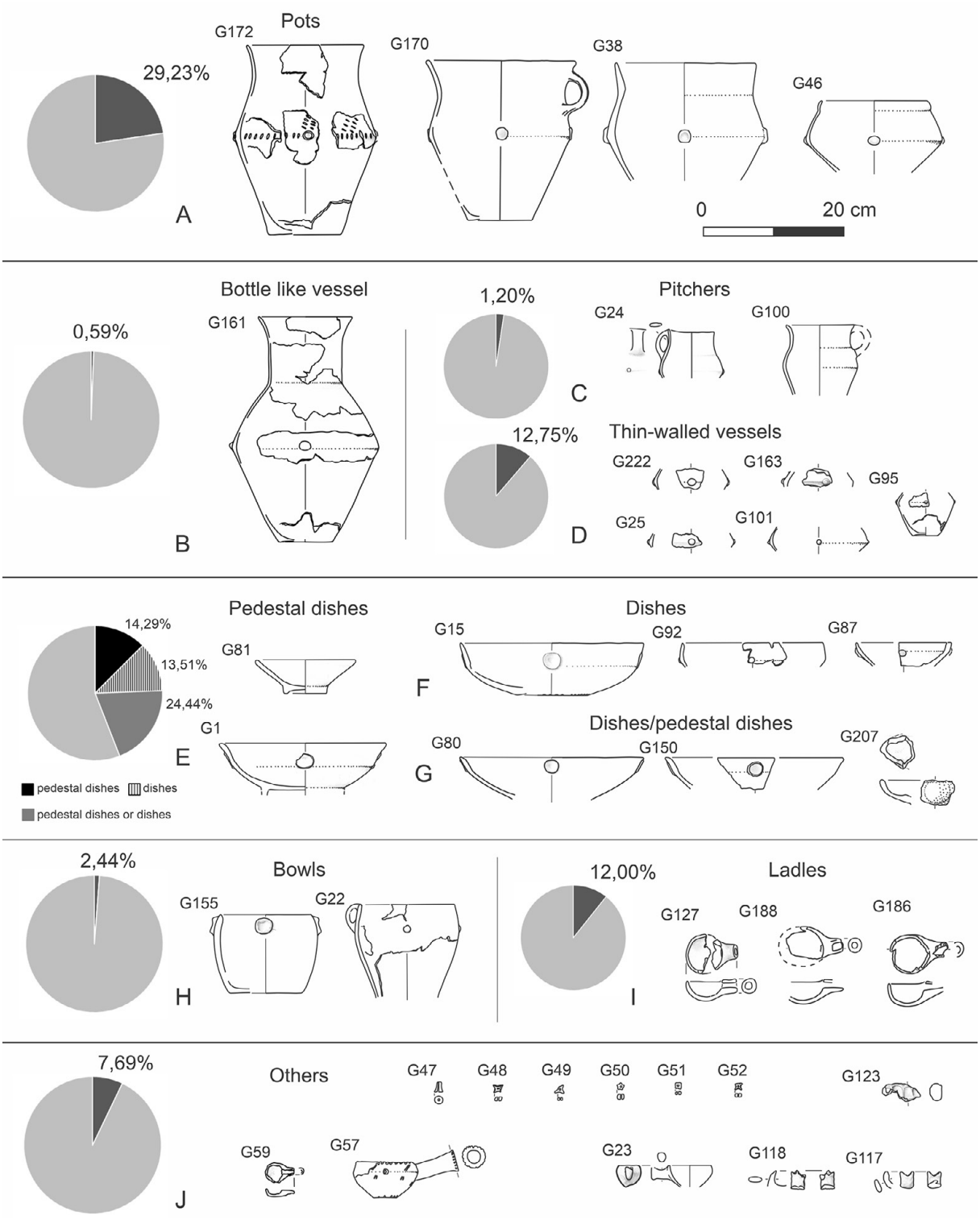

Fig. 8. Vessel shapes and their percentages within the typologically defined finds. Labels for the finds (*e.g., *G4...) are taken from the monographic publication of the site (*Kramberger in press, G1–G511*). Scale 1:8.

ger 2020). Pottery from Drulovka near Kranj, Ponikve near Trebnje and phases 4 and 5 in Moverna vas shows a similar decoration. Round appliqués do not appear on the largest circumference of the pots. The pots are decorated with regular bundles of incisions, often combined with impressions on the largest circumference and/or lip. The zig-zag incised decoration and the motif of horizontal incised lines are characteristic. All these motifs are also present at Ozalj – Stari grad (Fig. 1.19; *Težak-Gregl 2001; 2005*) in northern Croatia and at Spaha in Kočevsko region (Fig. 1.20; *Velušček 2011*). Small biconical vessels with a tubular attachment on the shoulder and a clay coating must also be mentioned as characteristic vessel type (see also

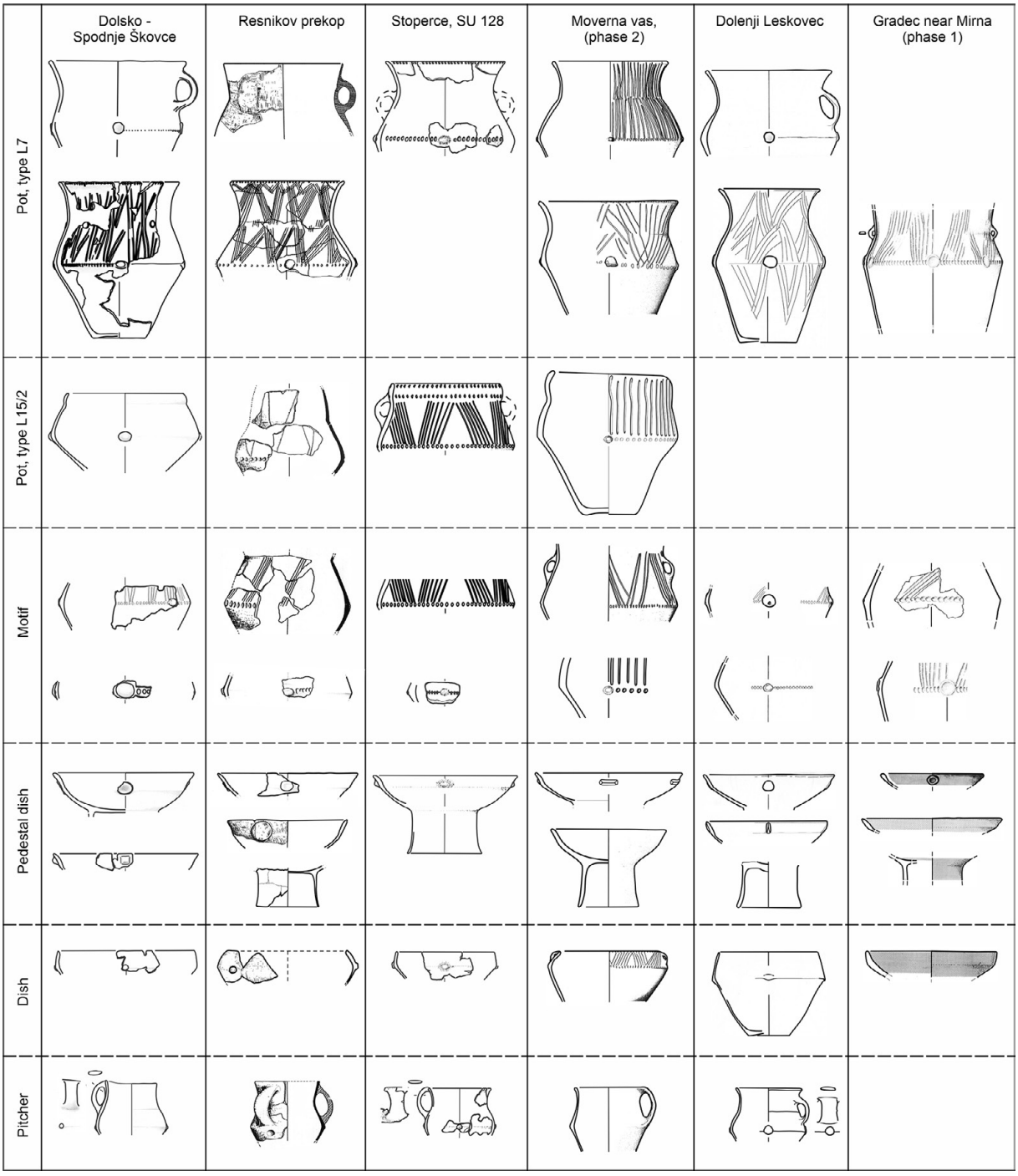

Fig. 9. Most important Late Neolithic pottery types at Dolsko – Spodnje Škovce and at sites Resnikov prekop, Stoperce (SU 128), Moverna vas (phase 2), Dolenji Leskovec, Gradec near Mirna (phase 1) representing Sava group Ib (after* Korošec 1964; Harej 1975; Budja 1995; Tomaž 1999; Dular *et al.* 1991; Hlad 2015; Kramberger 2020; Kramberger *et al.* 2023*). Not to scale.

here Fig. 14.15). They were found only at the sites of Ponikve near Trebnje (Fig. 1.10; *Ravnik, Tica 2018. find nos. 7,8,198,289,290,292*), Drulovka (Fig. 1.2; *Korošec 1960.Pl. 32: 5*), phases 4 and 5 of Moverna vas (Fig. 1.15; *Tomaž 1999.Pl. 21: 1; Pl. 26: 2*), and one in feature II at Ptuj – Šolski center in NE Slovenia (Fig. 1.23), where similar Late Neolithic pottery was found together with the Lasinja Culture ceramic forms (*Kramberger 2020.68–70, Fig. 6: 11*).

Overall, the pottery from Dolsko – Spodnje Škovce can be attributed to the Sava group, but with deviations in decoration compared to the nearby Dragomelj and Čatež – Sredno polje, and with significant differences compared to the pottery from Drulovka, Ponikve near Trebnje and phases 4 and 5 at Moverna vas. The pottery can be assigned to Sava group Ib according to the proposed terminology (*Kramberger 2020; cf. Tomaž 2022.151–152*).

Animal remains

The archaeozoological assemblage from Dolsko – Spodnje Škovce comprises 1645 animal remains from the Late Neolithic, Middle Copper Age, Late Bronze Age and Early Mediaeval periods (*Toškan in press*). The Late Neolithic material that is the subject of this study consists of several hundred tiny bone/tooth fragments (Fig. 10), most of which were recovered by wet sieving. Only 82 of these finds could be identified taxonomically, with tooth fragments clearly outnumbering bones ($NISP_{bones} = 3$). This is not surprising considering that highly fragmented diaphyseal splinters are usually only identified at higher taxonomic levels or not at all (*cf. Morin* et al. *2017.921–923*; *McGrath* et al. *2019*). Cattle is by far the best represented species, with domestic pig, caprines and possibly wild boar being the remaining identified taxa (Tab. 1).

Bovine remains were all attributed to domestic cattle. This is due to the size of the better-preserved teeth and bone fragments, although the metrical separation between domestic cattle and aurochs is far from clear (*e.g., Wright, Viner-Daniels 2015*). Caprines are represented by two partially preserved teeth, neither of which allows a reliable differentiation between sheep and goat (*cf. Payne 1985*; *Zeder, Pilaar 2010*). In suines, the distinction between wild and domestic animals is probably the most complex. Apart from the question of interbreeding and/or feralization, studies combining genetics, geometric morphometrics and isotopic analysis show that large specimens traditionally assigned to wild boar may also contain feral individuals or domestic pig (*Evin* et al. *2015*; *Balasse* et al. *2016*; *Orton* et al. *2016*). Due to the highly fragmented nature of the archaeozoological material from Dolsko – Spodnje Škovce, no standard measurement data for suines could be collected. However, based on the general size of the best-preserved specimens, most have been tentatively assigned to domestic pig. A single fragmented lower second incisor may have come from a wild boar.

Most of the archaeozoological remains examined come from Pit 1 (Tab. 1). The vertical distribution of these finds in the pit is clearly uneven, with over 80% of them coming from the lowest fill SU 194 = 196 = 217. Interestingly, about 70% of these specimens are calcined, as evidenced by the predominantly white colour of the exposed surfaces, often in combination with heat-induced cracks (*Krap* et al. *2019.1–2*). Although specific sedimentological conditions (*e.g.,* well-drained, acidic, well-aerated soils) can also favour the rapid degradation of whole bones and teeth into small fragments (*Kendall* et al. *2018.12–13*), and sodium salts or carbonate-rich sediments can be responsible for white staining (*Dupras, Schultz 2013.323*), none of these factors contributed in any meaningful way to the taphonomic history of the archaeozoological material from Pit 1 in general, and SU 194 = 196 = 217 in particular. Having said that, a few specimens exhibit water-related abrasion, weathering or dark brown colou-

Fig. 10. Dolsko – Spodnje Škovce. A selection of highly fragmented, often calcined animal bones from Late Neolithic pit 1 (photo D. Valoh).

ration, the latter due to oxide staining in a waterlogged, anaerobic environment (*Stathopoulou* et al. *2019*).

The high proportion of calcined teeth and bones from SU 194 = 196 = 217 contrasts strikingly with the almost complete absence of such finds in other, similarly thick (Fig. 5.3) fills of the same pit (Tab. 1). This observation is even more remarkable as fill US 148, overlaying US 194 = 196 = 217, contained significantly more charcoal (up to 40% of the volume compared to <15% in SU 194 = 196 = 217 and <1% in the uppermost SU 113; *Kramberger in press*). No burnt/calcinated bones were found in any of the other features that yielded Late Neolithic archaeozoological material. Even unburned animal remains were only collected in pit 2 and paleochannel SU 218 (Tab. 1) (*Kramberger in press*).

Plant remains

Archaeobotanical analysis at Dolsko – Spodnje Škovce includes plant identification of seed/fruit remains and charcoal fragments. A stereomicroscope with up to 50x magnification, light microscope with up to 600x magnification, the reference collection of seeds, fruits, wood and charcoal at the Institute of Archaeology ZRC SAZU and specialized literature for seed/fruit and wood identification (*e.g., Berggren 1981; Schweingruber 1990; Anderberg 1994; Gale, Cutler 2000; Cappers* et al. *2006*) were used.

Among the archaeobotanical remains charcoal remains predominate. It was not always possible to identify them to the tree taxa level due to poor preservation. Charcoal was found in almost every sediment sample analysed (70 from all settlement phases). One to three randomly selected charcoal fragments per sample were analysed. In many cases, the charcoal fragments selected were from the same part (or piece) of wood, so there was no need to identify multiple fragments from the same sample. In several cases (32 samples) the species or even the genus of the taxa could not be determined due to poor preservation state, in these cases only DPW (diffuse porous wood), RPW (ring porous wood) or coniferous wood is indicated. Other plant macro-remains (*i.e.* seeds/fruits) were rarely found in the sediment samples from Dolsko. They were found in only 11 sediment samples: mostly (four) from the Copper Age, two from the Middle Ages and one from the Late Neolithic; other samples (four) were from unspecified contexts (*Tolar in press*).

In the sediments of the Late Neolithic contexts of the Dolsko site no macro-remains of cultivated or gathered plants were found. The only sample containing seed/fruit remains from the Late Neolithic is Flot. No. 34/1-4 (SU 194) with one non-carbonized seed of plantain (*Plantago lanceolata*) – most likely a contaminant, *i.e.* not archaeological (*Tolar in press*). Therefore, among the archaeobotanical remains from the Late Neolithic settlement, only charcoal remains are worth discussing (35 in total). The charcoal comes from different pits, most of them from pits 1 (28) and 2 (four). In general, species diversity is not high, with nine different tree taxa identified (Tab. 2). The identifications are dominated by oak (*Quercus* sp.; n = 12) and other ring-porous tree taxa (RPW; n=9; *i.e.* oak/ash (*Quercus* sp./*Fraxinus* sp.) or chestnut (*Castanea sativa*)). Conifers are identified in only three cases. They are probably represented by fir (*cf. Abies alba*) and pine (*cf. Pinus* sp.). Eleven charcoal fragments were identified as diffuse-porous tree taxa (DPW), among which *Cornus*, white hornbeam (*Carpinus betulus*) and maple (*Acer* sp.) are frequently identified (Tab. 2).

Feature	SU	*Bos taurus*	Caprinae	*Sus cf. domesticus*	Non-identified	Taphonomic observations
Pit 1	113	4 (4)				no traces of exposure to fire
	148	11 (11)	1 (1)		10++	two calcined fragments
	194 = 196 = 217	53 (50)	1 (1)	10 (10)	478 (6)	~70% of finds calcined
	190	2 (2)			2	no traces of exposure to fire
Pit 2	200	1			3	no traces of exposure to fire
Paleochannel	218				18	no traces of exposure to fire

Tab. 1. Dolsko – Spodnje Škovce. Late Neolithic animal remains per feature. The number of tooth fragments is given in brackets.

Results of radiocarbon dating

Six radiocarbon dates were obtained from the Late Neolithic settlement features at Dolsko – Spodnje Škovce as part of the research conducted as part of the rescue excavation project (see Acknowledgements). Five samples were radiocarbon dated in 2009 in the *Leibniz Laboratory for Radiometric Dating and Stable Isotope Research* in Kiel and one in the *Beta Analytic* Miami in 2021. All attempts to date collagen from animal bone were unsuccessful due to poor preservation of the collagen. In four cases, animal teeth, identified as *Bos taurus* from different fills of pit 1 (SUs 194, 196, 113, 148), from the bottom to the top, was dated. In addition, a charcoal sample of undetermined wood taxon from pit 1 (SU 194) and a charcoal sample from pit 2 (SU 200), identified as oak or chestnut (*Quercus* sp./*Castanea sativa*) were radiocarbon dated (Tab. 3). Charcoal samples were first examined under a microscope in laboratories to remove contaminants, then the appropriate amount of each charcoal sample was chemically treated (acid/alkali/acid) (*Grootes 2009b; Hatfield 2021*).

The dating of four teeth was based on enamel apatite (carbon from carbonate). The secondary calcite in the outer part of each individual tooth was removed. This was done by mechanically crushing the sample and dissolving it in HCl to a minimum of 28%. The remaining sample material was hydrolysed to CO_2 with 4ml of 60% phosphoric acid. To remove any sulphur compounds present, the CO_2 sample was placed in a quartz ampoule together with CuO and Ag wool, which was sealed and burned at 900°C for 4 hours. The resulting CO_2 sample was then converted to graphite with H_2 at 600°C using an iron catalyst, and finally the iron-graphite mixture was pressed into a tablet in the sample holder for AMS dating (*Grootes 2009a*).

Plant taxa	Amount of identified charcoal fragments
Quercus sp.	12
Quercus sp./*Castanea* sativa	3
Fraxinus sp.	1
Fraxinus/Castanea	1
RPW	4
Cornus sp.	4
Sorbus/Cornus	1
Acer sp.	1
Carpinis betulus	4
Coniferous; cf. *Abies alba*	2
Coniferous; cf. *Pinus* sp.	1
TOTAL	35 (28 pit 1; 4 pit 2; 3 SU 86; 1 SU 76; 1 SU 218)

***Tab. 2. Charcoal identifications (nos. of identified items) in Late Neolithic contexts at the site Dolsko – Spodnje Škovce (sum: 35 wood-anatomical identifications; items). For the results of plant macro-remain analyses for other periods at Dolsko – Spodnje Škovce site see* Tolar in press.**

The samples were then dated by AMS. The Conventional Radiocarbon Age was calculated using the Libby half-life (5568 years, *Stuiver, Polach 1977*), and this was then corrected for total isotopic fractionation. At the Leibniz Laboratory for Radiometric Dating and Stable Isotope Research the correction for isotopic fractionation was based on the $^{13}C/^{12}C$ ratio measured by AMS. These $\delta_{13}C$ values include isotope fractionation effects that occur during graphitization and in the AMS device and are therefore not directly comparable to $\delta_{13}C$ values measured in a CO_2 mass spectrometer. At Beta Analytic, these were measured separately in an IRMS (isotope ratio mass spectrometer), thus eliminating fractionation effects from natural, chemical and AMS induced sources. The radiocarbon age of the samples dated at Beta Analytic is rounded to the nearest 10 years and calculated sigmas less than 30 BP are conservatively rounded up to 30 (*Grootes 2009a; 2009b; Hatfield 2021*).

All samples contained more than the minimum recommended amount of carbon ^{14}C for accurate age determination. The earliest date was provided by a charcoal sample (*Quercus* sp./*Castanea sativa*) from pit 2. A charcoal sample from pit 1 yielded a later date, as did samples of enamel apatite from cattle teeth in pit 1. The apatite samples had $\delta_{13}C$ values typical of CO_2 apatite and showed very similar ages, which may support their reliability (*Grootes 2009a*): approx. 4500 and 4350 cal BC (95.4% probability).

Details of existing radiocarbon dates from Dolsko are listed in Table 3. Listed below are those from settlements associated with the most similar pottery (Sava group Ib) from the area of distribution of the Sava group as it was initially defined (*Guštin 2005*). These radiocarbon dates are compared in the following chapter with those of the Lengyel Culture, other dates from the Sava group in central Slovenia, dates from the subsequent Early Copper Age Lasinja Culture in the same area, and the radiocarbon sequence from Moverna vas in the Bela krajina.

Comparative analysis and evaluation of results in a regional and supra-regional context

Large pits filled with deposits containing ceramic fragments, stone implements, charcoal, animal remains and other finds showing evidence of human occupation have been found at various prehistoric sites and are also characteristic of 5th millennium BC settlements in central and south-eastern Europe (*e.g., Palečková 2008; Šavel, Karo 2012; Minichreiter, Marković 2013; Sava 2015; Barna 2017; Barna* et al. *2019; Tomaž 2022*). Two such pits found in the Late Neolithic settlement at Dolsko – Spodnje Škovce have been studied in terms of the archaeological excavation results, distribution of finds, technological and typological aspects of pottery, taxonomy of animal and plant

LAB number	Site	Material	Context	Age (BP)	$\delta^{13}C$ (‰)	PMC corrected*	Cal BC (68.3%)	Cal BC (95.4%)
KIA37347	Dolsko – Spodnje Škovce	Charcoal (*Quercus sp./Castanea sativa*)	Pit 2, SU 200	5837±32	-26.29±0.28	48.35±0.19	4770-4620	4788-4608
Beta-591316	Dolsko – Spodnje Škovce	Charcoal (n/a)	Pit 1, SU 194	5690±30	-28.9 o/oo	/	4547-4458	4609-4450
KIA37351	Dolsko – Spodnje Škovce	Tooth (enamel apatite, *Bos taurus*)	Pit 1, SU 194	5587±35	-13.36±0.23	49.88±0.22	4452-4369	4488-4352
KIA37350	Dolsko – Spodnje Škovce	Tooth (enamel apatite, *Bos taurus*)	Pit 1, SU 113	5602±32	-13.25±0.34	49.79±0.20	4459-4370	4493-4358
KIA37346	Dolsko – Spodnje Škovce	Tooth (enamel apatite, *Bos taurus*)	Pit 1, SU 148	5612±30	-11.49±0.22	49.73±0.18	4486-4371	4500-4360
KIA37349	Dolsko – Spodnje Škovce	Tooth (enamel apatite, *Bos taurus*)	Pit 1, SU 196	5563±30	-14.00±0.39	50.03±0.19	4446-4360	4454-4350
Poz-72746	Gradec near Mirna	Animal bone (n/a)	Phase 1, »below wall rubble« (assemblage 1)	5540±40	-24.00±0.5	/	4443-4345	4445-4331
Poz-72747	Gradec near Mirna	Bone (heel bone, *Bos taurus*)	Phase 1, »below wall rubble« (assemblage 2)	5570±40	-21.4±0.2	/	4445-4358	4491-4342
Poz-72751	Gradec near Mirna	Bone (mandible, *Bos taurus*)	Phase 1, »in the layer behind the wall« ((assemblage 3?)	5580±40	-26.1±1.2	/	4447-4363	4493-4345
Poz-66248	Dolenji Leskovec	Charred seed (*Cratageus* sp.)	Pit 3 (SU 1099)	5680±40	-25.9±0.1	/	4546-4454	4656-4371
Poz-66249	Dolenji Leskovec	Charred residues (pot; n/a)	Pit 3 (SU 1099)	5680±40	-27.8±0.1	/	4546-4454	4656-4371
Poz-66250	Dolenji Leskovec	Charcoal (n/a)	Pit 3 (SU 1099)	5880±35	-27.0±0.2	/	4790-4716	4841-4625
Beta-339594	Stoperce	Charcoal (n/a)	Pit SU 128	5690±30	-25.4 o/oo	/	4547-4458	4609-4450
Hd-24038	Resnikov prekop	Wood (*Alnus glutinosa*)	Pile with 10 rings	5718±23	/	/	4603-4501	4673-4459

Tab 3. List of ^{14}C AMS dated samples from Late Neolithic features at Dolsko – Spodnje Škovce and other sites with pottery of Sava group Ib (after* Velušček 2006; Sraka 2016; 2020; Kramberger 2014*) in its distribution as defined (*Guštin 2005; Tomaž 2022*). The list does not include data affected by the possible hard water effect from Resnikov Prekop (*Mlekuž *et al.* 2013*). * "PMC corrected" refers to the percentage of modern (1950) carbon, corrected for mass fractionation by ^{13}C measurement. Samples were calibrated using OxCal v4.4 (*Bronk Ramsey 2009*) and the IntCal 20 calibration curve (*Reimer *et al.* 2022*).

remains and radiocarbon measurements. The following section summarizes the results of comparing this data with that available from settlements of the 5th millennium BC in Slovenia and neighbouring regions.

The use of large pits of irregular plan

The largest pit at Dolsko – Spodnje Škovce (pit 1) did not yield any architectural elements, it was irregular in shape and filled with different layers in which ceramic fragments, bones, burnt clay, stone tools, implements and charcoal fragments were scattered. It was observed that fragments of individual vessels were distributed over an area of up to 4.5m, partly in fills in different stratigraphic positions. The distribution of fragments of certain vessels in different fills from the bottom to the top of pit 1 may to some extent be the result of post-depositional processes, partly it may reflect the accuracy of the excavation, but given the large number of such cases it seems likely that it is largely the result of the deposition process. It probably indicates that individual vessels were broken prior to deposition and that they came in the pit as fragments with different fills, together with charcoal, animal remains and stone implements.

The large amount and concentration of finds and two charcoal clusters suggest that pit 1 was probably filled by people, but some of the material may have been deposited naturally. This is indicated by the distribution of individual pot fragments found in pit 2 (SU 200) and pit 1 (SU 148). It can be assumed that a layer with Neolithic pottery running from northwest to southeast across pits 1 and 2 (Fig. 3.202,75) and consistent with the direction and orientation of the alluvial sediment in which the two pits were dug (Figs. 3.21 and 4), is related to this post-depositional process (*cf.* Fig. 2.4).

The situation where parts of a single vessel are distributed in different pits is not unique. In the Early Copper Age settlement at Zgornje Radvanje, parts of individual vessels were also distributed in different pits in several cases. One of the most significant examples is the distribution of ceramic fragments of a pot found in large pits 5 and 2 (*Kramberger 2021.342–343, find no. 235*). Alluvium and paleochannels were discovered above both pits, which may indicate that the upper parts of the pot were deposited by water from feature 5 to feature 2 (*Kramberger 2021.24–25, 149,137–139, Figs. 22,23,41a-b*).

Paleochannels found during the excavations at Dolsko with finds from different periods indicate the destruction of the archaeological record in the vicinity (Fig. 2.4). Similar phenomena can be observed at many other sites in Slovenia. In the Late Neolithic settlement of Dolenji Leskovec, for example, the Sava River completely washed away a part of the settlement, which was surrounded by two circular palisades (*Jovanović* et al. *2012.App. 7*). No post holes of possible houses could be identified in the area surrounded by ditches, only a few pits of irregular ground plan. Furthermore, at Dragomelj it was observed that the surface of less than half of the Late Neolithic ceramics was partially preserved, while the rest of the pottery had a completely destroyed surface (*Turk, Svetličič 2005.68; 2022. 37–38*). Redepositions of material are indicated by the finds from younger periods in the Late Neolithic pits and the results of radiocarbon dating (*e.g., Turk, Svetličič 2022.168,184–185, SU 402*). All these examples show that when interpreting large irregularly shaped pits and Late Neolithic settlements as a whole, we must consider site losses related not only to destruction during modern agriculture (*e.g., Guštin* et al. *2005.104; cf. Osztás* et al. *2012.386*), but also to post-depositional processes such as water, erosion and other sediment movements caused by natural factors.

Looking at the location of the sites where large, irregularly shaped pits were found, it can be concluded that they did not occur in the lakeside settlements, like Resnikov prekop and Verd (*Velušček 2006; Velušček* et al. *2023*). They are more widespread phenomenon of the Late Neolithic in the Carpathian Basin, south-eastern Alpine region and Northern Croatia, in regions with dry lands with thick layers of loam. The two larger pits at Dolsko were found on a clayey-loamy geological base (Fig. 4.21), which spread in a line from northwest to southeast over alluvial deposits of Sava gravel (Fig. 4.45; see also Fig. 3). Furthermore, it should be emphasized that the phenomenon of large irregularly shaped pits in Late Neolithic settlements represents a kind of change in comparison to Central European LBK settlements. Linear ditches next to the long houses, which were dug in the LBK settlements for the extraction of clay material (*e.g., Oross 2010; Oross, Bánffy 2009; Hofmann 2013; Bánffy 2013.131–137; Bickle 2013. 155–162, Fig. 7.2*), were almost completely (*e.g., Barna 2017.83–84, Fig. 16*) replaced by large pits in the Late Neolithic settlements.

Large-scale excavations over the last 25 years have uncovered many above-ground, timber-framed houses in Late Neolithic settlements in the Carpathian Basin, which required a reassessment of earlier theories. It

became clear that large pits, previously interpreted as residential buildings, were temporary shelters or features used for a variety of activities (*Pávuk 2003. 464; Raczky 2005.24; Osztás* et al. *2012.385; Barna* et al. *2019.126–128*). In most settlements, large pits of irregular ground plan were found near houses (*e.g.,* Fig. 11.A), and at Alsólnyék-Bátaszék, one of the largest Lengyel settlements in Transdanubia with more than 100 houses uncovered, some large pits extended along the edges of buildings, and these can in all probability be associated with these (*Bánffy* et al. *2016; Osztás* et al. *2016.192–196*). They were probably used to extract the clayey loam needed for construction, and later filled with household waste (*Osztás* et al. *2012.390, Fig. 12;* see also *Barna* et al. *2019.125*). In many settlements, rectangular houses and irregular large pits appear inside circular ditches, representing traces of defensive enclosures (Fig. 11.B,D), similar to those at Dolenji Leskovec (Fig. 1.12), where only two large pits and three smaller ones have survived in an area of 56x46m surrounded by ditches (*Jovanović* et al. *2012.App. 7*). However, in many other settlements the remains of palisades are not found, which may mean that they did not exist, or may be due to the state of research at individual sites. Such cases have been found in Transdanubia as well as in the neighbouring Croatia, in the Late Neolithic settlements attributed to the Sopot culture (Fig. 11.C). All these cases of better researched and preserved settlements with above-ground, timber-framed houses and large, irregularly shaped pits in their vicinity show that the latter were most likely not the remains of houses.

Pottery style(s) of the Late Neolithic Sava group

Analyses of the technological aspects of pottery production have been conducted at several Late Neolithic sites in Slovenia using the same analytical approach as at Dolsko (*Horvat 1999*), but the results have not been compared and evaluated since the recognition of the Sava group (*Guštin 2005*). These are Resnikov prekop (*Tomaž 1999.76–87; Tomaž, Velušček 2005.87–99*), Dragomelj (*Turk, Svetličič 2005; 2022.36–39*), Čatež – Sredno polje (*Tomaž 2005.113–129; 2022.62–73*) and Dolenji Leskovec (*Hlad 2015.15–29*), which were attributed to the Sava group of the Lengyel Culture (*Guštin 2005*), Moverna vas in the Bela krajina region (*Tomaž 1997; 1999.76–8*), Stoperce in Haloze (*Kramberger 2014.244–247; Kramberger* et al. *2023*) and Andrenci in northeastern Slovenia (*Kramberger 2014.244–247*), whose material culture has been attributed to the Late Lengyel Culture (*Bánffy 2002; Velušček 2006.33; Kavur 2010; Kramberger 2014*). The site Col 1 near Podgračeno was the first to be attributed to the Sava group (*Guštin 2005.8*) and the pottery found there was analysed using the same analytical approach. However, according to the excavator the pottery is later, contemporary with the pottery from SUs 43-44 in Ajdovska jama cemetery, Zgornje Radvanje and partly Ptuj–Šolski center (*Horvat 2005; 2020.120–121, Fig. 75, 59–62*), and a radiocarbon measurement also provided a later age (*Guštin 2005. Fig. 3; cf. Kramberger 2014; 2020; 2021*).

A comparison of pottery production methods between the above-mentioned sites has shown that the pottery from Dolsko – Spodnje Škovce differs significantly from the definition of the Sava group (*Guštin 2005.9–12*). The proportions of granularity groups, with the predominance of very fine (43%) and fine (36%) fabrics, contradict the definition in the first place, as it has been stated that the pottery of the Sava group was mainly made of medium-grained fabrics (Fig. 7.1). Similar proportions of granularity groups are found at Dolenji Leskovec, 50% of very fine-grained fabrics, 35.71% of fine grained and 14.28% of medium grained fabrics (*Hlad 2015.Fig. 19*). At the Late Lengyel site of Andrenci very fine grained pottery prevails (83%), at Stoperce – SU 128 very fine grained (42%) and fine-grained pottery (58%) were found in similar proportions (*Kramberger 2014.Fig. 27*). All other sites of the Sava group (*Tomaž, Velušček 2005.Fig. 1; Turk, Svetličič 2022.Fig. 46; Tomaž 2022.Fig. 42*) and phases 2, 4 and 5 of Moverna vas (*Tomaž 1997.Tab. 4*) yielded mostly medium grained pottery (see also Fig. 1).

The pottery from the Bela krajina region should have been coated with coloured clay slip significantly more often than that from the Sava group and from northeastern Slovenia (*Guštin 2005.20*). However, the pottery from Dolsko (27%) is more often coated with clay slip than the pottery from phases 2 (23.9%), 4 (22%) and 5 (12.3%) of Moverna vas (*Tomaž 1997.Tab. 7*). Very similar proportions of pottery with colour clay slip are also found at Dolenji Leskovec near the Sava in Posavje (29.03%; *Hlad 2015.21*) and SU 128 at Stoperce, in Haloze, northeastern Slovenia (32%; *Kramberger 2014.Fig. 29*). Only in the pottery from Dragomelj (*Turk, Svetličič 2005.68*), Čatež – Sredno polje (*Tomaž 2022.Fig. 45*), Andrenci (3%; *Kramberger 2014.Fig. 29*) and Resnikov prekop in the wetlands of the Ljubljansko barje (2.1%; *Tomaž, Velušček 2005. Fig. 3*) was colour clay slip rarely present (see also Fig. 1).

According to the definition, the pottery from the Sava group sites is mostly decorated with impressions, the rest with appliqués and incised decoration, which should be different from the pottery from northeastern Slovenia (predominant appliqués) and the Bela krajina region (predominant incised decoration) (*Guštin 2005.9–12;* see also Fig 1). In order to test this theory, we compared all sites with the available statistical data on decoration, and also conducted an analysis of published Late Neolithic finds from the sites of Drulovka near Kranj (*Korošec 1960.Pl. 9.1– Pl. 34.10; see also Guštin et al. 2005.43–47*), Ponikve near Trebnje (*Ravnik, Tica 2018.finds nos. 1–810*), Resnikov prekop (*Korošec 1964.Pls. 3–18; Harej 1975.Pls. 1–7;*

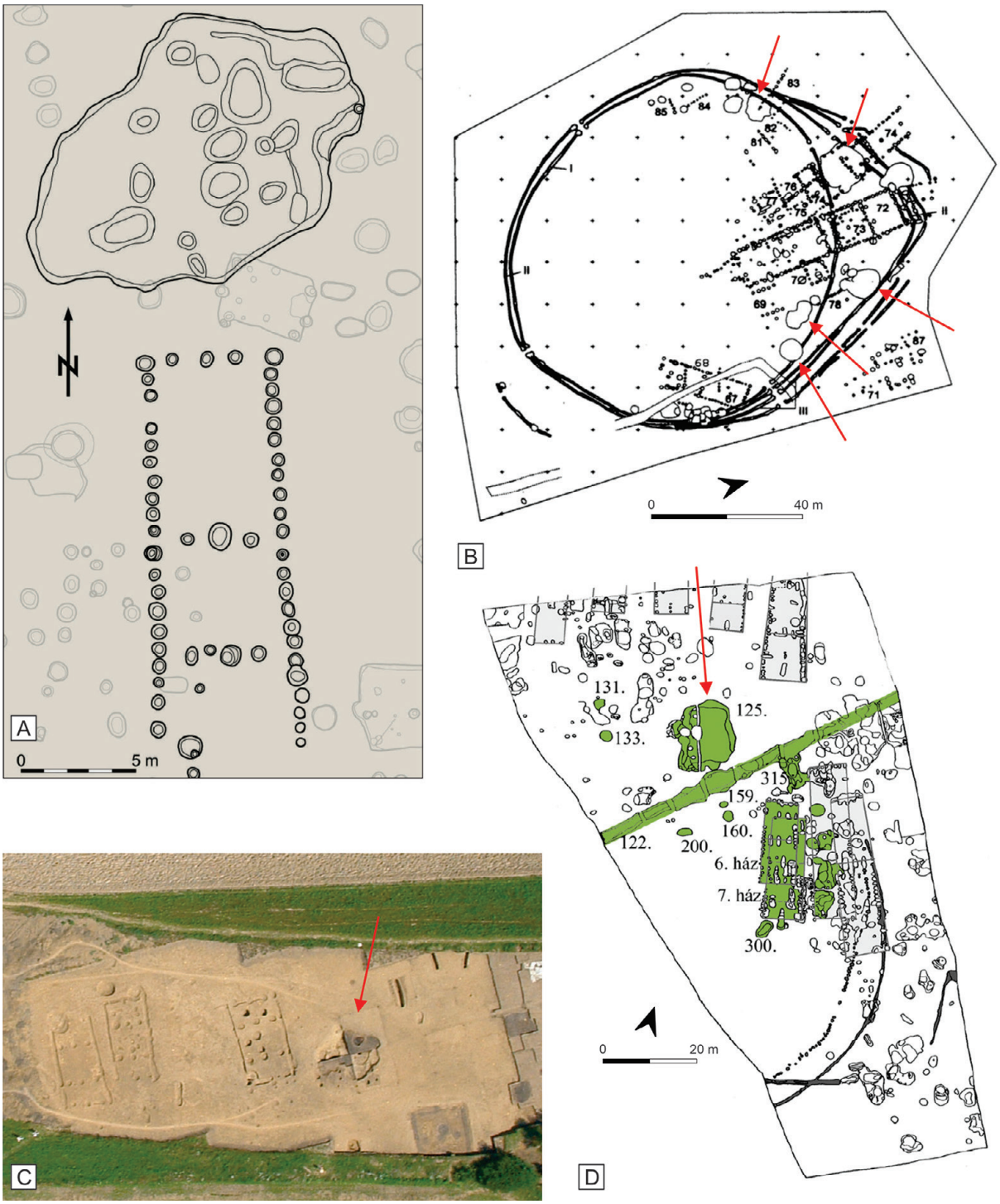

Fig. 11. Examples of above-ground rectangular houses and large pits in their vicinity at the Late Neolithic settlements of Lengyel and Sopot cultures. **A *Alsónyék-Bátaszék* (Osztás *et al.* 2012.Fig. 6*)*, B *Žlkovce* (Pávuk 1981*)*, C *Kruševica – Njivice* (Balen, Čataj 2014*)*, D *Veszprem – Jutasi út* (Regenye, Biró 2019.Fig. 1*)*.**

Veluščeк 2006.Pls. 1–19), Dragomelj (*Turk* et al. *2022. finds nos. 1–447*), Late Neolithic finds from Moverna vas (*Tomaž 1999.Pls. 1–32*) and Bukovnica (*Šavel 1992.Pl. 1–6*) in northeastern Slovenia. It can be concluded that only at the sites of Dragomelj (62% and 9%; *Turk, Svetličič 2022.Fig. 54*) and Čatež – Sredno polje (68% and 13%; *Tomaž 2022.Fig. 34*) are impression and a combination of impressions and appliqués dominant as decoration techniques. At Dolsko, applied decoration predominates (62%; Fig. 7.3), similarly at the Late Lengyel settlements at Andrenci (80%; *Kramberger 2014.Fig. 31*) and Bukovnica (86%; *Šavel 1992*), and the Sava group site at Dolenji Leskovec (50%; *Hlad 2015.Fig. 31*) (for all of these see Fig. 12).

In the earliest phase of Moverna vas (phase 2) most ornaments on the pottery were made with a combination of impressions and incisions (37%), followed by applied decoration (30%) and impressions (20%), with the rest being decorated with incisions and other combinations. This was probably used to support the statement that most of the pottery at the sites in the Bela krajina region was decorated with incised decoration and a combination of incisions and impressions (*Guštin 2005.13; cf. Tomaž 1997; 1999*). However, at Resnikov Prekop (Fig. 12.4) and SU 128 in Stoperce (Fig. 12.9) the proportions of pottery decorated with incisions and impressions, and with applied decoration and impressions, are more similar to those from phase 2 at Moverna vas (Fig. 12.8) than to those at Dragomelj (Fig. 12.2) and Čatež – Sredno polje (Fig. 12.7). Moreover, if we consider the sites of Drulovka (Fig. 12.3), Ponikve near Trebnje (Fig. 12.5) and later phases of Moverna vas (phases 4 and 5; Fig. 12.8), we can notice that the pottery found there has a very similar proportion of individual decoration techniques as in phase 2 at Moverna vas, with incisions and a combination of incisions and impressions significantly predominant. Specifically, at Drulovka 36% of the pottery is decorated with incisions and impressions, 33% with incisions, 20% with impressions, only 5% with applied decoration and impressions, 4% with applied decoration and 2% with other combinations. At Ponikve near Trebnje 43% of the pottery is decorated with incisions and impressions, 41% with incisions, 16% with impressions and not a single fragment with applied decoration. Moreover, in phases 4 and 5 of Moverna vas the pottery was decorated with the same decoration techniques with some deviations in proportions: 69% with incisions and impressions, 17% with incisions, 14% with impressions and not a single fragment with applied decoration (for all of these see Fig. 12).

The analysis showed that the most common vessel type at Dolsko was a pot with an everted neck that is approximately the same length as the shoulders, decorated with appliqués (Fig. 6.G33, G34, G36, G38; Fig. 8.G170, G38; Fig. 13.1). A comparison of the proportions of types of pots at Late Neolithic sites in Slovenia (*Kramberger 2014; 2020*) shows that pots with a cylindrical neck dominate at only three sites (Fig. 13.d) – these are, again, Drulovka (65%; *e.g., Korošec 1960. Pls. 11.1, 19.1, 22.1,6,9*; Fig. 13.3), Ponikve near Trebnje (52%; *e.g., Ravnik, Tica 2018.finds nos. 1,178,181*; Fig. 13.5) and phases 4 and 5 (69%) at Moverna vas (*e.g., Tomaž 1999.Pls. 22.1–3, 24.1*; Fig. 13.8). At all other Late Neolithic sites pots with everted necks – similar to those at Dolsko – dominate (Fig. 13.a). At Resnikov prekop pots with cylindrical neck represent 10% of all pots (*e.g., Korošec 1964.Pl. 16.3; Harej 1975.Pl. 7.12*; Fig. 13.4), 2% at Čatež – Sredno polje (*e.g., Tomaž 2022. finds nos. 1758,1760*; Fig. 13.7), and at other sites no pots were found which could be described as having cylindrical necks (Fig. 13.d).

Pots with everted necks dominate at Dolsko – Spodnje Škovce (90%), followed by Čatež – Sredno polje (73%; *e.g., Tomaž 2022.finds nos. 251-253,1331*), Resnikov prekop (76%; *e.g., Korošec 1964.Pl. 5.5, Pl. 15.1. 3*), phase 2 at Moverna vas (65%; *e.g., Tomaž 1999.Pl. 11.1–2, 13.1*) and Dolenji Leskovec (63%; *e.g., Hlad 2015.finds nos. 16,17,19,20,23*). Fragments of everted neck of pots are rarely present at Drulovka (18%), Ponikve near Trebnje (24%) and in phases 4 and 5 at Moverna vas (25%). As it can be argued from the published material, they all belong to pots with short necks (*e.g., Tomaž 1999.Pl. 21.3, 23.1–2, 26.3; Korošec 1960.Pl. 10.1, 15.7, 19.6; Ravnik, Tica 2018.finds nos. 176–177,180,624,692*), which are rare or not present in other sites (Fig. 13.a).

In addition to pots with everted necks, a pot with a long sloping neck (5%; Fig. 13.b) and a pot with a short ellipsoid neck (5%; Fig. 13.c) were found at Dolsko – Spodnje Škovce (Fig. 13.1). Pots with a long sloping neck are also present at Dolenji Leskovec (26%; *e.g., Hlad 2015.finds nos. 4–6*; Fig. 13.6), Čatež – Sredno polje (21%; *e.g., Tomaž 2022.finds nos. 1329,759*; Fig. 13.7), Resnikov prekop (7%; *e.g., Harej 1975.Pl. 1.1*; Fig. 13.4), in the earliest (6%; *Tomaž 1999.Pl. 10.1*), as well as later (6%; *Tomaž 1999.Pl. 21.2*) Neolithic phases at Moverna vas (Fig. 13.8). Some pots with ellipsoid necks can also be found at Resnikov prekop (2%; *Harej 1975.Pl. 6.6*; Fig. 13.4), the earliest phase at Moverna vas (12%; *e.g., Tomaž 1999.Pl. 11.3*; Fig. 13.8)

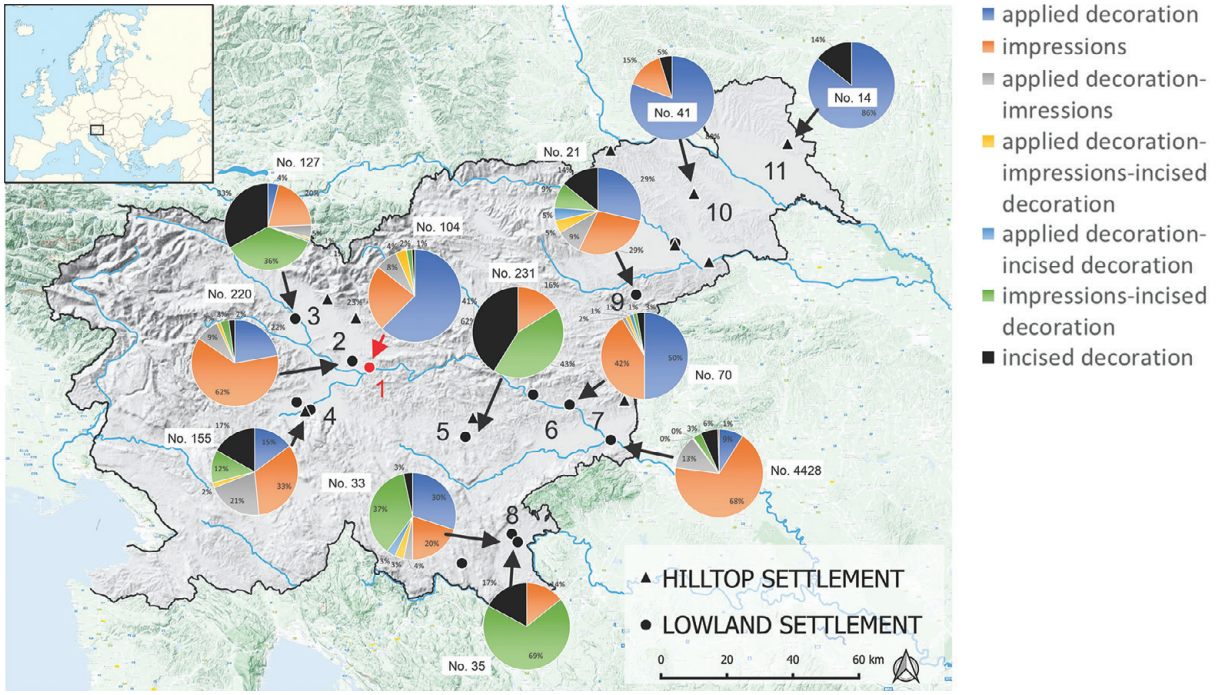

Fig. 12. Percentages of different decoration techniques in Late Neolithic settlements in Slovenia. Only sites with at least 50 typologically defined pottery fragments are included.* 1 *Dolsko – Spodnje Škovce,* 2 *Dragomelj,* 3 *Drulovka near Kranj (Late Neolithic finds),* 4 *Resnikov prekop,* 5 *Ponikve near Trebnje,* 6 *Dolenji Leskovec,* 7 *Čatež – Sredno polje,* 8 *Moverna vas (left phase 2, right phases 4 and 5),* 9 *Stoperce (SU 128),* 10 *Andrenci,* 11 *Bukovnica (Late Neolithic pit). The data from Dolsko – Spodnje Škovce are presented for the first time in this publication (Fig. 7) and are the result of the author's analysis. Data from Čatež – Sredne polje (*Tomaž 2022. Fig. 34*), Dolenji Leskovec (*Hlad 2015.Fig. 31*), Stoperce (SU 128) and Andrenci (*Kramberger 2014.Fig. 31*) are taken from the literature. Comprehensive analysis of finds from the Late Neolithic pile-dwelling at Resnikov prekop (*Korošec 1964.Pls. 3–18; Harej 1975.Pls. 1–7; Velušček 2006.Pls. 1–19*), Ponikve near Trebnje (*Ravnik, Tica 2018.finds nos. 1–810*), Drulovka (*Korošec 1960.Pls. 9–34*), Dragomelj (*Turk *et al.* 2022.finds nos. 1–447*), Late Neolithic finds from Bukovnica (*Šavel 1992*) and Moverna vas (*Tomaž 1999.Pls. 1–32*) were conducted by the author based on the published material.

and, as fragments, at Drulovka (4%; *Korošec 1965.Pl. 20.3*; Fig. 13.3) and Ponikve near Trebnje (5%; *Ravnik, Tica 2018.find no. 625*; Fig. 13.5). Much the same is true for pots without a neck (Fig. 13.f). They sparsely appear, in different variations, at the sites Čatež – Sredno polje (4%; *e.g., Tomaž 2022.find no. 1732*; Fig. 13.7), phase 2 at Moverna vas (17%; *e.g., Tomaž 1999. Pl. 7.1–2*; Fig. 13.8), Dolenji Leskovec (11%; *e.g., Hlad 2015.Pl. 1.3*; Fig. 13.6), Resnikov prekop (5%; *Harej 1975.Pl. 2.6*; Fig. 13.4) and Ponikve near Trebnje (10%; *e.g., Ravnik, Tica 2018.finds nos. 197–198*; Fig. 13.5). Pots with shoulders and sloping necks (Fig. 13.e) were identified only at Drulovka (13%; *Korošec 1960.Pl. 10.2*; Fig. 13.3) and Ponikve near Trebnje (9%; *Ravnik, Tica 2018.finds nos. 2, 179*; Fig. 13.5).

Overall, based on the results presented here, the sites in Bela krajina do not differ from the sites in Posavje, Savska ravan and Ljubljansko barje, either in terms of pottery production, decoration or ceramic forms, as has been suggested. On the contrary, a similar technology of pottery production was spread and used in Late Neolithic settlements throughout the southeastern Alpine region and northeastern Dinaric Carst, from Kranj in northwestern Slovenia, Bela krajina in southeastern Slovenia, to Stoperce in northeastern Slovenia, with some variations. The presence of coloured clay slip varies considerably from site to site, which may be largely due to local conditions, the characteristics of the soils in which the pottery is found, and taphonomic site loss. However, at Dolsko – Spodnje Škovce (Fig. 1.1) similar conditions could be assumed as at the neighbouring settlement at Dragomelj (Fig. 1.5; see also Fig. 2.1), yet there is still much more pottery with coloured slip at Dolsko. On this basis it cannot be excluded that the presence of coloured slip is to some extent related to the cultural variations within the pottery style, although not in the way that has been proposed (*Guštin 2005.13*). Similar proportions of coloured clay slip as at Dolsko – Spodnje Škovce are

known from the phase 2 at Moverna vas, Dolenji Leskovec (southeastern Slovenia), and SU 128 in Stoperce (northeastern Slovenia). These are the sites which together with Resnikov prekop and Gradec near Mirna (phase 1) yielded the most similar vessel types and ornaments and were therefore attributed to the same variation of the style – Sava group Ib (Figs. 9, 14). Another variation of the pottery style is represented at Dragomelj and Čatež – Sredno polje (Sava group Ia; Fig. 1.5,14) and the third at Drulovka, Ponikve near Trebnje, phases 4 and 5 at Moverna vas and similar sites (Sava group II; Fig. 1.2,10,15; Fig. 14) (for all see also *Kramberger 2020*).

Absolute chronology

As mentioned above, the absolute dating of the Late Neolithic in Slovenia is based on charcoal samples and on samples of charred organic residues on the pottery. This is also due to the rare finds of charred seeds/fruits, missing human graves and often poor preservation of collagen in animal bones (*cf. Stadler, Ruttkay 2007; Oross* et al. *2010; Ilon 2004; Bánffy* et al. *2016; Regenye* et al. *2022*). The old wood effect is a common phenomenon (*e.g., Whittle 1990; Brock* et al. *2010; Nowak* et al. *2017.189*), but in the case of Slovenian sites it is difficult to assess its influence on the results of radiocarbon measurements, as tree species are rarely determined prior to dating and control dates are not available. In the case of Resnikov prekop in the wetlands of Ljubljansko barje, the dating of charred remains on pottery also proved problematic, with a large number of measurements yielding significantly older dates than expected (*Mlekuž* et al. *2013*).

As collagen leached from the dentine, four radiocarbon measurements on apatite from samples of cattle teeth from Dolsko – Spodnje Škovce were introduced in the present study. Carbonate exchange takes place between the apatite and burial environment, so pre-treatment is required, but as a comparison of 155 samples from more than 100 sites worldwide has shown, pre-treatment is often inadequate (*Zazzo 2014*). This also applies to enamel, which has long been considered a more reliable dating material than bone apatite beca-

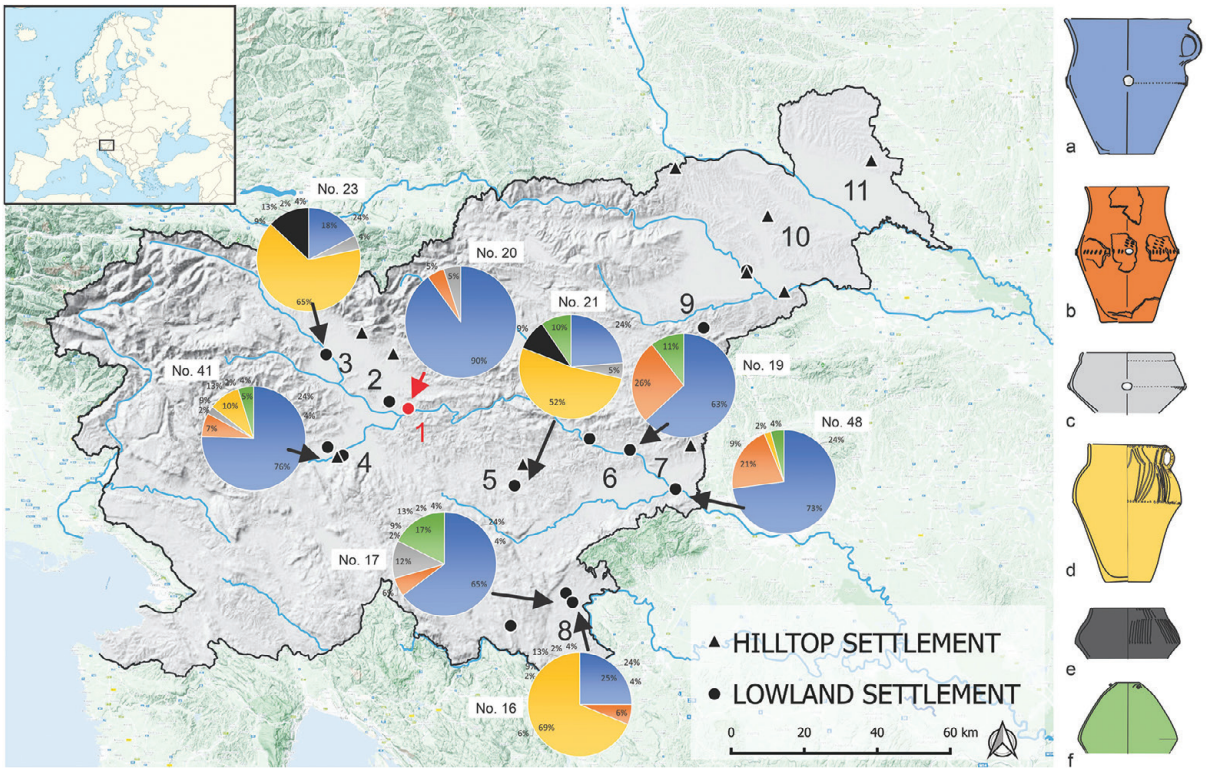

Fig. 13. Percentages of different types of pots in Late Neolithic settlements in Slovenia. Only sites with at least 15 definable pots are included. **1** ***Dolsko – Spodnje Škovce,*** **2** ***Dragomelj,*** **3** ***Drulovka near Kranj,*** **4** ***Resnikov prekop,*** **5** ***Ponikve near Trebnje,*** **6** ***Dolenji Leskovec,*** **7** ***Čatež – Sredno polje,*** **8** ***Moverna vas (left phase 2, right phases 4 and 5). All data were calculated from the finds published in the publications of individual sites (*****Kramberger in press; Turk *****et al.* ****2022.finds nos. 1–447; Korošec 1960.Pls. 9–34; 1964.Pls. 3–18; Harej 1975. Pls. 1–7; Velušček 2006.Pls. 1–19; Ravnik, Tica 2018.finds nos. 1–810; Hlad 2015.finds nos. 1–248; Tomaž 2022. finds nos. 1–3522; 1999.Pls. 1–32*****). The typological classification was based on the authors' typology (*****Kramberger 2014; 2020*****).***

use of its lower porosity, smaller surface area, larger crystallites, and lower solubility due to its lower carbonate content (*Hedges* et al. *1995; Wood* et al. *2016.*).

Mechanical grinding can significantly increase the amount of carbonate contamination removed in an acid leach compared to hand grinding, although in many cases not all contamination is likely to be removed (*Wood* et al. *2016*). Within the mid-late Holocene, this level of contamination has resulted in radiocarbon age estimates within approximately 100 ^{14}C years of the true sample age, but sometimes more. A recent study suggests that decontamination of younger samples may be possible if higher concentrations of hydrochloric acid solution are used in the chemical pretreatment (*Hopkins* et al. *2016*). Samples of modern equine incisors, a Roman cattle molar, and a Palaeolithic rhino molar were taken and pretreated with different acid solutions, dated at the Oxford Radiocarbon Accelerator Unit (ORAU), and compared with control dated dentine collagen from the same individuals. Such control dates are not available from Dolsko – Spodnje Škovce. The only other radiocarbon date available from pit 1 is a charcoal sample from an unknown tree species. Consequently, despite radiocarbon dates of enamel apatite from different samples of cattle teeth from pit 1 overlap, they should be treated with caution. They can be understood as a minimum age for the cattle, while both charcoal samples (from pits 1 and 2) can be taken as a maximum age for tree felling (Tab. 3).

Among the sites with the most similar pottery finds, radiocarbon dates are available from Moverna vas, Dolenji Leskovec, Resnikov prekop, Stoperce – SU 128 and Gradec near Mirna (see Tab. 3, *cf.* Figs. 1, 9). Of particular importance are the dates from Gradec near Mirna, where samples of animal bones (*Cervus elaphus, Bos taurus, Sus* sp. and two samples of undefined animal species) were radiocarbon dated. According to Marko Sraka (*oral information*) collagen was dated and δ^{13}C values measured by AMS range from –21.05±0.5 to –28.07±02.

A total of ten samples were measured from the multiperiod settlement of Gradec near Mirna (*Dular* et al. *1991; Dular 2001*), six from the occupation layers of the Sava group, two from the Lasinja Culture oven above the Late Neolithic layer and two from the highest settlement layer attributed to the Furchenstich horizon (*Sraka 2020*). The results of the radiocarbon dating indicated that the samples collected as belonging to the lowest settlement layer were most likely from two different chronological phases, the Late Neolithic and the Lasinja Culture, indicating that the material from the lowest cultural layer may be partially mixed. Nevertheless, three radiocarbon dates from this layer (Gradec phase 1) can be recognized as older than the radiocarbon measurements from the layer above it (Gradec phase 2 – Lasinja Culture), which is in agreement with published pottery assemblages (*Dular* et al. *1991; Dular 2001*) (Tab. 3).

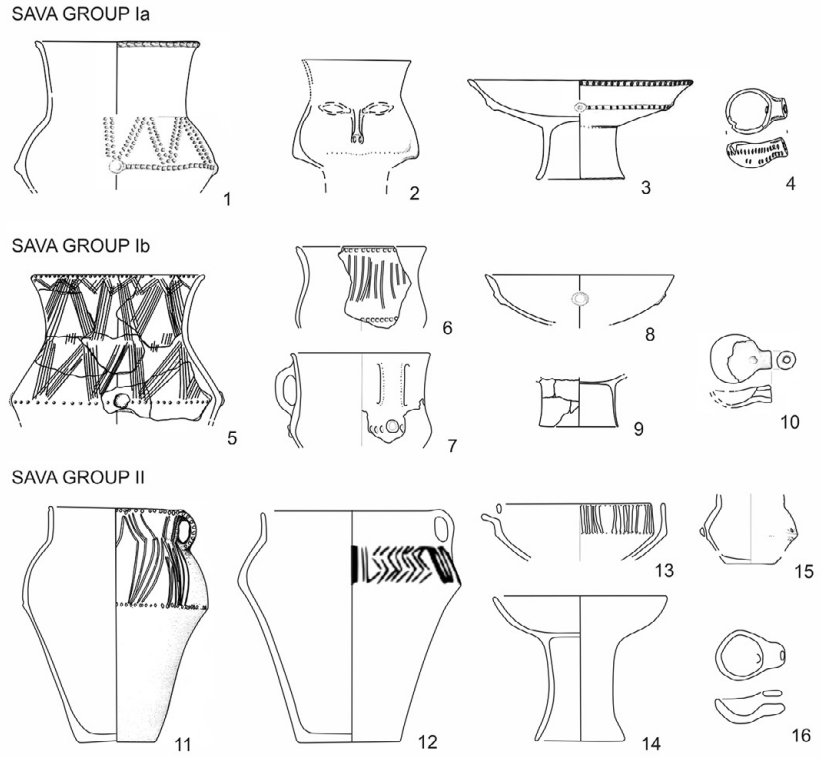

Fig. 14. Pottery of different variations of the Sava group of the Lengyel Culture.* 1–4 *Čatež – Sredno polje,* 5–10 *Resnikov prekop,* 11–16 *Moverna vas, phases 4 and 5 (after* Kramberger 2020; Tomaž 1999; 2022; Korošec 1964; Harej 1975; Velušček 2006*).

Another important group of samples was introduced from Dolenji Leskovec (Tab. 3*; Sraka 2016*). Three samples were measured, all from a single pit (SU 1099; *Hlad 2015*). The samples consist of different materials: charred seed, charred residues on pottery and a charcoal sample of unknown plant taxon. If we compare these measurements with

those from Dolsko, we can see that the dates of the charcoal from pit 1 at Dolsko and the dates of the sample of charred seed (hawthorn seed) and charred remains from one of the pots at Dolenji Leskovec overlap, while the charcoal from the same pit at Dolenji Leskovec is older. This date overlaps with the measurement of a charcoal sample from pit 2 at Dolsko (Tab. 3), and with charcoal samples from Čatež – Sredno polje, Dragomelj and the earliest phase at Moverna vas.

Based on the above, the dates of charcoal differ from the dates of cattle teeth and charred seeds even when they come from the same settlement contexts. They proved to be earlier both, in the case of pit SU 1099 at Dolenji Leskovec and in the case of pit 1 at Dolsko, at least in the case of Dolenji Leskovec most likely due to the old wood effect. A date from the pile from Resnikov prekop, dates from collagen from animal bones from Gradec near Mirna and a date from the charred seed and charred residues from Dolenji Leskovec seem to be reliable. In addition to these dates, the dates from Verd are reliable because two samples of the pile (*Fraxinus* sp.) were measured, which made it possible to determine the age of a pile more precisely using the Wiggle matching method: 4674±42 cal BC (*Veluščeк* et al. *2023*). Other currently available radiocarbon dates from Sava group sites are from charcoal, which should be regarded as the maximum possible age, with some also from the charred remains of pottery (Moverna vas, Resnikov prekop).

If we compare radiocarbon dates from the settlement context related to the Sava group Ib, we can see that they overlap, except for the dates of charcoal, charred residues from the phase 2 of Moverna vas (*Sraka 2012; 2016; 2020*) and the already mentioned problematic charred residues from Resnikov prekop (*Mlekuž* et al. *2013*), which are partly older. Comparable dates of collagen from animal bones are known from the Late Lengyel settlement of Zalaszentbalázs – Szőlőhegyi mező, and charcoal samples from this site again proved to be earlier (Fig. 15; *Bánffy 1995; Regenye* et al. *2022*). Radiocarbon dates of charred remains from the pottery from the Late Lengyel pits at Andrenci and Bukovnica, as well as those from animal bones from the Late Lengyel site Szombathely – metro and Szentgál-Teleki dűlő fall within a similar period (Fig. 15; *Ilon 2004; Regenye 2011; Kramberger 2014; Sraka 2014*). Finally, radiocarbon measurements of collagen from animal bones from Michelstetten (*Stadler, Ruttkay 2007*), and from horizons II-III at the Wildoner Schlossberg in Styria (*Tiefengraber 2018.Figs. 170–172,180–187*) are almost identical. All these dates indicate that Dolsko and related sites of the Sava group (Ib) in central Slovenia, Late Lengyel Culture in Transdanubia, regional variation of the Lengyel settlement in Styria and the MOG IIa phase in eastern Austria belong to the same horizon.

Two Bayesian models were then processed to compare the chronological sequences of the settlement at Moverna vas in Bela krajina (after *Sraka 2012; 2014*) and the ceramic sequences in the area of distribution of the Sava group in Posavje, Ljubljansko barje, Savska ravan, Krška ravan and Haloze (Figs. 16–17; see also Fig. 1). Dates from the entire period of the 5th millennium cal BC time range are included, *i.e.* the periods of the Late Neolithic and the Early Copper Age (Lasinja Culture). The first model assumes that sites with different variations of the Sava group pottery style were not contemporaneous (see also *Kramberger 2020*; Fig. 15). Čatež – Sredno polje (*Guštin 2005.Fig. 2; Tomaž 2022.135–141*) and Dragomelj (*Turk, Svetličič 2005; Turk* et al. *2022.14–144*) are representatives of the Sava group Ia, Dolsko – Spodnje Škovce (pit 1), Resnikov prekop, Dolenji Leskovec (SU 1099), Stoperce (SU 128) of the Sava group Ib (see Tab. 3) and Ponikve near Trebnje of the Sava group II (*Ravnik, Tica 2018.76–78*). The final phase of the sequence includes radiocarbon measurements from sites where finds can be chronologically correlated with the Lasinja Culture. The most important of these are samples of human bones and charred seeds from SUs 43 and 44 in Ajdovska jama cemetery (*Bonsall* et al. *2007; Sraka 2020*), where they were found together with typologically characteristic pottery (*e.g., Horvat 1989; 2009; Veluščeк 2006.29–30; Kramberger 2018.81–96; 2020; 2021*) and dates of collagen and a charred seed from the oven at Gradec near Mirna (phase 2), which was found above the occupation layer of the Sava group (*Dular* et al. *1991; Dular 2001; Sraka 2020*). Dates of charcoal samples from the oldest phase at Gradišče above Dešen, 5km to the northeast of Dolsko (*Guštin 2005.Fig. 3; Pavlin, Dular 2007*), Col 1 near Podgračeno (*Guštin 2005.Fig. 3; Horvat 2005; 2020*) and a radiocarbon measurement of charred residues from pottery from pit SU 6508 at Obrežje (*Kramberger 2022*) also belong to this chronological phase (Fig. 16).

With this model (Fig. 16), the beginning of Sava group Ia, as we know it from Čatež – Sredno polje and Dragomelj, is estimated to between 4779-4731 cal BC (68.3% probability) and has a duration between 173-248 years (68.3% probability). This beginning and duration

would probably be shorter if we had radiocarbon measurements on samples of short-lived materials. Settlements with the Sava group Ib pottery in Posavje, Ljubljansko barje and Savska ravan are dated to between 4568-4527 and 4403-4358 cal BC (68.3% probability) with the currently available set of radiocarbon measurements and lasted 133-198 years (68.3% probability). The settlement of Ponikve near Trebnje (Sava group II) is estimated to start 4403-4358 cal BC (68.3% probability) and lasted between 16-81 years or a median figure of 53 years (68.3% probability). The transition between Sava group II and the pottery style associated with human burials in Ajdovska jama (SUs 44 and 43), the oven at Gradec near Mirna (phase 2), Gradišče near Dešen, Col 1 and Obrežje is estimated to have been between 4353-4315 cal BC (68.3% probabi-

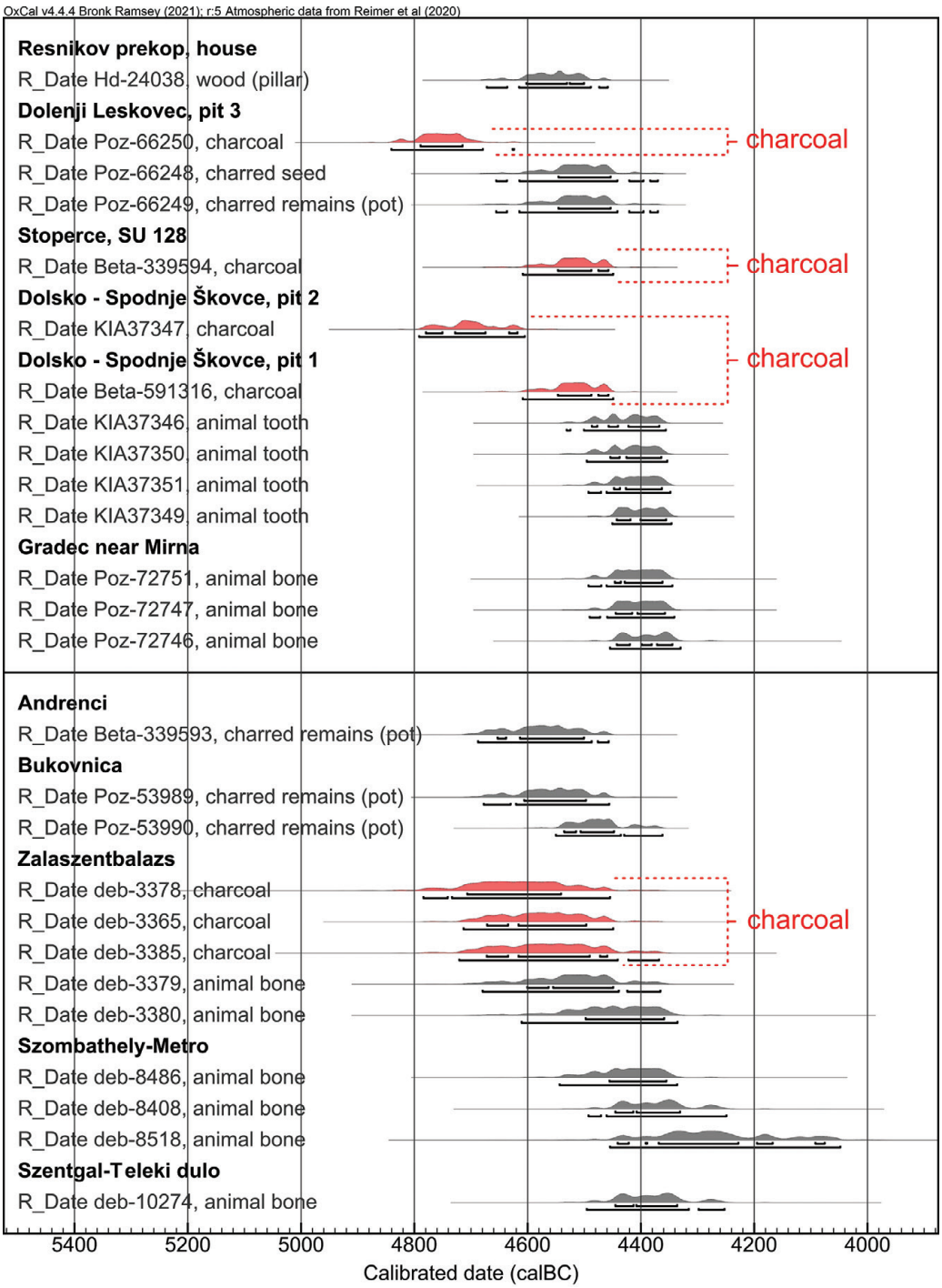

Fig. 15. Radiocarbon measurements from Dolsko – Spodnje Škovce and most similar sites of the Sava group (Ib) and the Late Lengyel Culture in Transdanubia. Charcoal dates are highlighted. Samples were calibrated using OxCal v4.4 (*Bronk Ramsey 2009*), and calibration curve IntCal 20 (*Reimer *et al.* 2022*).

lity), and the end of Lasinja Culture at these sites is estimated to have been between 4212-4118 cal BC (68.3% probability). Further details of the calculated Bayesian model are presented in Tables 4 and 5.

The median value for the beginning of the Čatež – Sredno polje and Dragomelj in the Bayesian chronological model presented here is 4758 cal BC. This is similar or slightly earlier than the age of the pile (*Fraxinus* sp.) from Verd, which was dated using the Wiggle matching method: 4674±42 cal BC (*Velušček* et al. *2023*). Unfortunately, the excavations in the trial trench yielded only a small number of ceramic fragments. In any case, from a broader perspective the date of the pile at Verd and the estimated beginning of the Sava group could correspond to the MOG Ia and Ib phases (*Stadler, Rutkay 2007*). Similar dates (collagen from animal bones) are known from the Lengyel II phase settlement of Nagykanizsa-Palin-Anyagnyerőhely in Transdanubia (*Barna* et al. *2016.319*) and a comparable time range was estimated for five Lengyel furnished burials at Veszprém-Jutasi út, which are supposedly later, from the Lengyel IIb phase, according to the typo-chronology (*Regenye* et al. *2022.288–290;* see also *Regenye 2007.392*).

The estimated time range for the beginning of phase 2 of Moverna vas is comparable, but slightly earlier than those from Čatež – Sredno polje and Dragomelj (*cf.* Figs. 16 and 17). This would mean that the settlement phase with finds of Sava group Ib at Moverna vas in Bela krajina was contemporary with the sites of Sava group Ia in Posavje, or even earlier (Fig. 1.16, 14, 5). However, due to the lack of radiocarbon measurements on short-lived material and the uncertainties associated with some dates on charred residues on pottery (*Mlekuž* et al. *2013.Tab. 1*), further research is needed to prove or disprove this. Dates similar to those from the Sava group Ib sites in Posavje are presented from phase 3 at Moverna vas (Fig. 17; *Sraka 2020. App.*), but so far no pottery finds from this settlement phase have been published.

The radiocarbon dates of charcoal samples from Ponikve near Trebnje and charcoal samples and charred remains on pottery from phases 4 and 5 at Moverna vas overlap and the estimated time spans in the Bayesian models are similar (*cf.* Figs. 16 and 17). In both cases, the occupation associated with the Sava group II pottery lasted for a rather short period, around 4400 cal BC. The calculated periods correspond to the later part of the Late Lengyel phase in Transdanubia, the later part of the MOG IIa and earlier part of the MOG IIb phases in eastern Austria (*cf. Oross* et al. *2010; Osztás* et al. *2016. 197–233; Regenye* et al. *2022; Stadler, Ruttkay 2007*). Both variations of pottery style – Sava group Ib with many similarities to that of Sava group Ia and Sava group II with more elements in common with the pottery of the subsequent Lasinja Culture (see *Kramberger 2020; 2021. 53,56–57*) – were thus parallel to the Lengyel III phase, and researchers in western Hungary have come to similar conclusions. The Late Lengyel horizon there can be divided into two subphases (Lengyel IIIa-b) and the researchers recognized that the settlements of the later subphase produced pottery with more elements of

Ceramic style sequence	Ranges with 68,3% probablity	Ranges with 95,4% probablity	Median
Start of Sava group Ia	4779-4731	4827-4726	4758
Sava group Ia-Ib transition	4568-4527	4598-4506	4548
Sava group Ib-II transition	4403-4358	4427-4348	4383
Sava group II – Lasinja	4353-4315	4366-4278	4332
End of Lasinja	4212-4118	4219-4004	4147

Tab. 4. List of values of probability distributions (in cal BC) of the ranges of transitions of ceramic sequences in the south-eastern Alpine region in Slovenia, derived from the chronological model in Fig. 16.

Ceramic style	Samples	Duration with 68,3% probablity	Duration with 95,4% probablity	Median
Sava group Ia	24 (all charcoal)	173-248	141-304	212
Sava group Ib	12 (3 collagen, 4 enamel apatite, 1 charred seed, 1 wood, 1 charred residue, 2 charcoal)	133-198	97-232	166
Sava group II	2 (charcoal)	16-81	0-114	53
Lasinja	26 (17 collagen, 6 charred seeds, 1 charred residues, 2 charcoal)	112-229	68-341	183

Tab. 5. List of values (in cal BC) of probability distributions of the durations of the Late Neolithic and Early Copper Age ceramic traditions in the southeastern Alpine region in Slovenia, derived from the chronological model in Fig. 16.

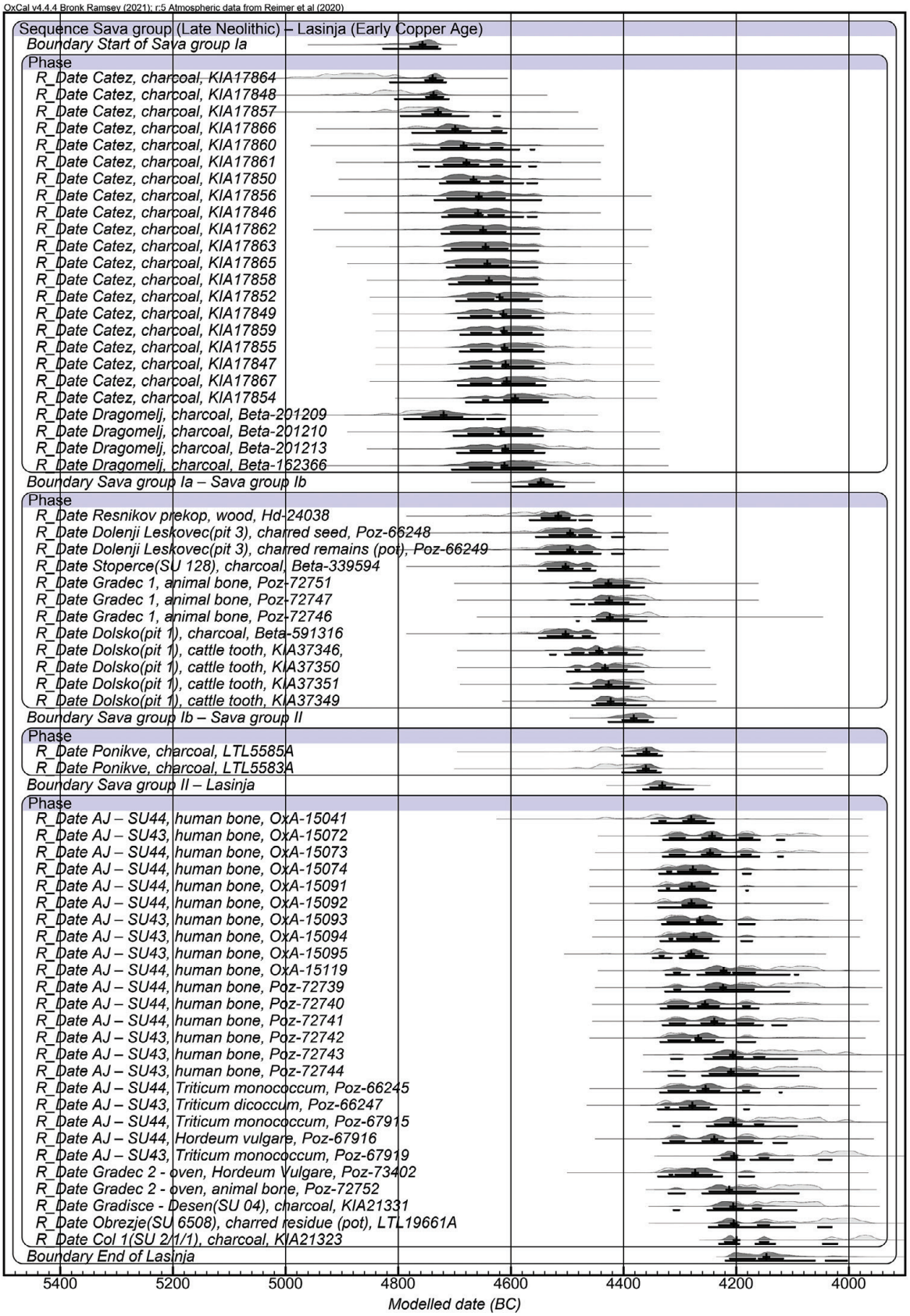

Fig. 16. Probability distributions of dates from the Late Neolithic and Early Copper Age ceramic sequence in southeastern Alpine region of Slovenia. In the model we estimate the dates of transition from one pottery style to another and no gaps. The Bayesian chronological modelling was carried out using OxCal v4.4 (*Bronk Ramsey 2009*) and the calibration curve IntCal 20 (*Reimer *et al.* 2022*).

the Lasinja (or Balaton-Lasinja) culture (*Kalicz 1991; Bánffy 1994; Regenye* et al. *2022.281*).

More significant changes in material culture, which can be associated with the Lasinja Culture (in Slovenian terminology representing the Early Copper Age), began in Posavje around 4350 cal BC according to the calculated chronological model (Fig. 16). This is similar to Moverna vas in Bela krajina (Fig. 17 – phase 7 and partly 6), northeastern Slovenia (*e.g., Sraka 2014; 2020*) and western Transdanubia (*Oross* et al. *2010; Regenye* et al. *2022*).

Archaeobotanical, archaeozoological data and subsistence strategies in the first half and beginning of the second half of the 5th millennium cal BC in the SE Alpine region

During the 7th and 6th millennia cal BC, agriculture gradually spread from southwestern Asia into nearby regions. Farming was first introduced into Mediterra-

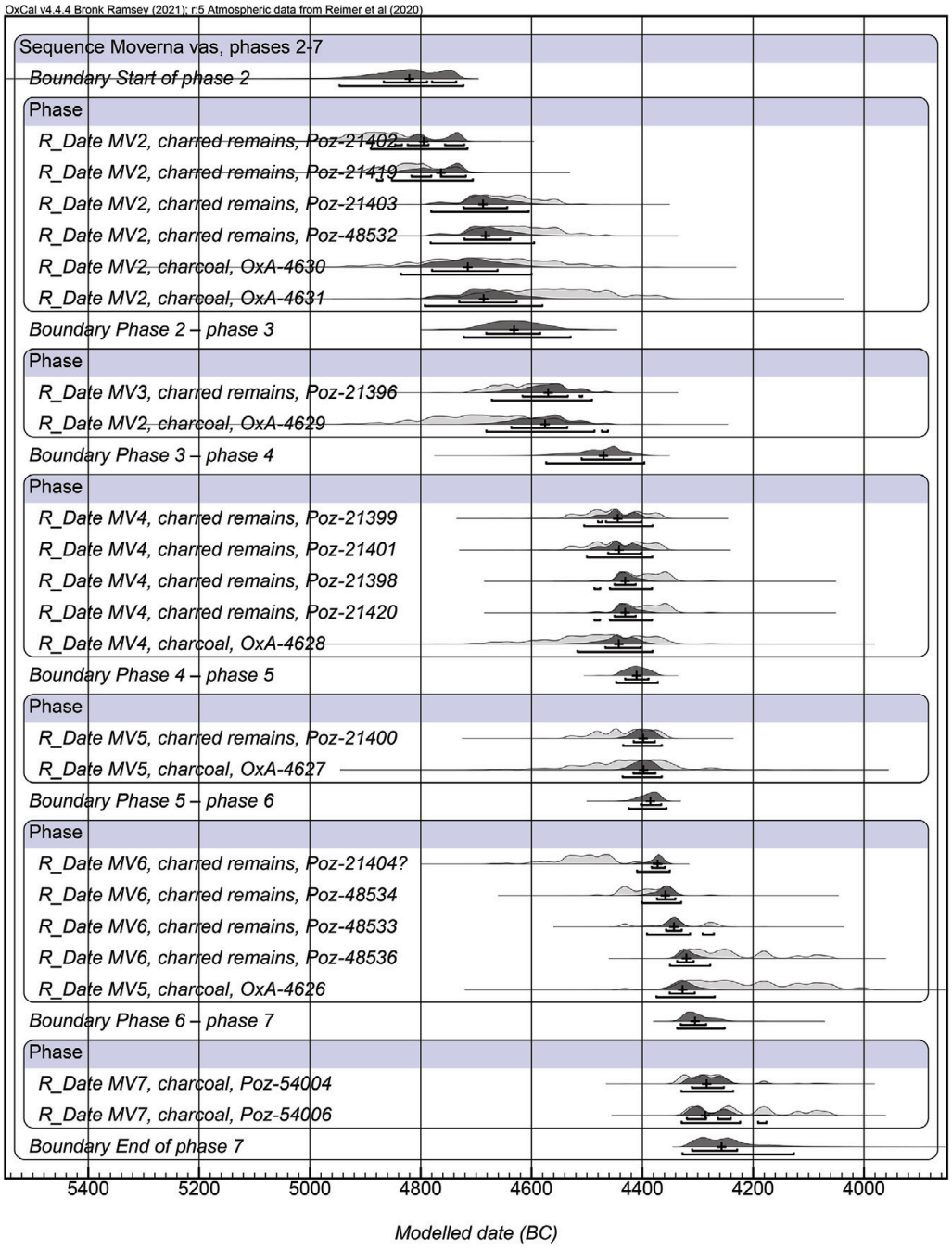

Fig. 17. Bayesian model of radiocarbon dates from Late Neolithic and Early Copper Age occupation layers at Moverna vas in Bela krajina (after* Sraka 2012.Fig. 2; 2014.Fig. 3*). Type of program and calibration curve is the same as in Fig. 16.

nean areas with climatic conditions similar to those in which it originated (*de Vareilles* et al. *2020*), and then progressively further north, starting in the Balkans. Archaeobotanical research on Early Neolithic sites in the Balkans has provided highly relevant data on the crop choices of early farmers. For example, some of the oldest directly dated cereal and pulse remains in Europe are from northern Greece (*e.g., Valamoti, Kotsakis 2007*), Bulgaria (*e.g., Marinova 2007; 2017*), Serbia (*e.g., Filipović 2014*) and North Macedonia, *i.e.* from *c.* 6400–5700 cal BC, where a wide range of crops has been found, with five cereal species and several varieties, two legumes and possibly two oil crops (*Sabanov* et al. *2024*). Some differences in the diversity and importance of certain crops were noted, probably depending on local environmental or cultural factors, *i.e.* early farmers adapted their crop choices.

The 5th millennium cal BC in Slovenia is characterized by the transition from the Neolithic to the Copper Age (*e.g., Budja 1995; Velušček 2011; Sraka 2020*). Archaeobotanical studies of Late Neolithic sites in Slovenia, including the site of Dolsko – Spodnje Škovce, are very scarce. There are several reasons for this, such as the limited and poor state of research, ineffective and insufficient sampling for archaeobotanical analyses, and poorly preserved cultural layers. The poor state of preservation of the plant macro-remains is certainly not the case for the pile-dwelling sites at Ljubljansko barje (*e.g., Culiberg 2006; Jeraj 2004; Tolar* et al. *2010; 2011; Velušček* et al. *2023*), the cave cemetery site in Ajdovska jama (*Culiberg, Šercelj 1986; Culiberg* et al. *1992; Sraka 2020*) or the hilltop settlement at Gradec near Mirna (*Dular* et al. *1991; Culiberg, Šercelj 1995; Sraka 2020*), where many macro-remains of cultivated plants were found, but all of them are younger (*i.e.* end of the 5th and 4th millennium cal BC).

The published archaeobotanical data on plant remains from Late Neolithic sites in Slovenia have been synthesized to expand the comparisons between sites in the area. In the next part of this paper, the archaeobotanical analyses of eight 5th millennium cal BC sites (dated around 4700-4400 cal BC) in Slovenia, from which at least some plant macro-remains (mostly charcoal) have been recovered, are presented to show the state-of-the-art, *i.e.* Dolsko – Spodnje Škovce, Čatež – Sredno polje (*Culiberg 2022*), Stoperce (*Kramberger* et al. *2023*), Dragomelj (*Tolar 2022*), Verd (*Velušček* et al. *2023*), Resnikov prekop (*Culiberg 2006; Čufar, Korenčič 2006*), Dolenji Leskovec (*Sraka 2016*) and Zamedvedica near Plešivica (*Turk, Vuga 1984*).

Very modest archaeobotanical investigations from the above listed sites have already been published (see references). This paper presents the first combined analysis of all of them. The oldest plant macro-remains recovered and analysed to date from the 5th millennium cal BC sites are listed and compared (seeds/fruits – Tab. 6; charcoal – Tab. 7; both tables see below). In most cases, the macro-remains compared were derived from the randomly and subjectively collected sediment samples. In some cases, the wash-over method (*Kenward* et al. *1980*) with a minimum sieve mesh size of 1 to 2mm was used to separate the plant macro-remains from the sediment sample material, and the macro-remains were then air-dried. Recognizable plant remains were then sorted out, but the volume of each sample varied according to the size of the approximate sediment sample value (*c.* 5–20 litres). In Tables 6 and 7, therefore, only the total number of recognized plant remains in an unknown volume are given, or only the presence/absence of plant taxa is marked. This methodological problem further limits comparisons between the sites. The context types for the sites compared are also given in Tables 6–7. Except for the pile-dwelling sites, most of the samples come from Neolithic secondary refuse deposits (*i.e.* pits). No large deposits of *in situ* preserved plant macro-remains have yet been recovered from the 5th mill. cal BC sites in Slovenia.

Tables 6–7 show that seed/fruit remains from Late Neolithic sites in Slovenia are less abundant than charcoal remains. Only four sites have at least one seed/fruit remain. Two of them (Dragomelj, Verd) may contain cereal remains, which could also be the remains of a wild plant of the Poaceae family, therefore the identification is uncertain. At two sites (Verd, Dol. Leskovec) the remains of wild edible fruits/nuts are preserved: *Fagus sylvatica* (beech), *Malus sylvestris/Pyrus pyraster* (wild apple/pear), *Crataegus monogyna* (hawthorn), *Rubus* sp. (blackberry/raspberry), *Trapa natans* (chestnut) – which point to a possible gathering economy. At three sites (Čatež, Dragomelj, Verd) the remains of other, nutritionally less important plant taxa are present, which provide information on the environmental conditions at the sites. The seed/fruit remains of Chenopodiaceae (goosefoot), *Polygonum* sp. (knotgrass), *Veronica* sp. (speedwell), *Setaria* sp. (foxtail), *Solanum nigrum* (black nightshade) found at the Čatež site confirm an anthropogenic, ruderal environment. The same is true for the remains of *Stellaria* sp. (chickweed) at the Dragomelj site. While the remains of various aquatic and marshy/

lakeshore plant taxa, identified at the Verd pile-dwelling site, such as *Sparganium* sp., *Alnus glutinosa*, *Betula pubescens*, *Nuphar luteum*, *Mentha aquatica*, *Schoenoplectus lacustris*, *Potamogeton* sp., *Alisma plantago aquatica, Euphatorium cannabinum*, *Ranunculus aquatilis*, *Oenanthe aquatica*, *Najas marina*, *Epilobium hirsutum*, *Trapa natans* and *Chara* sp., all attest to the existence of a water source and a marshy/lakeshore area at the site. The remains of *Urtica dioica*, *Acer* sp., *Abies alba*, *Cornus sanguinea*, Apiaceae and Poaceae at Verd could possibly be the remains of plant taxa that do not prefer moisture, and which could have been brought to the lakeshore settlement by the inhabitants.

The charcoal remains preserved at all eight considered Late Neolithic sites (Tab. 7) indicate palaeovegetational conditions in the surrounding forest and possible selection of wood for different purposes. At Dolsko – Spodnje Škovce a selection of mainly oak (*Quercus* sp.) and other RPW taxa (*Castanea*, *Fraxinus*) is shown, although five other tree taxa were also identified. Čatež – Sredno polje is the site with the most numerous charcoal fragments analysis among the sites considered (Tab. 7). The result shows that the forest vegetation of that time was quite similar to today's. In the lowland part of the wider area of the Čatež – Sredno polje, a floodplain oak forest still grows, in which hornbeam (*Carpinus betulus*) is also common. In addition to oak, elm (*Ulmus* sp.) and ash (*Fraxinus* sp.) are common, what is shown also by the analysed Late Neolithic charcoal. The elevated edges of the Gorjanci plain are now covered with light beech (*Fagus sylvatica*) forest, in which hornbeam and maple (*Acer* sp.) also thrive. The presence of vine (*Vitis vinifera* ssp.) charcoal at the Čatež – Sredno polje site is interesting, but it is not yet possible to say whether it is from the cultivated ssp. yet (*Culiberg 2022*). The result of charcoal analysis outline the natural environment from which people extracted natural resources, especially wood. Eighteen wooden piles of alder (*Alnus* sp.) used for construction at Resnikov prekop and seven of alder and willow (*Salix* sp.) at Verd pile-dwelling sites are of interest (Tab. 7), while mostly oak and ash wood is used at the younger Eneolithic pile-dwelling sites (*Čufar* et al. *2010*). In general, ash (*Fraxinus* sp.) charcoal has been found in five of the seven sites considered (Tab. 7); it seems to have been, along with oak (*Quercus* sp.), one of the tree taxa that was already selected by people in the Late Neolithic, not just in the Eneolithic (*Čufar* et al. *2010*). However, there are differences depending on the nearby forest vegetation and certainly also on the number of charcoal fragments and samples taken for analysis. The Čatež – Sredno polje site, with the largest number of charcoal identifications, clearly shows a relatively higher diversity (11 taxa) of the wood used, with a preference for beech, oak and maple – which probably grew in the vicinity of the settlement. In Dolsko – Spodnje Škovce, the oak charcoal can be interpreted in two ways: as natural oak wood or as selected oak wood. Today, almost two thirds of Posavsko hribovje is covered by forests, and the dolomite slopes of the Sava gorge are mainly beech (*Fagus sylvatica*) and hornbeam (*Carpinus betulus*) forests. Another important factor to be taken into account is the taphonomy and resistance of different types of wood/charcoal, which could also be the reason why oak charcoal is more often identified.

Archaeozoological knowledge about subsistence strategies in the settlements of the Sava group is limited (Tab. 8). This is mainly due to the lack of material caused by the poor preservation of bones in the often acidic sediments (*e.g., Hincak 2022*; *Kramberger* et al. *2023.71,108–109*) and/or the relatively small scale of the fieldwork (*e.g., Turk, Vuga 1984*; *Toškan, Dirjec 2006.Tab. 1; Velušček* et al. *2023*). In Dolsko – Spodnje Škovce, too, the small number of taxonomically identified animal remains probably does not allow a reliable assessment of local subsistence strategies (*Davis 1987.46*; *Bartosiewicz 2005.58–59*), especially since most finds come from a single feature, *i.e.* pit 1. The latter circumstance precludes a serious analysis of spatial differentiation within the settlement, so that a comparison of local archaeozoological data with those from other sites is more likely to reflect (dis) similarities in spatial use within the settlement rather than the degree of congruence of general subsistence patterns at different sites. Further difficulties arise from the fact that the archaeozoological material is highly fragmented. This makes the calculation of the Minimum Number of Individuals (MNI) rather impractical, even when focusing on several dozen taxonomically identified teeth. Since it is practically impossible to identify the tiny enamel fragments belonging to the same tooth, the actual calculated value of MNI = 3 may be close to or significantly different from the actual number of animals represented in the pit.

Another stumbling block in the interpretation of the archaeozoological assemblage from Dolsko – Spodnje Škovce is the limited understanding of the formation process of the deposits in pit 1. The pit may have been

formed by the extraction of clay material and later filled with waste, as is known from contemporary sites in the wider region, but it is unclear whether the pit was filled very quickly or much slower. Understanding the depositional processes associated with these features is crucial, as large pits may contain waste from a single building, from several households or possibly from the whole community; the deposits may be associated with ordinary daily activities, a special event (*e.g.,* a feast) or an exceptional situation (*e.g.,* the remains of a burnt-down house); they may contain primary or redeposited secondary waste, and so on (*Chapman 2000*; *Osztás* et al. *2012.388–390*; *Květina, Řídký 2017*; *Tóth* et al. *2020*; *Orton in press*). According to John Chapman (*2000.20,64*), in the Balkan Neolithic the *"...cultural material produced within, or domesticated into, the household was not subject to 20th century AD rules of refuse disposal but remained part of the household even after the end of its use."* In other words, not everything that was deposited in pits can be considered as 'normal' waste, because there must have been a deliberate choice to dump certain materials in pits and not simply dispose them in backyards, along paths, between houses, *etc.* (*cf. Orton* in press). Such 'special' pits may include an above-average amount of dumped material, evidence of *in situ* firing, backfills with evidence of deliberate burning or inclusion of products of deliberate burning (charcoal, ash, burnt clay, lithics, vessels and organic remains with evidence of burning), a basal layer of special/rare and/or mixed finds, deliberate placement of animal bones, evidence of ritual breakage (*e.g.,* of vessels) and evidence of parts of the same vessel being scattered in different parts of the feature/site, and so on (*Chapman 2000.69–73,82–83*).

Interestingly, most of the listed clues were found in Pit 1 in Dolsko – Spodnje Škovce. The list includes large quantity of deposited ceramics, especially in the basal layer SU 194 = 196 = 217, the presence of fragments of individual vessels in different parts of the pit, the fill SU 148 with a large amount of charcoal, the presence (deposition?) of the only almost complete, unburnt bone – a cattle mandible – at the bottom of one of the depressions in the bottom of the pit (*i.e.* SU 217; Fig. 5.2), the presence of burnt clay and possibly two charcoal clusters (hearths?) directly above fill SU 194 = 196 = 217, the prevalence of calcined animal teeth and bones in SU 194 = 196 = 217, and the peculiarity that they were almost absent from fill SU 148, which contained by far the largest concentration of charcoal (*Kramberger in press*).

A pragmatic approach to the interpretation of the almost exclusive occurrence of cattle in the Late Neolithic archaeozoological assemblage from Dolsko – Spodnje Škovce would focus on the considerable importance of this animal at (roughly) contemporaneous Lengyel sites in Lower Austria, the Carpathian Basin and the Western Balkans (*e.g., Bökönyi 1986.Tab. 1, 3, Fig. 2–3*; *Bartosiewicz 1995.Tab. 2*; *Schmitzberger 2008.227–240*; *Nyerges, Biller 2015.4–6*; see also *Bartosiewicz 2005.57–58*), as this suggests that the Late Neolithic community under study often placed a strong emphasis on cattle herding. Of course, to confirm the hypothesis the archaeozoological material studied here

Site	NISP	*B. taurus*	Caprinae	*Sus* sp.	*C. familiaris*	*C. elaphus*	*C. capreolus*	*A. alces*	*B. primigenius*	Other taxa
Dolsko – Spodnje Škovce (Fig. 1.1)	511	71	2	10						
Resnikov prekop (Fig. 1.6)	108	14	5	19	2	37	4	20		7
Zamedvedica (Fig. 1.7)	15			3		10			1	1
Verd (Fig. 1.9)	5					4				1
Gradec near Mirna (Fig. 1.11)	8	3	1	1		3				
Čatež – Sredno polje (Fig. 1.14)	166	22	26	31		37	11		39	
Spaha (Fig. 1.20)	38	15	3	10		4			1	5

Tab. 8. Species representation at Dolsko and other sites of the Sava group of the Lengyel Culture. Notes on the contexts considered: Dolsko – Neolithic material (Tab. 1); Resnikov prekop – complete assemblage (*Toškan, Dirjec 2006*); Zamedvedica near Plešivica – complete assemblage (*Turk, Vuga 1984*); Verd – complete assemblage (*Velušček *et al.* 2023*); Gradec near Mirna – phases 1a, 1b (Toškan, unpublished data); Čatež – Sredno polje – Neolithic material (*Hincak 2022; *unpublished data); Spaha – material from the 5th millennium cal BC (*Toškan 2011*). Explanation of abbreviation: NISP – Number of Identified Specimens (*Grayson 1984*).

would have to reflect subsistence strategies that go beyond the level of a single household or even a single event. Given the diversity of the material discarded in pit 1 and the considerable differences in the composition of different fills, this option is not to be ruled out completely (*cf. Osztás* et al. *2012.390*). The hypothesis that cattle breeding predominated in Late Neolithic Dolsko – Spodnje Škovce would indeed fit well with the local paleoenvironment, as the site is located on the edge of the agriculturally interesting lowlands of the Ljubljana Basin. On the other hand, for example, the nearby Resnikov prekop and Verd were located on the shores of the lake at Ljubljansko barje, with probably a less fertile soils, so the dominance of game at these sites (pile dwellings) is not surprising (Tab. 8).

On closer examination of the available data, however, the possibility seems realistic that the archaeozoological assemblage from the Late Neolithic contexts at Dolsko – Spodnje Škovce does not reflect 'average' subsistence practices, as the process of formation of the deposits from pit 1 appears to be peculiar in some respects. In this context, it is worth mentioning the taphonomic observations already highlighted in relation to the fillings of this pit. Also significant is the large discrepancy in the quantity of pottery, charcoal and animal remains between pit 1 and other pits discovered at this site, which is obvious even taking into account the differences in size between them (*Kramberger in press*). To mention only the number of animal remains (Tabs. 1, 8), several hundred specimens were collected from pit 1 (size: 11x7m; depth: up to 0.7m), no more than four from pit 2 (size: 10x5m; depth: 0.3m with deepenings in the floor up to a further 0.3m) and none from any of the other, indeed much smaller and shallower pits (N = 12; dimensions of the largest [SU 3029/3030]: 2.35x1.1m; depth: up to 0.35m; *Kramberger in press*). Finally, the preponderance of cattle in the various fills of Pit 1 is a remarkable circumstance. In fact, the sheer size of these animals implies that they were routinely consumed beyond the level of the individual household or nuclear family group, suggesting communal (and thus not 'ordinary'?) activity. Also worth mentioning is the possible social value of live animals of this domesticate as objects of prestige or exchange (*Orton 2012.27,32; Manning* et al. *2013a.250*).

Conclusions

Post-depositional processes related to the Sava River and smaller streams have shaped the found Late Neolithic archaeological record at Dolsko – Spodnje Škovce. Nevertheless, several smaller and two large pits (1 and 2), filled with material culture of the Sava group of the Lengyel Culture were found. Of particular interest is pit 1, which yielded most of the Late Neolithic pottery from the site. Based on its irregular shape, the distribution of parts of individual ceramic vessels in different fills of the pit and over large area, the large amount of very fragmented animal remains and the location of the pit on the 'island' of clayey alluvium, it may have been used for digging clay loam, which was used for construction activities, and in the later phase it was filled with waste. The same can be assumed for many other large pits of irregular shape at Late Neolithic sites in Slovenia. Lack of rectangular timber framed houses may be due to time-dependent site losses due to taphonomy.

Based on the analysis of the pottery, the definition of the Sava group of the Lengyel Culture needs to be supplemented. The sites in Bela Krajina do not differ from those in the Posavje, Ljubljansko barje and SU 128 in Stoperce (northeastern Slovenia) in terms of pottery production methods, decoration and ceramic forms. On the contrary, three variations of one pottery style (Sava group Ia-b, II) can be recognized. In Posavje and central Slovenia all three variations of one style are present, the only site of the Sava group in northeastern Slovenia (Stoperce, SU 128) has yielded pottery of the Sava group Ib style, and in the Bela krajina region so far only settlements with pottery of Sava group Ib and II were found, at Moverna vas in different occupation layers lying in stratigraphic superposition: settlement phases 2 (Sava group Ib), 4 and 5 (Sava group II).

According to the analysis, the material culture from pit 1 at Dolsko is attributed to the Sava group Ib and, based on radiocarbon measurements, it can be dated with caution to the middle and beginning of the second half of the 5th millennium cal BC. This period corresponds to a range of radiocarbon dates from short-lived material at other Late Neolithic sites with the Sava group Ib pottery in the Posavje region and Ljubljansko barje, as well as dates from the Late Lengyel Culture in Transdanubia and MOG IIa phase in Austria. It is later than the range of radiocarbon dates from Dragomelj and Čatež – Sredno polje, whose pottery can be attributed to Sava group Ia.

The Bayesian model presented in this study included a number of samples of short-lived materials related to Sava group Ib and Lasinja Culture of the Early Copper

Age from the area of central Slovenia and Posavje. According to the median value, the beginning of the Sava group (Ia) is estimated at 4758 cal BC and its end at 4548 cal BC, which could correspond to Lengyel II phase in Transdanubia and recently published dendrodata for the pile from Verd (*Velušček* et al. *2023*), but also to the time range estimated for five Lengyel furnished burials at Veszprém-Jutasi út, attributed to Lengyel IIb phase (*Regenye* et al. *2022.288–290*). The following part of the Sava group sequence (sites with pottery Sava group Ib and II) in Posavje was parallel to the Late Lengyel sequence in Transdanubia.

According to the chronological model presented here, the period of settlement phase 2 at Moverna vas overlaps with those from Čatež – Sredno polje and Dragomelj, or is even slightly earlier. This would mean that sites with pottery of Sava group Ia in central Slovenia and Posavje, and Sava group Ib in Bela Krajina were contemporary. However, since the radiocarbon dating at Dragomelj and Čatež – Sredno polje is based solely on charcoal, and at Moverna vas on charcoal and charred residues on the pottery, further research is needed to prove or disprove this. Later chronological sequence at Moverna vas (phases 3, 4, 5 and partly phase 6) is comparable with the later sequence in the here presented Bayesian chronological model for the Sava group in Posavje, and the beginning of the Lasinja Culture, which was part of a wider shift in settlement and society, is estimated in models for both regions to be around 4350 cal BC, which is similar to Transdanubia.

The synthesis of the scarce archaeobotanical results, especially no crop macro-remains (see Tab. 6), at Slovenian Late Neolithic (5th cal BC) sites to date aims to outline a regional gap in the study of the earliest agricultural communities and crop diversity among the early farmers in present-day Slovenia. The aim is to provoke a discussion about whether and why the potential botanical evidence for early agricultural decision-making at the local level is being dismissed, or indeed does not exist. The record of prehistoric crop cultivation in central Europe dates back to 5500 cal BC (*e.g., Baum* et al. *2016*). However, the synthesis presented in this article clearly shows that there is an urgent need for further revision and possible re-probing, which would allow us to expand the comparisons between the sites in the area and thus obtain more information about the first farmers in Slovenia. The discussion of cultural similarity and preferences in crop choice could then be developed, together with archaeological and archaeozoological evidences.

The oldest currently known finds of cultivated plants in Slovenia are therefore much younger, dating from the last third of the 5th and 4th mill. cal. BC or Early and Middle Copper Age; *e.g.,* form the sites: Pigl na Javorniku (*Tolar unpublished*), Ajdovska jama (*Culiberg, Šercelj 1986; Culiberg* et al. *1992; Sraka 2020*), Gradec near Mirna (2nd phase, *Culiberg, Šercelj 1995; Sraka 2020*), Stoperce (other pits than SU 128, *Kramberger* et al. *2023*), Zgornje Radvanje (*Kramberger 2021; Tolar 2021*). Strojanova voda and Maharski prekop (*Tolar 2018*), Stare gmajne (*Tolar* et al. *2011*), and Hočevarica (*Jeraj 2004*). The earliest crop taxa in Slovenia to date are represented by three species of cereals, barley (*Hordeum vulgare*), einkorn (*Triticum monococcum*) and emmer (*Triticum dicoccum*), one pulse, *i.e.* pea (*Pisum sativum*), and two or three oil crops: flax (*Linum usitatissimum*), poppy (*Papaver somniferum*), and possibly turnip (*Brassica rapa*; see *Tolar* et al. *2011*). The macro-remains of the listed taxa have all been found at the sites listed above and attest to the presence of the earliest cultivars in Slovenia. In addition to cereals grains and/or oilseeds, the remains of cereal or flax processings (*i.e.* chaff and capsulas remains) have been found at many of the above listed sites. At waterlogged sites (*i.e.* pile-dwellings) even the seeds of weeds are well preserved. All of these are evidences not only of the use of cultivated food plants (*i.e.* diet), but also of the cultivation practices (agriculture) directly at the archaeological site being investigated.

As far as the archaeozoological results are concerned, the first impression is that in the Late Neolithic in Dolsko – Spodnje Škovce cattle breeding played the main role in the supply of meat and fats. This is similar to other sites of the Lengyel Culture from Lower Austria and the Carpathian Basin (*Bökönyi 1986.Tabs. 1,3, Figs. 2–3*; *Bartosiewicz 1995.Tab. 2*; *Schmitzberger 2008.227–240*; *Nyerges, Biller 2015.4–6*), as well as most contemporaneous sites in the continental central Balkans (*Orton 2012; Manning* et al. *2013a; 2013b; Orton* et al. *2016; 2021*). However, it should not be forgotten that practically all the animal remains examined here came from a single, peculiar large pit. Moreover, since the general trend of increasing importance of large-scale cattle breeding in the Late Neolithic Balkans was neither universal nor synchronous (*Orton* et al. *2021* and references therein), it should not be taken for granted for the communities of the Lengyel Culture either. Heterogeneity in subsistence strategies is evident in the continued importance of wild species in the archaeofaunas of this period, suggesting that hunting

was not consistently reduced to a sporadic, seasonal or purely opportunistic practice (*Gaastra, de Vareilles, Vander Linden 2022.52–57; Orton in press*).

Indeed, the archaeozoological data for the sites of the Sava group, although sparse, reflect the non-uniform supra-regional picture mentioned above quite well (Tab. 8). The high proportion of wild fauna at Čatež – Sredno polje and the pile-dwellings of Zamedvedica, Verd and Resnikov prekop is probably influenced by the location of these sites on/near a large lake/river with a forested, game-rich background (*Turk, Vuga 1984*; *Toškan, Dirjec 2006; Hincak 2022; Velušček* et al. *2023.27–28*), but may not have been independent of a conscious, culturally determined decision to emphasize hunting (*cf. Bökönyi 1986*; *Gaastra* et al. *2022.56–57; Orton in press*). The relative abundance of cattle remains in the 5th millennium layers at the hilltop settlement of Spaha (*c.* 60km southeast of Dolsko – Spodnje Škovce), on the other hand, seems to reflect vertical transhumance as part of an already developed, large-scale cattle herding system. Since both extremes of subsistence strategy are found in the area occupied by the Sava group communities, the high prevalence of cattle remains in Dolsko – Spodnje Škovce could reflect either a strong emphasis on cattle herding by the local community or the holding of a special event in which cattle/beef played a notable role (*e.g.,* a feast).

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Tab. 6. 5th millennium cal BC Late Neolithic sites in Slovenia with macro-remains of seeds/fruits, state-of-the-art (n.d. – no data). Quantitative proportions of samples apply to all analysed samples (seeds and wood charcoal). Source of data: Culiberg (2022); Kramberger et al. (2023); Tolar (2022); Velušček et al. (2023); Culiberg (2006); Čufar, Korenčič (2006); Sraka (2016); Hlad (2015) and unpublished data.

Site	Dolsko – Spodnje Škovce (Fig. 1.1)	Dragomelj, SU 971 (Fig. 1.5)	Resnikov prekop (Fig. 1.6)	Zamedvedica (Fig. 1.7)	Verd (Fig. 1.9)	Dolenji Leskovec (Fig. 1.12)	Čatež – Sredno polje (Fig. 1.14)	Stoperce, SU 128 (Fig. 1.22)
No. sediment samples	34	1	34 wood samples	n.d.	2	1	70	2
Context	Neolithic pits 1 and 2, SUs 87, 87, 218	Neolithic pit	Pile-dwelling	Surface finds	Pile-dwelling	Pit	Neolithic pits	Neolithic pit
Age cal BC / Plant taxa (seeds/fruits)	Charcoal and apatite: 4788-4350	Charcoal: 4840-4456	*Alnus* wood: 4675-4465	/	*Trapa natans:* 4611-4630; dendrochr.: 4674±42	*Crataegus*: 4656-4371	Charcoal: 4954-4460	Charcoal: 4609-4450
Cerealia		1						
Poaceae (?Cerealia)					x			
Stellaria sp.		1						
Chenopodiaceae							x	
Polygonum sp.							2	
Polygonum persicaria							1	
Veronica sp.							1	
Setaria sp.							2	
Urtica dioica					2			
Sparganium sp.					1			
Solanum nigrum							1	
Betula pubescens					1			
Acer sp.					2			
Fagus sylvatica					2			
Malus/Pyrus					1			
Crataegus monogyna					2	1		
Rubus sp.					1			
Cornus sanguinea					1			
Abies alba-needles					30			
Alnus sp.					5			
Nuphar luteum					2			
Mentha aquatica					29			
Schoenoplectus lacustris					13			
Potamogeton sp.					2			

Tab. 6. Continued

Alisma plantago aquatica					6			
Eupatorium cannabinum					7			
Ranunculus aquatilis					3			
Oenanthe aquatica					4			
Najas marina					3			
Epilobium hirsutum					3			
Apiaceae					1			
Trapa natans					8			
Chara sp.					33			

Tab. 7. 5th millennium cal BC Late Neolithic sites in Slovenia with charcoal (wood) remains, state-of-the-art (n.d. – no data). Quantitative proportions of samples apply to all analysed samples (seeds and wood charcoal). Source of data: Tab. 2 and same as in Tab. 6.

Site	**Dolsko – Spodnje Škovce (Fig. 1.1)**	**Dragomelj, SU 971 (Fig. 1.5)**	**Resnikov prekop (Fig. 1.6)**	**Zamedvedica (Fig. 1.7)**	**Verd (Fig. 1.9)**	**Dolenji Leskovec (Fig. 1.12)**	**Čatež – Sredno polje (Fig. 1.14)**	**Stoperce, SU 128 (Fig. 1.22)**
No. sediment samples	34	1	34 wood samples	n.d.	2	1	70	2
No. ID charcoals	35			n.d.		n.d.	190	4
Context	Neolithic pits 1 and 2, SUs 86, 76, 218	Neolithic pit	Pile-dwelling	Surface finds	Pile-dwelling	Pit	Neolithic pits	Neolithic pit
Age cal BC / Plant taxa (charcoal)	Charcoal and apatite: 4788-4350	Charcoal: 4840-4456	*Alnus* wood: 4675-4465	/	*Trapa natans:* 4611-4630; dendrochr.: 4674±42	*Crataegus*: 4656-4371	Charcoal: 4954-4460	Charcoal: 4609-4450
Quercus	12						6+10+6+11+3+1+5+7+26	
Quercus/Castanea	3							
Tilia							1	
Populus/Salix					3 (piles)		1+3+1	
Acer	1		1 (piles)				13+2+3+2+1+1+8+4	
Carpinus	5						1+5+1	
Fagus					1 (pile)		2+32+1+4+1+1+1+6+1+3+1+1+7+4+2+4	
Ulmus							4+4+2+3	
Vitis							17	

Tab. 7. Continued

Fraxinus	1		8 (piles)		x (charcoal); 2 (piles)		2+1+4+3	2
Fraxinus/Castanea	1							
Betula							1+1	
Sorbus							2	
Cornus	4							
Sorbus/Cornus	1							
Alnus sp.			18 (piles)		4 (piles)			
Corylus avellana				x				
Coniferous	3							2
DPW			7 (piles)				1	
RPW	4							
not determined		x			x (charcoal)	x (charcoal)	x	