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Srednja vas v Bohinju – Palaeoenvironmental Record of Human Influence on the Lowlands of the Julian Alps

Srednja vas v Bohinju – paleookoljski zapis vpliva človeka na nižine Julijskih Alp

Nina CAF

Izvleček

Arheološke raziskave, ki so se na območju Bohinja v preteklosti osredotočale predvsem na alpske doline, so se v zadnjih desetletjih razširile še v visokogorje. Sledile so jim tudi palinološke raziskave. Da bi pridobili nove informacije o lokalnem vplivu človeka na okolje in posredno gospodarski izrabi prostora, smo v okolici Srednje vasi v Bohinju izvrtali vrtino za palinološke analize.

Rezultati analize kažejo človeški vpliv na vegetacijo od eneolitika naprej (ca. 4700 cal. BP). V železni dobi in rimskem obdobju so lokalni smrekov gozd nadomestili pašniki, kar je v skladu s prisotnostjo večjega števila arheoloških najdišč v bližini. V srednjem veku je opaziti upad drevesnih taksonov, kar je lahko posledica kontinuirane paše in vse večjih potreb po železu. V novem veku je krajina ostala odprta s kontinuiranim pojavljanjem peloda antropogenih indikatorjev, ki nakazujejo na pašništvo/poljedelstvo in posredno na metalurgijo.

Ključne besede: Julijske Alpe; Srednja vas v Bohinju; holocen; palinologija; človekov vpliv; spremembe vegetacije

Abstract

In recent decades, archaeological and palynological research in the Bohinj basin has mainly focused on the highlands, while research in the valley is much older and often insufficient. In order to obtain new information about the local human impact on the environment, a palynological analysis was carried out in a marsh-like environment near Srednja vas v Bohinju. The main aim of the investigation was to obtain more information about the former vegetation, economy and use of the environment.

The palynological results show an early human impact on the environment (since the Eneolithic, ca. 4700 cal. BP). In the Iron Age/Roman period, the local spruce forest was replaced by pastures, which is consistent with the archaeological sites nearby. Throughout the Middle Ages, a decline in tree taxa can be observed, which could be due to continuous pastoralism and an increasing demand for iron. In the Modern Period, the landscape remained open with continuous grazing/arable farming and indirectly due to metallurgy.

Key words: Julian Alps; Srednja vas v Bohinju; the Holocene; palynology; human impact; vegetation change

The Julian Alps is a mountain range that stretches between northeastern Italy and northwestern Slovenia. The area consists of high alpine plateaus and peaks that rarely exceed 2,800 m a.s.l. and alpine valleys in between (e.g., the Soča valley, the Bohinj valley, etc.; Perko, Orožen Adamič 2001). The climate in the Julian Alps is alpine, with high annual precipitation (ca. 2000–3500 mm). The

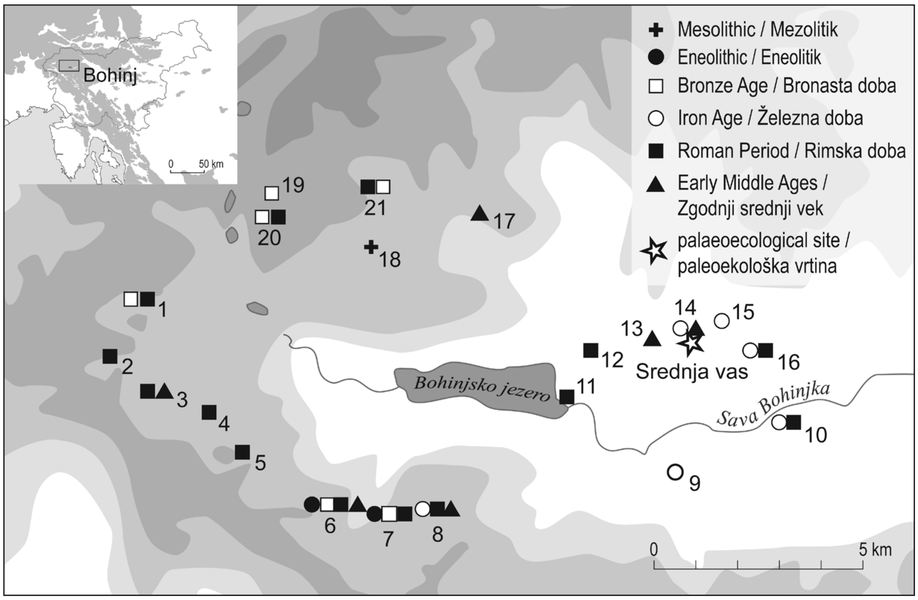


Fig. 1: Archaeological sites around the Srednja vas v Bohinju coring location (modified after Andrič et al. 2020b; ARKAS).
Sl. 1: Arheološka najdišča v okolici lokacije vrtanja pri Srednji vasi v Bohinju (povzeto po Andrič et al. 2020b; ARKAS).

1 – Poljanica na Zadnjem Voglu; **2** – Gracija; **3** – Govnjač; **4** – Krošnja; **5** – Snežna konta; **6** – Kal na Zadnjem Voglu; **7** – Poljanca; **8** – Dolga Planja; **9** – Žlan; **10** – Ajdovski gradec; **11** – Sv. Janez; **12** – Stara Fužina; **13** – Podojnce; **14** – Žale; **15** – Bohinjska Češnjica; **16** – Dunaj pri Jereki; **17** – Krstenica; **18** – Jama za skalami; **19** – Pod Kopico; **20** – Vodene Rupe; **21** – Mišeljski preval

Fig. 2: Srednja vas v Bohinju. Location of coring site.
Sl. 2: Srednja vas v Bohinju. Lokacija mesta vrtanja.

Modern average winter temperature is between 0 and –3°C, and the summer temperature is between 15 and 20°C (D. Ogrin 1996, 52).

Prevailing vegetation is *Ostryo-Fagetum* and *Anemone-Fagetum* tree association in the surrounding hills of the Bohinj basin and anthropogenic grasslands in the valleys (Marinček et al. 2002).

Archaeological research (*Fig. 1*) in the area of the Julian Alps has shown early human presence (stone tools) in the region since the Late Paleolithic/Mesolithic, mainly in the area of the Krn mountain range (Turk et al. 2005, 41; Turk, Podobnik 2024, 19). In the highlands of Bohinj, the oldest human traces were found at Jama za Skalami and

Žagarjeva glava, which were, based on charcoal analysis, dated to the Mesolithic (7500–6000 BC; Turk, Šercelj 1988, 13; Horvat 2002, 193). In the alpine valleys, including the Bohinj basin, archaeology has also provided evidence of the human presence, with the oldest traces belonging to the Bronze Age (Valič 1968–69, 148, Pl. 2: 1). Permanent settlements are known from the earlier Iron Age onwards, when the Bohinj basin belonged to the Posočje/Sveta Lucija group (Gabrovec 1975; 1987; Teržan 2022; Mlinar, Tecco Hvala 2022; last review by M. Ogrin 2023, 634–635). As a result of rich iron ore surface deposits, the Bohinj basin developed into an important ironworking area (Müllner 1909, 52; Gabrovec 1975, 168; Mušič 1999). The remains of a Roman settlement are rare, they are known from Ajdovski gradec near Bohinjska Bistrica (Kos 1988, cat. No. 96; Mušič 1999, 370–376; Ciglenečki 2015, 410) and Dunaj pri Jereki (Meterc 1992, 225). According to the coin finds, the two settlements existed approximately until the end of the 4th century (Kos 1988, cat. No. 96, 106/1, 106/2; Kos, Šemrov 1995, cat. No. 64, 66, 67). Next to Lake Bohinj, on the site of today's church of sv. Janez Krstnik (St John the Baptist) and in its surroundings, the remains of a Roman-era settlement and sanctuary were discovered, which were also in use until the end of the 4th century (Josipovič, Gaspari, Miškec 2012, 389–396). From the Early Middle Ages, the Žale and Podojnce cemeteries near Srednja vas are known (Lavrenčič 2019, with cited older literature). At Dunaj pri Jereki, an Avar strap end from the second half of the 8th century was found (Gabrovec 1955, 137; Ciglenečki 1992, 57, Fig. 2; Karo, Knific, Lubšina Tušek 2011, 132, 137, cat. No. 1).

Palaeoecological studies that would give us more relevant information about human impact on the environment have been limited to Lake Bohinj (Andrič et al. 2020a, 2). The palynological analysis of Lake Bohinj shows a broader/regional vegetation development due to wider catchment, so local impact can often be overlooked. Therefore, our study focused on the palynological analysis of the sedimentary record of Srednja vas v Bohinju, located at 580 m a.s.l. (ca. 4 km east of Lake Bohinj, in Zgornja Bohinjska dolina (the Upper Bohinj valley), *Fig. 2*). The main aim of this study was to find out how the vegetation changed in different archaeological periods depending on climate or anthropogenic impact and to compare this with other palaeoecological archives/archaeological analyses in the area.

STUDY AREA

The area of Srednja vas v Bohinju lies in the Upper Bohinj valley at the altitude of ca. 580 m. The Upper Bohinj valley is the north-eastern part of the Bohinj basin that is surrounded by the Pokljuka Plateau to the north and Lake Bohinj to the west. In the past, access to the Bohinj basin was possible only across mountain passes. Only in the Modern Period, the lowland connections to the Bohinj basin were established (Cundrič 2002, 73–74).

Samples for palynological analysis were collected in the marsh-like environment (mostly reeds) near river Suha (*Fig. 1*). The surrounding area is dominated by agricultural areas, mainly fields and meadows. The village Srednja vas v Bohinju is located north of the coring site.

Near the study site, there are several archaeological sites from different periods. About 500 m north of the core, modest traces of a prehistoric, probably earlier Iron Age settlement were discovered at Žale (Gabrovec 1958–1959a, 321, 323). At the same site, an early medieval burial site with 24 graves was excavated at the beginning of the 20th century (Šmid 1908; Lavrenčič 2019, with cited older literature). Another early medieval burial site was located only 600 m further west at Podojnce (Šmid 1908; Lavrenčič 2019, with cited older literature). East of Srednja vas, approximately 1800 m away from the study site, a fortified village named Dunaj pri Jereki was discovered. It was inhabited during the Hallstatt and Roman period (see above). An accidental find of an Avar strap end that has also been found at the aforementioned site. Approximately 3.5 km from the coring site, the Roman-era settlement and sanctuary at St John the Baptist (see above) church and the prehistoric and Roman highland settlement of Ajdovski gradec (see above) were discovered.

METHODS

Coring

A dense vegetation cover (mainly reeds) made drilling with the Livingstone drilling equipment difficult. Therefore, in October 2019, in a 1×1 m trench we first extracted a 1-metre-long profile (*Fig. 3*). The sediment samples were removed from the profile using metal boxes (length: 50 cm). In May 2020, we drilled a 382-cm-long core at the same place with the Livingstone drilling equipment. The sediment from the profile/core was taken in the field where it was cleaned and protected with plastic and aluminium foil to prevent contamination with modern pollen. Core samples were stored in a cold store at +4°C at Institute of Archaeology ZRC SAZU.

Radiocarbon dating

Altogether, four samples of plant macrofossils (*Fig. 4*) were measured at the Poznan Radiocarbon Laboratory. After obtaining dates, the age-depth model was comprised (*Fig. 5*) by using packages Clam (Blaauw 2010) and IntCal (Reimer et al. 2020), which are available in the R programming language (R Development Core Team 2011).

Palynology

Altogether, 40 samples (1 cm^3 of sediment each) were taken every 2 to 8 cm from the profile/ upper part of the core (*Fig. 3*) to obtain a resolution of 50 to 100 years. Samples were collected and prepared following the standard method for palynological samples – *Lycopodium* spores, 7% HCl, 10% NaOH, 40% HF, acetolysis, safranin dye, and silicone oil (Bennett, Willis 2002, 10–12). The standard number of counting a minimum of 300 pollen grains in each sample was followed. However, due to poor preservation (in a 76–93-cm section of the core), this could not be obtained in all samples; therefore, in the aforementioned samples, a minimum of 200 pollen grains were counted using the Nikon Eclipse Ci light microscope.

Identification keys, atlases (Faegri, Iversen 1989, 237–288; Moore et al. 1991; Reille 1992; 1995; Beug

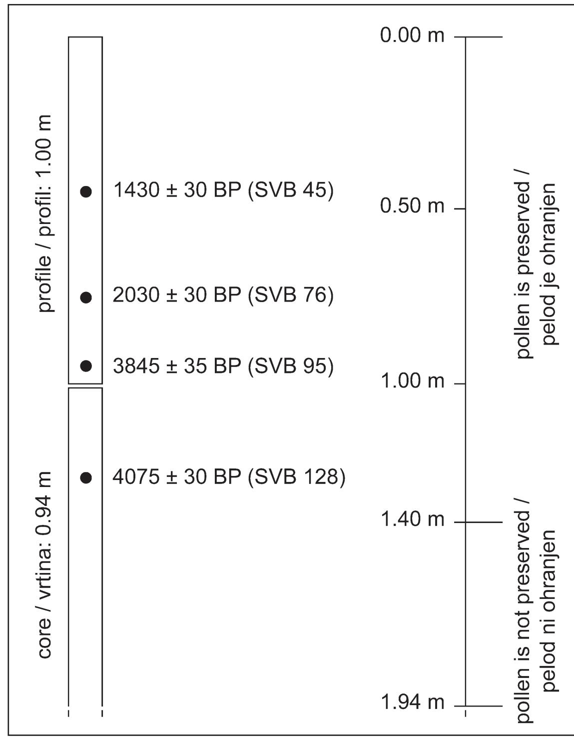


Fig. 3: Srednja vas v Bohinju. Length of the whole core (master core) was 3.82 m, but only the upper part of the core is shown (1.94 m). Radiocarbon dates (uncalibrated) are marked.
Sl. 3: Srednja vas v Bohinju. Dolžina celotnega jedra (master core) je bila 3,82 m, prikazan pa je samo zgornji del jedra (1,94 m). Označeni so (nekalibrirani) radiokarbonski datumi.

2004) and the palynological reference collection of the Institute of Archaeology, ZRC SAZU, were used for the identification of different taxa. Simultaneously, we noted the occurrence of charcoal particles (divided into two categories, depending on the length, <40 and >40 μm, Clark 1982), stomata (Hansen 1995; MacDonald 2001, 38–39; Sweeney 2004; Hu et al. 2016) and non-pollen palynomorphs (*Sporormiella* and *Cercophora*, van

Sample / Vzorec	**Depth / Globina (cm)**	**Age / Starost^{14}C (BP)**	**2σ cal. (BP)**	**Age / Starost (BC / pr. n. št.; AD / n. št)**	**Sample type / Tip vzorca**
SVB 45	45	1430 ± 30	1303–1375	575 AD – 647 AD	Needles / iglice
SVB 76	76	2030 ± 30	1932–2103	153 BC – 18 AD	Needles / iglice
SVB 95	95	3845 ± 35	4157–4406	2456 BC – 2207 BC	*Alnus, Picea* charcoal / oglje
SVB 128	128	4075 ± 30	4452–4804	2854 BC – 2502 BC	*Fagus, Fragaria* seeds / semena

Fig. 4: Radiocarbon results from Srednja vas v Bohinju.
Sl. 4: Radiokarbonski datumi iz Srednje vasi v Bohinju.

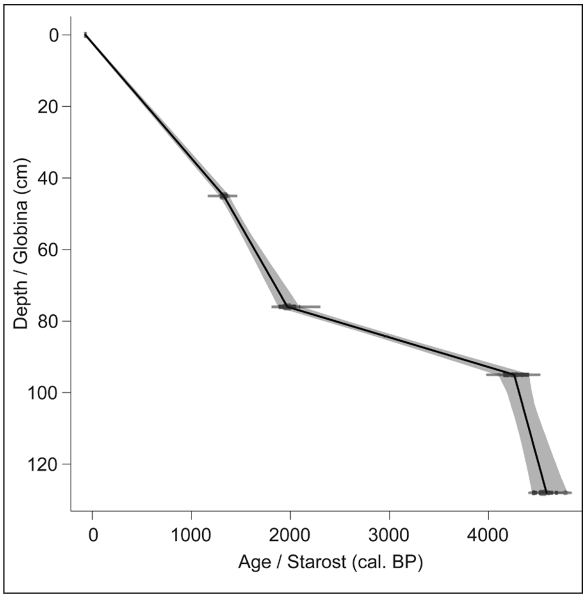


Fig. 5: Srednja vas v Bohinju. Age-depth model of the part of the core with preserved pollen. Model is based on radiocarbon dates (*Fig. 4*).
Sl. 5: Srednja vas v Bohinju. Časovni model jedra z ohranjenim pelodom. Model temelji na radiokarbonskih datacijah (*sl. 4*).

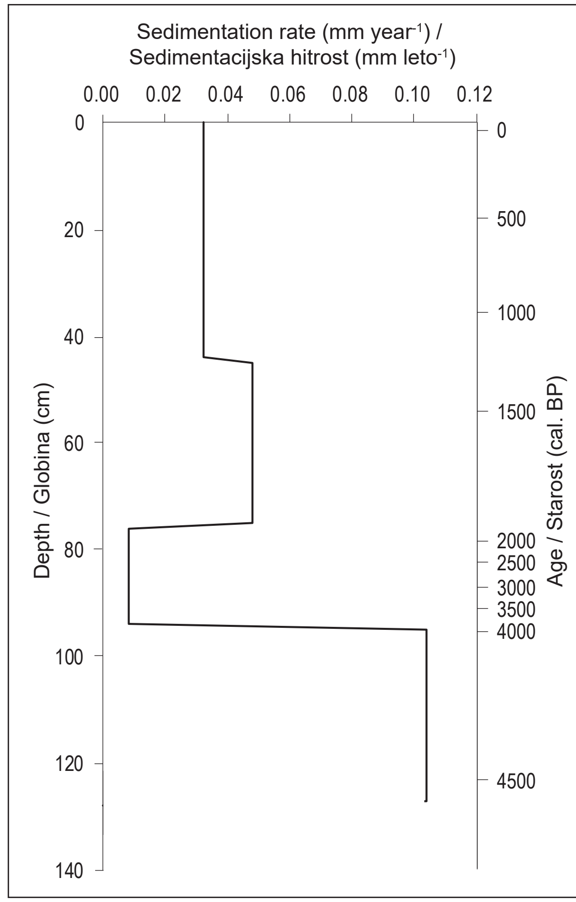


Fig. 6: Srednja vas v Bohinju. Sedimentation rate (mm year^{-1}).
Sl. 6: Srednja vas v Bohinju. Sedimentacijska hitrost (mm leto-1).

Geel 2002, 106–109; Gelorini et al. 2011). To create a pollen diagram, the Psimpoll 4.261 program was used. Samples were divided into zones that were determined by binary splitting by sum–of–square (Bennett 2005, 64). Additionally, the index of pollen richness was calculated using Psimpoll 4.261 to obtain a qualitative calculation of vegetation changes over time (Bennett 2005, 61–62). The pollen richness index represents the number of different pollen types in a pollen assemblage and is standardized for all the samples included in the palynological analysis (for Srednja vas v Bohinju, a minimum count of 250 pollen grains was used; Birks, Line 1992, 2–3). Therefore, in some samples (with a low pollen concentration) the pollen richness was not calculated.

RESULTS

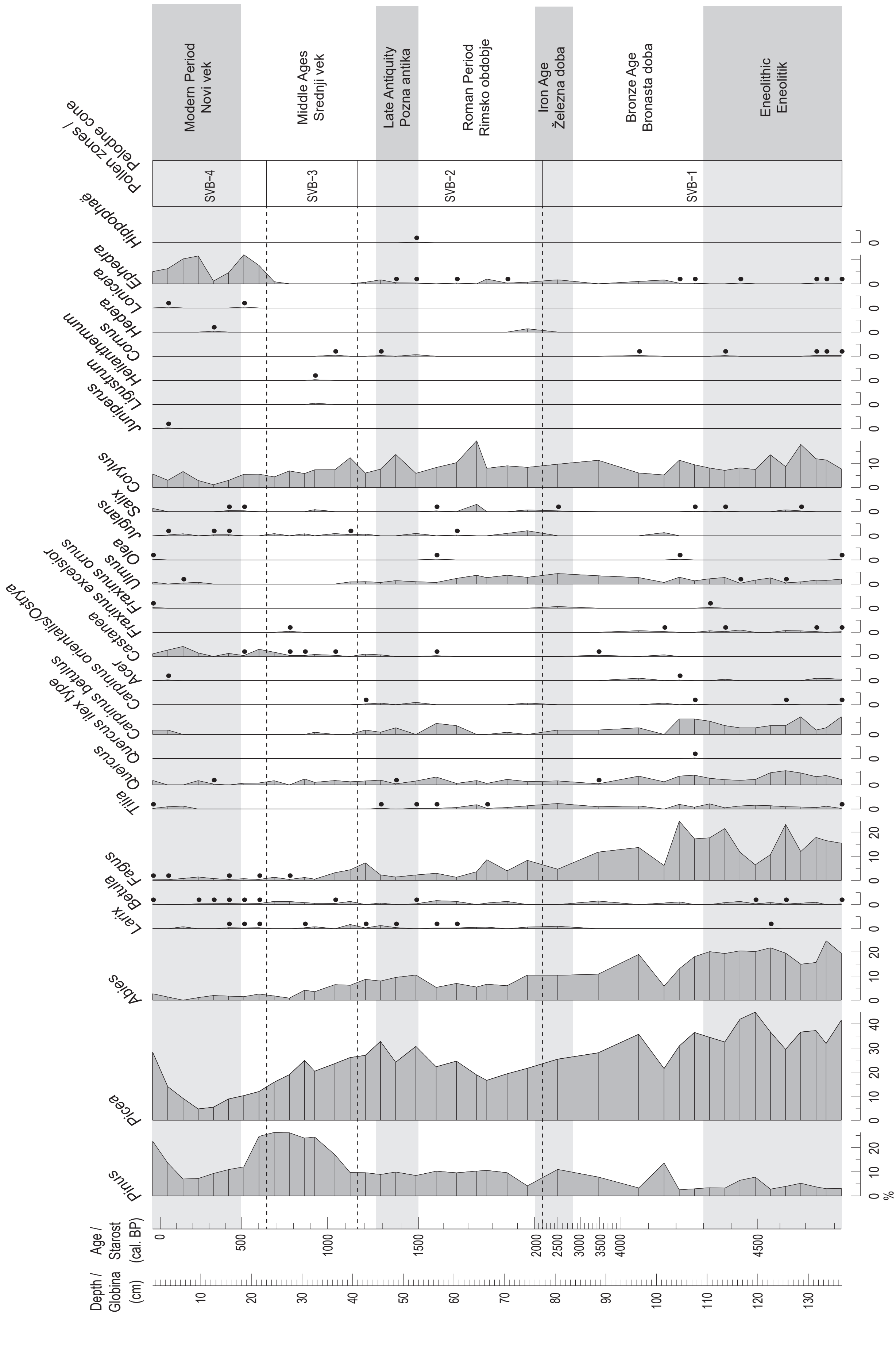
Age-depth model

A linear interpolation was used to create the age–depth model (*Fig. 5*). The time span of the core (in the upper part of 140 cm with preserved pollen) is about 4800 cal. BP (2800 BC–2019 AD). The sedimentation rate was also calculated (mm year^{-1}; *Fig. 6*).

Palynological analysis

A pollen diagram was constructed using 40 samples (*Fig. 7–10*). In certain parts of the profile (ca. 80–90 cm), the pollen concentration in the samples was poor (between 8500 and 10 000 pollen grains cm^{-3}) and/or the local taxa (*Alnus*, Cyperaceae, Filicales) presented a high percentage of the total pollen sums (*Fig. 9*). As a result, it was not possible to count more than 300 pollen grains per sample (excluding local taxa). Due to the poor preservation, low concentration of pollen and slow sedimentation rate (*Fig. 6*), the sampling resolution in this part of the profile was greater than ca. 100 years (*Fig. 5*; *6*). Below 140 cm (of the total length of the core), pollen was not preserved (except at the depth of 224 cm, which is not shown on pollen diagrams; the sample shows Pleistocene vegetation; *Fig. 3*).

Altogether, four pollen zones were produced by Psimpoll (Bennett 2005), with the zone SVB–1 spanning between 4800–2200 cal. BP, zone SVB–2 between 2200–1200 cal. BP, zone SVB–3 between



Modern Period
Novi vek
Middle Ages
Srednji vek
Late Antiquity
Pozna antika
Roman Period
Rimsko obdobje
Iron Age
Železna doba
Bronze Age
Bronasta doba
Eneolithic
Eneolitik
Pollen zones / Pelodne cone
SVB-4
SVB-3
SVB-2
SVB-1
Hippophaë
Ephedra
Lonicera
Hedera
Cornus
Helianthemum
Ligustrum
Juniperus
Corylus
Salix
Juglans
Olea
Ulmus
Fraxinus ornus
Fraxinus excelsior
Fraxinus
Castanea
Acer
Carpinus orientalis/Ostrya
Carpinus betulus
Quercus ilex type
Quercus
Tilia
Fagus
Betula
Larix
Abies
Picea
Pinus
%
Age / Starost (cal. BP)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
Depth / Globina (cm)
10
20
30
40
50
60
70
80
90
100
110
120
130

1200–650 cal. BP and zone SVB–4 from 650 cal. BP until the year of coring (AD 2019, *Fig. 7–10*).

In zone SVB–1, tree taxa were dominant (60–97%), with *Picea* (20–45%), *Abies* (5–25%), *Fagus* (5–25%), *Corylus* (5–18%), and *Pinus* (3–14%) being the most common. To a lesser extent, *Carpinus betulus* (2–7%) and *Quercus* (0.5–6%) were also present. The percentage of herb taxa was between 2–40%, among which Poaceae (0.5–20%) and Cichorioideae (0.5–13%) were the most common taxa. Stomata of *Picea* are common in this zone (1–11 stomata per sample).

In zone SVB–2, the percentage of tree taxa dropped to 55–70%, among which *Picea* (15–35%), *Corylus* (5–20%), *Pinus* (5–10%), *Abies* (5–10%) were the prevailing taxa. The percentage of herb taxa increased to 30–40%, among which Cichorioideae (10–20%) and Poaceae (5–20%) were most common and to a lesser extent Asteraceae (0.5–3%), Chenopodiaceae (0.5–3%) and *Plantago lanceolata* (0.5–2%). Non–pollen palynomorphs *Sporormiella* and *Cercophora* were more common in this zone, while stomata of *Picea* no longer appeared.

In zone SVB–3, the percentage of tree taxa was 55–65%. The most common taxa were *Picea* (15–25%), *Pinus* (10–25%), *Corylus* (5–12%), and to a lesser extent *Abies* (1–6%) and *Fagus* (0.5–5%). Herb taxa account for between 30 and 40% of the total pollen content. Poaceae (10–18%) and Cichoriaceae (8–20%) predominate, with *Cercophora* completely absent in this zone, while *Sporormiella* is uncommon.

In zone SVB–4, the percentage of tree taxa varied between 20 and 70%. The most common taxa were *Pinus* (7–25%), *Picea* (5–30%) and to a lesser extent *Abies* (2–3%), *Corylus* (1–7%) and *Fagus* (0.5–2%). Herb taxa accounted for between 25 and 75%. The most common taxa were Cichoriaceae (10–35%), Poaceae (6–45%) and *Ephedra* (1–12%). Both *Sporormiella* and *Cercophora* occurred regularly.

DISCUSSION

Palynological analyses show that during the 4800 and 4200 cal. BP the percentage of tree taxa was more than 90% (*Fig. 10*), with *Picea*, *Abies* and *Fagus* prevailing (*Fig. 7*). The high number of *Picea* stomata (*Fig. 10*) indicate local presence of the forest. This is furthermore indicated by a relatively low pollen richness (*Fig. 10*), which is probably a result of a low number of taxa in the samples and thus a lower number of identified pollen taxa. Presumably, this is due to predominant coniferous taxa and/or the lack of disturbances in the forest, which allowed a more closed canopy to develop. Among local taxa, ferns (Filicales) were common, probably growing at the edges of the spruce forest.

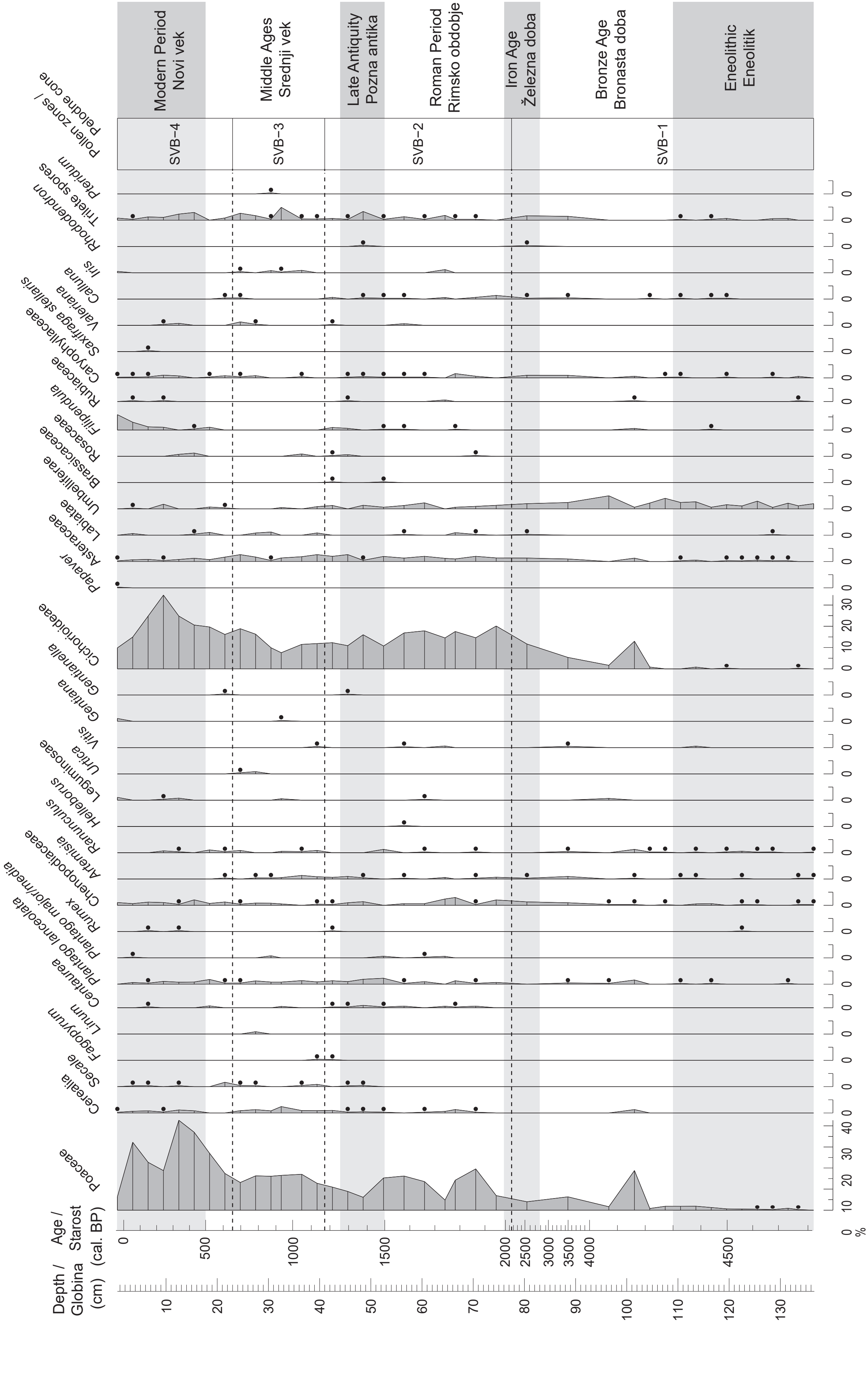
The high percentage of pollen and stomata of *Picea* is rather surprising, as we would expect more deciduous taxa in the alpine lowlands (now *Ostryo-Fagetum* and *Anemono trifoliae–Fagetum* tree association, Marinček et al. 2002). A higher percentage of spruce roughly in the same period could be a consequence of the cooler climate that has been reconstructed in other parts of Europe. Using sedimentological, palynological and macrofossil records from the Swiss Plateau, Haas et al. (1998, 304–305) reconstructed a colder period between 5350 and 4900 cal. BP. Moreover, around 5320 cal. BP, a rapid rise in the lake level in Switzerland was reconstructed on the basis of tree ring data, which also indicates a wetter climate (Magny, Haas 2004, 425).

The spread of beech to lower altitudes was probably also limited by more frequent temperature inversions (colder climate), which further shortened its vegetation period (Leuschner, Ellenberg 2017, 124–125). In addition, beech is much more sensitive to late spring frosts than spruce (Pretzsch et al. 2020, 963), which probably occurred much more frequently in the Alpine valleys during the period of colder climate than today.

←

Fig. 7: Pollen diagram from Srednja vas v Bohinju. Samples marked with a dot represent less than 0.5% of the total pollen percentage (excluding local taxa).
Sl. 7: Pelodni diagram vrtine iz Srednje vasi v Bohinju. Vzorci, označeni s piko, predstavljajo manj kot 0,5 % celotne pelodne vsote (brez lokalnih taksonov).

Taxa / Taksoni: *Pinus* (pine / bor), *Picea* (spruce / smreka), *Abies* (fir / jelka), *Larix* (larch / macesen), *Betula* (birch / breza), *Fagus* (beech / bukev), *Tilia* (lime / lipa), *Quercus* (oak / hrast), *Quercus ilex* (evergreen oak / črničevje), *Carpinus betulus* (European hornbeam / beli gaber), *Carpinus orientalis/Ostrya* (oriental hopbeam/hop hornbeam / kraški/črni gaber), *Acer* (maple / javor), *Castanea* (chestnut / kostanj), *Fraxinus excelsior* (European ash / veliki jesen), *Fraxinus ornus* (flowering ash / mali jesen), *Ulmus* (elm / brest), *Olea* (olive tree / oljka), *Juglans* (walnut / oreh), *Salix* (willow / vrba), *Corylus* (hazel / leska), *Juniperus* (juniper / brin), *Ligustrum* (privet / kalina), *Helianthemum* (rock rose / popon), *Cornus* (dogwood / dren), *Hedera* (ivy / bršljan), *Lonicera* (honeysuckle / kosteničevje), *Hippophaë* (sea buckthorn / rakitovec).



Modern Period
Novi vek
Middle Ages
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Late Antiquity
Pozna antika
Roman Period
Rimsko obdobje
Iron Age
Železna doba
Bronze Age
Bronasta doba
Eneolithic
Eneolitik
Pollen zones /
Pelodne cone
SVB-4
SVB-3
SVB-2
SVB-1
Pteridium
Trilete spores
Rhododendron
Iris
Calluna
Valeriana
Saxifraga stellaris
Caryophyllaceae
Rubiaceae
Filipendula
Rosaceae
Brassicaceae
Umbelliferae
Labiatae
Asteraceae
Papaver
Cichorioideae
Gentianella
Gentiana
Vitis
Urtica
Leguminosae
Helleborus
Ranunculus
Artemisia
Chenopodiaceae
Rumex
Plantago major/media
Plantago lanceolata
Centaurea
Linum
Fagopyrum
Secale
Cerealia
Poaceae
Age /
Starost
(cal. BP)
Depth /
Globina
(cm)
%

The first anthropogenic indicators appear around 4700 cal. BP with sporadic occurrences of *Plantago lanceolata*, Chenopodiaceae, Poaceae, Asteraceae, Cichoriaceae (*Fig. 8*). *Cercophora* spores were found in a sample dated to approx. 4450 cal. BP (*Fig. 10*), indicating grazing. A weak human influence on the environment can therefore be detected in the area, most likely with smaller pastures. Eneolithic archaeological sites in the Julian Alps have so far only been found in the highlands (based on radiocarbon dated charcoal at the sites Kal na Zadnjem Voglu, Mali Lepoč pod Bogatinom and Poljanica na Zadnjem Voglu; Horvat 2019, 23; 2020, 16).

The palynological diagram coincides with the pollen record from Lake Bohinj (Andrič et al. 2020a, 9–11), which also shows high percentages of tree taxa (especially *Picea*, *Abies* and to a lesser extent *Fagus*) and a weak human impact during the Eneolithic and the Early Bronze Age.

In other parts of the Alps, numerous palaeoecological analyses indicate an early use of the Alpine environment both in the lowlands and highlands (Colombaroli et al. 2013, 164; Kutschera et al. 2014, 164; Schwörer et al. 2015, 290; Pini et al. 2017, 1590), mainly with the occurrence of anthropogenic indicators (*Plantago l.*, *Rumex*, *Sporormiella*, type Cerealia, Chenopodiaceae) and higher values of microcharcoal.

The percentage of *Alnus* (ca. 10–50% of the total pollen sum; *Fig. 9*) among the local taxa increased around 4300 cal. BP in Srednja vas v Bohinju, which could indicate the opening of the landscape. Most likely it was dominated by *Alnus incana*, which is today a highly successful pioneer species in the valley of Sava Bohinjka river, forming extensive riparian forests (Dakskobler, Rozman 2013, 42). *Alnus incana* requires periodically flooded soils to thrive (Leuschner, Ellenberg 2017, 668–670) and that could indicate that the researched area was more frequently flooded during this period.

Around 4200 cal. BP (*Fig. 10*), the percentage of tree taxa decreased (to 60%). The percentage of herb taxa increased (40%), namely the percentage of Poaceae and Cichoriaceae. During this period, the stomata of *Picea* were absent (*Fig. 10*); however, the percentage of *Pinus* pollen increased (up to 14%). This probably indicates a short-lived human impact on the environment. However, it is important to point out that no Early Bronze Age archaeological sites have been found in the area of Srednja vas v Bohinju as well as in the high-altitude areas of the Julian Alps.

Major changes in the local hydrology are indicated by the lower sedimentation rate (the sedimentation rate dropped from 0.1 mm per year to less than 0.01 mm per year; *Fig. 6*), while at the depth of 76–93 cm, the record for the period of ca. 4000–2000 cal. BP is 'stored'. This could mean that some of the sediment was washed away, suggesting water erosion. At the same time, the preservation of the pollen is very poor, as in some samples no more than 200 pollen grains could be counted. Additionally, the expansion of *Alnus incana* could also be due to the human impact on the environment, where it developed as a secondary (pioneer) species and replaced natural spruce forests (Leuschner, Ellenberg 2017; *Fig. 9*).

Palaeoecological research in other parts of the Alps also indicates increased human activity at the beginning of the Bronze Age. Thus, in the area of the Swiss Alps (Lake Sulsseewli, 1921 m a.s.l.) pollen grains of anthropogenic indicators (Cerealia, *Alnus*, *Plantago l.*) and sedDNA from sheep (*Ovis* sp.) were noted since the Early Bronze Age (4200 cal. BP), which would indicate a combined arable and pastoral economy (Garcés-Pastor et al. 2022,

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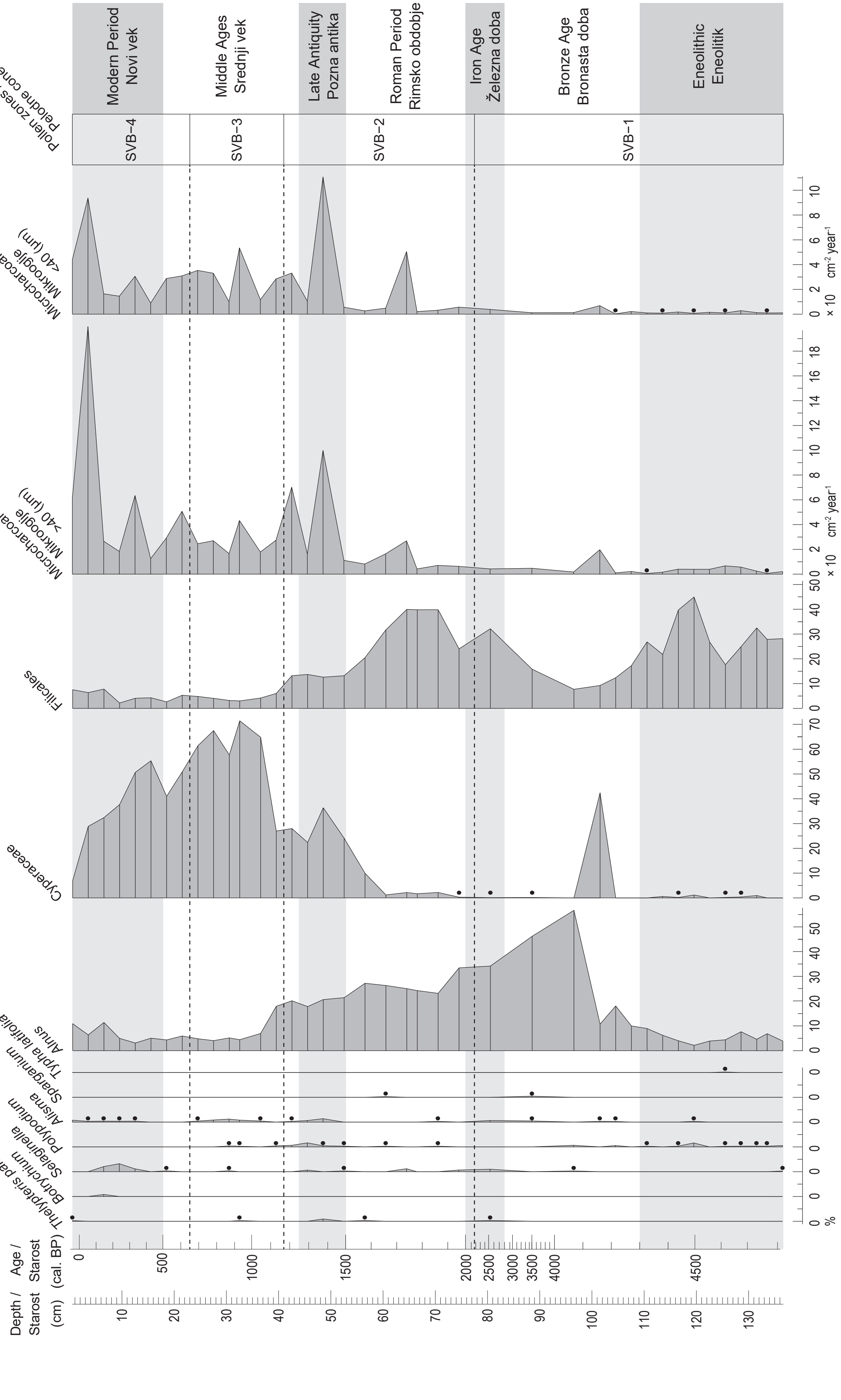
Fig. 8: Pollen diagram from Srednja vas v Bohinju. Samples marked with a dot represent less than 0.5% of the total pollen percentage (excluding local taxa *Alnus*, Cyperaceae, and Filicales).
Sl. 8: Pelodni diagram vrtine iz Srednje vasi v Bohinju. Vzorci, označeni s piko, predstavljajo manj kot 0,5 % celotne pelodne vsote (brez lokalnih taksonov *Alnus*, Cyperaceae in Filicales).

Taxa / Taksoni: Poaceae (grasses / trave), Cerealia (cereals / žita), *Secale* (rye / rž), *Fagopyrum* (buckwheat / ajda), *Linum* (flax / lan), *Centaurea* (centaury / glavinec), *Plantago lanceolata* (ribwort plantain / ozkolistni trpotec), *Plantago media/major* (broadleaf/hoary plaintain / veliki/srednji trpotec), *Rumex* (sorrel / kislica), Chenopodiaceae (goosefoots / metlikovke), *Artemisia* (mugwort / pelin), *Ranunculus* (buttercup / zlatica), *Helleborus* (hellebores / teloh), Leguminosae (legumes / metuljnice), *Urtica* (nettle / kopriva), *Vitis* (grapevine / vinska trta), *Gentiana* (gentian / svišč), Cichoriaceae (Cichoriaceae / radičevke), *Papaver* (poppy / mak), Asteraceae (daisy family / nebinovke), Labiatae (mint family / ustnatice), Umbelliferae (umbellifers / kobulnice), Brassicaceae (cabbage family / križnice), Rosaceae (rose family / rožnice), *Filipendula* (meadowsweet / oslad), Rubiaceae (bedstraw family / broščevke), Caryophyllaceae (pink family / klinčnice), *Saxifraga stellaris* (starry saxifrage / zvezdasti kamnokreč), *Valeriana* (valerian / špajka), *Calluna* (common heather / vresa), *Iris* (iris / perunika), *Rhododendron* (rhododendron / sleč), Trilete spores (trilete fern spores / triletne spore praproti), *Pteridium* (bracken / orlova praprot).


Modern Period
Novi vek
Middle Ages
Srednji vek
Late Antiquity
Pozna antika
Roman Period
Rimsko obdobje
Iron Age
Železna doba
Bronze Age
Bronasta doba
Eneolithic
Eneolitik
Pollen zones /
Pelodne cone
SVB-4
SVB-3
SVB-2
SVB-1
Microcharcoal /
Mikrooglje
<40 (μm)
× 10
cm-2 year-1
Microcharcoal /
Mikrooglje
>40 (μm)
Filicales
Cyperaceae
Alnus
Typha latifolia
Sparganium
Alisma
Polypodium
Selaginella
Botrychium
Thelypteris palustris
%
Age /
Starost
(cal. BP)
Depth /
Starost
(cm)

7). In the Silvretta Alps, Kothieringer et al. (2015, 191) found increased values of pastoral indicators and charcoal particles around 4200 cal. BP. In the French-Italian Alps (Petit Saint-Bernard Pass) coprophilous fungi spores and erosion increased, indicating first human occupation (Bajard et al. 2017, 230) around 4300 cal. BP and in the French Alps (Anterne Lake), the occurrence of *Plantago* sp. and DNA of *Ovis* sp. indicate pastoral activity since 3850 cal. BP (Giguet-Covex et al. 2023, 7).

The percentage of herbaceous taxa from the Srednja vas v Bohinju pollen diagram increased around 3500 cal. BP (*Fig. 8*), especially Poaceae and Cichoriaceae, indicating heightened anthropogenic activity. *Plantago lanceolata* and spores of *Sporormiella* and *Cercophora* begin to appear, which, together with the high percentages of *Alnus* and Filicales (*Fig. 8–10*), indicates the presence of nearby wet pastures where livestock grazed. This coincides with the study by Andrič et al. (2020a, 11) from Lake Bohinj, where human impact became more prominent around 3500 cal. BP with cereals, ruderal taxa and pasture indicators being more frequent. Furthermore, palaeoecological analyses in highlands (Lake 'jezero na Planini pri jezeru', Lake 'jezero v Ledvicah') indicate a gradual opening of the landscape and an increase in pastoral indicators (Caf et al. 2023, 117, Caf et al. 2025).

There are no known settlements from the Early and Middle Bronze Age in the low-attitude area, the only find that indicates modest human presence is a stray find of a bronze spearhead in Brod near Bohinjska Bistrica (Valič, 1968–1969). However, a number of settlement sites from the Middle and Late Bronze Age (e.g. Mišeljski preval, Pod Zelenim vrhom, Pod Kopico) confirm human presence in the high-altitude areas (Horvat 2020, 16). At Planina Lipanca, a bronze dagger dated to the Late Bronze Age was found, which probably also indicates a weak human presence (Šribar 1955, 328–329; Gabrovec 1974, 303). In the Iron Age, the pollen diagram from Srednja vas v Bohinju shows a continuous decrease in tree taxa. Around 2500 cal. BP (*Fig. 10*), *Picea* stomata disappeared indicating that the spruce forest has locally retreated and has been replaced by herbaceous vegetation possibly indicating intensification of human activity in the area.

This coincides with Hallstatt and La Tène pottery fragments, charcoal and bones that have been found in the area of Srednja vas near Žale (*Fig. 1; 2*). However, archaeological research has not yet provided any further information about the local settlement complex (Gabrovec 1958–1959a, 323). In the area of Dunaj pri Jereki (*Fig. 2*), which lies east of Srednja vas v Bohinju, archaeological remains indicate a settlement that was active in the Iron Age, the Roman Period and the Early Middle Ages. Furthermore, large quantities of slag indicate a strong centre of iron production (Gabrovec 1958–1959b, 323). The high-altitude areas around Bohinj continued to be used (Dolga Planja, Vodene Rupe; Horvat 2019; M. Ogrin 2020).

Around 2600 cal. BP, the pollen diagram from Lake Bohinj (Andrič et al. 2020a, 11) shows intensive deforestation and opening of the landscape, which led to severe erosion. Presumably, people needed wood for metallurgical activities, especially charcoal for iron smelting. The increased percentage of pasture and arable taxa from Lake Bohinj indicates fairly well-organised economic activities.

For the Iron Age, palaeoecological studies from the wider Alpine area indicate an increased human impact in some parts (e.g., the Swiss/Italian Alps, Tinner et al. 2003, 1452–1454; the Italian Alps, Pini et al. 2017, 1589, 1591) and a decreased influence in other parts (e.g., the Ötzal Alps, Kutschera et al. 2014, 943). Archaeological analyses in the area of the French Alps show that there are fewer archaeological sites than in the Bronze Age in the highlands (Walsh et al. 2007, 19–20; 2014, 65); however, in the Swiss Alps and the French Alps, archaeological finds indicate that lowlands were heavily populated (Walsh et al. 2007, 19–20; Rey et al. 2022, 389).

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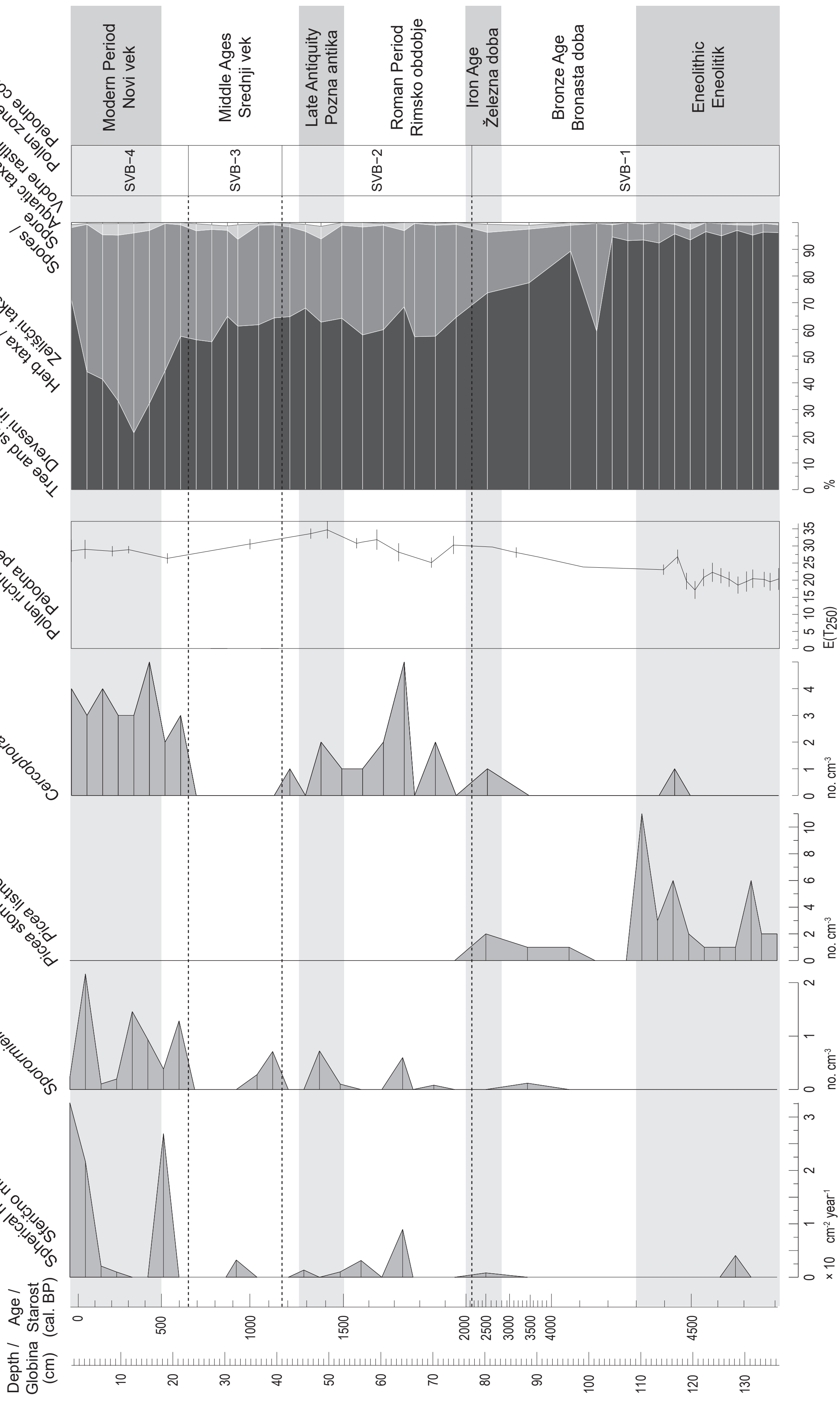
Fig. 9: Pollen diagram from Srednja vas v Bohinju. Samples marked with a dot represent less than 0.5% of the total pollen percentage (excluding local taxa *Alnus*, Cyperaceae and Filicales). Microcharcoal samples were calculated as influx (cm^{-2} $year^{-1}$).

Sl. 9: Pelodni diagram vrtine iz Srednje vasi v Bohinju. Vzorci, označeni s piko, predstavljajo manj kot 0,5 % celotne pelodne vsote (brez lokalnih taksonov Alnus, Cyperaceae in Filicales). Vzorci mikrooglja so navedeni kot influks (cm^{-2} $leto^{-1}$).

Taxa / Taksoni: *Thelypteris palustris* (marsh fern / močvirska krpača), *Botrychium* (moonwort / mladomesečina), *Selaginella* (spikemoss / drežica), *Polypodium* (common polypody / sladka koreninica), *Alisma* (water-plantain / porečnik), *Sparganium* (bur-reed / ježek), *Typha latifolia* (cattail / širokolistni rogoz), *Alnus* (alder / jelša), Cyperaceae (sedges / ostričevke), Filicales (monolete fern spores / monoletne spore praproti).



Pollen zones / Pelodne cone
Modern Period
Novi vek
Middle Ages
Srednji vek
Late Antiquity
Pozna antika
Roman Period
Rimsko obdobje
Iron Age
Železna doba
Bronze Age
Bronasta doba
Eneolithic
Eneolitik
SVB-4
SVB-3
SVB-2
SVB-1
Tree and shrub taxa / Drevesni in grmovni taksoni
Herb taxa / Zeliščni taksoni
Spores / Spore
Aquatic taxa / Vodne rastline
%
Pollen richness / Pelodna pestrost
E(T250)
Cercophora
no. cm-3
št. cm-3
Picea stomata / Picea listne reže
Sporormiella
Spherical microcharcoal / Sferično mikrooglje
× 10 cm-2 year-1
Age / Starost (cal. BP)
Depth / Globina (cm)

During the Roman Period (*Fig. 8; 10*), the pollen diagram of Srednja vas v Bohinju shows open landscape with increased percentages of e.g., *Centaurea*, Asteraceae, Poaceae indicating developed pastures. Percentages of *Juglans* also increased, which most likely spread within the region with the help of the Romans (Mercuri et al. 2013, 39).

During this period, microcharcoal concentrations started to increase, which is rather surprising since both palynological and archaeological research indicate metallurgical activity was present already in the Iron Age for which wood was needed. This could indicate that there was no metallurgical activity near the study site in the Iron Age. However, caution should be taken since no continuous sampling has been done and therefore individual fire events could not be detected.

The archaeological record supports the palynological analysis, mainly by numerous Roman archaeological sites that have been recognized both in lowlands and highlands (M. Ogrin 2010; 2020, 65; Horvat 2020, 18, 21–23). In the lowlands, in the vicinity of Srednja vas v Bohinju, the Roman settlement Dunaj pri Jereki (based on Roman coins and grave goods; Gabrovec 1958–1959b, 323; *Fig. 2*) was found. Moreover, at the sv. Janez Krstnik (St John the Baptist) church on the shore of Lake Bohinj, there was probably a settlement with a cult place between 1st to 4th century AD (1900–1600 cal. BP, Josipovič, Gaspari, Miškec 2012, 391–394). The number of archaeological sites in the high altitudes of the Julian Alps increased significantly during the Roman period/Late Antiquity (M. Ogrin 2010; Horvat 2019, 7, 9; 2020, 21–23), indicating major shifts in economy.

The palynological analysis from Lake Bohinj shows forest increase during the transition from Late Antiquity to the Early Middle Ages presumably due to lower population in the wider area (Andrič et al. 2020a). That is not supported by the pollen diagram from Srednja vas v Bohinju, probably due to Lake Bohinj presenting a more regional pollen record.

In Late Antiquity, cereal pollen grains (type Cerealia, *Secale*, *Fig. 10*) occurred more frequently in Srednja vas v Bohinju, which indicates an intensification of arable farming in the vicinity of the study area. Cereal pollen grains already appear sporadically from the Bronze Age onward in pollen diagrams from both Srednja vas v Bohinju as well as Lake Bohinj (Andrič et al. 2020a, 8), but caution is advised, as sporadic occurrence tends to indicate the regional presence of the taxa (Ammann et al. 2014, 259–262). Therefore, arable farming was probably locally present in Late Antiquity/the Early Middle Ages.

In the vicinity of the marsh in Srednja vas, more precisely in Žale and Podojnce, the graves were dated to the Early Middle Ages (based on the grave goods, 8th–10th century AD, Lavrenčič 2019, 95). However, the early medieval settlement to which the graves belonged has not yet been found. This corresponds with the palynological results that indicate an open landscape during this period due to human presence (approx. 70% of the tree taxa, *Fig. 10*).

Around 1200 cal. BP (ca. AD 750), the percentage of Cyperaceae increased (see *Fig. 9*), which means that the environment in the immediate vicinity became more marsh-like. The presence of spores of *Sporormiella* and, to a lesser extent, *Cercophora* (absent 1100–700 cal. BP) indicates continuous grazing.

Around 1200–1100 cal. BP (i.e. ca. AD 750–850), pollen of *Fagopyrum* was present in the pollen diagram (*Fig. 8*), which is rather surprising as the first mention of buckwheat in Slovenia is found in the Urbarium from 1426 (Gornjegrajski urbar, Blaznik et al. 1970, 255). The oldest macrofossil remains of buckwheat were found at the archaeological site Grofovsko 2 near Murska Sobota, where it occurred in layers from the Early Middle Ages (Kaligarič, Paušič 2011, 52–53).

It is important to note that the appearance of *Fagopyrum* pollen grains is no guarantee of the local presence. However, it definitely indicates that it was present in the region much earlier than previously thought. Researchers still disagree on exactly when buckwheat spread to Europe, as there are still many contradictory findings. De Klerk et al. (2015, 15) argued that buckwheat could have already spread to Europe around 4000 cal. BP (based on pollen), when the trade route between Asia and Europe was already sufficiently established, and appeared as a weed among other crops until the Middle Ages. Ohnishi (1993, 314) postulated that buckwheat spread to Europe only later. He

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Fig. 10: Pollen diagram from Srednja vas v Bohinju. Charcoal samples were calculated as influx (cm^{-2} $year^{-1}$). Stomata (*Picea*) and spore samples (*Sporormiella*, *Cercophora*) were calculated as concentration (no. cm^{-3}).
Sl. 10: Pelodni diagram vrtine iz Srednje vasi v Bohinju. Vzorci mikrooglja so navedeni kot influks (cm^{-2} $leto^{-1}$). Vzorci listnih rež (*Picea*) in spor (*Sporormiella*, *Cercophora*) so prikazani kot koncentracija (št. cm^{-3}).

pointed out that buckwheat was found as a grave accessory in the Ukraine in the 1st century AD, but was not an important crop until the Late Middle Ages. Gunda (1983, 164) argued that buckwheat was probably cultivated at different times and in different places. One of the possible routes to the Alps in the Middle Ages was the trade route from the Black Sea to Northern Italy and from there to the Alps, where it was cultivated as a crop in the higher mountain regions. Kreft (1980, 69) surmised that buckwheat, as a relatively new crop, was often neglected in feudal books because it was intended for the diet of the poor and was therefore often overlooked.

Between 1100 and ca. 600 cal. BP (ca. AD 850–1350), the overall percentage of tree taxa did not change significantly. The percentage of *Fagus*, *Abies* and *Picea* decreased and the percentage of *Pinus* increased, which could be the result of logging for metallurgical purposes. Spruce and especially beech were the taxa that were widely used to produce charcoal for the furnaces in which ore was smelted (Cundrič 2002). As a result, *Pinus* was able to spread in the cleared areas. The first metallurgical plants appeared in the 11th century (ca. 850 cal. BP) in the area of Nomenj, in the 12th century (ca. 750 cal. BP) in the area of Bohinjska Češnjica and in the 14th century (ca. 550 cal. BP;) in the area of Stara Fužina (Cundrič 2002, 32).

Agriculture (both arable and pastoral) continued to play an important role, as Cerealia and *Secale* grains as well as *Plantago lanceolata* were found, while *Sporormiella* and especially *Cercophora* were not present at the time. This could mean that the grazing areas were not in the immediate vicinity of the core, so that the spores were not washed to the coring location. The decline of *Abies* could be related to the continuous grazing of the forests rather than the deforestation for charcoal production (Tinner et al. 1999, 287). The palynological record from Lake Bohinj shows similar vegetation development, with relatively open landscape and decreasing values of tree taxa (especially *Abies*; Andrič et al. 2020a, 8,12). Palaeoecological research in the wider Alpine area shows the intensive use of the environment, mainly through grazing and also crop production during the Middle Ages (Walsh et al. 2007, 20; Bajard et al. 2016, 361), even in the more remote areas with less fertile soil (Rey et al. 2017, 583).

From ca. 600 cal. BP to 0 BP (AD 1350–1950), there is a noticeable decline in tree taxa, probably a consequence of the increase in grazing areas (larger percentage of Poaceae, Cichoriaceae, *Plantago lanceolata* and the continuous occurrence of spores of *Sporormiella*, *Cercophora)* and the production of charcoal for iron smelting. This is also reflected in other palaeoecological analyses in the Julian Alps area, where a decrease in the percentage of *Abies*, *Picea* and *Fagus* is observed (Andrič et al. 2020a, 8, 12–13; Caf et al. 2023, 113, 118).

In the last 70 years (AD 1950–2019), a reforestation of the area can be observed, where the percentage of *Pinus* and *Picea* increased, while the taxa of *Abies* and *Fagus* did not recover. One of the reasons for the slow establishment of beech and fir could be that both species grow more slowly (compared to spruce and pine) and flower relatively late (around the age of 50 to 70 years; Brus 2005, 138), which means that there is less pollen from these taxa. At the same time, artificial afforestation with spruce has been an important part of forest management in recent decades (Horvat–Marolt 1984, 7).

As a result of afforestation, the percentage of agricultural land decreased, which led to a decrease in the percentages of Poaceae and Cichoriaceae. The reforestation of the area is the result of the abandonment of agricultural activities and the establishment of the Triglav National Park, which limited excessive interventions in nature (Petek 2005, 113–132).

CONCLUSIONS

The human influence in the area of Srednja vas v Bohinju has been noticeable since the Eneolithic (most probably smaller pastures were established in the vicinity). During the Eneolithic and the Bronze Age, the high percentages of *Picea* indicate that spruce was a natural vegetation in the valleys of the Julian Alps. In the Iron Age, the spruce forest in the immediate vicinity of the drilling site declined and was most likely replaced by pastures, which is consistent with the Iron Age sites found in the vicinity.

From the Roman period to the Early Middle Ages, the anthropogenic indicators including cereals become more continuous, indicating an intensification of agriculture. The appearance of buckwheat pollen in the Early Middle Ages is noteworthy, indicating an earlier presence in the wider region than previously thought.

In the Middle Ages and the Modern Period, we can observe a decrease in tree taxa (*Picea*, *Abies* and *Fagus*), which could be due to continuous grazing (e.g. *Abies*) and an increase in metallurgical activities (e.g. *Fagus* and *Picea*).

In summary, the palaeoecological record in the area of Srednja vas v Bohinju shows how the local vegetation changed and what influence humans have had on these changes, which corresponds very well with the archaeological sites. This of course sheds further light on the importance of palynological research, which provides a lot of information about past environment, especially in areas that are archaeologically poorly researched as is the case in the lowlands of Bohinj.

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Srednja vas v Bohinju – paleookoljski zapis človekovega vpliva na nižine Julijskih Alp

Povzetek

Arheološke raziskave so se na območju Julijskih Alp v zadnjih desetletjih osredotočale predvsem na visokogorje. Arheoloških podatkov iz alpskih dolin je manj in so pogosto starejšega datuma, zato so manj povedni. Paleoekološke analize so bile omejene na večja jezera (npr. Bohinjsko jezero; Andrič et al. 2020a, 2), ki pa kažejo na bolj regionalne spremembe vegetacije, kar pomeni, da je lokalni vpliv človeka pogosto spregledan. Zato sem na močvirju na območju Srednje vasi v Bohinju (*Sl. 1, 2*), ki leži v zgornji Bohinjski dolini, opravila palinološko analizo (nadmorska višina 580 m). Glavni namen raziskave je bil ugotoviti, kako se je v holocenu lokalno spreminjala vegetacija, kakšen vpliv je imel človek na okolje in (če je možno) kakšna je bila ekonomija v določenih obdobjih.

METODE

Vrtanje je bilo zaradi poraščenosti močvirja s trstičjem zelo oteženo, zato smo sprva (oktobra 2019) vzeli vzorec sedimenta iz profila (dolžina 1 m), pozneje pa opravili tudi vrtanje z vrtalno opremo Livingstone (maja 2020). Sedimentni vzorci so bili na terenu zaščiteni s plastično in aluminijasto folijo, da smo preprečili kontaminacijo z modernim pelodom. Profil in vrtina so bili shranjeni na +4 °C v hladilnici na Inštitutu za arheologijo ZRC SAZU. Za določitev časovnega obsega profila in vrtine sem na določeni globini (*Tab. 1*) za radiokarbonsko analizo vzela ostanke rastlinskih makrofosilov (*Sl. 3*) ter izrisala časovni model (*Sl. 4*) v programskem jeziku R (R Development Core Team 2011) z uporabo paketov “clam” (Blaauw 2010) in “IntCal20” (Reimer et al. 2020).

Opravljene so bile naslednje metode: analiza peloda, nepelodnih palinomorfov (prepoznana tipa *Cercophora* in *Sporormiella*; van Geel 2002, 106–109; Gelorini et al. 2011), listnih rež rastlin (Hansen 1995; MacDonald 2001, 38–39; Sweeney 2004; Hu et al. 2016) ter mikrooglja (< 40 in > 40 μm; Clark 1982). Priprava pelodnih vzorcev je potekala po standardnem laboratorijskem postopku (Bennett, Willis 2002, 10–12), in sicer z dodajanjem 7-odstotne raztopine klorovodikove kisline (HCl), 10-odstotne raztopine natrijevega hidroksida (NaOH), 40-odstotne fluorovodikove kisline (HF), acetolizne mešanice, safranina in silikonskega olja. Pri štetju peloda sem prav tako sledila standardni metodi štetja, tj. najmanj 300 pelodnih zrn v posameznem vzorcu.

Za določitev pelodnih zrn sem uporabila identifikacijske ključe (Faegri, Iversen 1989, 237–288; Moore et al. 1991; Reille 1992; 1995; Beug 2004) in palinološko referenčno zbirko ZRC SAZU, Inštituta za arheologijo. Pelodni diagram sem izrisala v programu Psimpoll 4.261, ki prikazuje spreminjanje vegetacije skozi določeno časovno obdobje. V omenjenem programu sem določila pelodna območja z metodo binarne cepitve z vsoto kvadratov (binary splitting by sum–of–square; Bennett 2005, 64). Hkrati sem za posamezni vzorec izračunala indeks pelodne pestrosti, ki predstavlja število pelodnih tipov v pelodni združbi. Omenjen indeks je uporaben le, če je število pelodnih zrn v vzorcu standardizirano (Birks, Line 1992, 2–3). V vzorcih iz Srednje vasi v Bohinju sem se omejila na 250 pelodnih zrn na vzorec, kar pomeni, da so bili vzorci z manj kot 250 pelodnimi zrni izločeni iz analize.

REZULTATI

Z radiokarbonskimi datacijami sem izrisala časovni model. Ta je pokazal, da zgornjih 140 cm vrtine, kjer se je pelod ohranil, obsega obdobje med 4800 cal. BP in sedanjostjo (leto 2019, *sl. 3*, *sl. 4*). Hkrati sem izrisala sedimentacijsko hitrost (mm leto^{-1}, *sl. 5*). V pelodni diagram sem vključila 40 vzorcev (*sl. 6–9*). V določenih delih vrtine je bila pelodna koncentracija zelo nizka (od 8500 do 10.000 pelodnih zrn na cm^3) ali pa so lokalni taksoni (*Alnus*, Cyperaceae, Filicales) predstavljali visok odstotek skupnega deleža preštetega peloda (*sl. 8*). Tako v določenih vzorcih ni bilo mogoče prešteti minimalno 300 pelodnih zrn (če odštejemo lokalne taksone), kar pomeni, da v določenih delih vrtine ni bilo mogoče dobiti resolucije vzorčenja na ca. 100 let.

Program Psimpoll (Bennett 2005) je prepoznal 4 pelodne cone (*Sl. 6–9*), ki obsegajo obdobja 4800–2200 cal. BP (cona SVB–1), 2200–1200 cal. BP (cona SVB–2), 1200–650 cal. BP (cona SVB–3) ter od 650 cal. BP do leta vrtanja (2019, cona SVB–4). V coni SVB–1 je opazen visok delež drevesnih taksonov (60–97 %), med katerimi prevladujejo *Picea* (20–45 %), *Abies* (5–25 %), *Fagus* (5–25 %), *Corylus* (5–18 %) in *Pinus* (3–14 %). Delež zeliščnih taksonov je nihal med 2 in 40 %, med temi sta najpogostejša Poaceae (0,5–20 %) in Cichorioideae (0,5–13 %). V tej coni se pojavljajo listne reže *Picea*. V coni SVB–2 je delež drevesnih taksonov upadel na 55–70 %, najpogostejši taksoni so *Picea* (15–30 %), *Corylus* (5–20 %), *Pinus* (5–10 %) in *Abies* (5–10 %). Delež zeliščnih taksonov se je dvignil, in sicer na 30–40 %, z najpogostejšimi taksoni Cichorioideae (10–20 %) in Poaceae (5–20 %). V tej pelodni coni se pogosto pojavljata nepelodna palinomorfa *Cercophora* in *Sporormiella*. V pelodni coni SVB–3 je delež drevesnih taksonov podoben kot v coni SVB–2, in sicer niha med 55–65 %. Najpogostejši drevesni taksoni so *Picea* (15–25 %), *Pinus* (10–25 %) in *Corylus* (5–12 %). Delež zeliščnih taksonov je prav tako precej podoben kot v coni SVB–2, obsegal je 30–40 %. V pelodni coni SVB–4 je delež drevesnih taksonov precej nihal, in sicer je razpon med 20 in 70 %. Najpogostejša drevesna taksona sta bila *Pinus* (7–25 %) in *Picea* (5–30 %). Zeliščni taksoni so prav tako nihali med 25 in 75 %. Najpogostejši taksoni so bili Cichoriaceae (10–35 %), Poaceae (6–45 %) in *Ephedra* (1–12 %). Redno sta se pojavljali spori *Sporormiella* in *Cercophora.*

DISKUSIJA

Pelodni diagram iz Srednje vasi v Bohinju kaže na lokalno prisotnost (najverjetneje smrekovega) gozda v obdobju 4800–4200 cal. BP z deležem drevesnih taksonov > 90 % in visokim deležem listnih rež *Picea*. Na to kaže tudi razmeroma nizka pelodna pestrost, ki je verjetno posledica majhnega števila taksonov v vzorcih (in s tem tudi manjšega števila identificiranih taksonov peloda) zaradi prevladujočega iglastega gozda in/ali pomanjkanja motenj v gozdu. Med lokalnimi taksoni so bile pogoste praproti (Filicales), ki so verjetno rasle ob robovih smrekovega gozda.

Velik delež peloda in listnih rež *Picea* je precej presenetljiv, saj bi pričakovali več taksonov listavcev v alpskih nižinah (dandanes prevladujejo drevesne združbe *Ostryo-Fagetum* in *Anemono trifoliae–Fagetum*; Marinček et al. 2002). Večji delež smreke v tem obdobju bi lahko bil posledica hladnejšega podnebja.

Širjenje bukve v nižje lege so verjetno omejile tudi pogostejše temperaturne inverzije (hladnejše podnebje), kar je dodatno skrajšalo njeno vegetacijsko dobo (Leuschner et al. 2006). Poleg tega je bukev veliko bolj občutljiva za pozno spomladansko pozebo kot smreka (Pretzsch et al. 2020, 963), ki se je v alpskih dolinah verjetno veliko pogosteje pojavljala v obdobju hladnejšega podnebja kot danes.

Prvi antropogeni indikatorji se v pelodnem diagramu pojavijo okoli 4700 cal. BP, in sicer sporadično se pojavljajo *Plantago lanceolata*, Chenopodiaceae, Poaceae, Asteraceae Cichoriaceae. Okoli 4450 cal. BP se pojavi tudi spora *Cercophora*, ki nakazuje pojavljanje pašništva. To nakazuje šibek vpliv človeka na okolje, najverjetneje so se v tem obdobju pojavljale manjše pašniške površine. Arheoloških najdišč iz tega obdobja je malo in so po večini omejena na visokogorje okoli Bohinja (Kal na Zadnjem Voglu, Mali Lepoč pod Bogatinom in Poljanica na Zadnjem Voglu, Horvat 2019, 23; Horvat 2020, 16).

Okoli 4200 cal. BP je delež dreves upadel (na ca. 60 %) in posledično se je dvignil delež zeliščnih taksonov (ca. 40 %, predvsem delež Poaceae in Cichoriaceae). Povečal se je delež *Pinus* (do 14 %), kar bi lahko nakazovalo na kratkotrajen človekov vpliv na okolje. Pomembno pa je poudariti, da na območju Srednje vasi v Bohinju za zdaj ni bilo najdenih bronastodobnih arheoloških najdišč.

Na pelodnem diagramu iz Srednje vasi v Bohinju se je delež zeliščnih taksonov povečal okoli 2600 cal. BP (*sl. 7*), zlasti delež Poaceae in Cichoriaceae, kar kaže na povečano antropogeno aktivnost. Pojavljati se začnejo *Plantago lanceolata* in spore taksonov *Sporormiella* in *Cercophora*, kar skupaj z visokim deležem lokalnih taksonov *Alnus* in Filicales (*sl. 7–9*) kaže na prisotnost vlažnih pašnikov, na katerih se je pasla živina.

Paleoekološke analize iz Bohinjskega jezera kažejo, da je okoli 2600 cal. BP intenzivno krčenje gozdov in odpiranje pokrajine povzročilo močno erozijo (Andrič et al. 2020a, 9–11). Domnevno so ljudje potrebovali les za metalurške dejavnosti, predvsem oglje za taljenje železa. Povečan delež pašnih in poljskih taksonov iz Bohinjskega jezera kaže na dobro organizirano kmetijsko gospodarsko dejavnost.

Na ledini Žale v Srednji vasi v Bohinju so bili najdeni odlomki železnodobne keramike (Gabrovec 1958–1959a, 323). Višinska utrjena naselbina je bila na Dunaju pri Jereki (*sl. 2*), ki leži pribl. 1800 m vzhodno od Srednje vasi. Velike količine žlindre, najdene na Dunaju pri Jereki, kažejo na močno središče proizvodnje železa (Gabrovec 1958–1959b, 323).

V rimskem obdobju pelodni diagram Srednje vasi v Bohinju prikazuje odprto pokrajino s povečanim deležem npr. *Centaurea*, Asteraceae, Poaceae, kar nakazuje na pašniško dejavnost. Povečal se je delež *Juglans*, ki so ga v regiji najverjetneje širili Rimljani (Mercuri et al. 2013, 39). Najbližji poznani naselbini iz rimskega obdobja sta bili na Dunaju pri Jereki (Gabrovec 1958–1959b, 323) in pri cerkvi sv. Janeza Krstnika na obrežju Bohinjskega jezera (naselje s svetim mestom, ki je bilo aktivno med 1. in 4. st. n. št., Josipovič, Gaspari, Miškec 2012, 391–394).

V zgodnjem srednjem veku pelodna analiza vrtine iz Srednje vasi v Bohinju kaže na odprto krajino (< 70-% delež peloda dreves). V neposredni bližini močvirja so bili na območju Žal v halštatske in latenske plasti vkopani zgodnjesrednjeveški grobovi (8.–10. st. n. št., Lavrenčič 2019, 95).

Okoli 1200–1100 cal. BP se v pelodnem diagramu iz Srednje vasi pojavi pelod ajde (*Fagopyrum*), kar je precej presenetljivo. Uporaba ajde se namreč prvič omenja v urbarju iz leta 1426 (gornjegrajski urbar; Blaznik et al. 1970, 255), kjer jo imenujejo “paganka”. Prisotnost posameznih pelodnih zrn ajde nujno ne nakazuje na lokalno prisotnost, ampak kaže na to, da je morala biti prisotna v širši regiji že v zgodnjem srednjem veku.

Med 1100 in 600 cal. BP (850–1350 n. št.) se delež drevesnih taksonov ni bistveno spremenil. Upadel je predvsem delež *Fagus*, *Abies* in *Picea*, medtem ko je delež *Pinus* narastel. Zmanjšanje predvsem deleža bukve in smreke bi lahko bilo posledica metalurških dejavnosti. Metalurške delavnice so bile v okolici Nomenja vzpostavljene v 11. stoletju in pozneje v 12. stoletju v Bohinjski Češnjici ter v 14. stoletju v okolici Stare Fužine (Cundrič 2002, 32).

Kmetijstvo (tako poljedelstvo kot pašništvo) sta še vedno imela pomembno vlogo, saj se v pelodnem diagramu kontinuirano pojavljajo pelodna zrna tipa Cerealia, *Secale* ter *Plantago lanceolata*, medtem ko spore *Sporormiella* in zlasti *Cercophora* v tem času niso bile prisotne. To bi lahko pomenilo, da pašne površine niso bile v neposredni bližini vrtine. Upad taksona *Abies* je najverjetneje povezan z neprekinjeno pašo v gozdovih, in ne s krčenjem gozdov za proizvodnjo oglja (Tinner et al. 1999, 287).

Med ca. 600 cal. BP in 0 BP (med letoma 1350 in 1950) je opazen upad drevesnih taksonov, verjetno kot posledica povečanja pašnih površin (večji delež Poaceae, Cichoriaceae, *Plantago lanceolata* in stalno pojavljanje spor *Sporormiella*, *Cercophora*) in proizvodnje oglja za taljenje železa. To se odraža tudi v drugih paleoekoloških analizah na območju Julijskih Alp, kjer je opaziti zmanjšanje deleža *Abies*, *Picea* in *Fagus* (Andrič et al. 2020a, 8, 12–13; Caf et al. 2023, 113, 118).

V zadnjih 70 letih (1950–2019) je mogoče opaziti zaraščanje območja, saj se je povečal delež *Pinus* in *Picea*, medtem ko se delež taksonov *Abies* in *Fagus* ni spremenil. Eden od razlogov za počasno uveljavitev bukve in jelke bi lahko bil, da obe vrsti počasneje rasteta (v primerjavi s smreko in borom) in razmeroma pozno prvič cvetita (v starosti 50 do 70 let; Brus 2005, 138), kar pomeni, da je manj peloda omenjenih taksonov. Hkrati je umetno pogozdovanje s smreko v zadnjih desetletjih pomemben del gospodarjenja z gozdovi (Horvat-Marolt 1984, 7). Zaraščanje območja je posledica opuščanja kmetijskih dejavnosti in ustanovitve Triglavskega narodnega parka, ki je omejil pretirane posege v naravo (Petek 2005, 113–132).

ZAKLJUČKI

Vpliv človeka na območju Srednje vasi v Bohinju je opazen že od eneolitika (najverjetneje so bili v bližini manjši pašniki). Velik delež taksona *Picea* ter najdene listne reže v eneolitiku in bronasti dobi kažejo, da je bila smreka naravno rastje v nižinah Julijskih Alp. Arheoloških najdišč v Bohinjski kotlini iz tega časa trenutno ne poznamo. V železni dobi se je smrekov gozd v neposredni bližini vrtine umaknil pašnikom, kar se sklada s prisotnostjo železnodobnih najdišč v bližini.

Od rimskega obdobja do zgodnjega srednjega veka se antropogeni indikatorji, vključno z žiti, pojavljajo bolj kontinuirano, kar nakazuje na intenzifikacijo kmetijstva. V srednjem in novem veku lahko opazimo zmanjšanje števila drevesnih taksonov (*Picea*, *Abies* in *Fagus*), kar je lahko posledica kontinuirane paše (*Abies*) in povečanja metalurških dejavnosti (*Fagus* in *Picea*).

Če povzamemo, paleoekološki zapis na območju Srednje vasi v Bohinju kaže, kako se je vegetacija spreminjala in kakšen vpliv je na te spremembe imel človek. To seveda še dodatno osvetli pomen palinoloških raziskav, ki dajejo veliko informacij o okolju v preteklosti, zlasti na arheološko slabše raziskanih območjih, kot je okolica Bohinja.

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Nina Caf
ZRC SAZU
Inštitut za arheologijo
Novi trg 2
SI-1000 Ljubljana
nina.caf@zrc-sazu.si
https://orcid.org/0000-0002-7923-7718

Illustrations: Fig. 2 (photo: Maja Andrič, ZRC SAZU).
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