Przegląd Archeologiczny
Vol. 37, 1990, pp. 195-228
PL ISSN 0079-7138

ZESPOŁY DATOWANE METODĄ ^{14}C
COMPLEXES DATÉS À L'AIDE DE LA MÉTHODE ^{14}C

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RADIOCARBON DATING OF NEOLITHIC ASSEMBLAGES FROM BRONOCICE

Bronocice is a large Neolithic site located at the eastern edge of the Miechów Upland region in southeastern Poland. The objectives of the Bronocice excavations were twofold: 1) to investigate the prehistoric environment, chronology, economy, settlement system, and social organization of Neolithic cultures, and 2) to demonstrate the origin of complex societies in the region. Radiocarbon dating provides information on the duration and sequence of each occupational phase at Bronocice and therefore is essential to understanding Neolithic chronology and achieving the above-stated objectives. For our study, 27 wood charcoal samples were dated at the Dicarb Laboratory in the United States. Since the samples were selected from the pits containing ceramics, the radiocarbon dates can be compared with the relative chronology of the ceramics. This procedure provided a general, yet a fairly accurate evaluation of the data. The primary results from the radiocarbon dating are as follows: 1) the Bronocice settlement was occupied between 3110±110 bc and 2130+65 bc, and 2) the Bronocice settlement spanned six occupational phases: Lublin-Volynian culture (Lengyel-Polgar cycle in southeastern Poland), Funnel Beaker culture (BR I–III phases), and the Baden cycle (BR IV–V).

The Bronocice (Fig. 1) excavations provided information on the economy, technology, settlement system, and social organization of Neolithic populations as well as palaeogeography of the Holocene period in

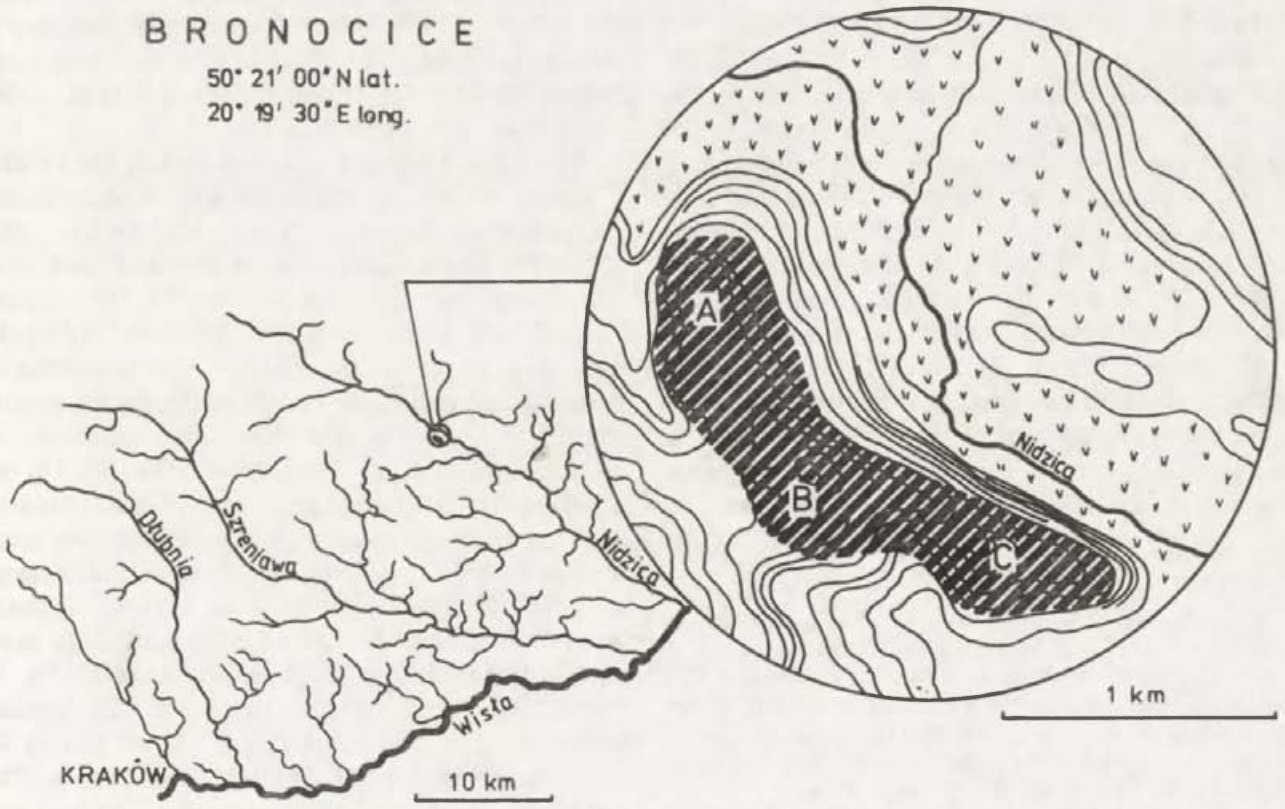


Fig. 1. Location of the Bronocice site

southeastern Poland (Milisauskas, Kruk 1984a; 1989; Śnieszko 1985)[1]. The radiocarbon dates indicate that the Neolithic occupation lasted for approximately 1000 years at Bronocice and it is associated with three archaeological manifestations: Lublin-Volynian, Funnel Beaker, and Baden features. The typological study of ceramics provides information on the relative chronology of the various Bronocice occupations, but it does not define the duration in years of each phase. Additionally, the stratigraphic relationship of the pits enables us to classify some of the Bronocice material according to occupational phases. Typological studies and stratigraphic relationships serve as general indicators of the chronology of various features and excavation units. For more precise information on the chronology, we turn to radiocarbon dating. The radiocarbon dating of 27 wood charcoal samples from Lublin-Volynian, Funnel Beaker, and Baden features greatly enhanced our understanding of Neolithic chronology at Bronocice.

In an article published in 1983, we discussed and evaluated radiocarbon dates and ceramic assemblages from 15 features at Bronocice and compared these dates with the chronological sequence of the ceramics (Kruk, Milisauskas 1983). Since then, 12 additional wood charcoal samples have been dated using the ^{14}C method. Thus presently these 27 dates will be analyzed as an aggregate.

NEOLITHIC SETTLEMENT SEQUENCE AT BRONOCICE

Before giving a detailed description of the ^{14}C dated features, we will provide a review of the chronology of each occupational phase. Over 650 pits, 3 ditches, and 26 burials were excavated at Bronocice, the majority of which are associated with the Funnel Beaker and Baden cultures (Kruk, Milisauskas 1981b). A small number of features belong to the Lublin-Volynian culture. Some Globular Amphora and Comb- and Pit Ornamented Pottery culture sherds were also found (Kruk, Milisauskas 1981a). The latest Neolithic material at Bronocice belongs to the Corded Ware culture burial (Milisauskas, Kruk 1984b).

The early phase represents Bronocice's first occupation (BR I) of the Funnel Beaker culture on the loess uplands. It was a small settlement, approximately 2 ha, located in area C of Bronocice, whose duration was short, approximately 100 years (Figs. 2, 3). This occupation correlates with the earliest Wiórek phase of the Polish Lowlands (Kruk, Milisauskas 1983, 267, Fig. 3). Following the disappearance of the early Funnel Beaker settlement in area C, a late Lublin-Volynian fortified settlement was established in this place. After the Lublin-Volynian settlement period, a large Funnel Beaker settlement was established in the eastern part of the elevation in area A, which consists of two Funnel Beaker occupational phases (Fig. 2).

BR II, the earlier phase (Fig. 2), is associated with the developed Wiórek phase, while the later occupation, BR III (Fig. 2), correlates with the Luboń phase of the Polish Lowlands (Kruk, Milisauskas 1983, 271–272, Fig. 4, 5). BR II represents the "classic" Funnel Beaker phase on the loess uplands. BR III is associated with the later development of the "classic" phase. Some BR III ceramics are ornamented with motifs which are characteristic of the early Baden phases (Boleráz). BR II and III phases lasted without an interruption at Bronocice, in other words, there was no time gap between these phases. A Funnel Beaker cemetery located in area C is associated with either or both of these phases. The cemetery is situated on the highest point of area C, where early Funnel Beaker (BR I) and Lublin-Volynian settlements had been previously located.

The BR III phase is followed by the BR IV and V phases, which are associated with a local Baden group, named Bronocice (Kruk, Milisauskas 1983, 272–276). The Bronocice Baden ceramics have several common characteristics with the BR III material. The BR IV phase is partly correlated with the Radziejów group of the Funnel Beaker culture in Kuyavia and periods Ic and II of the Baden culture (according to the chronological sequence of Němejcová-Pavúková 1981; 1984). The BR IV occupation covered the largest area, 26 ha, compared with the other occupations and extended over areas A and B (Fig. 2). During this time period, a large enclosure (4 ha) was located in area C. Perhaps domesticated animals such as cattle and sheep were kept in this enclosure (Kruk, Milisauskas 1981b, 73, Fig. 5). BR V phase can be correlated with the late Radziejów group in Kuyavia and Baden phases III and IVa (Němejcová-Pavúková 1981; 1984). The settlement of phase V covered only 17 ha and was situated in area B (Fig. 2). A distinguishing feature of

[1] The excavations at Bronocice were conducted by the Institute of the History of Material Culture, Polish Academy of Sciences and The State University of New York at Buffalo, USA. The Director and Principal Polish Investigator was Prof. dr hab. Witold Hensel and Prof. dr Sarunas Milisauskas was the Principal American Investigator. We are grateful to the Smithsonian Institution (Grant FR4-60106) and the National Science Fundation (Grant BNS 7919890) for supporting the field work and data analysis.

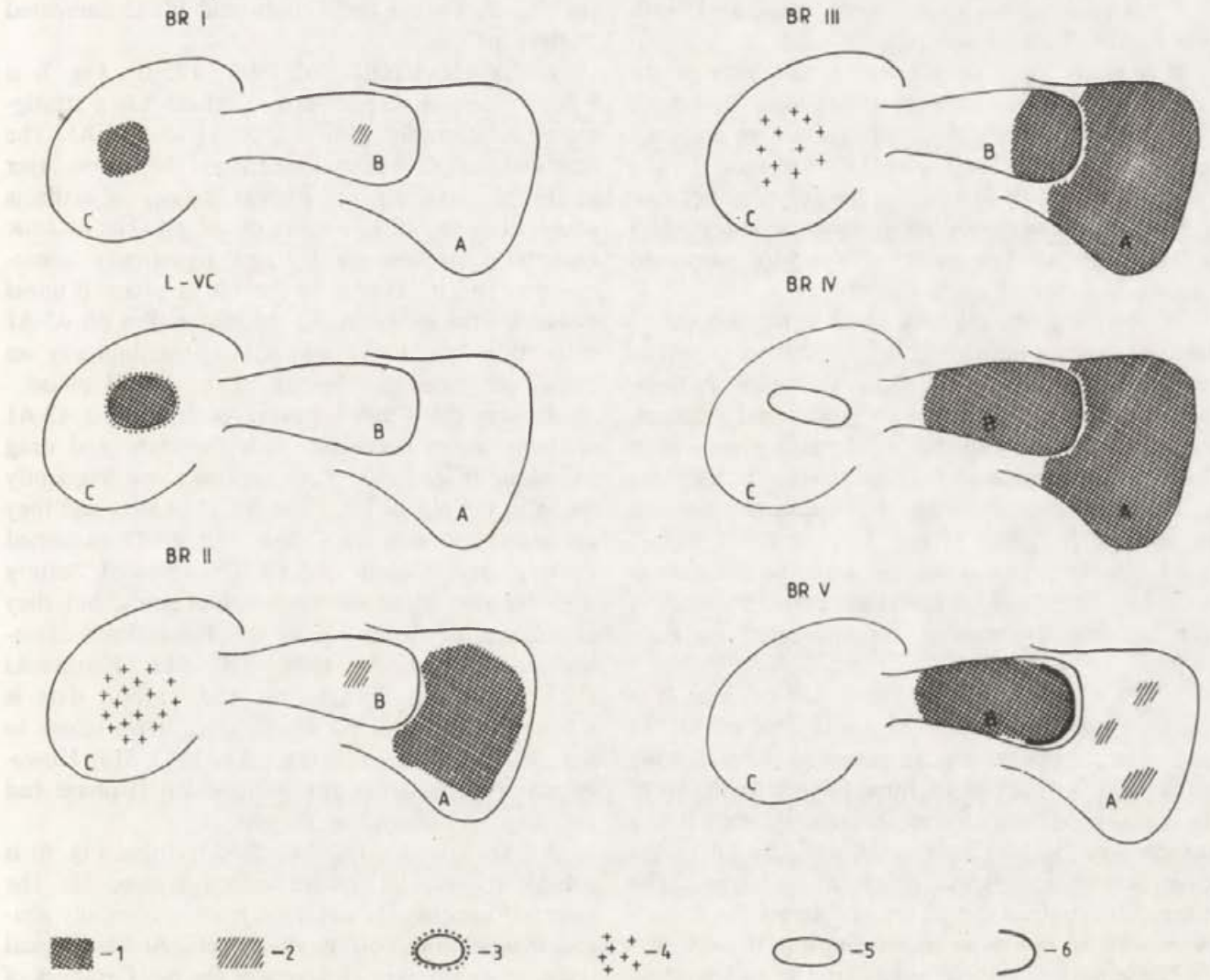


Fig. 2. Sequence of Neolithic settlement at Bronocice

A,B,C – excavation areas; BR I–III – Funnel Beaker settlement, L-VC – Lublin-Volynian settlement, BR IV-V – Baden cycle settlement; *1* – extent of the settlement, *2* – zone utilized beyond the settlement area, *3* – fortified settlement of the Lublin-Volynian culture, *4* – cemetery from BR II–III phases, *5* – enclosure from BR IV phase, *6* – fortification ditch from the BR V phase

this occupation is the deep ditch, i.e. a fortification, which was located on the eastern side of this settlement. Perhaps the ditch also enclosed the other sides of the settlement (Kruk, Milisauskas 1981b, 73–75).

Following the BR V occupation, a Corded Ware burial is located in area B (Milisauskas, Kruk 1984b). The burial is dated to the Sandomierz-Kraków II_2 phase and represents the last Neolithic occupation at Bronocice (Machnik 1966).

DESCRIPTION OF DATED ASSEMBLAGES

All the wood charcoal samples that were dated by the ^{14}C method came from the pits and features at Bronocice. Most of the charcoal samples were branch remains less than 8 cm in width. The Neolithic people probably used these branches as firewood. Only a sample of all the wood charcoal remains was dated by the ^{14}C method. The following criteria were used for selecting the wood charcoal samples:

1. The Majority of the charcoal samples came from completely excavated pits.

2. All the charcoal samples came from one layer in the pits.

3. Combined charcoal samples were not dated; only good quality charcoal samples were used (Waterbolk 1971; Pazdur 1980).

4. Ceramic assemblages were associated with each of the charcoal samples.

It was our aim to obtain a sampling which represented all the excavation units at Bronocice (Fig. 3). With the exception of area C, we achieved our goal. We have only one date for area C. The Funnel Beaker (BR I) and Lublin-Volynian occupations lasted a relatively short time period in area C (Fig. 2), therefore most of the pits contained a small quantity of charcoal remains.

We will describe the pits which contained the 27 charcoal samples dated by the ^{14}C method as well as the ceramic material, avoiding an extensive typological discussion of the ceramics. Additional information about the pits and their contents is presented in Tables 1–4. Some data from our earlier publication on the relative chronology of the ceramic material are incorporated here (Kruk, Milisauskas 1983).

The assemblages associated with the earliest radiocarbon dates will be described first. Drawings of each ceramic assemblage are presented in Figs. 4–26.

1. Pit 5-B6[2] (DIC 719 3110±110 bc; Fig. 4) is a large trapezoidal feature with a layered pit fill. At the bottom of this pit was an extended skeleton lying on its back with its head turned towards the west. No burial goods were found with the skeleton which was covered by 50 cm layer of fill. The fill in the upper part of this pit was deposited by erosion. The primary function of the pit was probably for domestic use. Later on, it was used for burial.

The charcoal sample used for the radiocarbon dating came from the layer above the skeleton which also contained several ceramic pieces. The radiocarbon date obtained from this pit is from the BR I phase. Pit 5-B6's ceramics represent Bronocice's earliest phase, BR I. The BR I settlement in area C is at a great distance from pit 5-B6. The radiocarbon date agrees with the ceramic material in the pit.

Some of the ceramics are decorated with the stab-and drag technique (Fig. 4: 16, 22) which is associated with the Comb- and Pit Ornamented Pottery culture. The Comb- and Pit Ornamented Pottery material was frequently found in the pits of the BR I phase (Funnel Beaker). However, no data suggests that a Comb- and Pit Ornamented Pottery settlement existed at Bronocice. The presence of this material probably is the result of the trade between the Funnel Beaker and Comb- and Pit Ornamented Pottery people.

2. Pit 42-A1 (DIC 362 2990±125 bc; Fig. 5) is a hemispherical shaped feature, which has a stratigraphic relationship with pits 46-A1 and 49-A1. The charcoal sample was collected from the lowest layer in the pit, however, the highest density of artifacts occurred in the middle layers of the pit. The ceramic material is technologically and stylistically homogeneous and it belongs to the BR II phase (Funnel Beaker). Probably some of the material in pit 42-A1 came from pit 46-A1 which is chronologically an earlier pit. Both pits belong to the BR II phase.

Besides the Funnel Beaker ceramics, pit 42-A1 contains a rim decorated with the stab- and drag technique (Fig. 5: 12). Such ceramics are frequently found in the pits of BR I and BR II phases, and they are associated with the Comb- and Pit Ornamented Pottery cycle. Comb- and Pit Ornamented Pottery sites are not found on the loess uplands, but they occur east of Bronocice in the Nida Basin (Samsonowicz, Czarnocki 1909, 510–512; Kozłowski 1923, 128–129). Perhaps the radiocarbon date is a little too early for pit 42-A1, since it fits closer to the BR I phase (Kruk, Milisauskas 1983, 310). However, the date generally fits with the BR II phase and the ceramic material in the pit.

3. Pit 101-A1 (DIC 542 2850±70 bc; Fig. 6) is a large trapezoidal feature with a layered fill. The charcoal sample was obtained from a conically shaped layer at the bottom of the pit. Archaeological material occurred in all layers of the pit. Ceramics of the pit 101-A1 are stylistically and typologically homogeneous and the radiocarbon date correlates with the relative chronology of the ceramic material.

4. Pit 21-A1 (DIC 2265 2750±60 bc; Fig. 7) is a trapezoidal feature with a homogeneous pit fill. It has stratigraphic relationship with two younger pits, 20-A1 (BR III phase) and 22-A1 (BR IV phase). The charcoal sample was collected from the bottom layer of the pit. The ceramic material is homogeneous and the technological and stylistic attributes of the pottery are characteristic for the classic phase of the Funnel Beaker culture in southeastern Poland. The ceramic material belongs to the BR II phase and the radiocarbon date agrees with the relative chronology of the ceramics.

5. Pit 15-C2 (DIC 364 2740±240 bc; Figs. 8,9) is large trapezoidal feature with a layered fill. The charcoal sample was collected from a layer in the middle of the pit. The ceramics of pit 15-C2 exhibit great diversity. Numerous sherds belong to the late phase of the Lublin-Volynian culture (Kruk, Milisauskas 1985, 74–84) and several small sherds (Fig. 8: 3,4) are associated with the BR I phase (Funnel

[2] We identify our pits with a number followed by a letter and a number. The first number refers to the number of the pit within the excavation unit. The following letter-number e.g. A1, corresponds to the number of an excavation unit within an area of the site (A, B, C; see Fig. 3).

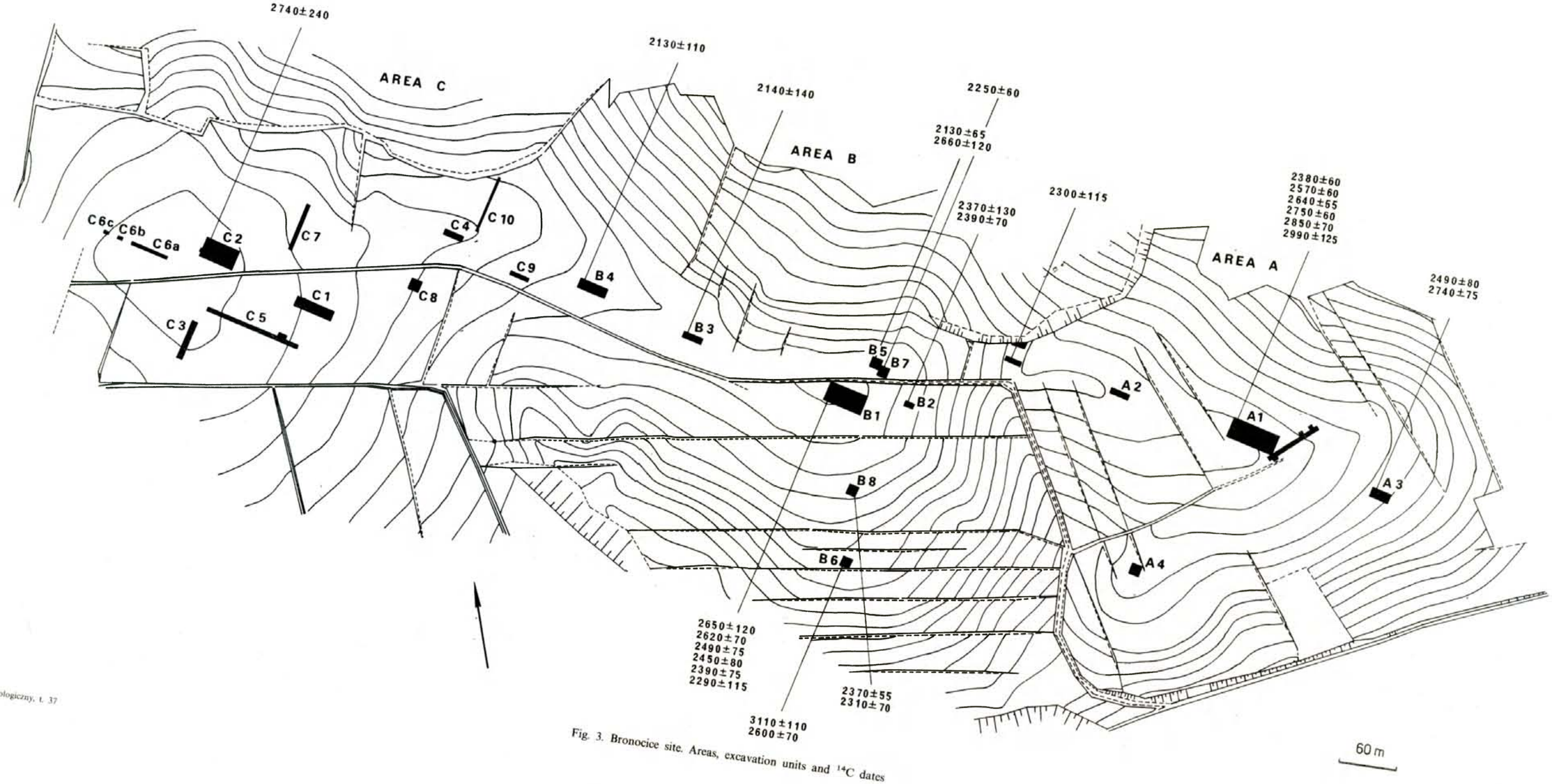


Fig. 3. Bronocice site. Areas, excavation units and ^{14}C dates

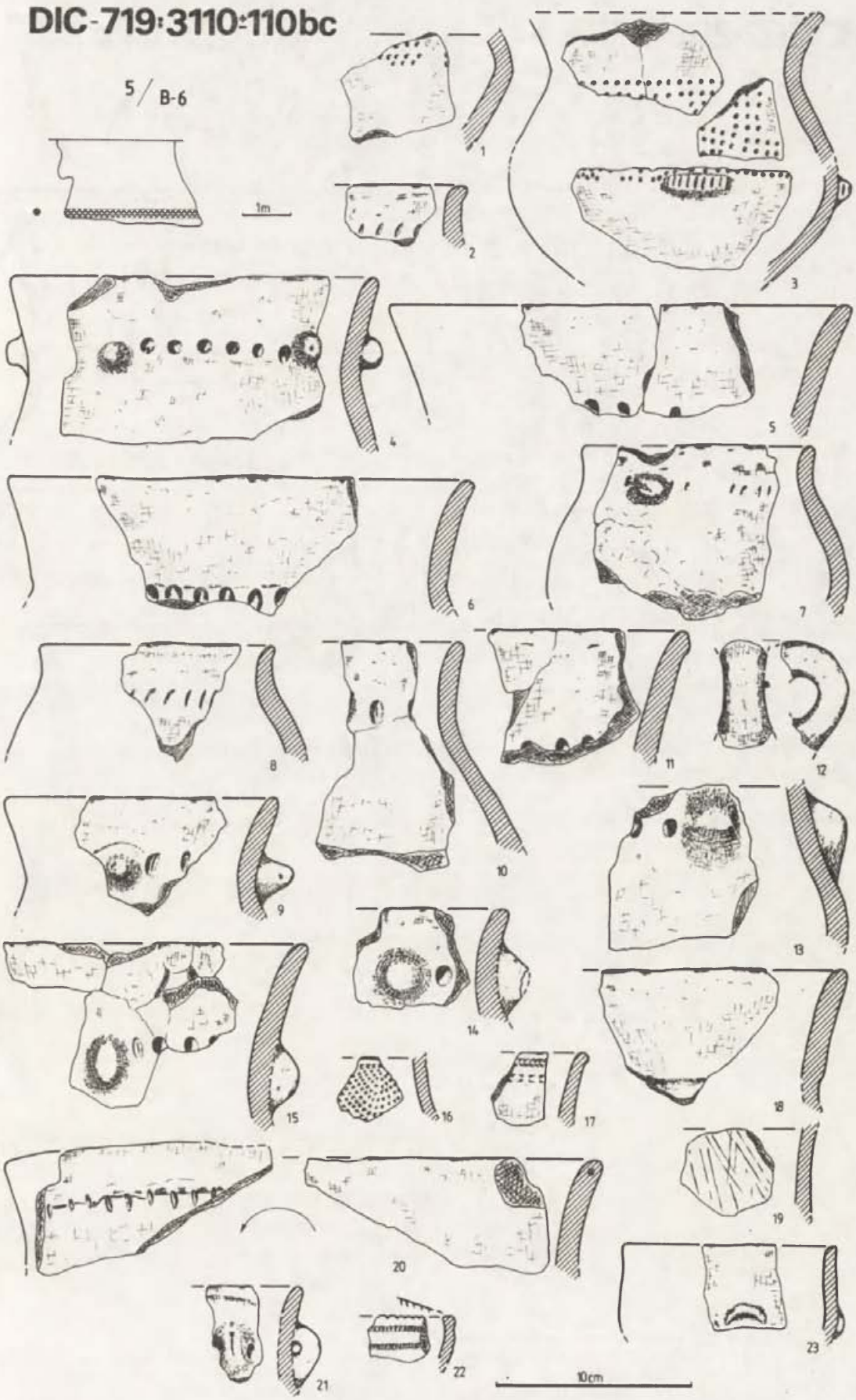


Fig. 4. Ceramics from pit 5-B6 (BR I phase)

– 19 – ceramics found in a layer above the ^{14}C dated sample, *20* – a sherd found in the same layer as the ^{14}C sample, *21 – 23* – ceramics found in a layer below the ^{14}C sample

Note: on Figs. 4–26 the layers with ^{14}C samples and associated ceramics were noted with black points.

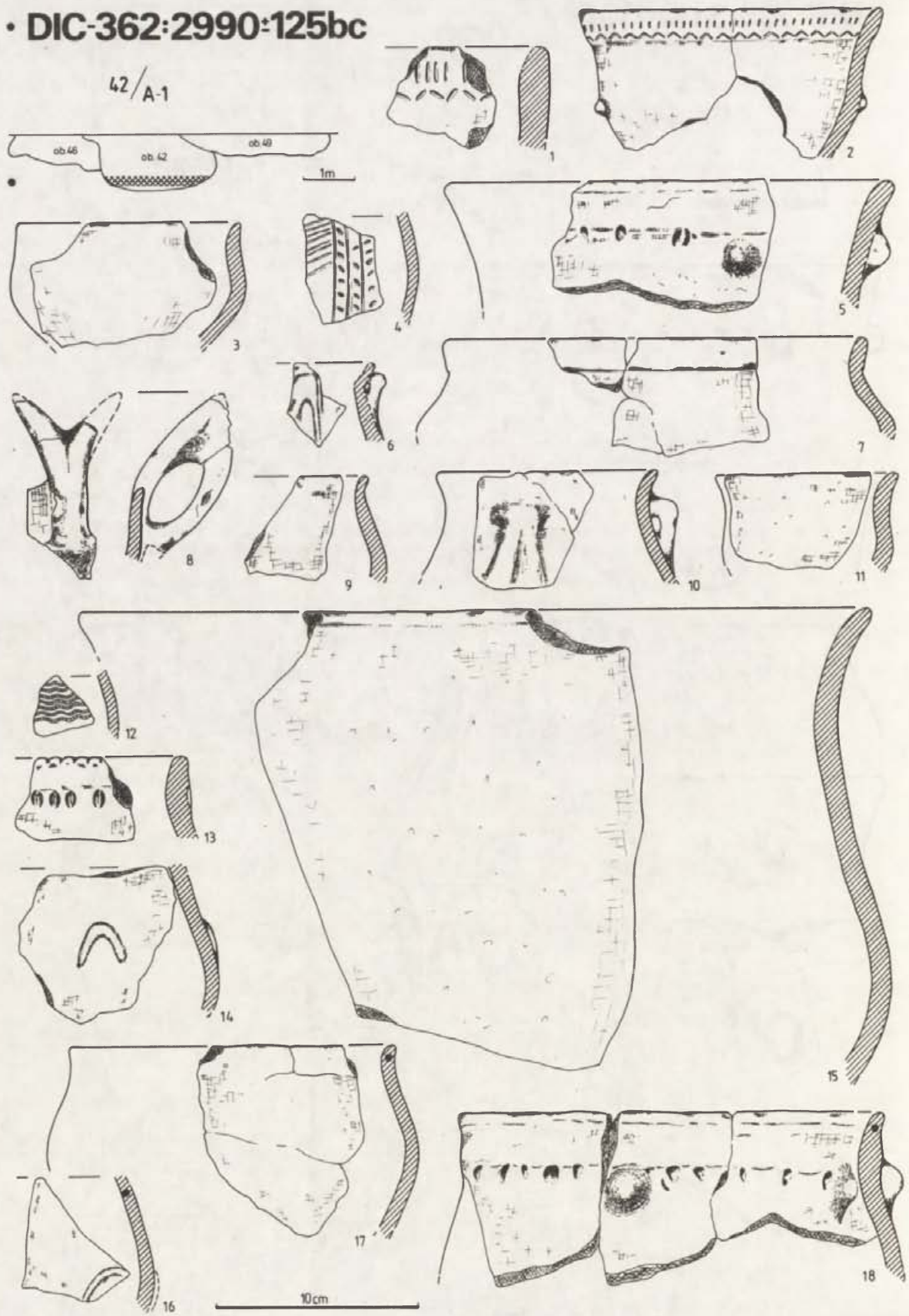


Fig. 5. Ceramics from pit 42-A1 (BR II phase)

1–15 – ceramics found in layer above the ^{14}C dated sample, *16, 17* – ceramics found in the same layer as the ^{14}C sample, *18* – a sherd found in layer below the ^{14}C dated sample

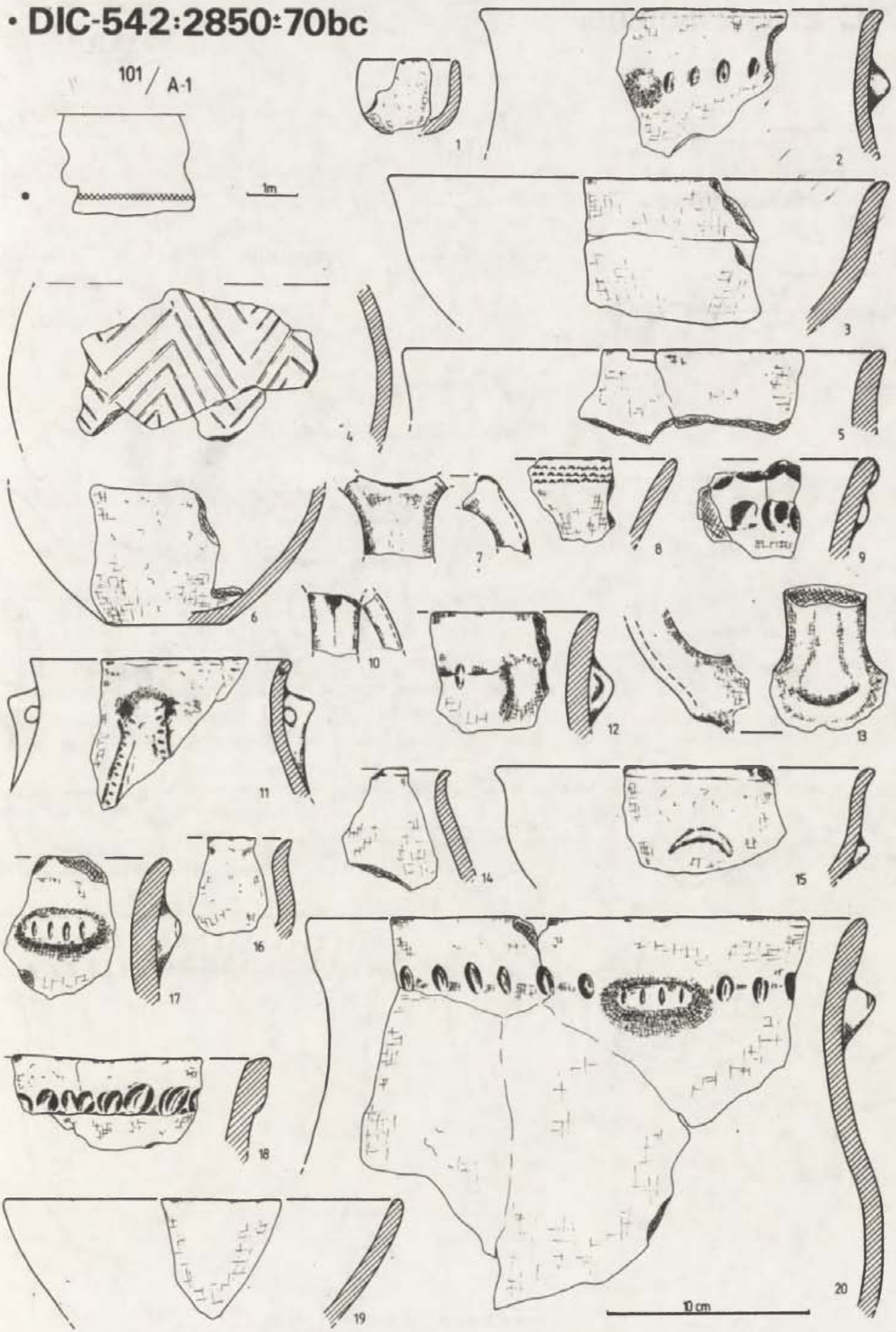


Fig. 6. Ceramics from pit 101-A1 (BR II phase)

1–10 – ceramics found in a layer above the ^{14}C dated sample, *11* – a sherd found in the same layer as the ^{14}C sample, *12–20* – ceramics found in a layer below the ^{14}C sample

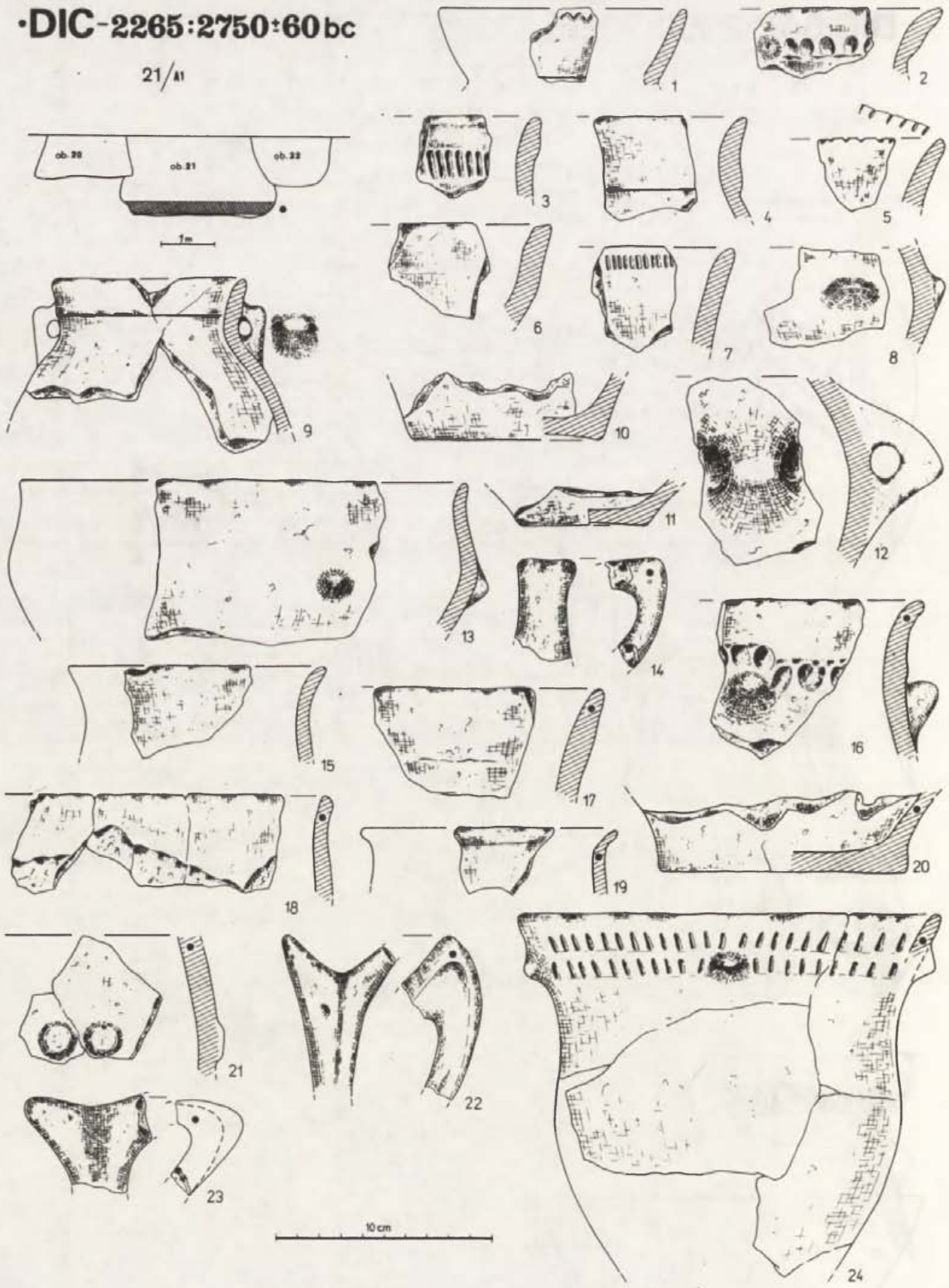


Fig. 7. Ceramics from pit 21-A1 (BR II phase)

1–15 – ceramics found in a layer above the ^{14}C dated sample, *16–24* – ceramics found in the same layer as the ^{14}C sample

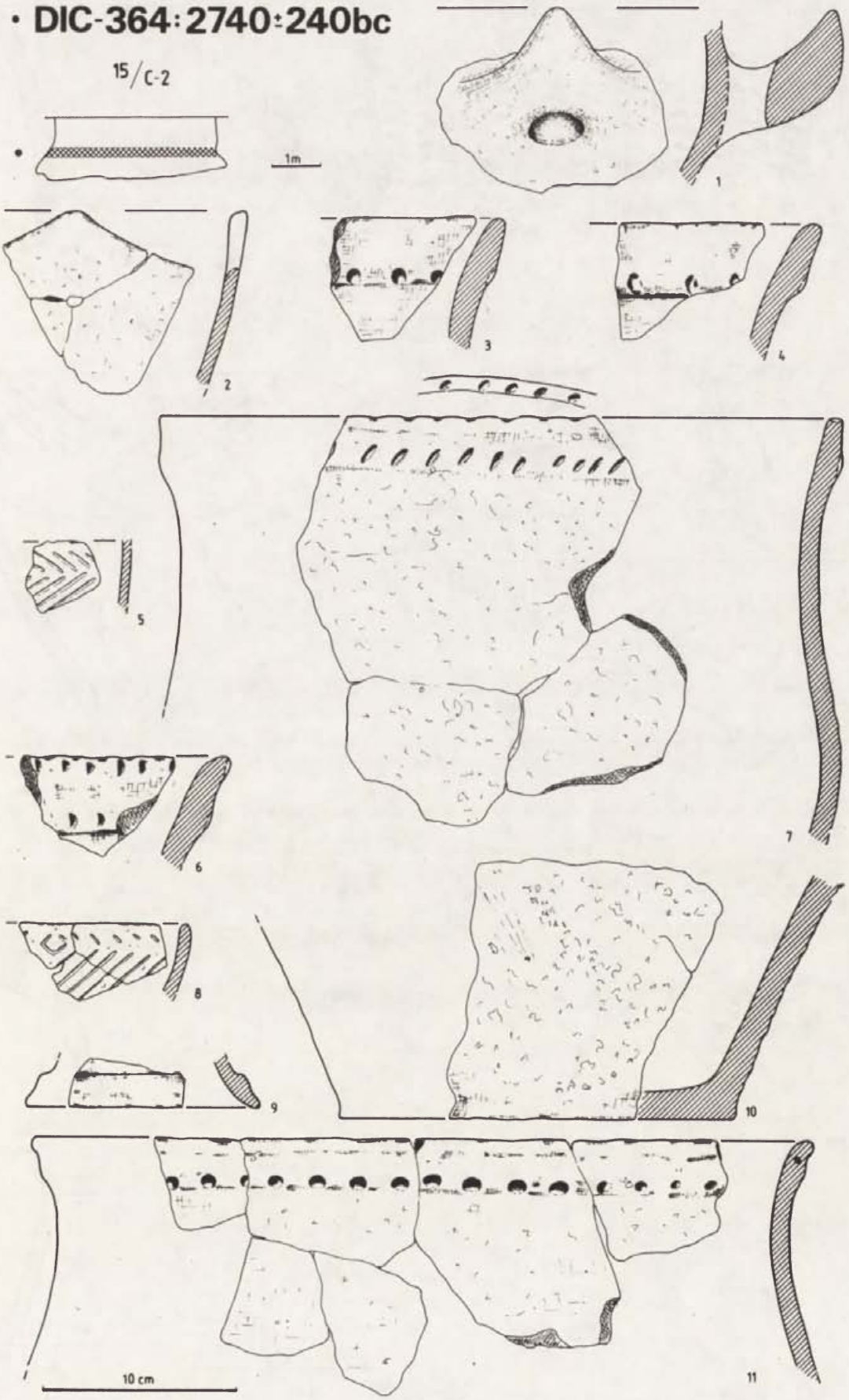


Fig. 8. Ceramics from pit 15-C2 (late phase of the Lublin-Volynian culture of the Polgár cycle in southeastern Poland)

1–10 – ceramics found in layer above the ^{14}C dated sample, *11* – a sherd found in the same layer as the ^{14}C sample

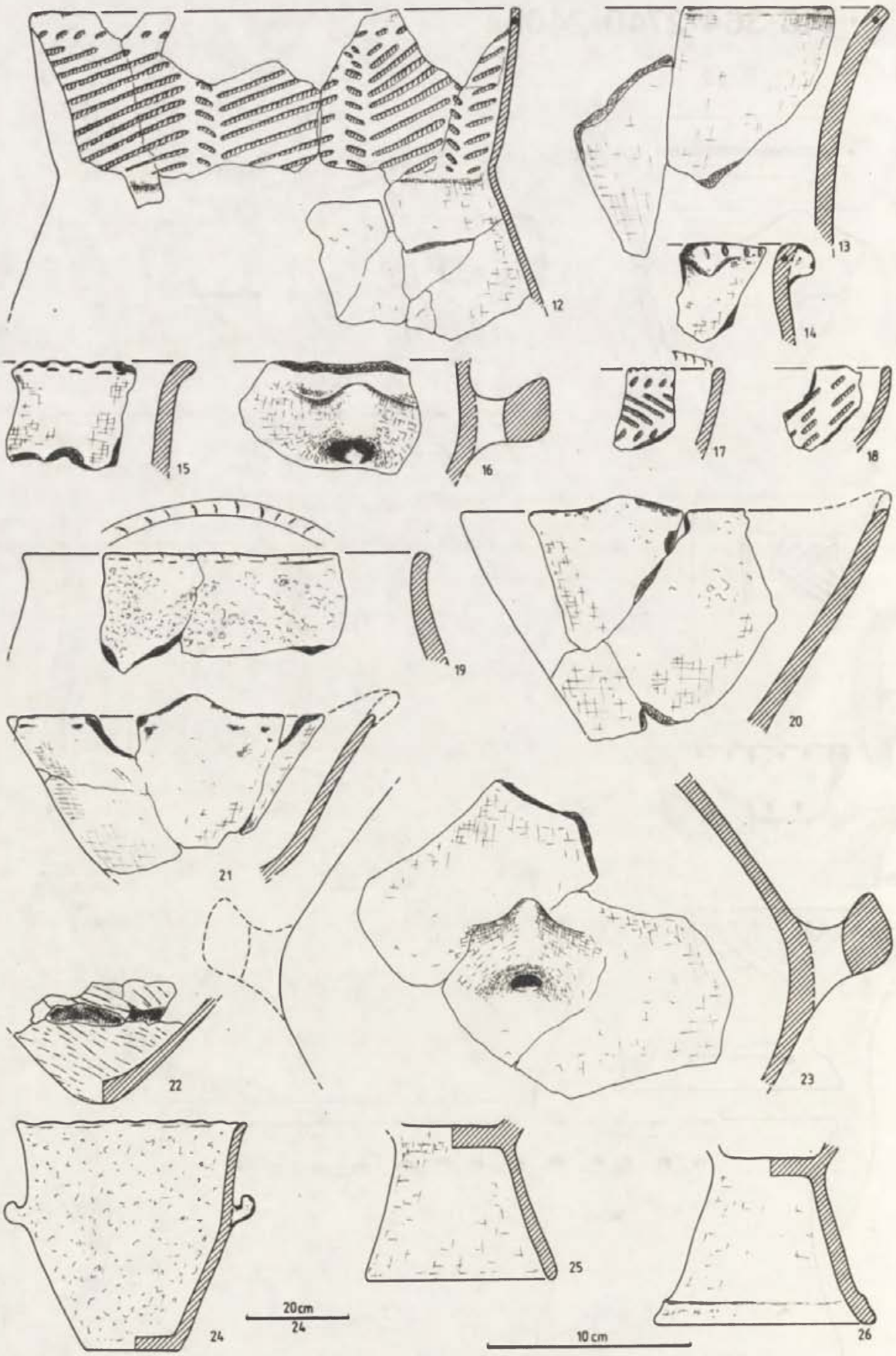


Fig. 9. Ceramics from pit 15-C2. The numbering of drawings is continued from Fig. 8

12–14 – ceramics found in the same layer as the ^{14}C dated sample, *15–26* – ceramics found in a layer below the ^{14}C dated sample

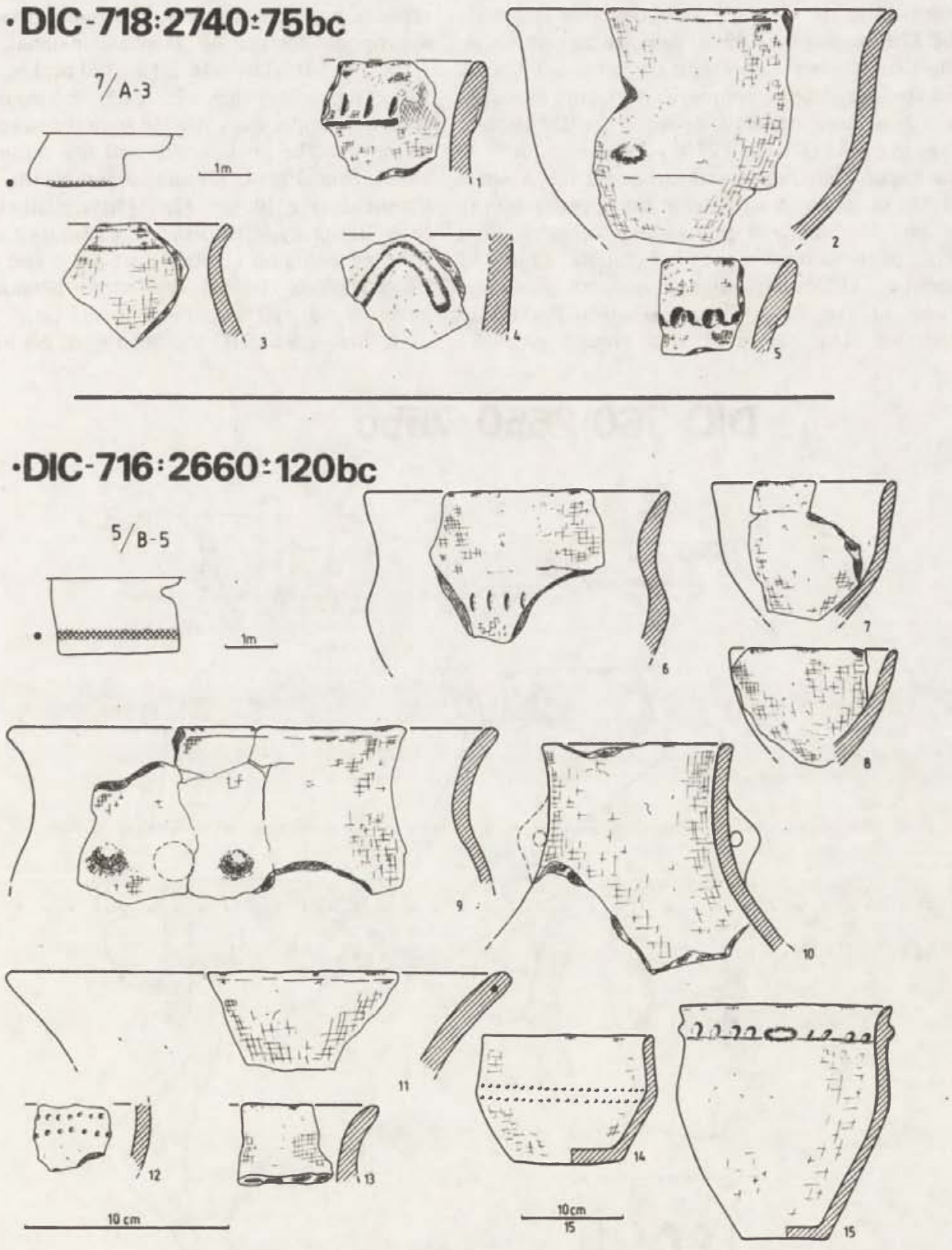


Fig. 10. Ceramics from pits 7-A3 (BR II phase) and 5-B5 (BR III phase)

1–5 – ceramics from pit 7-A3 (all artifacts found in a layer above the ^{14}C dated sample), *6–10* – ceramics from pit 5-B5 found in a layer above the ^{14}C dated sample, *11* – a sherd from pit 5-B5 found in a same layer as the ^{14}C dated sample, *12–15* – ceramics from pit 5-B5 found in a layer below the ^{14}C dated sample

Beaker). BR I ceramics represent an intrusive and older material in the pit. In addition, the Comb- and Pit Ornamented Pottery material was found in the pit (Figs. 8: 5, 8, 9: 12, 17, 18, 22). These ceramics differ technologically from similar finds in the BR I settlement. It is unclear whether these ceramics were mixed with the Lublin-Volynian material by natural processes or if they may represent an interaction between two archaeological cultures. The Comb- and Pit Ornamented Pottery cycle had dense

settlement in the eastern part of the Nida Basin. Pit 15-C2 belongs to the Lublin-Volynian culture. Generally the ^{14}C date agrees with the ceramic material. Perhaps the date is somewhat too late, however, there is a large standard deviation for the date.

6. Pit 7-A3 (DIC 718 2740±75 bc; Fig. 10: 1–5) is a trapezoidal feature with a layered fill. A small number of ceramics occurred in the upper section of the pit. The charcoal sample was collected from a layer at the bottom of the pit. Ceramics of pit 7-A3 comprise a chronologically homogeneous group and belong to the BR II phase (Funnel Beaker) at Bronocice. The excavated area around pit 7-A3 revealed no earlier features. The radiocarbon date is appropriate for the BR II phase material.

7. Pit 5-B5 (DIC 716 2660±120 bc; Fig. 10: 6-15) has a trapezoidal form with a homogeneous fill. The charcoal sample was collected from the lower section of the pit. The pit fill contained few ceramics: two vessels (Fig. 10: 14, 15) and several sherds. Perhaps the sherds (Fig. 10: 6, 9, 12, 14) have attributes of the early Baden cycle (Boleráz I). Ceramics forms and their technological attributes are associated with the BR III phase (Funnel Beaker) at Bronocice. No intrusive material was found in the pit.

8. Pit 98-B1 (DIC 360 2650±120 bc; Fig. 11) is

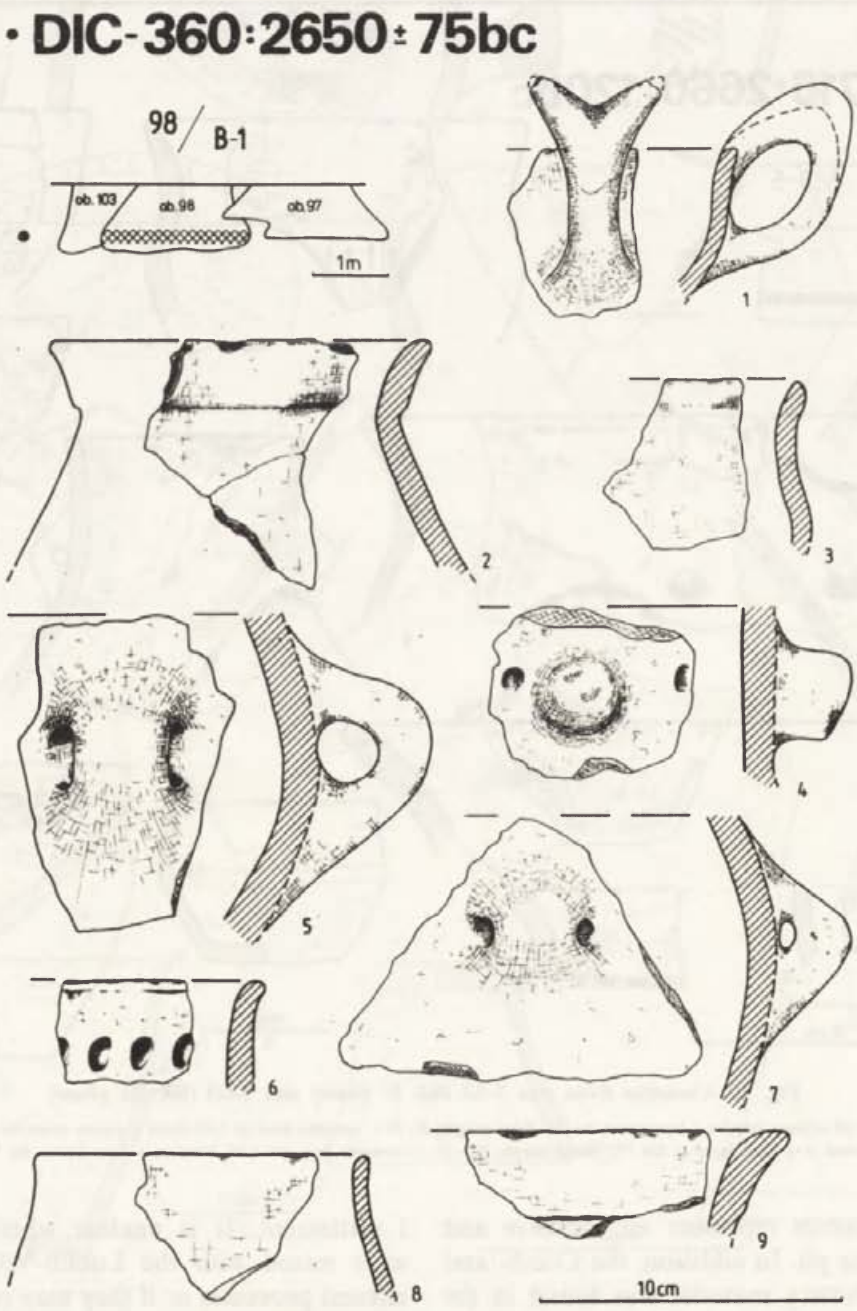


Fig. 11. Ceramics from pit 98-B1 (BR III phase)

1–9 – ceramics found in a layer above the ^{14}C dated sample

a trapezoidal feature which has its upper part destroyed by erosion. The pit fill is layered and the charcoal sample was collected from a layer near the bottom of the pit. There were only a small number of sherds in the pit and some of them belong to the "classic" Funnel Beaker culture in southeastern Poland. The ceramics do not have the characteristic attributes for the BR II and BR III phases at Bronocice. The stratigraphic relationship with pit 103-B1 (BR III) indicates that pit 98-B1 was later, however, it was earlier than pit 97-B1 (BR IV). Thus we can classify pit 98-B1 to the BR III phase.

9. Pit 64-A1 (DIC 2266 2640±55 bc; Fig. 12) is a trapezoidal feature which was damaged by erosion and pit 63-A1 (BR III). The pit fill was layered and the charcoal sample was collected from the lowest layer in the pit. The ceramic assemblage is technologically and stylistically homogeneous. A fragment of drum-like vessel (Fig. 12; 12), an amphora with a small opening (Fig. 12: 14) and a small handle of a semi-lunate shape (Fig. 14: 18), occurred in this pit. The attributes of ceramics indicate that this pit can be dated either to the BR II or the BR III phases. The radiocarbon date supports the latter while the stratigraphy favors the former.

10. Pit 23-B1 (DIC 1738 2620±70 bc; Fig. 13) is a small trapezoidal feature with a homogeneous pit fill. The charcoal sample was collected from a layer above the bottom of the pit. Ceramics consisted of thick sherds from bag-like vessels (Fig. 13: 1, 2, 9, 10, 13, 17). No finely made ceramics such as beakers, amphorae or cups, were found in this pit. However, it is possible to assign this pit to the BR III phase (Funnel Beaker) and the radiocarbon date is appropriate for that phase.

11. Pit 6-B6 (DIC 1796 2600±70 bc; Fig. 14) is a trapezoidal feature. The charcoal sample was collected from a homogeneous conical layer in the lower part of the pit. Most of the archaeological material was found in the upper and the middle parts of the pit. The ceramics exhibit little variability and their technological attributes are characteristic of the Funnel Beaker pottery on the loess uplands of southeastern Poland. The shapes of the vessels and their ornamentation indicate that this pit belongs to the BR III phase and the ^{14}C date agrees with the ceramic material.

12. Pit 68-A1 (DIC 363 2570±60 bc; Fig.15) has a trapezoidal shape and its upper part was damaged by erosion. The pit fill was homogeneous and the charcoal sample was collected from a layer at the bottom of the pit which contained numerous ceramic pieces. The ceramic assemblage exhibits variability and has characteristic types and attributes for the BR II and BR III phases. The BR II ceramics consist of an amphora with legs (Fig. 15: 15), a bag-like vessel (Fig. 15: 8) and cups with small semi-lunate handles (Fig. 15: 7, 10). BR III phase ceramics are characterized by thick funnel necked beakers (Fig. 15: 1, 2), sometimes with a sharp profile and vase-like pots (Fig. 15: 3, 12, 13). Since the radiocarbon date is associated with the BR III material, the BR II ceramics are intrusive in the pit.

13. Pit 45-B1 (DIC 1791 2490±75 bc; Fig. 16) is a small trapezoidal feature with a layered fill. The charcoal sample was collected from the lowest layer in the pit. Some of the Funnel Beaker ceramics in pit 45-B1 have incised lips and attached clay pieces on the rim (Fig. 16: 8–10) and perhaps some of them exhibit stylistic characteristics of the early Baden types (Fig.16: 8). The ceramic assemblage is associated with the BR III phase and the radiocarbon date is acceptable for this phase, however, similar dates are also associated with the BR IV phase.

14. Pit 29-A3 (DIC 717 2490±80 bc; Fig: 17:1–7)[3] is a small trapezoidal feature with its upper part damaged by erosion. A small part of the pit was not excavated, since it extended beyond the excavation unit. The pit fill was homogeneous. The ceramics of pit 29-A3 consist of two technological types. One group represents characteristic types for the Funnel Beaker BR II and BR III phases (Kruk, Milisauskas 1983, 270–280). However, the majority of the ceramics exhibit technological attributes characteristic of the BR IV and V phases (Kruk, Milisauskas 1983, 277–280). No typical Funnel Beaker ceramics types were found in pit 29-A3, but some younger types exhibit shapes and ornamentation characteristic for the BR IV phase (Kruk, Milisauskas 1983, 272–275, Fig. 6). These ceramics consist of vase-like vessel (Fig. 17: 7) and especially amphorae with narrow necks and two or four knobs below the lip (Fig. 17: 1, 5). The majority of the ceramics and the ^{14}C date indicate that pit 29-A3 belongs to the BR IV phase. The BR III ceramics are intrusive in this feature from pit 17-A3 (Fig. 17).

15. Pit 54-B1 (DIC 541 2450±80 bc; Fig. 17: 8–13)[4] is a trapezoidal feature with its upper part damaged by erosion. The pit fill is homogeneous and the charcoal sample was collected from the lowest part of the pit. The ceramic material consisted of small sherds, some of which were burnt. Most of the ceramics belong to the BR IV phase, however, some intrusive Funnel Beaker ceramics were also found in

[3] In a previous article (Kruk, Milisauskas 1983, 287, Fig. 12B) the ^{14}C date for pit 29-A3 was incorrect.

[4] This date was incorrectly published in a previous article (Kruk, Milisauskas 1983, 290, Fig. 14A).

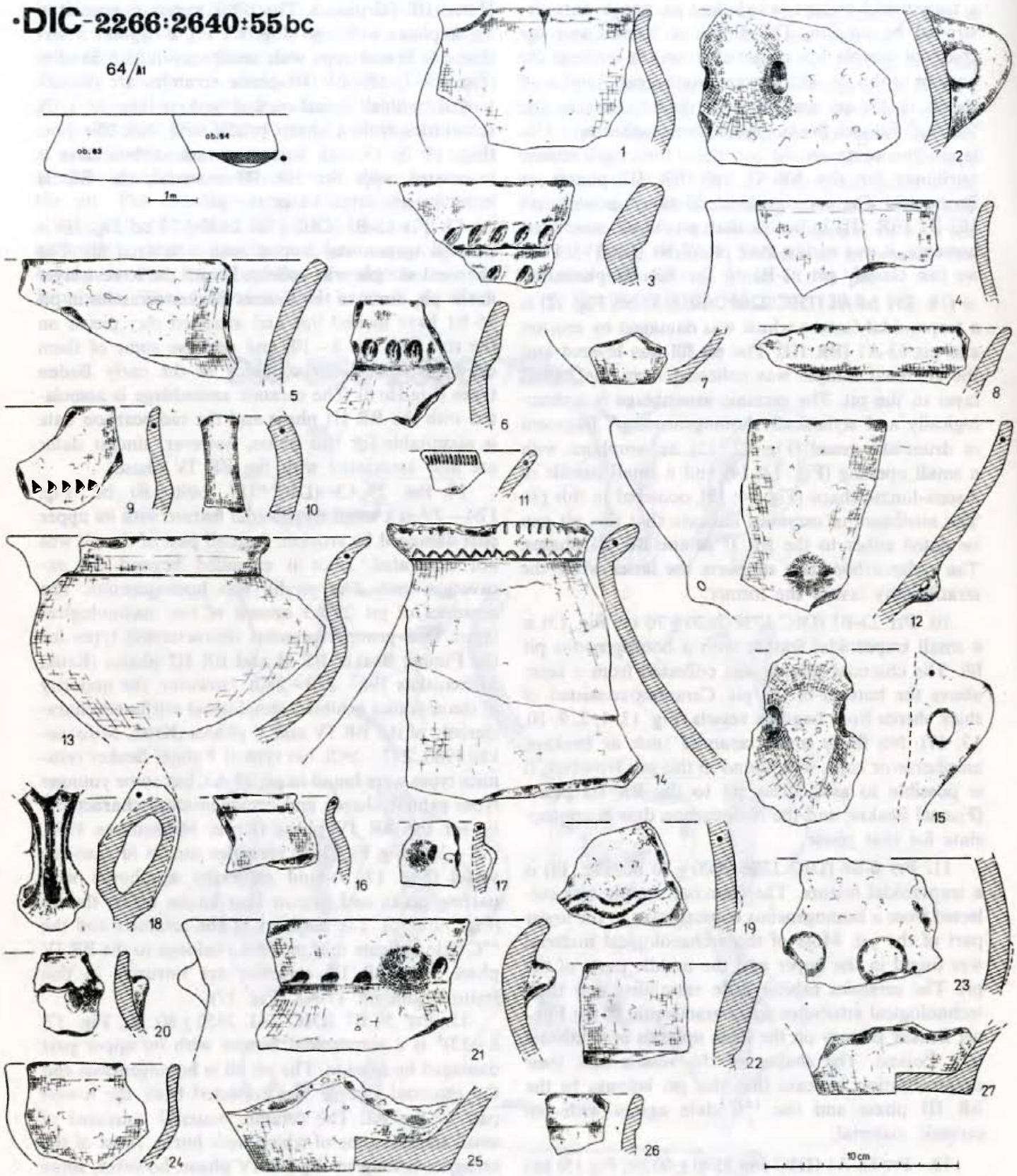


Fig. 12. Ceramics from pit 64-A1 (BR II–III phases)

1–8 – ceramics found in a layer above the ^{14}C dated sample. *9–19* – ceramics found in the same layer as the ^{14}C dated sample, *20–27* – ceramics found in a layer below the ^{14}C dated sample

Fig. 13. Ceramics from pit 23-B1 (BR III phase)

1–8 – ceramics found in a layer above the ^{14}C dated sample, *9–19* ceramics found in the same layer as the ^{14}C dated sample

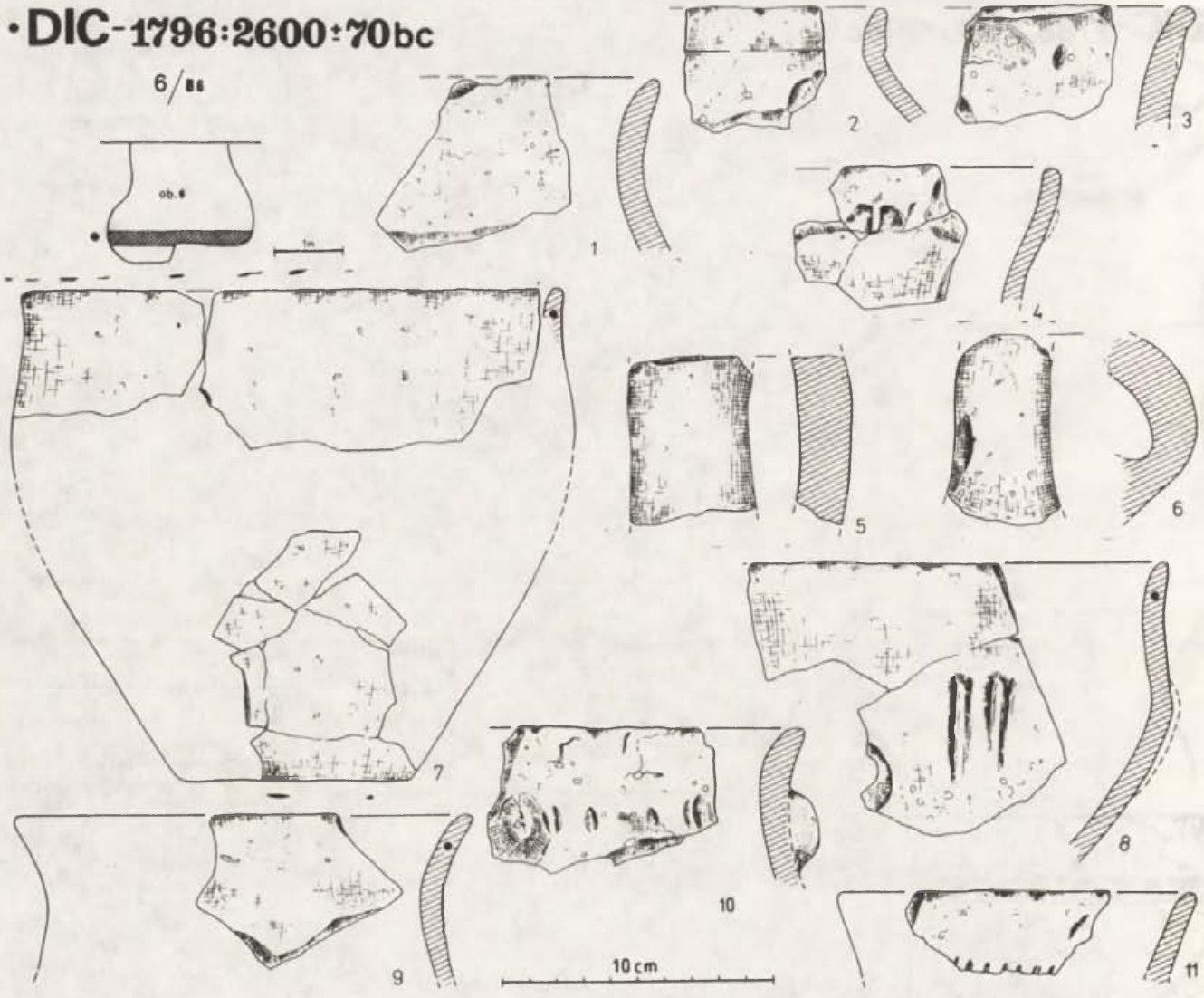


Fig. 14. Ceramics from pit 6-B6 (BR III phase)

1–6 – ceramics found in a layer above the ^{14}C dated sample, *7–9* – ceramics found in the same layer as the ^{14}C dated sample, *10, 11* – ceramics found in a layer below the ^{14}C dated sample

the pit (Fig. 17: 8). The radiocarbon date is appropriate for the BR IV phase.

16. Pit 95-B1 (DIC 1739 2390±75 bc; Fig. 18: 1–11) is a trapezoidal feature which has a layered fill. The charcoal sample was collected from a conical layer at the bottom of the pit. The ceramics of pit 95-B1 are not a chronologically homogeneous group. Some of the ceramics are Funnel Beaker types (BR III; Fig. 18: 1, 5), however, most of the pottery belongs to the BR IV phase. The radiocarbon date associated with the BR IV ceramics.

17. Pit 6-B2 (DIC 1797 2390±70 bc; Fig. 18: 12–15) is a trapezoidal feature with a homogeneous fill. A small part of the pit beyond the excavation unit was not excavated. The charcoal sample was collected from the middle of the pit. Ceramics of the pit 6-B2 are characteristic of the BR IV phase. A fragment of a funnel beaker (Fig. 18: 15) which represents a characteristic form for the late phases at Bronocice was found in pit 6-B2. Such forms occur in the pits of the BR IV phase and this indicates some continuation of the Funnel Beaker styles in the BR IV phase. Also a cup with a handle above the rim was recovered in pit 6-B2 (Fig. 18: 14) which resembles Baden types of the phase II in Slovakia (Němejcová-Pavúková 1981, 266–267, Figs. 3, 4). Similar relationship is shown by a rim with a wavy lip which was incised from the inside (Fig. 18: 13). The ceramics and the ^{14}C date are characteristic for the BR IV phase.

18. Pit 56-A1 (DIC 1736 2380±60 bc; Fig. 19) has a trapezoidal cross-section and its upper part

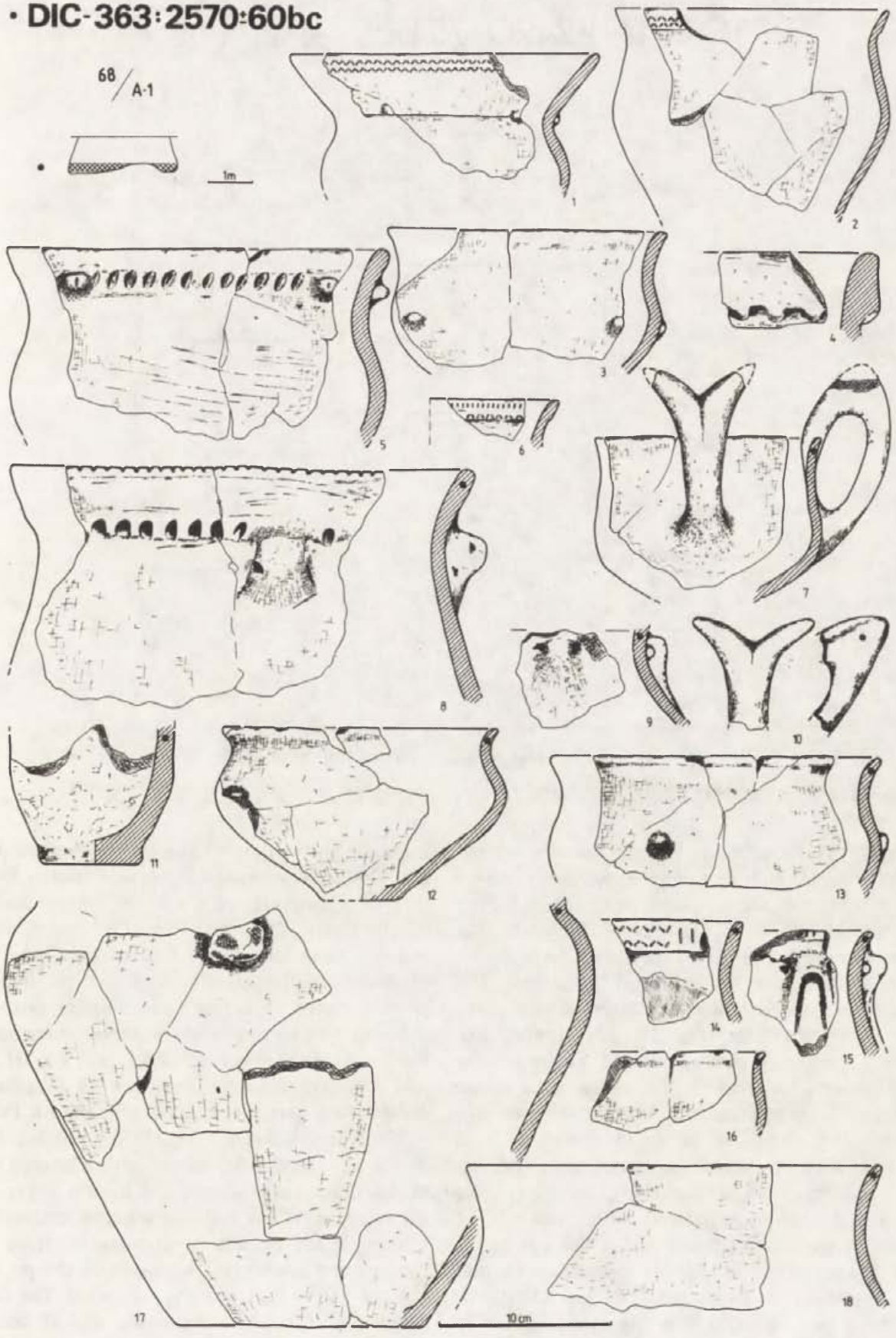


Fig. 15. Ceramics from pit 68-A1 (BR III phase)

1–6 – ceramics found in a layer above the ^{14}C dated sample, *7–18* – ceramics found in the same layer as the ^{14}C dated sample

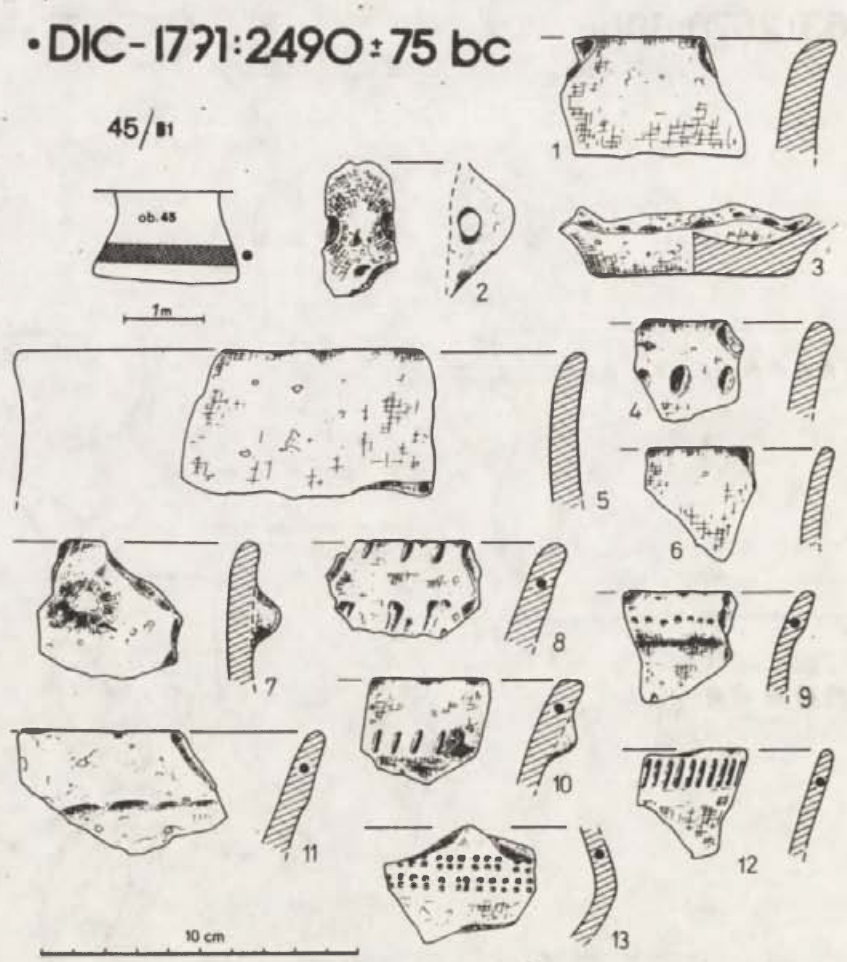


Fig. 16. Artifacts from pit 45-B1 (BR III phase)

1–7 – ceramics found in a layer above the ^{14}C dated sample, *8–13* – ceramics found in the same layer as the ^{14}C dated sample

was destroyed by erosion. The pit fill was layered and the charcoal sample was collected from a layer near the bottom of the pit. Some small sherds belong to the BR II and BR III phases of Funnel Beaker culture, however, majority of the sherds have Baden culture stylistic and technological attributes. The characteristic attributes are wide handles with channelled linear ornament (Fig. 19: 10), "tunnel"-like handle, horizontally perforated, and knobs on the rim of the amphorae which frequently occur in the later assemblages at Bronocice. Some of the previously mentioned attributes occur in materials from phases I to III in Slovakian Baden sites (Němejcová-Pavúková 1974; 1981; 1984), however these observations should be treated with caution. The contents of pit 56-A1 suggest that it belongs to the BR IV phase and the ^{14}C date is appropriate for that phase. Pit 56-A1 intersects with pits 120-A1 (BR II) and 53-A1 (BR III) and it is the latest feature in a group of three intersecting pits.

19. Pit 1-B8 (DIC 977 2370±55 bc; Fig. 20) is a trapezoidal feature with a homogeneous pit fill. The charcoal sample for ^{14}C dating was collected from the lower part of the pit. Numerous Jurassic flint artifacts occurred in the pit (Tables 3, 4) and they were concentrated above the bottom and in the middle layers of the pit. These flint pieces represent remains from the production of axes which were produced in the area around the pit. Numerous pottery pieces, including one complete pot, are associated with three phases. Some ceramics belong to the Funnel Beaker culture (BR II and BR III phases) and some are associated with the BR IV phase. The radiocarbon date is appropriate for the BR IV phase.

20. Pit 2-B2 (DIC 543 2370±130 bc; Fig. 21: 1–10) is a trapezoidal feature with a layered fill. The charcoal sample was collected from a lower part of the pit. Most of the material was concentrated at the bottom of the pit and on the characteristic step at the opening of the pit. A section of the pit beyond the excavation unit was not excavated. The ceramics are technologically homogeneous and all the vessels were made according to the technique which was characteristic for the later phases at Bronocice (Kruk, Milisauskas 1983, 287–289). The ceramic material of this pit has specific stylistic characteristics

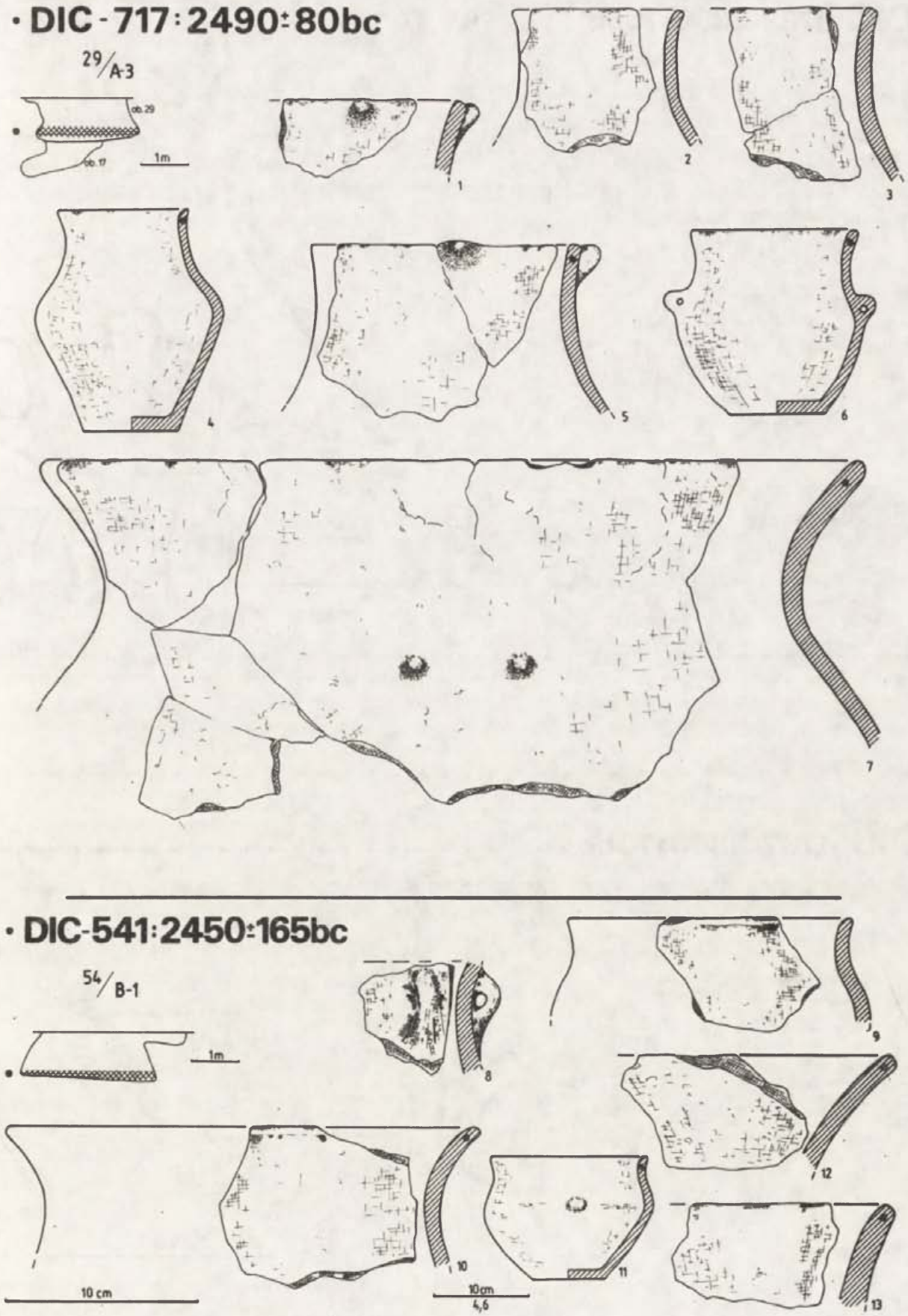
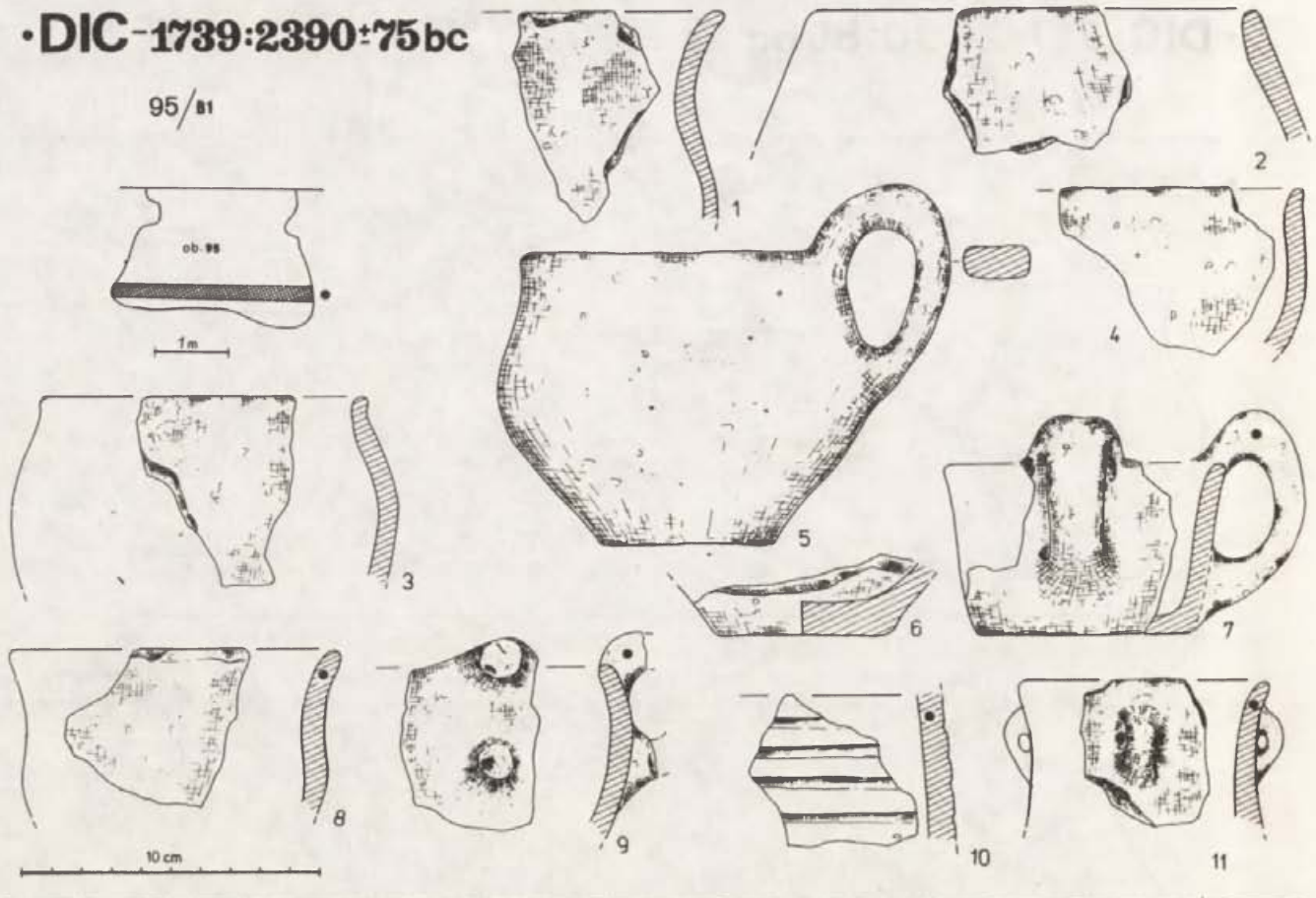


Fig. 17. Ceramics from pits 29-A3 (BR IV phase) and 54-B1 (BR IV phase)

1–4 – ceramics from pit 29-A3 found in a layer above the ^{14}C dated sample, *5–7* – ceramics from pit 29-A3 found in the same layer as the ^{14}C dated sample, *8, 9* – ceramics from pit 54-B1 found in a layer above the ^{14}C dated sample, *10–13* – ceramics from pit 54-B1 found in the same layer as the ^{14}C dated sample



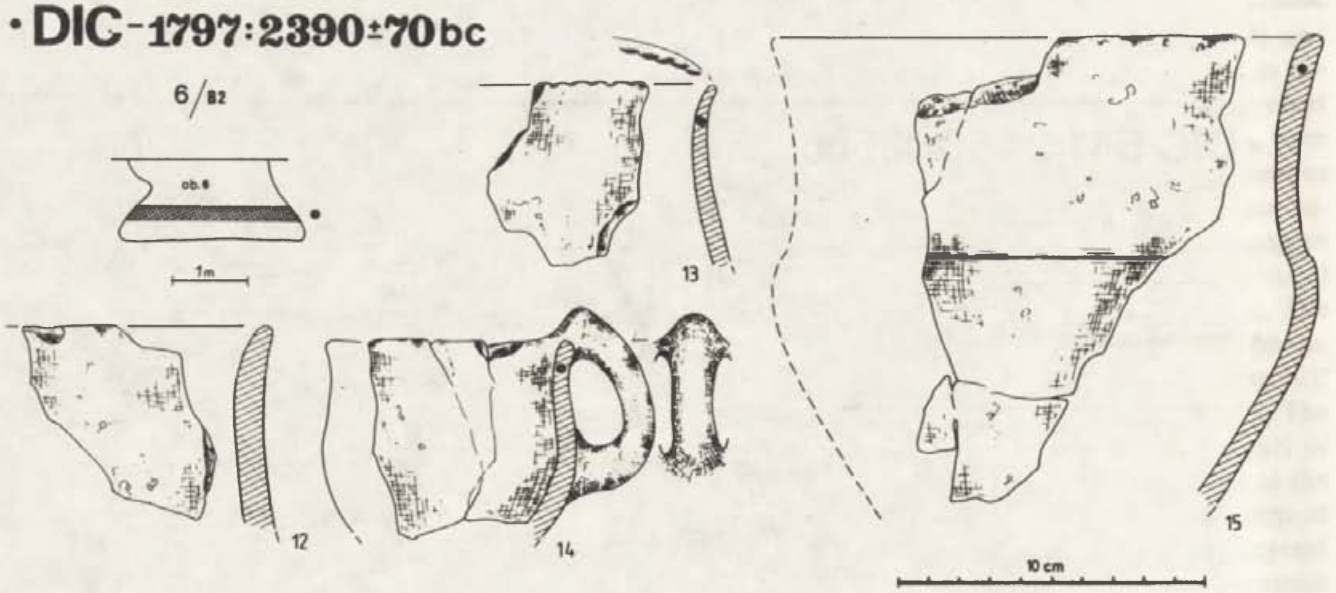


Fig. 18. Ceramics from pits 95-B1 (BR IV phase) and 6-B2 (BR IV phase)

1–6 – ceramics from pit 95-B1 found in a layer above the ^{14}C dated sample, *7–11* – ceramics from pit 95-B1 found in the same layer as the ^{14}C dated sample, *12* – a sherd from pit 6-B2 found in a layer above the ^{14}C dated sample, *13–15* – ceramics from pit 6-B2 found in the same layer as the ^{14}C dated sample

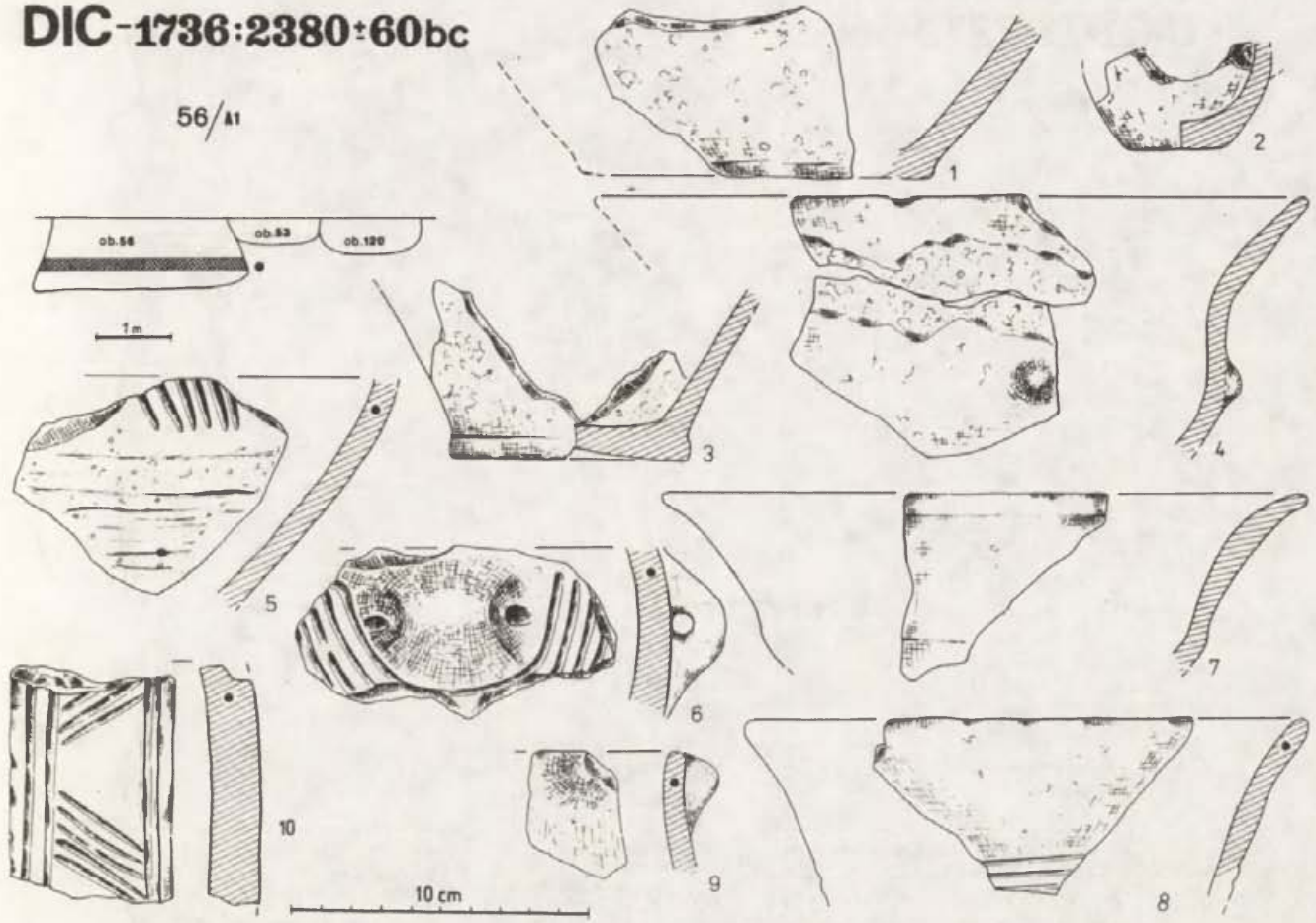


Fig. 19. Ceramics from pit 56-A1 (BR IV phase)

1–4 – ceramics found in a layer above the ^{14}C dated sample, *5–10* – ceramics found in the same layer as the ^{14}C dated sample

and is related to the classic (III–IVa) phase of the Baden culture (Němejcová-Pavúková 1981, 1984). The contents of the pit are characteristic for the Bronocice V phase. The ^{14}C date correlates with the ceramic material.

21. Pit 6-B8 (DIC 1794 2310±70 bc; Fig. 22) is a feature with a trapezoidal cross-section and a layer ed fill. A small part of the pit beyond the excavation unit was not excavated. The charcoal sample was collected from the lower part of the pit. The contents of the pit consist mainly of ceramics (Table 3) and represent a homogeneous assemblage. The ceramics have attributes characteristic of the later phases at Bronocice such as "saddle-shaped" (Fig. 22: 10) and band-like (Fig. 22: 11) handles and rims of amphorae with thick lips and knobs (Fig. 22: 8, 9). The assemblage is characteristic for the BR V phase and the ^{14}C date agrees with the ceramic material.

22. Feature 1-A5 (DIC 978 2300±115 bc; Fig. 21: 11–28) is a part of a ditch (fortifications) which enclosed the settlement during the BR V phase (Kruk, Milisauskas 1981b, 73–75, Fig. 2, 5). The feature was formed of a layered fill, however, a part of the fill was deposited by erosion. Only at the bottom of the ditch there was a homogeneous layer of fill and the charcoal sample for ^{14}C dating came from this layer. The archaeological material, some of which was burnt, occurred in the middle and upper layers of the ditch.

The ceramics were technologically homogeneous and most of the ornamentation and shapes of ceramics also represent a chronologically homogeneous group except for a few earlier types (BR IV). The ^{14}C date is acceptable for the BR V phase. The presence of sherds with black painted colour should be noted (Fig. 21: 20). These types of ceramics usually occurred in the BR IV features and are associated with the late Tripolye cycle (Kruk, Milisauskas 1981b, 98; Kośko 1981, 119; Jastrzębski 1983, 129, Fig. 16, 17).

23. Pit 39-B1 (DIC 361 2290±115 bc; Fig. 23) is a trapezoidal feature with a layered fill and it was intersected near the bottom by a younger pit 96-B1 (BR V). The charcoal sample was collected from a conical layer in the lower part of the pit. Numerous

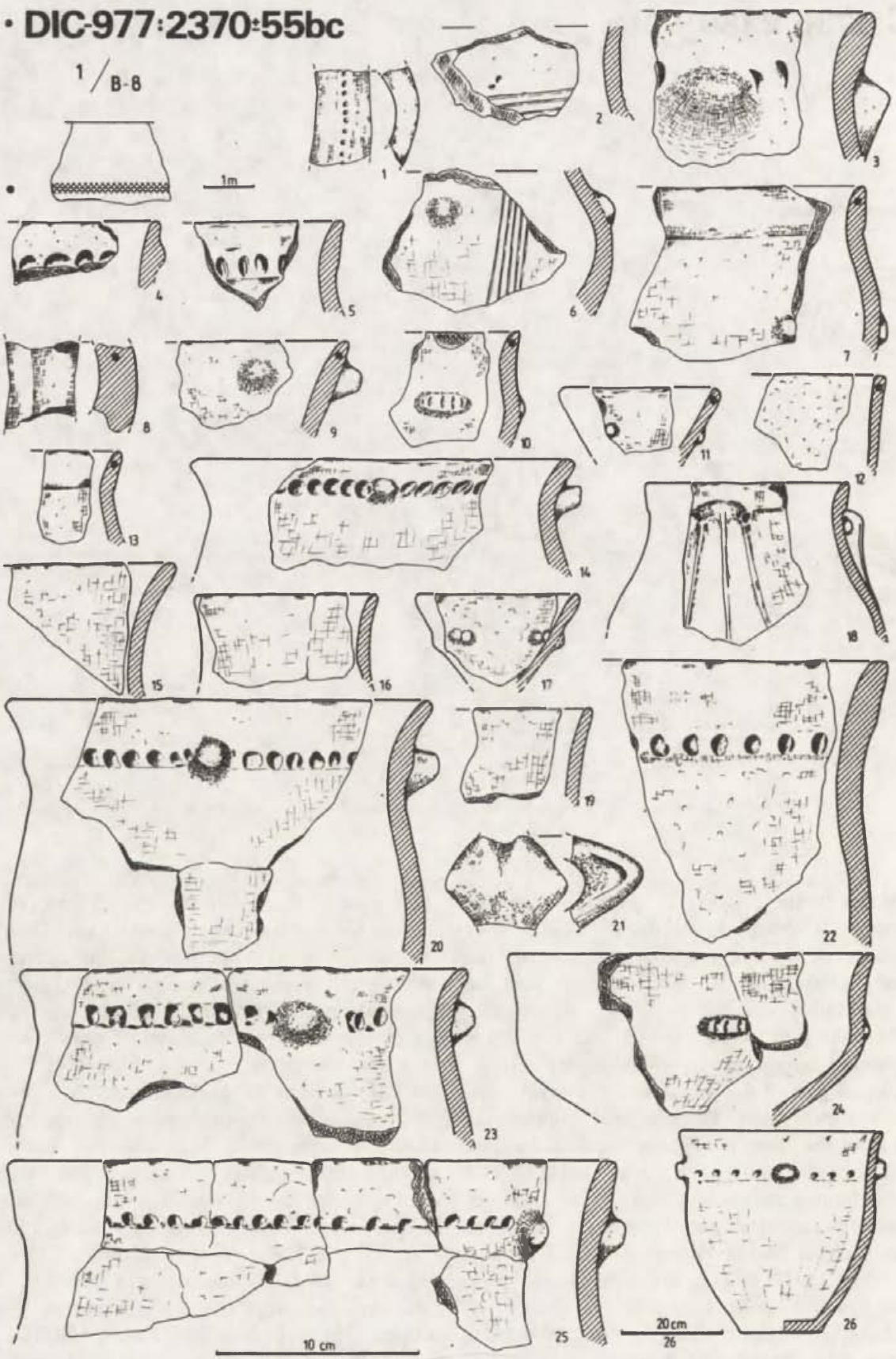


Fig. 20. Ceramics from pit 1-B8 (BR IV phase)

1–6 – ceramics found in a layer above the ^{14}C dated sample, *7–13* – ceramics found in the same layer as the ^{14}C dated sample, *14–26* – ceramics found in a layer below the ^{14}C dated sample

Fig. 21. Ceramics from features 2-B2 (BR V phase) and 1-A5 (BR V phase)

1–5 – ceramics from pit 2-B2 found in a layer above the ^{14}C dated sample, *6–9* – ceramics from pit 2-B2 found in the same layer as the ^{14}C dated sample, *10* – a sherd from pit 2-B2 found in a layer below the ^{4}C dated sample, *11–26* – ceramics from feature 1-A5 found in a layer above the ^{14}C dated sample, *27, 28* – vessels from feature 1-A5 found in the same layer as the ^{14}C dated sample

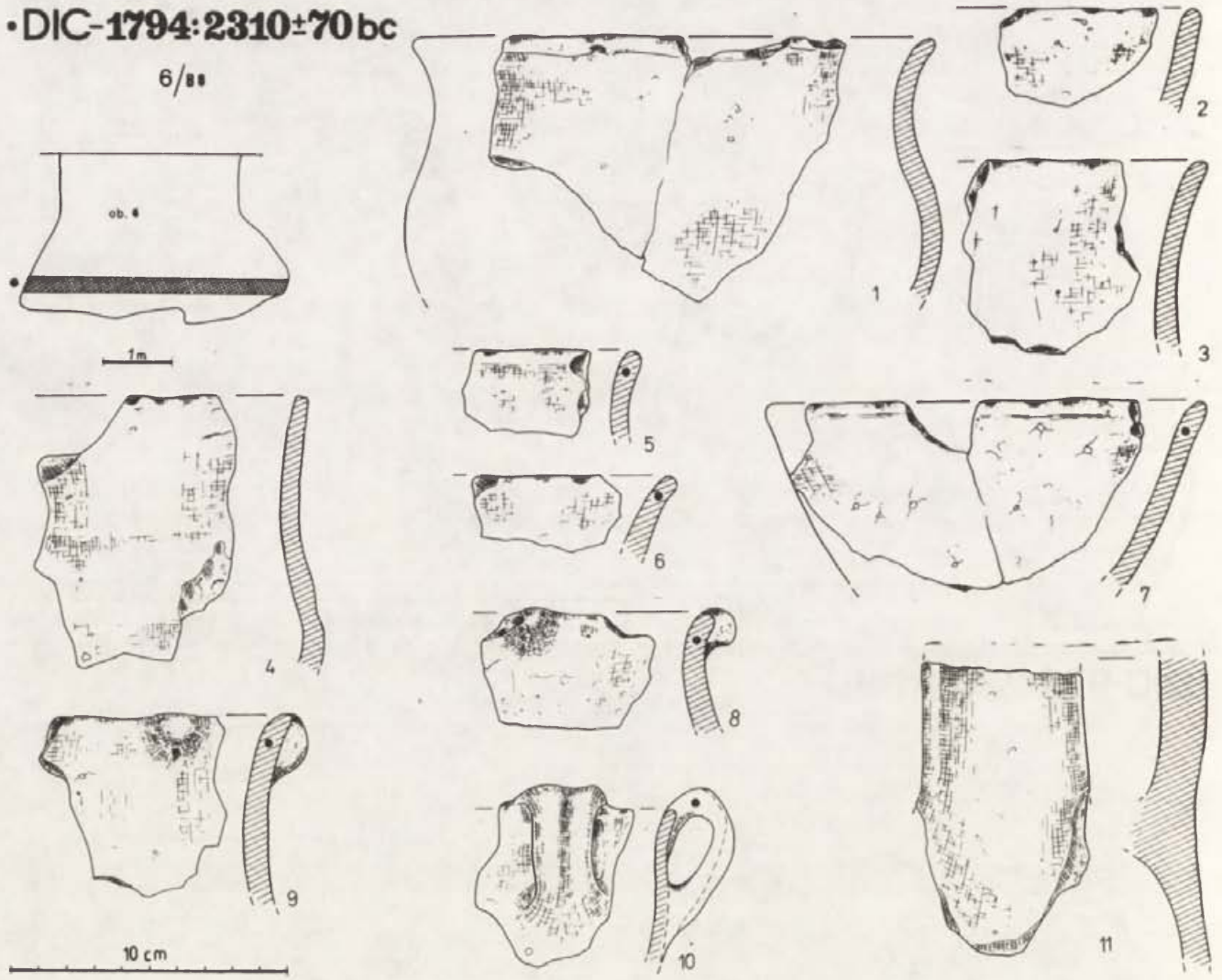


Fig. 22. Ceramics from pit 6-B8 (BR V phase)

1–4 – ceramics found in a layer above the ^{14}C dated sample, *5–10* – ceramics found in the same layer as the ^{14}C dated sample, *11* – a sherd found in a layer below the ^{14}C dated sample

artifacts, especially ceramics, occurred in the middle and lower parts of the pit. Three complete vessels were found in pit 96-B1 (Fig. 23: 5, 11, 12), but the ceramic assemblage is not homogeneous. There are some Funnel Beaker sherds (BR III phase; Fig. 23: 1, 8, 10) and ceramics of BR IV phase at Bronocice, however, sherds of the BR V phase (Fig. 23: 2, 13) characterize the assemblage. It should be noted that the majority of sherds belong to the BR IV phase (Fig. 23: 3, 5). Briquette-type forms ("conical beakers", Rook 1971, 225) which were probably associated with salt exploitation were found in this pit. Only rarely complete vessels were recovered (Fig. 23: 11, 12). These types of ceramics have special technological characteristics (Kruk, Milisauskas 1983, 279–280) and occur in features of the BR IV and V phases.

The ^{14}C date is associated with the BR V phase, but could be related to the BR IV phase because of the a large standard deviation. Pit 39-B1 was older than pit 96-B1 which was dated to the BR V phase.

24. Pit 8-B7 (DIC 979 2250±60) bc; Fig. 24) is a trapezoidal feature with its upper part destroyed by erosion. The pit was intersected by feature 7-B7 (BR IV). Ceramics of pit 8-B7 are characteristic for the BR V phase, however, some types belong to the BR IV phase (Fig. 24: 1, 11, 13). The ^{14}C date fits with the relative chronology of the pit (BR V).

25. Pit 4-B3 (DIC 1795 2140±140 bc; Fig. 25) is a trapezoidal feature with a layered fill. The charcoal sample was collected from a layer near the bottom of the pit. This pit was younger than pit 6-B3 which was closely located to it and was dated to the BR V phase. Most of the ceramics occurred in the middle and lower parts of the pit. The ceramic assemblage is

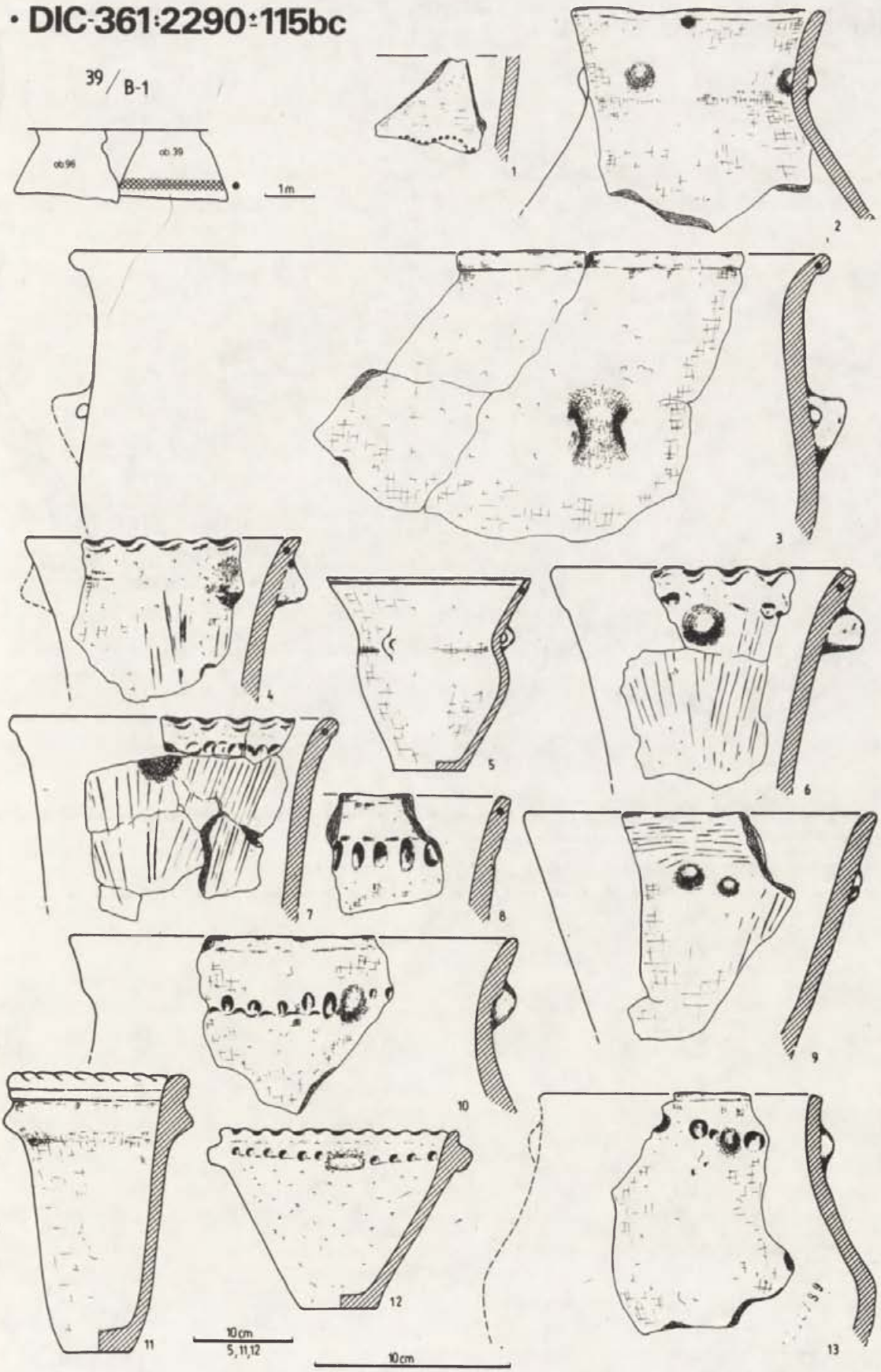


Fig. 23. Ceramics from pit 39-B1 (BR IV–V)

1–3 – ceramics found in a layer above the ^{14}C dated sample, *4–8* –ceramics found in the same layer as the ^{14}C dated sample, *9–13* – ceramics found in a layer below the ^{14}C dated sample

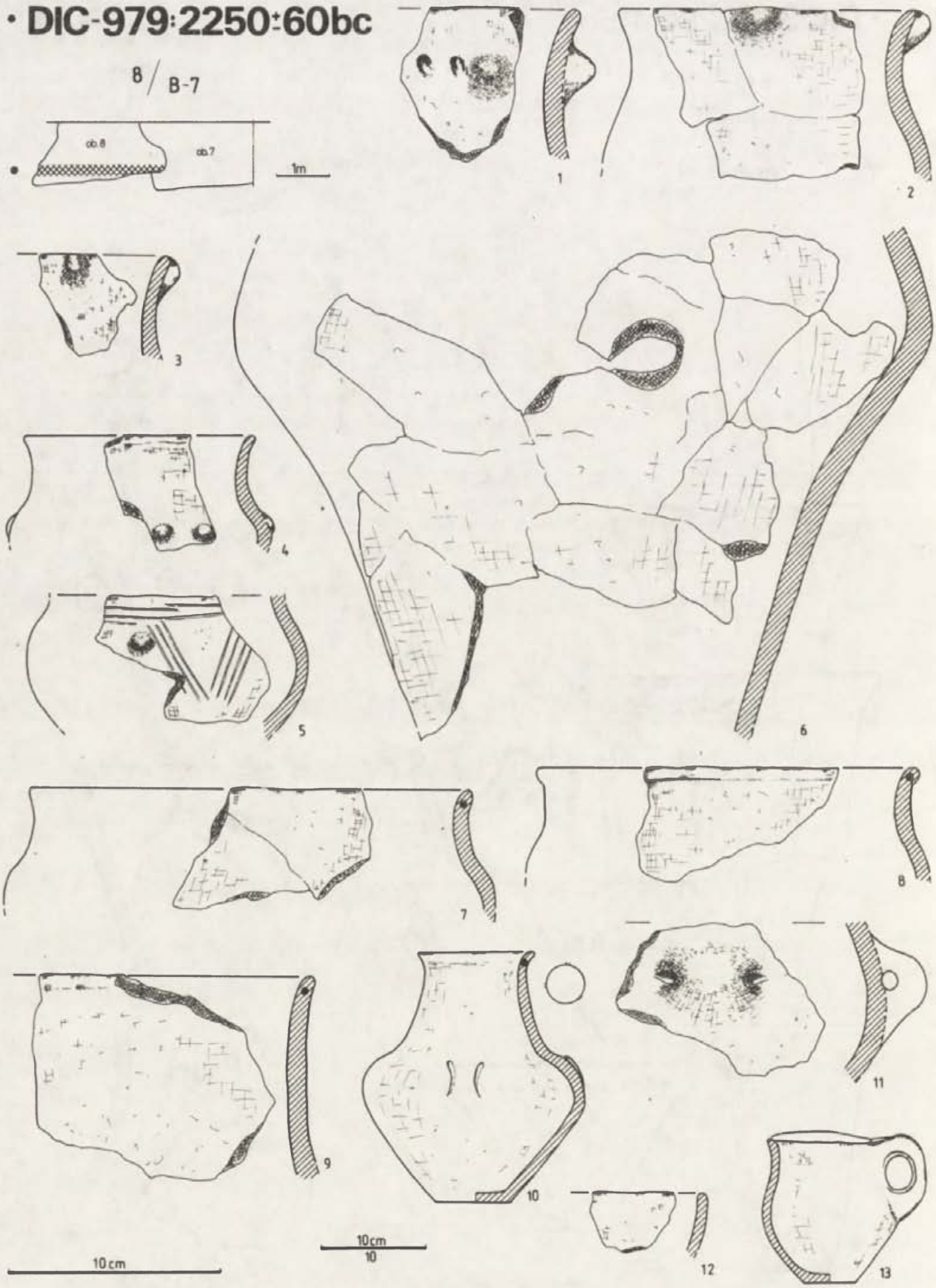


Fig. 24. Ceramics from pit 8-B7 (BR V phase)

1–6 – ceramics found in a layer above the ^{14}C dated sample, *7–10* – ceramics found in the same layer as the ^{14}C dated sample, *11–13* – ceramics found in a layer below the ^{14}C dated sample

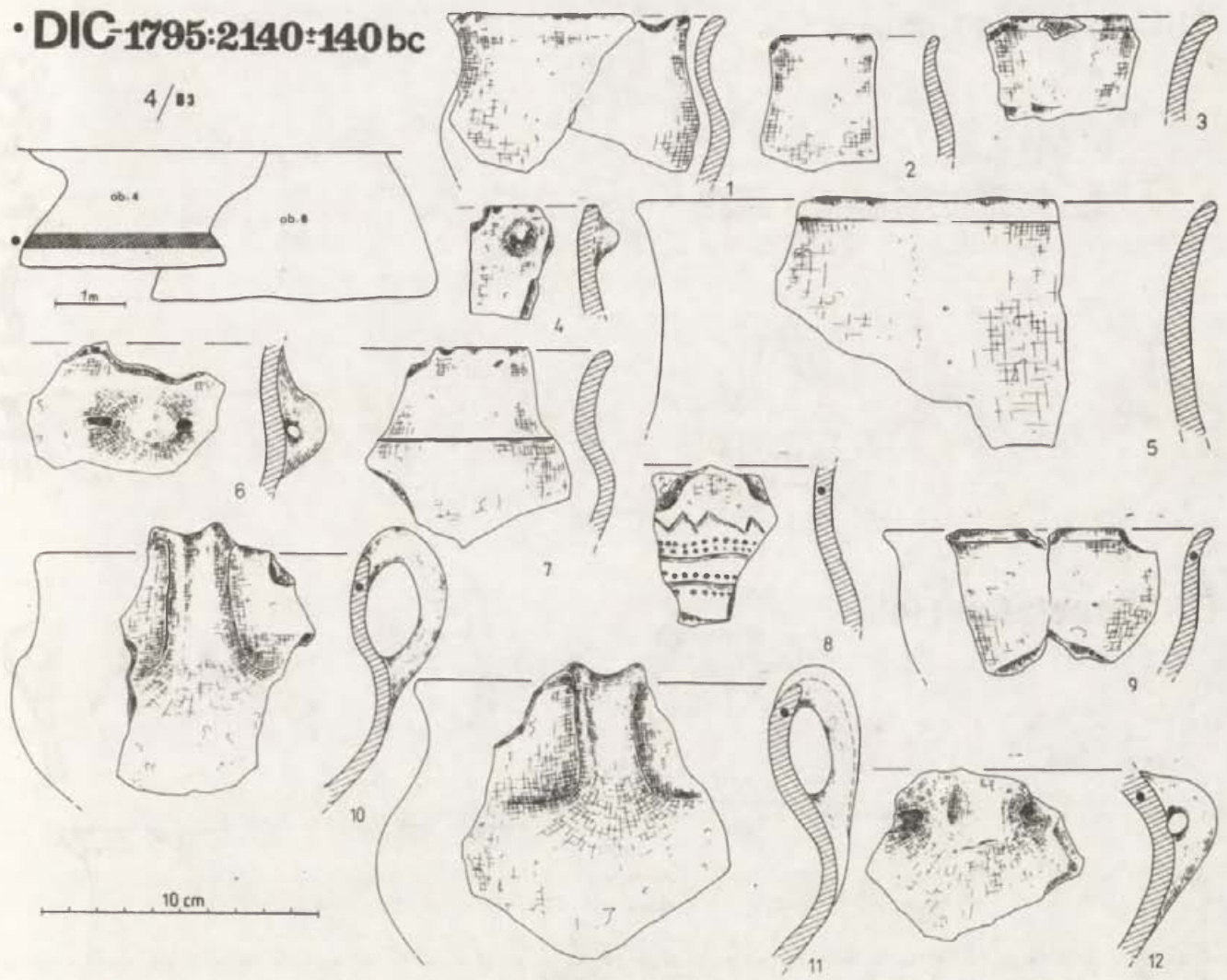


Fig. 25. Ceramics from pit 4-B3 (BR V phase)

1–7 – ceramics found in a layer above the ^{14}C dated sample, *8–12* – ceramics found in the same layer as the ^{14}C dated sample

technologically homogeneous and the shapes and ornamentation of ceramics are characteristic of the BR V phase. There are cups with "saddle" like handles (Fig. 25: 10, 11) and incised band ornamentation (Fig. 25: 8). The stratigraphic relationship between pits 4-B3 and 6-B3 indicates that the pit 4-B3 assemblage is associated with the very late occupation of the BR V phase. The ^{14}C date fits the relative chronology of the ceramics.

26. Pit 10-B5 (DIC 1740 2130±65 bc; Fig. 26: 1–14) is a trapezoidal feature with a layered pit fill and the charcoal sample was collected from a layer above the bottom of the pit. Pit 10-B5 was younger than pit 9-B5 which belongs to the BR V phase. Numerous sherds occurred in the pit (Table 3) and they comprise a technologically homogeneous group. Most of the forms and ornamentation types are typical for the BR V phase, however, some types belong to the BR IV phase (Fig. 26: 4–7). The ^{14}C date fits with the ceramic material.

27. Pit 3-B4 (DIC 1792 2130±110 bc; Fig. 26: 15–24) is a trapezoidal feature with its upper part destroyed by erosion. The charcoal sample was collected from the lowest layer of the pit. Pit 3-B4 was younger than pit 3A-B4 which was dated to the BR V phase. The ceramic assemblage is homogeneous. Several types of handles (Fig. 26: 15–19, 21, 22) are characteristic for the BR V phase. One sherd has a similar ornamentation to the Baden IIb–III types in Slovakia (Fig. 26: 20; Němejcová-Pavúková 1974, Fig. 40, 44; 1981, Fig. 4). Also a sherd with similar ornamentation was found in pit 4-B3 (Fig. 25: 8) which was dated to the BR V phase. The ceramic assemblage is typical for the BR V phase and the ^{14}C date agrees with the ceramic material.

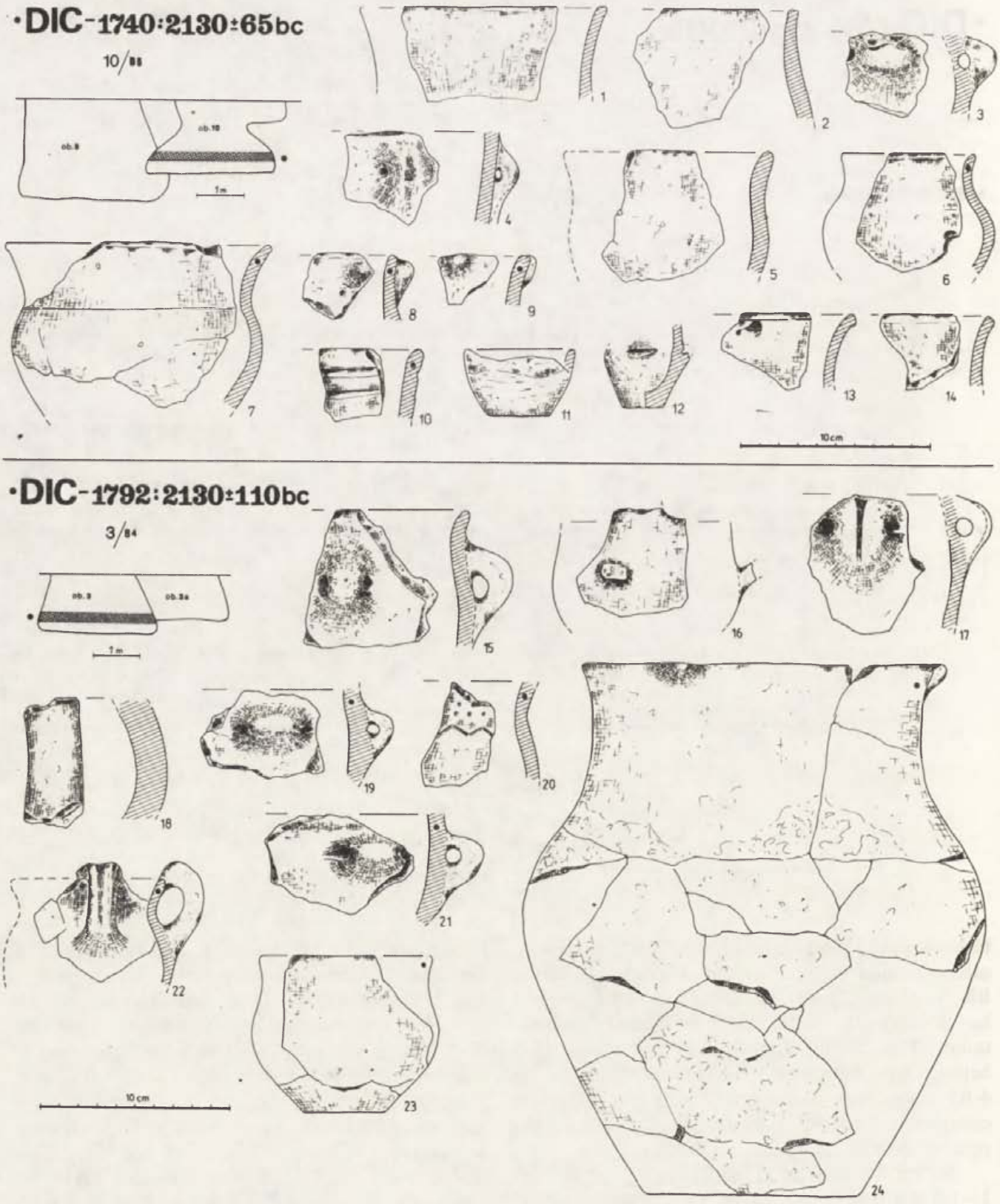


Fig. 26. Ceramics from pits 10-B5 (BR V phase) and 3-B4 (BR V phase)

1–6 – ceramics from pit 10-B5 found in a layer above the ^{14}C dated sample, *7–10* – ceramics from pit 10-B5 found in the same layer as the ^{14}C dated sample, *11–14* – ceramics from pit 10-B5 found in a layer below the ^{14}C dated sample, *15–18* – ceramics from pit 3-B4 found in a layer above the ^{14}C dated sample, *19–24* – ceramics from pit 3-B4 found in the same layer as the ^{14}C dated sample

CONCLUSION

The twenty-seven ^{14}C dates provided valuable information on the chronology of various features and excavation units at Bronocice (Fig. 27). It should be noted that the relative chronology of the settlement was already presented earlier (Kruk, Milisauskas 1981a; 1981b; 1983). It is possible to compare the radiocarbon dates from Bronocice with other sites, especially Funnel Beaker and Baden culture settlements. Furthermore, the comparison with other sites helps to evaluate the Bronocice dates. If we assume that the ^{14}C dates are representative for the entire settlement, then the site was continuously occupied. This observation does not apply to the oldest three dates which show a greater range of variability (Fig. 27, Table 1). Radiocarbon dates reflect a certain period of time and not specific years on account of standard deviations (Walanus 1980, 8–9). For the Bronocice dates, the standard deviations are usually less than 100 years. The ^{14}C date from pit 15-C2 (Table 1) has a high standard deviation (± 240) and thus it has a lower chronological value. No other ^{14}C date is available for the Lublin-Volynian culture at Bronocice.

Radiocarbon dates from Bronocice indicate that the occupation of the settlement extended from 3110 ± 110 bc to 2130 ± 65 bc (2140 ± 140 bc). The

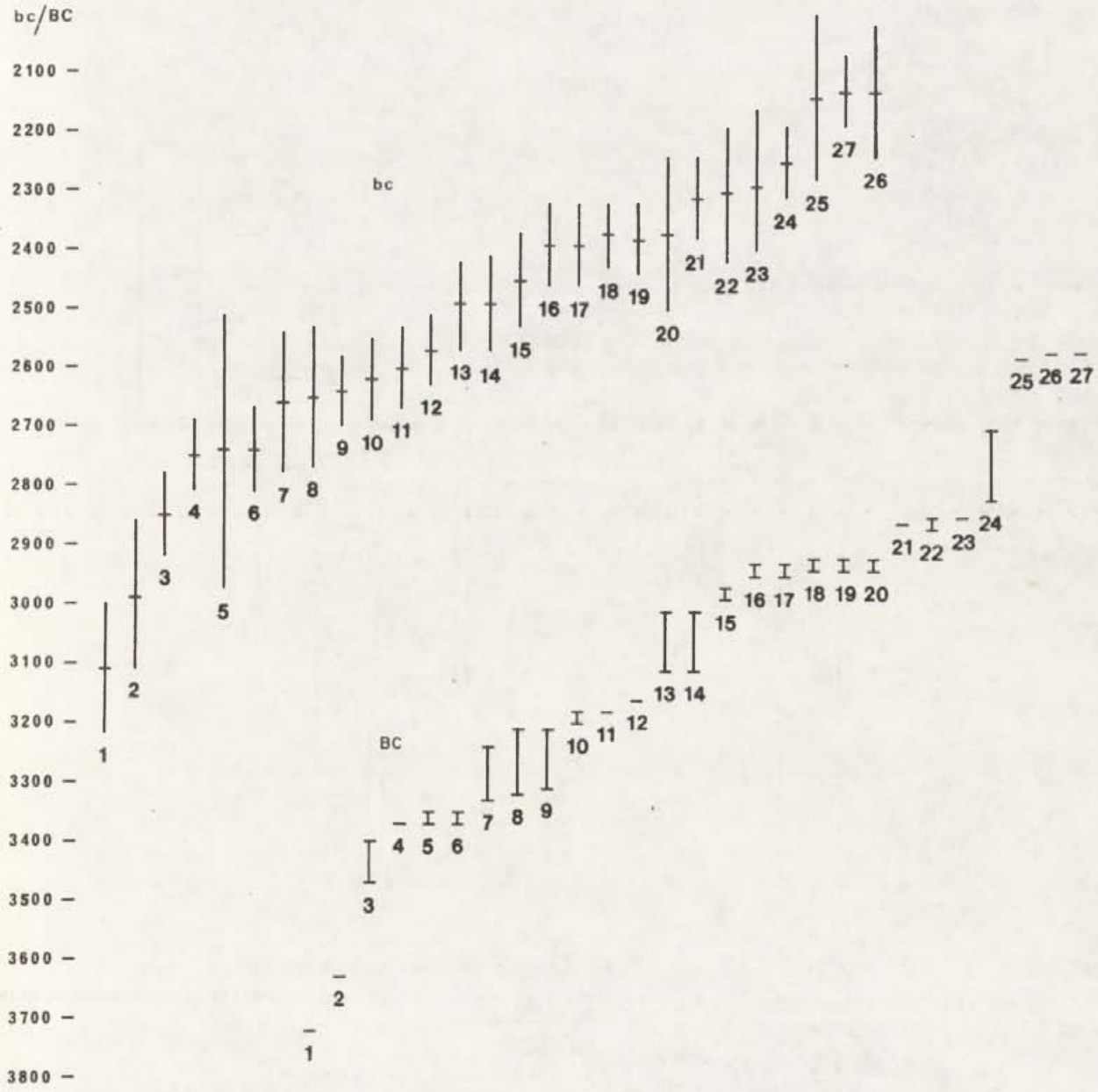


Fig. 27. Radiocarbon dates from Bronocice

bc – radiocarbon age, BC – calibrated dates (MASCA; Ralph, Michael, Han 1973), *1–27* – dates (Table 1)

standard deviation of the ^{14}C dates indicate the length of occupation from 1220 to 805 years. Six occupational phases are included into this time period. All these phases have ^{14}C dates, however, only single dates are available for the BR I and Lublin-Volynian occupations (Pazdur, Pazdur 1983, 19). The length of the six occupational phases at Bronocice is as follows:

1. BR I (earliest Funnel Beaker occupation) – approximately 100 years (3200/3100–3000 bc).
2. Lublin-Volynian (L-VC) settlement – approximately 100 years (around 2900 bc).
3. BR II (Funnel Beaker occupation) – 200 years (2900–2700 bc).
4. BR III (Funnel Beaker occupation) – 200 years (2700–2500 bc).
5. BR IV (Post-Funnel Beaker occupation of the Baden cycle) – 200 years (2500–2300 bc).
6. BR V (Baden cycle) – at most 200 years, at least 100 years (2300–2200/2100 bc).

We should not treat the estimated lengths of occupations as a fact. The calculated length of occupations is based on generalized data. It is also possible to use the average of the ^{14}C dates to estimate the length of occupations (M. F. Pazdur et al. 1979). Each occupational phase is chronologically defined, however, the dates indicate no clear break between the periods (Fig. 28; Kruk, Milisauskas 1983, 310).

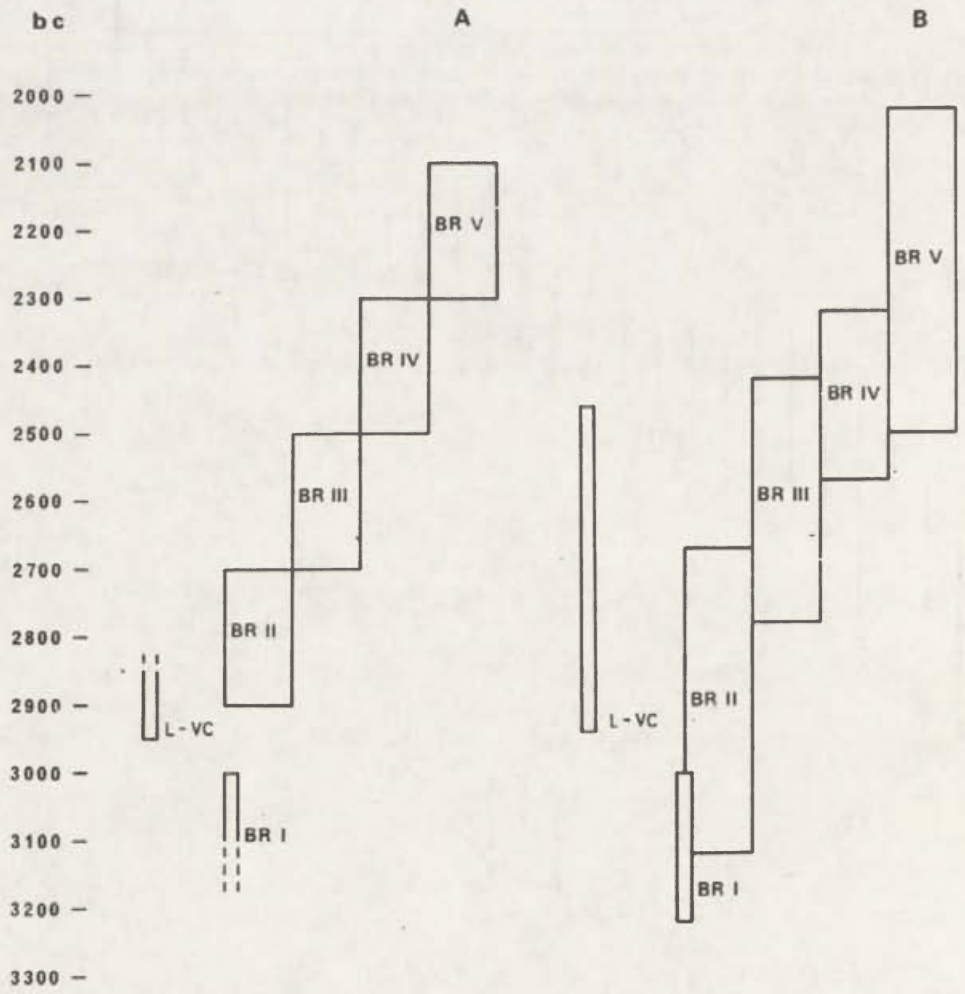


Fig. 28. The length of different phases at Bronocice (radiocarbon age)

A – estimated "average", B – chronological phases using ^{14}C dates with standard deviations, L-VC – Lublin-Volynian settlement, BR I–III – Funnel Beaker culture, BR IV–V – Baden cycle settlement

Table 1. Radiocarbon dates from Bronocice
BR I–III – Funnel Beaker, BR IV–V Baden cycle, L-VC – Lublin-Volynian culture (Lengyel-Polgár cycle in the Upper Vistula basin)

No.	Laboratory no.	Radiocarbon dates: radiocarbon age bh	Radiocarbon dates: radiocarbon age bc	Radiocarbon dates: calibrated* BC	Feature Area	Layer (cm)	Relative chronology based on ceramics
1	DIC 719	5060±110	3110±110	3720	5-B6	170–180	BR I
2	DIC 362	4940±125	2990±125	3630	42-A1	110–130	BR II
3	DIC 542	4800±70	2850±70	3400–3470	101-A1	210–220	BR II
4	DIC 2265	4700±60	2750±60	3370	21-A1	120–140	BR II
5	DIC 364	4690±240	2740±240	3350–3370	15-C2	115	L-VC
6	DIC 718	4690±75	2740±75	3350–3370	7-A3	130	BR II
7	DIC 716	4610±120	2660±120	3240–3330	5-B5	130–150	BR III
8	DIC 360	4600±120	2650±120	3210–3320	98-B1	110	BR III
9	DIC 2266	4590±55	2640±55	3210–3310	64-A1	110–130	BR II/III
10	DIC 1738	4570±70	2620±70	3180–3200	23-B1	70–90	BR III
11	DIC 1796	4550±70	2600±70	3180	6-B6	150–170	BR III
12	DIC 363	4520±60	2570±60	3160	68-A1	110–130	BR III
13	DIC 1791	4440±75	2490±75	3010–3110	45-B1	70–90	BR III
14	DIC 717	4440±80	2490±80	3010–3110	29-A3	110–130	BR IV
15	DIC 541	4400±80	2450±80	2970–2990	54-B1	110–130	BR IV
16	DIC 1739	4340±75	2390±75	2930–2950	95-B1	150–170	BR IV
17	DIC 1797	4340±70	2390±70	2930–2950	6-B2	60–80	BR IV
18	DIC 1736	4330±60	2380±60	2920–2940	56-A1	70–90	BR IV
19	DIC 977	4320±55	2370±55	2920–2940	1-B8	160–180	BR IV
20	DIC 543	4320±130	2370±130	2920–2940	2-B2	120–140	BR V
21	DIC 1794	4260±70	2310±70	2860	6-B8	180–200	BR V
22	DIC 978	4250±115	2300±115	2850–2870	1-A5	170	BR V
23	DIC 361	4240±115	2290±115	2850	39-B1	130–150	BR IV/V
24	DIC 979	4200±60	2250±60	2700–2820	8-B7	110–130	BR V
25	DIC 1795	4090±140	2140±140	2580	4-B3	140–160	BR V
26	DIC 1740	4080±65	2130±65	2570	10-B5	130–150	BR V
27	DIC 1792	4080±110	2130±110	2570	3-B4	100–120	BR V

* The radiocarbon dates were changed to calibrated ones using the following method, MASCA; RALPH, MICHAEL, HAN 1973.

Table 2. Characteristics of features with radiocarbon dates (see Table 1 for headings)

Feature/ Area	Type of feature: pit	Type of feature: ditch	Extent of excavation: complete	Extent of excavation: part	Stratigraphy	Shape of feature: trapezoidal	Shape of feature: hemispherical	Fill: homogeneous	Fill: layered	Dated layer: from the period of usage	Dated layer: erosion	Artifact assemblage: homogeneous	Artifact assemblage: diverse	Relative chronology of features based on ceramics	Possible intrusive material in the assemblage
5-B6	+	–	+	–	+	+	–	–	+	–	+	–	+	BR I	–
42-A1	+	–	+	–	+	–	+	–	+	+	–	+	–	BR II	–
101-A1	+	–	+	–	–	+	–	–	+	+	–	+	–	BR II	–
21-A1	+	–	+	–	+	+	–	+	–	+	–	+	–	BR II	–
15-C2	+	–	+	–	–	+	–	–	+	+	–	–	+	L-VC	BR I
7-A3	+	–	+	–	–	+	–	–	+	+	–	+	–	BR II	–
5-B5	+	–	+	–	–	+	–	+	–	+	–	+	–	BR III	–
98-B1	+	–	+	–	+	+	–	–	+	+	–	+	–	BR III	–
64-A1	+	–	+	–	+	+	–	–	+	+	–	–	+	BR II/III	–
23-B1	+	–	+	–	–	+	–	+	–	+	–	+	–	BR III	–
6-B6	+	–	+	–	–	+	–	–	+	+	–	+	–	BR III	–
68-A1	+	–	+	–	–	+	–	+	–	+	–	–	+	BR III	BR II
45-B1	+	–	+	–	–	+	–	–	+	+	–	+	–	BR III	–
29-A3	+	–	–	+	+	+	–	+	–	+	–	–	–	BR IV	–
54-B1	+	–	+	–	–	+	–	+	–	+	–	–	+	BR IV	BR III

Table 2 continued

Feature/ Area	Type of feature: pit	Type of feature: ditch	Extent of excavation: complete	Extent of excavation: part	Stratigraphy	Shape of feature: trapezoidal	Shape of feature: hemispherical	Fill: homogeneous	Fill: layered	Dated layer: from the period of usage	Dated layer: erosion	Artifact assemblage: homogeneous	Artifact assemblage: diverse	Relative chronology of features based on ceramics	Possible intrusive material in the assemblage
95-B1	+	–	+	–	–	+	–	–	+	+	–	–	+	BR IV	BR III
6-B2	+	–	–	+	–	+	–	+	–	+	–	+	–	BR IV	–
56-A1	+	–	+	–	+	+	–	–	+	+	–	–	+	BR IV	BR II/III
1-B8	+	–	+	–	–	+	–	+	–	+	–	–	+	BR IV	BR II/III
2-B2	+	–	–	+	–	+	–	–	+	+	–	+	–	BR V	–
6-B8	+	–	–	+	–	+	–	–	+	+	–	+	–	BR V	–
1-A5	–	+	–	+	–	V-shape	–	–	+	–	+	–	+	BR V	BR IV
39-B1	+	–	+	–	–	+	–	–	+	+	–	–	+	BR IV/V	BR III
8-B7	+	–	+	–	+	+	–	–	+	+	–	–	+	BR V	BR IV
4-B3	+	–	+	–	+	+	–	–	+	+	–	–	+	BR V	–
10-B5	+	–	+	–	+	+	–	–	+	+	–	–	+	BR V	–
3-B4	+	–	+	–	+	+	–	+	–	+	–	–	+	BR V	BR III/IV

Table 3. Contents of pits with radiocarbon dates*

Feature, Area	Volume (m^3)	Ceramics: vessels	Ceramics: sherds	Ceramics: spindle whorls	Ceramics: loom weights	Ceramics: other	Bone: tools, ornaments	Bone: animal bones	Bone: human bones	Flint: tools	Flint: artifacts	Stone: tools	Stone: without traces of usage	Other	Daub
5-B6	9.43	–	595	–	–	–	4	382	1 sk	4	147	–	+	–	+
42-A1	1.69	–	391	1	3	1	2	106	–	4	12	4	–	–	+
101-A1	14.68	–	383	–	2	1	8	627	–	5	13	11	–	–	–
21-A1	8.01	1	357	–	–	–	1	225	–	2	10	–	+	–	–
15-C2	16.30	6	1083	2	–	–	5	250	–	18	24	2	–	copper	+
7-A3	6.31	–	138	–	–	–	1	37	–	–	–	–	–	–	+
5-B5	8.83	2	809	6	2	1	–	835	–	17	162	–	+	–	+
98-B1	7.96	–	125	–	–	–	–	46	–	1	7	–	+	–	+
64-A1	1.43	–	266	–	–	–	–	235	–	–	8	–	+	–	+
23-B1	2.82	–	483	–	–	–	–	595	–	12	91	–	–	–	+
6-B6	4.07	1	161	–	–	–	2	73	–	4	29	–	+	–	–
68-A1	7.88	1	1073	1	1	1	1	491	–	2	49	3	–	–	–
45-B1	2.70	–	171	–	–	–	–	69	–	3	23	1	–	–	+
29-A3	4.47	2	130	–	–	–	1	18	–	–	–	–	–	–	+
54-B1	8.47	–	654	–	1	–	3	197	–	10	53	–	+	–	+
95-B1	7.76	1	235	5	–	–	3	178	–	4	37	2	+	–	+
6-B2	3.56	–	88	1	–	–	–	80	–	–	3	–	+	–	+
56-A1	6-92	–	191	2	–	–	6	116	–	6	19	6	–	–	–
1-B8	5.64	1	710	1	3	2	3	553	–	22	2685	1	+	–	+
2-B2	6-52	3	817	6	4	–	–	254	–	11	42	1	+	–	+
6-B8	18.58	–	166	1	–	–	–	44	–	2	12	–	+	–	+
1-A5	–	2	800	1	10	–	7	220	–	18	112	25	+	–	+
39-B1	3.89	3	795	13	2	–	2	189	–	7	71	2	–	–	+
8-B7	4.52	2	507	6	5	1	1	122	–	11	31	1	–	–	+
4-B3	10.18	–	362	2	1	–	2	73	–	8	48	3	+	–	+
10-B5	8.22	1	955	1	2	1	2	166	–	10	87	–	+	–	+
3-B4	2.48	2	160	–	–	–	–	34	–	7	12	–	+	–	+

*Some numbers of artifacts were corrected from a previous publication; KRUK, MILISAUSKAS 1983, table 3

Table 4. Flint tools in pits with radiocarbon dates
j – Jurassic flint, s – Świeciechów flint, c – chocolate flint, w – Volynian flint, n – not definable (burnt pieces)

Feature	Retouched blades on both edges	Retouched blades	Sickles	Sickle blades	Endscrapers	Retouched flakes	Sidescrapers	Retouched pieces on both edges	Notched pieces	Perforators, drills	Burins	Projectile points	Multi-functional tools	Four-sided tools	Axes	Adze	Truncated pieces	Other	Total
5-B6	–	–	–	1j	3j	–	–	–	–	–	–	–	–	–	–	–	–	–	4
42-A1	2s	–	–	1c	1c	–	–	–	–	–	–	–	–	–	–	–	–	–	4
101-A1	2s	–	–	–	–	–	–	–	2j	–	–	–	1j	–	–	–	–	–	5
21-A1	2s	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2
15-C2	1j1w	7j	–	1j	2j2w	1j	–	–	–	–	1j	–	–	–	–	–	–	2j	18
7-A3	–	–	–	–	–	–	–	–	no tools		–	–	–	–	–	–	–	–	–
5-B5	3j	1j	3j	–	–	5j	–	–	–	–	1j	–	–	–	3j	–	1j	–	17
98-B1	–	–	–	–	–	1j	–	–	–	–	–	–	–	–	–	–	–	–	1
64-A1	–	–	–	–	–	–	–	–	no tools		–	–	–	–	–	–	–	–	–
23-B1	1j	–	–	1j	–	6j	1j	–	–	–	–	–	–	–	1j1n	–	1j	–	12
6-B6	–	–	–	–	1j	1j	–	–	–	–	–	–	–	–	2j	–	–	–	4
68-A1	–	1n	–	–	–	1j	–	–	–	–	–	–	–	–	–	–	–	–	2
45-B1	–	1j1n	–	–	–	–	–	–	–	–	–	–	–	–	1j	–	–	–	3
29-A3	–	–	–	–	–	–	–	–	no tools		–	–	–	–	–	–	–	–	–
54-B1	–	2j	–	–	1j1n	2j1n	1j	–	–	–	1j	–	–	–	–	–	1j	–	1o
95-B1	1j	1j	–	–	–	1j	–	–	–	1j	–	–	–	–	–	–	–	–	4
6-B2	–	–	–	–	–	–	–	–	no tools		–	–	–	–	–	–	–	–	–
56-A1	3j	–	–	1j	–	2j	–	–	–	–	–	–	–	–	–	–	–	–	6
1-B8	2j	6j	–	–	–	3j1n	3j	–	–	–	–	1j	–	–	3j	2j	1j	–	22
2-B2	–	–	–	–	–	6j	–	–	–	–	–	–	–	4j	1n	–	–	–	11
6-B8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1n	–	1j	–	2
1-A5	1j	3j	–	–	1j	4j	–	–	–	–	–	–	–	2j	6j	–	1j	–	18
39-B1	–	1j	–	–	1j	1j3n	–	–	–	–	–	–	–	–	1j	–	–	–	7
8-B7	1j1s	2j	–	–	–	1j1n	1j	–	–	1j	–	–	–	–	1j1s	–	–	–	11
4-B3	2j	–	–	–	–	1j	1n	–	–	–	2j	–	–	–	1j	–	1j	–	8
10-B5	1j	–	2j	–	–	4j	–	–	–	–	–	–	–	–	3j	–	–	–	10
3-B4	2j	–	1n	–	–	–	–	1n	–	–	–	–	–	1j	1j	1j	–	–	7
Total	28	24	6	4	11	50	7	1	2	2	5	1	1	7	27	3	7	2	188

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APPENDIX

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CALIBRATION OF ^{14}C DATES FROM THE BRONOCICE SITE

1. Introduction. Series of 27 radiocarbon dates obtained on organic materials (charcoals) from the Bronocice site covers almost exactly one thousand conventional ^{14}C years. Complete list of ^{14}C dates with location of dated samples within the site, and associated archaeological context, as well as subdivision into five chronological phases, are given in the preceeding article (J. Kruk, and S. Milisauskas, this volume). The aim of this appendix is to present detailed discussion of problems involved in calibration of those dates in light of recent advances and international agreements and recommendations. We do not intend to touch here any other questions besides strict statistical treatment of ^{14}C dates included in Table 1 of the source article and presentation of calibration results in a standard format.

2. Calibration curves. During the 12th International Radiocarbon Conference in Trondheim, Norway, in June 1985, the results of high-accuracy ^{14}C dating of know-age tree-ring samples were presented. Following discussion at the meeting of the Working Group on Calibration of the Radiocarbon Time Scale all participants of this conference have accepted the resolution which officially recommends the resulting high-precision calibration cur-

ves, elaborated by M. Stuiver and G. W. Pearson (1986) in the time range from AD 1950 to 500 BC, and by G. W. Pearson and M. Stuiver (1986) in time range from 500 to 2500 BC. The third high-precision curve, elaborated by G. W. Pearson et al. (1986) was tentatively recommended for calibrating ^{14}C dates older than 2500 BC. These recommendations were confirmed during 13th International Radiocarbon Conference in Dubrownik (June, 20–25, 1988). All ^{14}C dates of the Bronocice site are out of range of the first two curves, so they should be calibrated according to calibration curve of Pearson et al. (1986). Appropriate part of this curve is shown in Fig. 29.

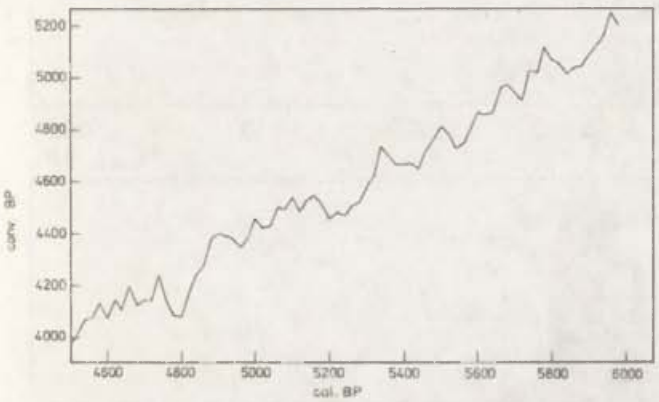

Fig. 29. Fragment of high-precision calibration curve

After Pearson et al.1986

3. Method of calibration. All dates were calibrated according to the procedures for probabilistic calibration of ^{14}C dates using the IBM PC/XT compatible microcomputer. The theory of probabilistic calibration and involved methodological problems were discussed in details elsewhere (Michczyńska, M. F. Pazdur, Walanus 1988: M. F. Pazdur, Michczyńska 1989). For the purpose of this article we should explain only that the probabilistic calibration consists of transformation of initial Gaussian probability distribution of conventional ^{14}C date into calendric time scale. This procedure may be applied to single ^{14}C date or any set of ^{14}C dates, either related or not. The result of calibration is obtained in form of probability distribution of calendric age of dated sample. Because of sophisticated shape of high-accuracy calibration curves, characterized by numerous wiggles, the form of resulting probability distribution of calendric age is also complex and may reveal several distinct peaks. However, in the case of medium accuracy dates (with error greater than 50 yrs) the result of probabilistic calibration can be reasonably characterized by quoting the midpoint (= median) of probability distribution of calendric age. The value of median can be regarded as that value of calendric age which corresponds to given conventional radiocarbon age of dated sample. The uncertainty of calendric age is more difficult to describe; we will characterize it by quoting two ranges, the so-called interquartile range and the 95% confidence interval. The probability that the real value of calendric age of dated sample is confined within the interquartile range is equal to 50%, there is, of course, the same probability that it is beyond this interval. On the contrary, finding of true value of calendric age within the second range (i.e. the 95% confidence interval) is almost certain; the probability of finding it elsewhere is only 5%, and may be regarded negligible. These two concepts will be applied to describe the results of calibration of single ^{14}C dates as well as of group of dates.

An example of calibration output of single date representing Bronocice I phase (DIC-719; 5060 ± 110 BP) is shown in Figs. 30 and 31. Figure 30 contains relevant introductory information about considered date, including sample name, laboratory number, the values of conventional ^{14}C date (D) and its standard error (σ). Graphs show probability distribution of conventional ^{14}C date, appropriate part of calibration curve, and the resulting probability distribution of calendric age. Some other numeric data

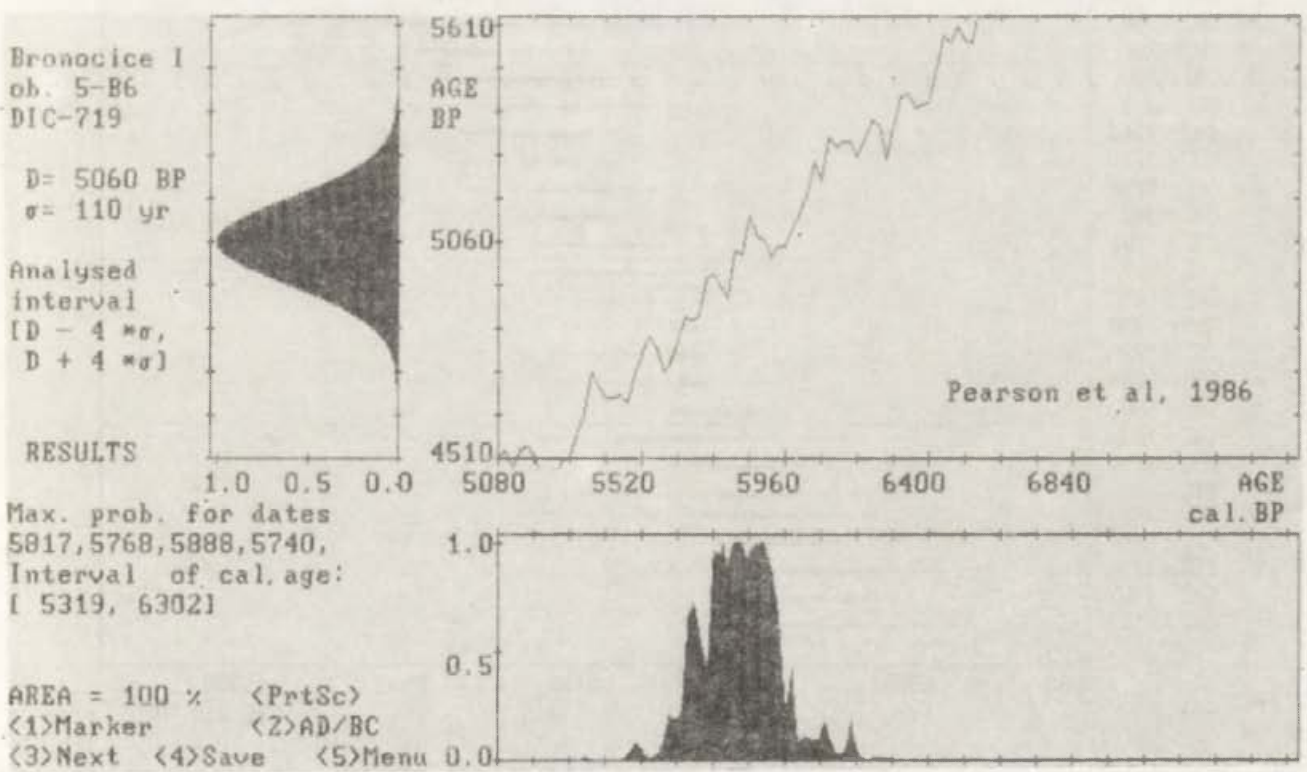

Fig. 30. Example of calibration of single date. Copy of first screen of calibration output

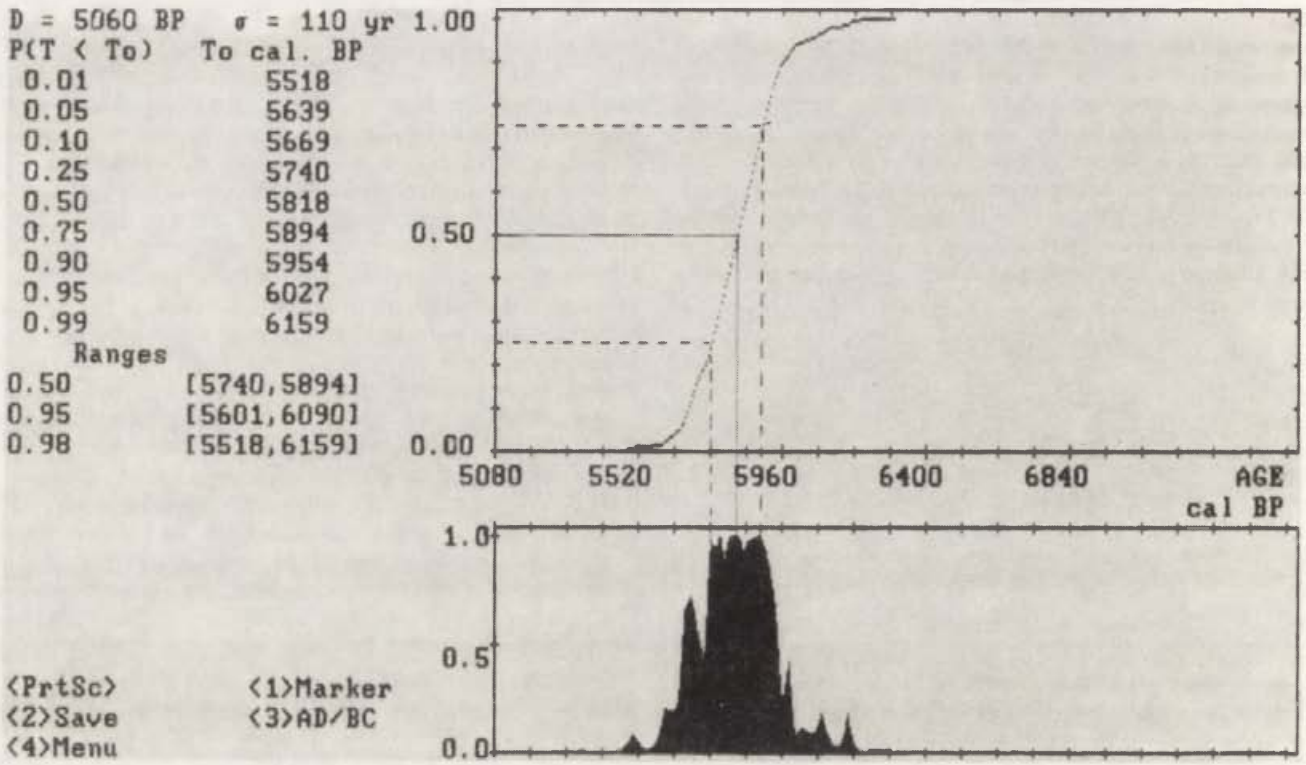

Fig. 31. Example of calibration of single date. Copy of the second screen of calibration output (same date as in Fig. 2)

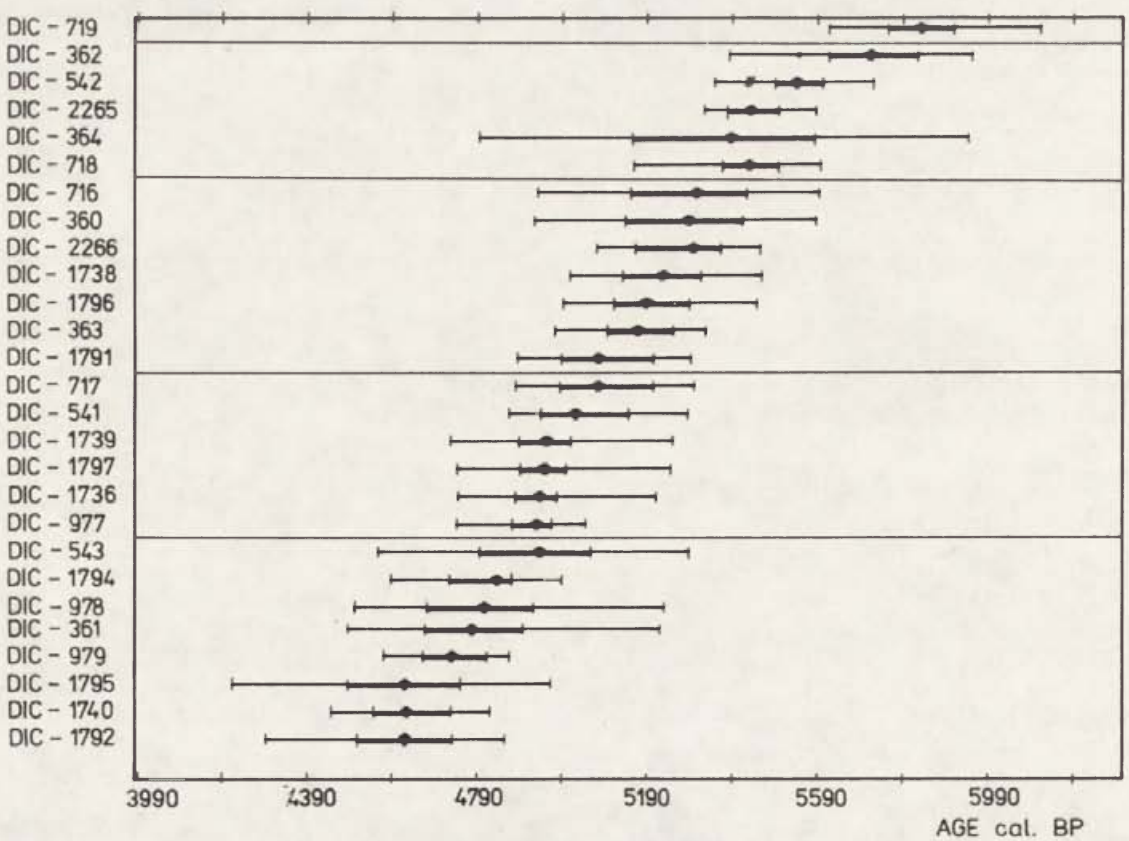

Fig. 32. Plot of results of calibration of all ^{14}C dates from the Bronocice site showing median values (dots), interquartile ranges (bold lines), and 95% confidence intervals. Dates belonging to different cultural units are separated with horizontal lines

which are not relevant in this specific case characterize the obtained probability distribution of calendric age (location of the most distinct peaks, and total interval of calendric age). All important data are included in Fig. 31, which contains plots of probability distribution of calendric age and two tables of numeric data; upper table contains values of quantiles, the lower table gives ranges of calendric age corresponding to quoted values of probability. Calibrated age of considered sample, i.e. the median value of obtained probability distribution is shown by solid line, starting from the vertical scale at the value 0.50; the interquartile range of calendric age is contained within two dashed lines, starting from the vertical scale at values equal respectively to 0.25 and 0.75.

4. Results. The calibration was performed in two steps. In the first step each ^{14}C date was treated separately according to the procedure for calibration of a group of arbitrary independent dates in order to obtain estimates of mean value of calibrated age and its uncertainty. The results of calibration of individual ^{14}C dates are given in Table 5. Values of calendric age are rounded to nearest ten years ; relative chronology in the last column is quoted after Table 1 of source article. The same results are shown in graphical form in Fig. 32. In the second step ^{14}C dates were treated in groups, according to their relative chronology (cf. Table 1) in order to estimate duration of subsequent cultural phases distinguished in this site. The results are summarized in Table 6. Obtained interquartile ranges are shown in graphical form in Fig. 33 and 95% confidence intervals in Fig. 34. As shown in Fig. 34. the confidence intervals representing duration of different cultural phases significantly overlap; it seems therefore that the best

Table 5. Calibration of individual ^{14}C dates from the Bronocice site

No.	Lab.code and no.	^{14}C date conv. BP	Calendric dates cal. BC			Relative chronology
			median	interquartile	95% conf. interval	
1	DIC-719	5060±110	3870	3940–3790	4140–3650	BR I
2	DIC-362	4940±125	3750	3860–3660	3990–3420	BR II
3	DIC-542	4800±70	3580	3640–3530	3760–3390	BR II
4	DIC-2265	4700±60	3470	3540–3420	3620–3360	BR II
5	DIC-364	4690±240	3420	3620–3190	3970–2820	L-VC
6	DIC-718	4690±75	3470	3540–3410	3630–3200	BR II
7	DIC-716	4610±120	3350	3460–3190	3630–2970	BR III
8	DIC-360	4600±120	3330	3450–3180	3630–2970	BR III
9	DIC-2266	4590±55	3340	3400–3200	3500–3110	BR II–III
10	DIC-1738	4570±70	3260	3360–3170	3500–3050	BR III
11	DIC-1796	4550±70	3230	3330–3150	3490–3040	BR III
12	DIC-363	4520±60	3210	3290–3140	3370–3020	BR III
13	DIC-1791	4440±75	3120	3250–3030	3340–2930	BR III
14	DIC-717	4440±80	3120	3250–3030	3340–2930	BR IV
15	DIC-541	4400±80	3060	3190–2980	3320–2910	BR IV
16	DIC-1739	4340±75	2990	3060–2930	3290–2780	BR IV
17	DIC-1797	4340±70	2990	3040–2930	3290–2790	BR IV
18	DIC-1736	4330±60	2980	3020–2930	3260–2790	BR IV
19	DIC-977	4320±55	2970	3010–2920	3090–2790	BR IV
20	DIC-543	4320±130	2980	3100–2840	3330–2600	BR V
21	DIC-1794	4260±70	2880	2920–2770	3040–2640	BR V
22	DIC-978	4250±115	2850	2970–2720	3270–2550	BR V
23	DIC-361	4240±115	2820	2940–2710	3260–2530	BR IV–V
24	DIC-979	4200±60	2770	2860–2710	2910–2620	BR V
25	DIC-1795	4090±140	2660	2800–2530	3000–2250	BR V
26	DIC-1740	4080±65	2660	2770–2590	2870–2500	BR V
27	DIC-1792	4080±110	2660	2780–2560	2890–2340	BR V

Table 6. Calibrated radiocarbon chronology of the Bronocice site

Relative chronology	Number of ^{14}C dates	Age intervals in cal. BP		Age intervals in cal. BC	
		interquartiles 50%	95%	interquartiles 50%	95%
Bronocice BR I	1	5890–5740	6090–5600	3940–3790	4140–3650
Bronocice BR II	4	5600–5400	5880–5310	3650–3450	3930–3360
Bronocice L-VC	1	5570–5140	5920–4770	3620–3190	3970–2820
Bronocice BR III	7	5310–5100	5540–4910	3360–3150	3590–2960
Bronocice BR IV	6	5030–4890	5260–4740	3080–2940	3310–2790
Bronocice BR V	8	4850–4610	5200–4400	2900–2660	3250–2450

sestimates are given by the interquartile ranges, shown in Fig. 33. It should be also noted, that relatively wide time range corresponding to the settlement of the Lublin-Volynian culture (marked as L-VC in Figs. 33 and 34) is caused simply by large uncertainty of single ^{14}C date, associated with this episode (error of conventional ^{14}C date is equal to $\pm$ 240 yrs) and cannot be interpreted as representing its real duration.

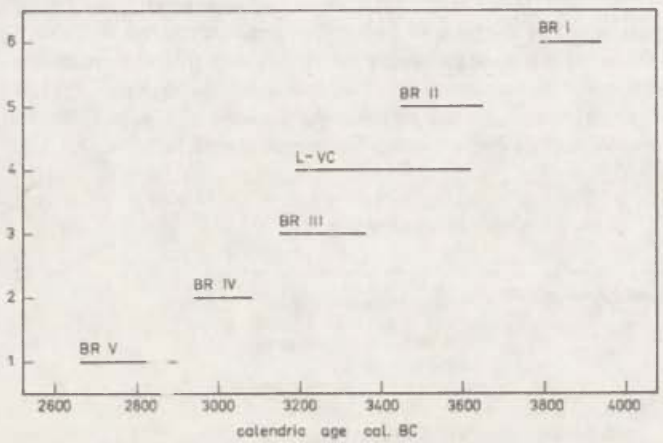

Fig. 33. Plot of interquartile ranges of calendric age representing duration of different cultural units

Finally, treating all dates according to the procedure for calibration of a group of related dates (i.e. neglecting their association with distinguished phases) we obtain composite probability distribution of calendric ages from this site. The result of such calculation is shown in Fig. 35. If we would accept the hypotesis that the amount of datable organic material within the investigated site is a measure of human activity or population, so

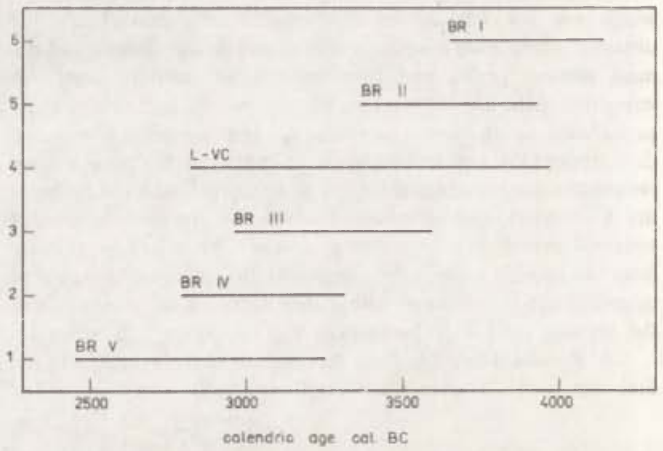

Fig. 34. Plot of 95% confidence intervals of calendric age representing maximum duration of different cultural units in the Bronocice site

the plot of density of calibrated ^{14}C ages shown in the lower part of the Fig. 35 may be interpreted as graphical presentation of changes of the population density in function of time. Four periods can be clearly distinguished in this plot: first, gradual increase of population from ca 3900 to 3300 cal. BC, then period of stabilized settlement. lasting ca 300 yrs to ca 3000 ca BC, followed with short episode (ca 50–60 yrs) of high population, and then decline, lasting ca 350 yrs, from ca 2950 to 2600 cal BC.

Concluding remarks. Comparison of results of probabilistic calibration, i.e. the median values listed in Table 5, with calibrated ^{14}C ages quoted in Table 1 of source article, shows systematical differences. Values of calibrated ^{14}C ages obtained using MASCA calibration tables (Ralph, Michael, Han 1973) are systematically

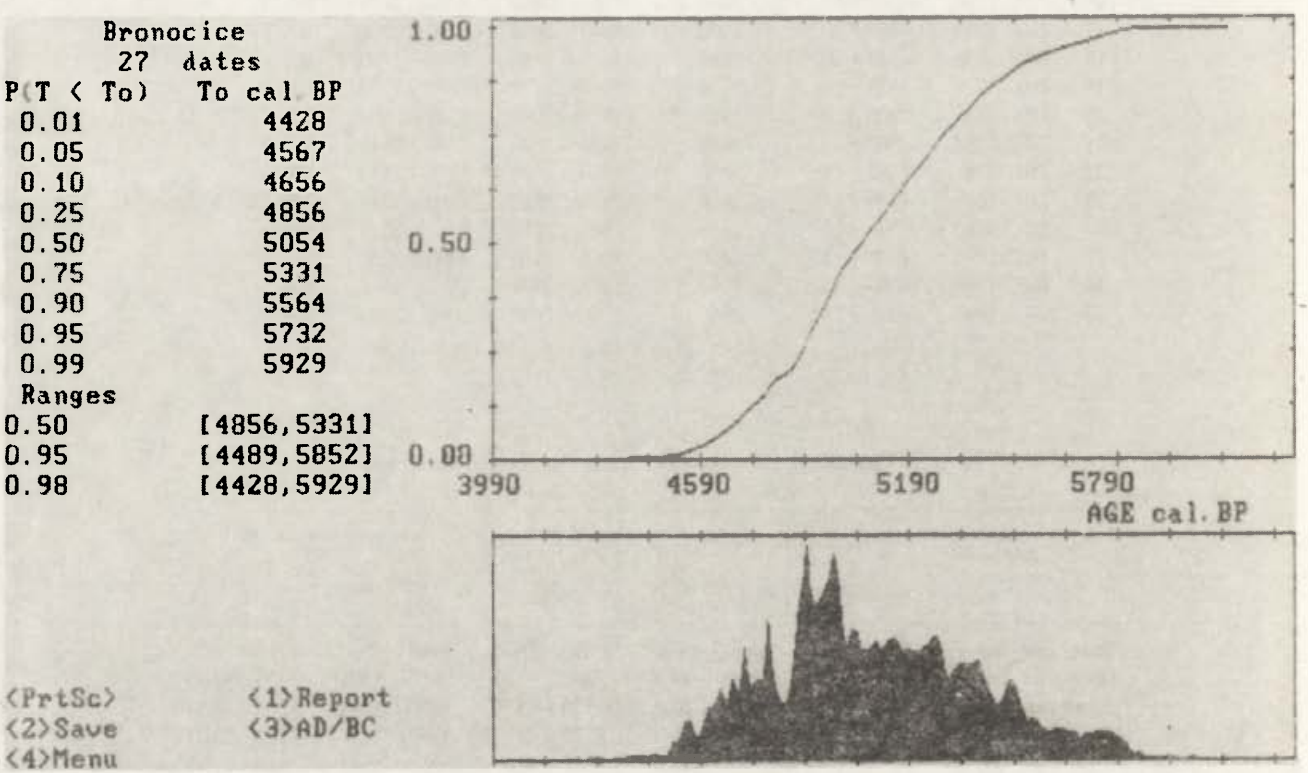

Fig. 35. Composite probability distribution of calendric age of all samples from the Bronocice site

lower by ca 60–120 yrs. It seems that the recent high-accuracy calibration curves are more appropriate for calibration of ^{14}C dates of European prehistory. Detailed discussion of advantages resulting from using those curves is given in other article (Goslar, Michczyńska, M. F. Pazdur 1989).

From data of Table 5 it may be also concluded that the result of probabilistic calibration, representend by median, and the uncertainty of this value, represented by either interquartile range or 95% confidence interval, depend strongly on the value of conventional ^{14}C date and its error. Identical conventional ^{14}C dates may lead to different values of calibrated age if they obey different erros (cf. dates DIC-364 and DIC-718).

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