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ROMAN PERIOD WELL FILLS RESULTING FROM USING AND ABANDONMENT IN ENVIRONMENT OF A RIVER VALLEY (KWIATKÓW SITE, CENTRAL POLAND)

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Abstract

The research was conducted at the Kwiatków site,[1] in the Koło Basin (Central Poland). It included a fragment of a low terrace and the valley floor of the Warta river valley. The archaeological investigation documented over 100 wells that archaeological material indicates are associated with the Przeworsk culture. Geomorphological, lithological and geochemical studies were carried out at the archaeological sites and their surroundings. Selected for the presentation were two wells whose fillings were carefully tested and subjected to geochemical and lithological analyses. The wells showed a slightly different content of artifacts, as well as differences in their grain-size distributions, the structure of their filling deposits, and their geochemistry. This allows us to conclude that the two wells were used differently, but also probably about a different course for how each well was filled after the end of its operation.

Key words: archaeology, Iron Age, filling of well, geochemistry, lithology, Warta river valley, Polish Lowland

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INTRODUCTION

Wells are unique archaeological features – they are remnants of material culture and economy and sometimes also reflect the beliefs of past communities. Their attractiveness comes from the fact that their wooden casings are frequently preserved to the present day (Rzepecki *et al.*, 2016). These features are important and interesting "data carriers" as they provide an opportunity to perform various analyses of their fills.

The documented wells functioned on a low terrace of the Warta river valley, where a vast settlement was situated in the Roman Period (Piotrowska, 2016; Rzepecki *et al.*, 2016; Petera-Zganiacz *et al.*, in press). The sandy substratum was not an obstacle to the digging of a pit in which the structure of a well was installed. However, after its function as a water drawing point had ceased and possible deconstruction and recovery of the wood from the casing, sandy material could easily move inside. Under the conditions of a low river terrace that was susceptible to a permanently high water level, as well as floodings, such a depression left by a well might have functioned similarly to a small fluviogenic basin (e.g. part of an oxbow channel) and be a place of deposition for flood sediments or a place of lake-peat accumulation or deposition of alluvial organic matter.

The article presents the results of geochemical and lithological studies conducted for two wells from the Kwiatków 11/20 site, in relation to the archaeological context and the geological and geomorphological conditions in the area of the site. Furthermore, a dendrochronological analysis and radiocarbon datings of the wood that the construction of the well was composed of were carried out. The immediate surroundings underwent a complex archaeological

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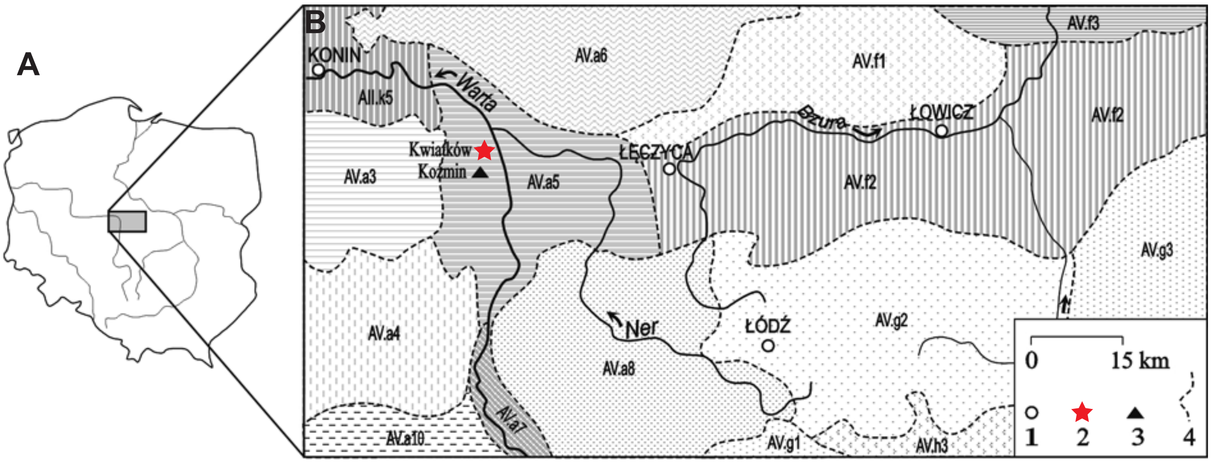

Fig. 1. Location of Kwiatków site. A – Location on the territory of Poland, B – Location of Kwiatków on the background of geomorphological typology of Poland (Gilewska 1986). 1 – selected cities, 2 – Kwiatków site 11, 3 – Koźmin-Las site, 4 – boundaries of geomorphological units: AII.k5 – Dolina Konińska, AV.a3 – Wzgórza Złotogórskie, AV.a4 – Wysoczyzna Turecka, AV.a5 – Kotlina Kolska, AV.a6 – Wysoczyzna Kłodawska, AV.a7 – Dolina Sieradzka, AV.a8 – Wysoczyzna Łaska, AV.a10 – Wysoczyzna Złoczewska, AV.f1 – Równina Kutnowska, AV.f2 – Równina Łowicko-Błońska, AV.f3 – Kotlina Warszawska, AV.g1 – Wysoczyzna Bełchatowska, AV.g2 – Wysoczyzna Łódzka, AV.g3 – Wysoczyzna Rawska, AV.h3 – Równina Piotrkowska.

investigation, and the long-term geological, geomorphological and palaeoecological studies mean that this part of the Warta river valley can be considered to be very well described (Petera and Forysiak, 2003; Dzieduszyńska and Petera-Zganiacz, 2012; Twardy, 2014; Dzieduszyńska *et al.*, 2014; Petera-Zganiacz *et al.*, 2015a,b). Such a set of interdisciplinary studies may allow for an interpretation of the functioning conditions and an understanding of the validity of the utilisation of the well at this study site.

STUDY AREA

The Kwiatków site (Brudzew Commune, Wielkopolska Voivodeship), is located in the geomorphological mesoregion of the Koło Basin (AV.a5, see Fig. 1B). This unit is classified as part of the Southern Wielkopolska Lowland (AV.a) and the sub-province of the Central Polish Lowland (AV) in the geomorphological classification of Poland (Gilewska, 1986). The Koło Basin is an extension of a longitudinally oriented valley of the Warta in the zone of its connection with the latitudinally running Warsaw–Berlin Urstromtal. The area of the Koło Basin underwent glaciation during the penultimate glaciation of the Quaternary – the Wartanian glaciation (Rdzany, 2009). During the last glacial – the Weichselian – in the Poznań Phase it reached the northwest edge of the basin and crossed the Warta valley to the west of the town of Koło (Petera and Forysiak, 2003).

The relief of the bottom of the basin (Fig. 2), also in the immediate vicinity of the Kwiatków site, is of plain character with two terraces, and narrow-bottomed river valleys (Petera, 2002; Forysiak, 2005). The high terrace (level) has been preserved, but only in the edge parts of the Koło Basin (Fig. 2, signature 9). Nearly the entire bottom of the basin is occupied by a very extensive low terrace (level) (Turkowska *et al.*, 2004; Fig. 2, signature 10). The study site is situated within the low level – at ordinates ca. 95–98.8 m a.s.l. The low level is divided by the contemporary Warta river and Ner river, but also by many smaller rivers – e.g. the Telszyna, the Kiełbaska, Struga Janiszewska, and the Siedza, as well as by a number of unnamed small watercourses. In addition, many dry, shallow channels with small meanders are visible in the relief of the low terrace (Fig. 2, signature 11). There are multiple river channels that are at present utilised by small watercourses, as well as non-active river channels, and these are the remnants of a complex multichannel system that developed in the bottom of the Koło Basin during the Late Weichselian (Turkowska *et al.*, 2000, 2004; Dzieduszyńska *et al.*, 2014; Petera-Zganiacz *et al.*, 2015a) and was reactivated in the Holocene (Forysiak, 2005; Petera-Zganiacz *et al.*, 2015b; Petera-Zganiacz *et al.*, in press). The Kwiatków site is located on an interchannel area, which is delineated to the west by the shallow valley of the course of the Siedza river, to the east by the more clearly-marked valley of the Teleszyna and to the south by a dry channel connecting said watercourses. The area of the above-mentioned site has been estimated at 110 ha (Twardy *et al.*, 2014). Its central part is elevated by 1–2 m by an aeolian cover or the remnants of a small, irregular dune.

A factor that could have facilitated settlement activity in the Koło Basin was its location being favourable to transit. It was within the reach of the longitudinal system of the Warta river as well as the latitudinal system of the Warsaw–Berlin Urstromtal. Cartographic studies of the spread of sites of the Przeworsk culture suggest that the Koło Basin and Grabów Basin were particularly densely populated in the Roman Period (Twardy *et al.*, 2004). This was probably the place where one of the variants of the "Amber Road" ran – an ancient trade route that made this area even more attractive to ancient settlers.

The significantly high number of artificial water intake systems distinguishes the Kwiatków 11/20 site (Fig. 3) from

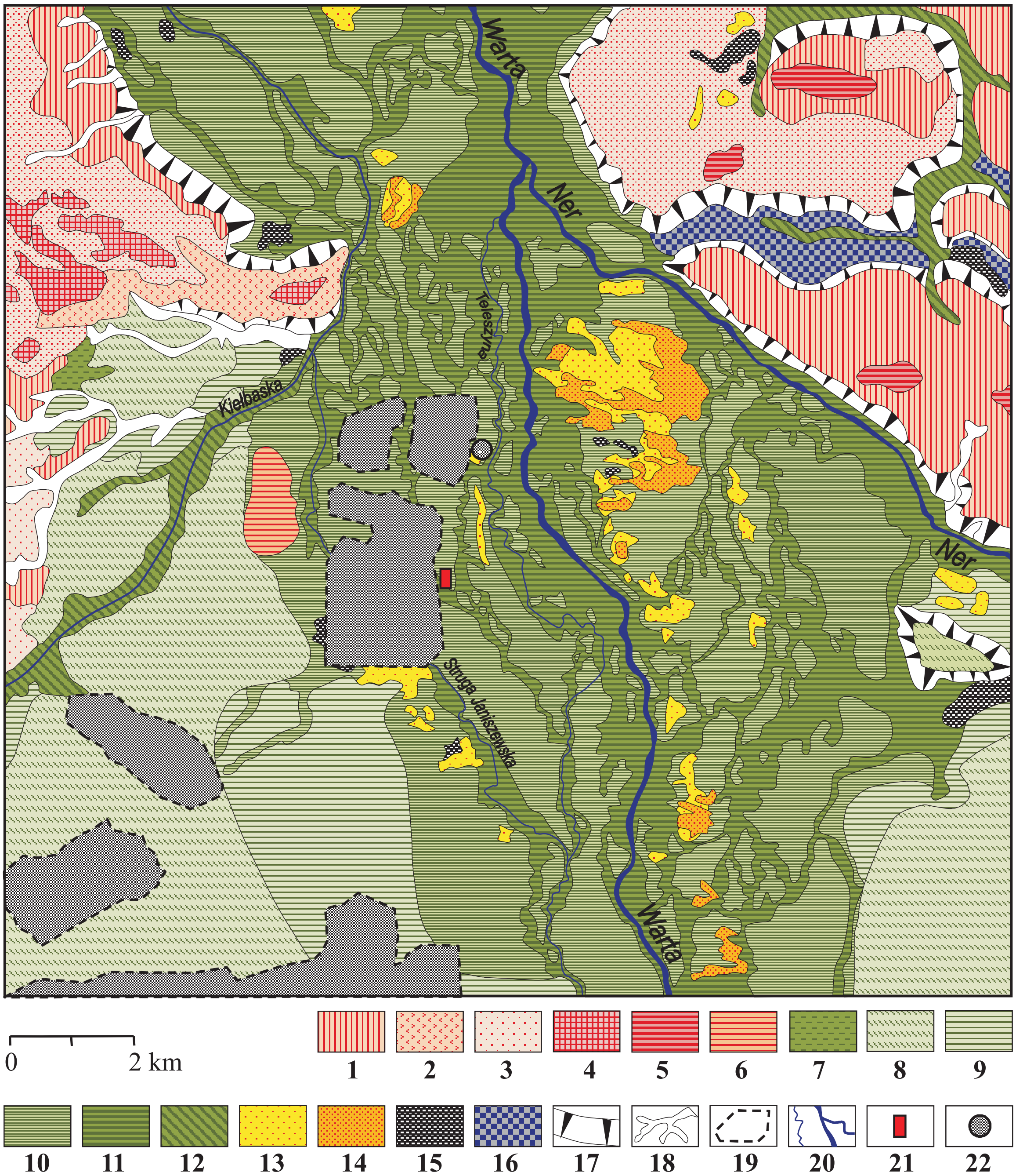

Fig. 2. Geomorphological map of central part of Koło Basin (after Forysiak 2005, partly changed). 1 – morainic plateau, 2 – morainic, hummocky plateau, 3 – glaciofluvial plain, 4 – terminal morains, 5 – kames, 6 – erosional terrace, 7 – floor of inactive valley, 8 – low level of marginal valley, 9 – high terrace, 10 – low terrace, 11 – valley floor of Warta river system, 12 – valley floor other rivers, 13 – aeolian plain, 14 – dunes, 15 – peatlands, 16 – pool-water plain, 17 – slopes, 18 – denudational valleys, 19 – post-mining areas (outcrops, heaps, reclaimed areas, etc.), 20 – larger river channels, 21 – Koźmin-Las site, 22 – Kwiatków 11/20 site.

other settlements related to the Przeworsk culture. A question worth raising is why the inhabitants of the Kwiatków settlement needed so many wells if the site was located in the vicinity of rivers. Perhaps, the discovered features had various functions – not only as a source of water but maybe also as features connected with some production process. This might be indicated by their location within the settlement area and their spatial and functional relationships with other features. In the case of this site, neither the size nor the shape of the excavations have been restricted by investment: the rescue surveys that preceded the enlargement of an opencast lignite mine allowed the entire relic space to be researched, together with the impressive cluster of wells. These artificial water intakes were recorded throughout the whole area covered by the excavations.

Both wells selected for specialised analyses were lo-

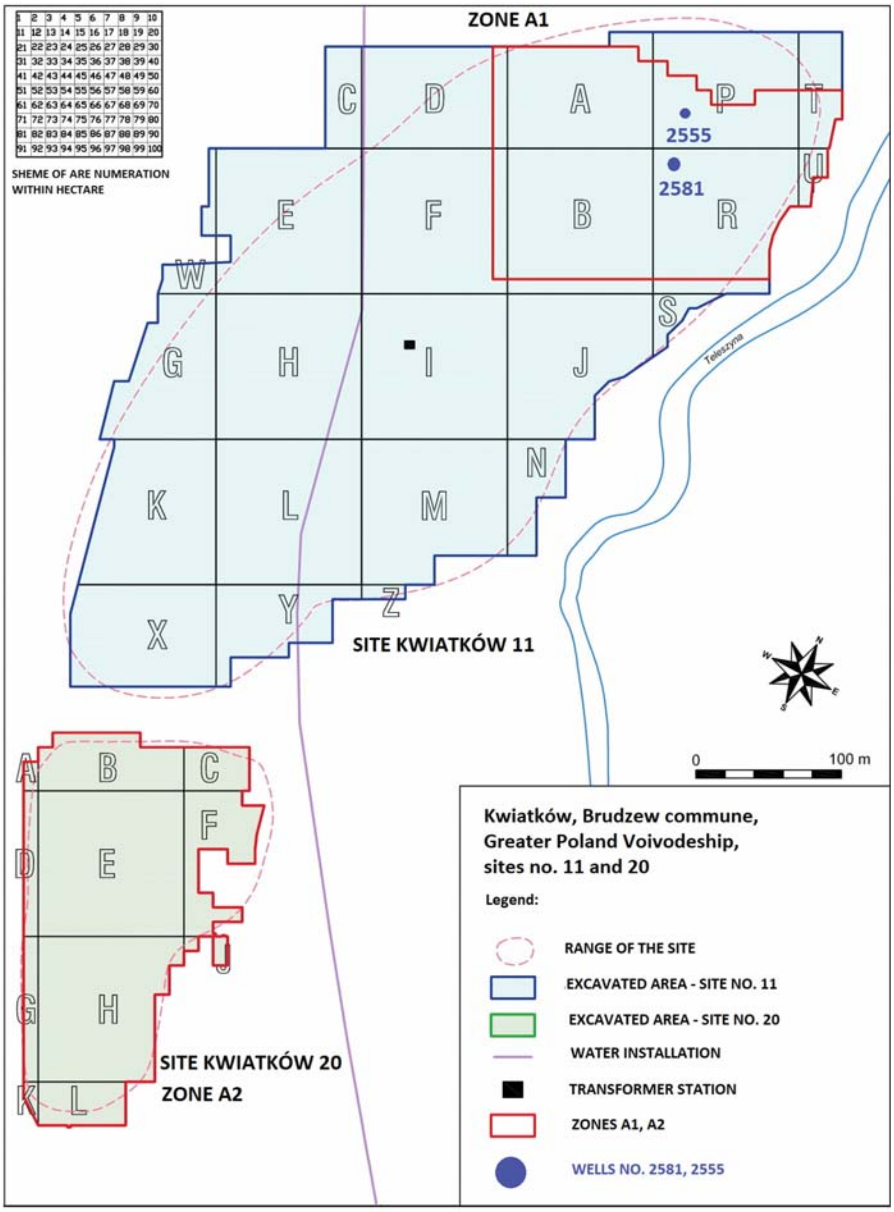

Fig. 3. Kwiatków 11/20 site, Brudzew commune: range of the site, excavated area, zones A1 and A2, location of the wells no. 2555 and 2581 (after Rzepecki 2016 with some changes by M. Piotrowska).

cated in zone A1 of the site. This is the north-eastern part of the excavated area (Kwiatków 11) located in the vicinity of the Warta river (about 800 m) and the Teleszyna river (about 100 m). The area of site Kwiatków 20 was defined as zone A2 (Fig. 3; see: Rzepecki, 2016).

METHODS

Archaeological studies. The wells excavated at the Kwiatków site were explored according to the relevant standards for large-area excavations. The study features were first cleaned on the surface, then documentation was made (pre-excavation plans) and finally they were explored by mechanical layers of approx. 10 cm thickness (Rzepecki, 2016). In the case of the wells, after recording the remains of the wooden structure, the feature was not "cut". Instead, its surroundings were explored to the undisturbed subsoil, the documentation was prepared, and then the remains of the casing were removed. After taking off the wooden structures from the two wells described in this article, cores – full sequences of fills – were obtained.

Dendrochronological studies. The timber from the construction of the wells was prevailingly of oak. TREE-RINGS software was used to measure and process the annual growth sequences (Krąpiec, 2016). Absolute datings were based on standard chronologies of subfossil oaks from South Poland (Krąpiec, 2001). Thanks to the possibility to precisely date the year that the trees used for the construc-

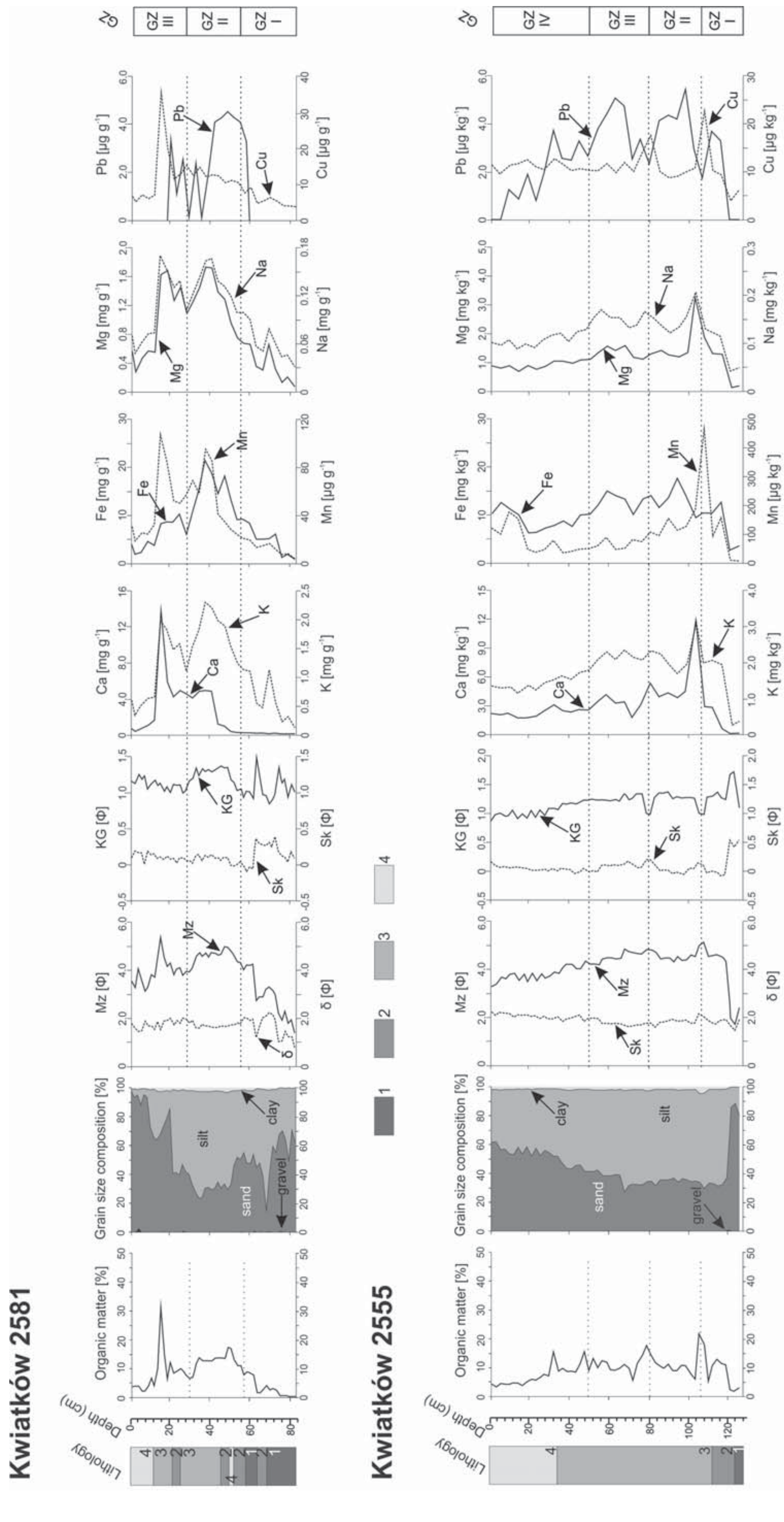

Fig. 4. Geochemical diagram of the sediments from 2581 and 2555 wells profiles. Lithology: 1 – medium sand, 2 – fine sand, 3 – coarse silt, 4 – very fine sand.

tion of casings were felled, it was possible to verify and correlate the typological arrangements for the artifacts that were extracted from the wells' interiors. The artifacts also helped determine the chronology of the sites at which they were discovered. Moreover, they allow for an assessment of the carpentry skills of the ancient communities and help determine the preferences for tree species selected for the construction of, for example, wells.

Geochemical studies. Geochemical analysis was carried out on 56 samples taken every 2 cm (at high lithofacies differentiation of sediments) or every 5 cm (in the case of homogeneous sediment) from the fills of well number 2581 (thickness 83 cm) and 2555 (thickness 126 cm) (Fig. 4). The organic matter (OM) was determined by loss on ignition following the protocol described by Heiri *et al.* (2001), and the amount of calcium carbonates ($CaCO_3$) was determined by the volumetric method using the Scheibler apparatus. The total concentrations of macroelements (Na, K, Ca, Mg, Fe) and microelements (Mn, Cu, Zn and Pb) were determined. Samples of constant weight were digested in concentrated acids (nitric, hydrochloric and perchlorate) (Borówka, 1992). The acid solutions were analysed by the Atomic Absorption Spectrophotometry (AAS) method, using the Solaar 969 apparatus.

Lithological analyses. The grain size composition of the ash samples remaining after loss on ignition analysis was determined using the laser particle size analyzer Mastersizer 3000 with a Hydro MU dispersion unit (Malvern). In the case of well 2581, 52 samples were examined, and for well 2555, 57 such analyses were made. In the graphic representations (Figs 5 and 6) of the calculated grain parameters of Folk and Ward (Mycielska-Dowgiałło, 1995) for both profiles, the three samples located at the greatest depth were not included because they contained the sediments of the substratum (bottom unit), which form the barren part of the studied archaeological objects. Sixty-one sediment samples extracted from a few short lithological profiles (up to 1.2 m thickness) from the Kwiatków 11 site (Twardy, 2016) were used as the material for comparison (part a in Figs 5 and 6). The grain properties of these samples were analysed with a Fritsch mesh set as well as using the areometric method of Bauyoucose (the Cassangrande and Prószyński modification). For this reason, it is necessary to bear in mind the limitations of the comparison of the results of analyses of grain properties obtained through various laboratory methodologies (Nicieja, 1996; Płoskonka, 2010).

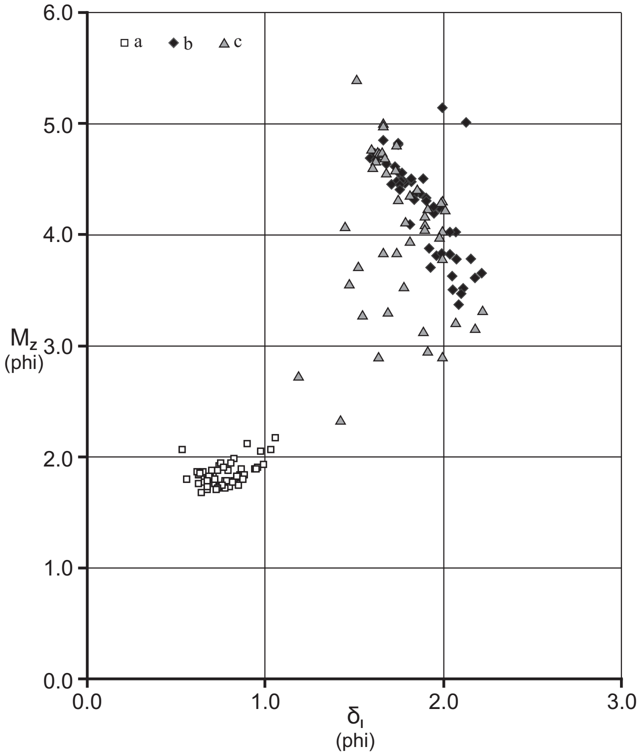

Fig. 5. Medium diameters (Mz) of grains and sorting (δI) relations of deposits from Kwiatków 11 site (a), well 2555 filling (b), and well 2581 filling (c).

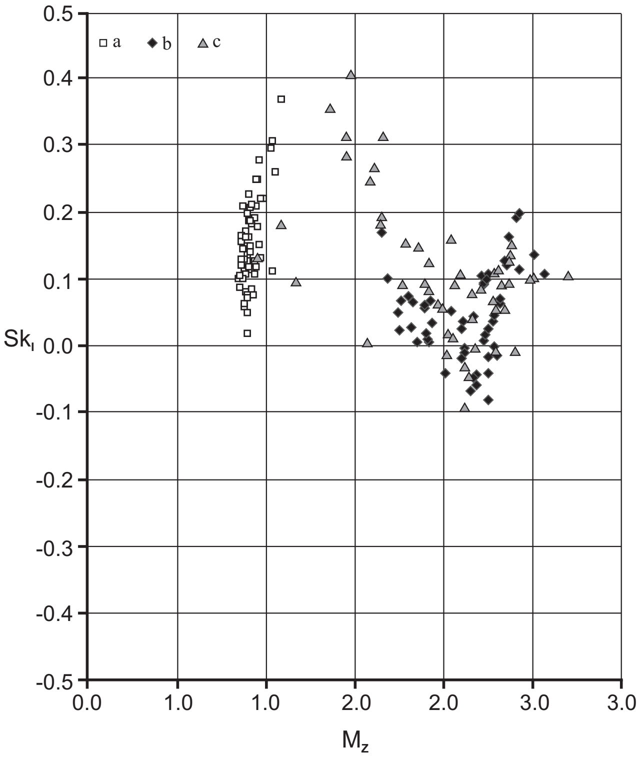

Fig. 6. Comparison of skewness of the grain size distribution (SkI) and medium diameters (Mz) of deposits from Kwiatków 11 site (a), well 2555 filling (b), and well 2581 filling (c).

RESULTS

Archaeological and dendrochronological investigations

Wells 2581 and 2555 have fairly well preserved wooden casings. In the case of the former feature, thanks to dendrochronological analyses, dates were obtained for almost all laths used in the construction of the casing,

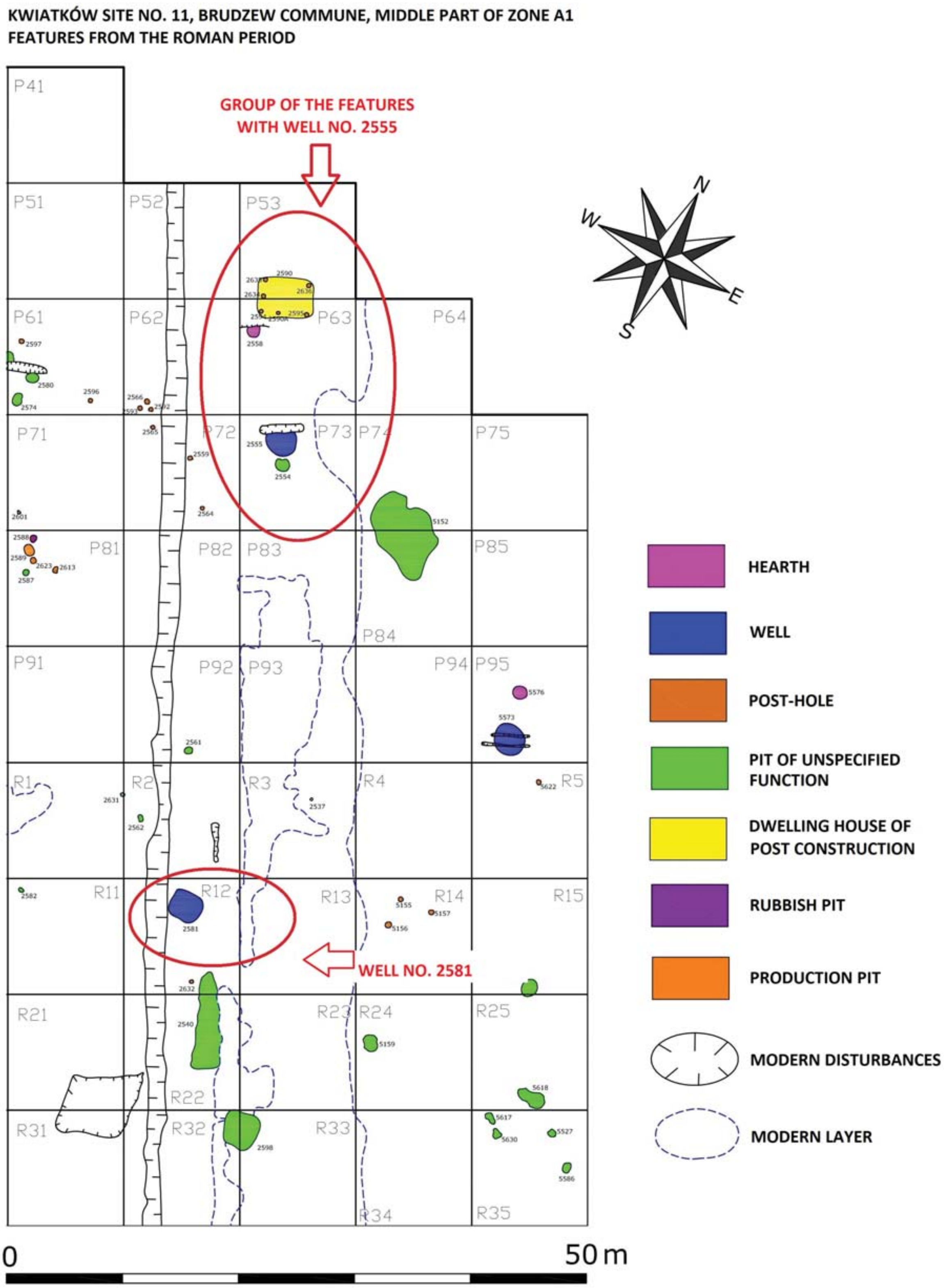

Fig. 7. Kwiatków 11 site, Brudzew commune, zone A1. Features from Roman Period (after Rzepecki 2016 with some changes by M. Piotrowska).

which were made of oak wood (Krąpiec, 2016). The dendrochronological dates mainly point to the first half of the second century AD. Some designations are: 121 AD, 128 AD, and about: 122 AD, 127 AD, 129–130 AD and 138 AD. The chronology of these wells, which was based on more than a dozen dates, became the basis for selecting these features for detailed specialist analyses. The selection of well 2555 for detailed study resulted from the

Fig. 8. Well no. 2581 during the excavation.

Fig. 9. Well no. 2555 during the excavation.

Fig. 10. Ceramic vessel in situ from well no. 2581.

desire to compare the results from well 2581 with another well located in zone A1 (Fig. 7). Both wells had a casing constructed in the same way, but their location and function in the settlement and the contents of the fills showed significant differences.

Feature 2581 was located in the centre of zone A1 (Fig. 8). No features related to the Przeworsk culture were recorded in its immediate vicinity. Feature 2555 was located in the northern part of zone A1, at the edge of the study area (Fig. 7, 9). We can assume that average duration of functioning of the well was several dozen years – probably about 30 years. Both chosen wells were used as water intakes during the Roman Period.

The chronology of feature 2555 was based on analysis of the pottery from its fill and the dendrochronological dates obtained for the base parts of the posts that were preserved in the half dugout; one indicated the period after the year 119 AD and the other the period after the year 129 AD (Krąpiec, 2016; Piotrowska, 2016). The relationship of well 2555 with that half-dugout raises no doubts (the well was located in the vicinity of this building and was functionally connected with it). The ceramic material from this water intake correlates with the dendrochronological dates obtained for the remaining lower parts of the earthfast posts. Well 2555 can be related to phase B2b of the Roman Period.

The chronology based on the dendrochronological analysis of feature 2581 shows that this feature was in use after 138 AD (i.e., after the youngest date of cutting down the tree used for the construction of the casing of this well). Among small pottery fragments, one almost entirely preserved vessel was discovered in the bottom part of this feature (Fig. 10). Considering the chronology of the pottery from this water intake, it can be assumed that this well was used after phase B2b of the Roman Period and possibly until the end of the younger Roman Period. It is highly probable that well 2581 was functioning a bit later than feature 2555.

The geological substratum and well fills

The geological substratum from when both of the analysed wells were dug was located in the top parts of sediments forming a low terrace of the Warta in the area of the Koło Basin. The structure of the sediments of this terrace in Kwiatków is the same as at the thoroughly-studied site of Koźmin (Fig. 2), which is located about 1.8 km from Kwiatków. The upper series of sediments (3 m) is formed by a sequence of three sedimentation units that may be encountered in various other locations within the Koło Basin. The bottom unit is composed of multi-grained alluvial sands with gravels, and its age is connected with the Upper Plenivistulian (marked “a” in Fig. 11). The middle unit is composed of grey-black organic silts containing traces of a fossil pine forest that covered the bottom of the Warta river valley in the Allerød and Younger Dryas (Fig. 11, marked “a”). The upper unit is mainly composed of medium- and coarse-grained sand (Fig. 11, marked “a”), deposited during frequent and intensive floods that occurred from the Warta at the end of the Younger Dryas (Dzieduszyńska *et al.*, 2011; Dzieduszyńska and Petera-Zganiacz, 2012; Dzieduszyńska

Fig. 11. Kwiatków site. Structure of substratum deposits and filling of 2581 well: a – lower unit – varigrained fluvial sand, (Upper Plenivistulian), a' – middle unit – organic silt with fossil wood (Younger Dryas), a" – upper unit – fine fluvial sand (Younger Dryas–Early Holocene); well filling: b – massive-structure deposits with clods of deposits from a, a' i a" units, c – studied well fillind, d – massive-structure deposits in pit of post-usage well. (Fot. E. Schellner).

et al., 2012; Kittel *et al.*, 2012; Dzieduszyńska *et al.*, 2014; Twardy, 2014; Petera-Zganiacz *et al.*, 2015a, b; Petera-Zganiacz *et al.*, in press).

The profiles extracted from the fillings of the wells were well-preserved in the part protected by the non-decomposed timber that the wells had been built out of (Fig. 11, marked "c"). The sequence of sediments connected with the studied wells is finished by a massive-structure filling of the bottom of the well (Fig. 11, marked "d").

The fillings of both wells have predominantly massive structure and the fine disturbed lamination is mainly contained in the top parts of the fillings (Fig. 12). To a lesser extent, in the studied profiles, sediments with fine lamination are visible as inserts with thicknesses of a few centimetres. The material from the filling of well 2555 (Figs 5 and 6) is the most fine-grained – the mean grain size (M_z) is 4.24 phi,

Fig. 12. Structure of top of filling well 2581. (Fot. E. Schellner).

which corresponds with the fraction of very coarse-grained silts. It is generally uniform throughout the profile, and poorly and very poorly sorted (d_I from 1.6 phi to 2.2 phi). The material from the filling of well 2581 (Figs 5 and 6) is more diverse both in its distribution throughout the profile and its mechanical content and properties. The mean grain size (M_z) is usually 3.95 phi, and the sorting (d_I) is also poor and very poor, but in the case of the most coarse-grained material it is approaching moderately sorted. In both fillings, the skewness of grain distribution (Sk_I) is generally symmetrical (from -0.1 to +0.1); nevertheless, about half of the samples from object 2581 and scarce samples from object 2555 displayed a positively skewed distribution (from +0.1 to +0.3). A positively skewed distribution is indicative of admixture of more fine-grained material than the base fraction of the sediments; in this case the admixtures were medium- and fine-grained silts and tills.

It must be emphasised that the fillings of the wells are composed of material that is much more finely-grained and poorly sorted than the material present in the vicinity of the studied formations (see Figs 5 and 6). The material of the upper unit that composes the geological substratum at Kwiatków 11 is mainly sandy and contains very few admixtures of silts. The highlighted tendencies may indicate that the fillings of the wells were formed by material transported from the close vicinity of the sites.

The studied sediments are specific because of their layer structure; the layers assume a postsedimentary deformed composition. The deformation of the layers occurred under the influence of a continuous collapse of the formations filling the well.

Geochemical analysis of the fillings

We can distinguish three (for well 2581) and four (for well 2555) geochemical zones in the vertical deposits' succession (Fig. 4), using the PAST software (Hammer *et al.*, 2001). In order to determine the variability of factors controlling the chemical composition of the deposits we used principal component analysis (PCA), which is one of the basic ordination techniques applied to data in palaeoenvironmental research (Legendre and Birks, 2012). To compare the chemical composition of different types of deposits from wells 2581 and 2555, the similarity index of structures (w_p) was used (Pawłowski *et al.*, 2014). The values of this similarity index are expressed as a percentage. The closer the value of this ratio's value to 100%, the greater the similarity of the structures. An index value of 100% indicates that the structures' data are identical.

The sediments that constitute the fillings of the studied objects may be visibly different in terms of the geochemical composition and the percentage contribution of specific mineral fractions. This is most likely due to the non-simultaneous nature of the processes responsible for filling the studied wells. Despite the fact that the mean content of organic matter in both profiles is similar (7.7% for 2582 and 8.8% for 2555) only in the first case does the coefficient of variation reach 90%.

For feature 2581 the geochemical levels GZ-I (83–56 cm), GZ-II (56–30 cm) and GZ-III (30–0 cm) were determined on the basis of a distinct variability in the content of lithophilic elements (K, Mg, Na) whose contribution initially rises to, respectively, 2.32 mg/g, 1.72 mg/g, and 0.17 mg/g and then declines. Initially, it is medium- and fine-grained sand, in the middle part of the profile sandy silt dominate, and in the top part a prevalence of sand-silt fraction with scattered organic content (often over 10%) may be observed (Fig. 4).

In the case of feature 2555, all four geochemical levels GZ-I (123–108 cm), GZ-II (108–78 cm), GZ-III (78–48 cm) and GZ IV (48–0 cm) have a notably less diverse distribution of specific mineral fractions and contents of the studied elements (Fig. 4). It is interesting to note the border between the GZ I and GZ II geochemical levels, where there was a sudden increase in concentrations of Ca (from 0.1 to 11.8 mg/g), K (from 0.26 to 3.15 mg/g), Mn (from 8.5 to 464.5 ug/g), Mg (from 0.13 to 3.24 mg/g) and Na (from 0.04 to 0.20 mg/g). This is accompanied by an increase in organic matter content to 17.7%. The sediments classified as part of the geochemical levels GZ II, III and IV are fine-grained sand containing a silt fraction (from 38% to 70%) and organic content (from 4% to 14%).

A comparison of these two geochemical sequences from two wells was made on the basis of the structure similarity factor (w_p). The highest correlation values were found between the 8–20 cm section from the 2581 profile and the 108–92 cm section from the 2555 profile. The w_p factor values for the studied sediment series vary within the bounds of 30% for iron, up to 92% for calcium. The mean w_p value is 57.8 %, and the final result of the calculations was presented in graphical form (Fig. 13). As a result, it can be concluded that the processes responsible for the filling of both objects could not have been simultaneous. The initial phase of deposition with layered sediments within well 2555 (the border between geochemical levels GZ I and GZ II) displays the closest geochemical similarity to the final phase of the filling of well 2581 (geochemical level GZ III). Such a situation is also confirmed by the results of the PCA analysis, which identified the factors that shaped the chemical composition of the two studied wells' sediments. The graphs of the values of our own correlation matrices obtained in the Catell heap test indicate the presence of 2 to 3 important factors that characterise between 71.6% (well 2555) and 85.3% (well 2581) of the variability of the 9 geochemical properties of the documented sediments (Fig. 14A).

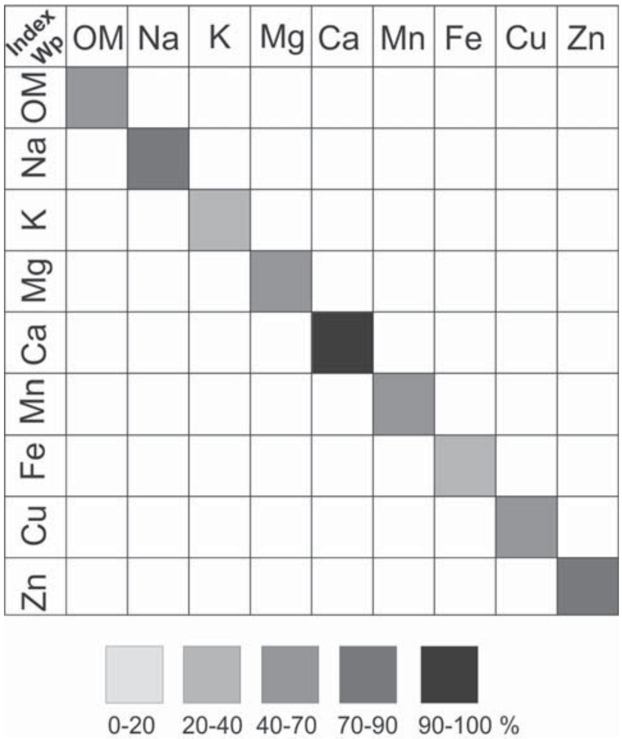

Fig. 13. Diagram of the index of similarity structures (Wp) for a series of sediments filling the studied wells.

DISCUSSION

The building of the well was related to the development of the extensive and quite flat surface of the Warta river terrace. The characteristic lithological features and the appropriate amount of water in the ground favoured the construction of outcrops in order to build wells. After the period of their functioning as water sources they were filled by deposits. The archaeological and geological studies performed make it possible to reconstruct the main stages of the study area's use in the Roman Period and in

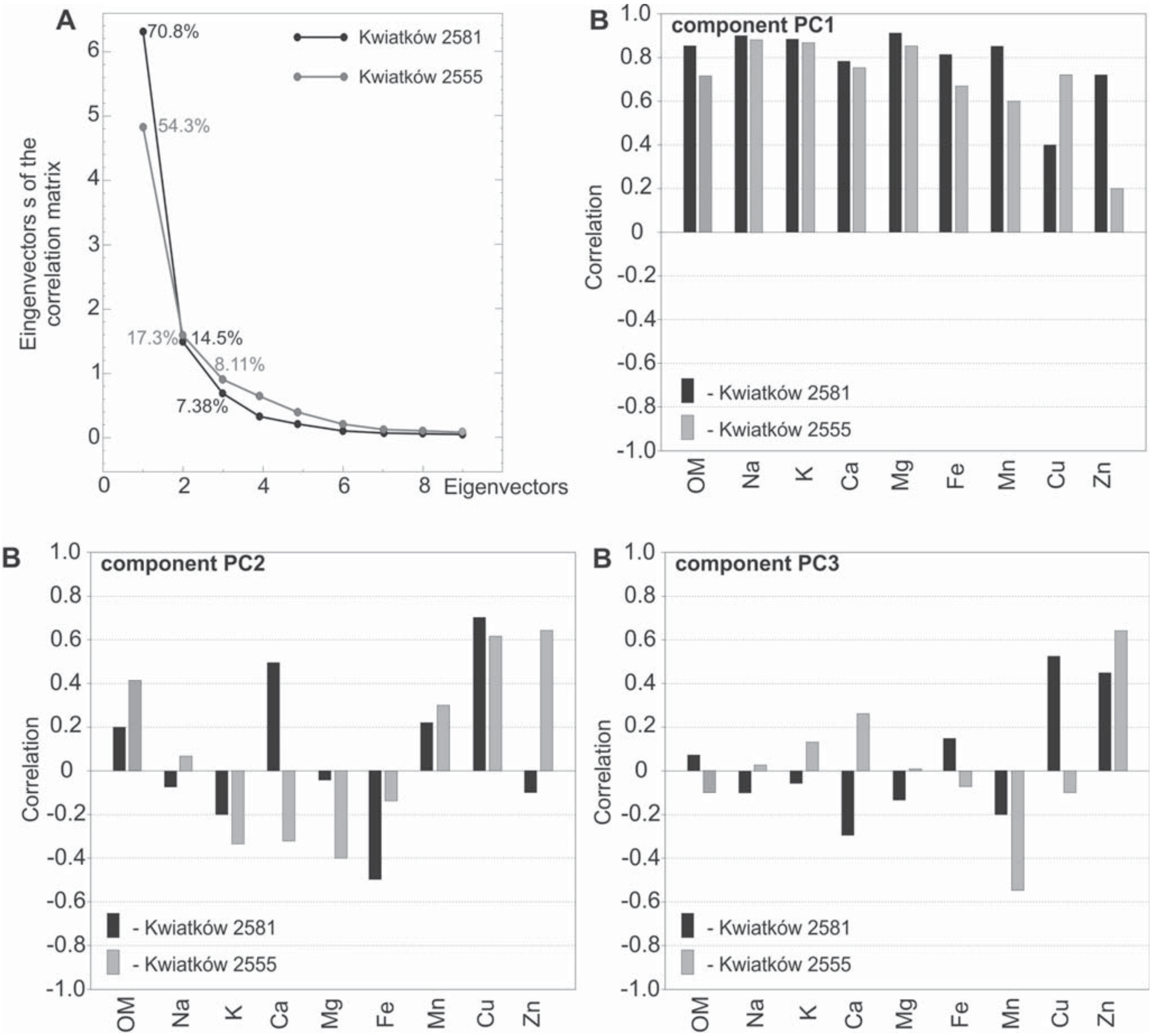

Fig. 14. Eigenvalues of correlation matrix for a set of results of chemical analysis for deposits of the 2581 and 2555 profiles (A); Correlation of geochemical variables (B).

the period after its abandonment. Detailed reconstruction of the development process of the area at this time and the accompanying environmental changes will be possible after completion of palaeoecological research.

It may be assumed that at the time the area was inhabited, about two thousand years ago, when the wells were created the level of the ground water of the first aquifer was slightly lower than at the modern time. This conclusion is confirmed by studies in other river valleys of the Polish Lowland (Kalicki, 2006; Starkel *et al.*, 2013). Settlements and wells were built on the terrace, but it was not threatened by floods.

The initial phase of the construction of a well was to prepare a pit into which a wooden casing was later inserted. Both studied features are characterised by the same casing in log construction that dominated area A1 of the site. A log construction method was most frequent for artificial water drawing points in the Roman Period (Nowakowski and Waluś, 1986; Piotrowska, 2016). As it was mentioned above, well 2555 is connected with phase B2b of the Roman Period and feature 2581 was used after this phase. Subsequently, the casing was entombed with material probably from the earlier dig. The notable difference in construction details is the presence of planks at the bottom of feature 2555.

The context of the localisation of both the wells within a settlement differs, too. Well 2581 was located in the centre of area A1, where no other accompanying features of the Przeworsk culture were registered (Kot and Piotrowska, 2016). The situation is different for well 2555, which was located in the back of a semi-dugout accompanied by a hearth and other Przeworsk features. These features together created a distinct functional set, a model complex of features that could be encountered in the settlement in Kwiatków (Kot and Piotrowska, 2016). The core of the complex is a small building – a semi-dugout of post construction, which according to older interpretations may have been used mainly for residential purposes (Godłowski, 1981; Jadczykowa, 1981; Kobyliński, 1988). At present, the opinion is held that features of this kind also functioned as independent workshops, e.g. for weaving (Michałowski, 2011). The said residential purpose cannot be ruled out, however. Such small semi-dugouts without a chamber for animals, and interpreted as various workshops, are quite well known from sites such as Feddersen Wierde and Tornow (Jankuhn, 2004).

The differing locations and functions of these features in the settlement in Kwiatków are also reflected by the amount and character of the ancient material extracted from their fillings. Only half the amount of pottery from well 2555 was recorded in feature 2581. The latter most likely contained only one completely preserved vessel, which was probably connected to drawing water, in addition to scattered, non-specific shards. Well 2555 contained a much higher amount of pottery. This is likely connected to the location of the well in the aforesaid complex of archaeological features. This may explain the presence of bone fragments and a higher ceramic content, both of which entered the well from its surroundings. It can be observed that despite the short distance between the two artificial water intakes (approximately 35 m) their purpose and contents are disparate. Feature 2581 may be designated as a "public" well, but 2555 as a "private" one that was clearly connected with the functioning of a semi-dugout. Feature 2581 could have been associated with delivering water for animals in the husbandry of the Kwiatków settlement dwellers. This is why it is located at some distance from the other sources of the Przeworsk culture and why the amount of movable artifacts within the filling is limited, in contrast to other wells connected with the functioning of pole buildings or located in areas of intense use and rich in immovable sources.

Geochemical data ordinated in the principal component analysis show that the PC1 components are strongly positively correlated mainly with the content of organic matter, Na, K, Mg, Fe and Mn. The main factor responsible for the chemical composition of the sediments was thus the adsorption of ions from the water solution by the highly decomposed organic matter deposited at the bottom of the infilling. The analysis of the changes in the concentration of the studied trace metals (Cu, Pb and Zn) as well as K and organic matter, leads to the conclusion that the dig site was subject to periodic flooding of the well. The graphs indicate that factors PC2 and PC3, which influence the chemical composition of the sediments from well 2581 (Fig. 14B, C, D), are connected with the delivery of calcium, manganese and copper. The highest calcium concentration (above 12 mg/g) in the studied profile occurs in the series of silts with a significant admixture of highly decomposed organic matter. That period is accompanied by a sharp rise in the amount of trace elements, which should be explained as the elevated sorption capacity of the dried out sediments probably resulting from partial charring/fire. What is more, under the conditions of abundance of organic matter, a lack of free oxygen and a surplus of CO_2 in water, the precipitation of manganese carbonate is viable (Borówka, 2007). In the case of the sediments from well 2555, PC2 and PC3 are positively correlated mainly with the content of organic matter, Mn, Cu and Zn. This may stem from the fact that the well is located near the said archaeological complex and, in consequence, was subject to the influence of a more intensive use of bronze tools or mineral dyes. The maximum concentration of Mn (464,6 μg/g) may indicate surface water floods. River water is either rich in Mn2+ ions or acts as a transport medium for its colloidal suspension (Kabata-Pendias, 2011). The results of the potassium content in the studied sediments (often exceeding 2 mg/g) are, in turn, typical of the sandy sediments that form the flood plains of lowland rivers in Poland (Salminen, 2005). Because of the recess in the passive delivery of potassium in the crystal structure of quartz and aluminosilicates, or as ions absorbed by mineral clay, this metal may be regarded as an intensity gauge for denudation processes in the vicinity of the studied wells. Hence, the geochemical record of increased erosion may be related to a higher surface exposition of the areas neighbouring the well due to fire or construction work. Similar changes in chemical properties and texture have recently been documented for the sediments of a shallow pit in Ludwinów in Kujawy, which was filled with material from the immediate vicinity and continuously became more shallow and expanded in diameter, which led to the creation of a depressed multi-layered filling (Papiernik *et al.*, 2017).

The reason for the increased content of organic matter may have been the delivery of carbon dust falling into the well following a number of fires. The variable content of organic matter in monofractional sediments of the flood plain can also be interpreted as flood rhythms. This situation has been documented by Szmańda (2008) in the sediments of the Tążyna Valley, where the boundaries of the rhythms are poorly expressed in the laminate grain size distribution. They could be macroscopically distinguished based on the changeable colour caused by a larger admixture of organic matter originating from the redeposition of peats in the fall-off phase of the flood wave.

After the retreat of settlers from the area of Kwiatków 11, the wells underwent gradual filling. The processes that led to the formation of the fillings of wells can be divided into two: anthropogenic and natural. The anthropogenic processes were connected with both intentional and unintentional filling of the wells. The intentional filling – a one-time event after the use of the well had ceased – decreased the risk of bodily injury of people and farm and household animals, which could have otherwise accidentally fallen into the unused well. These features were also sometimes reused as garbage pits, which were registered in the area of the presented site. During intentional filling of a well, unsorted massive-structure sediments were left, with ceramic shards, bones, timber fragments and organic macro remains.

The unintentional destruction of a well was connected with the destruction of the wooden framework; this led to the shaping of deposits without clear structures. The sediments that reached the well after a partial collapse of their structure came mainly from the material previously displaced during the digging of the well shaft. The admixture in these sediments is composed mainly of degraded construction timber. It should be stressed that the bottom parts of the fillings could have formed during the active functioning of the well. The massive structures in the formation of the sediments were in this case caused by the drawing of water from the well. This led to a repeated mixing of the sediments that had accumulated in the bottom. The verification of such an interpretation may be delivered by the vessel discovered at the bottom of object 2581 (Fig. 8), which was preliminarily connected with drawing water.

The studied deposits could have then been delivered to the well as washout from the waters from the slopes of a moderate hillock in the middle of the archaeological dig site, surface water floodings and aeolian processes. Aeolian processes in the investigated section of the Warta river valley induced by human activity took place at the beginning of the Subboreal Period (Forysiak and Twardy, 2012), so in the Roman Period, when the deforestation was much larger, it could have been much more strongly. The lithological analyses show differences in the grain properties of the material composing the filling of the well and the area of the site. They indicate that the fine-grained silt and clay material that entered the well originates from outside the site, because it is composed mainly of well-sorted sands. In terms of texture, it bears a resemblance to the fine-grained sediments of the Warta that came from outside the river bed and were studied by Petera (2002) and Forysiak (2005). Silt and clay in the fillings of the well most likely come from the dilution of older, glacigenic deposits from the Warta or smaller rivers – the Teleszyna and Siedza. They were accumulated in the well during high water levels and floods, which affected the bottom of the shallow Teleszyna and the lower parts of its slopes (Kittel *et al.*, 2015).

Studies by Kamiński and Moszczyński (1996) were conducted in the valley of a small river, the Moszczenica, to the north of Łódź, and proved that floods did affect the areas occupied by the river settlement of the Przeworsk culture. As a result of a flood or high water level, the area occupied by the settlement was flooded, including the well, which may have been why the settlement was abandoned. Palaeofloods of the Moszczenica river have been dated to 1930 ±100 years BP and 1800 ±80 years BP (Kamiński, 1993, 1998). In the Łódź region, for the period corresponding with the end of the Przeworsk culture, the increase in flood sediments is also documented by a dating to 1640 ±50 years BP (Marosik, 2002). Heavy rains were recorded for that period, leading to increased soil erosion (Starkel, 2005), and even the development of ravines in the vicinity of Łódź (Twardy, 1995, 2014). The increase in the activity of fluvial systems in Poland in the years 1825–1625 BP is noted by Starkel *et al.* (2013). According to said researchers, it was of minor rank and a much more important revival of fluvial systems happened after 1500 BP, lasting approximately 150 years. The results of research by Kalicki (2006) also suggest an increase in the humidity of the climate and the frequency of floods as early as the end of the Roman Period, especially in the period of the migration of people.

The collected data do not allow the moment of complete recession of the traces of wells in the terrain to be determined, and the topographic surface in the area of the well may have been levelled a number of times. The levelling of the pit is likely to have accelerated until the period of agricultural use of the Kwiatków 11 site area in the middle ages and present times.

CONCLUSIONS

The settlement area is located within a lower terrace and the bottom of the Warta River valley, on an interchannel area between the main river channel and the Teleszyna and Siedza channels belonging to an anastomosing system of the Warta River. The current beds are dry, but in the Roman Period they were active channels of a fluvial system.

The Kwiatków 11 archaeological site constitutes a vast multicultural settlement complex where most of the discovered archaeological sources are associated with the long-lasting settlement of the Przeworsk culture population, dated to the Pre-Roman and (mostly) Roman Period – i.e. the first centuries AD and the Early Migration Period. The archaeological research has documented more than one hundred wells, and two were selected for detailed research. Wells 2581 and 2555 have fairly well preserved wooden casings and mineral-organic infilling. When the wells were created, the level of the ground water of the first aquifer was located lower than at in the 20th century. Both studied features are characterised by the same in log construction casing. Subsequently, the casing was entombed with material probably derived from a previous dig. Well 2581 was located in the central part of the area, where no other accompanying features of the Przeworsk culture were registered. Well 2555, was located in the back of a semi-dugout accompanied by a hearth and other Przeworsk features. Feature 2581 may be designated as a public well, but 2555 as a private one that was clearly connected with the functioning of a semi-dugout.

After the retreat of settlers from the area of Kwiatków 11, the wells underwent gradual filling. The processes responsible for the filling of both objects could not have been simultaneous. Well 2581 was filled faster than the second. Mineral elements could have then been delivered to the well as washout from the slopes of a small hillock, surface water floodings and aeolian processes. The analysis of the changes in the concentration of the studied trace metals and organic matter leads to the conclusion that the dig site was subject to periodic flooding. The studied sediments are deposited as a layer structure, but the layers assume a post-sedimentary deformed composition due to the continuous collapse of the formations filling the well.

The collected data do not allow the moment of complete recession of the traces of wells in the terrain to be determined. The filling of the well pit may have been resumed a number of times.

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