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RADIOCARBON CHRONOLOGY OF THE POST-LBK MALICE CULTURE IN LESSER POLAND

ABSTRACT

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A series of new radiocarbon dates from Neolithic Malice Culture (MC) sites in Lesser Poland allow for making significant corrections in the absolute chronology of this culture. Bayesian modelling of a series of MC dates made it possible also to specify the absolute chronology of individual phases of the development of this culture. The early classic phase (MC1a) is around 4800-4700 BC, the classic phase (MC1b) between 4700 and 4450 BC, and the late phase (MC2) between 4450 and 4200 BC. In addition, the review of the definitions of the MC phases and their new absolute chronology allow for the synchronization of their development with the cultural units in the Tisza basin. Phase MC1b developed parallel to phase III of the Herpály culture, phase MC1c to Proto-Tiszapolgár (layer 5 on the Herpály tell), and phase MC2 with the Tiszapolgár culture.

Keywords: MC, Lesser Poland, Neolithic, bayesian modelling, radiocarbon chronology
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INTRODUCTION

In recent years, several works have been published presenting quite numerous series of radiocarbon dates from Neolithic sites in south-eastern Poland (Czekaj-Zastawny *et al.* 2020; Kadrow *et al.* 2021; Kadrow *et al.* 2022; Golański and Kadrow 2022; Oberc *et al.* 2022; Zastawny 2022). They have already influenced the new picture of the absolute chronology of the end of the *Linienbandkeramik* (hereafter: LBK) and the whole duration of the Malice culture (hereafter; MC). This is confirmed by studies on the chronology of other regions of Poland (*e.g.*, Marciniak *et al.* 2022) or Carpathian Basin (*cf.,* Staniuk *et al.* 2020).

The aim of this article is to achieve a more precise absolute chronology of the Malice culture, including chronology of the house at Targowisko Site 14-15 (Kadrow *et al.* 2021, 162-164; table 1, figs 8, 9) against the background of the absolute dating of this culture in south-eastern Poland (Włodarczak 2017; Zastawny 2022, 168-169, figs 9, 10).

THE STATE OF RESEARCH ON THE ABSOLUTE CHRONOLOGY OF THE POST-LBK MALICE CULTURE

We may begin with a few remarks about the chronology of the LBK, the culture that preceded the development of MC. Until recently, it was believed that the LBK population reached the areas of south-eastern Poland as early as around 5500/5400 BC in its pre-music-note phase (Czekaj-Zastawny *et al.* 2020). The appearance of the oldest farmers in the Polish Lowland was similarly dated, *i.e.*, in the period 5500-5400 BC (Czerniak 1990), and this period was later moved to the years 5400-5300 BC (Czerniak 2012). The youngest phase of the LBK was dated to the period 5000-4900/4800 BC (Czekaj-Zastawny 2017, 27), similarly in the Lowlands (5000-4900/4800 BC; Grygiel 2004, 523).

Bayesian modelling of a series of dates related to the LBK, mainly from Lesser Poland, showed that the emergence of this culture occurred much later than previously thought, *i.e.*, around 5280 BC. Also its end is now dated earlier, *i.e.*, around 5080 BC (Oberc *et al.* 2022, 208). Moreover, the duration of phase I overlapped significantly with phase II, and Phase III with Phase II (Oberc *et al.* 2022, 204). Similar results were obtained from the analyzes of LBK dates from the area of the Polish Lowlands, mainly from Kuyavia. This culture appeared there around 5265 and lasted until 5015 BC (Marciniak *et al.* 2022, 398). It was a common phenomenon to overlap the development phases of the LBK while maintaining their traditionally understood sequence in its development (Marciniak *et al.* 2022, fig. 12).

The beginning of the classical phase of MC1b was dated to 4800 BC and its end to 4100 BC (Kadrow 1996, 68). Later, it was proposed to date the beginning of this culture (phase MC1a) to 5000 and the end (MC1c) to 4200 BC (Kadrow and Zakościelna 2000, 244-247, fig. 44). The Rzeszów phase of MC (2a-2b) was dated to the period 4200-3800 BC (Kadrow

and Zakościelna 2000, 245-249, figs 44, 45). Calibration of over thirty radiocarbon dates of MC, collected recently, made it possible to define the framework of this culture in Lesser Poland between 4850 and 4330 BC (Zastawny 2022, 169).

Bayesian modelling of the series of dates of the late phase of MC (MC2) from the site Wzgórze Zawichojskie in Sandomierz allowed its chronology to be shifted to the period 4400-4200 BC (Włodarczak 2017).

BAYESIAN MODELLING OF THE RECENTLY PUBLISHED SERIES OF RADIOCARBON DATES FROM LESSER POLAND

Albert Zastawny recently published 36 radiocarbon dates of MC assemblages from Lesser Poland (Fig. 1; Zastawny 2022). He described the dated pottery sets in detail. However, in presenting radiocarbon dates, he limited himself only to their calibration. This creates the need for their Bayesian modelling, at least on a basic level, to obtain a more realistic absolute and inner MC chronology.

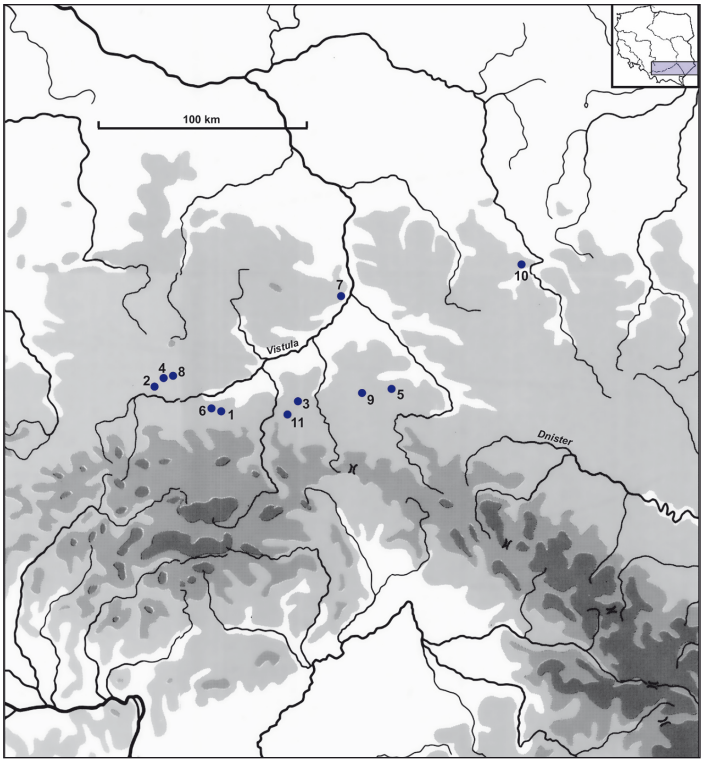

Fig. 1. Map of the locations from which the radiocarbon dates come (see Table 1)

Table 1. List of radiocarbon dates from MC sites in Lesser Poland. 1-3 – MC1a phase; 4-15 – MC1b phase; 16-34 – MC2 phase. Calibration after OxCal v4.4.4 Bronk Ramsey 2021. Acc. to Zastawny 2022 with some changes

	Site	Lab.	BP	BC 1 sigma	BC 2 sigma
1	Targowisko TRG core	MKL-4183	5960±80	4940(86,3%)4776 4759(0,13%)4726	5198(0,01%)5189 5049(95,3%)4672
2	Aleksandrowice 2	Poz-121003	5890±35	4792(68.2%)4718	4844(95.5%)4687
3	Targowisko 10-11	Poz-71637	5800±35	4709(68,2%)4611	4774(1.3%)4762 4726(94.2%)4544
4	Łoniowa 18	Poz-15978	5880±40	4794(68,3%)4710	4846(93,4%)4657 4636(2,0%)4616
5	Kraków-Olszanica 2	Poz-77984	5830±40	4776(8.1 %)4758 4726(47.5%)4654 4638(12.7%)4614	4792(92.7%)4585 4569(2.7%)4552
6	Targowisko 14-15	MKL-A5167	5821±23	4686 (65.0%) 4602 4562 (3.3%) 4556	4674 (7.6%) 4636 4616 (85.9%) 4492 4472 (1.9%) 4461
7	Rozbórz 42	MKL-799	5820±90	4784 (2.4%) 4740 4735 (50.2%) 4582 4572 (5.7%) 4551	4898 (2.2%) 4866 4851 (93.2%) 4456
8	Targowisko 14-15	MKL-A5166	5779±24	4686 (65.0%) 4602 4562 (3.3%) 4556	4703 (95.4%) 4549
9	Zakrzowiec 8	Poz-45435	5760±40	4677(26,2%)4632 4620(42,1%)4548	4712(95,4%)4502
10	Targowisko 14-15	MKL-A5165	5755±23	4658 (15.0%) 4636 4616 (53.3%) 4548	4703 (95.4%) 4549
11	Targowisko 14-15	MKL-A5162	5741±23	4652 (6.5%) 4640 4613 (61.8%) 4542	4681 (90.2%) 4531 4526 (5.2%) 4502
12	Targowisko 14-15	MKL-A5163	5737±23	4650 (4.7%) 4641 4613 (63.6%) 4540	4678 (18.0%) 4631 4621 (77.5%) 4501
13	Targowisko 14-15	MKL-A5168	5737±23	4650 (4.7%) 4641 4613 (63.6%) 4540	4678 (18.0%) 4631 4621 (77.5%) 4501
14	Targowisko 14-15	MKL-A5164	5705±24	4585 (8.9%) 4569 4553 (56.6%) 4493 4469 (2.7%) 4464	4611 (95.4%) 4456
15	Zakrzowiec 8	Ki-13694	5690±90	4674 (9.7%) 4634 46 71 (58.6%) 4446	4721 (95.4%) 4351
16	Sandomierz 6/6	Poz-57913	5590±40	4451(68.3%) 4362	4498 (95.4%) 4347
17	Sandomierz 6/6	Poz-57916	5590±40	4451(68.3%) 4362	4498 (95.4%) 4347
18	Sandomierz 6/6	Poz-60513	5580±35	4446 (9.0%) 4436 4428 (59.3%) 4363	4490 (4,1 %) 4474 4460 (91.4%) 4347
19	Sandomierz 6/6	Poz-57917	5565±35	4444 (25.0%) 4418 4402 (43.3%) 4356	4484 (0.6%) 4480 4456 (94.8%) 4342
20	Sandomierz 6/6	Poz-60512	5545±35	4443 (25.2%) 4420 4399 (15.9%) 4381 4372 (27. %) 4348	4450 (95.4%) 4340
21	Sandomierz 6/6	Poz-62480	5525±35	4442 (20.9%) 4421 4396 (7.4%) 4385 4370 (39.9%) 4338	4448 (95.4%) 4330

22	Kraków-Witkowice II	Poz-43316	5525±35	4442 (20.9%) 4421 4396 (7.4%) 4385 4370 (39.9%) 4338	4448 (95.4%) 4330
23	Sandomierz 6/6	Poz-505596	5520±40	4442 (9.6%) 4421 4396 (7.3%) 4385 4370 (41.4%) 4335	4450 (91 .0%) 4326 4286 (4.4%) 4266
24	Sandomierz 6/6	Poz-505595	5490±40	4361 (50. %) 4326 4287 (18.1 %) 4266	4445 (10.6%) 4416 4406 (59.9%) 4315 4300 (24.9%) 4252
25	Rzeszów 31	Poz-16473	5480±40	4358 (43.0%) 4324 4290 (25.3%) 4262	4443 (6.3%) 4420 4400 (2.5%) 4382 4372 (86.7%) 4249
26	Sandomierz 6/6	Poz-63725	5452±35	4344 (28.0%) 4322 4292 (40.3%) 4260	4356 (95.4%) 4244
27	Rzeszów 31	Poz-16474	5450±40	4346 (27.7%) 4319 4295 (40.6%) 4256	4361 (93.6%) 4237 4189 (1.8%) 4174
28	Sandomierz 6/6	Gd-2910	5450±100	4442 (4.8%) 4420 4398 (2.9%) 4382 4371(49. %) 4227 4196 (7.0%) 4167 4094 (4.5%) 4071	4493 (1.4%) 4471 4461(93.9%) 4044 4007 (0.2%) 4004
29	Świerszczów Kolonia 28	Ki-4193	5430±60	4347 (67.0%) 4240 4183 (1.3%) 4180	4440 (1.3%) 4424 4366 (73.5%) 4216 4206 (9.9%) 4158 4136 (0.7%) 4054
30	Sandomierz 6/6	Poz-62494	5420±35	4334 (19.3%) 4313 4301 (49.0%) 4251	4349 (90.2%) 4231 4194 (5.2%) 4169
31	Sandomierz 6/6	Poz-57821	5360±35	4320 (14.3%) 4294 4258 (18.6%) 4226 4198 (18.8%) 4166 4124 (3.6%) 4151 4096 (13. %) 4068	4328 (8.6%) 4283 4270 (47.7%) 4158 4137 (29.2%) 4054
32	Świerszczów Kolonia 28	Ki-4189	5350±50	4318 (8.5%) 4296 4256 (14.6%) 4222 4201 (17.0%) 4163 4131 (28. %) 4060	4330 (14.7%) 4282 4273 (80.8%) 4048
33	Sandomierz 6/6	Poz-62493	5300±35	4230 (19.2%) 4194 4168 (7.0%) 4154 4143 (28.0%) 4092 4078 (14. %) 4050	4246 (92.0%) 4042 4016 (3.5%) 3995
34	Tworkowa 20	Poz-47533	5200±40	4044 (68.3%) 3968	4224 (2.8%) 4199 4165 (7.4%) 4128 4101 (0.6%) 4100 4066 (84.8%) 3948

In order to more precisely determine the beginning and end of the phase in question, it was therefore decided to perform Bayesian modelling of the recently published series of radiocarbon dates from Lesser Poland (Zastawny 2022).

Several small changes have been made to the list of MC radiocarbon dates prepared by Zastawny (Table 1). From the list of 36 dates, 3 dates from the Las Stocki were removed

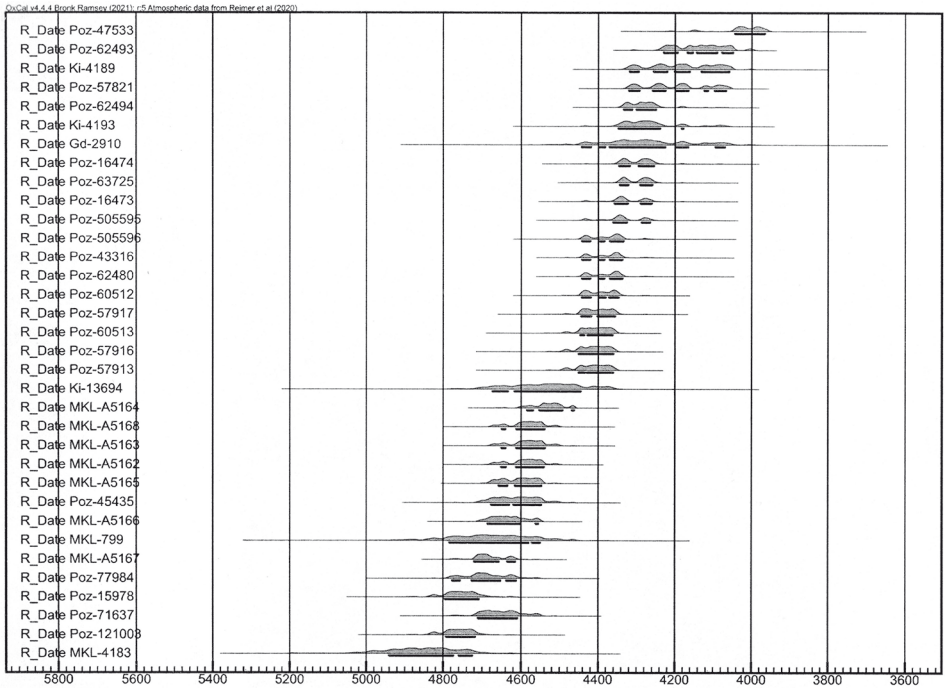

Fig. 2. Calibration of MC radiocarbon dates from Lesser Poland by the OxCal 4.4 package (Bronk Ramsey 2021)

due to their unclear relationship with the MC (Zastawny 2022, fig. 9). However, one date from the TRG core of biogenic sediments in Targowisko (MKL-4183 5960±80 BP) was added, which is clearly related to the functioning of the nearby MC settlement in its older phase (MC1a) at the Targowisko 11 site (Forysiak *et al.* 2021, tab. 1; fig. 4; Kadrow *et al.* 2022, tab. 1; fig. 11). In a few cases, the affiliation to a specific MC phase was also changed.

The indefinite complex from Aleksandrowice 2 was assigned (with hesitation) to phase Ia. The complex from Łoniowa 18, unspecified in terms of phase, was assigned to phase Ib. The assemblage assigned to the turn of phases (MC1a/1b) from Kraków-Olszanica 2 was qualified for phase MC1b. Two assemblages from Zakrzowiec 8, identified as phase MC1c, were qualified for phase MC1b. The unspecified complex from Kraków-Witkowice was qualified for the Rzeszów phase (MC2).

Therefore, 34 dates classified under three phases were sent for further analysis: early classic (MC1a) – 3 dates; classic (MC1b) – 12 dates, and late (Rzeszów–MC2) – 19 dates. Unfortunately, there are no radiocarbon-dated late classic (MC1c) assemblages (Fig. 2).

As a result of *Phase* modelling, time intervals of MC evolution within three phases were obtained (Fig. 3). The beginning of the MC and the beginning of the early classic phase

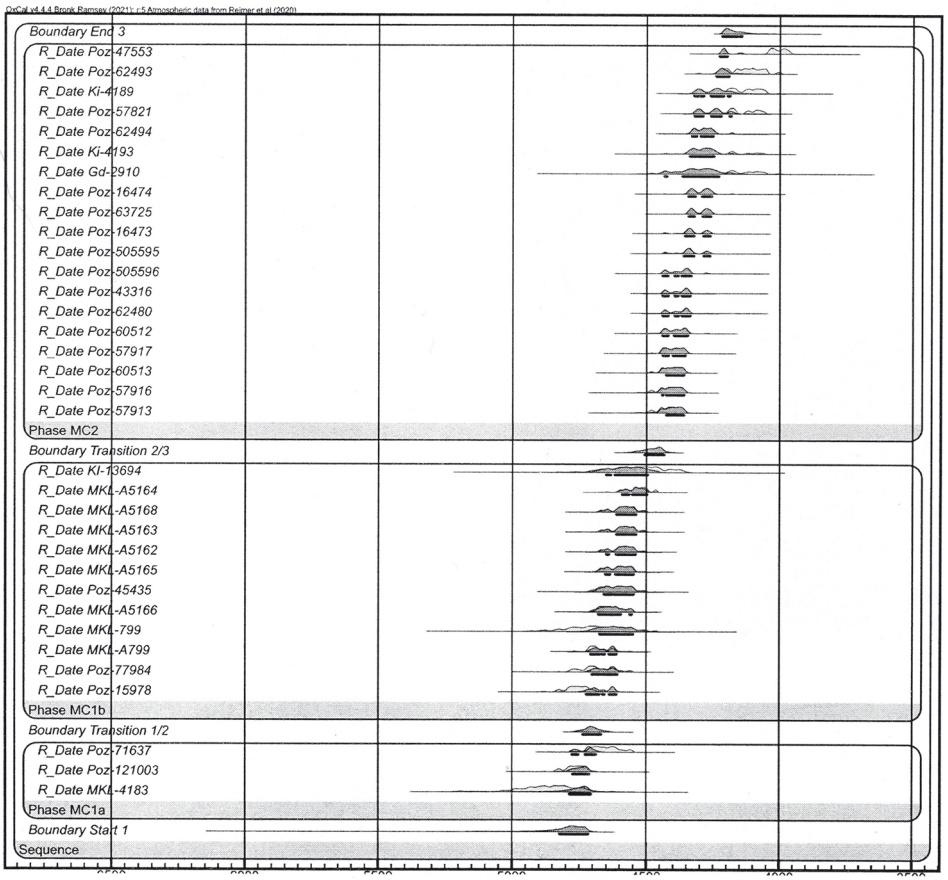

Fig. 3. Bayesian modelling of radiocarbon dates of MC phases in Lesser Poland by the OxCal 4.4 package (Bronk Ramsey 2021)

(MC1a) is marked by the *Boundary start* 4822-4717 BC or its median 4785 BC. The end of phase MC1a, and at the same time the beginning of phase MC1b, is marked by *Boundary Transition* 1/2, *i.e.*, the period 4736-4669 BC or its median 4703 BC. The end of phase MC1b and at the same time the beginning of phase MC2 is marked by *Boundary Transition* 2/3, *i.e.,* the period 4508-4435 BC or its median 4474 BC. The end of phase MC2 (late) and at the same time the end of MC is marked by the *Boundary end*, *i.e.*, the period 4220-4146 BC or its median 4184 BC. The obtained results are reliable due to the values of the compatibility parameters A_{model}=60.4 and $A_{overall}$=66.5 for the whole model. However, two single dates from the list demonstrate poor agreement (Poz-15978 A = 40,1% and Poz-47553 A=17,6%).

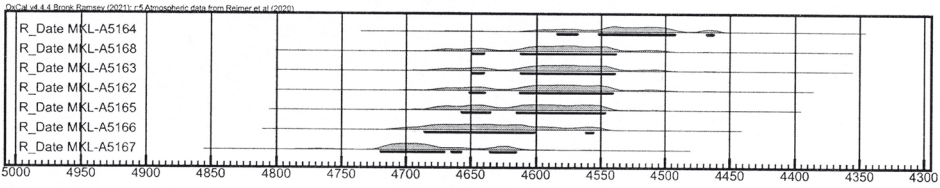

Fig. 4. Calibration of radiocarbon dates from MC house at Targowisko Site 14-15 by the OxCal 4.4 package (Bronk Ramsey 2021)

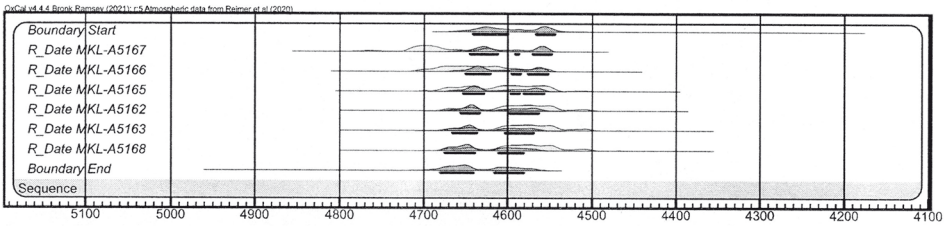

Fig. 5. Bayesian modelling of radiocarbon dates from the MC house at Targowisko Site 14-15 by the OxCal 4.4 package (Bronk Ramsey 2021)

The logic and dynamics of the succession of the development phases of the MC indicate that the late classic (MC1c) phase, which is not yet chronologically defined, should be included in the period 4550-4450 BC.

An unusual opportunity to precisely assess the chronology of the duration (use) of one house is provided by the analysis of seven dates from the MC house from Targowisko 14-15 (Fig. 4; Table 1). The samples for dating, in the form of charred grains, were taken from the fillings of pits which are relics of this house. It was located on the outskirts of the settlement. Only there could one expect to obtain material from one settlement phase, without the remains of older and younger phases, according to the observations of Ryszard Grygiel (1986, 273, fig. 3).

A series of seven dates of the MC house from Targowisko 14-15 (Fig. 5) was subjected to modeling a *Sequence* of events (Bronk Ramsey 2023). In this model, I assume, that charred grains, as samples for radiocarbon dating, represent selected events from the time of construction and use of the house. As a result of this modelling (Fig. 5), the period of residence of this house was estimated to have lasted from 4642-4545 BC (from *Boundary start*) to 4681- 4581 BC (*Boundary end* of the 1 sigma range). The medians of these parameters significantly narrow the duration of this period from 4643 to 4597 BC. The credibility of the quoted values is reduced by the compatibility parameter A_{model}=51.2, which is slightly lower than required, while the other parameter $A_{overall}$=64.8 is sufficiently high.

ABSOLUTE AND RELATIVE MC CHRONOLOGY

For the first time, the reason for distinguishing the early classic phase (MC1a – Fig. 6) of MC was the presence of pottery with a bulging neck in the pottery complex from Rzeszów Site 20 (Kadrow 1990b, 102; fig. 2: h, j; 3: g, h). The second reason was the registration of

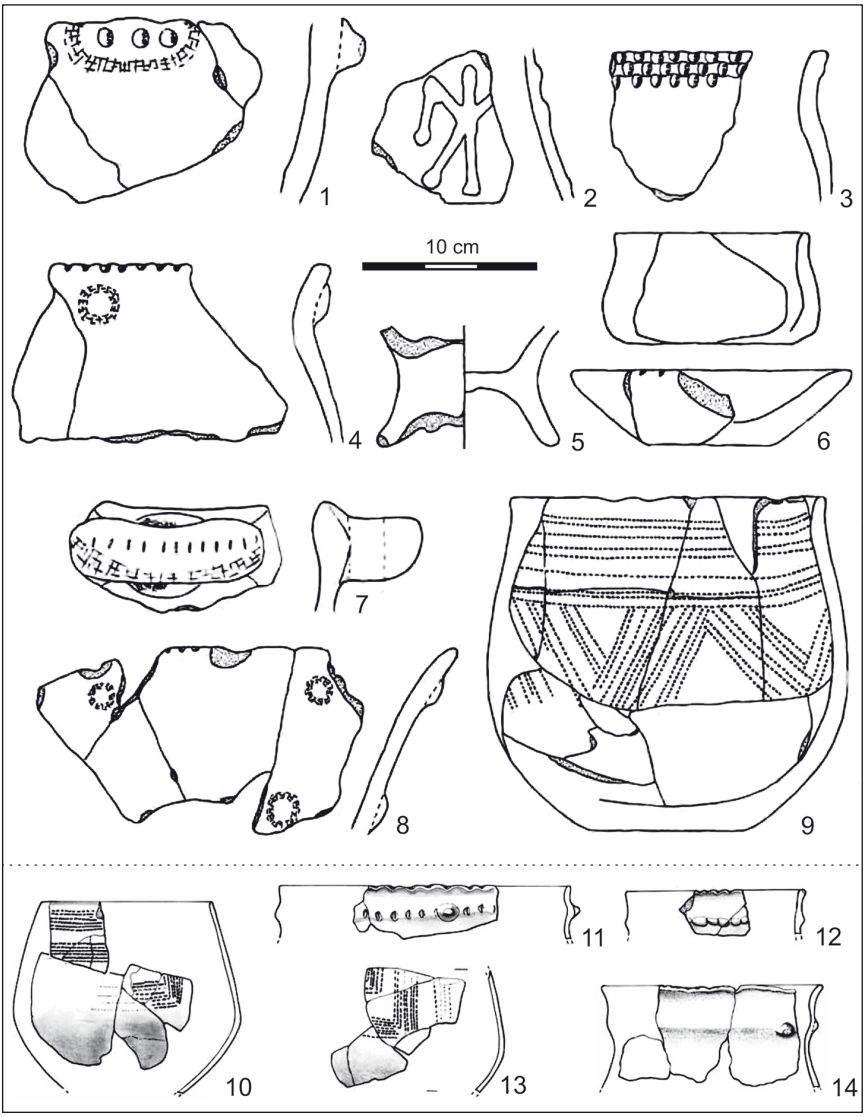

Fig. 6. Pottery characteristic for the MC1a (10-14) and MC1b (1-9) phases of MC; 1-9 – Targowisko Sites 14-15; 1-9 – Targowisko Sites 10, 11 (after Kadrow *et al.* 2022; Zastawny 2022)

a stroked ornament in the shape of a meander in the MC assemblages (Czekaj-Zastawny *et al.* 2002, 28-34; fig. 9). They were considered to be characteristic indicators of the Samborzec-Opatów group, which was considered older than MC, and synchronized with phase IVa of the *Strichbandkeramik* (hereafter: STK; Kaczanowska *et al*. 1986, 100-101). A good representative of the early classic phase of MC (MC1a) is the set of pottery from the feature 2271

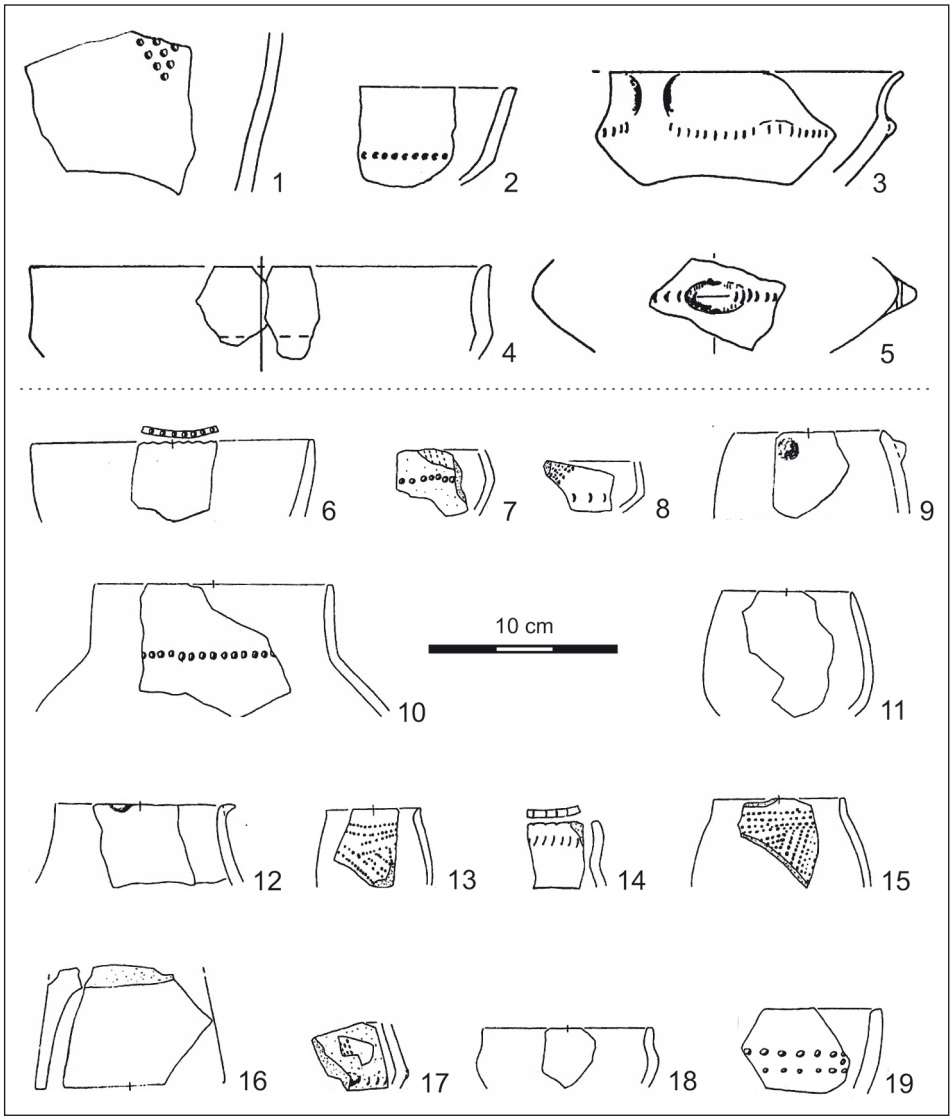

Fig. 7. Pottery characteristic for the MC1c (6-19) and MC2 (1-5) phases of MC; 1-5 – Rzeszów Site 24; 6-19 – Rzeszów Site 16 (after Kadrow 1996)

from Targowisko 10-11, which includes pots with a bulging neck and a meander ornament (Zastawny 2022, fig. 5: 11, 12, 15, 20). The set is dated Poz-71637 5800±35 BP. The early classical phase MC1a understood and dated in this way is an adequate context for the amphora with an anthropomorphic image from Targowisko 10-11, stylistically connected even with the older STK phase in Bohemia (Grabowska and Zastawny 2007, 128-132, figs 3, 8).

The classic phase of the MC (MC1b – Fig. 6) was defined half a century ago (Kamieńska 1973). It is represented by a fairly rich collection of pottery from the house at Targowisko 14-15 (Golański *et al.* 2021, fig. 19, 20) with seven ^{14}C dates (Table 1). The absolute chronology of this phase (4703-4474 BC) corresponds to phase II and, above all, phase III of the Herpály group, in which ceramics were decorated with white and red paint (Csőshalom stage) and white paint (Oborin I stage) applied after firing the vessel (Kalicz and Raczky 1987a, 30; Kalicz and Raczky 1987b, 124, 125, fig. 35). This is an adequate context for a pear-shaped cup decorated with white and red oil paint from Targowisko 12-13 (Golański and Kadrow 2022, fig. 11).

The specificity of the pottery assemblages from the cluster of features (No. 108) in Rzeszów Site 16 became the basis for defining the late classic phase (MC1c – Fig. 7) of MC (Kadrow 1990a, 70; fig. 11). Stroked ornament – very simplified – was then made only with a tool with spike with a round cross-section. In addition, ornamental threads consisting of round, shallow pits appeared, which has analogies in the pottery assemblages of the Proto-Tiszapolgár phase (Kalicz and Raczky 1987a, 27).

The definition of the late phase of MC (MC2 – Fig. 7) was completed only slightly later than the classic phase (*cf.*, Kamieńska 1973; Kadrow 1988; Kadrow and Zakościelna 2000, 204-208). The pottery of this phase is distinguished by a tendency to clearly profile the vessels, mainly bowls, and decorate them with deep punctures or round pits, similar to the Tiszapolgár culture. The absolute chronology of this phase of MC (4474-4184 BC) is very close to that of the Tiszapolgár culture (4420-4240 BC; Brummack and Diaconescu 2014, 254, 255, figs 4-9).

CONCLUSIONS

Thanks to the analyses performed above, we have come much closer to determining the sequence of MC development phases (Figs 6 and 7) and their exact framework in absolute chronology. The typological and stylistic relationships of the pottery confirm the synchronicity of the development of MC with the cultures of the Tisza basin. This will make it easier to understand the dynamics of changes at the turn of the Neolithic and Eneolithic in Lesser Poland.

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