ON SOME PROBLEMS OF INTERPRETATION OF PHYSICAL DATING METHODS RESULTS: AN EXAMPLE OF THERMOLUMINESCENCE DATING

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Abstract

It happens quite often that some absolute age assessments made by physical methods do not coincide with predictions based on archaeological information acquired during excavation and analyses of the findings. There may be numerous reasons for such discrepancy and erroneous results of physical methods can not be arbitrary excluded. However, the examples of comparison of TL and C-14 dates and other analyses, presented in this paper, indicate another possibility. Traditional methods, such as a ceramic typology or a stratigraphy, occur to be not sensitive enough to separate multiple phases of occupation of an archaeological site, for example. The present work supports this opinion by results obtained for several Polish sites covering time from the Middle Ages back to the Middle Paleolith and calls for a different approach to the problem of using absolute age estimates, produced by physical methods, in archaeology and other earth sciences.

1. Introduction

When the objects collected from archaeological sites, especially those with more complex stratigraphy and chronology, are dated by absolute physical methods, it happens that some results do not agree with the chronological frame established using traditional archaeological methods such as one basing on typological ceramic dating, for example. There may be numerous reasons for such discrepancy and erroneous results of physical methods can not be arbitrary excluded.

The examples of several sites, which are given below, show many instances of such disagreement: a sample from a particular horizon gives an age estimate which would rather place it in another, or a date lies somewhere between or outside the predicted limits. The most likely reaction is to reject a result which do not coincide with an earlier hypothesis. This may be justified in a case when only a single or few dates are available for a given site but the other side of the coin is that accepting a single or few dates compliant with a hypothesis may be equally unjustified.

In three examples, out of four presented below, a medium size sets of dates (about 5–15) obtained by two different methods, namely thermoluminescence and radiocarbon, were available. A larger set of 35 dates, obtained by the TL method only, was available for a Paleolithic site. The results of dating are compared with the chronology established by archaeologists.

In all cases samples were submitted for dating together with information regarding the stratigraphy position, cultural layer identification and ceramic typology (the last information regards ceramic samples only).

Radiocarbon datings were performed in the Gliwice Radiocarbon Laboratory (see for example: Abłamowicz et al. 1993; Pazdur et al. 1994a & b). Thermoluminescence

datings were performed in the Gliwice Luminescence Dating Laboratory by the author.

2. Results of dating

2.1. Early Medieval site in Wolin

The archaeological site in the town Wolin, on Wolin Island in north-west Poland, has a very well established chronology based on archaeological and historical evidence as well as on numerous radiocarbon dating results (Pazdur et al. 1994a, Pazdur M. F. – private communication). The ceramic samples were collected from one ditch positioned over the remnants of the early Medieval harbour and from one cultural layer belonging to the series covering the 9th – 10th centuries AD time span.

Results of TL datings of 8 ceramic fragments and 6 results of radiocarbon dating are presented in Fig. 1 in the graphic form and compared with archaeologist's expectations.

2.2. Pomeranian/Medieval site in Hańcki

The fortified settlement in Hańcki, north-east Poland, was extensively dated by means of radiocarbon method (Pazdur et al. 1993) but the results did not agree with an ar-

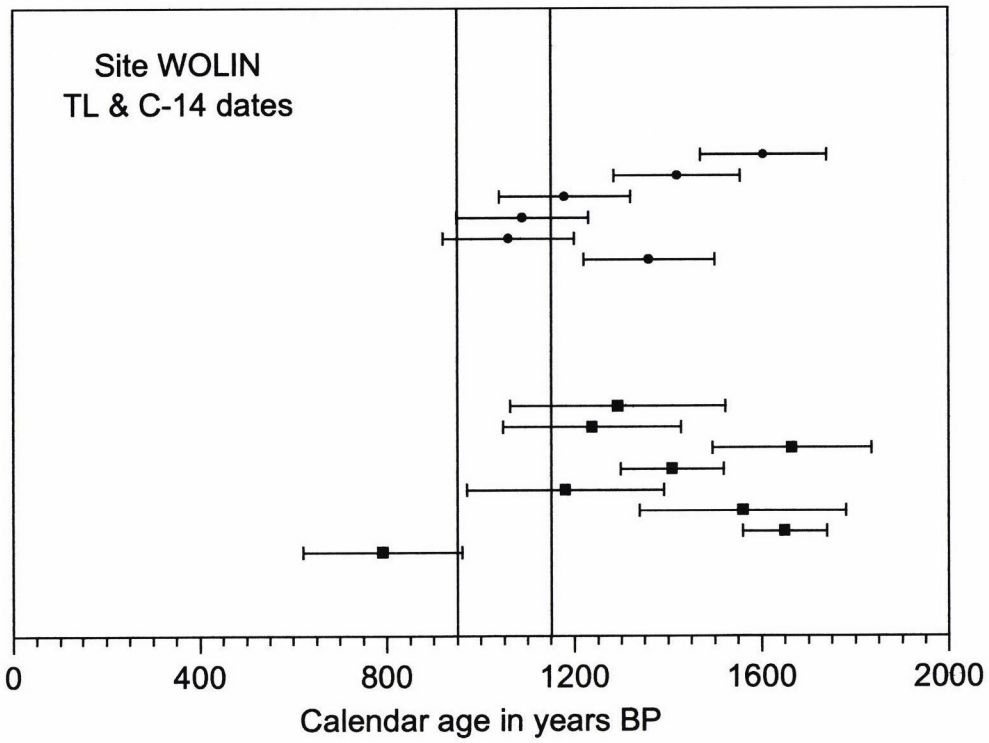

Fig. 1. Results of TL and C-14 (uncalibrated) dating for samples from Wolin. ■ – TL dates, ● – C-14 dates. The period of 9th and 10th centuries AD marked with vertical lines. (cf. Table 1 and 2).

chaeological interpretation. Additionally a set of 17 ceramic fragments was collected at the site in the collaboration with the archaeological team. Each fragment was immediately examined and typologically identified. Four fragments were identified as belonging to the Pomeranian culture (3rd – 2nd centuries BC; type P here), twelve were identified as early Medieval (6th – 7th centuries; type M) and one remained unidentified. Sixteen samples gave finally TL ages and nine of them showed a "double plateau" thus enabling double dating. Author interprets this phenomenon as reflecting the last two heating events in the ceramic history, the latter taking place at lower temperature and erasing only a part of a formerly acquired TL signal. This possibility is supported by clustering the low temperature plateau dates to the "normal" TL dates and to the new group around 1100 AD. Fig. 2. presents the results in a graphic form and compares them with archaeologist's expectations.

2.3. Lusatian/Medieval site in Kamieniec

The archaeological excavation site in Kamieniec, south Poland, consists of the Lusatian culture (Hallstatt period, stages C–D) settlement with the overlaying early Medieval fortified settlement.

The archaeological evidence indicated two main periods of occupation: the first prehistoric phase is represented here by the Lusatian culture settlement, archaeologi-

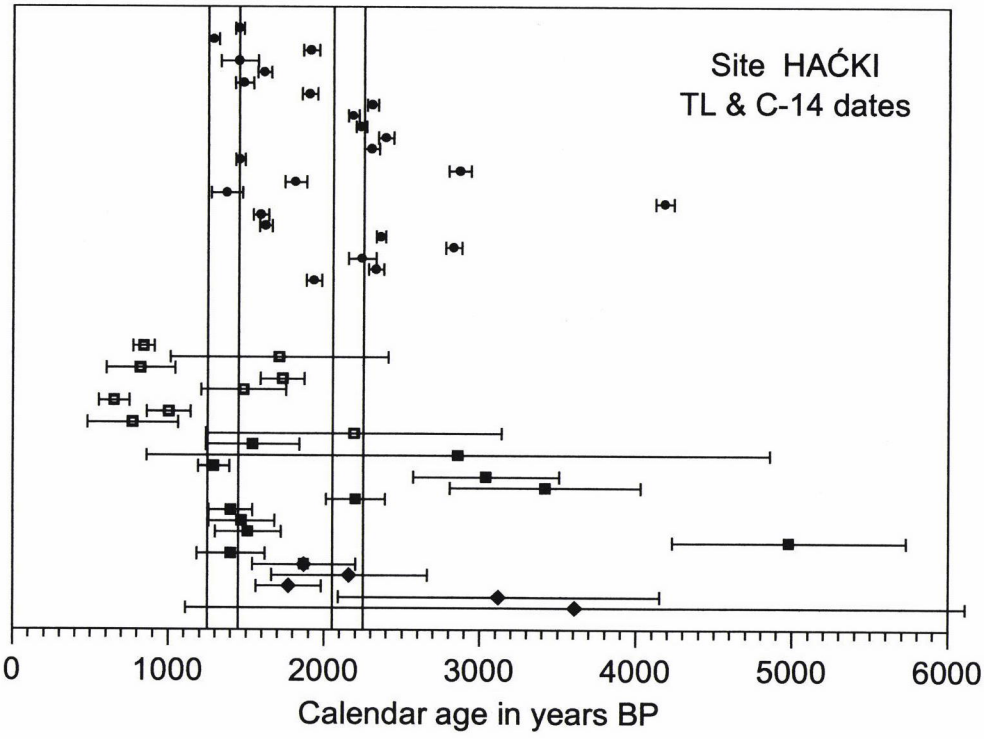

Fig. 2. Results of TL and C-14 (uncalibrated) dating for samples from Haćki. ■ – TL "M" dates, ◆ – TL "P" dates, ✱ – TL date for an unidentified samples, □ – low temperature plateau dates, ● – C-14 dates. Periods: 3rd - 2nd cent. BC and 6th - 7th cent. AD marked with vertical lines.

cally dated to 7th – 5th centuries BC (type L), and the second by the early Medieval stronghold archaeologically dated to 8th – 9th centuries (type M).

A collection of 13 ceramic fragments from the both cultural layers was sampled for thermoluminescence analyses and for 7 organic (wood and bone) samples radiocarbon dates were obtained.

Fig. 3. presents the results in a graphic form and compares them with archaeologist's expectations.

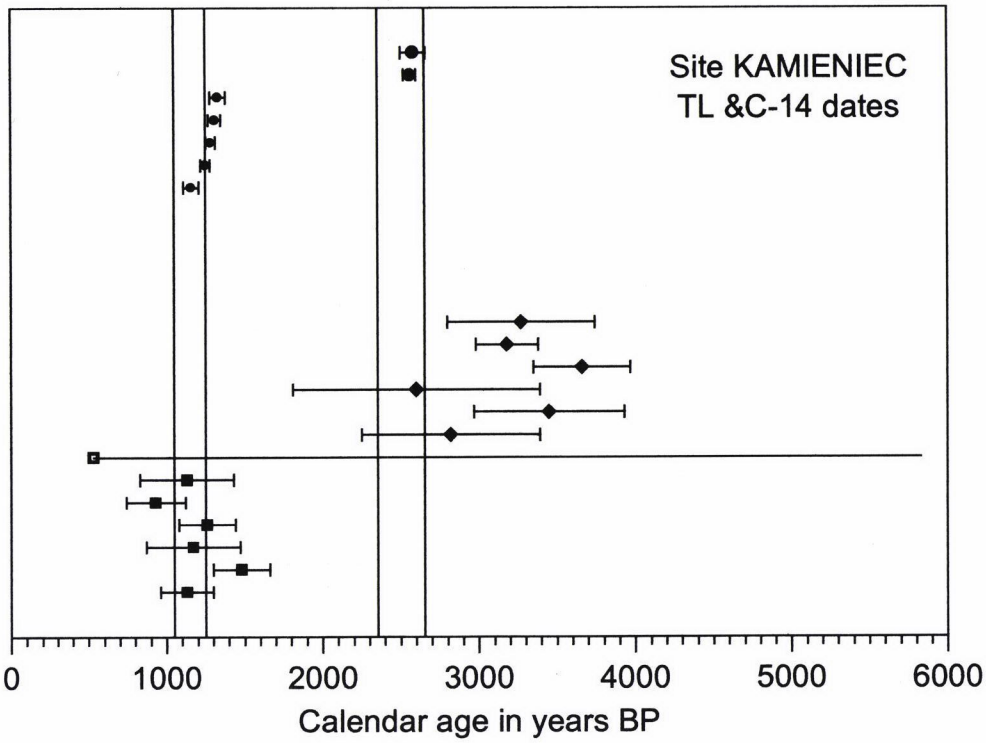

Fig. 3. Results of TL and C-14 (uncalibrated) dating for samples from Kamieniec. ■ – TL "M" dates (□ – an infinite age), ◆ – TL "L" dates, • – C-14 "M" dates, ● – C-14 "L" dates. Periods: 7th - 5th cent. BC and 8th - 9th cent. AD marked with vertical lines.

2.4. Middle Paleolithic slaughter site in Zwoleń

Excavations in the valley of the Zwolenka river, a small tributary of Vistula, at the eastern edge of the town Zwoleń revealed a Middle Paleolithic slaughter site with cultural layers rich in flint artefacts and animal bone remnants (Schild et al. 1988). The full stratigraphic profile exposed in the site ranges from the Oder glaciation sediments (a boulder clay) to alluvial sands and gravels associated with the maximum of Vistulian glaciation. The Paleolithic artefacts and bones are not suitable for the direct dating and thus geological sediments were collected and dated by the TL method. There were

35 samples collected altogether that yielded 34 finite dates and one infinite (an older-than) date. Results of TL dating are presented in a graphic form in Fig. 4, below. The diagram contains also information on an assignment of particular samples to identified stratigraphic units.

3. Discussion of results

In the above presented examples the predicted ages of samples submitted for dating based on an archaeological and stratygraphic evidence and very clearly a significant

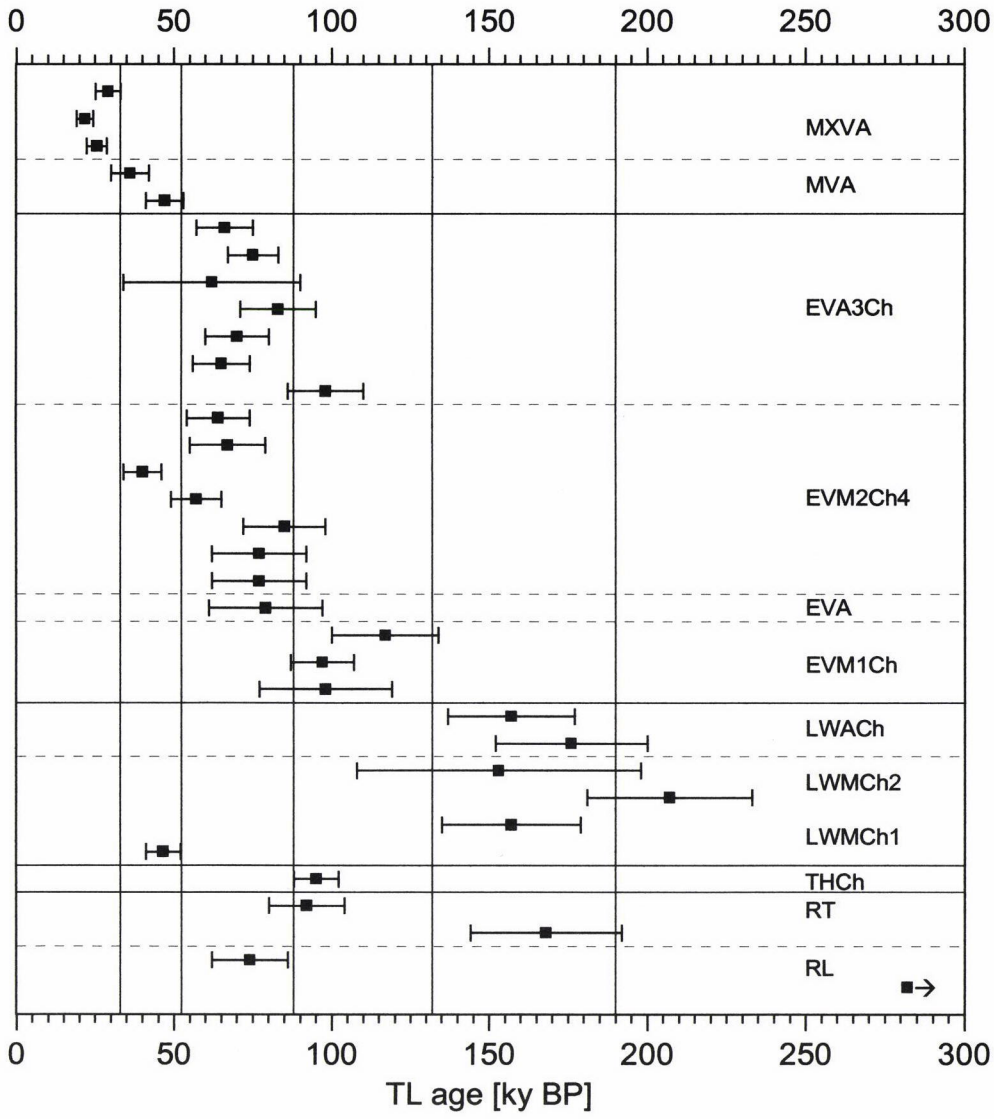

Fig. 4. Results of TL dating for samples from Zwoleń (finite ages). → – result GdTL-230 482±98 ka. Horizontal lines mark samples from the distinguished stratigraphic units. (cf. Table 7).

part of obtained dates do not agree with such predictions. In some cases the results of TL or C-14 datings were rejected or regarded as unreliable. On the other hand, in the case of three sites where independent TL and C-14 methods were applied, the correlation between results obtained by these two methods may be noticed.

To enable a more correct comparison of C-14 dates with absolute TL dates the former should be calibrated and converted to calendar ages. This was done using the original programme developed in the Gliwice Radiocarbon Laboratory (Pazdur, Michczyńska, 1989; with later changes). An output of this calibration programme for a single radiocarbon date (i.e., a date and an error) is, in the most general form, a distribution of probabilities of calendar dates from a certain range. A single TL result consists of a date and an error also, and may be similarly regarded as a calendar date probability distribution given by the normal (or Gaussian) distribution with the TL date as a mean and the TL date error as a standard deviation. Thus, the natural way of comparison of two sets of TL and C-14 dates consists in the comparison of cumulative date distributions resulting from summing up appropriate single date distributions. Corresponding cumulative date distributions have been generated for TL and C-14 dates quoted above and are presented in the graphic form below. TL dates are generally biased with larger errors than C-14 dates and a significant portion of a TL date error has a systematic character connected with procedures applied in a particular laboratory (a radiation source calibration, for example). These systematic errors which are the same for all

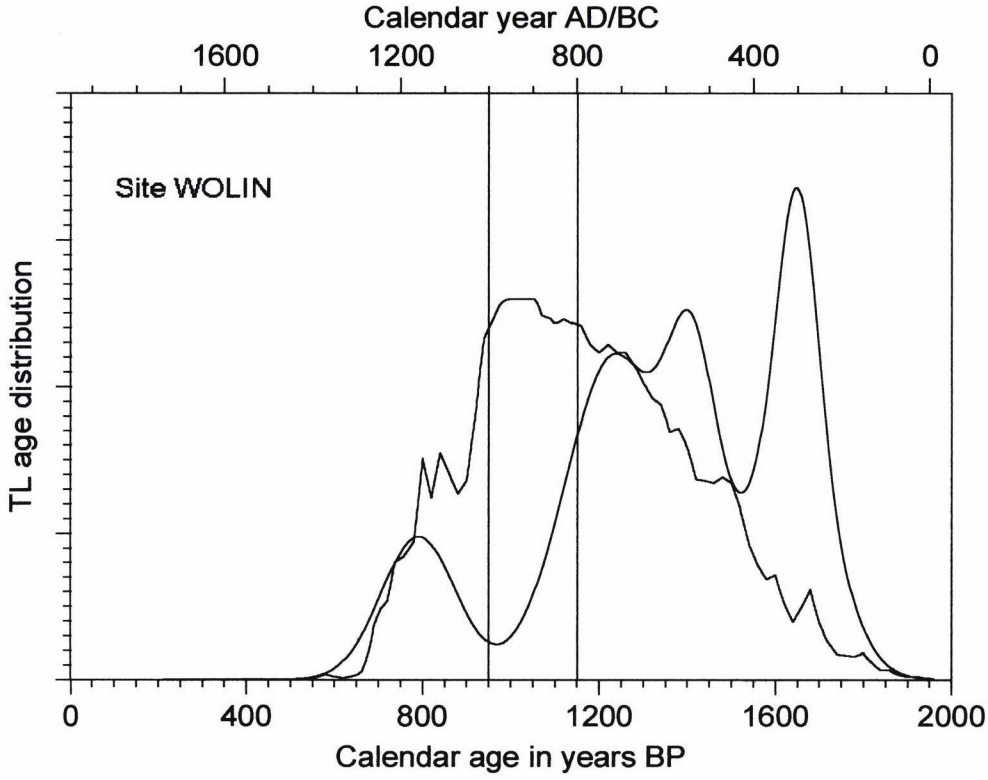

Fig. 5. Radiocarbon and thermoluminescence (smoother line) age distributions based on results obtained for samples from the site Wolin. There are 6 C-14 dates and 8 TL dates included in the plots. Vertical lines are limits of the archaeologically expected period.

dates from a particular laboratory, and constitute approximately 50% of a total error, obscure, to a certain extent, the structure of a cumulative distribution. To account for this the cumulative TL date distributions have been generated using errors reduced by 50%. The resultant distributions are presented in Figs. 5 to 8.

In the case of the site Wolin a maximum of C-14 age distribution coincides well with the period indicated by archaeologists for the set of cultural layers dated. The other C-14 dates indicate, probably, that the cultural layers contain a mixture of material coming from different periods. This picture is also supported by TL dates which generally agree well with C-14 except that not a single date falls within archaeologically predicted period.

For the site Haćki TL and C-14 age distributions match perfectly except the group of TL dates younger than ca 1000 years BP. There are five distinct periods indicated by both methods and only two expected by archaeologists. This is a clear evidence that traditional methods can not be used without an independent control provided by absolute dating methods and that some types of ceramic had been produced for much longer time than usually accepted.

This particular example shows also that apparently uniform cultural layer could be in fact a rich mixture of remnants coming from all periods of occupation of the site.

For the site Kamieniec the TL and C-14 distributions match well again and this time they also match with the archaeological frame. There is also a group of older TL

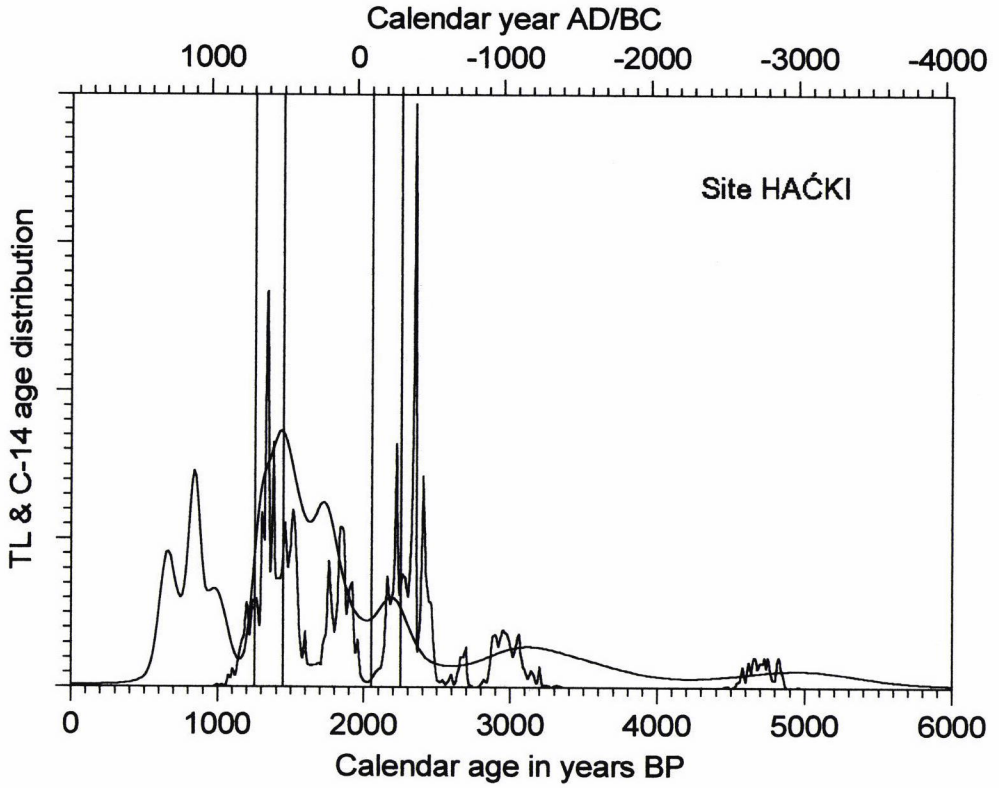

Fig. 6. Radiocarbon and thermoluminescence (smoother line) age distributions based on results obtained for samples from the site Haćki. There are 24 C-14 dates and 25 TL dates included in the plots. Vertical lines are limits of the two archaeologically expected periods.

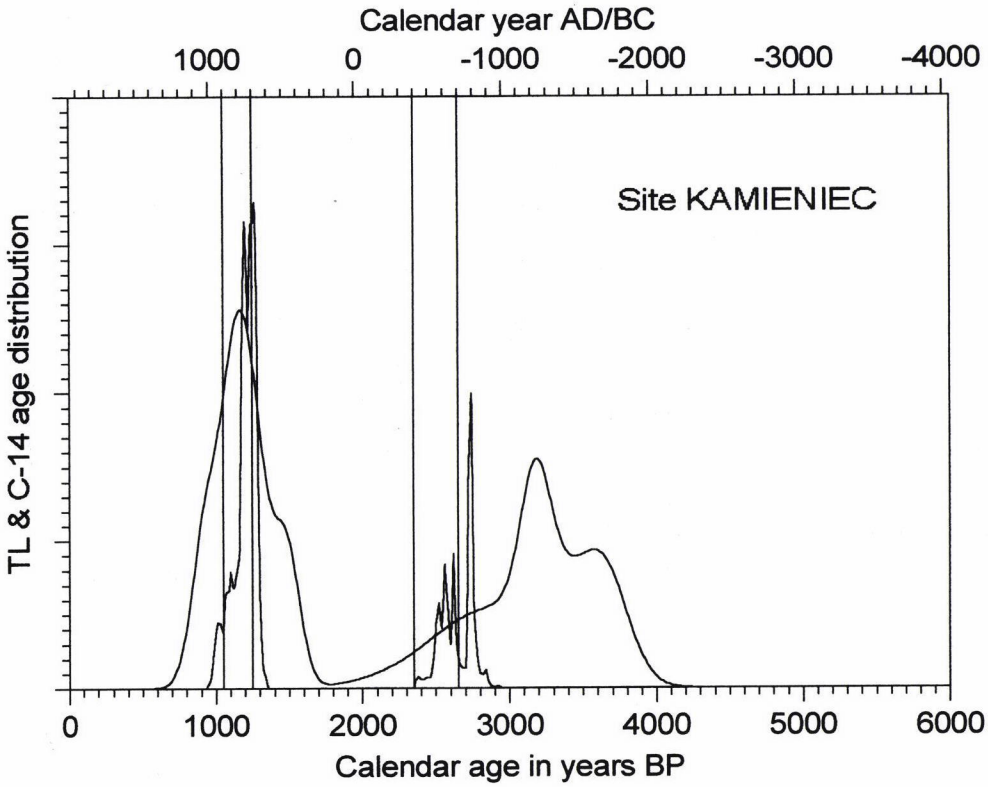

Fig. 7. Radiocarbon and thermoluminescence (smoother line) age distributions based on results obtained for samples from the site Kamieniec. There are 7 C-14 dates and 12 TL dates included in the plots. Vertical lines are limits of the two archaeologically expected periods.

dates indicating that the first occupation of this site could start earlier.

In the case of Paleolithic site Zwoleń only results of the TL method were available, thus there was no possibility to perform a comparison with another independent method. The general view is similar, though. There are several samples assigned to a certain unit that yield a TL age placing them in another one. Again, the distinguished units probably contain a mixed material of different origin.

The probability distribution of calendar dates obtained for ceramic samples may be interpreted as reflecting the intensity of human activity resulting in higher or lower production rates of ceramic wares and finally resulting in bigger or smaller numbers of ceramic findings. Two conditions should be satisfied to justify such an assumption. First, the number of dates forming the cumulative distribution should be big enough to support its statistical significance. Second, the ceramic sherds should form a random sample taken from the whole site. There may be some doubts about satisfying the second condition, because the ceramic pieces are usually chosen by the archaeologist according to his knowledge about the site. However, the a posteriori analysis of the dates indicates that the demand of randomness is met to a satisfactory degree. Thus the cumulative distribution maxima correspond to the past periods of intense habitation and the minima correspond to the periods when the site was deserted or used less intensively.

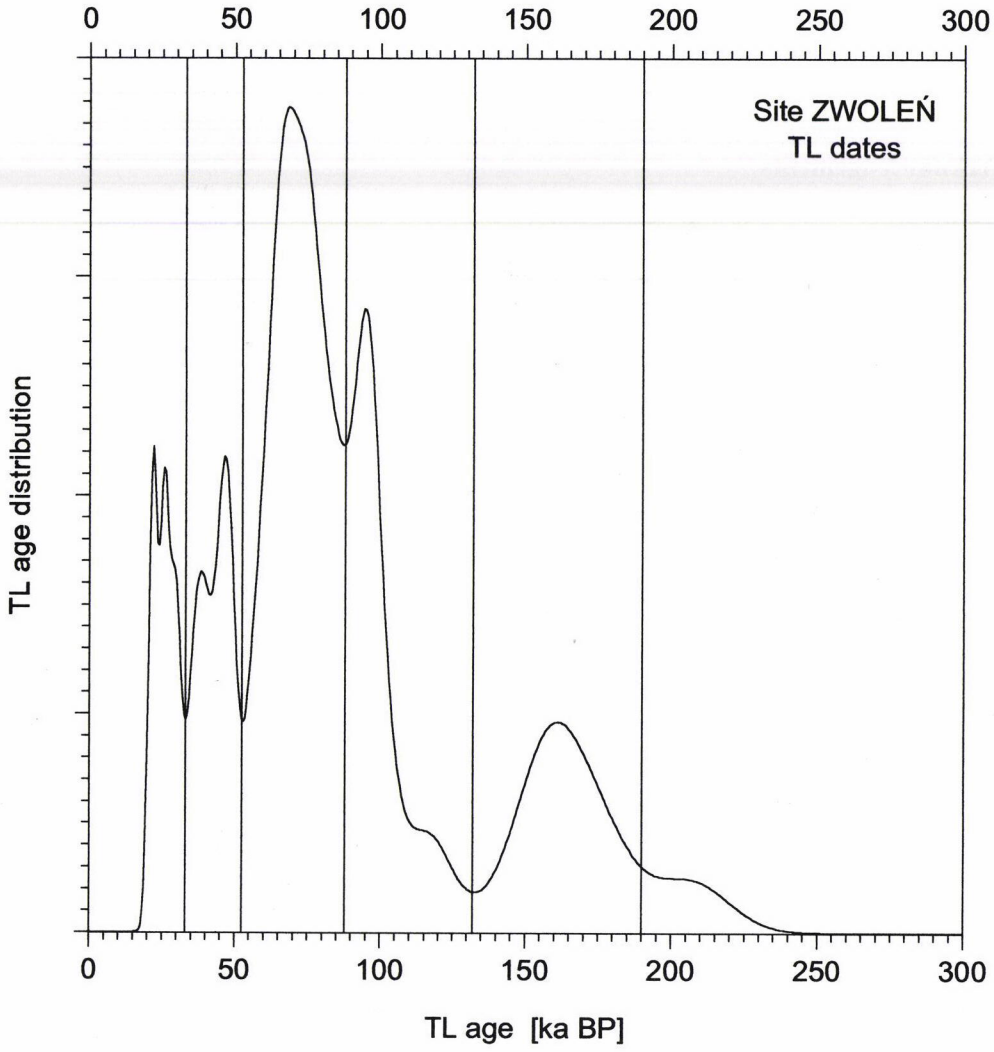

Fig. 8. A thermoluminescence age distribution based on results obtained for sediment samples from the site Zwoleń. There are 33 TL dates included in the plot. Vertical lines are limits proposed for the stratigraphic units.

4. Conclusion

For a long time archaeologists used to, and in some instances still do, apply physical dating methods to very few samples collected in the site. The examples given in this paper clearly show that no matter how carefully the samples are chosen they may "deceive" the archaeologist and the dates obtained may either lead to unjustified conclusions or be equally unjustly rejected when do not satisfy prior hypotheses.

The more competent approach should base on numerous datings of different samples and using different methods, whenever possible. The physical absolute dating methods can finally give much more precise age estimates for archaeological cultures than

the traditional dating can do, and enable independent verification and refinement of archaeological theories. This is specially important in cases of complex sites with multiple occupation events.

Acknowledgements

All the datings cited in this paper have been performed in the course of several dating projects carried out in collaboration with Polish archaeological institutions.

The author is greatly indebted to the late Prof. M. F. Pazdur, the former Head of the Gliwice Radiocarbon Laboratory, for co-operation and many valuable advises and discussions during the dating projects.

This work was supported with the KBN grant no. 6 P04E 026 10.

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