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PRELIMINARY DENDROCHRONOLOGICAL INVESTIGATION
IN ARCHAEOLOGICAL STAND ON "VEGETABLE MARKET"
IN SZCZECIN (POLAND)

INTRODUCTION

A few years ago, different branches of research began to co-operate, although they were not very familiar one with another. A typical example is archaeology, which deals with many aspects of material remains of past human life and activities. Archaeologists establish the dates of archaeological objects and use in addition to methods of geology, atomic physics and chemistry, also certain methods of dendrology. These aspects of dendrology should be more correctly described as a particular branch of science concerning the growth rings of trees, and have created a new subject — dendrochronology as an aid to archaeology. The use of dendrochronology in the dating of archaeological objects has made it possible to achieve accuracy almost to one year — a degree formerly impossible.

Dendrochronological methods were used several decades ago; but in the last twenty years they have become common. Now, almost every country has many reasons for applying dendrochronological methods, particularly in archaeology and climatology. Dendrochronology as an aid to climatology is still under discussion but can already be applied in the preliminary stage. Dendrochronology as an aid to archaeology is commonly used and has many supporters. By applying these methods in archaeological excavations, it is possible in certain specific regions for archaeologists to place exact historical dates many centuries back.

In Poland, dendrochronological methods were known by archaeologists before the Second World War. In 1938, a several sections of trunks were sent from Biskupin excavation to Professor G. de Geer in Stockholm.¹ These sections were in part used by Mrs. E. de Geer in order to compose a chronology and compare the growth rings of these trunks with sequoias from California, U.S.A.²
In 1962, on the suggestion of the Polish Academy of Sciences Institute of the History of Material Culture, directed by Professor Dr. Witold Hensel, dendrochronological methods were introduced to archaeological research in Poland. This research was undertaken by the Department of Botany of the Central School of Agriculture in Warsaw and sponsored by the Central Laboratory of the Institute of the History of Material Culture.

The first need was to examine the methods applied by different schools of dendrochronologists, and to choose from among them the most suitable to the tree rings of trunks from Polish archaeological excavations. This phase of work was executed. Ten trunks were examined from the oldest layers of the material remains of past human life and activities taken from the Szczecin “Vegetable Market” archaeological site. Some of the results are presented in the present paper. But before discussing these results, it may be useful to refer to Polish investigations into problems concerning the influence of ecological factors on tree growth.

CLIMATE AND TREE GROWTH

The most important influence on tree growth may be earthliness factors. Such factors potentially exist as sunspot cycles which appear periodically. But so far, in spite of many investigations, the controversy between conflicting opinions as to whether or not there is interdependence between the sunspots and the growth of trees has not yet been resolved. Considerable research undertaken in the U.S.A., Sweden, Germany, Finland and Switzerland seemed to prove such dependence, but other similar investigations undertaken by other dendrochronologists seemed to deny such dependence between sunspots and tree growth.

In 1951, similar research was undertaken in Poland. This investigation showed that the growth of trees does in part depend on sunspots, but is also in part independent of such. This investigation constitutes an important contribution to the problem of the dependence of tree growth on sunspots, and it may probably be assumed to be almost correct and suitable for use in determining results. Fifteen trunks of Norway spruce (Picea excelsa /Lam./ Link) from the Tatra Mountains — Kościelisko district — which were over a hundred years old, were used for research. As regards fifty-nine years of their growth, they demonstrated a relationship between sunspots and tree rings; but as regards thirty-two years of growth there was no relationship at all. The intensity of sunspots as in Wolf’s curve was compared directly with the second
Fig. 1. The comparison of the curves indicates the fluctuation in a number of sunspots as in Wolf’s curve with the second curve which indicates the fluctuation of sizes of tree rings of 15 trees of Norway spruce from the Tatra Mountains. (After K. Ernich and J. Mergentaler, 1953)

The thickness of the tree rings in millimetres from 1856 to 1872 and from 1931 to 1946 shows the agreement of the two curves. From 1875 to 1887 and from 1890 to 1901 the agreement of the two curves was not so clear. There was an agreement of both curves for 39 years, but there was no agreement for 32 years

curve, which expressed the sizes of tree rings (fig. 1). The authors concluded that it was possible to correlate the two curves for all the fifteen trees, but such correlation involved indirect factors such as temperature and rainfall. They further concluded that the correlation between sunspots and tree rings may be markedly obscured by such local factors as microclimate or soil of the specific small area where the trees investigated were growing.

It has been proved by numerous meteorological investigations, that the geoadvctivity of the Sun has a marked influence on the shape of the macroclimate of the Earth. This of course, does not mean that the appearance of the sunspots bears a direct relationship to an exact correlation with rainfall or temperatures. Meteorological investigations have proved that this correlation is often local as regards both temperatures and rainfall. For example, in Germany the years with the maximum of sunspots usually have the coldest winters, but in the tropical regions, the years with the minimum sunspots have particularly warm summers. In general, it can be said that the years with maximum sunspots usually have higher temperatures, and years with minimum sunspots have lower temperatures.

But the same cannot be said of rainfall; here, the problem is more complicated. Baur reported that in Middle Europe, moist and very moist years frequently appear one year before and one year after the extreme sunspots. Z. Kaczorowska found that this statement is only partly true for Poland. She also found that usually in Poland the occurrence of very dry summers has been observed only in two years before, and very moist summers in one year after the extreme sunspots.
The relationship between sunspots and different elements of climate is highly complicated, as has been demonstrated in numerous publications. But the relationship between the sunspots and sizes of tree rings is much more indirect, and complicated; it is very difficult to ascertain any direct relationship between them. Nevertheless, all these factors contribute to the size of tree rings and cause some aperiodicity, even in such climatic conditions as those in Poland. This means that the size of tree rings can be used as an aid to chronology, but in order to understand the formation of tree rings investigators should have a knowledge of biology. Investigations into the influence of solar climate on the size of tree rings lead directly to investigations of the processes of the formation of sizes of tree rings, by way of climatic elements (i.e. a macroclimate — primarily rainfall and temperature).

A certain number of investigations into the influence of climate on the formation of the sizes of tree rings have been made in Poland.

Climate in Poland, as in other regions of the world, undergoes continuous aperiodical changes. For example, in the year 1092 there were very tragic incidents in Polish forests; fires damaged most forest areas owing to scarcity of rainfall with consequent drying up of vast areas. Długosz reported in his Chorographia that in 1412 there was an unusually warm winter and in 1473 there was drought, and that all rivers dried up. For this reason, fire damaged large areas of forest. But very often such disasters were common only in certain parts of the country. For example, in 1118 Western Europe and Poland are recorded as having suffered great floods, but in the East of Europe there was a severe drought. And in 1221—1223 there were low temperatures and considerable rainfall in Poland and Western Europe, while, in 1279 and 1282 the opposite occurred; Poland and the East of Europe had the same temperatures, and in the West of Europe there were very high temperatures. Climatic conditions in Poland were sometimes the same as those in the West of Europe and sometimes the same as those in the East of Europe.

Such unusual years are well marked on tree rings and are very important in dendrochronological methods. In his unpublished investigations into the influence of very cold winters on the growth of trees, J. Tumiłowicz pointed out that different species of trees react in different ways. For example, the Eastern hemlock (Tsuga canadensis L. Carr.), and Silver fir (Abies alba Mill.) during the years of severe winters add very narrow tree rings, but in the same cold winters the Northern white cedar (Thuja occidentalis L.) were not marked so well; and in European larch (Larix decidua Mill.) and White pine (Pinus strobus L.) the years with very cold winters were not marked at all; the size of
tree rings were almost unchanged. Thus different species of trees may react differently to the same meteorological factors.

Nature's record of the history of the effect of climate on tree rings may reveal a great deal of the history of a certain community, which in those times was more dependent on nature. Thus dendrochronology may, in its service to archaeology, make a marked contribution not only to dating; for such further application, however, dendrochronology has to be greatly developed.

Immediately after the Second World War, W. Zinkiewicz in Lublin (Poland) investigated in connection with climatic conditions nine trunks of pine which were growing on dunes. From this investigation, as the author concluded there is no direct relationship at all between tree rings, temperatures and rainfall. Unfortunately, sections for this investigation were taken only from a very low part of the trunks, 20 centimetres above the level of the ground. Individual deformations of tree rings in this part of the trunks cannot represent the growth of trees. Zinkiewicz's investigations are not comparable with other similar researches; usually, sections for such research should be taken at least 1 metre above ground level. In spite of using such sections, the author of this publication established a relationship between the minimum rainfall, minimum temperatures and tree rings. For example, in 1940 and 1941 there were particularly low monthly temperatures and also the rings of the trunks examined had shrunk to a marked degree. The climatic conditions and the growth of trees for the period of seventy-two years were investigated and it was found that the year 1942 had the minimum rainfall and particularly small tree rings. From the W. Zinkiewicz's investigation emerged an important conclusion for dendrochronology: The large yearly differentiations in temperatures and rainfall are marked very well in tree rings even in those low parts of trunks, slightly above ground level, which are easily deformed.

In 1953, K. Ermich investigated the relationship between climatic conditions affecting tree rings in the Tatra Mountains. He was investigating three species of trees: Silver fir (Abies alba Mill.), Norway spruce (Picea excelsa /Lam./ Link.), and European larch (Larix decidua Mill.). As regards a period of thirty years he compared tree rings of these trunks with the records of the Zakopane meteorological station. The statistical elaboration performed by that author proved the influence of meteorological factors on combined action; in spite of the interrelationship with other factors, the influence on the growth of trees was notably dominated by meteorological factors. He stated that it is impossible to ascertain in such investigations the marked relationship expressed by high value correlation coefficients. This, he contended, was caused
by complex interaction of the factors referred to above. Therefore, the relationship between tree rings and meteorological elements is always more or less distorted.

Growth of trees depends on the environmental condition of a site. Trees which grow in suitable environment show a more marked correlation between tree rings and fluctuation of meteorological factors than when they grow in an unsuitable environment. Sizes of tree rings and their annual changes faithfully represent the fluctuation of climate only in those trees which are grown in suitable ecological environment and are biologically vigorous, healthy and resistant to effects of incidental factors. In such circumstances, climate could undoubtedly dominate over other outside influences. Trees which are growing in unsuitable environment develop poorly and cannot resist attacks of either fungi or insects, but every tree is attacked by insects or fungi in different ways. Thus, a curve representing sizes of tree rings reflects of many different factors. In addition to factors, such as macroclimate, operative over a large area, the growth of trees is influenced by other factors such as the phytosociological condition inside the forest, insect pests and fungi, fires, seed years; moreover, different species, and even trees of the same species, may grow variously owing to genetical factors. These factors are much more important in the temperature zone where decisive and constant domination of a single meteorological factor is lacking, than in any other climatic zone; for example, in arid and semi-arid regions, rainfall determines the size of tree rings, while in the Arctic zones it is determined by temperatures.

METHODS AND MATERIALS

The growth of trees has already been described by many scientists. In general, the rules of the growth and development of trees are well known, but most of the theoretical investigations in connection with sizes of tree rings can in dendrochronology be employed only in part, because the size of tree rings has been investigated for forestry purposes only in classes which include the growth of five or ten years. All yearly variations are levelled out by the arrangement of tree rings by classes, and summarising the growth of trees over a particular period illustrates the effect on growth of silvicultural intervention on various ecological environments. These research results are not applied in dendrochronology, because they are not reflected year by year on the formation of sizes of tree rings. Thus dendrochronologists have to conduct their own form of research into processes of the yearly formation of tree rings.
This new research should be developed on the basis of the achievements of the science of measuring the growth of trees.

We cannot to any great extent simplify the method of dendrochronology in the temperate zone, where sizes of tree rings depend on many different interlocked factors, such as soil, temperature, moisture, the presence of other trees, insects, etc. In this zone, every one of those factors may cause narrow tree rings. And in such circumstances it is necessary to find a precise method of examining tree rings. Probably, such a method is the application of the half-logarithmic curve.

The method of the half-logarithmic curve is well known in nomography and was introduced in 1942 by a German botanist, Huber undertook research concerning the measuring tree growth. This method of the half-logarithmic curve depends on the years of growth of trees which are marked arithmetically on a horizontal line in a millimetre scale, while the sizes of tree rings are marked logarithmically on a perpendicular line on the millimetre scale. This method is very easy to operate if suitable half-logarithmic lined paper is used.

A half-logarithmic curve has many advantages in dendrochronology as used to assist archaeology. We know from what has been said already concerning the theoretical basis of dendrochronology that trees always, and over their whole length, react sharply to thermal or rainfall disasters. W. Zinkiewicz's investigation proved also that in spite of the lack of direct relationship between tree rings and climatic factors, the years with unfavourable temperatures and rainfall showed narrow tree rings. This investigation (in spite of the use of a very untypical section of the trunk — 20 cm. above ground level — demonstrated that all trees reflected meteorological minimum by way of more or less explicit narrow tree rings. This research proved once more the thesis commonly accepted by dendrochronologists to the effect that the smallest tree rings rather than the large or medium ones are the most important for dendrochronology. Rapid increases in the sizes of tree rings can be caused by a rapid improvement in the ecological condition for a single tree, but a decrease in the sizes of tree rings is not generally caused by rapidly deteriorating growth conditions of a single tree. If we have to choose between large and small tree rings, it is of course better to choose the small. A half-logarithmic curve magnifies small tree rings and levels the large ones, tendency therefore to reduce the curve of tree rings to a more straight line. Such a curve may level out the influence of tree age, since tree rings are usually larger in the early stages of growth. Thus a half-logarithmic curve for the deformation of tree rings is deliberately presented in order to emphasize the small ones.

In dendrochronological investigations now being conducted three
methods are applied: (i) to draw a curve of tree rings in an arithmetical millimetre scale; (ii) to draw a curve of tree rings in a half-logarithmic millimetre scale; and (iii) to draw tree rings plots called skeleton plots, as used by Douglass. The next phase of investigation is to look for analogical parts of curves for cross-dating and to build up a chronological sequence. Such an examination of the same trunks in several different ways makes it easier to eliminate errors, which are the result of double rings and partial or total absence of some rings. These three principal methods are particularly important in comparing trunks of the same period or from the same stratum.

Archaeologists in the U.S.S.R. in their dendrochronological investigations also apply several methods concurrently. Rudakov proposed to introduce into dendrochronological investigations the coefficient modulus of tree rings. This coefficient modulus depends on the calculation of sizes of tree rings according to the pattern \( M = \frac{a}{b} \times 100 \), where \( a \) is the current size of tree rings, and \( b \) — the average size of tree rings for the entire period of tree growth. Such calculated sizes of tree rings are free from minor or major inaccuracies and better express true differences. Such calculations indeed have many advantages, but are very complicated and when dealing with a larger quantity of material would be very difficult to execute. If we are very familiar with the rules of the formation of tree rings and the way to apply them in dendrochronology as an archaeological aid, it will probably not be necessary to correct the sizes of tree rings by way of calculation of the coefficient modulus and certainly the labour involved will be unproportionate to the benefit occurring. If we have a lot of trunks, it is more to the purpose to cut out more sections and measure the tree rings in many various directions than to spend a lot of time in complicated arithmetical calculations. Moreover, for a few sections cut out, the calculation would be easy, but for numerous sections the calculation takes much longer unless an electronic computer is used. Rudakov's methods may also be used as a fourth method in the elaboration of sizes of tree rings.

Dendrochronological methods discussed by Rudakov and Kolčin are correct, but the question arises as to which of the methods should be applied to any one particular archaeological stand, and to which trunks? For example, Rudakov has stated that size of tree rings of different species cannot be compared. He is right in certain circumstances — that is, when sizes of tree rings are compared directly as figures. But we know also, that most native species react in the same way to ecological factors which form the sizes of tree rings. Decreases or increases in the
sizes of tree rings in several species of trees run parallel. Sizes of tree rings in such species can be compared, but before comparing them, we have to find out how those species react to lack of water or very low temperatures. If increases and decreases in sizes of tree rings of several species of trees run parallel, it would be difficult to conclude that these species do not react similarly to the same environmental influences on tree growth. Ermich’s investigations on the relationship between tree growth and climatic conditions in the Tatra proved that Silver fir (Abies alba Mill.) and Norway spruce (Picea excelsa /Lam./ Link.) or European larch (Larix decidua Mill.) do react similarly. Tumiłowicz stated in the report on his investigation that one species will react very sharply to a severe winter, others less, and some do not react at all.

Rudakov was undoubtedly right when he pointed out that we cannot judge climate from the tree rings of different species of trees. But dendrochronology as an archaeological aid is applied on tree rings only in the identification of the growth period of trees, and it suffices to conclude that these species of trees react similarly. It is to be deplored that but little research has been undertaken as regards the growth of tree rings in connection with different ecological factors. But all investigations pursued in this matter of dendrology are of value. Even so, problems concerning the effect of ecological factors on tree rings cannot be resolved by the examination of archaeological trunks. Many interesting and conclusive materials concerning the application of dendrochronological methods may enable a precise analyses of tree rings on different species of trees which grow in different ecological areas. But such investigation can determine only which is the best method. Unfortunately such research will not be pursued by scientific forestry concerning the growth of trees because foresters are mainly interested in the examination of the influence on tree growth of those factors which can be controlled by man.

Several trunks from the archaeological excavation of the “Vegetable Market” were investigated in the Old Town of Szczecin with a view to examining dendrochronological methods on Polish materials. This excavation has thirty-three strata and is about ten metres deep. In the oldest of stratum was preserved an old Slav ship, probably beyond repair and abandoned on the shore of the River Odra where sand engulfed it. It happened that after several years the population increased and more houses were built on the bank of the river. The thirty-second stratum contained remains of houses. The material for investigation was taken from several strata — from thirty-three to twenty-eight, but the material is not extensive. There were only a few beams, including two which were particularly important. One of the beams is assumed
Fig. 2. The chronological sequence of curves illustrates trunk from the stratum of XXVIII to the stratum of XXXIII of the excavation of "Vegetable Market" in the Old Town of Szczecin. (The curves are drawn in arithmetical and millimetre scales)

A: oak trunk from the stratum of XXVIII; B: elm trunk from the stratum of XXX; C: alder trunk from the stratum of XXIX; D: alder trunk from the stratum of XXX; E: birch trunk from the stratum of XXVIII; F: oak trunk from the stratum of XXIX; G: birch trunk from the stratum of XXXI; H: birch trunk from the stratum of XXXII; I: birch peg from the stratum of XXXIII which served probably for tying the ship; J: oak trunk found inside the ship in the stratum of XXXIII
Fig. 3. The chronological sequence of curves illustrates trunk from the strata of XXVIII to XXXIII of the excavation of "Vegetable Market" in the Old Town of Szczecin. (The curves are drawn in a half-logarithmic millimetre scale)

A: oak trunk from the stratum of XXVIII; B: elm trunk from the stratum of XXX; C: alder trunk from the stratum of XXIX; D: alder trunk from the stratum of XXX; E: birch trunk from the stratum of XXVIII; F: oak trunk from the stratum of XXIX; G: birch trunk from the stratum of XXXI; H: birch trunk from the stratum of XXXII; I: birch peg from the stratum of XXXIII which served probably for tying the ship; J: oak trunk found inside the ship in the stratum of XXXIII
Fig. 4. The chronological sequence of the skeleton plots illustrating trunks from the strata of XXVIII to XXXIII of the excavation of "Vegetable Market" in the Old Town of Szczecin

A: oak trunk from the stratum of XXVIII; B: elm trunk from the stratum of XXX; C: alder trunk from the stratum of XXIX; D: alder trunk from the stratum of XXX; E: birch trunk from the stratum of XXVIII; F: oak trunk from the stratum of XXIX; G: birch trunk from the stratum of XXXI; H: birch trunk from the stratum of XXXII; I: birch peg from the stratum of XXXIII which served probably for tying the ship; J: oak trunk found inside the ship in the stratum of XXXIII
to have driven firmly into the ground for the purpose (probably) of mooring the ship and the other was found inside the ship. It was thought that these two beams might help to determine the period in which the ship was used and the time when it was condemned. The other beams might help to determine the period when a river existed and the time when there were houses.

Many of the beams collected were rejected because they were from very young trees. Of the twelve that were left for investigation, two were later rejected after measuring the sizes of tree rings. A few beams used for the investigation belonged to deciduous species as follows: three oak beams (*Quercus* sp.), four of birch (*Betula* sp.), two of alder (*Alnus glutinosa* L. Gaertn.) and one of elm (*Ulmus* sp.). These beams were partly deformed by the compression of a thick layer of soil; thus, they were measured in several directions in order to restore the sizes of the annual tree rings of the beams.

Every tree ring was measured under the microscope with a micrometer magnifying fifty-times so that it could be seen without doubt whether the tree rings were normal or abnormal. Measurements were also made of the microsections in the directions of a few xylem rays. Units of micrometers were used for all mathematical calculations of tree rings. The average sizes of tree rings were also ascertained in these units. These average sizes of tree rings were drawn on a millimetre paper as actual sizes; thus on the millimetre paper were obtained.
graphically the actual sizes of tree rings. In this way, the result was ascertained more accurately, because all calculations were performed in large figures.

After the curves had been drawn and analysed in an arithmetical scale, they were all passed on for further research. The next step was to draw curves in a half-logarithmic scale and skeleton plots. After the curves and the skeleton plots of all the trunks had been obtained, they were correlated by direct graphic analysis. All those methods — arithmetical curves, half-logarithmic curves and the skeleton plots — were used concurrently in correlation.

It proved possible to ascertain the comparative period when the ship was used and the time when houses existed, but it did not prove possible to ascertain the exact date of the existence of the town. Different schools of dendrochronologists are trying to apply a variety of methods to find the exact dates. In the Middle East for example, in the investigation of Gordion's excavation, radio-carbon methods (C\textsuperscript{14}) were used to ascertain the exact dates; in this case, several of the outermost tree rings were examined. This method can be applied successfully only in an excavation of a site which is two or three thousand years old, and is not appropriate for an excavation such as that in Szczecin.

In Novogród, beams from extant old churches were used for the identification of tree rings, that is, the tree rings in these beams were compared with the tree rings collected from the excavation. Of course, the years in which these churches were founded were well known, an such a method can be applied only in excavations in big towns where old buildings of known date of origin are extant. In the U.S.A., where there are today alive sequoias from 3 to 3½ thousand years old, the problem is solved by using such trees as the standard diagram of yearly growth, to which are compared diagrams from excavations. Mrs. E. de Geer compared the tree rings of European trees with skeleton plots of sequoias from California and found a correlation between them. Hustich\textsuperscript{17} conducted similar research in Finland, examining the spruce from Alaska, Labrador and the North of Europe (Norway, Sweden and Finland). He declared that there is no correlation in the growth of these trees, although there were correlations in the smallest tree rings. However, the smallest tree rings in Labrador are very often one year later than those of Alaska — for example the smallest tree rings applied to Alaska in 1922 and to Labrador in 1923, etc.

Mrs. Muller-Stoll in her investigation\textsuperscript{18} found that the analogy as between sizes of tree rings diminishes with different species of trees, and also that similarity between curves of tree rings from different areas diminishes with increased distance between the areas. She also stated
that there is a closer analogy between the curves appropriate to the same species of trees in different areas in Middle Europe than between the curves of different species of trees growing in the same area. She further proved that there is no analogy between the tree rings of trees from, on the one hand, Middle Europe, and, on the other, the North of Europe, or between Europe and North America. She also affirmed that tree rings of trees growing far apart cannot be compared. Ermich in his investigation proved that the growth of oaks (Quercus sp.) in Bavaria and Poland is the same or differs only slightly. He further proved that tree rings of trees grown in different climatic conditions cannot be compared. 19

These investigations proved that tree rings of trees which grow far apart are not comparable. Therefore, it was impossible to correlate the tree rings of the trunks in Szczecin with others in other parts of Europe or of the world as a whole. On the other hand, it was possible to correlate tree rings of different native species of trees.

CONCLUSIONS

The object of this investigation was not to establish a full chronology of the excavation, but merely to effect a preliminary reconnaissance of dendrochronological methods as used in Polish excavations. On the other hand it was, so fortunate that tree rings of different trunks were correlated without great difficulty. Even those young beams (i.e., the stake which probably served for mooring the ship and the beam found inside the hull) might have been difficult to correlate, but were correlated with the tree rings of the oldest oak beam. If we had ample materials available, then probably we might exclude from analysis some of the young beams. But in this case, the youngest beams were the only ones.

Such an easy correlation was made possible by the fact that the trees had grown in the region of Szczecin. Beams from this region close to the sea cost are particularly good for dendrochronological investigations, because the region has high humidity, and temperatures predominate over other factors in determining sizes of tree rings. In such ecological conditions, rainfall and temperatures do not run concurrently in the creation of tree rings and, moreover, the shape of the curves is not particularly complicated. In spite of the material being scarce and imperfect in quality, we can draw chronological conclusions. However, when all the beam material from this excavation is available, then some of the conclusions may have to be revised.

In the eighth or ninth century, the hill where today stands Szczecin
Castle (called Castle Hill) was probably a small town, and very close to the hill flowed the River Odra. It appears from the excavation that inhabitants of this town knew how to build ships well suited to the bay of Szczecin and the southern areas of the Baltic Sea. Along the river bank, the inhabitants drove stakes into the ground for mooring the ships. After a period of years, one of the ship was condemned and left on the river bank. The river was probably the only means of communication, and used for transporting timber. It is thought that the piece of oak beam found inside the abandoned ship was probably unsuitable for use and was left in the ship on the river bank. Over the years the river silted up, later covering the ship with sand and also changing the course of the bed of the river. One of the stakes used for mooring was found with the condemned ship during the excavation of the “Vegetable Market.”

It is supposed that the stake (for mooring the ship) was cut from a tree in a year of the period when the moored ship was still in use, and that the year when the beam found inside the ship was cut from another tree indicates the years when the ship was abandoned. The length of time covered is twenty-two years. It is supposed that the stake was driven fast into the bank of the river when the ship was still in use, for the safety of other ships. The finding of a large piece of a beam inside the ship indicates that the ship had been abandoned before that block of wood was left in it; if the ship had been used afterwords, the piece of beam would have been removed.

After some time, the ship was covered by a thick layer of sand and the course of the river shifted to one side. But later, when the population increased, numerous houses were built on the new bank of the river. Dendrochronology indicated that from the time when the stake was driven into the bank of the river to the time when the first houses were built on the same site, covered a span of 117 years, the village existed about 80 years. But unfortunately we do not have sufficient beams to give the exact dates of the full chronology of the excavation. Least 300—400 beams should have been investigated from this excavation, together with some beams from the old buildings which still exist in Szczecin in order to arrive at a full chronology of the “Vegetable Market” excavation in Szczecin. It is hoped that such excavation and investigation will be realised in the future.
NOTES


5 Ernich, Mergentaler, op. cit; Ernich op. cit.


7 M. Polaczkówna, Wahania klimatyczne w Polsce w wiekach średnich [Climate Fluctuations in Mediaeval Poland], "Prace Geograficzne" edited by E. Romer, Lwów 1925, No. 5.

8 J. Dlugossi, Opera omnia, 1412 — Lib. XI sub anno; 1473 — Lib. XII sub anno; 1118 — Lib. IV sub anno; 1221—1223 — Lib. VI sub anno; 1279 i 1282 — Lib. VII sub anno.


10 W. Zinkiewicz, Badania nad wartością przyrostu rocznego drzew dla studiów nad wahaniami klimatycznymi [Research on the Value of Annual Tree


15 Ermich, op. cit.


19 Ermich, op. cit.