Isotopic study of Szczepankowice Early Bronze Age barrow burial ground (southwestern Poland).

Dalia Anna Pokutta (Gothenburg University)
Karin Margarita Frei (Saxo Insitute, University of Copenhagen)

Abstract: This paper presents the current stage of an ongoing research project regarding isotopic analyses of Únětice culture in Silesia District (southwest Poland). The main core of our undertaking has been divided into several parts, targeting different aspects of diet, migratory patterns and archaeological cultural diversity. These components may be observed on macro- and micro-regional scales in the South West of Poland under the Early Bronze Age period. This study provides a new model of contextual interpretation of barrow burial ground in classic phase of Únětice culture in Central Europe. The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 212402.
Publication of the Szczepankowice barrows case study sums up the first level of investigation. It has been designed to combine varied elements: archaeological diagnostic, paleopathology, isotopic analyses (local strontium baseline level plus migration case study) and finally radiocarbon dating, which enables us to place the whole structure within a chronological framework. Testing multi-functional tools was one aspect of the investigation, but in general this initial stage has been dedicated to *'people of the barrows'*, the upper class of the Early Bronze Age community.

Introduction

The Early Bronze Age barrow burial ground in Szczepankowice (German *Schönbankwitz*), located 24 kilometers southwest of Wroclaw in the vicinity of the Jaksonow and Kuklice villages, was discovered at the beginning of the twentieth century by pure chance during an exploration of sand morene by a local brick factory (Sarnowska 1962,61).
This site has been chosen for isotopic research due to its archaeological significance which combines three elements: spatial and stratigraphical structure, the presence of flat cemetery surrounding the burial mounds and the unique construction of the stone chamber within barrow IA.
We wish to briefly describe those elements, in order to give an overall view of the site.
The burial ground consisting of three (known) barrows is surrounded by the large Únětice cemetery, which over long period of time has been almost completely destroyed by industry. While barrows Ia and Ib have formed one massive feature (sitting on top of each other), the third barrow is visible *in situ*, approximately a further 150 m southeast at the edge of a sand mining platform (Fig 1).
Archive records provide some information in regards to cultural affiliation and types of assemblages retrieved from this area at the beginning of the twentieth century. The cemetery was adjacebt to barrows from the east, and it's important to stress that both barrows and flat graves created one complex structure.
On Early Bronze Age Polish territory we have examples of barrow burial grounds where no surrounding cemeteries were found (i.e. Łęki Małe, Greater Poland), or on the other hand, there are many large Early Bronze Age cemeteries with no barrow structures (i.e. Przecławice or Tomice in Silesia region). The combination of those two elements on one single site at Szczepankowice creates significant interpretational differences from archaeological point of view. Drawings and photos hint that the Únětice inhuamtions in this case were mixed with materials from Neolithic, Late Bronze Age and Iron Age, however pottery assemblages undoubtedly suggest presence of the early Únětice phase. Typical pottery, mostly mugs and jugs, bowls and bone pins (as parts of clothing), a bronze necklace and bronze axes have been found, although the depositional context of bronze objects remains inconclusive.
Grave 1380:30 contained an interesting dual-inhumation of a man and a cow, and some crematory graves have been discovered as well. The original size of this cemetery remains unknown today, but in

the 1930's the barrows in Szczepankowice were legally protected, although incorrectly described as 'remains of medieval motte-and-bailey' (Sarnowska 1962, 63).
In the spring of 1960, the unusually small medieval keep (25 m diameter and 5 m in high) caught the attention of Wanda Sarnowski, the director of the Wrocław Archaeological Museum. She decided to investigate the hill by opening trial trench in the northern part of the barrow. Within few days she realized the feature was much older than previously thought, and that settled her decision to open the excavations (Sarnowska 1963, 31). In the rainy summer of 1960, history began once more for the forgotten Únetice necropolis.

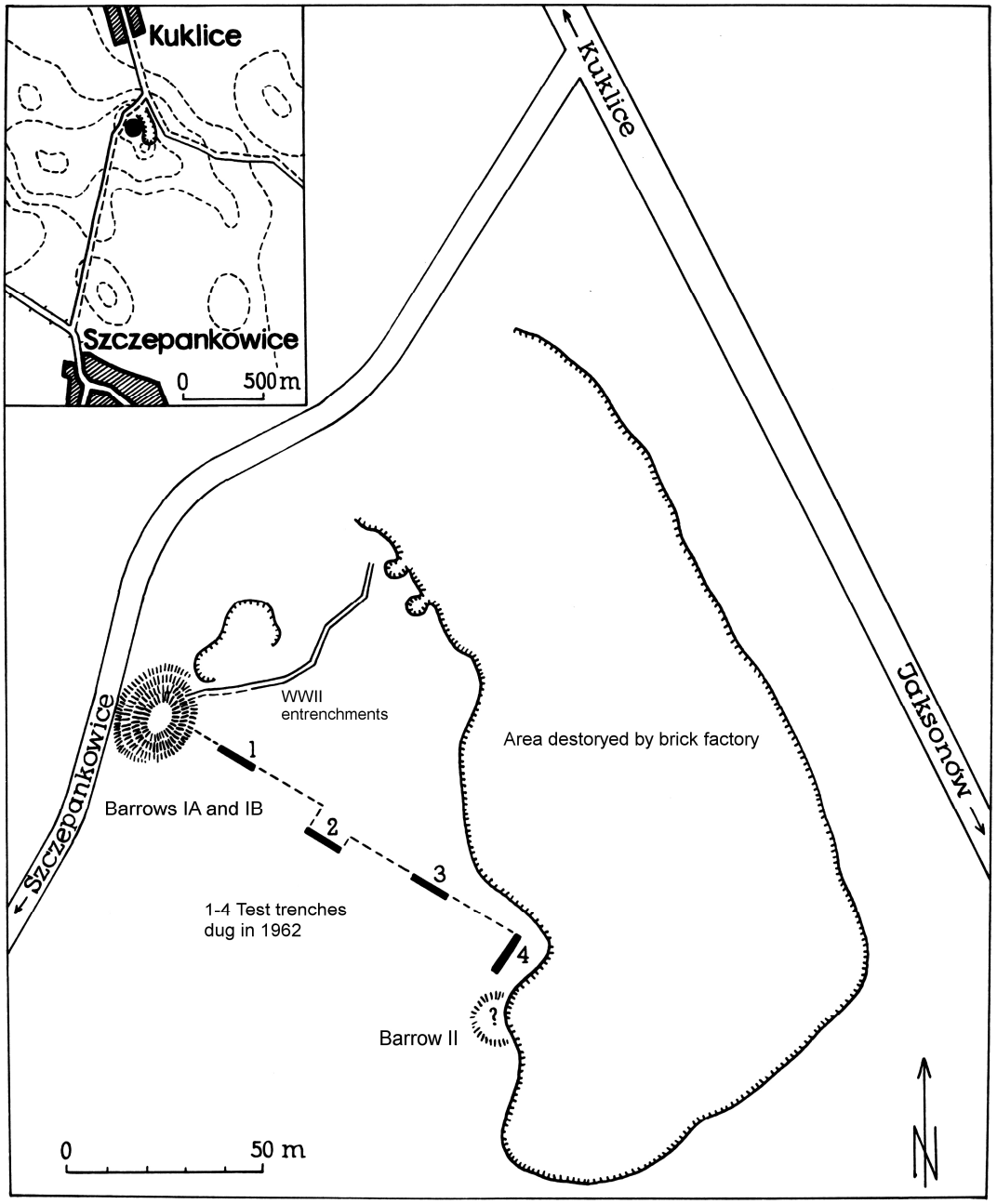


Fig 1. Location of barrows, Szczepankowice, Wrocław District, Silesia (after: Sarnowska 1969, 294 with modifications)

History of the monument

The importance and uniqueness of the Szczepankowice necropolis is based on the difficult dependency of archaeological diagnosis (changes and alterations in startigraphy of the monument, mostly) and interpretational phenomenon, which enable us to have an insight into the relationship between the individual and the community in the Únětice Early Bronze Age.
For centuries, Szczepankowice barrows had been exposed to processes that changed or modified theirs startigraphy, which made the task of exploration and correct interpretation more difficult than usual. Barrows had been robbed, probably in antiquity, and traces of that fact has been observed by Sarnowska in 1961. Plunderers had reached the core chamber of barrow Ia, and excluding a small pot, all grave goods were stolen. Merged and heavily disrupted infilling of the chamber suggested that robbers were working in a hurry, covering the open dug with every material they had at hand. By braking into the tomb from above, they destroyed the wooden structure of the chamber, but traces of postholes and logs of wood (30 cm in diameter) at the bottom had been recorded by the Sarnowska team. Sizes and inclination angles of logs (approx. 45 degree) may suggest the presence of some sort of roof or entrance within a stone setting, but of course, due to the damages, any far-reaching reconstructions are problematic. In this part of the barrow La Tène pottery had been found at the depth of ca. 4 m, which may suggest the potential date of robbery. It is quite likely that the Únětice tombs at Szczepankowice could have been marked somehow in the surrounding area (or toponymy suggested their presence perhaps), because when considering the details, it's difficult to resist an impression that Iron Age thieves knew exactly what they were looking for.


Fig 2. Cross-section of the Szczepankowice barrows-working shot.
In the middle stone setting of the lower barrow, in top section Iron Age plunder cut. Photo courtesy of Archaeological Museum of Wrocław.

World War II has left a stamp on the history of the Szczepankowice monuments as well. In August 1944, Hitler declared the city of Breslau a fortress (*Festung*), ordering that it be defended at all costs.
An encirclment the city took place on 13th of Febuary 1945,when two wings of the Russian forces met at Domslau as a part of the Lower Silesian Offensive Operation commanded by Marshal Ivan Konev.
During following three months the city was heavily bombed by Luftwaffe, and both Germans and Russians resorted to setting entire districts of Wrocław on fire. (Davies 2002,40,46-57). During the chaos, materials from another Únětice cemetery (Wrocław-Oporów) were lost (over 100 graves; from burning Museum buildings only part of documentation could have been saved).

During that time a random missile hit the Szczepankowice barrow resulting in further stratigraphical disruption and dislocation of stones. The hill was used as an anti-aircraft artillery position and Sarnowska discovered 33-meter long entrenchments in the northern part of the site. Compared to the damages of II World War, hundreds of years of medieval and modern age farming activities in area left almost no traces.

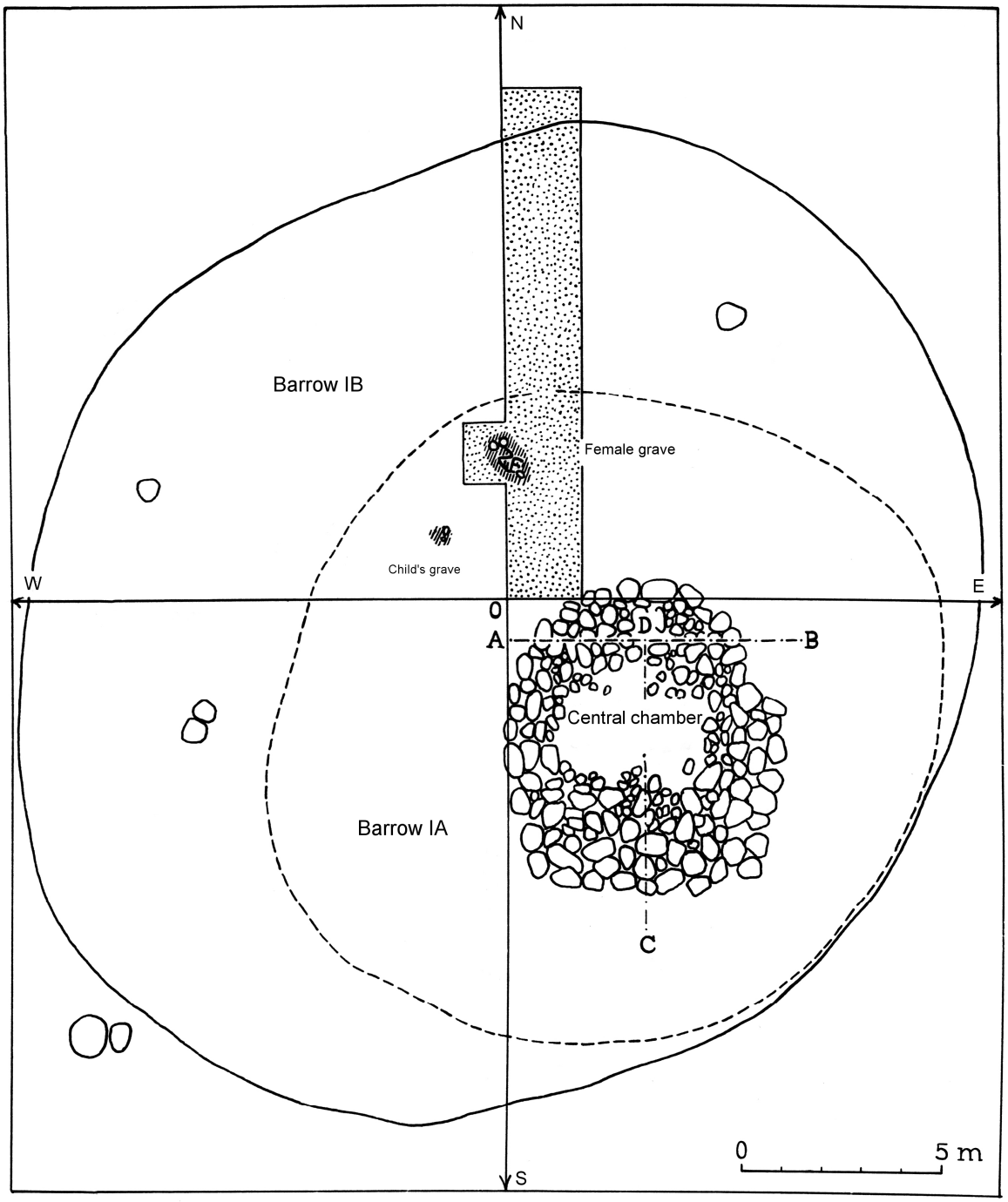


Fig 3. Plans of Szczepankowice barrows (after: Sarnowska 1969, 297 with modifications)

‘The wish’. Szczepankowice: between individual memory and collective identity.

History may have played an important factor in deformation of the original archaeological context, making overall interpretation more difficult and demanding. Many authors today stress the importance of Early Bronze Age rich grave furnishing as physical manifestation of social and personal significance of deceased (basing usually on Leubingen and Helmsdorf examples), but having said that many of them overlook additional aspects of burial practices that led into formation of so-called ‘princely‘ graves phenomena in Únětice period.

'The message' or meaning of Szczepankowice barrows lies not in rich assemblages of gold and bronze objects given to whoever was buried in stone chamber of barrow IA, but in stone chamber itself – in objects the chamber was build of.

Marie Louise Stig Sørensen (2004a,168) in her papers dedicated to work of Collin Renfrew, investigating Leubingen grave and stressing an importance of new approach towards understanding of materiality, says: *'Prehistoric burial monuments therefore contain significant clues about the society that built them. Through investigation of the construction of specific graves we can explore how objects were employed as a means of making significant social statement in and by themselves*.(…) *When we approach the construction of the grave as a practice that responds to and exploits the polysemic quality of objects a set of associations within the burial are brought into play'.*

Basing on example of EBA tumulus in Leubingen, Sørensen (2004a, 2004b) is addressing new questions of use of objects and creation of identity visible through carefully arranged spatial distribution of things within tent-like chamber. The whole point of what we see in Leubingen is not the economic value of daggers, bronzes, gold clips or wooden housing structure itself, but the order of '*social statements'* through which we may observe an interesting process of ultimate cultural transfiguration of the deceased. In Leubingen, the body of deceased and overall arrangement of grave goods within wooden chamber leads to re-creation of his *'identity'* by the community he once belonged to. Using ritual and tradition this group of people is trying to make a statement regarding the social importance of the dead, but what we can really see is more the creation of '*artificial identity'*, which encapsulates rather the collective memories of the group than historical truth about deceased.

In Szczepankowice we can observe similar process, however the final interpretation is much more complicated and ambiguous.

Few hundreds of stones and slabs were used as building material of stone chamber in barrow IA excavated by Sarnowska. In plan chamber was oval in shape, with total high of walls approx.1.5 m and traces of wooden structure inside of it. Among stones forming the walls of the tomb excavators discovered thirty grinding stones, some of which were of significant size and weight. Petrologic analyses proved that some of those objects were made of non-local material and had to be imported in area (Sarnowska 1963,72-74).Grinding stones were located at different depths around central grave. How can the presence of so many objects in one single depositional context be explained?

Applying M.L.S Sørensen inductive model of reasoning, grinding stone can be seen as physical manifestation of household wealth and stability. This heavy, immobile object once placed within household can be interpreted as visible functional indicator of its prosperity.

Looking from archaeological point of view these objects may have belonged to larger, more economically stable households and the fact, that all of them had been offered to one single individual buried in Szczepankowice tomb, creates the message of both social and cultural importance. At Szczepankowice a creation of a new model can be seen through metaphorical *'social statement'* expressed with stones: by offering so many heavy and economically necessary objects, the community was trying to built *'a connection'* between the collective and person buried in the barrow.

Thirty households surrounding the tomb chamber, give an unspoken statement of solidarity of the group with individual, however the substance of this *'connection'* was not only expressed by need to pay a tribute or commemorate the deceased, but to set up the *'final bound'* between individual and the group he/she once belonged to.

Facing fear of death and uncertainty of existence in the Underworlds, the community gathered around Szczepankowice barrow declared the will *'to support'* one of its members by expressing - literary - *'the wish'* of prosperity and stability '*for the journey'* and creating deeper, eschatological and metaphorical bridge between them, the deceased and the Underworlds.

At this moment archaeology reaches the real *core* of what this community was comprised of: internal relationships,emotions,memories and obligations.Despite the fact that usage of working stones in such quantities in Early Brozne Age makes this monument unique on European scale, the message concealed beneath this surface is of even greater importance.

Human remains

During excavations in 1961 the remains of three individuals has been retrieved from both barrows. Within heavily disrupted and merged infilling, at the very bottom of the core stone chamber (barrow IA) Sarnowska has discovered the remains of possible 'owner' of the barrow. It had been impossible to describe the exact alignment of the body and possible location of grave furnishing however shreds of very small '*minature-size'* EBA vessel were found in situ. (Sarnowska 1963,49, 1969 298-301). Pieces of cranium from lower barrow have been used by us for radiocarbon dating, which shall be discussed in following chapter, but due to scarcity of skeletal material in this particular case, samples has been taken for further isotopic analyses (migration, diet) as well.

Fig.4. Skeleton of the women - reconstruction of grave setting at the exhibition. Photo courtesy of Archaeological Museum of Wrocław

Upper barrow (IB) contained the remains of child and female. The location of child's burial (grave 2) in the lowest stratigraphical strata and its central alignment in comparison to axis of the upper barrow and position of female skeleton, may suggests special importance and position of this child within local community. Grave goods consisted of partially preserved ceramic vessels, but what interesting is we can track analogical *children-of-special-importance* burials in Leubingen barrow and at Łęki Małe barrow burial ground in Greater Poland.

During excavation at Łęki Małe barrow IV in 1957 (50 m diameter, 5 m high massive Únětice tumulus, county Kościan) similar to Szczepankowice child inhumation has been discovered, but what differs them is the location of the burial. The stratigraphy of Łęki Małe barrows *necropolis* set up the general rule, that after erection of the main stone core of the barrow (central grave), all *'additional'* burials were added and located later in the western parts of the monuments (Kowianska-Piaszykowa 2008, 141). This rule can be observed in barrows I, III and IV at Łęki Małe. Adaptation of this pattern to Szczepankowice IB, enable us to clarify the situation - female grave has been located in the western part of the barrow and child burial is situated somehow closer to central point: she was buried there to accompanying the child, not the other way around.

Female skeleton retrieved from the barrow had been shown as a part of permanent Early Bronze Age exhibition at Archaeological Museum of Wrocław for many years (Fig.4).

She was described as *adultus maturus* (approx. 28-35 years old) and the estimation of sex and age at death relied on the pelvis, cranial suture closure and wear of dentition (Sarnowska 1963,75). Her grave was situated in western part of the upper barrow, at depth of approximately 1,50 m. The decedent was lying in typical for Únětice contracted position on right site, head towards south and face towards east, together with ceramic storage vessel and flat bowl.

Fig 5. Left part of mandible-visible caries, lost of third molar and exposition of teeth in teeth sockets. Archaeological Museum of Wrocław

Anthropological and paleopathologic examinations give us some insight into biological status of this particular individual.

Women from Szczepankowice suffered from *peridontosis*. Periodontal disease is one of the most common dental diseases today. It commences with infection and inflammation of the jaw soft tissue (swelling and bleeding from gums), which over longer time period leads to transmissions of infection to bone and eventually loss of teeth occurs. (Hillson 1996, 260-7). Recent studies show that periodontal disease has been overdiagnosed in archaeological skeletal material (Roberts, Manchester 2010, 73), however in our case peri-mortem the lost of third molar, significant decalcification of the mandible, wear of teeth (exposition of dentine) and visible caries on second lower molar (Fig.5) suggest this diagnosis.

Fig 6. Pathological changes (osteophytes) in spine. Archaeological Museum of Wrocław

This condition can arise for a variety of reasons, but mostly is caused by low level of oral hygiene. Poor quality diet and deficiency of vitamins (vitamin C) may have played an important role (Andersen 1982), however preliminary results of ongoing diet study ($\delta^{15}N$/ $\delta^{13}C$) for this particular individual suggest diversed diet and high level of nutrition, adequate to her high status burial.

In some cases periodontal disease might be combined with cardiovascular desease and heart problems, but that hypothesis has to remain inconclusive (Buhlin 2004).

Peridontosis might have caused painful physical discomfort for this female, but in her case was combined with another pathological problem, that is degenerative spinal joint disease (vertebral *osteoarthritis*) (Fig 6).Early stages of degenerative deformations (*osteophytes*) can be seen mostly in lumbar part of the spine which indicates occupation-related aetiology.

Women buried at Szczepankowice barrow probably had to carry heavy manual work (i.e. lifting heavy objects, carrying a wood or buckets of water perhaps). Some slight asymmetry of *acetabulum* can be seen as well, which may have led to moderate difficulties for her while walking or running.

Taking under consideration her gracile body posture, relatively young age at death and rich diet, we may conclude that this individual had to lead a very active and physically demanding lifestyle. Moreover, despite the fact she was buried in Silesia region, isotopic analyses performed on samples taken from this individual indicates her non-local orgin. These results shall be discussed in following chapter.

The strontium isotope analysis of Szczepankowice and Magnice skeletons

The main aim of this part was to investigate the problem of local versus non-local origin of two females. Samples taken from Szczepankowice women were compared with another one, taken from Magnice, site located approximately 5 km towards south from Wrocław, where the remains of the female individual (Neolithic in date) has been discovered during excavations in summer 2007 (Baron et al. 2011).
Plain and simple Neolithic grave of Magnice women yielded with no finds, so no specific cultural affiliation can be given, but radiocarbon dating of human remains has given date of 3970+/-40 BP. At this stage of experiment, our working assumption was of local 'immobile' provenance of Neolithic individual, but final results prove us wrong, yielding with unexpected and intriguing conclusions.

Strontium isotope analysis represents today an important toolkit for archaeologists working in the field of migration studies in prehistory. Today this is a well known analytical technique that relies on the fact that strontium isotope ratios which depend on the geochemical compositions of the soils do not alter when entering the biosphere (Bentley 2006; Montgomery 2010; Price et al. 2002). Consequently, strontium isotope signatures recorded in human and animal bone tissues can potentially be used to pinpoint the geographical area of origin. Furthermore, recently this type of analysis is has shown to be a good provenance indicator also for materials of organic nature, e.g. textiles (Benson et al. 2006; Frei et al. 2009a; Frei et al. 2009b; Frei et al. 2010), leather (Von Carnap-Bornheim et al. 2007), and human skin (Frei et al. 2009b). The current effort of developing new ways in which the strontium isotope tracing system can be of use for the archaeological community, show the potential and importance of this tracing system.
In the following we aim at a very brief introduction of strontium isotopes, as well as sample preparation and analytical techniques. For more information on how to perform this type of analysis, problematic involved as well how to interpret the data, we refer to several review articles on the matter (Bentley 2006; Montgomery 2010; Price et al. 2002).

Strontium (Sr) isotopes

Strontium is a member of the alkaline earths of Group IIA in the periodic table, which consists of beryllium, magnesium, calcium, strontium, barium, and radium (from top down). Its ionic radius, i.e. its size, is 1.13 Å and thereby the strontium ion is slightly larger than the calcium ion with an ionic radius of 0.99 Å (Faure 1986). Because of the similar ionic radii, strontium can replace calcium in mineral lattices. Strontium therefore is concentrated in Ca-bearing minerals such as e.g. plagioclase, apatite (teeth enamel is composed of hydroxyapatite), and calcite (calcium carbonate). Strontium, due its capability of being incorporated in numerous Ca-bearing phases, is therefore an abundant trace element in many magmatic, volcanic and sedimentary rocks.
Strontium has four naturally occurring isotopes ^{88}Sr (82.53%), ^{87}Sr (7.04%), ^{86}Sr (9.87%), and ^{84}Sr (0.56%) (Faure, 1986). Three of the four natural occurring isotopes of strontium are called "stable", whereas ^{87}Sr is radiogenic and therefore variable, as it is partially formed by radioactive decay of naturally occurring ^{87}Rb (half-life of 48.8 billion years) (Faure 1986). A fifth, non-natural and short-lived radioactive isotope of strontium is ^{90}Sr.
The strontium isotopic tracer system relies on the use of two of the four "natural occurring" isotopes, namely ^{87}Sr and ^{86}Sr and particularly on the variations of their ratio $^{87}Sr/^{86}Sr$. This ratio is somewhat related to the natural abundances of these two isotopes and therefore often is ~0.7 (~7% ^{87}Sr /~10 % ^{86}Sr). The variations of the $^{87}Sr/^{86}Sr$ ratio of a geological material (rock, soil, mineral) derive from a combination of initial parent (Rb) to daughter (Sr) ratio (expressed by $^{87}Sr/^{86}Sr$), the respective concentrations of these elements, and the age of the material. Most rocks present in Earth´s crust (e.g. granitoids) contain appreciable concentrations of rubidium and strontium, usually in the order of tens to several hundred parts per million. Evolved, i.e. magmatically highly differentiated rocks, are enriched in

the incompatible element rubidium and therefore develop high Rb/Sr concentration ratios. Such rocks, with time, eventually produce highly radiogenic $^{87}Sr/^{86}Sr$ ratios (e.g. in granites), whereas undifferentiated or primitive rocks (e.g. basalts, ultramafic rocks, etc.), due to their low primary Rb/Sr concentration ratios, are not affected to same degree by the radioactive in-growth of ^{87}Sr since the time of their formation. The isotopic evolution of strontium in the Earth geological history is complicated by the fact that the Earth acts as a continuous recycling system, where earlier formed rocks are sometimes recycled (remolten and recrystallized; e.g. beneath subduction zones like those along the Pacific-side of the South American continent) and recombined to create new ones (Faure 1986). From the isotopic information contained in meteorites one can model the early history of the solar system, which has led us to the understanding that the Earth formed from a solar nebula around 4.5 +/- 0.1 billion years ago and that its $^{87}Sr/^{86}Sr$ initial ratio was close to 0.699.

All in all, the age and the type/nature of primary magmatic rocks are parameters which control the strontium isotopic composition of a geological basement and the sedimentary derivates from them. These strontium isotopic properties are maintained in recent processes (i.e., the strontium isotopic signatures are not changed in - from a geological perspective – very small time spans, because of the very slow decay of the parent ^{87}Rb) and can be followed through processes of weathering, and on into the food chain. Even though differences in the strontium concentrations may occur (due to different partitioning of strontium into various phases (such as water, plants, bones, etc) along such uptake chains, strontium isotopes are not significantly fractionated and strontium isotopic compositions are not affected and thus remain "stable", making these signatures extremely useful for tracing. Still, monitoring strontium concentrations is important for tracing studies as they can provide additional information on the degree and effectiveness of uptake processes as well as to monitor contamination issues as I will show later on in my articles herein. In conclusion, the rate of production of ^{87}Sr is so slow that the $^{87}Sr/^{86}Sr$ ratio of a substance can be considered invariant over archaeological timescales. Thus, in terms of strontium delivery to a plant, the groundwater inherits $^{87}Sr/^{86}Sr$ ratios characteristic of the soluble "biologically available" (=bio-available) fractions/components in a soil which, in turn, are transferred isotopically unchanged and unfractionated on to the plant (Benson et al. 2006). The first to suggest that the strontium isotopic system could potentially be a good indicator of human mobility in the past was Ericson (1985). This important suggestion to use strontium isotopes for tracing studies led to an entirely new research field within archaeology and numerous migrations studies have been conducted since then applying this system (among others,(Bentley et al. 2003; Bentley et al. 2002; Grupe et al.,1997; Grupe et al. 1999; Knudson et al. 2004; Price and Gestsdottir 2006; Price et al. 1994a; Price et al. 1994b; Price et al. 2000). It is important to state that the use of strontium isotopes to study human migration patterns will be successful only if the bio-available strontium possesses distinctive source-area signatures that are dependent on the geological background of an area (Price et al. 2002). This means that a kind of baseline map providing the strontium isotopic signatures of the areas of interest is highly needed. Recently, several attempts have been made in order to delineate the bio-available strontium isotope ranges of several areas worldwide, e.g. by mineral and surface water (Frei and Frei 2011; Montgomery et al. 2006; Voerkelius et al. 2010).

In the case of Poland, there as yet not much data available as this point on the topic of the bio-available strontium isotope ranges within the Polish region. Therefore, the samples presented herein, cannot as yet be placed to a certain area of origin, still they can preliminarily be regarded as local or non-local by comparison with the local soil and fauna samples from the sites (Table 1).

Table 1. Samples isotopic specification

Sample ID	Taken from	Specification	$^{87}Sr/^{86}Sr$ value	Error ppm+/- [2sabs]
P1	Magnice 8, grave 46	Teeth, female *adultus maturus*, Neolithic	0.71286	14
P2	Szczepankowice Barrow IB,grave 1	Teeth,female *adultus maturus*, EBA	0.71314	10
P4	Szczepankowice Barrow IB	Animal bone sample, rodent (*Cricetus cricetus*), from depth ca.1.5 m	0.71470*	19
PS3	Szczepankowice Barrow IA	Geological sample, from depth ca.3.3 m; western part of barrow Ia	0.71427**	17

* Underlined values stand for Wrocław area geological strontium level baseline
** Median of $^{87}Sr/^{86}Sr$ value: 0,714485

Samples, sample preparation and analytical techniques

Samples
Small pieces of tooth enamel (~10 mg) from the two women and rodent were sampled by drilling after mechanically abrading the outer surface to remove contaminants from the burial site. Soil sample (~1 gram) was exposed to 5 ml of 0.05% HNO_3 for 1 hour at room temperature in an ultrasonic bath. The solution was centrifuged, pipetted off and dried down.

Sample preparation
Tooth and soil samples were dissolved in a 1:1 mixture of 30% HNO_3 (Seastar) and 30% H_2O_2 (Seastar). The samples typically decomposed within 10 minutes (soil sample takes more time), after which the solutions were dried down on a hotplate at 80 °C.
Samples were taken up in a few drops of 3N HNO_3 and then loaded on glass extraction columns with a 0.2 ml stem volume charged with intensively pre-cleaned mesh 50-100 SrSpec™ (Eichrome Inc.) resin. The elution recipe essentially followed that by (Horwitz et al. 1992), scaled to our needs. Sr was eluted / stripped by pure deionized water and then the eluate was dried on a hotplate. Organic matter from the soil sample stained the resin during the elution procedure.

Thermal ionization mass spectrometry
Samples were dissolved in 2.5 μl of a Ta2O5-H3PO4-HF activator solution and directly loaded onto previously outgassed 99.98% single rhenium filaments. Samples were measured at 1250-1300 °C in dynamic multi-collection mode on a VG Sector 54 IT mass spectrometer equipped with eight faraday detectors (Institute of Geography and Geology, University of Copenhagen). Five ng loads of the NBS 987 Sr standard gave $^{87}Sr/^{86}Sr$ = 0.710236 +/- 0.000010 (n=10, 2σ). Errors reported in Table 1 are within-run (2 σ_m) precisions of the individual runs.

Reagents and blanks
We systematically used ultrapure acids (Seastar™, and dilutions thereof) and water from a Milli-Rho-Milli-Q (Millipore) system in the chemical treatment procedures of the mice samples. All chemistry was performed inside better than Class 100 Hepa filter equipped chemical workstations located inside a suite of Class 1000 overpressured clean rooms. Total procedure blanks amounted to <65 pg of Sr. One blank Sr composition measured during the experimental period yielded a $^{87}Sr/^{86}Sr$ ratio of 0.708. The amount of

blank Sr (<65 pg) is insignificant relative to the amount of sample Sr (>>100 ng), and therefore the measured Sr isotopic compositions were insensitive (in the critical first five digits) to a blank correction.

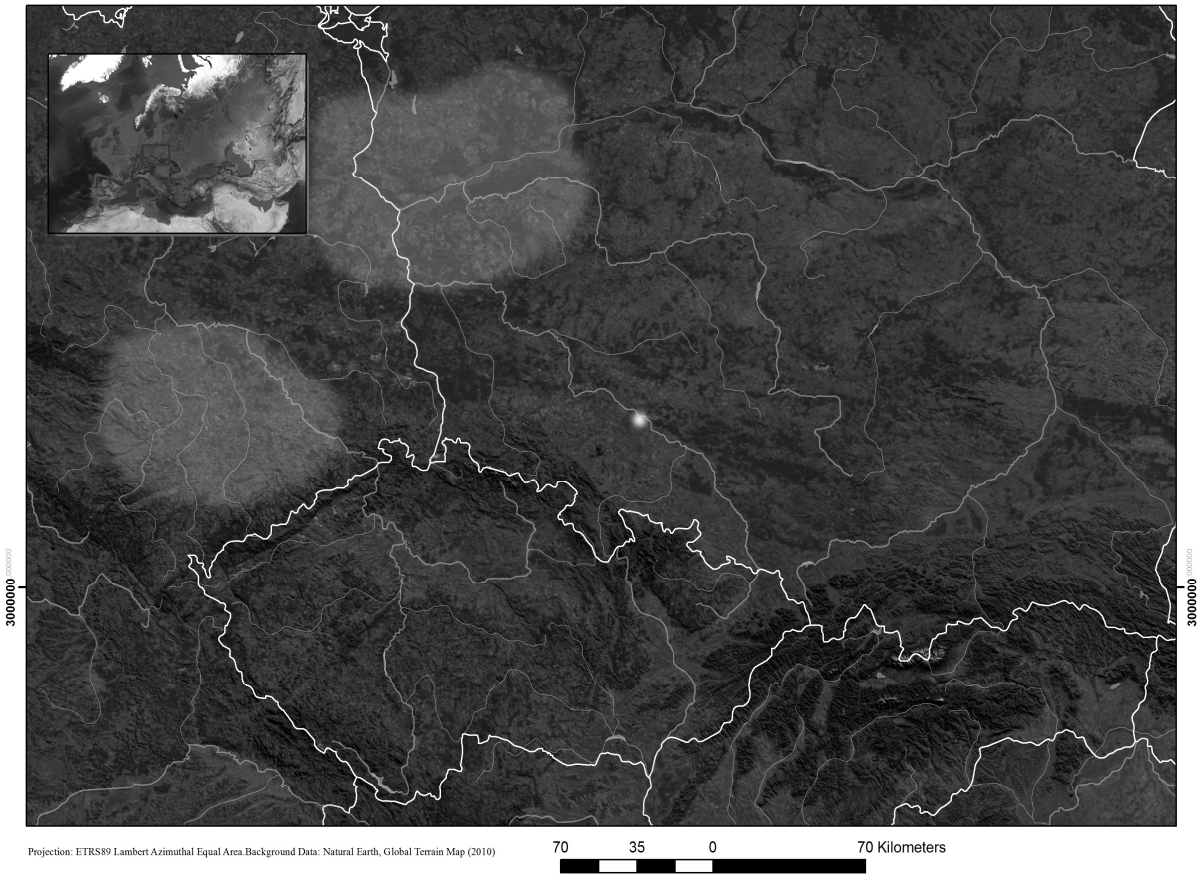
Results and discussion

Polish soils are mostly characterized by being of postglacial nature (Białousz et al. 2005). Similarly, the soils of northern Germany and Denmark are also characterized as being of glaciogenic origin. In general, most of northern Poland is composed of Cenozoic sediments whereas the southern part is less homogenous with Mesozoic and older rocks.
Unfortunately there is little available data on the bio-available strontium isotope ratios of the soils in the Polish area, and therefore the results and the following discussion of the data presented herein should be regarded as preliminary, and more baseline data is needed to define the bio-available strontium isotope ratios that would be enable future studies to better ascertain potential areas of origin.
Recently, a set of mineral water's strontium isotope ratios from Europe was published focusing on their provenances (Voerkelius et al. 2010). The $^{87}Sr/^{86}Sr$ mineral water values presented by Voerkelius et al, (2010) from Poland are mostly in agreement with some of our own not yet published archaeological data from the same areas. In addition, we analyzed a soil sample from Szczepankowice barrow I (geological sample was taken in 1961 at depth of 3,3 m), as well as a local fauna sample (a rodent) from the same site, for the purpose of distinguishing the bio-available $^{87}Sr/^{86}Sr$ range of the areas (which it is delineated as local, for values see Table 1). The soil sample has a $^{87}Sr/^{86}Sr = 0.71422$ which is very similar to the $^{87}Sr/^{86}Sr$ value of the fauna sample of $^{87}Sr/^{86}Sr = 0.71470$. These values show that the bio-available fraction of the soil from Wrocław area is relatively high, and they most probably contain some components of older rocks. Contrary, the values of the two women studied herein (Szczepankowice and Magnice) (P1 and P2, Table 1), are lower than the fauna and soil samples from the site. In other words, the two women seem to be of non-local, 'foreign' provenance. Furthermore, the two women have somewhat similar $^{87}Sr/^{86}Sr$ values, and can eventually come from within the same area. Comparing the $^{87}Sr/^{86}Sr$ values of the two women presented herein, to the $^{87}Sr/^{86}Sr$ values from mineral water's analyzed by Voerkelius et al. (2010), it seems as their values are seen in areas towards the north to north-eastern Poland as well as the south-eastern Germany. Still, we must keep in mind that these are just very preliminary results, and much more data is needed to ascertain possible areas of origin.

Conclusion

The strontium isotopic results of the two women seemed to preliminarily point to a non-local origin at least in relation to the fauna and soil samples from the burial sites. Strontium isotope ratios of a few mineral water samples from north and north-eastern parts of Poland have values that lie close to the ones analyzed in the tooth enamel of the two women. More data is needed to potentially delineate the bio-available strontium isotope ranges from Poland and the surroundings areas.

Fig 7. Migration in Únětice culture: Szczepankowice female possible places of orgin
* Due to geological variability of Europe please consider this map as rough guide only



Radiocarbon dating of Szczepankowice barrows. The chronological sequence

Radiocarbon dating of human bones retrieved from both barrows enable us to date these particular burial mounds on 3559± 24 and 3522±24 BP respectively. Pedologic analyses done by Sarnowska's team in 60's suggested a very short period of time within which an upper barrow had been built on top of existing one (Sarnowska 1963, 66-71). That assumptions were not entirely correct: lower barrow IA was erected ca.1874 BC, while upper overlapping burial mound was build probably ca.110 years later, around 1760 BC. If that is the case, we can see that this specific place was in centrum of interest of local community for over a century, for four to five generations. Having said that we have to keep in mind technical limitations of ^{14}C methodology and variability of calibrations.

This simple statement could have been the final conclusion at this stage of analyses, however, in this case the end is the beginning: chronological frames within which these monuments had functioned can lead us much further.

As we have said in the beginning the barrows belong to wider local EBA landscape. Theirs spatial location constitute a very important element being a central 'point of orientation' for several Únětice sites located almost concentrically around Szczepankowice necropolis: Domasław (11km), Magnice (9 km), Jaksonów (4 km), Glinica (12 km), Królikowice (7km) but above all Przecławice (2 km). Modern, contemporary land divisions may blur this picture but it's important to stress that this sort of pattern (6 sites distributed equally, within range less than 15 km around one point) hardly ever is a matter of pure coincidence.

In Przecławice regular excavations, carried out by I.Lasak (1988) revealed EBA cemetery consisting of over 50 graves and its close relationship with Szczepankowice burial ground, both in spatial and chronological frames, cannot be denied.
Another interesting relationship can be observed in respect of Wojkowice, site situated approximately 16 km NE from Szczepankowice *necropolis*,where local cemetery was into use long before barrow IA has been erected. At this relatively small Únětice site comprising both settlement and cemetery,human activity can be observed for probably at least 400 years. Data retrieved from Wojkowice cemetery suggest presence of proto-Úněticean phase as well. Further research will provide more data and comments in respect of chronological evolution of locally clustered sites in area (Table 2).

Fig 8. Summary calibration of ^{14}C dates from barrow IA (OxCal)

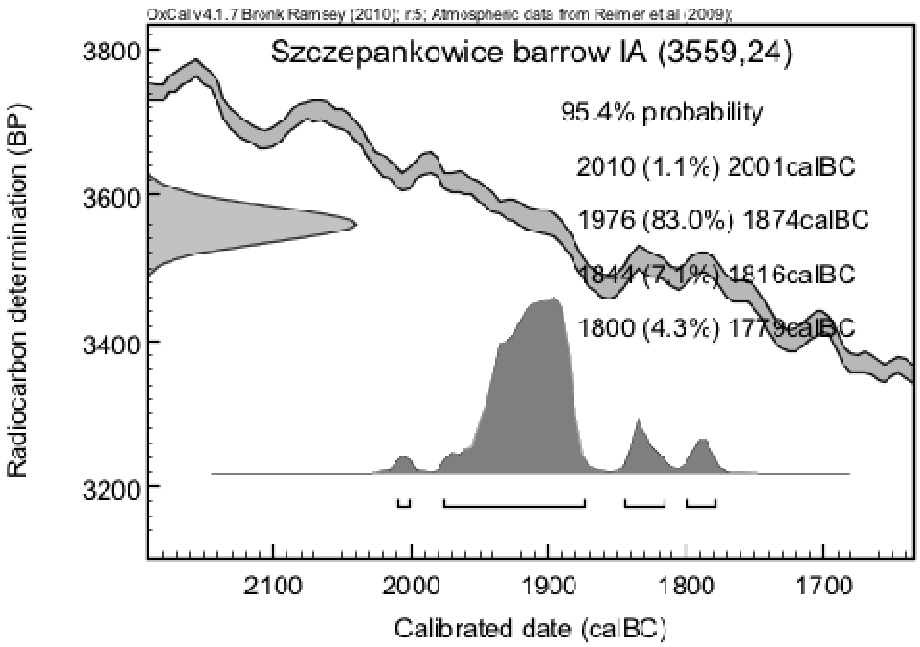


Fig 9. Summary calibration of ^{14}C dates from barrow IB (OxCal)

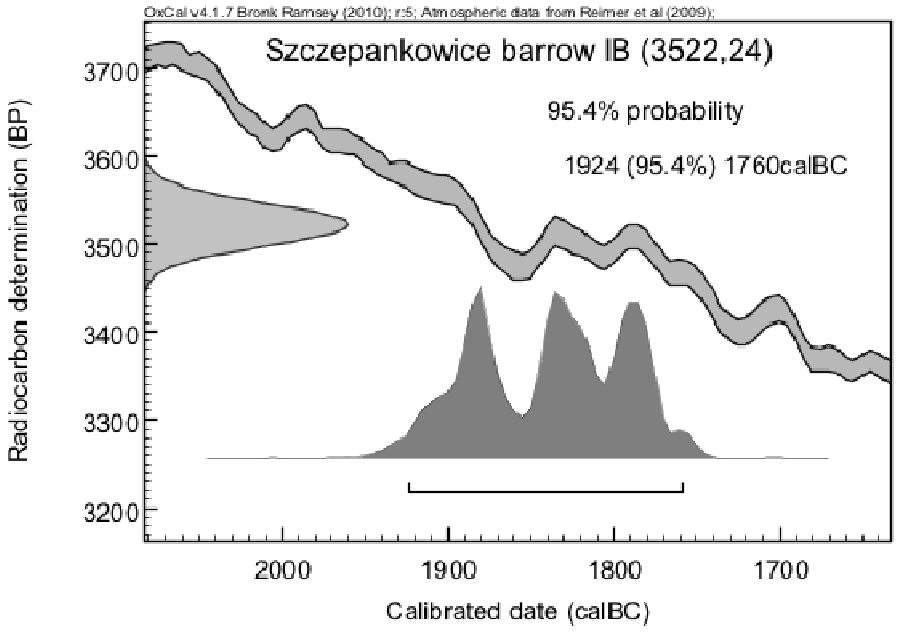


Table 2. Chronology of Szczepankowice barrows in comparison with local Early Bronze Age sites in area

Site name	Material	Context	Dating	Calibration (OxCal)
Szczepankowice IA	Human bones	Central chamber burial	3559 ± 24 BP	1874 BC
Szczepankowice IB	Human bones	Female grave	3522 ± 24 BP	1760 BC
Magnice 8	Human bones	Grave 46 (Neolithic female) Grave 106 (EBA male)	3970 ± 40 BP* 3630 ± 35 BP*	2345 BC 1894 BC
Wojkowice 15	Human bones	Grave 1097-III-00 Grave 774-II-99 Grave 784-II-99	3790 ± 35 BP** 3720 ± 35 BP** 3550 ± 35 BP**	2131 BC 2022 BC 1771 BC

* Baron, J., 2011 (ed.), Wyniki ratowniczych badań archeologicznych wielokulturowego stanowiska w Magnicach, gm. Kobierzyce, woj. dolnośląskie, Archeologiczne Zeszyty Autostradowe, vol. 11, p.48

** Gralak, T., Osadnictwo ludności kultury unietyckiej na stan. Wojkowice 15, gm. Żórawina, pow. Wrocław, in: Gediga B. (ed.) Archeologiczne Zeszyty Autostradowe, vol. 5, Badania na autostradzie A4, part. III,p.241

Looking from general perspective, Únětice culture in Polish territory covers over 400 known sites (hoards inclusively) situated exclusively between Vistula to the east and Oder river in the west. That covers western part of the country from Baltic coast to Sudetes, however distribution of Únětice cemeteries (and closely associated settlement units) seems to thin down radically from south towards north. Barrows are present in Silesian (Wrocław) and so-called Kościan groups of Únětice culture in Greater Poland only, but no larger flat cemetery has been found in vicinity of Łęki Małe so far (only individual single graves in random locations). Apparent shortage of graveyards strongly contrasts with omnipresent traces of Únětice activity and colonization in Kościan area. This peculiar situation shed some light on chronological sequence of events leading up to creation of *'princely grave'* phenomenon in Early Bronze Age period.

The excavations in Łęki Małe enable us to set up the Szczepankowice barrows in broader European perspective. Unfortunately, there are only few ^{14}C dates from barrows of Kościan Group (effectively we can use only two: from barrows no. IV and I - see Table 3), but old discoveries documented by M.Kowiańska-Piaszykowa suggest presence of some interesting patterns in this matter. According to her observations (based mainly on pottery stylistic) barrow IV- massive and solid tumulus (50 m diameter, 5 m high) was actually chronologically the oldest and strongly related to Neolithic traditions and activity, traces of which have been recorded in lower cultural layers of this monument.
Barrow no I, the smallest among others, was considered to be chronologically the youngest (Kowiańska-Piaszykowa 2008, 144). At Łęki Małe barrows decline in sizes as the burial ground expanded spatially and linearly from south towards north. Obviously, we may call into question that kind of assumptions based on analyses of single group of artifacts only, although richness and variety of burials (bronzes, amber, gold objects, pigments-ochre, presence of additional burials located in separate, but somehow designated areas of those tumuli) suggests existence of complicated social hierarchy, and valuable artifacts can only partially reflect this issue.

The youngest and the smallest barrow in Łęki Małe (25 m diameter, 4 m high) is strikingly similar in sizes to Szczepankowice barrows IA and IB, however radiocarbon dates proves it can be older in date (see and

compare chronology of Helmsdorf and Leubingen- Table 3). Moreover, several of 'smaller barrows' can be traced and seen i.e. in German territories, surprisingly matching the chronology of Szczepankowice as well. It seems clear that transformation is taking place simultaneously in Silesia and Greater Poland and can be tracked according to radiocarbon dating of barrows (see Fig 10.) Sørensen (2004a, 167) stresses that '(...) *the change from the Late Neolithic focus upon communal monuments to the practice of individual burials in smaller barrows that emerge with the Beaker/ Early Bronze Age is an expression of the change from group-oriented societies to individualizing ones.*'

Penetration of new territories by Únětice brought not only an inflow of bronzes but also led to re-adaptation of Neolithic monuments for burial purposes when available, as we see it in Łęki Małe barrow IV or in newly discovered Kąty Wrocławskie barrow. Intended choice of place and re-use of existing Neolithic monuments however not necessary meant anything more than technical opportunism, possibly wishfully combined with claim of ancient ancestry of newcomers. On the other hand in the same time in many places Neolithic tumuli still remain untouched and seem to be of no importance for new traditions of rising Bronze Age world.

This initial phase of *adaptation* and ramifications of Únětice ritual seems to be followed by another phase, starting soon after 2000 BC when fully developed in form *princely grave* arise and inseparably is linked to tribal elites, stabilization of settlement and greater social stratification. It remains an open question to what extent migrations played a part in that processes. By what other means archaeology can trace this internally intercutting relationships to understand the nature and dynamics of social changes within Polish Únětice formation? Undoubtedly more research is needed and we would like to avoid any general conclusions at this stage of discussion, leaving this questions unanswered.

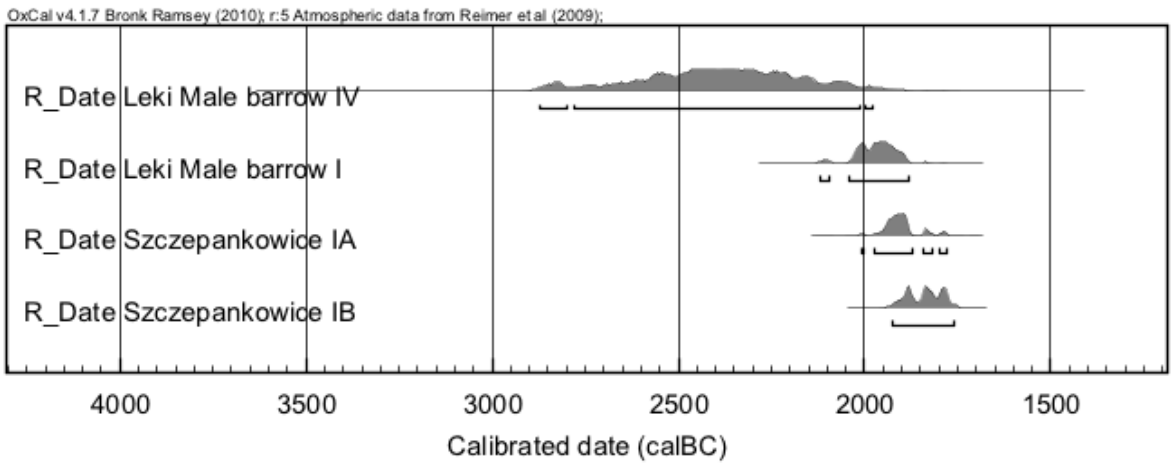
Table 3. Chronology of Szczepankowice barrows in comparison with selected EBA burial mounds in Europe

Site name	Material	Dating	Calibration (OxCal)
Łęki Małe IV Greater Poland	Wood	3900 ±150*	2330 BC
Łęki Małe I Greater Poland	Wood	3605 ± 35 BP	1970 BC
Szczepankowice IA Silesia	Human bones	3559 ± 24 BP	1890 BC
Szczepankowice IB Silesia	Human bones	3522 ± 24 BP	1785 BC
Leubingen Thuringen	Wood		1942 ± 10** BC
Helmsdorf Thuringen	Wood		1840 ± 10** BC

* after: Czebreszuk 2001, p.220-221

** dendro-dates after: Hinz M.,Eine multivariate Analyse Aunjetitzer Fundgesellschaften,Universitätsforschungen zur Prähistorishen Archäologie, Band 173,9. 115-117, Bonn 2009

Fig 10. Early Bronze Age barrows in Poland- radiocarbon dating comparison



Acknowledgments

We would like to express our gratitude to prof Robert Frei for providing access to the Danish Isotope Laboratory at the Institute of Geography and Geology (University of Copenhagen) and the team of the ^{14}Chrono Center Isotopic Laboratory at Queen's University in Belfast, United Kingdom.
We also thank prof T. Douglas Price for fruitful discussions and Wrocław Archaeological Museum for providing us with permission to use some of archival photographs. Special thanks go to Witold Pokutta for help in paleopathological re-analyses of human remains and Christian Horn for interpretative suggestions.

References:

Andersen,D.L.,1982, Periodontal Disease and Aging,Gerodontology 1,p.19-23

Baron, J., 2011 (ed.), Wyniki ratowniczych badań archeologicznych wielokulturowego stanowiska w Magnicach, gm. Kobierzyce, woj. dolnośląskie, Archeologiczne Zeszyty Autostradowe, vol. 11

Benson, L.V., Hattori, E.M., Taylor, H.E., Poulson, S.R., Jolie, E.A., 2006, Isotope sourcing of prehistoric willow and tule textiles recovered from western Great Basin rock shelters and caves - proof of concept: Journal of Archaeological Science, vol. 33, p. 1588-1599

Bentley, R.A., 2006, Strontium isotopes from the earth to the archaeological skeleton: A review: Journal of Archaeological Method and Theory, vol. 13, p. 135-187

Bentley, R.A., Chikhi, L.,Price, T.D., 2003, The Neolithic transition in Europe: Comparing broad scale genetic and local scale isotopic evidence: Antiquity, vol. 77, p. 63-66

Bentley, R.A., Price, T.D., Luning, J., Gronenborn, D., Wahl, J.,Fullagar, P.D., 2002, Prehistoric migration in Europe: Strontium isotope analysis of early neolithic skeletons: Current Anthropology, vol. 43, p. 799-804

Białousz, S., Marcinek, J., Stuczyński, T., and Turski, R.,2005, eusoils.jrc.ec.europa.eu/esdb.../eusoils_docs/...soilresources.../Poland.pdf, Soil Survey, Soil Monitoring and Soil Databases in Poland: European Soil Bureau, p. 263-273

Buhlin, K., 2004, The role of periodontitis in cardiovascular disease, Stockholm

Butent-Stefaniak, B.,1997, Z badań nad stosunkami kulturowymi w dorzeczu górnej i środkowej Odry we wczesnym okresie epoki brązu, Wrocław

Czebreszuk, J., 2001, Schyłek neolitu i początki epoki brązu w strefie południowo-zachodniobałtyjskiej (III i początki II tys.przed Chr), Poznań

Davis, N., Moorhouse, R.,2002, Microcosm. Portrait of a Central European City,Cape

Ericson, J.E., 1985, Strontium isotope characterization in the study of prehistoric human ecology: Journal of Human Evolution, vol. 14, p. 503-514

Faure, G., 1986, Principles of isotope geology, New York

Frei, K.M., Frei, R., 2011, The geographic distribution of strontium isotopes in Danish surface waters - A base for provenance studies in archaeology, hydrology and agriculture: Applied Geochemistry, (in press)

Frei, K.M., Frei, R., Mannering, U., Gleba, M., Nosch, M.L.,Lyngstrøm, H., 2009a, Provenance of ancient textiles- a pilot study evaluating the strontium isotope system in wool: Archaeometry, v. 51, p. 252-276

Frei, K.M., Skals, I., Gleba, M., Lyngstrøm, H., 2009b, The Huldremose Iron Age textiles, Denmark: an attempt to define their provenance applying the Strontium isotope system: Journal of Archaeological Science, vol. 36, p. 1965-197

Frei, K.M., Vanden Berghe, I., Frei, R., Mannering, U., Lyngstrøm, H., 2010, Removal of organic dyes from wool - implications for ancient textiles provenance studies: Journal of Archaeological Science, vol. 37, p. 2136-2145

Gralak,T., Osadnictwo ludności kultury unietyckiej na stan. Wojkowice 15, gm. Żórawina, pow. Wrocław, in: Gediga B. (ed.) Archeologiczne Zeszyty Autostradowe, vol. 5, Badania na autostradzie A4, part III, 131-304

Grupe, G., Price, T.D., Schroter, P., Sollner, F., Johnson, C.M., Beard, B.L., 1997, Mobility of Bell Beaker people revealed by strontium isotope ratios of tooth and bone: a study of southern Bavarian skeletal remains: Applied Geochemistry, vol. 12, p. 517-525

Grupe, G., Price, T.D.,Sollner, F., 1999, Mobility of Bell Beaker people revealed by strontium isotope ratios of tooth and bone: a study of southern Bavarian skeletal remains. A reply to the comment by Peter Horn and Dieter Muller-Sohnius: Applied Geochemistry, vol. 14, p. 271-275

Hillson , S., 1996, Dental anthropology, Cambridge

Hinz, M., 2009, Eine multivariate Analyse Aunjetitzer Fundgesellschaften,Universitätsforschungen zur Prähistorishen Archäologie, Band 173, Bonn

Horwitz, E.P., Chiarizia, R.,Dietz, M.L., 1992, A novel strontium-selective extraction chromatographic resin: Solvent Extraction and Ion Exchange, vol. 10, p. 313-336

Kadrow, S., U progu nowej epoki: gospodarka i społeczeństwo wczesnego okresu epoki brązu w Europie Środkowej, Kraków 2001

Knudson, K.J., Price, T.D., Buikstra, J.E., Blom, D.E., 2004, The use of strontium isotope analysis to investigate Tiwanaku migration and mortuary ritual in Bolivia and Peru: Archaeometry, vol. 46, p. 5-18

Kowiańska-Piaszykowa, M., 2008 (ed.), Cmentarzysko kurhanowe z wczesnej epoki brązu w Łękach Małych w Wielkopolsce, Poznań

Lasak, I.,1988, Cmentarzysko ludności kultury unietyckiej w Przecławicach, Warszawa

Montgomery, J., 2010, Passports from the past: Investigating human dispersals using strontium isotope analysis of tooth enamel: Annals of Human Biology, vol. 37 (3), p. 325-346

Montgomery, J., Evans, J.A., Wildman, G., 2006, Sr-87/Sr-86 isotope composition of bottled British mineral waters for environmental and forensic purposes: Applied Geochemistry, vol. 21, p. 1626-1634

Sarnowska W., 1961, Kultura unietycka na Śląsku, I, Silesia Antiqua 1961,p.7-38

Sarnowska W., 1962, Kultura unietycka na Śląsku, II, Silesia Antiqua, 1962, p.19-79

Sarnowska W., 1963, Kultura unietycka na Śląsku, III, Silesia Antiqua, 1963,p. 24-80

Sarnowska W., 1965, Kultura unietycka na Śląsku, IV, Silesia Antiqua,1965, p.77-144

Sarnowska W., 1969, Kultura unietycka w Polsce, vol.1, Wrocław

Sarnowska W., 1975, Kultura unietycka w Polsce, vol.2, Wrocław

Sørensen, M. L. S., 2004a, Stating Identities: The Use of Objects in Rich Bronze Age Graves, in: Explaining Social Change: Studies in Honour of Colin Renfrew. J. Cherry, C. Scarre,S. Shennan (eds.), Cambridge, p.167-176

Sørensen, M. L. S. 2004b, The Grammar of Drama: An Analysis of the Rich Early Bronze Age Grave at Leubingen, Germany, in: Die Dinge als Zeichen: Kulturelles Wissen und materielle Kultur, Universitätsforschungen zur prähistorischen Archäologie 127, Bonn, p.283-291

Price, T.D., Burton, J.H., Bentley, R.A., 2002, The characterization of biologically available strontium isotope ratios for the study of prehistoric migration: Archaeometry, vol. 44, p. 117-135

Price, T.D.,Gestsdottir, H., 2006, The first settlers of Iceland: an isotopic approach to colonisation: Antiquity, vol. 80, p. 130-144

Price, T.D., Grupe, G., Schrotter, P., 1994a, Reconstruction of migration patterns in the Bell Beaker Period by stable strontium isotope analysis: Applied Geochemistry, vol. 9, p. 413-417

Price, T.D., Johnson, C.M., Ezzo, J.A., Ericson, J.,Burton, J.H., 1994b, Residential-mobility in the prehistoric southwest United-States - a preliminary-study using strontium isotope analysis: Journal of Archaeological Science, vol. 21, p. 315-330

Price, T.D., Manzanilla, L., Middleton, W.D., 2000, Immigration and the ancient city of Teotihuacan in Mexico: A study using strontium isotope ratios in human bone and teeth: Journal of Archaeological Science, vol. 27, p. 903-913

Voerkelius, S., Gesine, D.L., Rummel, S., Quétel, C.R., Heiss, G., Baxter, M., Brach-Papa, C., Deters-Itzelsberger, P., Hoelzl, S., Hoogewerff, J., Ponzevera, E., Van Bocxstaele, M., and Ueckermann, H., 2010, Strontium isotopic signatures of natural mineral waters, the reference to a simple geological map and its potential for authentication of food: Food Chemistry, vol. 118, p. 933-940

Von Carnap-Bornheim, C., Nosch, M.-L., Grupe, G., Mekota, A.-M.,Schweissing, M.M., 2007, Stable strontium isotopic ratios from archaeological organic remains from the Thorsberg peat bog: Rapid Communications in Mass Spectrometry, p. 1541-1545

Streszczenie

Niniejszy artykuł prezentuje wyniki analiz izotopowych nekropoli unietyckiej w Szczepankowicach. Jest to studium pilotujące szerszy, trwający obecnie program badań dynamiki populacyjnej oraz migracji kultury unietyckiej na Dolnym Śląsku i zostało zadedykowane 'ludziom kurhanów', czyli elicie plemiennej epoki wczesnego brązu.To kompleskowy model interpretacyjny nekropoli unietyckiej we wczesnej fazie klasycznej. Składają się na niego następujące elementy: historia stanowiska w Szczepankowicach, nowe spojrzenie na stratygrafię i elementy alteracji i ich znaczenie dla diagnostyki archeologicznej omawianego stanowiska, uwagi na temat elementów kultury duchowej, w tym unietyckiej koncepcji zaświatów, widocznej w strukturze grobowców. Kolejno prezentowane są ponadto badania paleopatologiczne szczątków ludzkich, omówienie metodologi badań migracji w oparciu o spektrometrię mas, praktyczne zastosowanie wspomnianej technologii na przykładach dwóch kobiet (epoka brązu i neolit) oraz określenie chronologii absolutnej kurhanów, tak w kontekście lokalnym jak i w porównaniu z innymi podobnymi stanowiskami w Europie.

Prezentujemy pierwszy w Polsce przypadek udowodnionej migracji ludzi w oparciu o badania bioarchaeologiczne. Materiał szkieletowy pochodzący z kurhanów szczepankowickich posłużył do ustalenia wartości lokalnego geologicznego poziomu izotopu strontium, wynoszącego dla obszarów Wrocławia 0,714485. Wspomniana wartość wyznaczyła punkt zerowy umożliwiający badania ruchów migracyjnych (tak ludzi jak zwierząt) na obszarach Równiny Wrocławskiej, przy zastosowaniu jonizacji termalnej i technologii spektrometrii mas. Próbki pobrane ze szkieletów dwóch kobiet (osobnika z kurhanu IB w Szczepankowicach, datowanego na wczesną epokę brązu oraz neolitycznego pochówku kobiecego z Magnic) posłużyły do testu czynnika migracyjnego. Rezultaty wykazały, że obie poddane badaniu kobiety były imigrantkami i autorki prezentują wstępne hipotezy dotyczące miejsca/miejsc, skąd mogły przybyć.

Próbki pobrane ze szkieletu kobiety szczepankowickiej (kurhan IB) oraz ze szczątkowo zachowanego osobnika z dolnego kurhanu IA, posłużyły do ustalenia sekwencji chronologicznej kurhanów. Po kalibracji data usypania pierwszej mogiły to 1874 BC, podczas gdy drugi kurhan został nasypany na już istniejący obiekt po upływie przypuszczalnie ok.110 lat,czyli ok.1760 BC.