3_4_1_The_Nebelivka_1B_sediment_core_(Albert_et_al._in_press)

Introduction

The reconstruction of the vegetational history of Ukraine has been based on major sediment cores in the principal river basins (e.g., the Dniester, the Southern Bug and the Dnieper), with occasional pollen cores recovered from archaeological sites (Kremenetski 1997; 2003; Pashkevich 2012). None of these cores provided sequences for an inter-fluvial region and, therefore, none lay close to the classic mega-site concentration in the Bug - Dniester interfluve. Moreover, none of the current pollen diagrams were well-dated by modern standards, often relying on relative vegetational changes to infer absolute dates. The Project relied on two sources of information to discover promising sites for sediment coring:- the peat database and local fieldwork.

In the 1960s, the USSR Ministry of Agriculture instructed each Republic to compile a list of peat-rich locations for future exploitation as organic fertilizer for local agriculture. In Ukraine, part of the peat archive is held at national level in the Geological Institute, while other parts of the archive are held in regional capitals (in our case, Kirovograd). Dr. Kremenetski's study of the National archive helped to locate two possible peat-coring sites: Lisove / Lysycha Balka, a small fen site 60 km East of Nebelivka, and Onopriivka, an equally small basin close to the mega-site of Vesely Kut, some 25km from Nebelivka.

At Lisove/Lysycha Balka (48°47’25.1” N, 31°07’50.3” E), 250 cm of peat with some visible layers of increased mineralization were recovered until the mineral bottom was reached.

At Onopriivka (49°01’41.48” N, 30°40’23.5” E), we obtained 500 cm of peat with well defined mineral layers (traces of erosion). Below the peat, we recovered 170 cm of lacustrine sediments before reaching the mineral bottom. In 2012, the Onopriivka core is the longest peat core obtained so far for that part of Ukraine.

The preliminary results from Onopriivka indicated that the diagram covered a large portion of the Holocene, including the Trypillia period, and that the spectra were not dominated by alder, which means that alder carr is quite recent. The regional environment was most likely a forest-steppe; it was never completely forested but there were always natural open landscapes – which was one of the reasons for choosing this place for agricultural colonization. The Loss on Ignition data show a large variability in the mineral content of the peat, which reflects

local erosion history. The uppermost mineral layer should, as elsewhere, demonstrate erosion in recent historical times (since the AD 10th century), but there were traces of the earlier stages of agricultural expansion/fluctuations in the lower part of the core. However, neither of these sites offered any potential for a reconstruction of the human impact story of the Nebelivka mega-site.

The second method was walking the river valleys near the mega-site to discover potential reduced, low-energy alluvial deposits where pollen is preserved by virtue of a sub-aqueous situation, promoting reduction in Holocene accumulations of sediment within valleys deeply incised in the Pleistocene. Areas topographically suited for Holocene sediment deposition were determined by field reconnaissance, aided by high-quality 1:10,000-scale maps provided by the Kirovograd Regional Government. The most desirable morphological characteristics include low slope aspect, especially after a break in slope, along a long valley profile and high potential for sediment accumulation based on a high transverse profile. Desired qualities assumed to be operative in the location of the mega-site include most importantly high land-erosion levels within the drainage basin following arable agriculture. The advantage of such alluvial areas was that the sediment catchment of the small basins was equally constrained, while the pollen catchment was also limited. Fieldwork by Dr. Bruce Albert and Dr. Konstantin Kremenetski resulted in the discovery of three coring sites, each within 2km of the Nebelivka mega-site. Preliminary coring of each site enabled AMS range-finder dating of all three cores. The most promising core was the Nebelivka 1 core, located in the stream valley 250m from the edge of the mega-site, East of its North East margins. The core's sediments appeared to be continuous from the period well before the mega-site occupation, lasting through the mega-site occupation and continuing well after the abandonment of the mega-site (viz., 6th - 3rd millennia BC).

Investigations of the palaeo-environment at Nebelivka provide an excellent opportunity for testing the ecological impact of a mega-site, the more so since the coring site is only 250m from one edge of the mega-site (ADS LINK TO 3_4_2_IMAGES/3_4_2_1_map_of_catchment). Previous investigations of Trypillia lifeways indicate an expectation of five kinds of impact: (1) forest clearance to provide crop land for intensive or extensive farming, with timber for building the hundreds of houses as well as cooking and heating; (2) intensive charcoal concentrations marking the regular burning of houses at the end of their life-cycle; (3) agricultural and/or pastoral indicator species; (4) high

soil erosion caused by mega-site settlement which would have resulted in high sedimentation rates; and (5) the stress that a supposedly large site population would place on the water supply provided by a network of small streams.

The study focuses on Holocene sediments in a six-meter sediment core where pollen is preserved under reducing and neutral conditions, designated P1. The core was taken at the south-east edge of a small basin c. 200m in length and c. 80m in width. The topography indicates that the coring site was an alluvial site rather than a cut-off side-channel with fen or bog characteristics. On the West side of the basin, nearest the mega-site, slopes approached 30° - the steepest slopes of any area on the edge of the mega-site - with more gradual slopes of 15° - 20° on the East side of the valley.

Methods

Sediments were extracted by a Cobra corer with a one-meter window sampler with plastic sampling tubes. A total of 89 samples for pollen analysis was taken with a scalpel at 5 mm intervals in sediment core P1, from 4900 to 3340 mm dept. Particle size analysis, loss-on--ignition analysis, micro-charcoal analysis were performed. A radiocarbon chronology was constructed on the basis of 11 AMS dates to produce a Bayesian age-depth model (ADS LINK TO 3_4_2_IMAGES/3_4_2_2_age_depth_model) (for technical details, see Albert et al., submitted). The Bayesian model for the 80+ AMS dates for the mega-site indicated a duration of 150 - 200 years, within the dates 3950 - 3750 Cal BC [ADS - LINK TO SECTION 4_9]. This, in turn, suggests that the mega-site was contemporary with Pollen Zones 5 - 7 in the P1 core.

Assessment of ecological impact

The general assessment of each of the five kinds of human impacts we expected to find in the Nebelivka P1 diagram - cereals, charcoal, agro-pastoral indicators, erosion and hydrology - is based upon a tabulation of the key depths at which changes can be noted (ADS LINK TO 3_4_2_SPREADSHEET/3_4_3_Human_impacts).

Forest cover was highest in the early Zones, reaching peaks of 55% total land pollen in Zone 1 and 45% in Zones 2 and 3 but rarely more than 30% in Zone 8 (ADS LINK TO 3_4_2_IMAGES/3_4_2_3_Nebelivka_P1B_final). There is thus a gradual, cumulative

decline in forest cover over the central part of the core, with cycles of forest clearance and re-afforestation in each Zone from Zone 3 to Zone 8 - viz., before, during and after the mega-site occupation. Minor episodes of elm decline are dated to the mega-site period but both were reversed within a period of decades. Both episodes were of a magnitude found before and after the mega-site occupation. There is no single forest clearance event indicating a massive phase of building and/or burning in the entire diagram.

The **micro-charcoal** sequence shows a series of peaks in either two or all three size ranges but nothing on the scale of a major 5210mm fire event at the end of Zone 3 (ADS LINK TO 3_4_2_IMAGES/3_4_2_4_Nebelivka_P1B charcoal). Although cereal indicators pre-date this event, it is likely that the fire represented a significant opening-up of the Nebelivka landscape for agro-pastoral activities through widespread burning of the primary forest. Age-depth modelling puts this fire event at c. 100 years before the foundation of the mega-site. Thereafter, the periodicity of minor micro-charcoal peaks before, during and after the mega-site period, rarely matched those of Cerealia pollen, suggesting the cause lay in house-burning rather than burning of primary forest.

The age-depth model suggests a long duration of **cultivation**, at least 400 years from initial cultivation in Zone 2 to a maximum in Zone 6 (5.1% cereals). This timespan is much longer than the modelled occupation period of the megasite. After an early Zone 3 spike in Cerealia pollen at 5305mm, a continuous curve of *Triticum*, *Hordeum* and Cerealia pollen lasted well into the mega-site period, when especially large *Triticum* grains suggest *T. spelta* rather than *T. dicoccum*. The sequence of cereal pollen findings indicates variable levels of cultivation rather than increased agricultural intensification, with the poverty of definitive annual weed flora suggestive of a four - five-year fallowing system. There is a decline in cereal indicators in the post-mega-site Zone 8. NPP pastoral indicators began to be important before dwelling on the mega-site (Zone 4) and increased in Zones 5 - 7, although signals for intensified pastoralism are contradictory. Further increases in Zone 8 indicate the likelihood of greater reliance on pastoralism in the post-mega-site period,

Sedimentation from A-horizon sources is strongly indicated by very high levels of ascospores of *Glomus* (HdV 207, in many cases, above 5% TLP), a native to biologically active soils (ADS LINK TO 3_4_2_IMAGES/3_4_2_5_Nebelivka_1B_NPP). This NPP type is present throughout the pollen sequence albeit in much lower values or absent in Zone 8. Its appearance from Zone 2 onwards was often correlated with agricultural indicators. The

highest *Glomus* values were found in Zone 4 (pre-mega-site) and in the three phases coeval with mega-site dwelling. These data suggest that land erosion was a long-term effect of mega-site dwelling.

Our indicators for **palaeo-hydrology** reveal a striking pattern of increasing water depth and flow through the pre-mega-site Zones 2 - 4, with water depth estimated at 1m above the coring surface. The disappearance of full-aquatic plants in Zones 5 - 7, and their replacement by shallow-water species, shows a fall in water quality and a drop in the water table. An even lower water table is proposed for the post-mega-site period. The mega-site demand for drinking water, water for the construction of houses and animal use of rivers and streams must have placed a strain on the relatively small water resources of the Nebelivka area. We have identified four 'impact events' where three of the five classes of information changed at the same depth (ADS LINK TO 3_4_3_SPREADSHEET/3_4_3_Human_impacts). All but the fourth 'impact event' occurred before the occupation of the mega-site, in Zones 2 (5300 - 5295 mm), 3 (5235 - 5230mm) and 4 (5185 - 5175mm) respectively. The fourth 'impact event', in Zone 6 (5055 - 5050mm) is defined by a combination of a fall in arboreal pollen- mostly *Quercus* - with the re-start of a continuous curve for Cerealia and *Glomus* (an erosion indicator). One significant conclusion is that the impact events are by no means limited to, or indeed correlated with, the mega-site dwelling period, reinforcing the suggestion that there were pre- mega-site settlements in the Nebelivka area which have not yet been discovered during fieldwalking. A second point is the lack of synchronisation between the micro-charcoal peaks, of which ten were found in the core, with any of the impact events. Only three microcharcoal peaks were found in layers coeval with the mega-site occupation and, of these three, only the 4980mm peak was found in all three microcharcoal sizes.

It is important to underline what is perhaps the most important conclusion of our investigations - namely that there is no sign of major human impact at **ANY** point in the P1 sequence. The well-preserved pollen, charcoal and NPPs permit an assessment of ecological impacts and there is no concentrated impact of all five forms of evidence anywhere in the sequence. Accepting the age-depth model, what we find are increases in erosion rates and a decline in water quality during the mega-site occupation. Given the variations in population numbers even between the various 'minimalist' models (currently modelled at 1,500 - 4,000), not to mention the maximalists' estimates of 10,000 - 46,000, the increase in land erosion rates and the decline in water quality in what is, after all, a small hydrological network, come as no surprise. What is more significant is the lack of sustained high cereal values and high

pastoral indicators, as much as the absence of spikes in the micro-charcoal curve, especially at the end of the mega-site occupation. It is these absences which suggest that the minimalist models are far more likely to be correct and that it is time to consider them seriously in place of the seriously weakened account of maximalist ecological impact.

The second most important conclusion stemming from the acceptance of the age-depth model concerns the high probability that there were indeed mixed farmers living in the Nebelivka area before the settling of the mega-site, even though their artifactual footprint has not yet been found. There is ceramic evidence for an earlier (Phase A) settlement only 20km from Nebelivka. Intriguingly, the persistence and strength of pre-mega-site agro-pastoral indicators were comparable to those found in the mega-site period. However, the strongest evidence for a major fire event indeed dated to the pre-mega-site period, as the probable opening up of the area for agro-pastoral activities. Nothing on the same scale as the 5210mm event has been detected in the micro-charcoal record for the mega-site occupation. It seems highly likely that this pioneer clearance event increased the attractions of the Nebelivka promontory for subsequent dwelling.