INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE

ISSN: 2067-533X Volume 1, Issue 3, July-September 2010: 167-173 www.ijcs.uaic.ro

HUMAN IMPACT AND VEGETATION HISTORY ON SALT SPRING EXPLOITATION (*HALABUTOAIA* – TOLICI, PETRICANI, NEAMT, ROMANIA)

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Abstract

Salt exploitation from the mineral spring of Halabutoaia - Tolici (Neamt, Romania) is one of the earliest in Europe. Salt production is documented from the Early Neolithic to the end of Chalcolithic period (6000-3500 BC) with an important stratigraphy of 8 m high. In 2008, a core drilling was performed in the salty swamp of the spring closed to archaeological site. Pollen analysis and the study of non-pollen palynomorphs suggest a very anthropic environment since the Early Neolithic. Salt exploitation, agriculture and pastoralism (presence of spores of coprophilous fungi) are directly in connection with these variations. After this intense exploitation, human impact is always perceptible in spite of reforestation.

Keywords: *Salt spring; palaeoenvironment; Neolithic; human impact; pollen; non-pollen palynomorphs; Romania.*

Introduction

Located in the Moldavian Subcarpathians (Fig. 1), *Halabutoaia* salt spring site in Tolici is one of the earliest in Europe. This salt spring is located in a zone rich in salt springs. Several archaeological deposits, related to salt exploitation from the Early Neolithic [1, 2], were found in this area.

This site was discovered during an archaeological survey in 2005, assessed in 2006 [3] and excavated since 2007 in collaboration with the Piatra Neamt Museum [4]. It's an exceptional site for its stratigraphic development (8 meters of combustion features and ceramic deposits), the abundance of archaeological material, its high level of preservation and its informative potential (large swamp around the salt spring) (Fig. 2). Salt must have influenced prehistoric communities in fundamental ways and salt production was probably linked to the sustained existence of significant Neo-Chalcolithic settlements located less than 10 km away.

So, this research aims to establish vegetation history in the surrounding of the *Halabutoaia* - Tolici (Petricani, Neamt) salt spring and to assess human impact in this particular area, using pollen and non-pollen palynomorphs (NPPs) proxies and AMS radiocarbon dates of the sequence.

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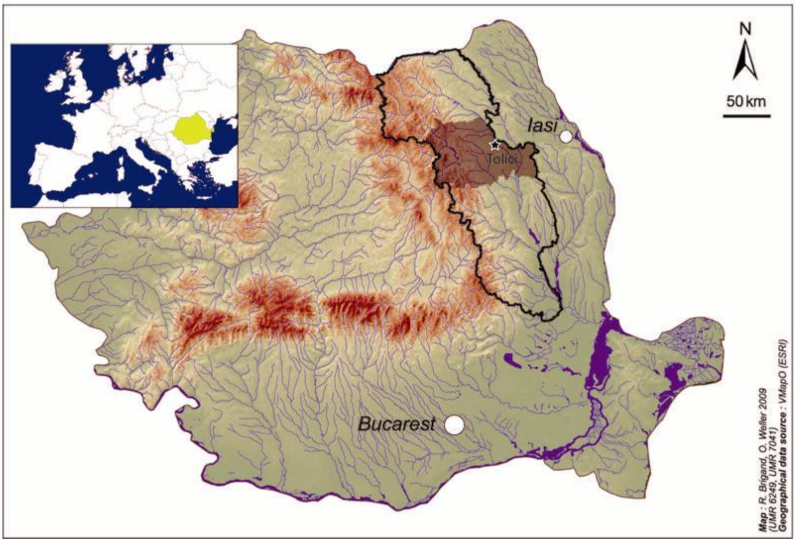

Fig. 1. Location of the study area (Tolici, Petricani, Neamt, Romania)

Fig. 2. General view of *Halabutoaia* salt spring site - Tolici (Neamt)

Materials and Methods

In 2008, a core drilling (S. 14) with an auger was performed in a swamp nearby the spring and the archaeological site (Fig. 3).

Sediment samples were processed for pollen and non-pollen palynomorph (NPP) analysis, using standard techniques [5]. They were treated with HCl (10%), NaOH (10%), HF (40%), $ZnCl_2$ acetolysis (8 min). A minimum of 400 pollen grains of terrestrial plants was counted in each sample to ensure statistical significance. Spores and non-pollen palynomorphs were excluded from the pollen sum. Pollen grains were identified with the aid of a reference collection and keys [5, 6], photographs [7, 8]. Non-pollen palynomorphs were identified according to Bell [9], van Geel [10], van Geel et al. [11, 12]. The pollen diagram was drawn using TILIA and TGView software [13].

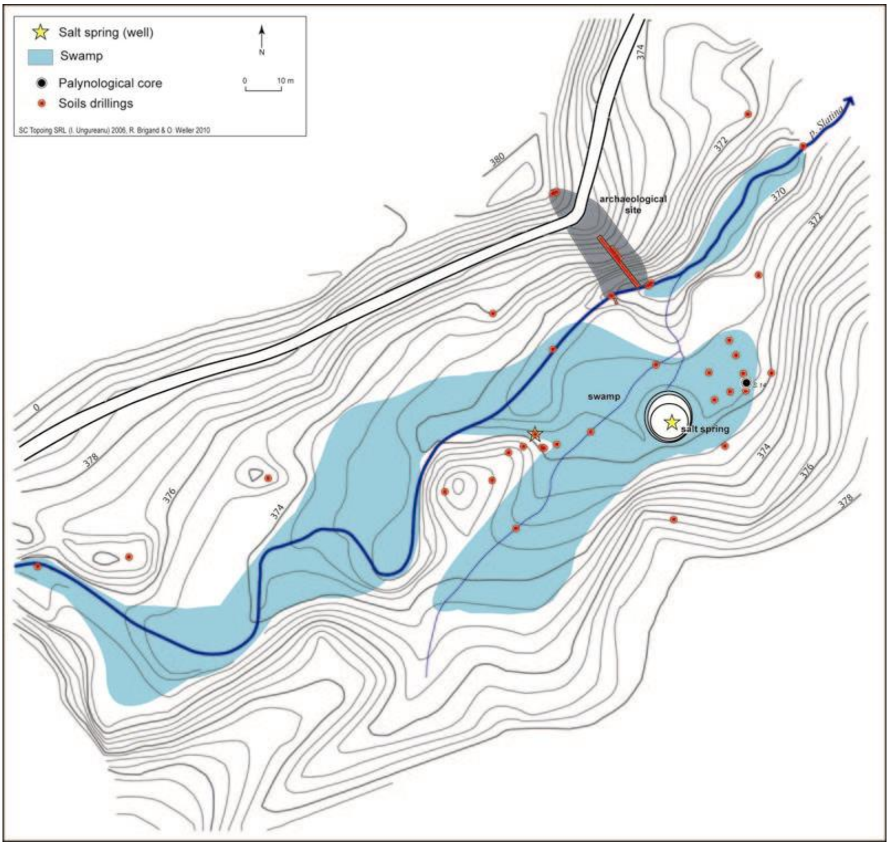

Fig. 3. Location map of the *Halabutoaia* – Tolici area
(salt spring, swamp, archaeological site and palynological core)

Four samples were dated at the Poznan Radiocarbon Laboratory (Poland) and calibration has been done according to Reimer *et al*. [14] (Table 1).

Table 1. Radiocarbon dates from *Halabutoaia* – Tolici (Petricani, Neamt)

Depth (cm)	Material	Laboratory code	Radiocarbon age (BP)	Calibrated age (BC) (95.4% probability)
232	charcoal	Poz-24387	5020 ± 40	3950-3700
285	wood	Poz-24388	6140 ± 40	5220-4980
326	wood	Poz-30824	6300 ± 40	5370-5210
397	charcoal	Poz-30825	6500 ± 40	5540-5360

Results and Discussions

A simplified percentage diagram with selected curves of pollen and non-pollen palynomorphs taxa (NPP) is presented in Fig. 4. Many plants related to human activities (*Cerealia*, ruderals and plants from grassland pasture) are apophytes (they are naturally a part of the local flora however they were favored by agropastoral activities) [15]. They are also heliophilous taxa: clearance and the development of human activities have favoured their development.

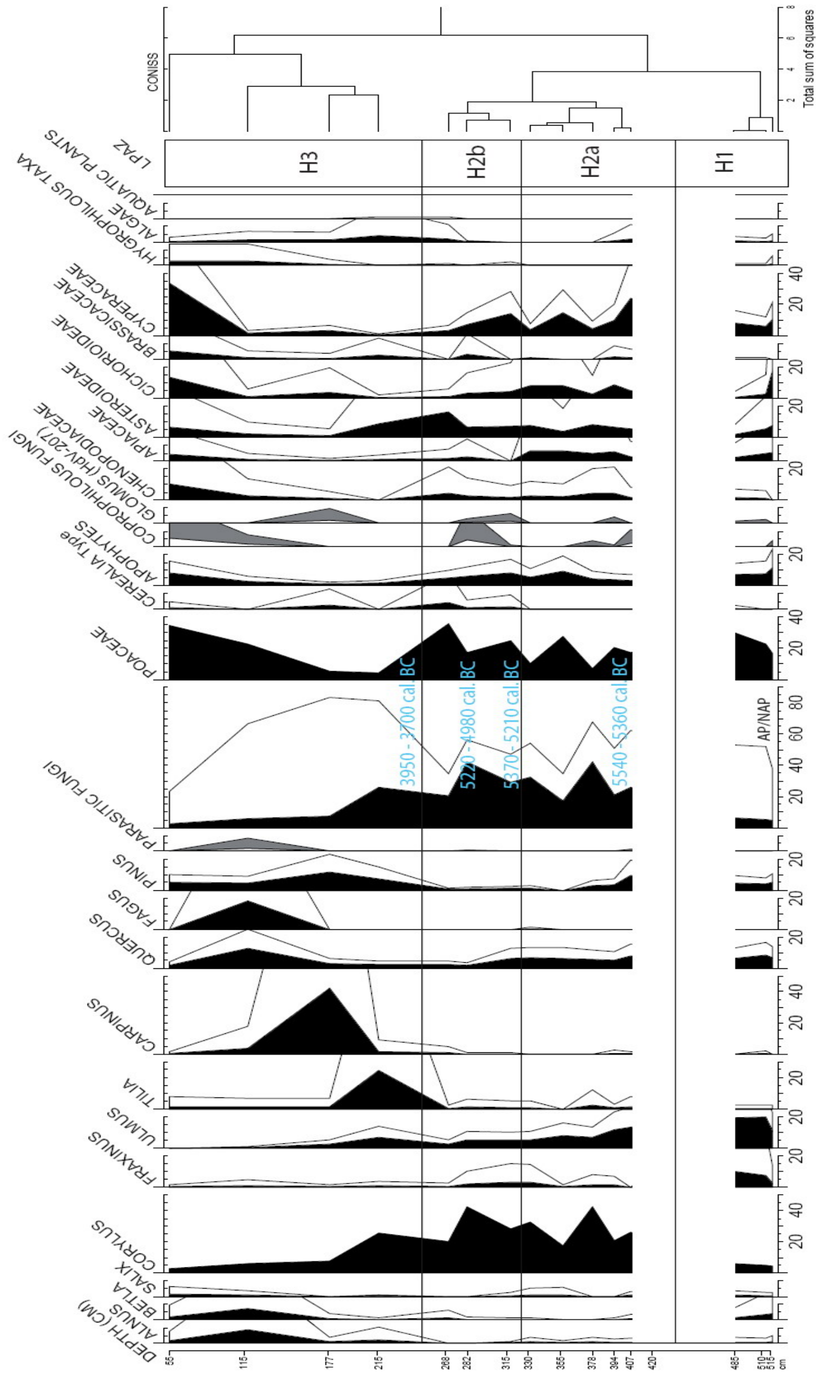

Fig. 4. – Simplified pollen and non-pollen palynomorph (NPP) diagram (based on a relative percentage calculation) from *Halabutoaia* – Tolici (Petricani, Neamt), S. 14

The curve of "NPP" or "Non-Pollen Palynomorphs" represents the sum of non-pollen palynomorphs. These non-pollen palynomorphs are, in this case, mainly fungal spores, in particular parasites fungi of trees as *Ustulina deusta* and coprophilous fungi as *Sordariaceae* [12]. These last ones develop on herbivores dung and their finding often suggests a pastoral presence nearby the site. *Glomus* is an endomycorrhizal fungus occurring on the roots of a variety of host plants. Chlamydospores observed in sediment are indicative of erosion of soils in the catchment of the site [11].

To facilitate description and interpretation of the pollen diagram with respect to vegetational changes, 3 Local Pollen Assemblage Zones (LPAZ) were established (Fig. 4). The pollen zones are described below.

In LPAZ 1 (H1: 515 cm – 485 cm), oak (*Quercus*), elm (*Ulmus*) and ash tree (*Fraxinus*) are the dominant taxa of the forest. There are also lime (*Tilia*) and hornbeam (*Carpinus*), however percentages of this two taxa remain very low. Hazel (*Corylus*), alder (*Alnus*), birch (*Betula*) and willow (*Salix*) are present but their values remain lower than 10%. The herbaceous spectra is dominated by *Artemisia*, *Anthemideae* and *Cichorioideae*. Among the anthropogenic indicators, *Plantago lanceolata*, *Rumex* and *Cerealia* occur regularly.

The LPAZ 2 (H2: 420 cm – 233 cm) can be subdivided into two subzones (2a and 2b). In the first subzone (H2a: 420 cm – 326 cm), we observe an increase in *Corylus* (10 in 30%). Others tree taxa (*Quercus*, *Ulmus*, *Fraxinus*) are slightly decline. Occurences of *Carpinus* pollen grain remains punctual. Herbaceous are mainly represented by *Artemisia*, *Anthemideae* and *Cichorioideae*. *Polygonum aviculare type* appears for the first time. The rates of *Poaceae* are fluctuating (from 5 to 20 %) and the *Cyperaceae* increases slightly. The anthropogenic indicators are increasing but there is no pollen of *Cerealia*. In the second subzone (H2b: 325 cm – 233 cm), *Corylus* still has important percentages (from 10 to 30 %). Values of ash (*Fraxinus*), elm (*Ulmus*) and oak (*Quercus*) are decreasing. The percentages of *Anthemideae*, *Cichoroideae* and *Polygonum aviculare* also decrease. Pollen grains of *Cerealia* type appears. We can observe, among the non-pollen palynomorphs, coprophilous fungi (*Sordaria* -Type 55) and chlamydiospores of *Glomus*.

LPAZ 3 (H3: 232 cm – 55 cm): The beginning of this sequence is related to high percentages of *Poaceae* (40%), of *Anthemideae* (10%) and of *Chenopodiaceae*. At the same moment, percentages of *Corylus* (15%) collapse and a peak of *Cerealia* is visible. *Cyperaceae* are in decline. A significant characteristic of this pollen zone is the sudden increase of deciduous trees (elm, lime, charm, beech). A small peak of *Cerealia* accompanied with an increase of the anthropogenic indicators is observable in this zone. Towards the end of this zone, the tree taxa rates collapse. The values of *Poaceae* stabilize and the rates of *Cyperaceae* increases. *Anthemideae*, *Cichoroideae* and *Polygonum aviculare* type also increase. The rates of non-pollen palynomorphs are more important. Among the non-pollen palynomorphs, the Type 44 (*Ustulina deusta*) dominates.

The first part of the diagram (LPAZ H1, H2a, H2b) corresponds to an open environment which is dominated by herbaceous taxa, *Poaceae*, *Cyperaceae*, *Anthemideae* and *Cichorieae*. The first zone could correspond, according to radiocarbon dates, to the beginning of the Holocene (8200-6900 cal. BC): elm and birch (pioneer trees) expended during the Boreal period [16, 17]. Contrary to Western Europe, hazel is not the dominant taxa during this period. Maximum of hazel occurred during Atlantic period, which is dated, in Romania, from 6900 to 3700 cal. BC [16, 17]. Within this open environment appear numerous anthropogenic indicators: pollen grains of *Cerealia*, presence of pollen of weeds (*Polygonum aviculare*) and plants of trampled and grazed areas (*Plantaginaceae*, *Rumex*). The occurrence of chlamydiospores of *Glomus* [10] is concomitant with spores of coprophilous fungi (*Sordariaceae*, Type 55), and definitively confirms the existence of human impact (deforestation and agro-pastoralism) dated from the early Neolithic period (around 5500 BC) to the Chalcolithic period (before 4000 BC). However farming activities can’t explain the importance of clearance. Salt exploitation can be deducted from the low percentages of pollen trees, probably related to a human-driven deforestation and the quest for fuel [18]. Evidence of soil erosion indicators (*Glomus*) are another good proof of human activities in the area.

In the second part of the diagram (LPAZ H3), afforestation seems obvious. There are very few human disturbances. Neolithic clearances made easier the installation of lime. Then, a natural succession of forest vegetation is visible in spite of the reduced number of analyzed samples: elm and hornbeam appears, and then beech and oak. Considering the altitude (approximately 377 m), the percentages relatively high of spruce, pine and fir can be explained by aerial pollen transport from montaneous areas. Our results are in accordance with those obtained by I. Tantau [19] for a site (Avrig 1, Sibiu) situated almost at the same height. The decrease in sedimentation, compared to the first two pollen zones, is explained by the almost absence of the agro-pastoral activities, the reforestation of this particular area at the end of the Chalcolithic period and the probable abandonment of salt exploitation.

The very end of diagram corresponds to a more open landscape: increase in *Cerealia* and anthropogenic indicators, occurrence of *Sordariaceae* attest the presence of farming activities. Hygrophilous plants and aquatic taxa are indicative of a wet zone in the vicinity of the site.

Conclusions

In conclusion, this sequence from *Halabutoaia* provides a pollen record of the first part of the Holocene period. The first pollen zone (LPAZ H1), could be related to the Boreal period. However, nothing allows us to really assert this datation except the percentages of elm, slightly superior to those of hazel. In the first two zones, the rate of sedimentation, very important, seems related to the human activities (salt exploitation, agriculture and pastoralism from 5500 BC). By the end of the Chalcolithic period, the reforestation began with a natural succession of forest vegetation. It is now necessary to date and to analyze more samples from this last zone to understand and confirm the afforestation and eventual human activities. Further analyses from the Neolithic zones are also necessary to precise in detail human impact and vegetation history in this remarkable dilated sediment context.

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Funding Body

Funding for a part of this study was provided by the "*Developing the innovation capacity and improving the impact of research through post-doctoral programmes*" project (POSDRU/89/1.5/S/49944). Special thanks to the department of archaeology and social sciences of the French Ministry of Foreign Affairs and the CNRS Human and Social Sciences Department for their support in this project and the Piatra Neamt Museum for its collaboration.

Received: July 14, 2010
Accepted: August 26, 2010