ARCHAEOLOGY OF SALT

APPROACHING AN INVISIBLE PAST

EDITED BY

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Contents

Spatial analysis for salt archaeology: a case study from Moldavian Neolithic (Romania)

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Abstract. This paper presents the results of a spatial analysis project in Romanian Moldavia focused on the dynamics of salt exploitation in the longue durée. Spatial and statistical measures are used to investigate the relationship between salt resources distribution and settlement patterns from the Early Neolithic to Chalcolithic (6000-3500 BC). This work combines methodologies used in landscape archaeology with the potential of the Geographic Information System to mobilise archaeological artefacts in a large-scale setting and for many thematic purposes. General goal is to evaluate how salt resources were a driving factor for these farming groups of eastern Romania.

Keywords. Moldavia, Neolithic, settlement pattern, GIS.

Résumé. Cette contribution présente les résultats des analyses spatiales menées en Moldavie roumaine autour de la dynamique des exploitations préhistoriques du sel dans la longue durée. Des études statistiques et spatiales sont menées afin d'explorer les relations entre la distribution des ressources en sel et la trame des peuplements néolithique et chalcolithique (6000-3500 BC). Ce travail combine les méthodologies de l'archéologie du paysage avec un outil puissant comme les Systèmes d'Information Géographique afin de mobiliser les découvertes archéologiques dans le cadre d'une approche multi-scalaire et ouverte à différentes entrées thématiques. L'objectif général est d'évaluer comment les ressources en sel ont été largement intégrées aux territoires des premières communautés agricoles de l'est de la Roumanie.

Mots-clés. Moldavie, Néolithique, système de peuplement, SIG.

The aim of the present work is to study prehistoric settlement patterns, as well as the nature and distribution of salt resources. In salt archaeology, the territorial dimension related to its production has been traditionally put forward for the more recent periods of the Bronze Age and especially for the Iron Age. More recently, many studies have focused on understanding the forms of territorial organisation inherent to the colonisation of saliferous regions, and the contexts of emergence of fortified settlements, stable and directly linked to the control and exploitation of salt springs or rock-salt deposits. In this respect, the Subcarpathian region of eastern Romania (Moldavia) is particularly interesting, since it displays a unique density of saline-water springs, reflected by the discovery of the first forms of salt exploitation recorded for the earliest Neolithic (Criş) and, thereon, the emergence of a cultural centre of an unparalleled richness and importance during the Chalcolithic (Precucuteni and Cucuteni). A decade of research concerned both with the nature and with the use of the salt resources, as well as the establishment of an archaeological database covering the timespan from *c.* 6000 BC to *c.* 3500 BC, allowed us to advance a first archaeological assessment of the territorial strategies employed by these societies in the eastern-Carpathian regions. Several questions frame this endeavour: is salt a structuring resource, attracting and fixating human populations for nearly 3000 years? Is the control of salt able to attract massively, objects and materials that are socially valued and thus to indirectly stimulate a strong local dynamics capable of fuelling long-distance trade circuits? Can salt, by itself, explain the remarkable trajectory of the prehistoric societies from Moldavia? To provide some answers to these fundamental questions on the place of salt in these ancient societies, we relied on an integrated study of the social and environmental facets involved. A major tool like a Geographic Information System (GIS) completed the archaeological and ethnographic approaches around the salt springs, in order to modelize the forms and dynamics of land occupation. It also served to enrich the discussion on the territorial organisation and resource management, now the centre of an emerging approach dealing with several key objects of prehistoric archaeology: supply, accessibility and availability of mineral, lithic or agronomic resources; distribution of raw materials; inter-site relationships; territorial delimitation and construction of territories. The work presented in these pages adds rigour to this approach: it seeks to improve our view of the diachronic relations and interactions between society and the environment.

The Moldavian Salt

Romania has the most abundant and accessible salt resources in the whole of Europe (fig. 1). Connected to the Carpathian orogenesis, the saliferous deposits of lagoonal origin from the Aquitanian and the Tortonian appear as halite formations or saliferous clays, and are distributed both along the outer and inside edge of the Carpathian range (Moldavia, Muntenia, Oltenia, Transylvania) (*e.g.* Merutiu 1912; Velcea and Savu 1982, 239-243). In Moldavia, the halite deposits are distributed along a north-south axis and generally mark the transition between the Oligocene-Eocene formations and the more recent ones of the Miocene. South of

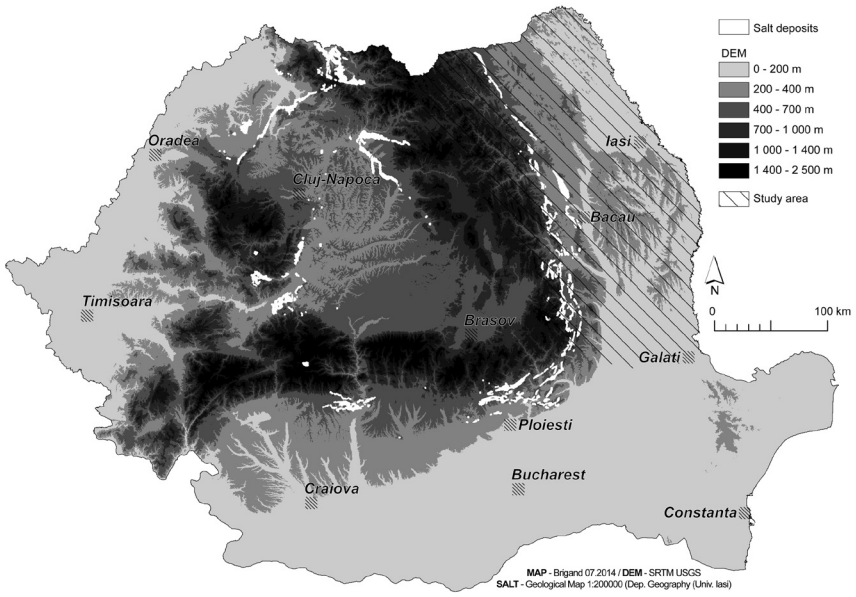


Figure 1. Salt deposits, study area and main agglomerations.

Bacău, near the Curvature Carpathians, the tectonic dynamics and the interplay of differential erosions contributed to the low depths of these deposits and their recurrent outcrop (fig. 2).

Halite outcrops, found particularly in the area of the Curvature Carpathians, are located high up between 300 m and 700 m above sea level, on steep slopes of minor waterways which are often torrential. As for the salt springs, fed by the groundwater that washes the saline bedrock, they are found at variable hights (from 135 m to 936 m) and generally on two types of topographic contexts: at the top of a little secondary valley, more or less deeply cutting through the substrate; and at the bottom of a valley and close to the thalweg, on modest terraces that protect them from alluvial processes. Those above 700 m are, for the most part, found north of Piatra Neamț (fig. 3), along the minor tributaries of the Bistrița or Suceava rivers, or on the first chain of the Carpathian foothills. Those below 300 m are found near the middle courses of the Siret and Bistrița rivers, save for one spring, located much further east in the Moldavian Plain (Iași County).

Apart from the latter, to which we will return later on, the availability of the salt resources puts the Subcarpathian region in direct opposition to the Moldavian lowlands. This fundamental difference may however seem contrived, since we have also recorded east of the Siret almost a hundred saline soils (and many more remain unrecorded) of which less than half are emerging waters that are very little or slightly brackish. Their reduced salinity, often difficult to determine, results *a priori* of the dissolution of salts contained by the marl and clay of the geological substrate, followed by their capillary movement to the surface. The use of these saliferous resources is not well documented, either by ethnography or archaeology.

Figure 2. Salt springs and rock-salt outcrops in Moldavia. A. Solca-Slatina Mare (Suceava), B. Cucuieți-Slatina Veche (Bacău), C. Hangu-Slatina (Neamț), D. Oglinzi-Poiana Slatinei (Neamț), E. Coza-Grochile (Vrancea), F. Coza-Alghianu (Vrancea). Photos RB and OW.

Still, very specific customary uses by pastoral communities are not excluded. Since we have only very limited data on these soils and saline waters, and their role in the clustering of settlements cannot be demonstrated for the time being, we have not dwelled on them.

State of the art

We know that the first forms of salt exploitation, whether in liquid or solid form, should be put in connection with the emergence of the first agro-pastoral communities and the emergence of complex economies from the Neolithic onwards (Weller 2002). In addition, the earliest traces of salt production in Europe have been found in the eastern Carpathians (Ursulescu 1977; 1995; Dumitroaia 1987; Weller and Dumitroaia 2005; Weller *et al.* 2010a). Concurrently with these first archaeological evidences, which complete our systematic surveys conducted since 2004 (Weller *et al*. 2007; 2010b), the rise and flourishing of ethnographic research (Alexianu *et al.* 1992; 2011)[1] emphasised the fundamental role of this resource in human and animal alimentation, in the preparation and preservation of food, as well as in the consolidation and socio-economic development of the human communities.

The spatial relations between the Moldavian salt springs and the Neolithic and Chalcolithic settlement patterns (6000-3500 BC) were first underlined by a geographer from the University of Iași in the late 1950s (Șandru 1952; 1961). For the first time ever in Moldavia, this researcher advanced the hypothesis that salt was a resource that fostered stability and development among the Cucuteni communities. At the same time, the discovery and excavation of the Chalcolithic settlement from Poduri-*Dealul Ghindaru* in Bacău County (*e.g.* Monah *et al.* 2003), in a region that abounds in salt springs, stimulated approaches of a spatial standpoint, initially focused on Neamț County (*e.g.* Weller and Nuninger 2005; Weller *et al.* 2011; Brigand and Weller 2012). We present in these pages a first study conducted for the entire region of Moldavia (fig. 3).

Ethnoarchaeological Background

The specificity of the Moldavian landscape is a unity of place seldom found in European ethnoarchaeological studies, in terms of both traditional practices still very much alive, and in archaeological remains attesting the antiquity and continuity of these salt extraction points for almost 8000 years. Of the nearly 189 salt springs surveyed in Moldavia by the French-Romanian team, 21 have yielded traces of Neolithic or Chalcolithic exploitation. Less than half (8) require confirmation through archaeological soundings and radiocarbon dating (fig. 3). The 19 rock-salt outcrops, found almost exclusively in Vrancea County and along the Carpathian curvature, have not yet provided evidence of ancient exploitation.

Salt exploitation generally comes with large amounts of fragmentary coarse pottery in the immediate proximity of the sodium chloride waters. Some are intensively exploited during the first Neolithic, for instance the springs from

1 Research carried out within the framework of a French-Romanian collaboration, conducted in Romania through two CNCS (Romanian National Research Council) research projects (2007-2010; 2011-2014) managed by M. Alexianu (for a presentation of the goals and the most recent results, see Alexianu *et al*. 2012), and an archaeological mission of the French Ministry of Foreign and European Affairs overseen by O. Weller after 2004.

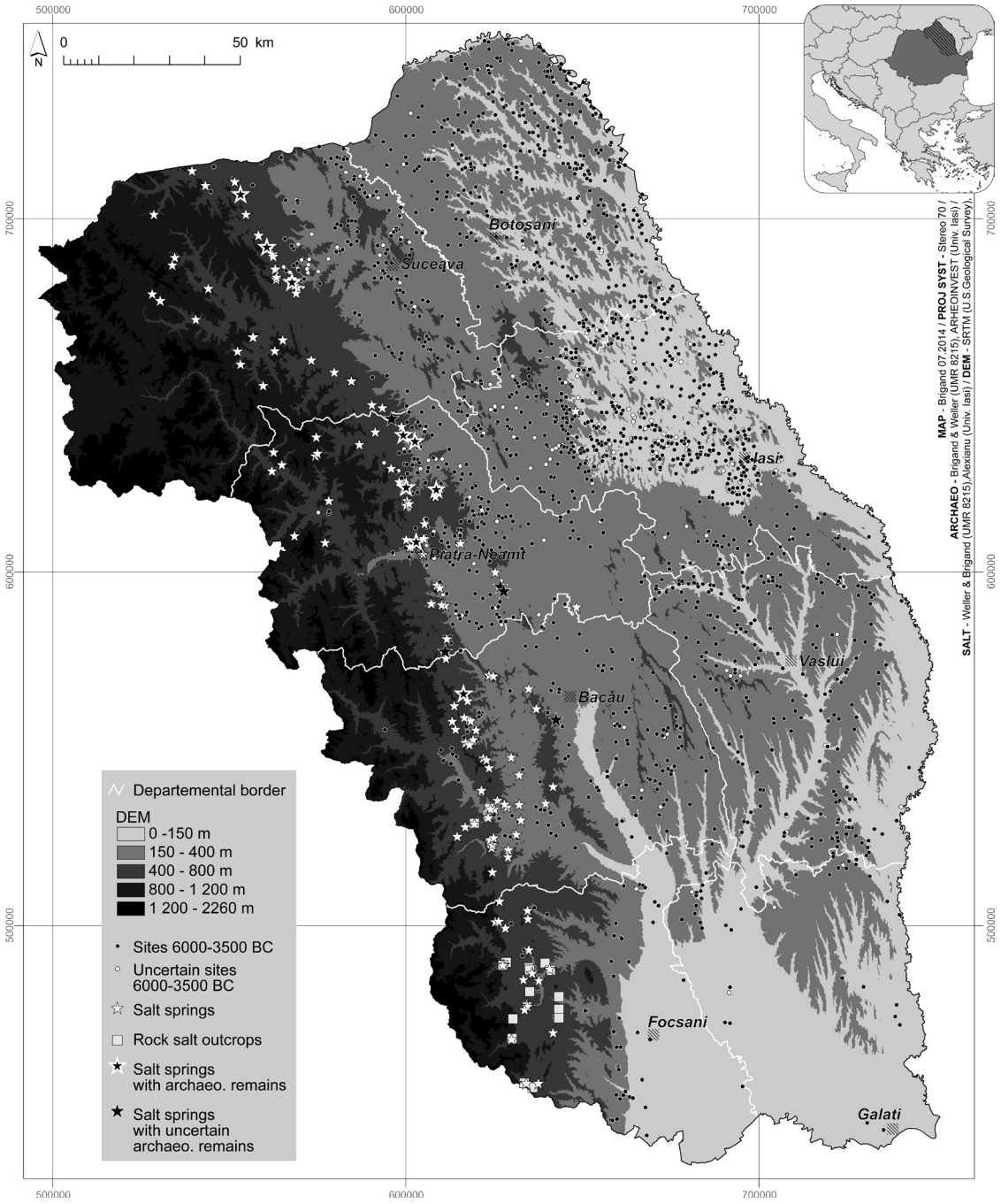
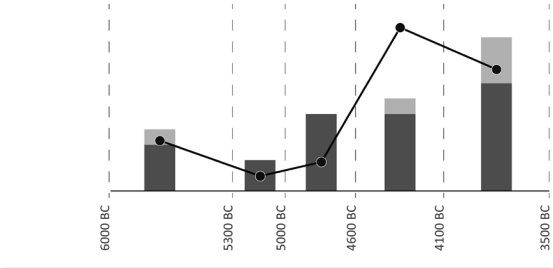


Figure 3. Salt springs, rock-salt outcrops, settlement (6000-3500 BC) and salt-exploitation sites.



	6000 BC	5300 BC	5000 BC	4600 BC	4100 BC	3500 BC
Exploited salt springs	3	2	5	5	7	
Uncertain exploited salt springs	1	-	-	1	3	
Archaeo. sites	191	56	109	620	461	

Figure 4. Chart of the evolution of salt springs exploitation and of the population dynamics during the Neolithic and Chalcolithic of Moldavia. The sites for which the chronology has not been established or questionable are not taken into account. 6000-5300 BC: Criș, 5300-5000 BC: Linear Pottery, 5000-4600 BC: Precucuteni, 4600-4100 BC: Cucuteni A, 4100-3500 BC: Cucuteni A-B and B.

Țolici-*Hălăbutoaia* (Neamț)[2], Oglinzi-*Băi* (Neamț) and Oglinzi-*Poiana Slatinei*, *zona A* (Neamț). Almost a thousand years later, following the demographic growth and population expansion of the Cucuteni A period (fig. 4), the first briquetage appeared. Of standardised shapes and weights, they mark the inclusion of salt into the long-distance trade networks (Weller 2002) and are linked to the large-scale exploitation of the salt springs, despite the conspicuous demographic fall from the dawn of the 4th millennium BC.

The absence of briquetage and salt pans probably reflects a less-established exploitation procedure, more seasonal and often less conspicuous to archaeologists. In this sense, the research of P. Pétrequin and O. Weller on the present-day methods of exploitation of salt resources in Papua (the Indonesian New Guinea) have filled the repository on the production of crystallised salt by stressing the importance of techniques which do not use recipients, nor fired clay (Pétrequin *et al.* 2001). These observations led to interpretative models which, applied on the field to the putative exploitations of salt springs from eastern France (Pétrequin and Weller 2008), have demonstrated the use of more rudimentary techniques during the Neolithic, namely the direct salt water sprinkling of fireplace.

Also, research on the first exploitations of salt faced a major hurdle: only the production sites that produced abundant ceramics and/or accumulations of charcoal were able to be identified; those that display less intensive production practices are not identifiable, this for taphonomic (sedimentary dynamics of the slopes, leaching of springs often found near watercourses, *etc.*) as well as technical reasons (the direct use of the saline waters, without crystallisation, collecting and transportation in organic containers, *etc.*). In order to go beyond the mere representation of salt exploitation provided by field archaeological surveys, inherently limited, we have also implemented a statistical approach aimed at classifying the salt springs not only according to their salinity, but in terms of a set of typological (the nature and complexity of the catchments, depth, water flow), chemical (salinity) and ethnographic (uses) descriptors that have been systematically registered.

2 First mentioned by S. Marinescu-Bîlcu (1974, 20), this spring was discovered by O. Weller *et al.* in 2005 (2007, 143-146). The archaeological deposit has a stratigraphy estimated at around 8 m, and extends from the Early Neolithic to the Bronze Age (Weller *et al.*, in press).

Exploratory Statistical Approach

The goal of this approach is to outline a typology of salt springs grouped in homogeneous classes, in order to focus on those that display the essential characters of an ancient exploitation.

This undertaking is based, from the outset, on the finding that the salt springs exploited during prehistoric times as well as today, have always a series of distinct characteristics: a high salinity, an important water flow, a generally complex catchment structure, a current or sub-current production of crystallised salt[3]. A factor analysis is conducted to reveal inter-data relationships. This comes prior to an HAC hierarchical ascendant classification that aims to sort the series into homogenous groups. For the construction of the space factor, it will be required to differentiate the active variables from the illustrative ones, which do not affect the analysis, but which nevertheless help for the interpretation of the groups. The qualitative variables are the following:

- Catchment: simple (dugout trunk, wells in square wooden fittings or assembled planks), complex (composite wells, cistern-wells, platform), stone or concrete, pit, not available;
- Depth: reduced (below 1 m), medium (1-3 m), high (over 3 m), not available;
- Water flow: none, weak, moderate, strong, not available;
- Salinity: slightly saline (10-30 g/l), moderately saline (30-80 g/l), very saline (80-110 g/l), exceptionally saline (over 110 g/l);
- Use: ignigenous salt and common use, common (domestic) use, therapeutic, not used, not available;
- Archaeology: presence of pre- and proto-historic, medieval, modern and contemporary vestiges.

Because our aim is to identify the springs likely to have been exploited in the past by human communities (high salinity, strong water flow, *etc.*), the 'archaeology' variable will not be used, so that it does not influence the construction of the factorial axes. It is, nonetheless, kept as an illustrative variable. The results of the factorial analysis and of the HAC of the salt springs are presented in figure 5; excluded from the statistical analysis are the undetermined salt springs (generally those not surveyed), the mineral (sulphurous) springs, and the rock-salt outcrops, nevertheless present in the final document. The number of classes (2) is determined from reading the dendogram generated by the automated classification.

Class 1 (37 entries, 19.6%) is formed by a coherent group of springs. It comprises foremost springs with extremely or very saline waters, captured in complex structures, with high (to medium) depths. The contribution of the descriptor 'ignigenous salt' is particularly important because almost all the springs where production of *huscă* is attested are part of this class, despite the absence of some

3 Practically, some of these springs have been used for the production of ignigenous salt (Rmn. *huscă*) distributed on a local as well as regional scale (*e.g.* Alexianu *et al.* 2011).

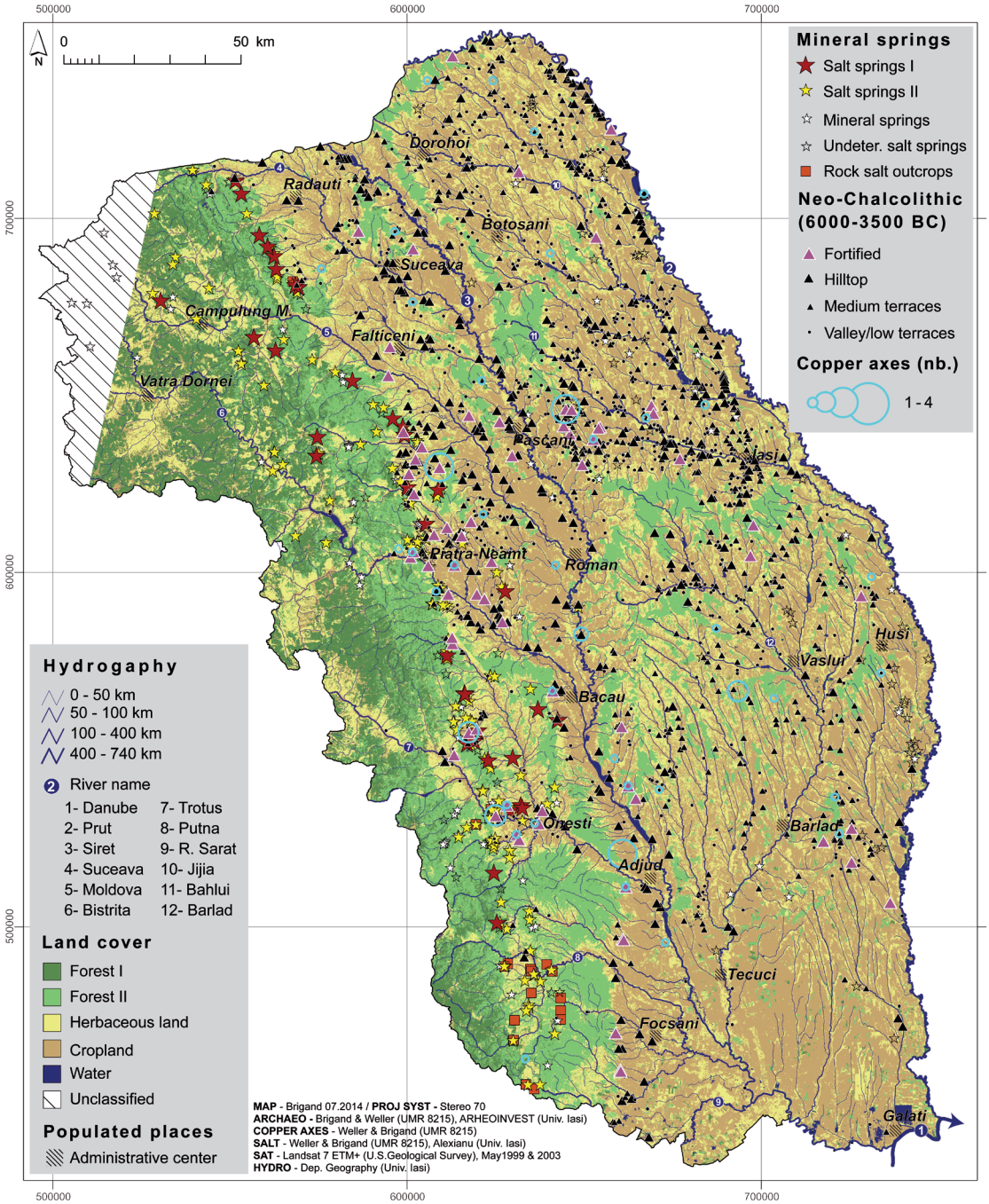


Figure 5. Map of Neolithic and Chalcolithic settlements (classified according to the topography), copper axes, salt resources (sorted by their typological, chemical and ethnographic descriptors), and land occupation (supervised classification of Landsat images).

variables. The salt springs exploited in prehistory are well represented in this class[4]. Some are not, because of typological or chemical descriptors (*i.e.* catchment and salinity) not consistent with the group in its whole.

Class 2 (152 entries, 80.4%) is mostly made up by rudimentary and unspecified catchments, with variable water flow (practically absent, weak and medium), and where the uses are domestic or not specified, sometimes therapeutic and hardly ever for the production of ignigenous salt. Their depth varies, it is generally low to medium and unspecified. The salinity likewise varies, from weakly to very saline. This class also gathers the entries for which a number of descriptors are missing, basically for taphonomic reasons (lost, clogged or replaced springs).

Geo/Archaeological Database & Dynamics

The elaboration of the archaeological map of Moldavia, limited to the Neolithic (*c.* 6000-5000 BC) and the Chalcolithic (*c.* 5000-3500 BC), was made possible by the development of a georeferenced database comprising all information available from inventories and contributions published since the 1970s. It only contains the definite sites and those for which the georeferencing is certain; the database has information on 1641 sites dating between 6000 BC and 3500 BC, of a total of 1989 sites. The database on 'copper axes', populated by 57 entries, is built starting from various articles and inventory records published by I. Mareș (2002), updated and enhanced in 2012.

Owing to this wealth of information, it was possible to develop an exhaustive archaeological database, precise in terms of the discovery contexts, the nature of the artefacts, the quality of the geographical position in the GIS, *etc.* A major problem arose when it came to qualifying the nature of the archaeological sites. A first important criterion is the presence or absence of anthropic fortifications. We acknowledge that on account of the sometimes elusive character of defensive works as the sites taphonomy, it is possible that many habitations were fortified and because of land levelling, due to agricultural work or erosion, the still-standing vestiges or the ditches have disappeared and are perceivable only through extensive digging. Despite this limitation, the presence/absence of defensive structures constitutes the first level of hierarchy that we took into account (fig. 5).

The nature of the artefacts discovered during field surveys or excavations should help define another level. Nevertheless, considering the fact that a large majority of sites remain poorly defined, insufficiently prospected and unequally documented, how should one elaborate a typology of sites using unspecified descriptors?

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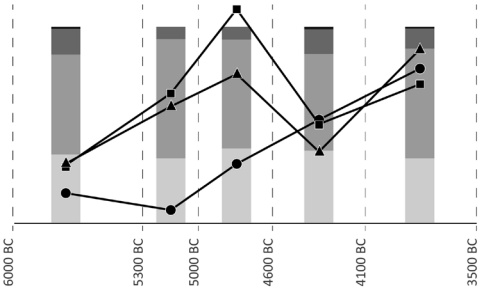
4 For the most important: Țolici-*Hălăbutoaia* (Petricani, Neamț), Oglinzi-*Poiana Slatinei* (Răucesti, Neamț), Voitinel-*Slatină* (Gălănesti, Suceava), Solca-*Slatina Mare* (Solca, Suceava), Cucuieți-*Slatina Veche* (Solont, Bacau), Ghindăoani-*Slatină* (Balțătești, Neamț), Negrițești-*Slatina Mare* (Podoleni, Neamț). The springs that have traces of Neolithic exploitation and which have not been included into this class are the following: Balțătești-*Slatina A* (Balțătești, Neamț), Garcina-*Slatina C* & *Slatina III* (Garcina, Neamț), Oglinzi-*Băi* (Răucești, Neamț), Tazlău-*Slătioara* (Tazlău, Neamț).

A classification of sites has therefore been attempted by taking into account their topographic situation. We will follow in this regard a paradigm of Romanian archaeological research, which, after the 1970s, used topographic criteria to distinguish between different types of habitats. As such, we find in the old registries of N. Zaharia *et al.* (1970, 32-34), D. Monah and Ş. Cucoş (1985, 42-43), or in the more recent ones of M.-C. Văleanu (2003, 49-51) and D. Boghian (2004, 56), a more-or-less elaborate classification between high, medium and low positioning of archaeological sites. The GIS and the morphometric analysis applied to a DEM (Digital Elevation Model) with a medium resolution (SRTM, corrected, refined and resampled at 50 m) allows to control multiple natural processes (such as the slope, solar exposure, *etc*.) by automating this procedure (Wilson and Gallant 2000; Conolly and Lake 2006; Rodier 2011).

In this line of thought, we used the 'topographic position index' (TPI), which allows a comparison of the elevation of each cell with the average one of a given surrounding: a negative value represents the lowest areas in relation to their immediate environment (valley, thalweg), while a positive one corresponds to an area much higher than its vicinity (peak, ridge, headland). The archaeological database is therefore enhanced by this value, which is then used to classify the sites according to their position within the landscape. The classification proposed (fig. 5) according to 3 classes (HAC) thus distinguishes the elevated sites, the valley ones, and those located in intermediary positions, generally on slopes. A note should be made that this is by no means a ranking of archaeological sites, since only a single descriptor has been considered (TPI). It will be necessary to introduce further variables, starting with the cultural ones (duration of habitation, richness of the settlement, *etc.*).

Two other descriptors derived from topography are used: the 'topographic openness' and the 'total viewshed'. The former is a basic morphometric analysis, which provides an adequate apprehension for the main models (Yokoama *et al.* 2002). It consists in considering, for each pixel, the line of sight over 8 azimuths, and in measuring both convexity and concavity. The second descriptor determines the total viewshed (Llobera 2003). It defines, for each pixel, the number of pixels that can see it. Considering that this analysis produces for the entire landscape a visibility potential, it can be compared to the topographic openness, which, depending on a different computation, will determine if a pixel is located in an open or closed visual landscape. Particularly time-consuming and requiring computer resources which are rarely available, this particular computation was performed for a dense set of points (every 2 km, nearly 130,000 points) and an 8 km viewshed radius.

The scaled values of the topographic index, the landscape openness and the total visibility of each site were converted into statistics in order to evaluate, from 6000 BC to 3500 BC, the evolution of the contexts of the sites (fig. 6). We similarly established shares per class of soils (pedological map, at a 1:200,000 scale, reclassified): class 1- valley soils, little or moderately fertile, generally young and weakly developed, sometimes waterlogged; class 2- very fertile soils with high contents of organic matter (chernozems); class 3- soils of high plateaus often under



Soils 1	35	32,8	38	36,9	32,9
Soils 2	51	61	55,6	49,3	56,1
Soils 3	13	6,2	6,4	12,6	10,1
Soils 4	1	-	-	1,2	0,9
TPI	-0,21	-0,26	-0,12	0,01	0,16
Openess	-0,12	0,05	0,14	-0,09	0,22
Tot. View.	-0,13	0,09	0,34	-0,01	0,11

Figure 6. Diagram of the evolution of the sites contexts between 6000 and 3500 BC (for the chronology of the different cultural phases, see fig. 4). The values represent the percentage of habitation sites by soil class and for the topographic index, openness and total visibility, to the average scaled values set for chrono-cultural phase.

forest covering, of limited productivity for agriculture and suitable for livestock farming; class 4- altitude soils unsuitable for agriculture.

Salt attractivity

Starting from the GIS-based tools and an abundant dedicated literature, the objective is to propose a map cost-distance of salt resources in the pre-Carpathian area, expressed in time units (fig. 7). The computation of the anisotropic distances is particularly useful for our study, since it takes into account various elements of the landscape, starting with the slope and the land occupation. The determination procedure first consists in defining a friction surface, which sets the degree of constraint affecting movement. Its energy cost is primarily dependent on the value of the slope, but also of the vegetation cover, although it is difficult to evaluate for the targeted periods. We believe, nonetheless, that the elevated forests bordering the study area to the west were similarly a hindrance to human movements during the recent prehistory. Also, the resulting friction surface (or cost) takes into account a 20% forest covering. It is therefore 80% of the friction surface that the topographic surface alleges.

The rest of the procedure uses the 'path distance' function in ArcMap to obtain an estimation of the anisotropic time, which means that the direction of movement (to the springs, in our case) is taken into account. The Reciprocal Tobler's Hiking Function consists in an anisotropic distance calculation largely distributed. The values of the slope is used for augmenting or reducing the cost incurred by the crossing of each pixel; a 0-slope gradient has the lowest cost and, conversely, a value over 70 degrees has the highest cost. The speed of movement used in this study is 5 km/h. These values are subsequently converted into time slots representing the distance-time expended to reach a salt spring (fig. 7). They are determined through the use of a vertical factor taking into account the relation between the value of the

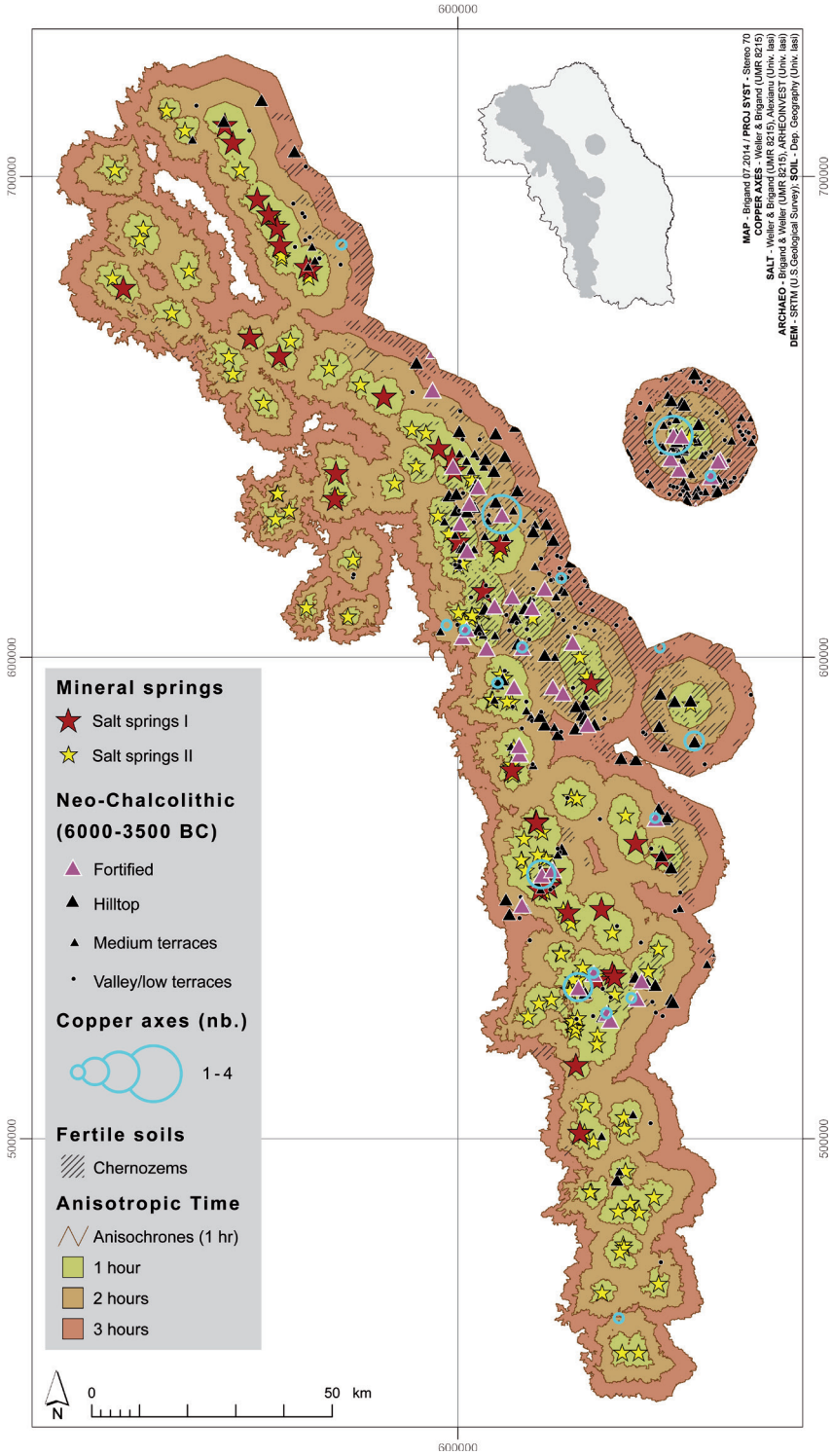


Figure 7. Anisochrones representing the travel distances to the salt springs (one hour interval).

slope and the cost incurred[5]. The map of distances-times is stopped at three hours. Within this radius and according to a one-hour interval, we have measured the number of fortified settlements, unfortified sites, and copper axes (fig. 8), as well as the dynamics of the attractiveness of salt springs between 6000 and 3500 BC (fig. 9).

Final Discussion

The analyses presented in these pages allow us to draft a synthesis on the forms and dynamics of settling in the Moldavian Neolithic and Chalcolithic, in interaction with the natural resources and the landscape.

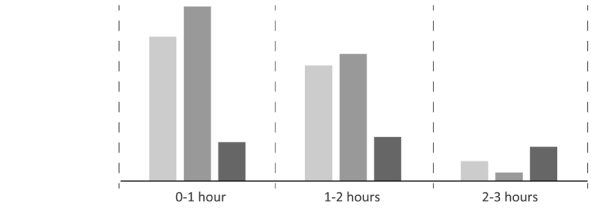
Regional Distribution

The archaeological sites are distributed to the east of the Carpathian range; the salt springs form the western limit of settling area, especially in the pre-Carpathian depression delimited by the Bistrița and the Moldova rivers (fig. 5). The main area of settling is found at heights of about 200 m on average: the lowest sites are found on the Moldavian Plain and the low alluvial valleys of the Siret, Prut and Bârlad rivers; the highest ones on the first plateau (pre-Carpathian depression – the Suceava Plateau), the Central Plateau and the Curvature Carpathians. The highest sites (over 500 m) are distributed homogeneously in the narrow and deeply furrowed valleys that characterise the Carpathian piedmont; they are all linked to saliferous areas – particularly where there are springs with a strong attraction value (class 1), save for the site from Agăș-În *Spatele Gării* (Agăș, Bacău County) located in the high valley of the Trotuș River, and Hangu (Chirițeni, Neamț County).

These sites in high altitude are nevertheless rare. Could this be a consequence of the level of archaeological investigation and thus an effect related to the exhaustiveness of archaeological map? As a matter of fact, since these pre-mountainous environments are largely occupied by dense tree vegetation, the archaeological surveying is quite difficult. It is nevertheless possible to suggest that the climate, the elevation and the scarcity of agronomic resources contributed to a low density of occupation, which in these sectors remain almost exclusively focused on the saliferous resources. We bet that future research focused on the pre-Carpathian forested areas, ever more so thanks to the recent tools of remote sensing (LIDAR), will allow us to document even more precisely the occupation of the Carpathian foothills.

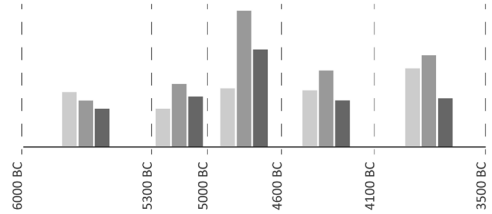
Where contemporary anthropic pressure is most important, the archaeological density is consistent. This is particularly true for the sectors south of the Moldavian Plain (the valleys of the Bahlui, Bahluieț and Jijia valleys). Elsewhere, particularly in Botoșani and Vaslui counties, occupation is widespread and does not seem to be particularly concentrated, with a few exceptions (notably east of Bârlad or between

5 For three salt springs found in distinct topographic sectors – the Carpathians: Ceahlău-*Slatină* (Ceahlău, Neamț); Moldavian Plateau: Țolici-*Hălăbutoaia* (Petricani, Neamț); Moldavian Plain: Balș-*Arcaci* (Târgu Frumos, Iași) – field walking tests conducted on the occasion support the results presented here.



	0-1 hour	1-2 hours	2-3 hours
Copper Axe	26,3	21,1	3,5
Fortified Settlement	31,9	23,2	1,4
Settlement	7	8	6,2
Total	65,2	52,2	11,1

Figure 8. Percentages of copper axes, fortified and unfortified settlements, within less than one, two and three walk hours from a salt spring.



	6000 BC	5300 BC	5000 BC	4600 BC	4100 BC
0-1 hour	6,8	4,7	7,3	7	9,7
1-2 hours	5,7	7,8	16,9	9,5	11,4
2-3 hours	4,7	6,3	12,1	5,8	6
Total (0-3 hours)	17,2	18,8	36,3	22,2	27,1

Figure 9. Percentages of habitation sites within less than one, two and three walk hours from a salt spring.

the Prut and Dorohoi; also note that where the land occupation is largely comprised of herbaceous or forest surfaces, the Neolithic and Chalcolithic population density is low or even absent): the Tutova hills, the central plateau south of Iași and, generally speaking, the piedmont area between Rădăuți and Fălticeni or south of Piatra Neamț.

Does that mean that the distribution map does not objectively reflect ancient occupation, but rather a reflection of the intensity of archaeological surveys, as in the nature of the land cover? Let us consider for instance the weak prehistoric occupation of the area delimited by the Focșani-Bârlad-Galați triangle. Does it reflect a modest occupation pattern, or just limited archaeological prospecting? It is difficult to decide, and it is possible that the conjunction of these two factors contribute to an apparent shortcoming on the archaeological map. Nevertheless, despite this limitation, it is possible to provide a summary of the key characteristics of settling, particularly by focusing on the population dynamics between the Criș and the Cucuteni A-B and B periods.

General Dynamics

Figure 4 provides a pertinent image of the evolution of the number of sites between 6000 and 3500 BC. A significant decline occurred between the Criș (*c.* 6000-5300 BC) and the Linear Pottery (*c.* 5300-5000) periods, perhaps due to a difficulty in identifying sites in eastern Romania. From the Precucuteni (*c.* 5000-4600) onwards, we observe a manifest increase in the number of sites that reached

their peak during the Cucuteni A (*c.* 4600-4100). This particularly high value reflects, without a doubt, an unprecedented demographic outburst, as well as a very strong territorial investment. It also indicates a reorganization of the settling processes, based on structuring of the territories clearly distinct from the previous periods. This is how the establishment of new agro-pastoral practices, based on an increased mobility of the domestic units, could equally explain the notably large number of sites from the Cucuteni A phase (Lazarovici and Lazarovici 2003, 413).

In what concerns the Cucuteni A-B, researchers have already noticed that the relatively low number of sites for this period (148 sites calibrated with certainty) is more a reflection of the research linked to difficulties in identification, than a sign of demographic retraction (Zaharia *et al.* 1970, 33; Boghian 2004, 57; Petrescu-Dîmbovița and Văleanu 2004, 335). For example, in Moldavia, around 60 sites assigned to the Cucuteni A-B were the result of a planned archaeological action. As we are more interested in the settling forms and dynamics, it seems opportune to regroup the Cucuteni A-B sites with the Cucuteni B ones, since the distinguishing elements of the two periods are, in the absence of extensive archaeological investigations, almost impossible to define only on the ground of surface material. This chronological simplification within a single chrono-cultural period is also based on the fact that more than 40% of the sites assigned to the Cucuteni A-B continue during the Cucuteni B phase. Thus, in general, we note between Cucuteni A on the one hand, and Cucuteni A-B and B (*c.* 4100-3500 BC) on the other, a demographic relapse marked by a notable reduction in the number of habitations, generally well reflected in the literature (*e.g.* Boghian 2004, 55)[6].

Soils and settling

From 6000 to 3500 BC, the lands occupied are more or less the same (fig. 6): foremost the fertile soils of the chernozem type, followed by the less fertile soils of the great alluvial valleys, and then, of marginal share, the high-altitude soils with very limited agricultural output. However, changes in the occupation shares according to the soil typology deserve clarification. During the Criș period, we observe that the high-elevation soils (classes 3 and 4) are occupied to an unprecedented level throughout the entire time span, not much so during the Cucuteni A, and to a lesser extent during the Cucuteni A-B and B. This occupation shows a more diversified occupation strategy than it would be during the Linear Pottery and Precucuteni periods, during which the very fertile soils of the chernozem type were favoured. This finding profiles the first settling wave associated to the exploration of the different types of terrains. We observe this dynamics in the Cucuteni A period, during which the demographic growth is reflected in the occupation of a very varied range of ecosystems. Nevertheless, regardless of the area and period

6 Also observe that almost 45% of the Cucuteni A-B sites are located in Botoșani county. Here, the number of Cucuteni A-B sites in relation the number of Cucuteni A or B ones is relatively equal, which contrasts sharply with what has been ascertained for other counties in Moldavia. We consider that this reflects a research bias depending on the different scientific strategies and competencies across the territory, rather than a prehistoric reality.

considered, the archaeological sites are spread in ecotone contexts, that is to say in the proximity of different pedological contexts, so that the types of accessible resources are varied.

Topographic contexts

The Criș sites are found in low areas and on terraces near minor watercourses characterised by modest hydrographic regimes, those that emerge from low values of the topographic index, topographic openness and total viewshed (fig. 6). With the Linear Pottery period, the topographic index decreases significantly: it reflects a continuing tendency to settle valleys and in the proximity of watercourses. However, the increase in the openness value as well as that of total visibility leads to crucial observations: although in their majority valley ones, the sites are henceforth established in more open environments and where the visual field is noticeably wider. This finding, which corroborates the increase in visibility observed in Iași and Neamț counties (Brigand *et al.* 2012; Brigand and Weller 2013, 202-203), supports the idea that this period witnessed the emergence of the first coherent territorial pattern that was based on important establishments likely to exert an efficient control of the territory.

The first half of the 5th millennium BC saw a radical evolution of the topographic contexts. Right away, we observe that the high and middle terraces are preferred, reflecting a tendency to establish habitations on widely opened promontories, where the degree of submission to the view factor is particularly high. Accordingly, habitations are founded in large alluvial valleys – beginning with that of the Bistrița, downstream from Piatra Neamț – and directly involved in the control of the main communication routes. Apart from the value of the topographic index, which continues to increase during the Cucuteni A – reflecting the surge in the number of hilltop habitations – the value of landscape openness, as that linked to the total visibility, drops drastically. This is a result of the diversification of forms of occupation observed during the second half of the 5th millennium BC. Although most of them were perched on headland, the settlements of the Middle Chalcolithic now occupy a wide variety of valleys, both large and visually very wide, or very narrow and with very reduced visibility. This trend reversed again at the end of the Cucuteni: the high values of all the topographic index values seem to underline a territorial reorganisation resulting in a shift towards habitations located in the wide alluvial valleys and, in fact, the abandonment of the marginal areas occupied during the Cucuteni A.

Salt attractiveness

Proximity analyses are common in prehistoric archaeology, especially when it comes to measuring the distance between a source of raw materials and the objects from which they come. In the archaeology of salt, this method is proposed in order to highlight the correlation between objects that were socially valued and salt, the assumption being that the elites who had abundant reserves of salt were likely to similarly acquire other prestige goods. F. Harding (2013, 99-109) has engaged

in this exercise and tried to establish a spatial connection between salt resources – as well as the copper and gold ones – and bronze swords. It is this methodology that we hereby take further, through the use of four data sets (the salt springs; the fortified settlements; the unfortified habitations; and the copper axes) and the presentation of the results in the time units (limited to three hours of walk from a salt spring), rather than in Euclidean distances (fig. 8). The proposed diagram eloquently presents several important results.

The percentage of unfortified sites located within a three-hours-walk radius from a salt spring remains modest (*c.* 21%) and shows no significant variations. Still, the highest value is in the time range between one and two hours (8%). A look at the archaeological map (figs. 3 and 5) clarified these results and reminds us that the majority of sites are found east of the Siret River, or much more than three hours away from a salt spring. In contrast, the percentage of fortified habitations located within a 3-hours radius around a salt spring is particularly high (*c.* 55%), and suggests a strong attractiveness of these resources and an eagerness of the prehistoric communities to control both their exploitation and the distribution of finished products. This hypothesis seems fully confirmed by the very high percentage of fortified sites located less than one hour (*c.* 32%) and between one and two hours walk (23.2%). With respect to the percentage of long copper axes, our observations are in the same line: a concentration of wealth in an area near the salt resources, at less than one hour walk (*c.* 26%), and between one and two hours (*c.* 21%).

It is as if the exploitation of salt and the distribution of salt cakes were heavily invested and controlled activities, which attracted towards these centres rare and sought after objects. The significant and gradual reduction in the number of fortified sites and copper axes, as the distance to the salt spring increases, is a paramount argument: it illustrates the attraction role of the salt resource; its capacity to stimulate the exchange of goods and to attract objects of very high social value, such as massive copper axes; its control across a very dense network of fortified settlements. Nevertheless, these results call for a series of comments on some particular areas.

- The first comment concerns the presence of the spring from Balș-*Arcaci* (Târgu Frumos, Iasi) located near the eponymous site from Cucuteni and therefore in an extremely rich archaeological environ (Petrescu-Dîmbovița and Văleanu 2004; Brigand *et al.* 2014). The integration of this ancient spring, whose uses are well documented by ethnography (Weller *et al.* 2007, 175-177)[7] is legitimate even though it is not without some questions as to its marginal position in relation to other salt springs from the pre-Carpathian area.

7 This source of salt water marked on the territory of the village of Băiceni, identified thanks to the decisive intervention of V. Cotiugă from the University of Iași and the former Cucuteni mayor (I. Tun), is located in an area of salty soils characterised by abundant halophile vegetation. Though abandoned in the 1960s, we were able to obtain a series of precious information both on the nature of the catchment system (in stone wells of *c.* 1 m in depth) and on the uses made by the locals (preserving food and as fodder, production of crystallized salt, *etc.*).

- The second comment is about the existence, to the east of Piatra Neamț and of Cracău, of soils that have a very high agronomic potential. The intensity of archaeological occupation in this area can be explained both by the presence of very rich soils (fig. 7) – see the chernozem peninsula vaunted by P. Enculescu (cf. Lupașcu 1996, 83) – and also by the abundance and accessibility of very saline springs that display all the characteristics of a prehistoric exploitation (fig. 5).

What about the settlement dynamics close to sodium chloride springs? Figure 9 provides some answers, showing a steady increase in the number of sites within the three-hours radius around a salt spring, between 6000 and 3500 BC. Only the Precucuteni seems singular, with a share of 36% of sites. This increase in the vicinity of salt during the first half of the 5th millennium BC occurs simultaneously with the intensification of the salt springs exploitation, especially starting with the Linear Pottery (fig. 4). This enhanced occupation of the areas near the salt springs seems nonetheless to favour areas found between one and two hours walk (*c.* 17%), or even two and three hours walk (*c.* 12%), over those at less than one hour walk (*c.* 7%).

This dynamics reflects a characteristic of the Precucuteni occupation that we have already observed elsewhere (Brigand and Weller 2013, 203-204): the immediate vicinity of a salt spring is rarely settled; on the contrary, the control of the access to the salt and of the main waterway outlets seems to be a priority of the Chalcolithic communities. The very high values of the total viewshed and of the landscape openness (fig. 6) clearly show that it is the control of the communication and exchange routs which is at the centre of the territorial strategies of the Precucuteni period. During the Cucuteni A, but especially during the Cucuteni A-B and B, there is a strengthening of the occupation of areas located at less than one hour from the salt spring, despite a notable decline in the population (fig. 4); we witness an escalation of the process of appropriation of the salt resources, concurrently with a heightened and reorganised territorial control (fig. 6).

In general, the habitation sites appear to favour the areas found between one and two hours walk from the salt spring (fig. 8). There is nevertheless an exception, the Criș period, during which the largest share is taken by sites located between two and three hours walk from the source. This observation supports the idea outlined after having examined the context of the settlement – especially the agronomical ones (fig. 6): a less structured settling front involved in exploring different terrain types.

This exploratory research aimed to characterise the forms of human settling between 6000 and 3500 BC. The use of the GIS allowed us to shed light on the place of salt in the territorial and economic organisation of human societies from recent prehistoric times. This contribution stresses that the salt resources, probably as well as its circulation, were subject to an increased interest. Multiple periods emerge from the analyses presented in these pages. The Early Neolithic (Criș) appears as a first phase of colonisation during which the salt resources are explored, though without being integrated into any particularly structured form of territorial

organisation. The Precucuteni appears as an experiment expected to last, which witnesses the emergence of a coherent population network sustained by elevated settlements, and of a control of the access to the salt and of its transportation. As for the Cucuteni, it is marked by the flourishing of the Chalcolithic cultures of Moldavia, as evinced by the extremely dense network of settlements involved in a manifold exploitation of various resources, be they saliferous, agronomic or pastoral.

It has sometimes been stated that the development of the Neolithisation process in Eastern Europe and the Balkans rested on the availability of salt resources and the availability of rich and fertile soils. The conjoined study of a consistent archaeological database, of an exhaustive registry of salt resources, and of the geographic contexts, allowed us to expound our assertions and to provide a solid baseline for understanding the form, as well as the dynamics of human settling in this area, across nearly three millennia.

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