



HAL
open science

SPATIAL ANALYSIS OF SALT SPRINGS EXPLOITATION IN MOLDAVIAN PRE-CARPATIC PREHISTORY (ROMANIA)

Olivier Weller, Robin Brigand, Laure Nuninger

► **To cite this version:**

Olivier Weller, Robin Brigand, Laure Nuninger. SPATIAL ANALYSIS OF SALT SPRINGS EXPLOITATION IN MOLDAVIAN PRE-CARPATIC PREHISTORY (ROMANIA). ARCHÆDYN 7 millennia of territorial dynamics. Settlement pattern, production and trades from Neolithic to Middle Ages, 2007, Dijon, France. pp.225-230. hal-01066423

HAL Id: hal-01066423

<https://hal.science/hal-01066423>

Submitted on 19 Sep 2014

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

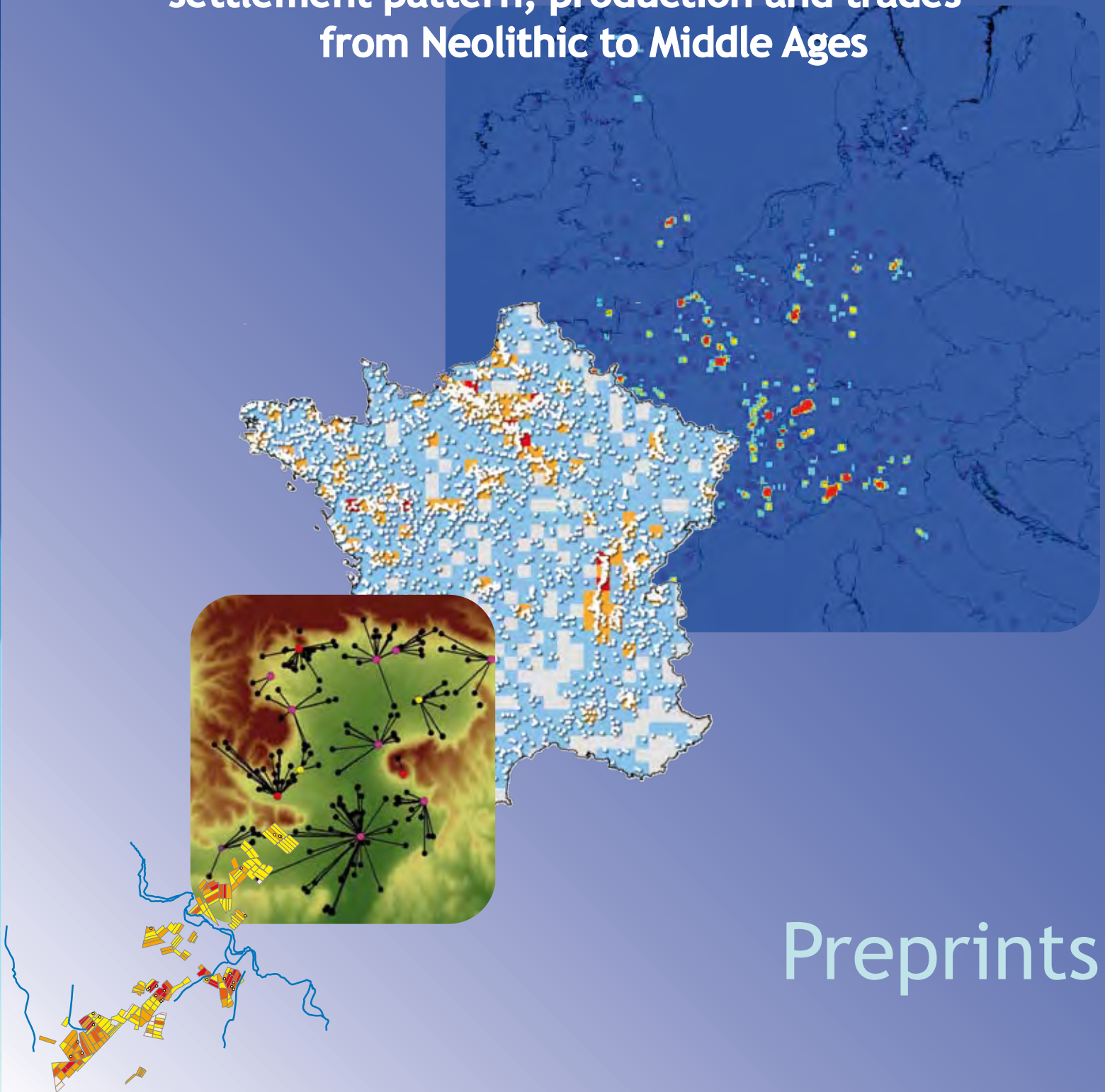
L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

ACI "Spaces and territories" 2005-2007
Final conference - Dijon, 23-25 june 2008

ARCHAEDYN

7 millennia of territorial dynamics

**settlement pattern, production and trades
from Neolithic to Middle Ages**



Preprints

Pre-proceedings directed by

Cristina GANDINI (*UMR 8546 AOROC, ENS Ulm Paris*)

François FAVORY*

Laure NUNINGER*

Organisation committee

Cristina GANDINI,

Laure SALIGNY***

Laëtitia BASSEREAU**

Jean-Marc BOURGEON***

Brigitte COLAS**

Marion LANDRÉ****

Isabelle MOURET****

Sophie BUI****

Sylvie COSTILLE-VAREY*

Nathalie PUILLET*

Scientific committee co-chairs

François FAVORY*

Claude MORDANT**

Laure NUNINGER*

* *UMR 6249 ChronoEnvironnement*

** *UMR 5594 ARTeHIS*

*** *MSH Dijon UMS 2739*

**** *MSH C. N. Ledoux, Besançon USR 3124*

ACI « Spaces and territories » 2005-2007

Contract ET 28

**Spatial dynamics of settlement and natural resources :
toward an integrated analysis over the long term
from Prehistory to Middle Ages**

Final Conference – University of Burgundy, Dijon, 23-25 June 2008

ARCHÆDYN

7 millennia of territorial dynamics

*settlement pattern, production and trades
from Neolithic to Middle Ages*

Preprints

SPATIAL ANALYSIS OF SALT SPRINGS EXPLOITATION IN MOLDAVIAN PRE-CARPATIC PREHISTORY (ROMANIA)

Olivier WELLER¹, Robin BRIGAND² and Laure NUNINGER²

¹Protohistoire européenne, UMR 7041 ArScAn, CNRS-Universités Paris I et Paris X
olivier.weller@mae.u-paris10.fr

²Chrono-environnement, UMR 6249, LEA ModelTER, CNRS-Université de Franche-Comté
robin.brigand@univ-fcomte.fr
laure.nuninger@univ-fcomte.fr

ABSTRACT:

This paper presents the first results of the spatial analysis concerning the dynamics and interaction between settlement patterns from the Neolithic to Chalcolithic times (6000-3500 BC) and a particular mineral resource exploited since the Early Neolithic, the salt springs in the Oriental Carpathian Mountains. Using kernel densities and viewsheds, we propose some natural and anthropological factors which structure this regional territory.

KEY WORDS : Settlement patterns, salt spring, Neolithic-Chalcolithic, Romania, Moldova

This paper aims at presenting part of an interdisciplinary French-Romanian project focusing on the dynamics and interactions between human societies and a particular mineral resource, the salt springs. The Oriental Carpathian Mountains in Romanian Moldova offer a perfect research area for studying the continued exploitation of salt springs from Neolithic times to the present. This poster focuses on the relation between Neolithic-Chalcolithic settlements (6000-3500 BC) and distribution of salt springs in the Neamt department, where we have direct evidence of their exploitation since the Early Neolithic (Weller, Dumitroaia, 2005).

1. Objectives and methodology

In order to better understand the evolution of the relation between Man and the environment, notably human settlements and salt springs, our general approach is interdisciplinary (Weller *et al.*, 2007a) and involves the following:

- Archaeological field-walking around the salt springs, identifying prehistoric techniques of exploitation, chronological and exploitation dynamics (Weller *et al.*, 2007b);
- Paleo-environmental analysis of pollen, charcoal and remains of soil combustion (Weller *et al.*, 2008a);
- Spatial analysis, using GIS to correlate archaeological and salt resource databases, settlement networks, viewshed and access (Weller, Nuninger, 2005; Weller *et al.*, 2008b);

- Ethnographic investigations around the salt resources (Alexianu, Weller, 2008);
- Geological and chemical analyses of the salt springs.

Among these approaches, this study focuses on the spatial archaeological approach involving GIS. The aim is to explore: 1) how did the salt springs, exploited or not, impact the settlement patterns during the Neolithic and Chalcolithic periods; 2) what are the ways in which the salt resources, production and circulation were controlled.

2. Settlement patterns over times

The first step of this project aims at analysing the relationship between settlement patterns and the distribution of salt springs over time. Our GIS includes an archaeological database (241 sites and 79 springs of which 58 are salty and 8 are exploited) mainly based on fieldwork records (GPS measurements), a digital elevation model with a resolution of 25 m made from satellite imagery by K. Ostir (IASS, ZRC SAZU, Slovenia) and the administrative district map on the level of the village (M. Consinschi, University of Lausanne).

First, we developed a mapping approach based on municipality units for the Neamt department (area 2, fig. 1). Using a selection of reliable archaeological sites (184 out of 241), we attempted to show the relationship between the settlement density and the

Fig. 1: Study areas in Romania

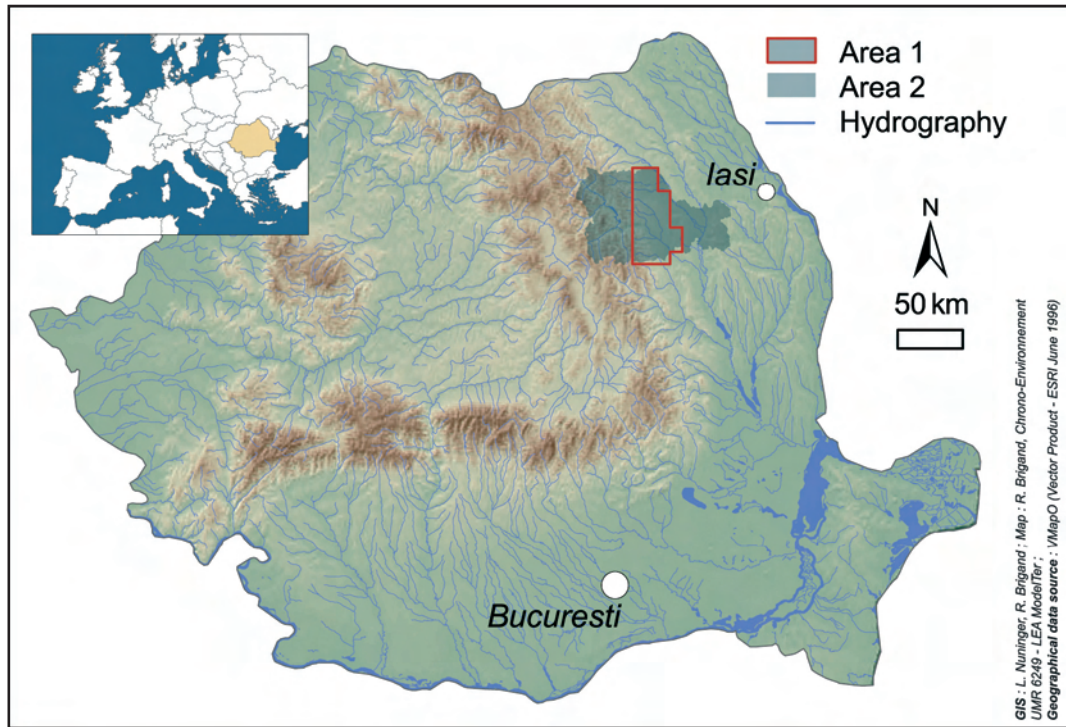
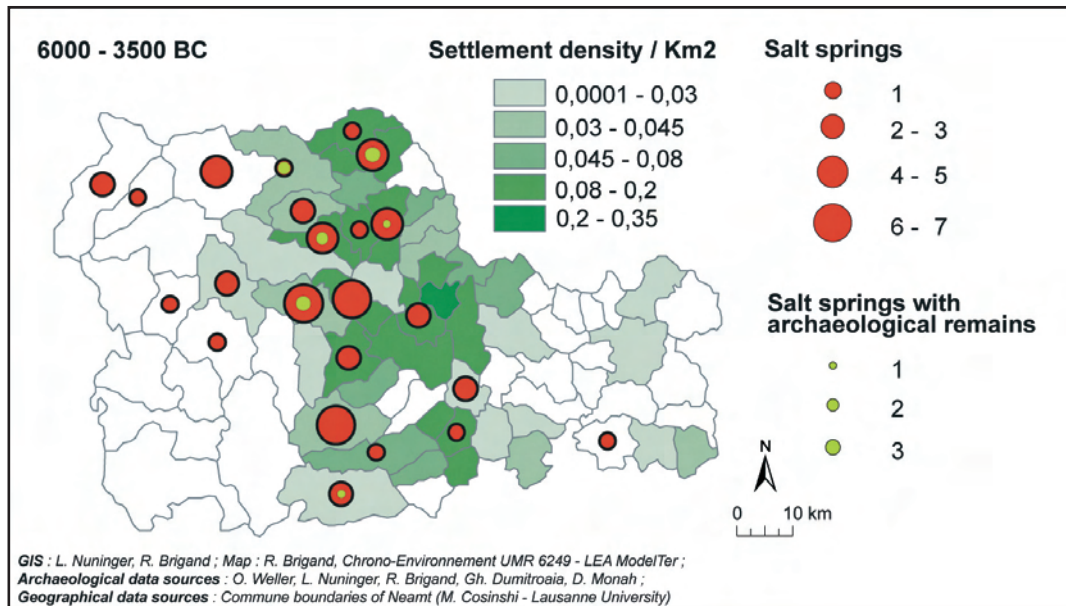


Fig. 2: Settlement density and salt springs



number of salt springs (fig. 2). With the exception of the area of the Carpathian Mountains, where the archaeological inventory is probably less reliable, this first map shows interesting results. In general, during the period studied, the high occupation density of salt springs is undoubtedly to the detriment of alluvial plains in the east and the Carpathian Mountains on the southwest. In detail, in the Pre-Carpathian Mountains, even if the higher number of salt springs is usually located within a settlement of high density, there is no strict correlation and some highly inhabited areas do not have any salt resources in their vicinity. Regarding occupation type, the settlements on high position are well linked to the location of salt springs. Such observations suggest a specific organisation of the settlement pattern

which is in all likelihood associated to the salt resource economy, but probably complex and not directly linked to the exploitation of salt springs.

The settlement pattern changes over time (fig. 3) were quantified by using mapping and the kernel density estimation method (KDE) to improve the first approach in the Carpathian foothills (area 1, fig. 1). The KDE method provides an estimation of density for a surface using the value from a starting point which decreases as soon as the distance increases, and according to the model of curve chosen (kernel function). The kernel function used is based on a quadratic kernel function (Silverman, 1986). Since the result of the analysis is not strongly influenced by the kernel function as long as the function

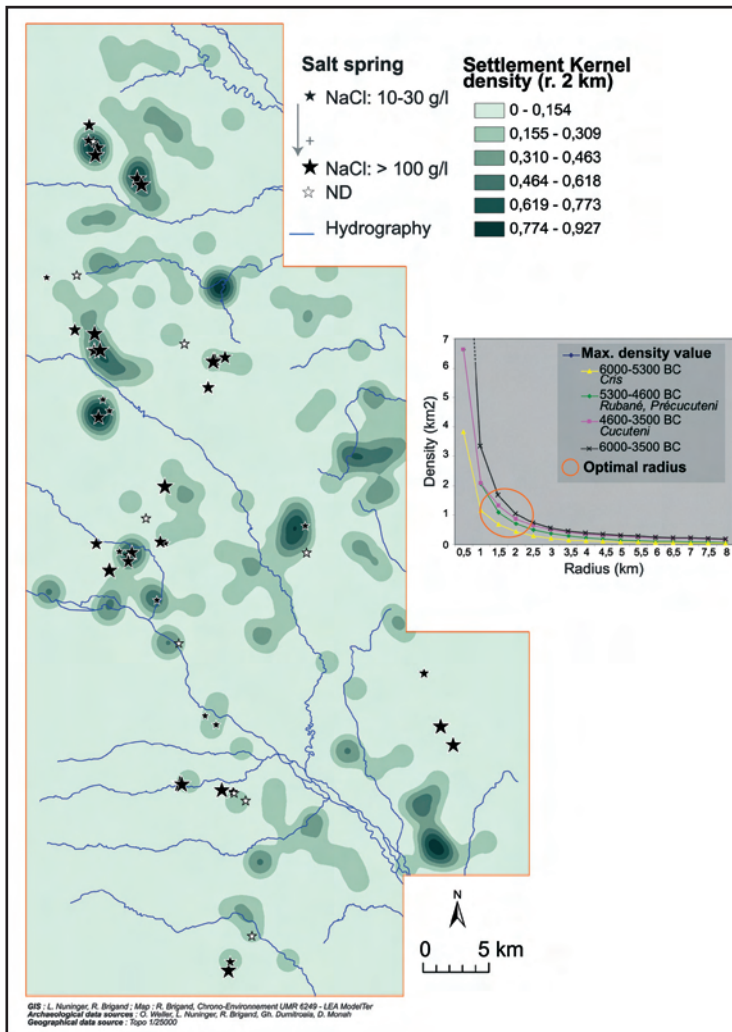


Fig. 3: Spring salinity and occupation density between 6000-3500 BC

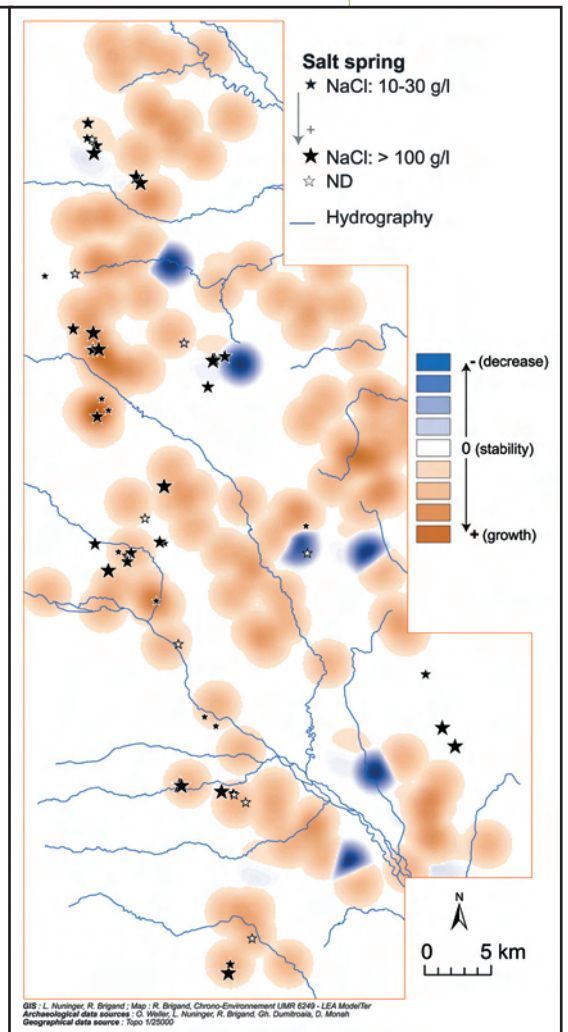


Fig. 4: Settlement dynamics between 5300 and 3500 BC

is symmetrical (Silverman, 1978), we did not do any tests with other kernel functions. On the other hand, the choice of the width of the window and the radius is very important (Silverman, 1978). Since our approach was exploratory, we used the graphical method defined by F. Tolle, ThéMA (UMR 6049) to determine the optimal radius. Thus, the final choice in our case was a radius between 1.5 and 2 km (fig.3). The results show that most of the salt springs are located in prehistoric settlements of higher density during the entire period. In reality, the Neolithic archaeological sites show the main background tendencies which insure the Chalcolithic demographic development.

The same KDE method was used to compute density per chrono-cultural period (about 1 millennium for each period). By subtracting the values of the KDEs of the Middle-Late Neolithic (5300-4600 BC) from these of the Cucutenian period (4600-3500 BC), an overview of the settlement pattern dynamics is obtained according to its stability or instability (fig. 4). The main axes of circulation and a majority of the highly salted springs are the object of settlement densification, in particular during the first period of Cucuteni (4600-4000 BC).

Fig. 5: Fortified villages, settlements and salt springs

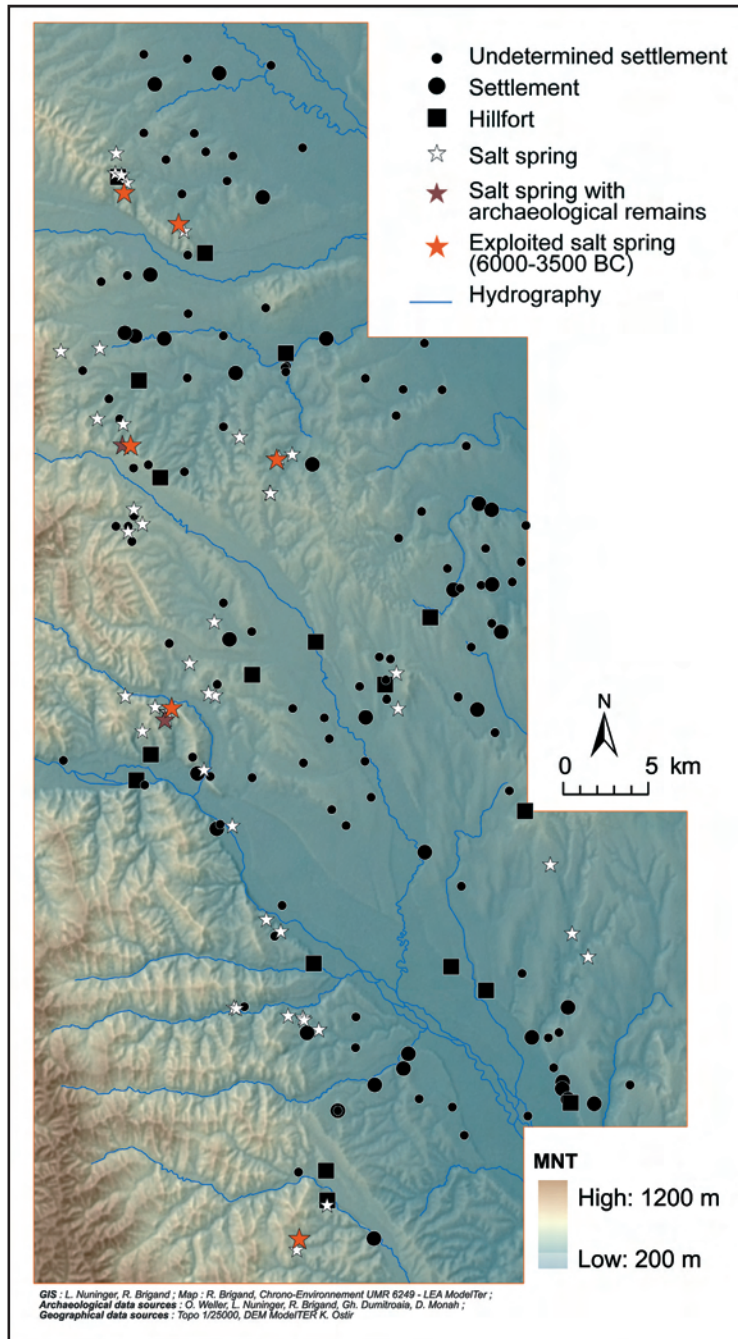
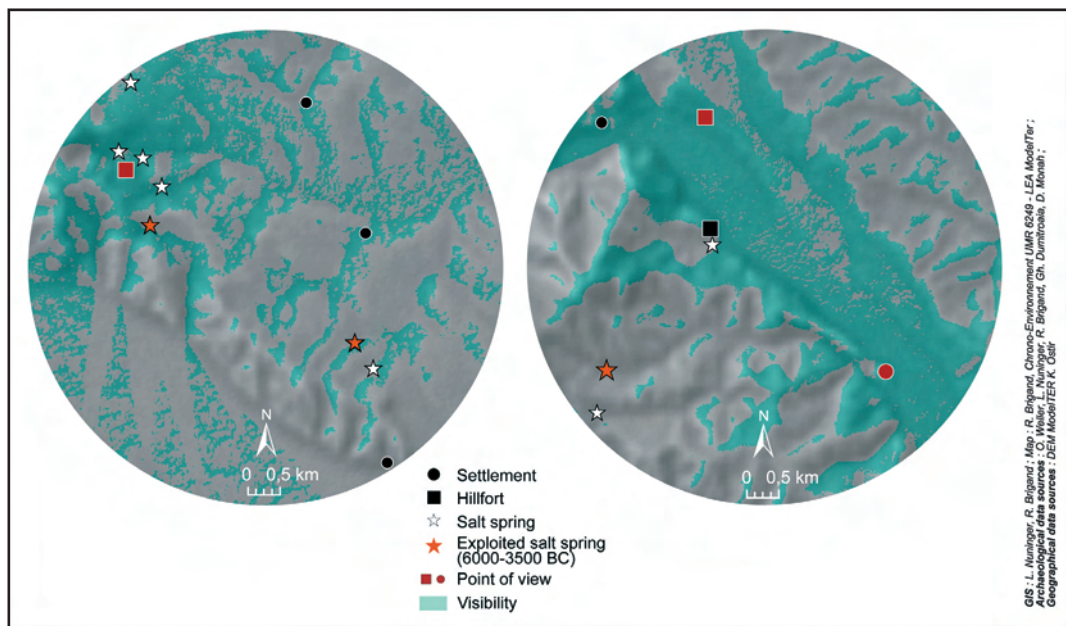


Fig. 6: Viewshed analysis: 2 types of visual control



3. Territorial control

A qualitative approach is in progress in order to qualify the type of control practised on salt resources, production and circulation. First, we mapped the distribution of salt springs, with or without archaeological remains of exploitation, and the distribution of high ground settlements in area 1 (fig. 5). Direct and systematic links were not observed, except in some cases.

With the 25 m Digital Elevation Model, a simple viewshed analysis was processed from the perspective of archaeological sites. The preliminary results show that two modes of visual control can be defined: 1) a direct visual control of the salt springs (example of Cetatua promontory village, fig. 6-left); 2) an indirect visual control which impacts the main access (example of Tazlau valley, fig. 6-right). In this last case, the fortified

sites of Cucuteni A located on the right and left sides of the Tazlau River (Cetatua and La Coboras) were taken into account. Their visibilities were overlaid to define the visual control area. The visual control of the salt springs is null from both settlements, even from the exploited ones where archaeological remains have been found, but the control of the Tazlau Valley and the access to the salt spring valley seems to be optimal. A third one, a promontory settlement, within the visual control of both main settlements, is well located to control a secondary access to the salt spring. It is probably an intermediate settlement which served as a relay for more accurate territorial control.

This preliminary analysis has to be improved by testing several types of viewshed processing, and generalized for all the study areas in order to characterize the visual system of control (hierarchical organization of sites according to the size of visual space, the number of visible sites and the number of sites which can be seen from each site).

On the scale of the Pre-Carpatic Mountains, the results of the spatial analysis suggest that the Chalcolithic occupation (4600-3500 BC) integrates a complex settlement pattern in which the network and hierarchical organization of settlement has to be recognized. Apprehending these networks, still in its forward-looking phase, brings to light the importance of areas under visual control or densely inhabited, even if there is no direct relationship with the location of salt springs. In a region known for the important economical role of salt (Weller, Dumitroaia, 2005; Alexianu, Weller, 2008), the study of such "disconnected" areas is promising for territorial issues since their presence likely underlines a high level of social organisation.

Acknowledgments

This project has been supported since 2004 by the CNRS (Humanities Department), the French Foreign Office and the University of Franche-Comté, and is developed in association with the Museum of History and Archaeology in Piatra Neamt, the Al.I. Cuza University and the Archaeological Institute in Iasi (Romania). This English version was revised thanks to the support of the ArchæDyn programme.

Bibliography

ALEXIANU, WELLER, BRIGAND 2008 (in press)

Alexianu M., Weller O., Brigand R. – Usages et enjeux autour des sources salées de Moldavie précarpatique, Roumanie. In : O. Weller *and al.* (eds.), *Sel, eau et forêt : hier et aujourd'hui*. Colloque international, Saline royale d'Arc-et-Senans, 2006. Besançon, Presses Universitaires de Franche-Comté, Cahiers de la MSH Ledoux (coll. Homme et environnement, 1).

SILVERMAN 1978

Silverman B. W. – Choosing the window width when estimating a density, *Biometrika*, 65-1 : 1-11.

SILVERMAN 1986

Silverman B. W. – *Density Estimation for Statistics and Data Analysis*. Monographs on Statistics and Applied Probability, London, Chapman and Hall.

WELLER, BRIGAND, ALEXIANU 2007 B

Weller O., Brigand R., Alexianu M. – Cercetari sistematice asupra izvoarelor de apa sarata din Moldova, *Memoria Antiquitatis*, XXIV.

WELLER, BRIGAND, NUNINGER, DUMITROAIA, MONAH 2008 B (in press)

Weller O., Brigand R., Nuninger L., Dumitroaia Gh., Monah D. – Analyses et modélisation spatiale autour des sources salées de Moldavie précarpatique durant la Préhistoire. In : N. Morère Molinero (ed.), *Las salinas y la sal de interior en la historia : economía, medioambiente y sociedad*, colloque international, Sigüenza, 2006. Madrid, Universidad Rey Juan Carlos-Dykinson.

WELLER, DUMITROAIA 2005

Weller O., Dumitroaia Gh. – The earliest salt production in the world : an early Neolithic exploitation in *Poiana Slatinei-Lunca*, Romania, *Antiquity*, 79 (306).

www.antiquity.ac.uk/ProjGall/weller/index.html

WELLER, DUMITROAIA, MONAH, NUNINGER 2007 A

Weller O., Dumitroaia Gh., Monah D, Nuninger L. – L'exploitation des sources salées en Moldavie : un exemple de ressource structurante du territoire depuis le Néolithique. In : D. Monah *and al.* (eds.), *L'exploitation du sel à travers le temps*. Colloque international de Piatra Neamt (Roumanie), 2004. Piatra Neamt, Bibliotheca Memoriae Antiquitatis, XVIII : 99-113.

WELLER, DUMITROAIA, SORDOILLET, DUFRAISSE, GAUTHIER, MUNTEANU. 2008 A (in press)

Weller O., Dumitroaia Gh., Sordoillet D., Dufraisse A., Gauthier E., Munteanu R. – Première exploitation de sel en Europe : Techniques et gestion de l'exploitation de la source salée de Poiana Slatinei à Lunca (Neamt, Roumanie). In : O. Weller *and al.* (eds.), *Sel, eau et forêt : hier et aujourd'hui*. Colloque international, Salines royales d'Arc-et-Senans, 2006. Besançon, Presses Universitaires de Franche-Comté, Cahiers de la MSH Ledoux (coll. Homme et environnement, 1).

WELLER, NUNINGER 2005

Weller O., Nuninger L. – Les eaux salées de Moldavie roumaine : étude interdisciplinaire autour d'une ressource structurante du territoire. In : J.F. Berger *and al.* (eds.), *Temps et espaces de l'Homme en société, analyses et modèles spatiaux en archéologie*. XXVe Rencontres internationales d'Histoire et d'Archéologie d'Antibes, 2004. Juan-les-Pins, APDCA : 511-516.

SOMMAIRE CONTENTS

2	Scientific committee
2	Steering committee
3	Partners
6	Presentation ArchaeDyn
8	ArchaeDyn's members
13	Acknowledgments
15	Program
18	Presentation concert Laostic

19 Articles

21	Introduction
----	--------------

23 **Session 1 “Methods and tools of spatial analysis” (workgroup 4)**

Communications orales Oral communications

25	<i>L. SALIGNY, L. NUNINGER, K. OSTIR, N. POIRIER, E. FOVET, C. GANDINI, E. GAUTHIER, Z. KOK ALJ, F. TOLLE with the collaboration of the ArchaeDyn team</i> Models and tools for territorial dynamic studies
45	<i>DUCKE Benjamin, KROEFGES Peter C.</i> Managing complexity the simple way: examples from GIS modelling of human behaviour.
55	<i>KOHLER Timothy</i> Agent-Based Modeling and its Application to Prehispanic Settlement Ecodynamics in the Central Mesa Verde Region: Testing Optimality in Site Location in the Archaeological Record.
63	<i>HILPERT Johanna, ZIMMERMANN Andreas</i> Estimations of population densities from the Neolithic up to the 19th century: methods and results.
71	<i>ZIMMERMANN Andreas, HILPERT Johanna</i> Interpretive dimensions and variability of population densities

79 **Session 2 “Catchment areas, terroirs and community lands” (workgroup 1)**

Communications orales Oral communications

81	<i>POIRIER Nicolas, GEORGES-LEROY Murielle, TOLLE Florian, FOVET Elise</i> The spatio-temporal dynamic of agricultural areas, from Antiquity to modern period (ArchaeDyn Project)
95	<i>BARGE Olivier, CASTEL Corinne</i> Subsistence, sustainability and population at Tell Al-Rawda: a 3rd Millennium BC town in the Syrian steppe/ Autosuffisance alimentaire et population à Tell Al-Rawda: une ville du troisieme millenaire dans la steppe syrienne
107	<i>BINTLIFF John</i> Catchments, settlement chambers and demography: case studies and general theory in the Greek landscape from prehistory to early modern times.

Posters

119	<i>AUSSEL Sandra, GOGUEY Dominique, PAUTRAT Yves, SALIGNY Laure, CHARMOT A., MORDANT Claude, NUNINGER Laure</i> Spatial analysis of archaeological sites in the Châtillonnais forests (Côte-d’Or, France).
127	<i>FOVET Elise, POIRIER Nicolas</i> Characterization of Agrarian Resources for Archaeological Applications (ArchaeDyn Project).
133	<i>LE BRAS-GOUDE Gwenaëlle</i> Diet of ancient and middle Neolithic populations in the northwest of Mediterranean. Anthropological and isotopic studies

139 Session 3 “Settlement patterns, networks and territories” (workgroup 2)*Communications orales* Oral communications

- 141 *Frédérique BERTONCELLO, Elise FOVET, Cristina GANDINI, Frédéric TRÉMENT, Laure NUNINGER with the collaboration of the members of Workgroup 2*
The spatio-temporal dynamics of settlement patterns from 800 BC to 800 AD in Central and Southern Gaul: models for an interregional comparison over the long term
- 155 *BURILLO Francisco, ARENAS Jesús, PICAZO Jesús, ORTEGA Julián, POLO Clemente, VILLAGORDO Carolina, LÓPEZ Raul, SAIZ Esperanza*
The uncorrupting mountain. Historical dynamics in the Iberian Mountain Range from 5.500 B.C. to 1.800 A.D.
- 167 *POSLUSCHNY Axel*
GIS as a means to investigate «Princely Sites», Space and Environs. New ways to answer old questions.
- 175 *VAN DEN BOSSCHE Benjamin, MARCIGNY Cyril*
Changing settlement patterns in the Normandy countryside.

Posters

- 187 *KOROBOV Dmitry*
Using ArcGIS Spatial Analyst for the investigation of the system of habitation in the Kislovodsk basin (South of Russia).
- 193 *NOUVEL Pierre, BARRAL Philippe*
Rural settlement dynamic during Iron Age in Central Gaul: the excavation and fieldwalking data head to head

195 Session 4 . “Diffusion of raw materials and manufactured objects” (workgroup 3)*Communications orales* Oral communications

- 197 *GAUTHIER Estelle, WELLER Olivier, NUNINGER Laure et avec la collaboration de : GABILLOT Maréva, QUILLIEC Bénédicte, PETREQUIN Pierre*
Models for the study of the consumption and the circulation of resources and products in France and Western Europe during the Neolithic and the Bronze Age (ArchaeDyn project)
- 211 *CORNIQUET Claire*
Mobility and circulation of knowledge among potters of the Arewa (South-Western Niger): impact of the frameworks of practice on the spatial distribution of ceramics' techniques.

Posters

- 221 *FISCHER Viktoria*
Pin consumption on the shores of lake Neuchâtel (Switzerland) during the palafittic Late Bronze Age.
- 225 *WELLER Olivier, BRIGAND Robin, NUNINGER Laure*
Spatial analysis of the Salt Spring exploitation in Moldavian Pre-Carpathic Prehistory (Romania).

233 Session 5 . Synthèse/Open synthetic session*Communication orale* Oral communication

- 235 *FAVORY François, NUNINGER Laure*
Bilan général du programme triennal ArchaeDyn/synthesis of ArchaeDyn project ArchaeDyn 2005-2007 : ambitions, achievements and accomplishments