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Volume II

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Chalcolithic Territorial Patterns in Central Moldavia (Iaşi County, Romania)

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Abstract:
This paper aims to compare spatial and temporal distributions of archaeological evidence in the western part of Iaşi County. Applying integrated approaches through GIS analysis, it aims to explore natural, economic, and social phenomena involved in territorial trajectory during Later Prehistory (4600-3500 BC). In the chronological framework of the Cucuteni culture, different kinds of spatial analysis are computed (viewshed analysis, kernel density estimation) in order to strengthen the control of the Bahluieţ-Valea Oii basins, well-known for its fortified settlement density and its extremely suitable soils for agriculture.

Keywords:
Spatial Analysis, Cucuteni Culture, Viewshed, Kernel Density Estimation, Romania

Despite a long tradition of studies on Moldavian Neolithic and Chalcolithic cultures, the analysis of human communities' territorial behaviour remains underexploited. This work combines concepts used in spatial archaeology with the potentiality of a Geographic Information System (GIS) in order to mobilise archaeological artefacts in a large-scale setting and multiple thematic scopes. The general goal is to evaluate how prehistoric territories are constituted and how natural resources were driving factors for these farming groups of eastern Romania. Visual analysis and spatial patterning allow us to describe territorial models which explain the original organisation of these territories.

1. Regional Setting

Located in the south-west area of the Moldavian Plain, the studied area covers the hydrographic basin of the Bahluieţ, limited to the East by its confluence with the Bahlui. With the intention of defining a more restricted area according to the degree of advance of the archaeological map, the span of the study extends to the two basins of Bahluieţ and Valea Oii as strictly defined by the outlet located in the downstream part of Sârca (Bălţaţi), at the merging of these watercourses (Fig. 1). Those watersheds, respectively of 300 and 95 km^2, differ by a vast interfluve (a landform composed of the relatively undissected upland between two adjacent valleys containing streams flowing in the same general direction). This is a cuesta landform, a ridge formed by gently tilted sedimentary rock in a homoclinal structure, slightly bulged with one long and gentle side (dip slope) conforming with the dip of the resistant beds that form it (towards the South and Bahluieţ valley), and the other steep side (scarp slope) formed by the outcrop of resistant rocks (towards the North and Valea Oii valley).

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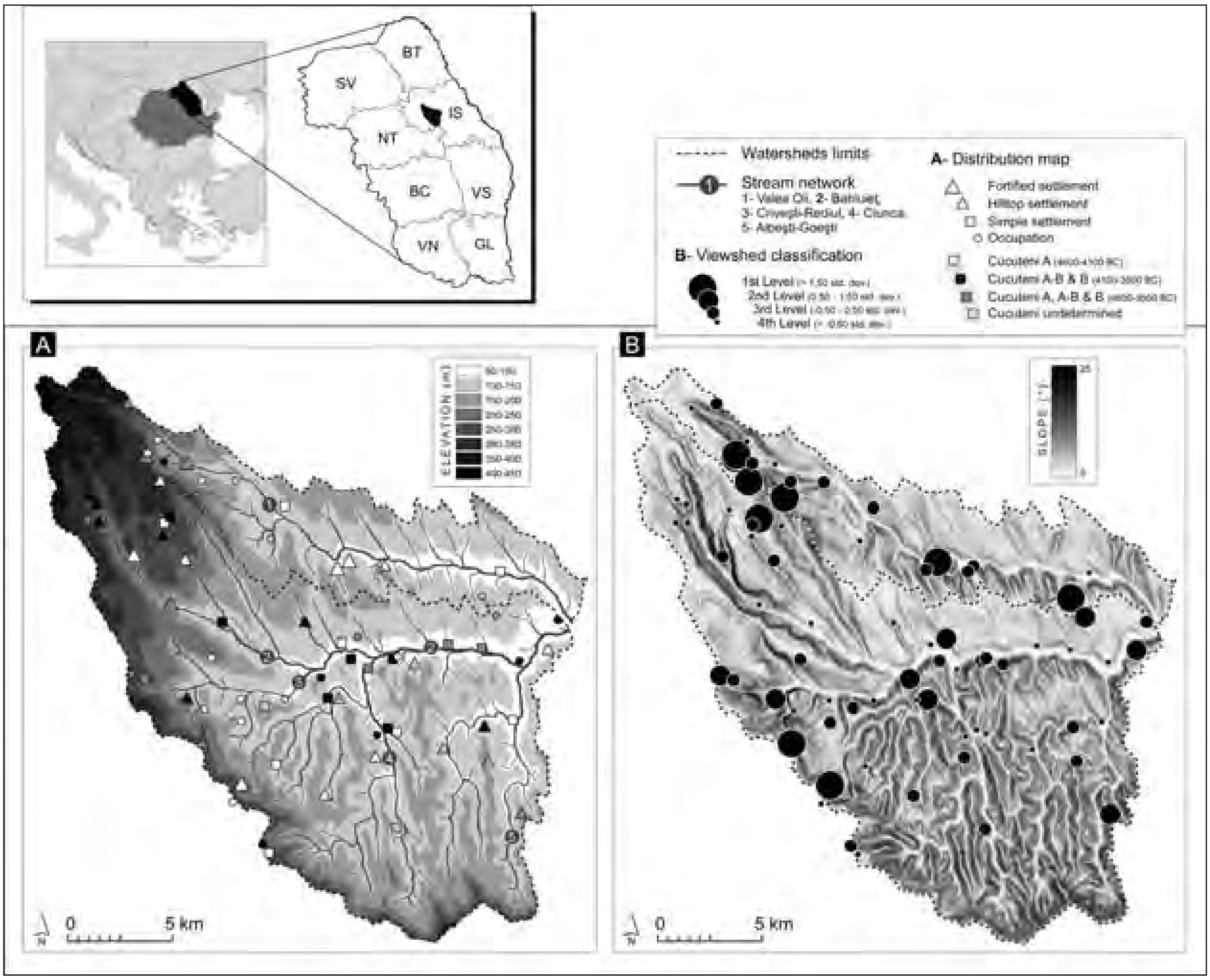

Figure 1*. Distribution map (A) and viewshed classification (B) in the Bahluieţ-Valea Oii watersheds during Cucuteni period (4600-3500 BC).*

Hydrography is the main factor of the current appearance of the Moldavian plain. Water has easily carved the geological sedimentary rock made of clay and sand. In the higher regions and on the Western and Southern limits, it has collided with sandstones and less crumbly sarmatian limestones of the Central Plateau or the Suceava Plateau. Above the marls and loess clay of the hydrographical basins of the Bahluieţ and Valea Oii, different types of soil have been observed. They belong to two main categories determined by the climatic zoning: the level of illuvial clay, made up of brown and grey steppic soils, that are occasionally found on the plateaus that limit the study area (West and South); the level of mollisols (chernozems) that occupy most of the Moldavian plain and its lower parts (Bacăuănu 1968). The former characterise surfaces that are currently covered by forest – or recently cleared – or by sylvosteppic forests. The latter include the back of cuestas and low interfluves, the terraces of the Bahluieţ and of the Valea Oii or the slightly steep sides, which are generally covered by meadows or fields.

2. Achaeological Database

Diverse actors have, since the end of the 19th century, marked the prehistoric archaeology of the Eastern Carpathian Mountains, with important discoveries that are now part of the institutional historiography of the Cucuteni culture (e.g. Zaharia, Petrescu-Dîmboviţa and Zaharia, 1970; Monah and

Cucoş 1985; Marinescu-Bîlcu 1993; Văleanu 2003; Boghian 2004; Bem 2007). The study area is particularly well-documented. Our study benefited from numerous geographic or thematic inventories that have been carried out at the scale of Moldavia, county or main geographical units. Given the complex history of research and an undeniable wealth of data, an exhaustive yet critical database has had to be achieved, gathering all available information: the context of the discovery, the chronological frame, the nature of the site, the cartographic and bibliographic observations, the accuracy of archaeological information, the field survey data, and the nature of georeferencing.

Excavation can provide a precise chronological framework from exhaustive samples. Dating a site from the single ceramic artefacts collected by field survey questions their very representativeness and reliability for periodic maps (Fig. 1A). The number of archaeological sites for Cucuteni A (4600-4100 BC) is the highest: 40 sites, among which 26 (34.5 %) were not occupied at a later date. As for the Cucuteni A-B, researchers have already noted the very low number of sites for this period. In our case, 8 sites are located in the Western area. This reflects the research difficulties (due to research conditions with the lack of abundant painted ceramic in field survey) rather than the retraction of the settlement. Since our study took a particular interest in long-term settlement patterns, it seemed appropriate to group together the Cucuteni A-B and Cucuteni B sites. Added to Cucuteni B, the number of sites considering a period stretching approximately from 4100 to 3500 BC reaches 33, among which 19 (25.5%) are not occupied during Cucuteni A. Fourteen sites (19%) are occupied from Cucuteni A to Cucuteni B. These are stable, generally significant economically and socially, and they attract settlement in the long term, over a thousand years.

The issue of archaeological classification has largely mobilised the scientific community. From the 1970s, the community started using topographical criteria in order to distinguish between different types of settlement. Looking at former inventories shows a more or less elaborate classification between higher, lower, or medium positions, but these are not always relevant given their variability depending on considered territories. Indeed, the appearance of territory plays an important part in the settlement patterns. For example, it has been observed that settlements sometimes selected steep slopes and cliffs formed by the outcrop of resistant rocks, such as the right side of the high and medium-high Valea Oii valley. Nevertheless, the topographical criterion on its own is insufficient to establish a valid hierarchy: it must necessarily be associated with other data, which facilitate the creation of a coherent hierarchical index.

The first criterion involves the presence or absence of man-made defensive structures. This points out social as well as spatial inequalities. In our area of study, seven sites are turned into defensive structures during the Cucuteni. This helps us to rank the data as follows. The lowest level is constituted of "occupations". These are small sites that only provided a limited number of ceramic remains and no obvious element of domestic architecture or materials of quality. They constitute an important category (28 sites, about 37.5%). This probably includes temporary sites, characterised by a strong mobility. Yet they are often little delineated and insufficiently surveyed. Contrary to these occupations, simple settlements display architectural structures and artefacts of quality (figurines, painted ceramics, bone and flint tools). Significant in terms of size and relatively numerous (21 sites, which constitutes 28%), they differ from hilltop settlements (19 sites, 25.5%), which are limited by steep slopes forming a headland open on one side. Low terrace settlements, closed on one side, are considered as simple and not hilltop settlements. Naturally, fortified hilltop settlements (7 sites, about 9%) are characterised by the existence of an man-made fortification. The generic category "settlement" includes sites with abundant artefacts and

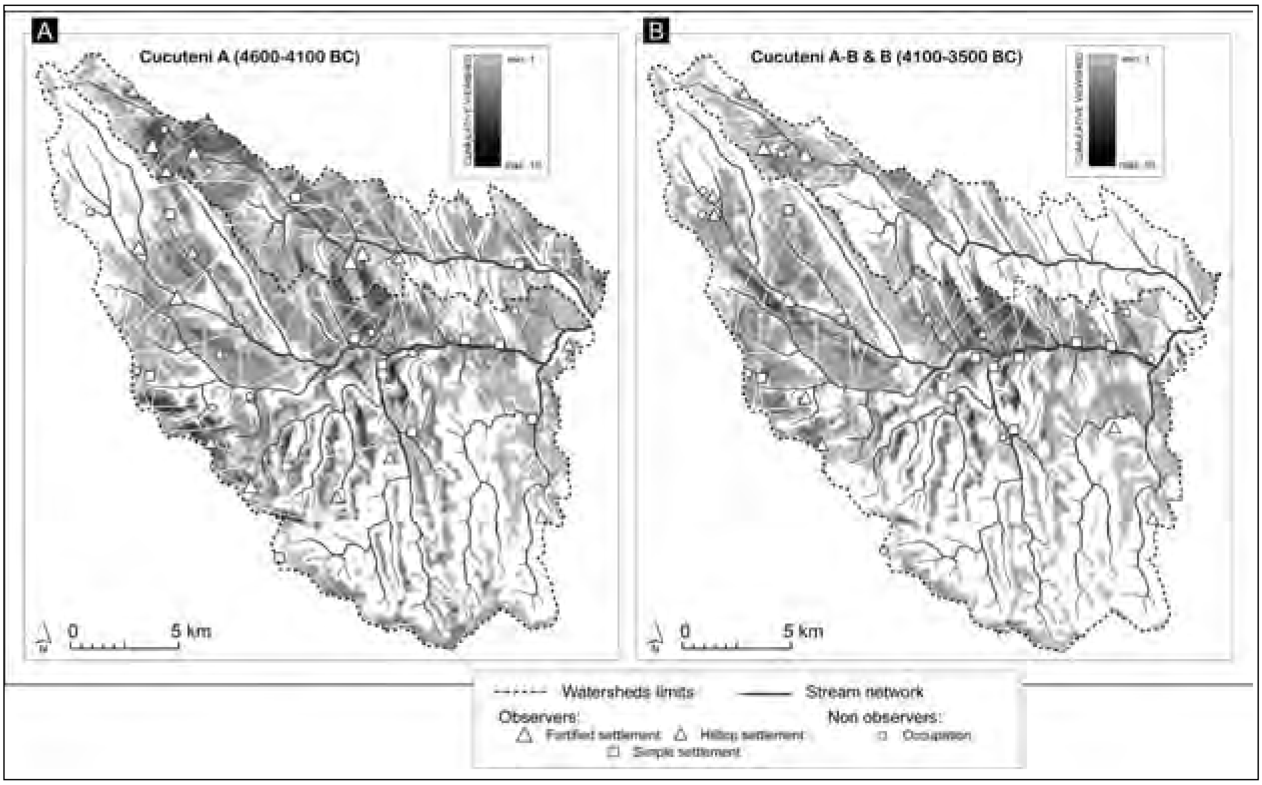

***Figure 2**. Cumulative viewsheds during Cucuteni A (A) and Cucuteni A-B and B (B).*

house remains, generally stable, structuring the settlement pattern.

The georeferenced archaeological database depends on a precise protocol that need not be presented in detail here. Surveyed sites have been mapped by differential GPS (38 sites, more than 50% of the total) precisely where the strongest concentrations of ceramic remains have been found. When dealing with settlements well-defined by topography, the edges of the site have also been noted. The other sites were manually located using the descriptions contained in the inventories and the combined use of 1970 topographical maps at a 1:25.000 scale and maps dating from the first half of the 20th century at 1:20.000, as well as orthophotography. Indeed, among all the sites, the position of 21 of them (28%) can be placed with a margin of error of approximately 50 metres. Fifteen other sites (20%) are so-called imprecise locations, as the margin of error varies between 50 to 200 metres. Only one location remains inaccurate and located in the centre of the village.

Starting from this pattern of dots, a series of spatial analyses have been undertaken, benefiting from the wealth of specialised literature, a French project developing a model for spatial processes (Gandini, Favory and Nuninger 2012), and several experiments carried out in Neamţ County (Weller et al. 2007; Weller et al. 2011).

3. Viewshed Analysis

In this section, the study of settlement patterns uses several parameters offered by GIS: viewshed analysis (Fig. 2), density estimation (Fig. 3) and more broadly, the anisotropic travel-times (Fig. 5). A major limit must be stated: since these studies are mostly based on indexes defined by field surveys, it is impossible to study their contemporaneity more precisely than in broad archaeological phases corresponding to 500-600 year periods (respectively Cucuteni A and Cucuteni A - B and B).

Viewshed analysis is one of the classic tools offered by GIS and has thus been largely used to resolve issues of territoriality peculiar to human societies (Wheathley and Gillings 2002, 202-216; Conolly and Lake 2006, 225-233). They allow the rephrasing of some crucial notions concerning the study of the forms of settlement: territory, considered as a transformed, occupied and appropriated space socially controlled by a group; status or rank, which corresponds to the different levels of hierarchy of the settlement; relations between the different parts of a spatial system, that is, the issues of specialisation and synergy of archaeological entities. Visibility calculation determines areas that can theoretically be seen from different observation points. Three essential shortcomings must be raised. The first one deals with the DEM resolution, since the calculated viewshed results depend on its accuracy. In our case, the small pixel value (25 m) elaborated by K. Ostir of Ljubljana University (ZRC Sazu) from ERS radar images allows for accurate and precise results. The second limit depends on how visibility analysis is programmed in each particular GIS software package. The software we used – ArcMap and Erdas Imagine – does not allow for any choice in the way in which visibility analysis is computed. With one single set of data, different algorithms produced different results. Several tests dealing with field observations resulted in our confidence in one of them: the Leica software package (Erdas Imagine). The third limit is fundamental and arises from the weakness of paleoecological data, such as vegetation and tree cover. Though forests can have a decisive impact on the field of vision, this study ignored this parameter because reconstructing vegetation history presented so many difficulties.

Several analyses have been carried out, from the theoretical assumption of an observer whose height is 1.7 m above ground, according to a standard offset. The field of vision is limited to 12 km, according to field observation (in different weather condition) and ethnographic information. It also corresponds to one day walking round trip. Besides, this value approaches general settings used in archaeological analysis. So, this paper assumes that a village, a small group of domestic units, or cattle located in an open landscape, are visible at 12 km in favourable weather conditions. The simplest way of visibility calculation is a binary map distinguishing between visible or invisible target cells from a specified viewpoint. The visible spectrum can then be quantified in square kilometres. Its classification using standard deviation offers a first level of hierarchisation according to the importance of theoretical visibilities for each site considered (Fig. 1B). The visibility map might be associated to one or more viewshed maps. The result is a multiple viewshed map in which the values are either 1 (visible) or 0 (not visible). Each map cells is noted 1 if it is visible from at least one viewpoint. On the other hand, the map algebraic sum of two or more binary single viewshed maps creates a cumulative viewshed (Fig. 2). Then, the cell values are integrated ranging from zero to theoretical maximum of the number of viewpoints, although this will only occur if at least one cell is visible from all viewpoints. The field of view being defined, the maximum value generally cannot be equal to the number of archaeological sites. This method is also used for defining a qualitative index of visibility taking into account not several archaeological sites, but the whole set of points lining a given settlement. It allows to qualify the visible spectrum that gives an account of the different viewpoints whether the observer stands at the centre or on the side of the settlement (Fig. 5). Contrary to cumulative viewsheds, the map of multiple viewsheds results from the association of several simple or binary visibilities. The outcome is thus a map of visibilities in which the values equal 0 or 1 (meaning the pixel is visible to 1 observer at least). Substracting multiple visibilities for Cucuteni A-B and B from Cucuteni A allows us to identify the dynamics of seen and unseen areas (Fig. 4b).

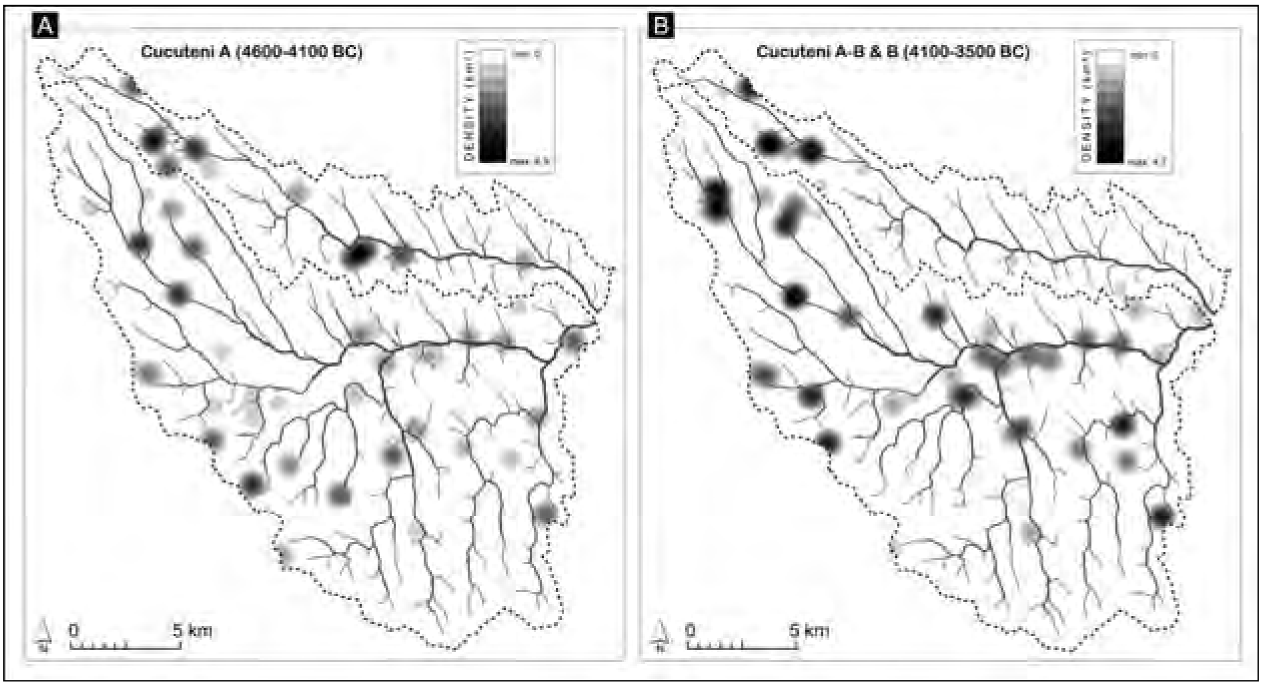

Figure 3. *Cucuteni sites density with chronological and quality weighting factors.*

4. Density Estimation

The kernel density estimation (KDE) provides an estimation of the density of a point pattern. For a circular kernel estimation, the density value obtained takes into account the size of the neighbourhood: thus, an area surrounded by other high-density spaces will in turn become more dense. The assigned weight decreases proportionally to the distance from the centre of the window. This method is well known since the 80's (Silverman 1986) and has largely been used for archaeological applications for intra-site or inter-sites analysis (Baxter, Beardah and Wright, 1997; Nuninger et al. 2012). The density estimations depend on two parameters: *k*, the kernel function chosen; *h*, the radius chosen. ArcGIS uses a quadratic kernel function, with no alternative choice. In archaeological analyses, the choice of the radius (*h*) is the main parameter, for it determines the smoothing of the data. Generally, using too small radius will produce irregular surfaces, similar to a pattern of dots. On the contrary, too large radius will result in a loss of accuracy, favouring general trends and preventing the observation of settlement patterns.

For determining the best radius, this study uses a graphic approach inspired by the *ArchaeDyn* programme (Nuninger et al. 2012, 32) and applied in the Neamţ County (Weller et al. 2011). It sets a curve of the maximum values obtained according to a series of calculations linked to a given interval (200 m). The inflection point of the curve corresponds to our situation, estimated at 900 m (in reality between 800 m and 1000 m). A major limitation is raised when the KDE method must be applied to archaeological data. In order to calculate the settlement densities by period (Cucuteni A, Cucuteni A-B and B), the sites with chronological dating that has been imprecisely attributed to the Cucuteni culture are not taken into account. In order to overcome this bias, a weighting according to the length of each period has been made. In the database, a site that can undisputedly be attributed to a period has a value of 1, and a site that undisputedly does not belong to a period has a value of 0. Each imprecisely dated site is given a value of 0.45 for Cucuteni A and of 0.55 for Cucuteni A-B and B. The main advantage of this method is that it takes into account sites that were previously excluded from the analyses by focusing on precise chronological periods. The density

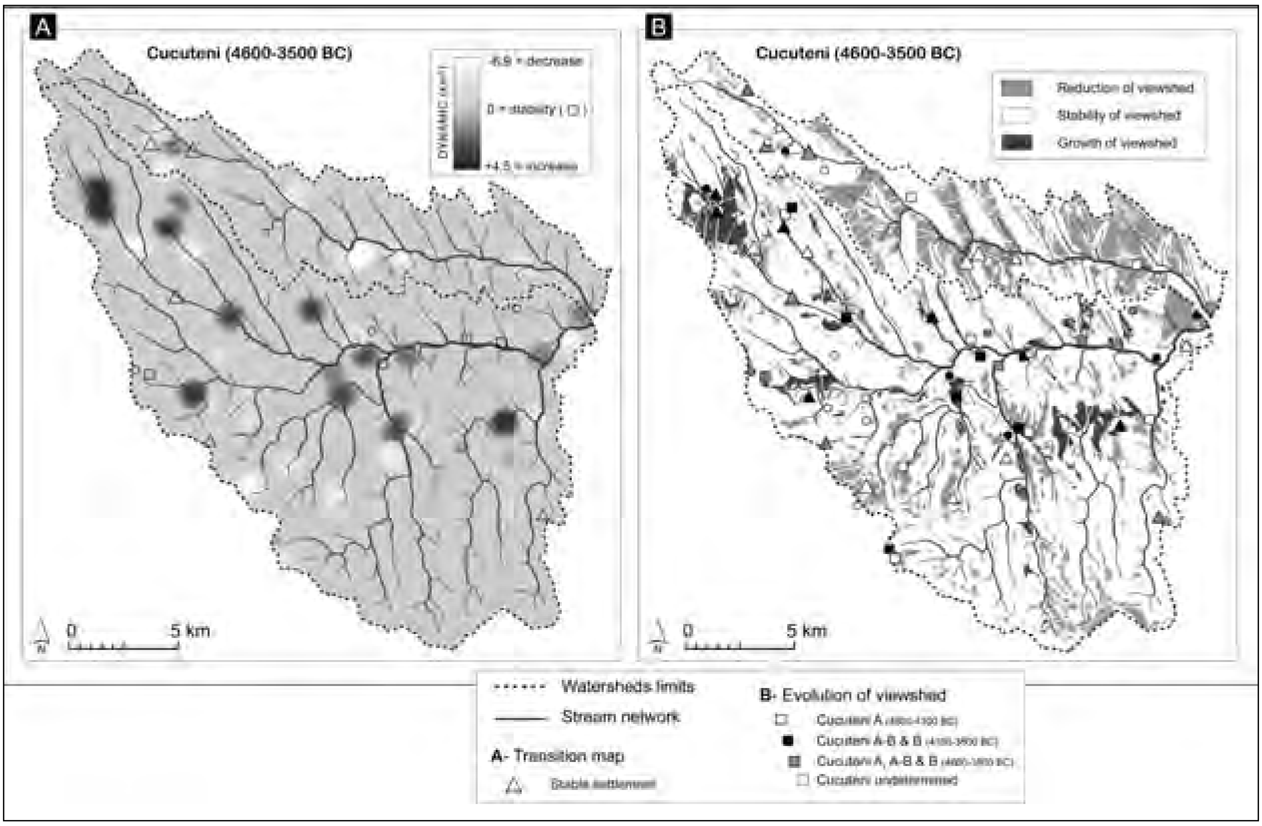

***Figure 4**. Dynamics of density (A) and viewshed (B) between Cucuteni A and Cucuteni A-B and B.*

varies with a lesser weight for these sites in order to give a more realistic image (Fig. 3).

Concerning the nature of the archaeological site, an arbitrary weighting is introduced on a scale of 1 to 4, which allows to discriminate quality settlements. Since this study tries to establish the importance of hilltop and fortified settlements in the organisation of Chalcolithic territories, those reaching a 4 should be given priority. They were most probably richer in terms of population and power, while the weight of short-lived or undefined occupations should be attenuated. Thus, small settlements, usually identified by fieldwalking surveys, are attributed a value of 1, whereas simple, hilltop and fortified settlements range from 2 to 4. The product of the two weighting factors, i.e. the nature of the site and its chronological framework, allows us to define a value which will be used for these KED analyses. Thus, simple settlements of which dating is uncertain are attributed to the Cucuteni but without specifications, will be given a value of 2x0.45 for Cucuteni A and 2x0.55 for Cucuteni A-B and B (Fig. 3).

With those density maps that provide a broad view of settlement processes by chronocultural period for the Bahluieț-Valea Oii hydrographic basin, differential density maps have been associated in order to visualise positive and negative evolutions between the two chronological sequences. The instability index, whether it be negative (abandonment) or positive (creation or development) is obtained by subtraction of the site density, weighted by its nature and chronology (Fig. 4). Negative values correspond to deserted sites; conversely, positive values correspond to created sites (i.e. new site or rise of the site's status). Finally, while a value 0 indicates the absence of occupancy between the two periods, it also indicates the stability of the settlement throughout the two periods. Hence, in order to differentiate between the two parameters, the location of stable sites between Cucuteni A, A-B and B has been specified (Fig. 4a).

5. Results and Discussion

Spatial analyses are mainly based on distribution maps from which graphic models are elaborated. In order to fully understand the method used in this study, two essential biases must be stated. On the one hand, archaeological information cannot be exhaustive and is bound to be partial. On the other hand, it is impossible to prove the contemporaneity of several sites placed in a centuries-old chronocultural phase (except in specific cases). The issue, while hard to solve in absence of radiocarbon dating and detailed excavations, can nevertheless be studied in terms of settlement patterns.

5.1. Regional Distribution

A glance at the maps showing the archaeological spatial organisation is sufficient to define the general characteristics of their geographical distribution: settlements are tightly linked to the stream channels since they systematically stand on the edges of alluvial or erosive terraces, as well as on the ridges of cuesta landforms lining the watercourses. A few exceptions can be singled out. First of all, the Southern part (Fig. 1) and more precisely the area where the tributaries of the right bank are gathered, a looser settlement pattern has been observed. It does not reach the concentration numbers of other settlements in the Valea Oii and Bahluieţ valleys. The settlements are distributed along the Ciunca and the Albeşti and, to a lesser extent, along their respective tributaries. Most Southern sites seem relatively isolated. They can be found in higher parts of rather minor and probably seasonal watercourses.

How can the unusual occupation in this area be explained? The topographical variable and the socio-economic environment suggest a few hypotheses. The morphology of the territory, with numerous narrow and symmetrical valleys with relatively steep slopes whose summits reach 150 to 200 m, does not provide a favourable place to settle. Furthermore, forest coverage may have been more than the current situation. In this context, the settlement pattern might be derived from pioneer settlers. It is suggested by isolated settlements, dissociated from the settlement patterns of the Bahluieţ valley. Two arguments suport this idea. First, the original topography offers many limited viewsheds, well-established by the map of hierarchies according to potential visibilities (Fig. 1B), as well as low viewshed competition emphasized by the cumulative viewshed maps (Fig. 2). The second argument points out the temporary nature of this occupation, without stable or fortified settlements (Fig. 1a).

On the contrary, in the Northern part (Valea Oii and Bahluieţ valleys), settlement patterns change radically. The archaeological distribution is very dense and organised according to several centres of population, usually indicated by the presence of stable settlements established on cuesta ridges or low alluvial terraces allowing them to control the fluvial landscape. We should keep in mind that the landscape is more open due to the rather flat topography, probably stimulating new occupations with close intervisibility.

5.2. Settlement Pattern

The change between Cucuteni A and Cucuteni A-B and B is well-established thanks to the combined use of distribution maps and density analyses (Fig. 1a, Fig. 3). A regression can be noted during Cucuteni A-B and B, characterised by a noticeable decrease in the number of settlements. This suggests a phenomenon already observed in the foothills of Neamţ County: a retraction and concentration of settlement according to specific choices about territorial control and land resources. Between Cucuteni A and Cucuteni A-B and B (Fig. 4a), the number of abandoned sites is high, notably in the middle-low Valea Oii valley. None of the eight sites seems to continue during the next period. This settlement duration probably reflects an agrarian colonization, as confirmed by the dating of at least three of them to

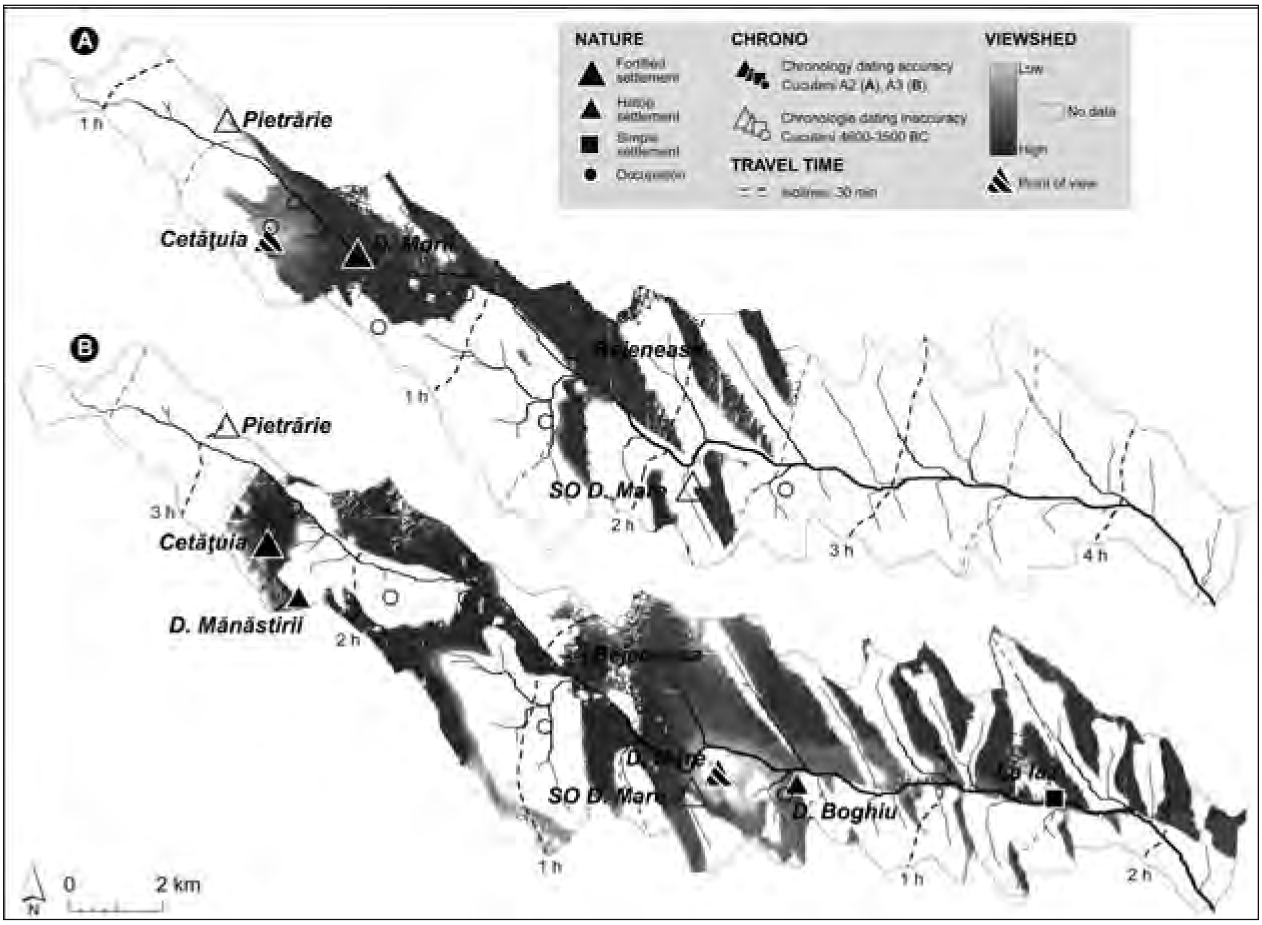

Figure 5. Viewshed analysis and travel time in Valea Oii from Cucuteni-Cetăţuie (A) during Cucuteni A2, from Filiaşi-Dealul Mare (B) during Cucuteni A3.

Cucuteni A3 (c. 4350/4300-4150 BC) (Fig. 5b). The creation of sites during Cucuteni A-B and B is also important, in most cases reaching new adjacent areas. It implies, after the extension of Cucuteni A and the massive diffusion of its settlements, that a displacement and resettlement of the same populations occurred. New creations of sites are often found in direct proximity to deserted sites. Thus, they indicate a displacement and rarely, the occupation of new land.

Next to these displacements of population between Cucuteni A and Cucuteni A-B and B, another situation should be documented, which is less a displacement than a genuine strengthening of the settlement pattern. The network is not radically changed, for it relies on a former pattern unchanged by new occupations. Except the desertions in the Valea Oii valley and in the Southern part, density maps (Fig. 3) show a strengthening of previous polarities, whether in the upper and middle Bahluieţ valley, more densely occupied, or in the upper Valea Oii valley. In this area, it has been clearly observed that following a period of extension and diffusion, a resettlement occurred around the main fortified sites (Cucuteni-*Cetăţuie*, Cucuteni-*Dâmbul Morii*, Stroeşti-*Pietrărie*). This new territorial organisation seems to characterise the final phase of the Chalcolithic, as the dynamic viewshed map also records (Fig. 4B). Indeed, apart from the drastic reduction of visible spectrums in the middle and lower Valea Oii valley, this map highlights stability of visible areas.

5.3. Territory, Mobility and Specialisation

The territory is defined as an area socially appropriated and domesticated by one or several communities, in which a population

***Figure 6**. The middle sector of the Bahluieţ Valley seen from the Ion Neculce-Livada de Visine settlement (Cucuteni B) and the distribution of visible Cucuteni A-B and B sites (**V**).*

exercises immediate leverage for its activities of production or hunting in relation to the ecological context (field, pasture, forest, etc.). For instance, some fortified settlements, stable over a few generations and evenly distributed along the main fluvial corridors, were central places tied to its economic activities but also to probable affective factors. Next to stable and federating entities, temporary and mobile settlements (small farmhouse, agrarian annex, sheepfold, etc.) belonging to a specific socioeconomic process.

Settlement patterns consist of a dense network, with a strong hierarchy conveyed by a variety of archaeological sites, whether fortified settlements, hilltop settlements without fortifications, open settlements or temporary occupations. Hilltop settlements, sometimes fortified, can generally be found on a side of cuesta or a high terrace of ridges. It is limited by cliffs and, in some cases, by an open defensive ditch. Located high up and in an overhanging position, it visually controls a territory of dozens of square kilometres, and thus shares intervisibility with other settlements, but also with more minor sites established in variable topographical contexts. Different hierarchical levels have been observed in such cases. Fortified settlements, appearing as federating centres, have a very different access to resources than settlements located in alluvial plain or on a low terrace next to a watercourse. Taking soil information into account, one may suppose that hilltops are made of areas exploited for wood and breeding purposes. In the valleys, these settlements are located near pastures and water resources, thus probably intended for agricultural and pastoral purposes. Many small farms, probably seasonal and mobile according to economic production necessities, surround these federating centres.

Viewshed analysis provides more information. The example of the Valea Oii valley can be studied here for short periods (Cucuteni A2: c. 4500-4350/4300 BC; Cucuteni A3: c. 4350/4300-4150 BC) (Fig. 5). For Cucuteni A2 (Fig. 5A) 8 sites are within the viewshed of Cucuteni-*Cetăţuie* fortified settlement, whether they are important settlements, fortified or without fortifications, or small agricultural units (generally imprecisely dated within Cucuteni A). Compared to Cucuteni A3 (Fig. 5B), with the creation of two hilltop settlements (Filiaşi-*Dealul Mare* and Podişu-*Dealul Boghiu-Crescătorie*), the analysis reveals a colonisation of the low valley. The remarkable concentration of sites under *Cetăţuie* throughout Cucuteni A2 can be viewed as the expression of the occupation of a territorial unit, less than one hour away from Cucuteni-*Cetăţuie,* where several settlements would have held different functions and coordinated the diffusion of satellite sites. A similar settlement association has been found in the low Valea Oii valley during the Cucuteni A3. One fortified settlement (Filiaşi-*Dealul Mare*) is directly connected to other sites:

- the nearby site of Filiaşi-*South West Dealul Mare* that, even though it is fortified, is still close in the alluvial valley and thus benefits from a specific access to resources;

- the more distant site of Bălţaţi-*Dealul Mândra,* located on a watercourse and in an open landscape, was probably based on agricultural production and/or hunting.

This synergy between sites with access to specific resources (water, soil and wood resources) defines a geographical and economic territory, in other words an area of land appropriated and exploited by a human community.

In the Valea Oii valley, it is particularly interesting to note that the two territories – the first one is structured on Cucuteni-*Cetăţuie,* the second one on Filiaşi-*Dealul Mare* – are over 10 km apart, which is more than a two-hour walk (Fig. 5). The site of Balş-*Bejeneasa,* although imprecisely dated in the Cucuteni A, is set in an interesting location since it is halfway between the two settlements.

This settlement pattern can also be found in other zones of our study area, such as upstream of the confluence of the Bahlueţ and Ciunca rivers. In this case, the strong visual competition between the settlements illustrated on the panoramic photograph (Fig. 6) could reflect their mobility on both sides of the fertile Bahlueţ valley without identifying any federating settlement.

6. Conclusions

This study has highlighted methods and problems in the study of settlement patterns in the 5th and 4th millennia BC. In Moldavia, similar settlement patterns have been observed in an earlier period, during the Precucuteni culture.They largely spread during Cucuteni A. In fact, Precucuteni settlement is distributed in the middle Bahlueţ valley and to a lesser extent in the upper Valea Oii valley, where settlement gradually becomes denser during Cucuteni. In Cucuteni A, the number of settlements increases. Their wide distribution involves three simultaneous factors: first, the demographic increase provides new agents of settlement; second, the development of agricultural practices leads to a greater mobility; last, the intensification of territorial hierarchy leads to the emergence of federating centres of settlement. GIS analyses, whether dealing with visibility or density, reinforce these hypotheses while underlining the short-lived nature of these settlement patterns.

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