Journal of Archaeological Science 39 (2012) 2810–2817

Contents lists available at SciVerse ScienceDirect

Journal of Archaeological Science

journal homepage: http://www.elsevier.com/locate/jas

The gravity model: monitoring the formation and development of the Tripolye culture giant-settlements in Ukraine

Aleksandr Diachenko [a], Francesco Menotti [b,*]

[a] Institute of Archaeology of the National Academy of Sciences, Kiev, Ukraine
[b] Institute of Prehistory and Archaeological Science, Basel University, Spalenring 145, 4055 Basel, Switzerland

ARTICLE INFO

Article history:
Received 17 February 2012
Received in revised form
9 April 2012
Accepted 13 April 2012

Keywords:
Tripolye culture
Gravity model
Giant-settlements
Pottery seriations
Chronology
Migrations
Settlement development
Ukraine

ABSTRACT

The formation, development and decline of the Tripolye culture giant-settlements in Chalcolitic Ukraine are strictly linked to complex processes of migration and settlement relocation. Despite being traceable through pottery typological analyses linked to contextual seriations, their identification is sometime not obvious. This paper shows how the application of the 'gravity model' not only facilitates their recognition, but it also helps increase the reliability of determining diachronic and/or synchronic occupations, shedding at the same time light upon the crucial 'internal' development of single settlements. Instead of clear-cut consecutive occupations, a more gradual settlement rotation with some synchronous phases seems to have prevailed.

1. Introduction

The Tripolye culture giant-settlements of the Southern Bug–Dnieper interfluve are unique phenomena in the development of the early agricultural communities of prehistoric Europe. Relative chronology, based on pottery in its typological contextual seriations, places their formation and development in the Chalcolithic (also known as Eneolithic), and more precisely during the Tripolye BII and CI (*c*. 4100–3600 cal BC) periods (; 2006: 22–26; Kruts, 2008; Videiko, 1995).

The existence of the giant-settlements was not known until the late 1960s, when Mr K. Shishkin noticed oval shapes in the landscape, while decoding aerial photographs for the army. A careful examination of these shapes revealed that they were indeed large settlements of the Tripolye culture (Kruts, 2008: 42). Initial investigations began in the 1970s and were mainly concerned with delineating the exact size of these large settlements (Shmagliy, 1980: 198–199; Videiko, 1995: 45–51). Scholars were astonished by their extent: the largest (Talianki) reaching 340 ha. It is important to stress that all the settlement sizes in this paper have been calculated with the proper ellipse area formula. In fact, the majority of publications contain 'old' data, such that their size was calculated using the rectangle area formula, despite the fact that the settlements have an elliptical shape. This method, of course, produced significantly exaggerated figures: for instance, Talianki was believed to be 450 ha instead of 340 (Diachenko, 2010: 7–8).

One of the liveliest debates amongst Tripolye culture specialists is whether the huge residential units should be considered as proto-cities. While some scholars (e.g. Shmagliy and Videiko, 2003) argue that such large settlements have all the characteristics of urban centres inhabited by a complex stratified society, others (see Kruts et al., 2001) maintain that their internal socio-economic structure and micro-chronology speak against the proto-cities option. There is also the possibility that, as argued by Kruts (1989) and Anthony (2007), the giant-settlements were built for defence purposes (e.g. protection from external attacks by Steppe populations).

An effective way of shedding light on this important dispute is to gain a better understanding of the various inter- and intra-chronological processes in the formation and development of the gigantic settlements. It is only by identifying precisely the various phases and stages of development in the single settlements that the complex rotation and migratory processes linked to chronological 'genetic' ties between the different Tripolye local groups can be

* Corresponding author. Tel.: +41 612010255.
E-mail address: francesco.menotti@unibas.ch (F. Menotti).

0305-4403/$ – see front matter
doi:10.1016/j.jas.2012.04.025

fully appreciated. Of great help in this case are analytical studies of spatial distributional patterns within and between settlements. Because of the characteristics of the archaeological data available from the settlements of the Vladimirovskaya–Tomashovskaya line of development, one suitable approach is the gravity model. Not only does this model facilitate the identification of various stages in the settlements' 'genetic' development, but it allows for comparison with more traditional relative chronological studies based on pottery typologies.

1.1. The gravity model

The gravity model, originally proposed by Reilly (1931), is widely applied in spatial archaeology and analytical geography for the study of the spatial distributional patterns of settlements (Clarke, 1977; Hodder, 1977; Haggett, 1979: 435–8; Sen and Smith, 1995). The intensity of the contact between the inhabitants of two locations is directly proportional to the size of their populations, and also inversely proportional to the distance between the locations:

$$I_{ij} = c\frac{M_i M_j}{D_{ij}^b}$$

where I is the intensity of the connection between the populations of two locations, M the population size, D^b the distance between the sites raised to power of b, and c the normalizing coefficient.

The gravity model has often been applied to verify the 'strength of ties' (economic or cultural) between the inhabitants of separate settlements, thus determining the spatial structure of groups of settlements and the centres of spatial groups of settlements (Fotheringham and O'Kelly, 1989; Haynes and Fotheringham, 1984). Lucy Wilson's work, for instance, provides a foundation for the possibility of applying the model to determine the subjective factors that influence the choice to settle in a specific region in connection with the availability of raw material resources (Wilson, 2007: 397–409). Kolesnikov (2003: 39–42), drawing on the works of Dodd (1950) and Chisholm (1975), argues that the importance and reliability of the gravity model lies in the fact that it bears the character of statistical probabilities, which are particularly useful in chronological modelling. He developed a formula describing the probability of Greek ships visiting different parts of the Mediterranean coast, whereby acquired values were transformed into probable dates for the establishment of colonies. The scheme of relative chronology (composed on this basis) was then revised, taking into account existing archaeological and historical dates. That allowed Kolesnikov (2003: 101–9) to build a probability model for major migration streams in the region.

2. Methods

2.1. The gravity model as a tool for understanding the Tripolye giant-settlement's chronological development

The versatile nature of the gravity model is particularly useful for studying the chronological development of settlements, especially if the mechanisms of a population's migratory behaviour are involved. Considering their reliable relative chronology, based on contextual seriations in pottery and the various migratory processes involved in their development, the Tripolye giant-settlements provide an excellent subject for research. In fact, because of the extensive agriculture and deforestation, people had to shift their settlements constantly (Kruts, 1989; Kohl, 2007: 45–46), leaving no chance for a second occupation (all giant-settlements are single-occupation settlements). Three basic preliminary assumptions concerning the various factors that stimulate interaction between communities have been made: a) the indexes derived from the application of the gravity model were the most likely to characterize the directions and dynamics of marital migrations; b) marital migrations were limited; and c) the anomalously high indicator-values obtained for localities of the same order confirm the diachronic nature of their development.

2.2. Data input and methodology

The study proposed in this paper is based on the settlements of the Vladimirovskaya–Tomashovskaya line of development in the Western Tripolye culture (WTC) in the Southern Bug–Dnieper interfluve. All the settlements taken into account are single-layered occupations. The settlements are attributed to three chronologically subsequent and 'genetically' tied local groups: the Vladimirovskaya, Nebelevskaya, and Tomashovskaya groups. The term 'genetic' ties stems from the studies of Dergachev (1980) and Ryzhov (1999), and it is used to describe the probable continuity of distinct social groups. Ryzhov (2011) identifies three stages in the development of the sites of the Vladimirovskaya local group and places the settlement of Gordashevka 1 into the transitional stage from Vladimirovskaya to Nebelevskaya group. He also distinguishes two phases in the development of the sites of the Nebelevskaya group, and four in those of the Tomashovskaya group (Ryzhov, 1999). Analysis of the possible variations in the indicator linked to the statistical regularity in the morphological-stylistic peculiarities of the settlements' ceramic complexes (also central to Ryzhov's scheme) subsequently allowed Diachenko to discuss three possible variants for the settlements' chronological distribution. These variants are: 1) the formation of the settlements that belong to a single phase of the 'genetic' line development (traditional variant); 2) the synchronization between the later sites of the Vladimirovskaya group with the earliest sites of the Nebelevskaya group, and the synchronisation of the later sites of the Nebelevskaya group with those belonging to Phases 1 and 2 of the Tomashovskaya group; and 3) the synchronisation between the settlements of the second and those of the third phase of the Tomashovskaya local group (Diachenko, 2008: 10–1).

In Tripolye studies, the number of inhabitants in a settlement is usually determined by the product of the settlement's relative density coefficient in relation to its area (e.g. the average number of houses within the settlement) and the average number of inhabitants per house. Using an estimate of the average number of people per house is the only option in demographic studies of the WTC settlements, because no burials have been found within the giant-settlements. The advantage of analyzing population size fluctuations in direct correlation with the number of habitations in each settlement is that the system of the development of small residential agglomerates is similar to that of the larger ones that are concurrent with them (Videiko, 2002: 76–7). However, about 78.4% of the buildings were functioning contemporaneously within large and middle settlements (Diachenko, 2008), and this corresponds well with the idea, that only a part of the buildings within large settlements are synchronous (Milisauskas, 2011: 251) (note that the 0.784 value was uses in the calculations).

The calculations have produced the following divisions: 6 settlements belonging to the Vladimirovskaya group, 24 to the Nebelevskaya group, and 22 to the Tomashovskaya group. The settlements have subsequently been grouped into four size categories with further sub-divisions: 'small' (S): up to 30 ha; 'medium' (M): 35–80 ha; and 'large' (L): 100–350 ha. The 'small' group is divided into three subgroups: S-1 (up to 10 ha); S-2 (10–20 ha); and S-3 (20–30 ha). The 'medium' group has also three subgroups: M-1 (35–40 ha); M-2 (50–60 ha); and M-3