The Investigation of the Early Medieval System of Signalisation in the Kislovodsk Basin (South of Russia) with Help of GIS

Dmitry KOROBOV

Institute of Archaeology RAS, Moscow, Russia
dkorobov@mail.ru

Abstract

The paper presents first results of an investigation of the Early Medieval signalisation system in the Kislovodsk basin, made by means of several visibility analyses using *ArcGIS* software (supported by RFBR grant No 06-06-80117). The model of the viewshed areas with 10km limit around the strongholds indeed demonstrates the system of control over the whole territory in the Kislovodsk basin. This limit was calculated during the experiment of transferring the smoke signal. According to the results of the analysis it is possible to observe a part of the area from each 'signal post', and to communicate with other similar sites. At this point, the use of the GIS tools allows already to discuss the function of different types of strongholds, and moreover to open methods of modelling the communication system, which undoubtedly had been of utmost importance to the Alanic population inhabited the Kislovodsk area during the Early Medieval period.

Keywords

GIS, viewshed analysis, experimental archaeology, Early Middle Ages

1. Preface

This paper presents the first results of a viewshed analysis of the Early Medieval sites of the Kislovodsk basin, as an important tool of landscape archaeology. This method started in the late 1970s as a technique (Gillings and Wheatley 2001, 27) and became very popular in recent decades because of the availability of computer applications, especially of GIS modules and tools. Thus from the 1970s viewshed modelling has formed a particular approach with a specific methodology and supporting case studies (van Leusen 1999, 218– 220; Gillings and Wheatley 2001, 25–34; Wheatley and Gillings 2002, 201–216). The main idea underlying these analyses is that good visibility was an important factor for people in the past (Wheatley and Gillings 2002, 201). The analysis of the lines of sight between places of habitation as well as viewshed zones around them should be important in the investigation of territorial control, in the reconstruction of ancient beliefs, and in the modelling of settlement and economic systems of ancient populations.

The application of GIS presents the possibility of making this analysis intensive, but also calls into question the accuracy of such modelling that is discussed in (van Leusen 1999, 218–219; Gillings and Wheatley 2001, 31–33; Wheatley and Gillings 2002, 209–210). These questions and possible ways of their solution are described below.

2. Methods and tools

Viewshed modelling is usually done by means of standard tools included in the *3D Analysis* modules of GIS. My case study was made using such a module in the *ArcGIS* 8.3 software. Viewshed analysis was performed on the basis of vector maps of the investigated region – the Kislovodsk basin situated in the south of Russia – at a scale of 1 : 100 000. A 3D terrain model was calculated from height information by means of a TIN and then several maps with *field-of-view* and *line-of-sight* were made. Viewshed zones were constructed as grid with cells of 100m x 100m that make it possible to calculate visible areas in hectares. Additional information on observation points and methods of observation was also used in the attribute table of the analysed sites in GIS. The fields SPOT, with the information of the absolute height of the site, RADIUS2, with a limit of observation of 10km and OFFSETA with the observer height were included in the table. The geographic position of the observation points was calculated in the field by means of a GPS receiver. Generally the rest of the stone fortification visible on the surface and looking like towers were fixed as points during observation of the basin. The absolute height of these points was calculated from 1 : 25 000 topographic maps to get more precise information compared to the GPS data. The height of the observer's position is hypothetical and calculated as 5m (1.5m of human height plus 3.5m from the

possible height of watch towers). The visibility from many points of observation was calculated by means of a cumulative viewshed map (see for example: Wheatley and Gillings 2002, 206–209).

It is rather important to stress the limitations of the computer viewshed analysis that was described in (van Leusen 1999, 218–219; Gillings and Wheatley 2001, 31–33; Wheatley and Gillings 2002, 209–210). The main weak points of computer modelling in this case are: the accuracy of the 3D terrain model that may be far from reality; the static model of observation that differs according to movements and different angles; and the assumption of ideal conditions of observation that are also unrealistic (transparent air, lack of vegetation and so on). There is also the question of the true importance of good visibility to the ancient population that should be also proved.

Computer modelling of visibility from the Early Medieval strongholds of the Kislovodsk basin is far from ideal. First of all the accuracy of the 3D terrain model constructed using TIN on the base of maps of 1 : 100 000 is insufficient. In this case the contour lines of relief were drawn with an interval of 20m that makes the 3D model rather rough. The analysed sites are considered as occupied simultaneously which could only be proved through detailed field study on every site. The information about the vegetation being in the basin during the Early Middle Ages is also not enough. But it seems that even in the model is far from reality the results obtained by means of GIS analysis of visibility could help to find the patterns in spatial distribution of the sites and to allocate different types of the places of habitation characteristic for the region.

3. Analysis of viewshed areas

The first step of modelling was the construction of the viewshed areas around the observation points. These are the strongholds of the Early Medieval period found in the Kislovodsk basin. During the archaeological observation of the region started in the middle of XIXth Cent. more than 120 fortified settlements were found in the comparatively limited territory of 20 x 30km. The ceramic sherds found on the surface and in the excavation trenches as well as the types of grave goods known from the catacomb cemeteries situated nearby give a possibility to date these sites to the Vth–VIIIth Cents. AD. It is very likely that the fortified settlements were the main places of habitation of the Alanic population that occupied the basin during Early Middle Ages as it is known from the written sources (Afanas'ev *et al.* 2004, 62).

There are 127 strongholds known in the present day and, evenly distributed in the Kislovodsk basin. In order to get better results the sites were classified into three types using topographic criteria: 6 forthills on the top of remnants, 101 strongholds on promontories, and 20 small fortified hills (see for details: Reinhold and Korobov 2007, 197–199). Primarily the difference in viewshed areas around these types was observed. The viewshed area of the 127 fortified settlements is equal to 68 200 ha that is around 62.3% of the analysed map window and covers approximate the whole territory of the basin (*Fig. 1*). The area of good visibility around the sites on the remnants is 31 700 ha that is around one half of the whole territory. It means that good visibility could be not the main factor in the distribution of these sites, looking like the 'central places' (*Fig. 2*). The strongholds situated on the promontories have cumulative viewshed area of around 63 000 ha, but that is more the question of their large quantity and equal distribution (*Fig. 3*) than the visibility from every site which is rather poor. The most interesting fact is that 20 small fortified sites on the hills have an approximately equal cumulative visible area of 60,000 ha (*Fig. 4*). It does not seem to be accidental and could reflect the spatial distribution of these sites on the hills with a good visibility around. The first investigator of these sites A.P. Rounitch described their specific features such as small size, absence of the cultural layers, lack of water supplies and traces of habitation (Rounitch 1974, 108). According to these factors and primarily because of good visibility, the scholar identified the fortified sites on the hills with 'signal posts'.

During the field observation made by the author in 1996–2004 eight sites of this type were found on the top of the Borgoustan Range on the northern border of the basin. They took the form of small hills situated on the edges and separated from the plateaus by small ditches. Their features are rather similar to those described above and give the possibility to assume their function also as 'signal posts'. They have rather equal distribution with a distance of 2–3km in between that could be an argument for their simultaneous occupation. The surface material found there as well as the specific ceramics from the excavation trench made on the larger forthill nearby confirm the Early Medieval attribution of these

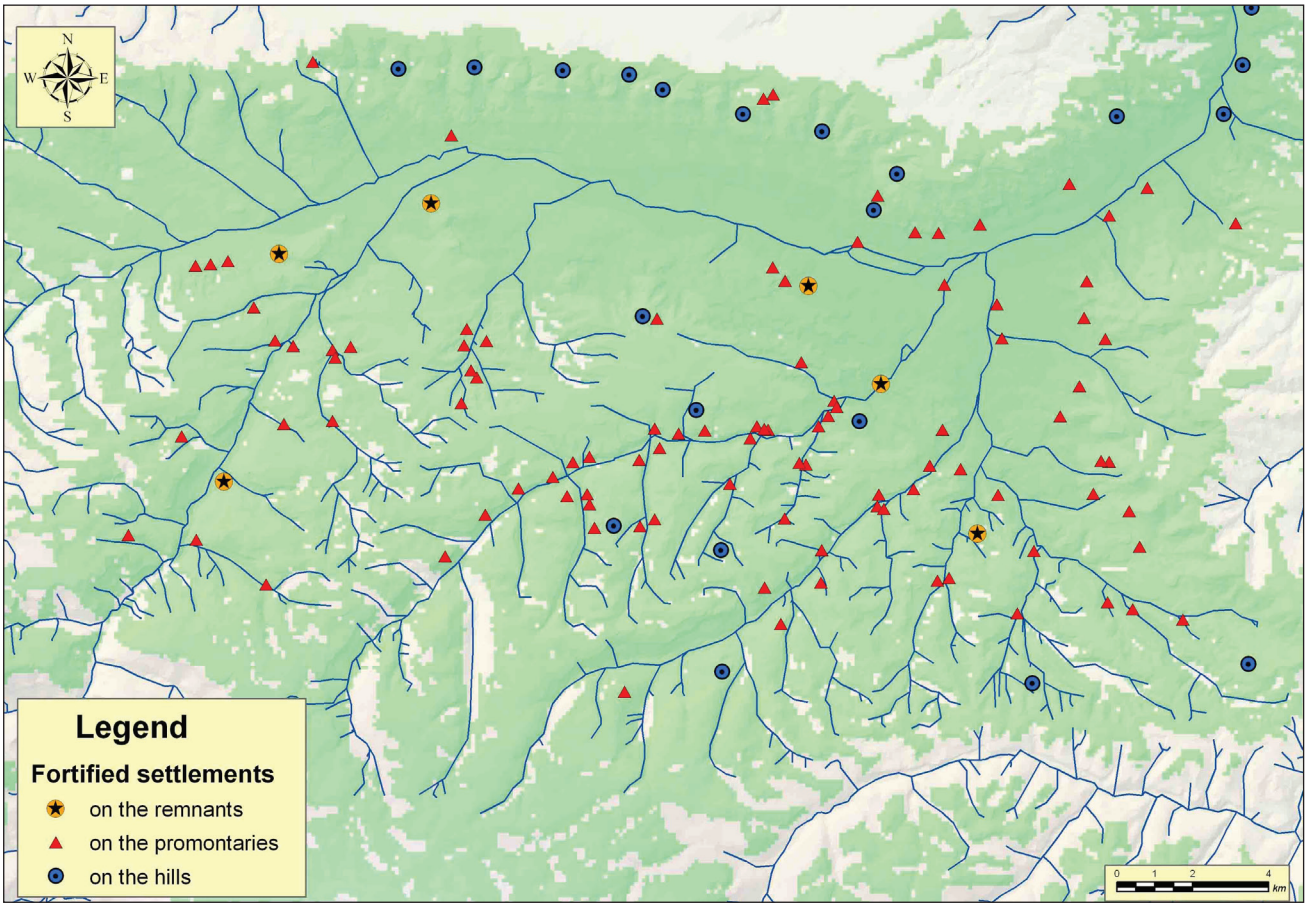

Fig. 1. Viewshed area around all Early Medieval strongholds of the Kislovodsk basin.

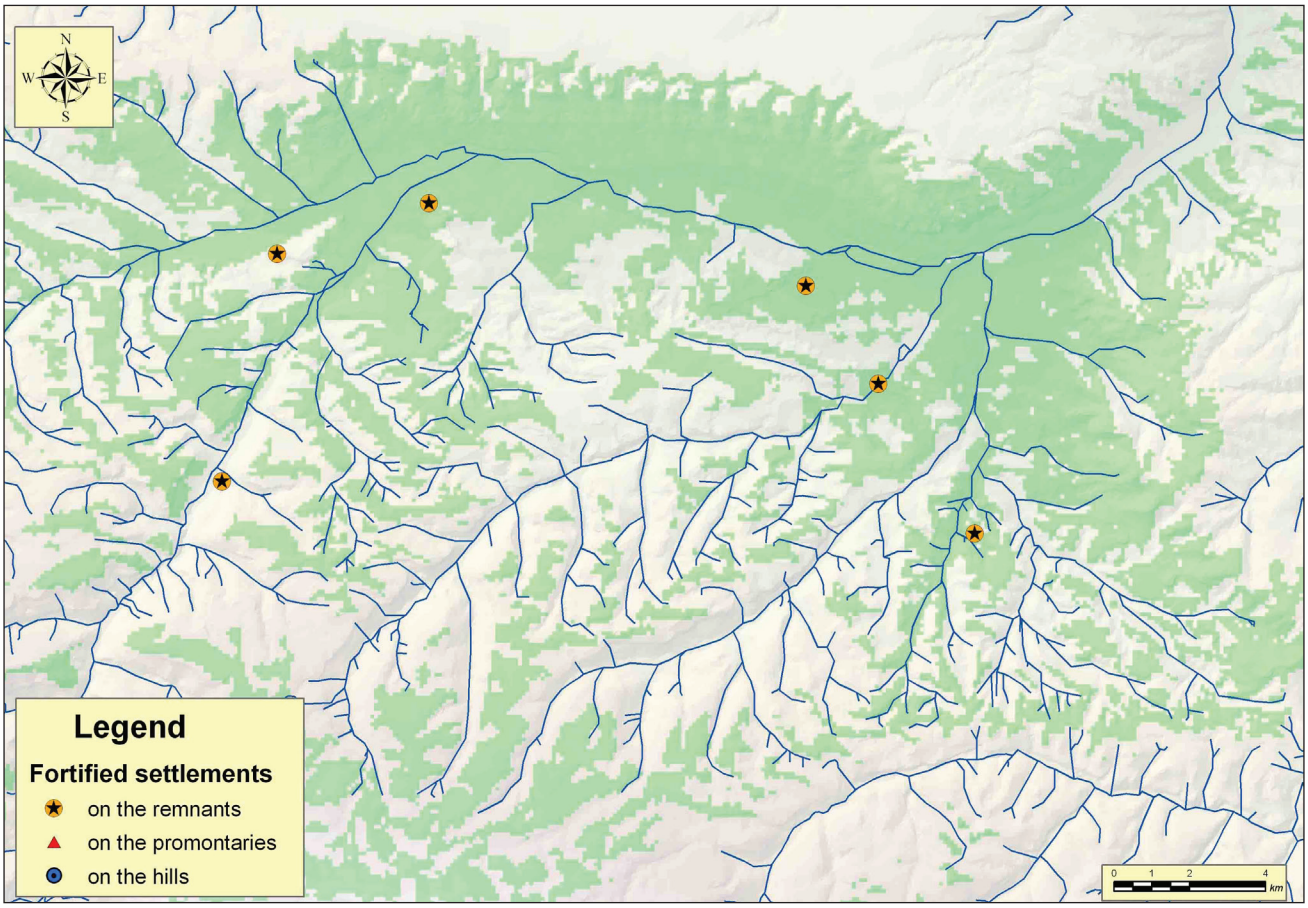

Fig. 2. Viewshed area around the first type of strongholds (forts on the top of remnants).

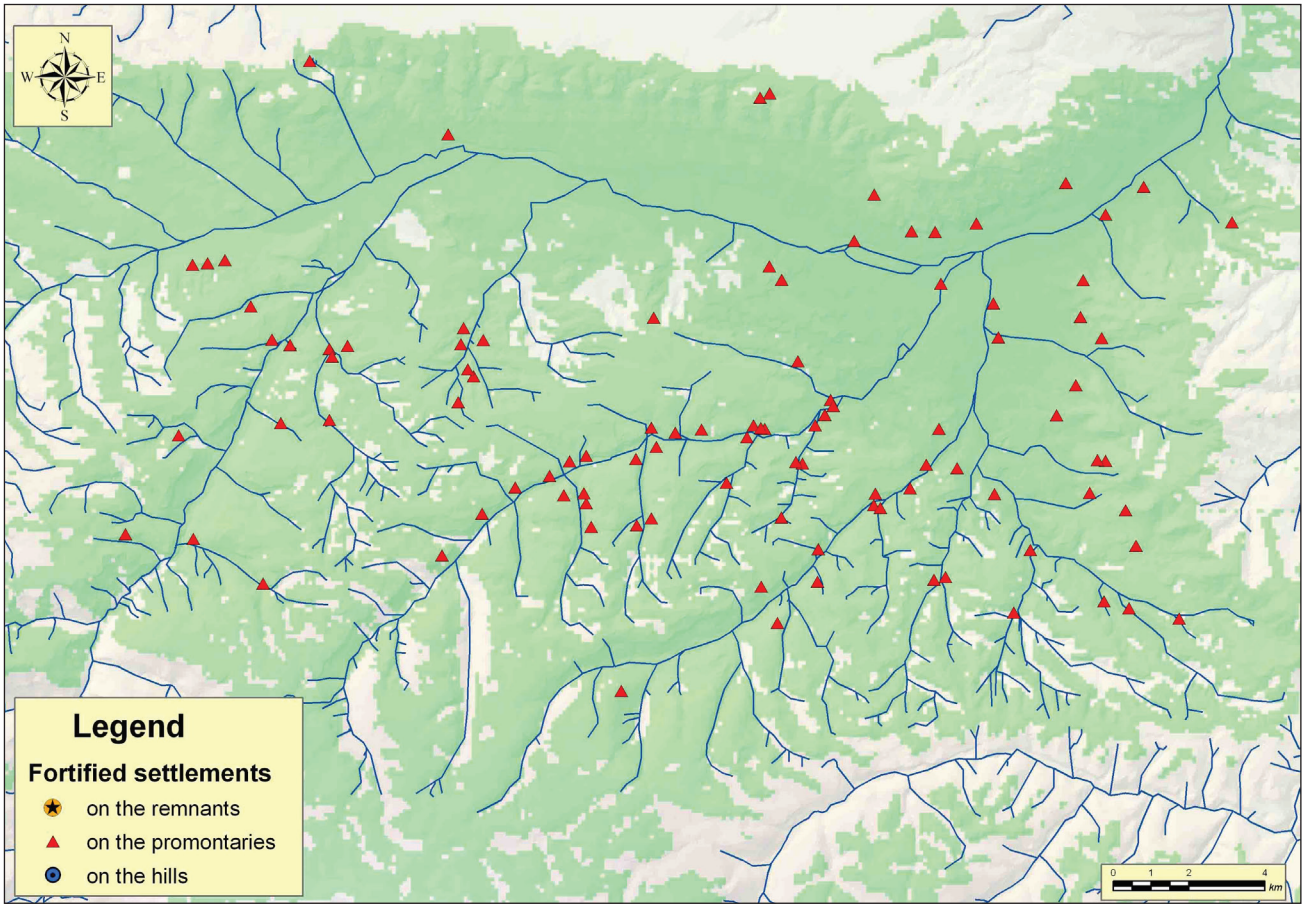

Fig. 3. Viewshed area around the second type of strongholds (strongholds on promontories).

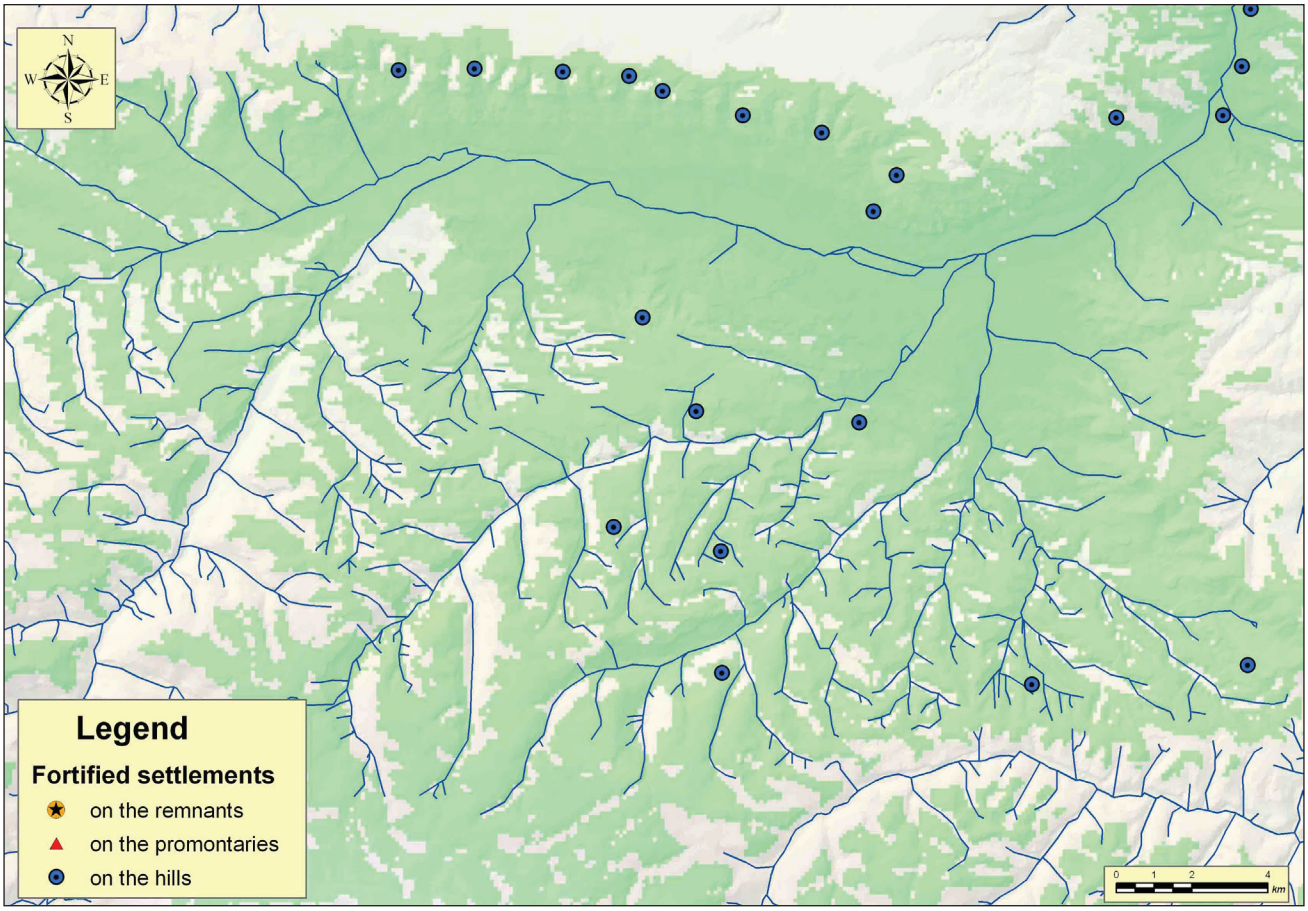

Fig. 4. Viewshed area around the third type of strongholds (small fortified hills).

sites. If our determination of 'signal posts' for the fortified sites situated on hills is right, we could note the distribution of such sites on the perimeter of the basin (*Fig. 4*) that could reflect the formation of the special system of signalisation.

4. Analysis of lines of sight and experiment of transferring the smoke signal

It is difficult to answer the question of which settlements were the main target of visual communication. Computer modelling of the line of sights showed that from the forthills on the remnants that seems to be the 'central places' of the region between five and eight 'signal posts' could be observed simultaneously (*Fig. 5*). Thus it is possible that the system of 'signal posts' situated in the Kislovodsk basin primarily was meant to warn the population of the sites in the center of the region.

The 'line-of-sight' procedure of the vewished analysis was also used for modelling the signal transfer, wich could be made by different ways. The main river course of the basin, that was the main transportation axis here for centuries, runs from west to east. That is why two models were made for two types of emergency. If the emergence comes from the west the population needs from four to five intermediate stations to allow the alarm to reach the whole area. If the situation is a danger in the east they need from eight to nine intermediate signal posts because of the terrain features. These results of modelling were tested experimentally.

In October 2004 four teams of the archaeological expedition of the Institute of Archaeology RAS transmitted smoke signals from four strongholds. The television group "Infofilm" took part at this experiment and made a record of the process on a digital video camera. The distance between intermediate points was calculated in GIS; also the time of transmission was measured. As a result we obtained the following chain of signals (*Fig. 6*):

1. From the 'signal post' of Borgoustanskoe 4 to the 'signal post' of Borgoustanskoe 9: the distance is 4.2km, time of transferring is 2 min (that means that the next smoke signal appears in two minutes after the first one);
2. From the 'signal post' of Borgoustanskoe 9 to the 'central place' of Gornoe Aekho: the distance is 5.5km, time of transferring is 4 min (*Fig. 7*);

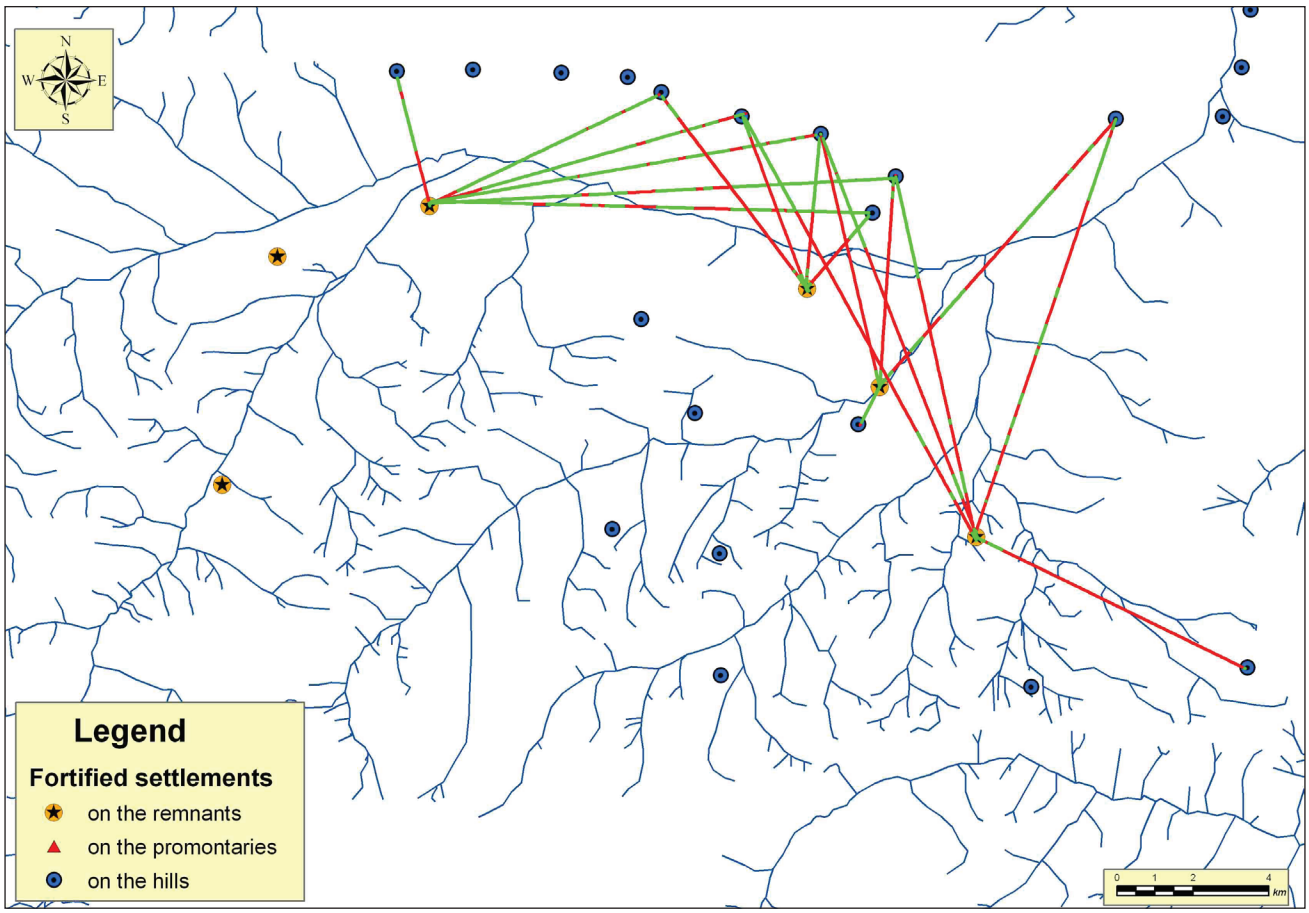

Fig. 5. Lines of sight from the forthills on the remnants to the fortified hills.

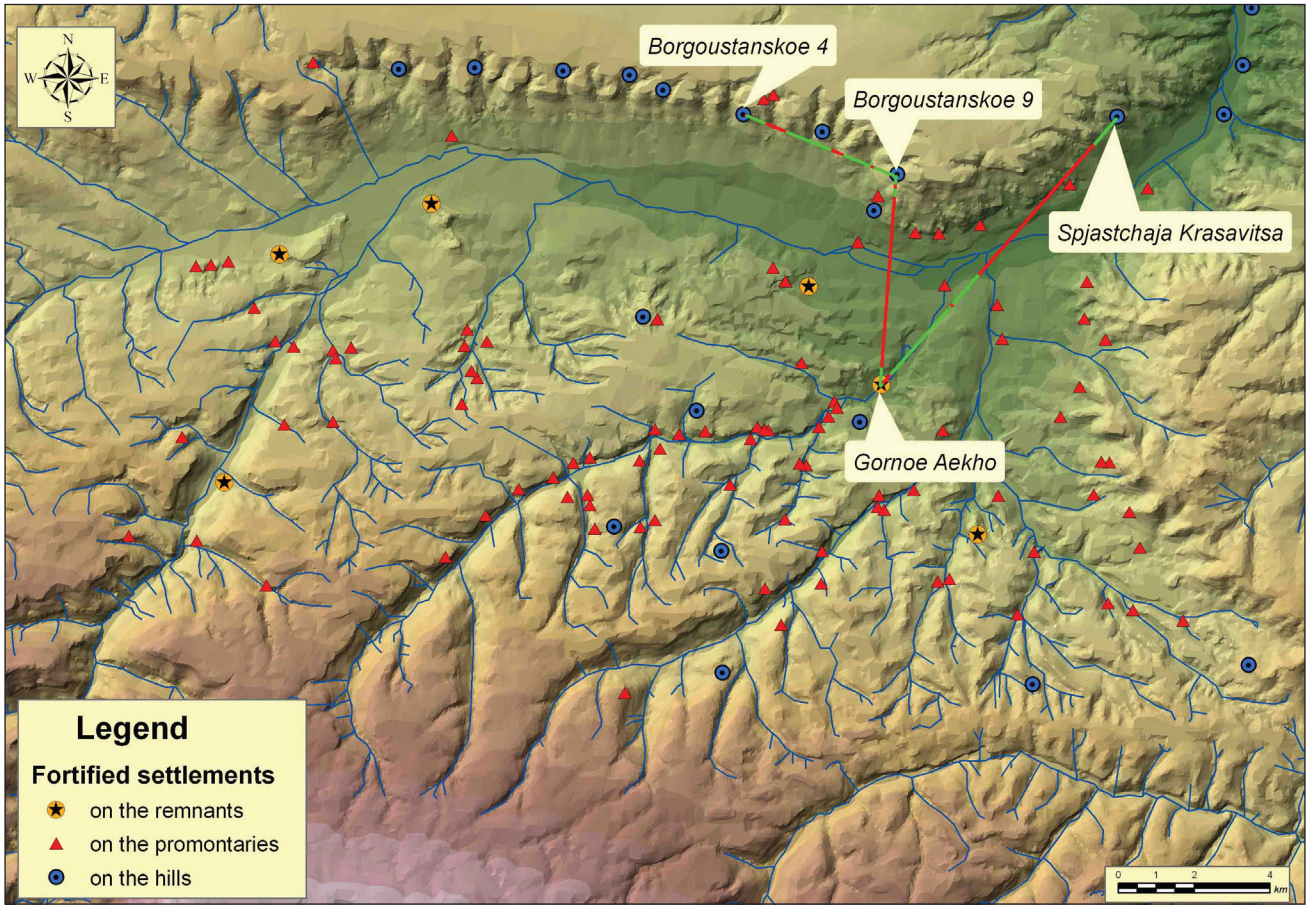

Fig. 6. Chain of observation points during the experiment on transferring the smoke signal (October, 2004).

Fig. 7. View from the 'central place' of Gornoe Aekho to the 'signal post' of Borgoustanskoe 9 with a smoke signal on the top (experiment made in October, 2004).

3. From the 'central place' of Gornoe Aekho to the 'signal post' of Spjastchaja Krasavitsa: the distance is 9.3km, time of transferring is 4 min.

Thus the total distance of signal transmission was equal to 19km. The straight distance between first and last observation points was 9.7km. The total time to transmit the smoke signal this distance was less than 15 min. During this time around one half of potential inhabitants of the Early Medieval strongholds could be warned.

It seems that the results of our experiment could be considered successful. The main conclusion obtained by means of veiwshed analysis using GIS was the confirmation that there is high visibility from the 'signal posts' situated in those places very convenient for the information transmission. The experimentally determined optimal distance between observation points is equal to 5km. With larger distances the smoke signal is not seen so clearly even in a very good weather conditions (transparent air, high cloud cover, sunshine). This observation connects with the common point of view that the limit of sight of a man of average height (1.6m) does not exceed 4.77km. This limit increases with increasing the height of the observation point (Men'chukov 1977, 46). For example, the famous scientist and traveler of 18th Cent. J. Güldenstädt described his visit to the tower in Mukhran (Georgia) from where he could clearly see eight villages and a fortress of Tsekhizire situated in seven miles to the south (Güldenstädt 2002, 94). If a luminous signal is transmitted during the night time this limit of sight also increases.

Taking into account the facts mentioned above the model of viewshed areas was recalculated using a 10km limit of sight. This limit was chosen as at this distance it is practically impossible to distinguish the smoke signal in the day time but it is possible to perceive the light signal in the night. The results of modelling give an impression of the zones of control around 'signal posts' (*Fig. 8*). If we claim the simultaneous occupation of all the fortified settlements it seems that the Alans had a rather elaborate system of signalisation and visual control over the whole territory of the Kislovodsk basin. According to this system it is possible to observe a part of the area from each 'signal post' and to communicate with other similar sites. It is possible that the strongholds of other types were also included into this system.

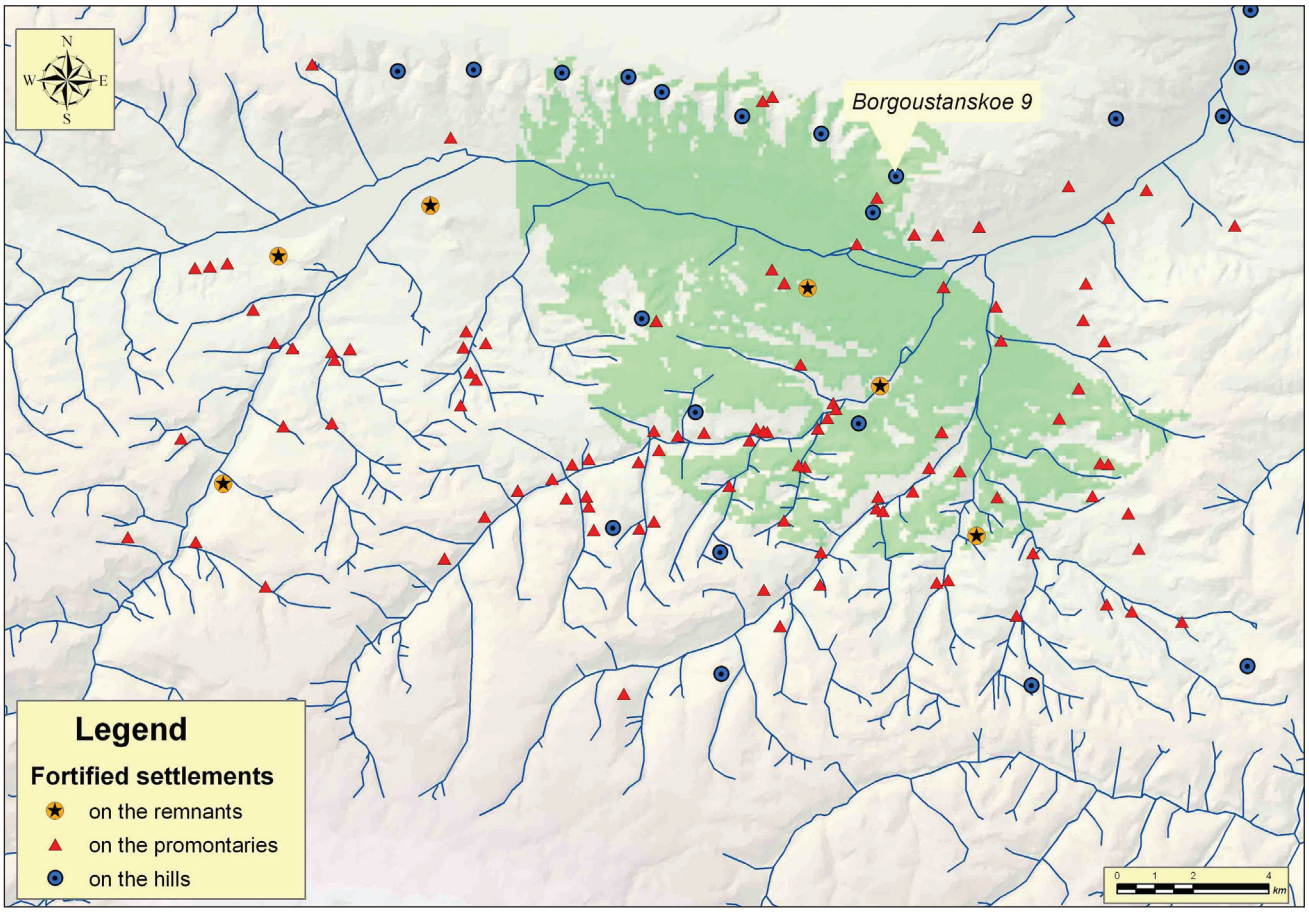

Fig. 8. Viewshed area with a limit of 10km around the 'signal post' of Borgoustanskoe 9.

5. Historical information about the signalisation in the Caucasus in ancient and modern time

We do not have direct evidence of the existence of smoke or light signalisation in the Kislovodsk basin during Early Middle Ages. But it is rather possible that such system could exist in the Vth–VIIIth Cent. It is mentioned in the historical written sources of the VIIth Cent. For example, Theophylactus Simokattis wrote about light signals that were transferred by the Persians in the Caucasus (Kovalevskaja 1984, 144–145). We also have to take into account the evidence of Caucasian ethnography from which is known the light and smoke signals transferred from special watch towers by the mountain population in the XVIth–XVIIIth Cents. (Dzattiaty 2002, 28; Tchotchiev 1985, 30–31). References to such systems of signalisation of the Caucasian population and Russian military troops could be found in memoirs from the XVIIIth and first half of XIXth Cents. (Güldenstädt 2002, 94; Frolov 1995, 108–109; Ermolov 1991, 373). Looking at these analogies it seems rather possible that the Early Medieval population used the same well known signalisation when the signal of emergency was transferred as smoke in the day time and as light in the night. It is very likely that the sound signals known from the Caucasian ethnography were also used.

6. Conclusions

The viewshed analysis of the Early Medieval fortified settlements made using GIS methods demonstrates that:

1. There are observation points with high visibility and specific features (small size, absence of the cultural layers, lack of water supplies and traces of habitation) that could be identified as 'signal posts' situated usually on the small hills.
2. The highest viewshed zone is observed from the Borgoustan Range where eight such 'signal posts' were found during our archaeological investigation of the Kislovodsk basin. All of them are situated on the equal distance from each other and have similar principles of fortification. It argues their simultaneous systematic character.
3. From five to eight 'signal posts' could be observed from the forthills situated on the remnants in the center of the basin and possibly played role of 'central places'. It could be the evidence that these 'signal posts' were oriented primarily to alarm the population lived in these forthills.
4. Computer modelling showed different ways of alarming the population in case of emergency from east and west. If the signal is transferred from the west, four to five intermediate stations could alarm the whole area. In case of emergency come from the east, the system of signalisation needs from eight to nine 'signal posts'. It means that if this system exists the Early Medieval population could be alarmed in 15–30 minutes according to the results of our special experiment of transferring the smoke signal made in the basin in 2004.
5. The model of the viewshed areas with 10km limit around the strongholds indeed demonstrates the system of control over the whole territory in the Kislovodsk basin. According to this system it is possible to observe a part of the area from each 'signal post', and to communicate with other similar sites.

At this point, the use of the GIS tools allows already to discuss the function of different types of strongholds, and moreover to open methods of modelling the communication system, which undoubtedly had been of utmost importance to the Alanic population inhabited the Kislovodsk area during the Early Medieval period.

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