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Typology of hillforts according to their functions in the Polish Carpathians and their foreland, in the Early Medieval state of the first Piast dynasty – research using the latest geoinformatic tools

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Summary

Early Medieval hillforts were characterized by a significant stratification of their functionality during the period of the rule of the first Piast dynasty. Using geoinformatic tools, and historical and archaeological data, it is possible to determine their place in the settlement hierarchy within a given research area (Polish Carpathians). The Middle Ages abounded in various antagonisms between the surrounding countries. Therefore, such structures were created according to old military technology with a simple defensive function. On the one hand, hillforts were conceived in terms of protecting the population from a potential invaders. On the other hand, they were bases for stationing the army (warriors). Additionally, they protected the produced raw materials and local and supra-local trade. Open settlements were susceptible to greater destruction as they lacked palisades or earthen ramparts. Therefore, the local population had to escape to the so-called 'closed' settlements – especially refugial, i.e. those that have large enough area to concentrate the local population originating from the surrounding hinterland of the stronghold. Hillforts are located in naturally advantageous defensive sites (at least most of them). Ships could sail on rivers – for transport purposes, among others. Therefore, often the location of individual hillforts along rivers meant a great socio-economic development around them. The Piast state in the eastern Polish Carpathians [Rajman 2018] had the opportunity to maintain Cherven Cities for a short time [Wołoszyn 2013].

Keywords
photogrammetry • laser scanning • typology of hillforts • geoinformatic tools • shadowing map

1. Introduction

1.1. Research problem

Early Medieval hillforts were characterized by a significant stratification of their functionality during the period of the rule of the first Piast dynasty. Using geoinformatic tools, and historical and archaeological data, it is possible to determine their place in the settlement hierarchy within a given research area (Polish Carpathians). The Middle Ages abounded in various antagonisms between the surrounding countries. Therefore, such structures were created according to old military technology with a simple defensive function. On the one hand, hillforts were conceived in terms of protecting the population from a potential invaders. On the other hand, they were bases for stationing the army (warriors). Additionally, they protected the produced raw materials and local and supralocal trade. Open settlements were susceptible to greater destruction as they lacked palisades or earthen ramparts. Therefore, the local population had to escape to the so-called 'closed' settlements – especially refugial, i.e. those that have large enough area to concentrate the local population originating from the surrounding hinterland of the stronghold.

Hillforts are located in naturally advantageous defensive sites (at least most of them). They once played an important role in the Early Medieval society. Their location between the elements is interesting [Urbańczyk 2019]. Ships could sail on rivers – for transport purposes, among others. Therefore, often the location of individual hillforts along rivers meant a great socio-economic development around them. The Piast state in the eastern Polish Carpathians [Rajman 2018] had the opportunity to maintain Cherven Cities for a short time [Wołoszyn 2013]. However, historically the border was quite well defined. Therefore, the settlement between former Poland and Ruthenia has a mixed history [Konstantinovski Puntos and Luc 2022]. Hillforts are an interesting form of terrain that can attract more attention both for researchers and other interested persons [Śpiewla 2017].

1.2. Literature review

Usually the articles on Piast Poland are concerned with the early (tribal) period in the history and archeology of Medieval strongholds. The publications also cover other objects, such as mounds [Buko 2015]. Often, these articles are focused on one selected stronghold, which is why they are local studies [Sajecki 2020]. Sometimes, focusing on a selected stronghold (especially archaeologically) can date a given archaeological site – especially in terms of pottery [Kotowicz 2015]. Dating can also be used in addition to dendrochronology [Krąpiec and Poleski 1996]. By means of dating, it is possible to initially assign a town to a given chronological period. Interesting visualization, cartographic and remote sensing solutions include the latest research in Poland [Kiarszys et al. 2023]. They are useful for a comprehensive description of a specific town, as well

as the use of the latest geoinformatic technology in space. An interesting topic is to describe are the Great Castles of Western Lesser Poland [Szmoniewski and Włodarczak 2017]. These include the historic Stradów, but there are no new solutions of these types of objects in the Polish Carpathians.

1.3. Aim of the study

The main objective of the study is to present the classification of strongholds in terms of their past functions in the society of early medieval Poland and southwestern Ruthenia. This typology is a research gap, because so far the typology has been created based on the shape of strongholds (doctoral thesis of dr Michał Wojenka from 2010). A similar classification in terms of stronghold layout is found in the publication by Poleski [2010]. They lack the indication of their main purpose in the Early Medieval times.

The next objective is to present a case study – Naszacowice near today's Nowy Sącz – explaining at the same time the refugial function on a specific example. The method – how to make such a classification in a large set (44) of closed settlements, i.e. strongholds – is also shown. A detailed classification based on the recognition of the dominant rank of the stronghold was used. For example, if there are 2 ranks (castellan and refuge), then the castellan was chosen. This selection is based on the higher function in the typology. It is also considered that in most cases the strongholds are of a lesser rank. A developed stronghold also had, for example, a guard function. Automating this process would be beneficial for larger data sets. Then it would be good to use MCDA (multi-criteria decision analysis) to generate the classification. Therefore, for the purposes of this article, manual assignment was performed.

2. Materials and methods

2.1. Data

The main data used were the hillshade layer on the National Geoportal, EU-DEM (Copernicus DEM), AZP (the Polish Archaeological Record) sheets from the south-eastern region of Małopolska, the Hillforts Atlas (atlasgrodzisk.pl) and the Marszałek's Catalog [1993]. A vector database of early medieval hillforts was also created, based on atlases, stronghold catalogs and municipal information. The map [Parczewski 2005] was used to verify the ecumene in the Polish Carpathians.

2.2. Methods

Recent years in geoinformation have seen, first and foremost, significant advances in methods of acquiring as well as processing spatial data. Very great progress can be seen especially in methods based on image data, i.e. photogrammetry, remote sensing or laser scanning [Głowienka et al. 2015, Bęcek et al. 2015]. Laser scanning and the recording of reflections not limited to tree crowns have made it possibile to acquire data from land

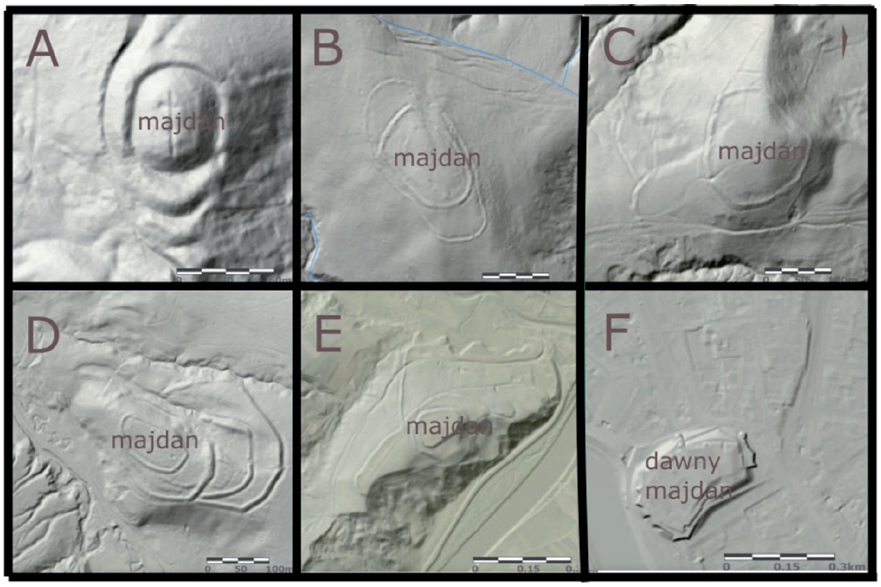
surfaces located e.g. under trees. Previous measurement techniques based mainly on imagery did not offer such possibilities. Digital terrain surface model (DTSM) was a 'tree-top' image. Laser scanning allows the penetration of terrain under trees. This provided very good ways of analyzing what might have been on that terrain centuries ago. A layer of trees has covered the former fortified settlements and it is only by the shapes that it can be seen that some form of buildings were once present there centuries ago. The temporal element therefore began to be introduced as a parameter in GIS, hence the name GIS4D. The use of multi-temporal data has become particularly important. These allow for the analysis of changes over the years – such as for the Tatra National Park [Mikrut at al. 2009]. Data from old maps, images or from laser scanning were the basis for research in the search for old settlements or early medieval strongholds.

At the very beginning, a database of early medieval strongholds was developed. The task was to determine the exact location of each archaeological object in space (on the map). Having these locations, in accordance with the Marszałek's Catalog [1993] and the Hillforts Atlas (atlasgrodzisk.pl), Kunysz's publication [1968] and selected other sources (for example local, municipal), a collective point layer was created of the research area. Then, the generated point locations were correlated with the location of individual defensive ramparts (on the hillshade layer). Based on the shaded model, the number of lines of ramparts there are in each stronghold was determined visually and manually(medium-sized strongholds can be classified as those with 3 lines of defensive ramparts; less often, if they have 2 – then other factors of functioning should be considered). Additionally, attention was paid to their area in the plan, i.e. how large these defensive structures were (Fig. 1).

2.3. How the functions were defined and divided

The hillforts built by the Slavs (Fig. 3) had different functions. They were not identical or similar to each other in terms of their shape in the plan. Five types of hillforts were proposed and specified according to their hierarchy. The lowest in importance are watchtowers, then are hillforts (medium), then refugiums (large strongholds useful for escaping from the enemy), castellan [Kozaczewski 2007] hillforts (seat of the Castellan, i.e. the administrator of a territorial unit, castellany), and finally central castles, from where the monarch of a given territory ruled. The main object for this type of analysis was the area of the occupied castle and its complexity (the number of individual lines of defensive ramparts). They were determined on a comparative basis. For example, Aksmanice hillfort was set on a smaller ecumene and has a total area of approximately 2.8 ha [Marszałek 1993]. The nearby Nowosiółki Dydyńskie hillfort is located on a larger ecumene and has a total area of over 2.3 ha (according to the measurements in the national geoportal, the total area including all the hillfort platforms is approx. 4 ha). Therefore, the first mentioned hillfort received the value of 1 in the classification, and the second – 2. The watchtowers were usually composed of only one line of defensive ramparts (i.e. only the courtyard and the rampart closing the defensive layout around it). Some of them had 2 rampart's lines – especially in areas with a lower settlement density. Such a hillfort could

not be used for significant utility purposes by a given community (it could not become a center of trade, for example). Using vectorization of individual points, open settlements were marked on the base map in ArcGIS Pro. These locations were determined using georeferencing of AZP (the Polish Archaeological Record) maps. Then, a given point was assigned in space. Among the many locations, only some were important places from the Early Middle Ages. The rest covered other eras, e.g. the Bronze Age. This task was easier than for closed settlements. An open settlement can be immediately marked on the map as a point. The hillfort is more extensive, which means that it is necessary to determine which point is best located. Therefore, the center of the majdan (the most important place) was most often chosen for this reason (Fig. 1).



Source: Authors' own study

Fig. 1. Individual examples of Early Medieval strongholds based on a shaded map. In order: A – Nowy Żmigród (watchtower, possible cult function), B – Aksmanice (watchtower), C – Nowosiółki Dydyńskie (hillfort, medium function), D – Tuligłowy (refugium), E – Naszacowice (castellan stronghold, possible additional refugium), F – Kraków (central stronghold). 'Majdan' is the most important place in the vicinity of each hillfort. Generated using the National Polish Geoportal – WMS (Web Map Service) shading layer

An analysis of the autocorrelation of points was also performed to check the mutual location of the strongholds (Fig. 2). As a result of statistical verification, the autocorrelation was determined to be 'random'. This indicates negligible spatial relations in the context of the location and functioning of the strongholds. Moran's scatterplot (Fig. 3) is proving this dependence from the ArcGIS Pro Report – it is not autocorrelation between points.

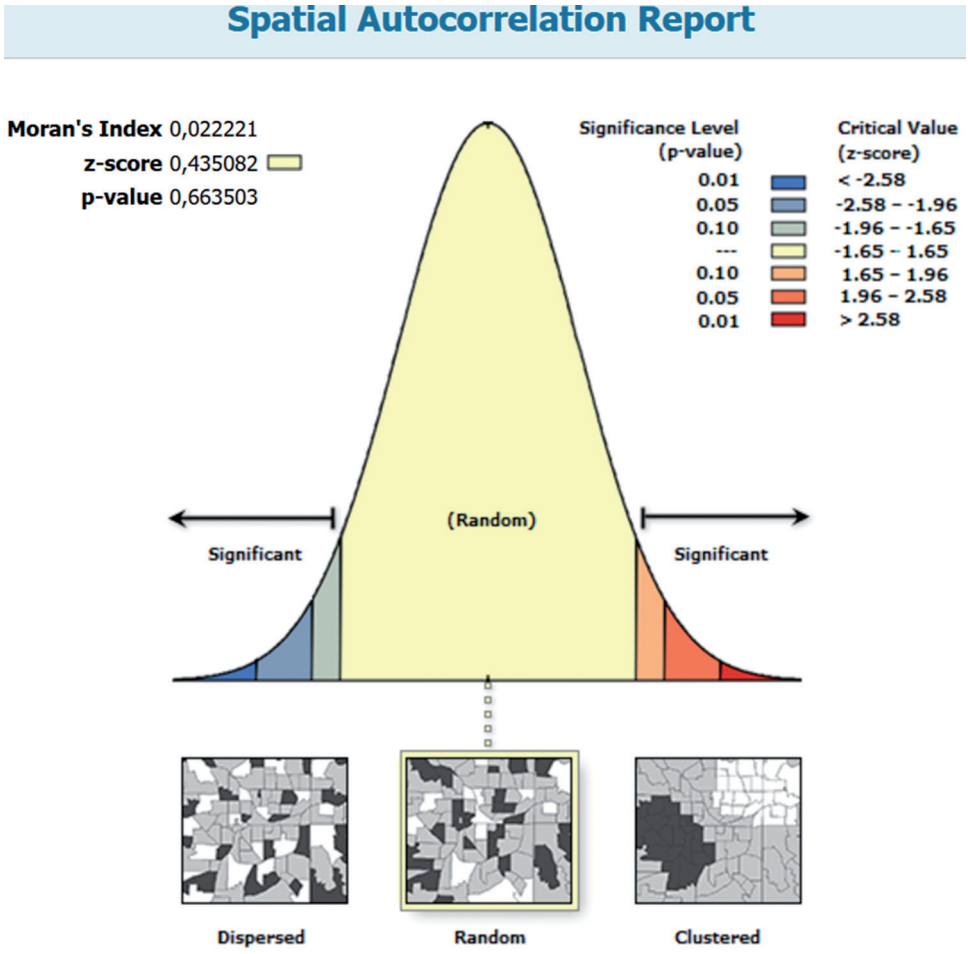
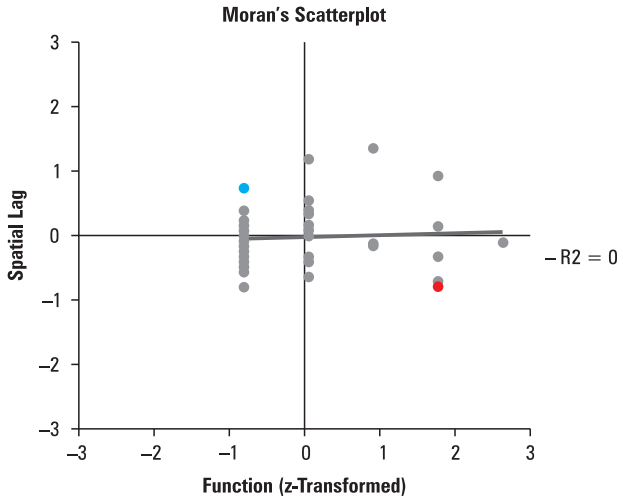


Fig. 2. Spatial autocorrelation report of the hillforts under study

The source descriptions from the online Hillforts Atlas and the Marszałek's Catalog [1993] were also very helpful. This procedure mainly concerned the castles lower in the hierarchy. Information about castellan castles was collected from available historical sources. In the West, they concerned the capitals of castellanies (the equivalents of later counties). In the East, the situation was different, as it was a disputed area (the territory of the so-called 'Cherven Gords'). Often, instead of a castellan, there was a prince. However, in a given duchy, these areas had castellan significance. In the later centuries

of the early Middle Ages, the central castle (Kraków) was the place from which the prince (or king) of Piast Poland ruled. It was also important to compare the location of the castles in the context of the range of settlement – thanks to which it was easier to decide whether the castle was a refugium or had a completely different function [Parczewski 2005].



Source: Analysis from the ArcGIS Pro application

Fig. 3. Moran's scatterplot of the hillforts in vicinity of Polish Carpathians

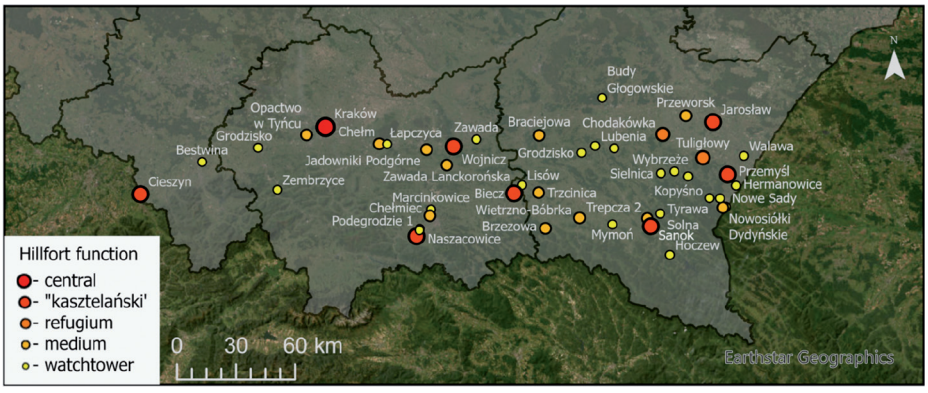
The purpose of the hillfort was to provide shelter for possible troops that were stationed in a given place. Refugium hillforts usually had more ramparts. They occurred primarily in areas with a very high population density (with a large number of open settlements). They were similarly large layouts. Between these two types, there were also hillforts that were difficult to classify as watchtowers (too large) and occupied a location further from human settlements. They were defined as intermediate (medium). They could usually have two lines of defensive ramparts. Higher in the hierarchy are historically confirmed castellan strongholds. They were local centers of trade, economy, religion and administration. The central stronghold is marked on the map as Kraków as the capital of the Vistulan state (https://www.krakow.pl/nasze_miasto/1115,artykul,historia.html) and the main stronghold, from where the prince ruled. Then it developed to become the capital of the Piast monarchy of Poland. An attempt at their typology due to their functioning was inspired by geoarchaeological research [Olczak and Siuchniński 1976]. If a given stronghold had several dominant functions, then the higher ones in the hierarchy were selected. For example, the stronghold in Naszacowice was a refugium and a castellan stronghold. The dominant feature is its castellan function, hence such classification within the table (Table 1).

A map classifying the strongholds in terms of area was also made. The Hillforts Atlas (www.atlasgrodzisk.pl), the Hillforts and Castles Catalogue [Marszałek 1993] were used, and measurements were partially made with an appropriate tool on the National Geoportal. 7 classes were characterized, counting in increments of 2 hectares. In some cases (e.g. Braciejowa) there is a lack of data. The strongholds are not always clearly visible in the field or on the plan. Hence the uncertainties. In the Carpathians, for example, one of the largest strongholds is Chodakówka. One of the smaller is Kopyśno. There is not always a relationship between the size of the stronghold and its rank. Therefore, this map verifies this relationship in a way.

3. Results

3.1. Classification

Based on the conducted research, it was found that (in terms of the functioning of the strongholds) there is: 1 central stronghold (Kraków), 7 castellan strongholds (outside of Kraków), 2 refugial strongholds, 12 medium hillforts, and 22 watchower strongholds. Their different functions can be understood as their purpose. However, sometimes these functions were complementary or mixed within a given stronghold.



Source: Authors' own study, basemap: Esri, Maxar, Earthstar Gegraphic, and the GIS User Community (in the ArcGIS Pro application)

Fig. 4. Classified hillforts according to their functioning

In the Carpathians and in the foreland there are a total of 44 confirmed strongholds (after the research for this publication). For functional reasons, they can also be divided into several types: central strongholds, castellan strongholds (which also contain central strongholds), medium hillforts, religious strongholds, refugial strongholds, 'gate' strongholds and guard strongholds. For example, Kraków was a central stronghold and at the same time a castellan stronghold. Based on literature research and our own estimates: for example, Tuligłowy is a refugial stronghold, Wapiennica is

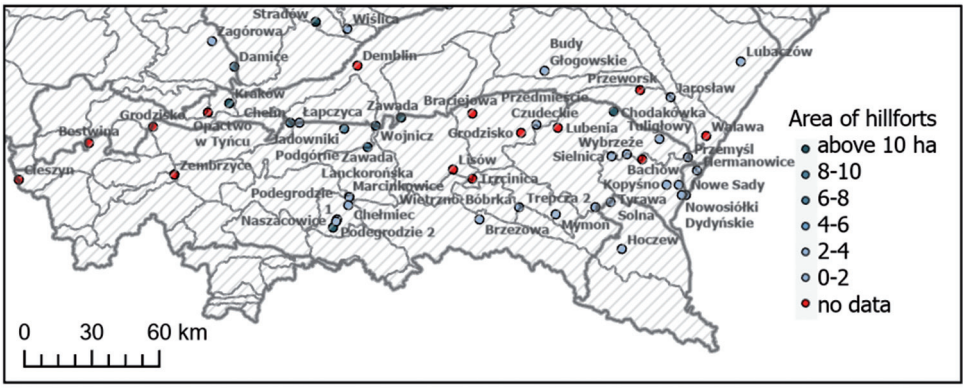
a religious stronghold [Buko 2008], Trepcza is an medium hillforts [Żurowski 1955], Naszacowice [Żaki 1971] is a refugial (and 'kasztelański') stronghold, Żmigród is a 'gate' [after Siemianowska 2015] stronghold and Aksmanice is a guard stronghold. The gate and religious strongholds were not specified on the map (Fig. 4), because they were additional functions. Due to the practically only function of the stronghold in Wapiennica [Buko 1999] – it was not included in the classification. The abbey in Tyniec was also added, due to its defensive importance and social function. For example, the stronghold in Żmigród had two functions: a watchtower and a gate. Additionally, its name refers to mythology (the silhouette of a 'viper', a creature from Slavic myths). Moreover, often places of religious significance (later due to the flourishing of the Christian religion in Poland) were in strongholds with a significant administrative (castellan) role. Depending on their age, they had different functions. It is possible that a guard stronghold could have become an medium hillfort. Sometimes, during the religious transition from pagan times to the Christianisation of the territories of then Poland, stone temples were built on the strongholds (mostly castellan) [Żaki 1974]. The 'gate' strongholds [after Dorocki and Struś 2007] were usually located on the border of countries, in the area of the greatest intensity of trade routes.

Table 1. Classification of the functioning of strongholds in the Early Middle Ages. Explanations: 1 – watchtower, 2 – medium hillfort, 3 – refugial stronghold, 4 – castellan stronghold, 5 – central stronghold. Watchtowers (lowest in the hierarchy) are marked in cream color. The most important strongholds – castellan strongholds – are marked in brown. Refugium strongholds are marked in blue

The name of the hillfort	Predominant functional type
Aksmanice	1
Bachów	1
Bestwina	1
Braciejowa	2
Brzezowa	2
Budy Głogowskie	1
Chełm	2
Chełmiec	2
Chodakówka	3
Cieszyn	4
Grodzisko	1
Grodzisko	1
Hermanowice	1
Hoczew	1

Table 1. cont.

The name of the hillfort	Predominant functional type
Jadowniki Podgórne	2
Jarosław	4
Kopyśno	1
Kraków	5
Lisów	1
Lubenia	1
Łapczyca	1
Marcinkowice	1
Mymoń	1
Naszacowice	4
Nowe Sady	1
Nowosiółki Dydyńskie	2
Opactwo w Tyńcu	2
Podegrodzie 1	1
Podegrodzie 2	1
Przedmieście Czudeckie	1
Przemyśl	4
Przeworsk	2
Sielnica	1
Trepcza 2	2
Trzcinica	2
Tuligłowy	3
Walawa	1
Wietrzno-Bóbrka	2
Wojnicz	4
Wybrzeże	1
Zawada Lanckorońska	2
Zawada	1
Zembrzyce	1
Żmigród	1



Source: Performed in ArcGIS Pro application

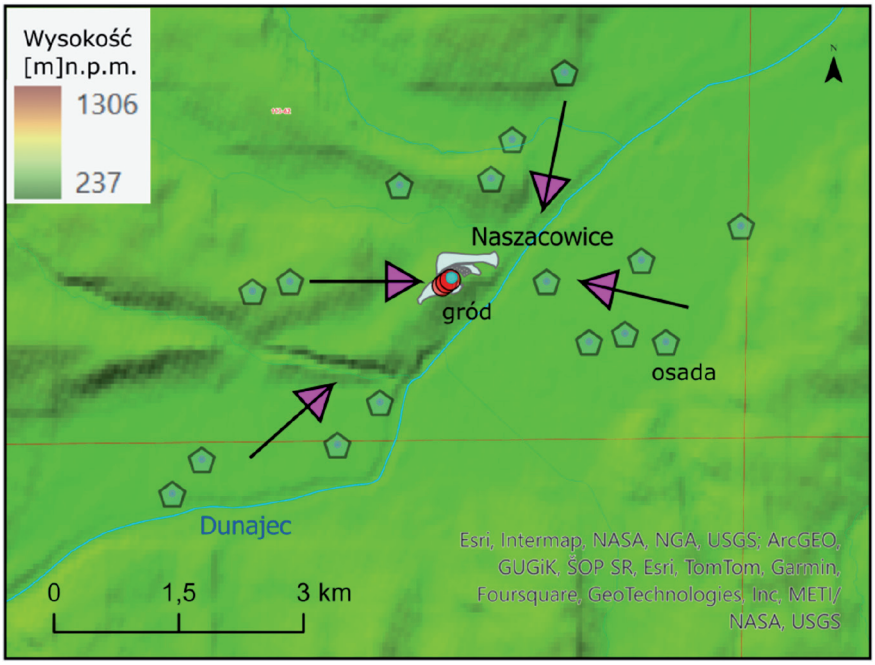
Fig. 5. Area of strongholds classification

The map (Fig. 5) shows the arrangement of Early Medieval strongholds in relation to their surface. Within the Carpathians there are approximately 10 strongholds marked as no data. Castellan strongholds such as Kraków, Wojnicz, Naszacowice were quite large. Hence, it can be confirmed that these are also shelter settlements. However, strongholds such as Przemyśl or Jarosław are not that large in terms of area. Strongholds marked as no data are found in the western part of the current Podkarpackie Voivodeship. Physico-geographic regionalization [Solon et al. 2018] has also been included to present areas in the Carpathians where, in terms of location, strongholds are smaller in size. The relationship can be seen among the strongholds in the south-eastern part of the Carpathians. There are mainly small strongholds (watch-towers) there. Larger strongholds are located within the Carpathian arch and there they were mostly castellan. The exception is f.ex. Naszacowice.

3.2. Case study of determining the function of the castle in Naszacowice

Naszacowice near Nowy Sącz fulfilled two basic functions – castellan (according to the Rocznik Sądecki) and, in addition, refugial. The refugial function was already noticed during research at this archaeological site [Poleski 1997]. According to the AZP data, there are 16 open settlements around the main stronghold. Each of them was a support base: social, economic, craft and agricultural. It would have been difficult to even expand Naszacowice without them and to maintain this important stronghold in the south of historical Lesser Poland. Its function was defined in a rather simple way, e.g. by the large number of open settlements around. In the event of a difficult military situation, it could accommodate the local population behind the lines of the ramparts (of which there were several). In the early Middle Ages, two additional strongholds were built nearby in today's Podegrodzie – a town located north-east of Naszacowice. The main directions of shelter for the local population in the stronghold are visible in the

engraving (Fig. 6). There are 6 settlements on the right side of the river. The rest (10) are located on the left side of the Dunajec. This is quite important, because it was more difficult to cross the river from the eastern settlements, towards Naszacowice. In the river valley there were good quality soils for agricultural cultivation. Hence the possibility of significant agrarian production in the Sądecki castellany. If there were so many open settlements in the area, it indicates the high importance of the region in vicinity of the main stronghold in Naszacowice. It is possible that it was of key importance in the direction of establishing the nearby castellany in this location. Naszacowice is the beginning of the pre-town period [Sołtysiak 2020], predating the establishment of the Sącz city in this area [Noga 2018].



Source: Authors' own study

Fig. 6. The functioning of a refugium in the early Middle Ages, using the hillfort (*gród*) in Naszacowice as an example. Open settlements (*osada*) are marked with pentagons. The hillfort in red – together with its outskirts. The arrows illustrate the directions of population movement in the event of antagonism. Red lines – AZP sheet boundaries. EU-DEM with Elevation (*Wysokość*)

4. Discussion

The exact number of Early Medieval strongholds is certainly a matter of debate. Their density on a map indicates the importance of a given area or communication route (trade route). There was also a difference between building a stronghold on a river, on

a plain, or on an elevation – at a considerable distance from the river. The functioning of strongholds depended on many factors. The shape of the stronghold largely correlated with the terrain – using its natural assets. The connection with the function indicates a greater expansion of the closed settlement, or a specific type of ramparts (including palisades). Currently, GIS tools can greatly help in research on determining 'what for?' and 'why?' the stronghold was built in a particular way and not otherwise. The architecture inside the strongholds had to be related to the purpose of a given stronghold. It will be different in refugial strongholds (where the population was protected) and different in watchtowers, where there rarely was any development – only as part of the military of past centuries.

5. Conclusions

Classifying strongholds based on their functionality was not an easy task. It included determining the area, location, social context and number of defensive ramparts. The strongholds can be grouped according to their strategic purpose, including defensive purposes. Five main classes have been established, where a hierarchy is presented with a division into strongholds according to their functions. Smaller and larger strongholds in terms of area have been specified, and a division has been made into strongholds that are more important socially, militarily and as a shelter. In most cases, watchtowers existed within the border area (for example, the former border of Lesser Poland and Ruthenia, or the Polish-Hungarian border). This is a logical arrangement. Larger strongholds were inside the country. Smaller defensive structures existed outside. Refugium hillforts played the role of protection, especially for the local population. They had to be larger for practical reasons. Watchtowers did not have to be large. They can be described as a garrison, operating similarly to the later defensive tower (in subsequent phases of medieval development). Smoke signals or the movement of scouts could be used to inform the castellan about military maneuvers on the borders of the castellany.

Open settlements are the most important part of the hinterland of a given stronghold. Using the example of a case study in Naszacowice, the number of 16 most important villages (open settlements) in the Sądecki castellany were based on data from AZP. The location of these settlements proves the refugial nature of Naszacowice (despite the castellany classification). This stronghold had to be large enough to accommodate the population of a dozen or so nearby settlements.

Watchtowers existed along the main rivers in the region, in the border areas (including hills and mountains). There were also 'gate' strongholds that connected individual strongholds on the borders of the countries. There is a gap of more important strongholds between Biecz and Sanok. The layout of three castellan strongholds in the southeastern part of Kraków indicates the strategic location of these closed settlements. There are fewer of them in the west, towards Cieszyn. Strongholds are located quite densely around Przemyśl, Sanok and Jarosław. Rivers served a communication and transport function. That is why larger centers were often located in their vicinity. The location of Tuligłowy is unusual, but the function of this defensive structure indicates

the shelter nature of the stronghold. Castellan hillforts were often not as large as refugial strongholds. This was due to their additional functions. For a castellan stronghold to be a refugium, it needed to have a larger area. If it was only a center, where only administrative power was exercised, it could be smaller. Interesting defensive complexes are: Tyniec Abbey (present-day Krakow) and Chodakówka. The naturally defensive monastery is located on a limestone elevation above the water surface. Chodakówka is an extremely large defensive complex (according to the Hillfort Atlas, as much as 11 ha) near the castellan (princely?) strongholds within the former Ruthenia (Cherven Cities). The hillshade map is the best way to visualize defensive ramparts from a bird's eye view. This method has proven effective in distinguishing and then classifying individual defensive structures. Sometimes it was difficult to visualize the old defensive ramparts – for example, because they have not survived (or are poorly outlined). Therefore (e.g. in Jarosław) the lines of the ramparts are not visible due to other buildings currently in the area.

However, the strongholds that had a large area were not always castellan. Additionally, not all castellan strongholds had a refugial function (or partially). It can be assumed that smaller strongholds were watchtowers that defended the routes in the Carpathians. Moreover, large strongholds did not have to be built in such places. Small, single-rampart towns were enough. This often included waterways as well. However, where there were a lot of people, there should also be larger strongholds to protect resources and the surrounding open settlements.

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