"r.calc.ItinerariumAntonini" Raster Based GIS Survey on Pannonian Mileage Data of Itinerarium Antonini

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Abstract

The main goal of the "Pannonian" Roman road survey was to identify the locations and settlements in Pannonia described by the data of the *Itinerarium Antonini*. The road reconstructions based on pure calculations on the mileage data are doubtful, because we do not know the exact locations of the starting- and end stations. They are also insecure, because we cannot be sure of the plausibility of the length-values of the antique source. In some opinion the mileage data of the *Itinerarium Antonini* shows not the exact distances, but the distances calculated upon the travel time between two places. If the length was calculated with the quotient of travel-time-need and average travel-speed, what was it? This assumption supports the logical question, what is the base entity, wherewith the time was deduced. We want to show – exploiting the analyzing possibilities of the GIS , and the movement/travel modeling forms applied in geographical research – a possibility for a new way source analysis.

Keywords

GRASS, Roman roads, Roman travel, least cost path, Roman archaeology, geographic analysis, Itinerarium Antonini

1. Introduction

At first sight the territory and settlement list of the quondam Roman province Pannonia according to such ancient sources as Tabula Peutingeriana (see. Dilke 1985), a map-like Itinerary from the 4th century AD, and the text-based Itinerarium Antonini (Cuntz 1929) dated for the last third of the 3rd century AD (Tóth 2006), or the late-Roman so-called *Notitia Dignitatum* are well-known. This area comprises for example *Aquicum*-Óbuda/Budapest, *Brigetio*-Komárom-Szőny, *Salla*-Zalalövő, *Savaria*-Szombathely, *Scarbantia*-Sopron. Namely, apart from the certain identification of some settlements, present-day researches do not have acceptable settlement or road network reconstruction. The reason for this is that in most cases only the starting- and end-stations of varoius routes can be localized; settlements and road sections between these settlements or road-stations are unknown.

The relief map (*Fig. 1*) illustrates the major part of the province Pannonia[1] and reflects the fact – as already mentioned early in the 20th century by G. Finály (Finály 1903) – that there is not much territory not crossed by roads. Since this problem has been recognised by researchers working in this field for 150 years (see Tóth 1975), the number of identifications and localization possibilities proved to be almost un-

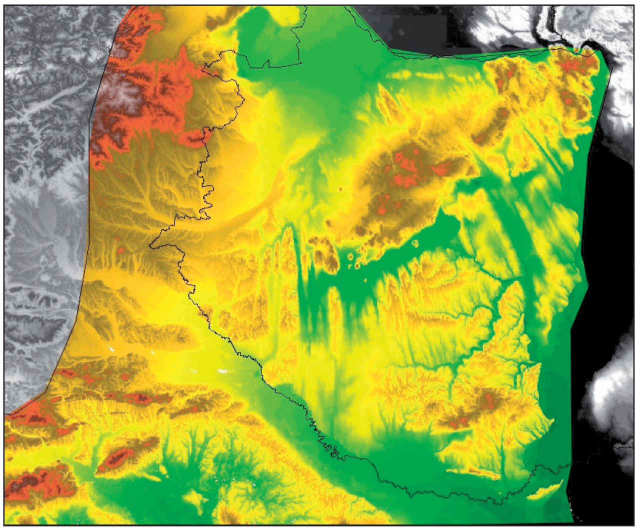

Fig. 1. The northern part of the province Pannonia, with the west-country border of Hungary.

[1] Under the reign of Traianus (ca. 103–107 AD) Pannonia was divided into two provinces (Superior and Inferior). In the late 3rd century, under the reign of Diocletianus (284–305 AD) the two Pannonian provinces were each subdivided into 2 provinces (Superior: Pannonia Prima, Savia; Inferior: Pannonia Secunda, Valeria). The territories of the provinces cover the today's Austria, Croatia, Hungary and Slovenia.

limited (Rómer 1873; Ortvay 1888; Finály 1903; Graf 1936; Mócsy 1962; Mócsy *et al*. 1990; Tóth 2006).

All road-reconstructions that have previously been made were based on the occurrence of collecting contemporary known sites and the *itinerarium*'s mileage data measured with bows. There are only few exceptions, such as the so-called limes road, or *ripa pannonica* published last by Zsolt Visy (Visy 1989; Visy 2000) and the so called "Amber Road", on which extensive researche has been carried out, for example, by Vajk Cserményi (Cserményi and Tóth 1979–1980), Gábor Ilon (Ilon 2002), Péter Kiss (Kiss and Sosztartis 1998), Gyula Nováki (Nováki 1956), Ferenc Redő (Redő 2003; Redő 2006), Ottó Sosztarits (Borhy and Sosztarits 1997; Kiss and Sosztarits 1998), Endre Tóth (Cserményi and Tóth 1979–1980) and Gábor Vámos (Vámos 2001). These road sections are rather well-known, practically giving a frame to the provincial interior.

Not only the road network, but also the reconstruction of settlements show a diverse picture, for instance a possible Roman town (*muncipium*) *Valcum/Volgum* (see Tóth 1986); *Mogetiana/Mogentiana*, (Nagy 2003; Kovács 2003; Tóth 2003; Mráv 2003) or *Floriana* (Tóth 1975; Fitz 1970; Tóth 2006) have been assigned to different locations over time. The basis of the localization is the use of mileage data of *Itinerarium Antonini*, because compared to Tabula Peutingeriana (which gives us information only about sections of the "Amber Road" and the "Limes Road"), the catalogue of *Itinerarium Antonini* offers a detailed settlement description of the ancient province Pannonia, and this is the reason why researchers use it for reconstructions.

During the interpretation of this source several difficulties occurred, one of them being the regular repetition of mile data: the values of 20-25-30 *millepassuum (MP)*, (*Fig. 2*) Roman miles. On certain sections, especially on the "unknown" interior territory, the repetition of these data is regular, which has so far been explained with distance of horse change plots (the system of stations that were a day's walk away from each other).

The usual way to analyse and try to localize the unknown interior settlements was measuring the distances of ancient data on maps, along curves, and in a straight line. This method raises the question: if we measure these distances in the field, how would the buffer zone containing a given settlement be changed?

2. GIS analysis – distance factor

An open source, GNU public-licenced environment and software – such as 64bit OpenSUSE(novell) Linux 10.2 (www.suse.org) and GRASS 6.2 raster GIS (www.grass.itc.it) analyzing software were used for the raster analysis. To create a coverage on which approximate values can be measured to those ones measured in real relief, a raster DEM with 10 meter cell size was used, which was occasionally complemented with the data of SRTMv2 projected in EOV (Hungarian National Datum) interpolated from the origin to 10 meter cell size. Although this method caused data loss, it was necessary for eliminating missing data.

Cell values of "SLOPEmap" developed from base DEM were calculated to degrees. This „SLOPEmap" was the starting base for creating new coverages. With the aid of calculating the difference from the adjacent raster cell's elevation, the raster resolution parameters and slope degree, the slope length could be calculated.[2] For a "SURFACEmap" a raster coverage was created, with raster cells containing the calculated slope length. After examining the

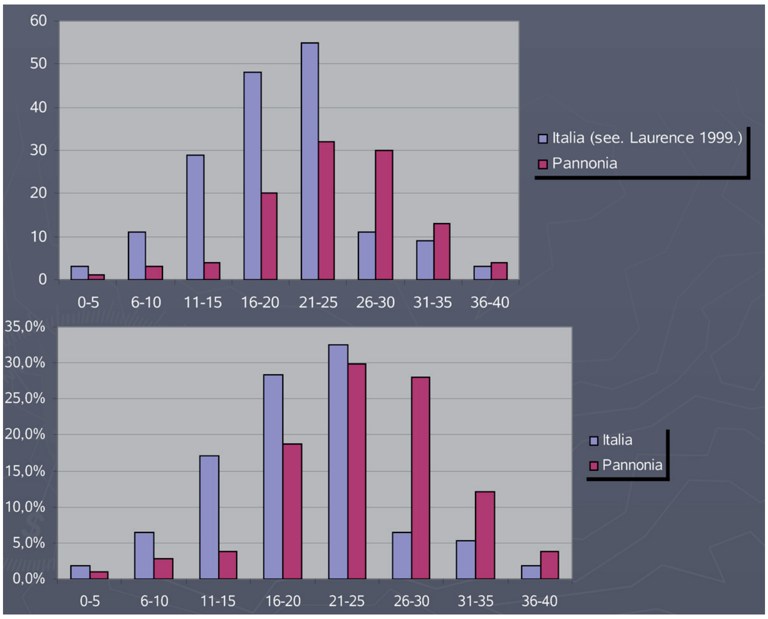

Fig. 2. The summary of mileage data of Itinerarium Antonini in Italia and Pannonia in relation of distance (x) and occurrence (y) in piece/percent.

2 $\sqrt{\text{cellsize}^2(1+\text{Tan}(slopedegree))}$

parameters of Roman roads and finding there had not been road sections with more than 25 slope degrees, these territories were eliminated from the newly created coverage and replaced with NULL values. Similarly to this, territories of lakes existing for sure in the Roman age were also omitted.

The next step was the distance determination with this simulated surface values instead of cartesian distance calculation.[3] To this was a cumulative cost surface analysis (r.cost) with Knight's move method adopted, starting out from coordinates of known Roman settlements. Boundaries of Roman mile buffer zones starting out from well-known settlements could be assigned by cumulative summarized slope lengths.

The results (*Fig. 3*) show that, almost predictably, a buffer zone determined by bows does not show a significant deviation from the previously calculated zone on the plains. The deviation is far more obvious in hilly territory. This is the maximal theoretic boundary, inside which new settlements with certain distances should be sought, depending of course on the curves of roads.

As it has already been mentioned, some theories say continuously repeating mileage data may reflect the station data with one-day-walk distances. On this basis it was worth creating a coverage that shows time zones.

3. GIS analysis – time factor

For this purpose the "hiking form"[4] of Waldo Tobler (Tobler 1993), from Santa Barbara University was used as a base. This form was determined by Tobler for 5km per hour speed on flatlands. If we want to increase the average speed, certain parameters of the form need to be altered. The coverage used for developing the mileage zones was made according to this form. On the basis of these results, starting out from known coordinates a new coverage was created with the help of cumulative cost surface function.

The results (*Fig. 4*) were such temp-zones that show the total time needed for getting there. By comparing mileage and time spans we can make some very interesting observations on certain fields. *Fig. 5* shows that if we compare the zones around *Aquincum*

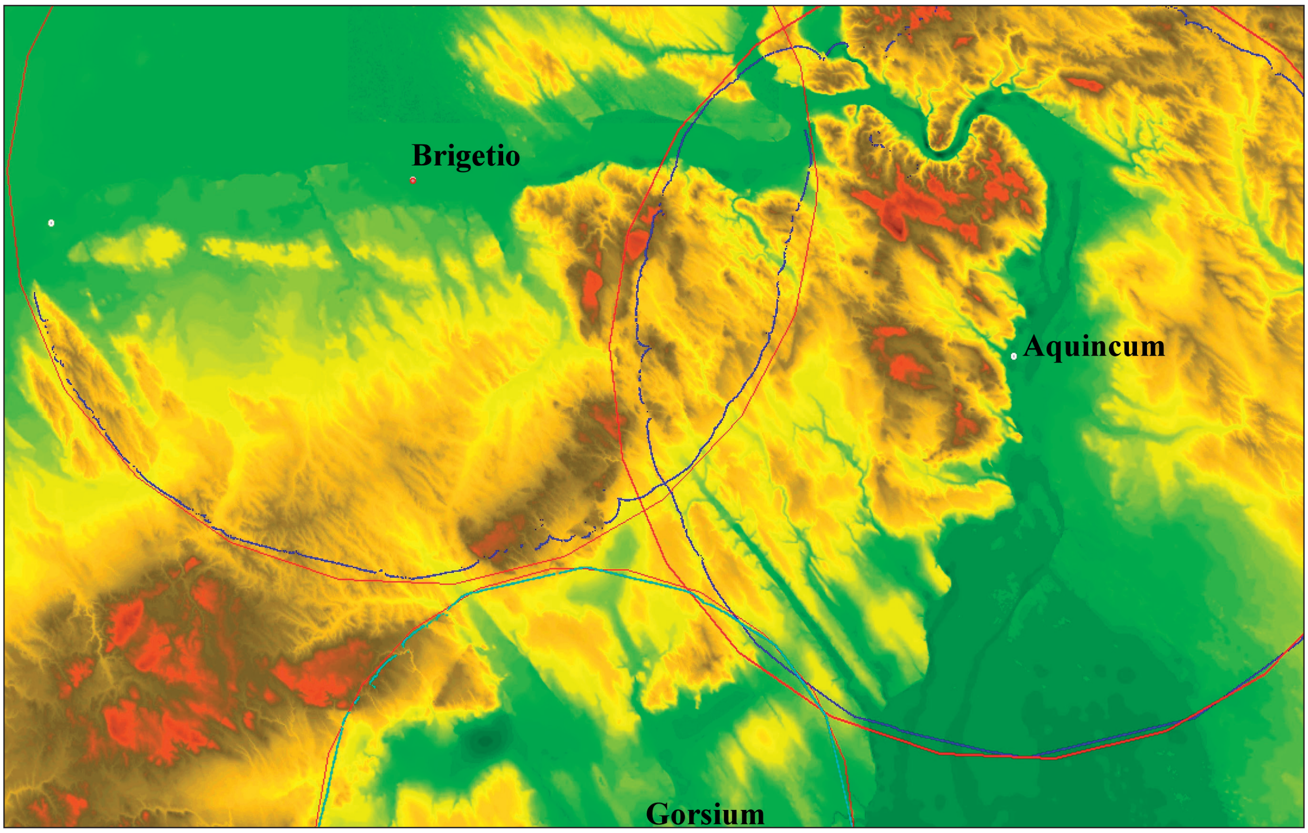

Fig. 3. Cartesian (red) and "relief" (blue) 30MP (ca. 44km) distance zones around Aquincum (Budapest), Brigetio (Komárom-Szőny) and Gorsium (Tác).

3 It has to be noted, that we do not know the exact relief and hydrological circumstances of the Roman period.

4 $W = 6e^{(-3.5|S+0.05|)}$

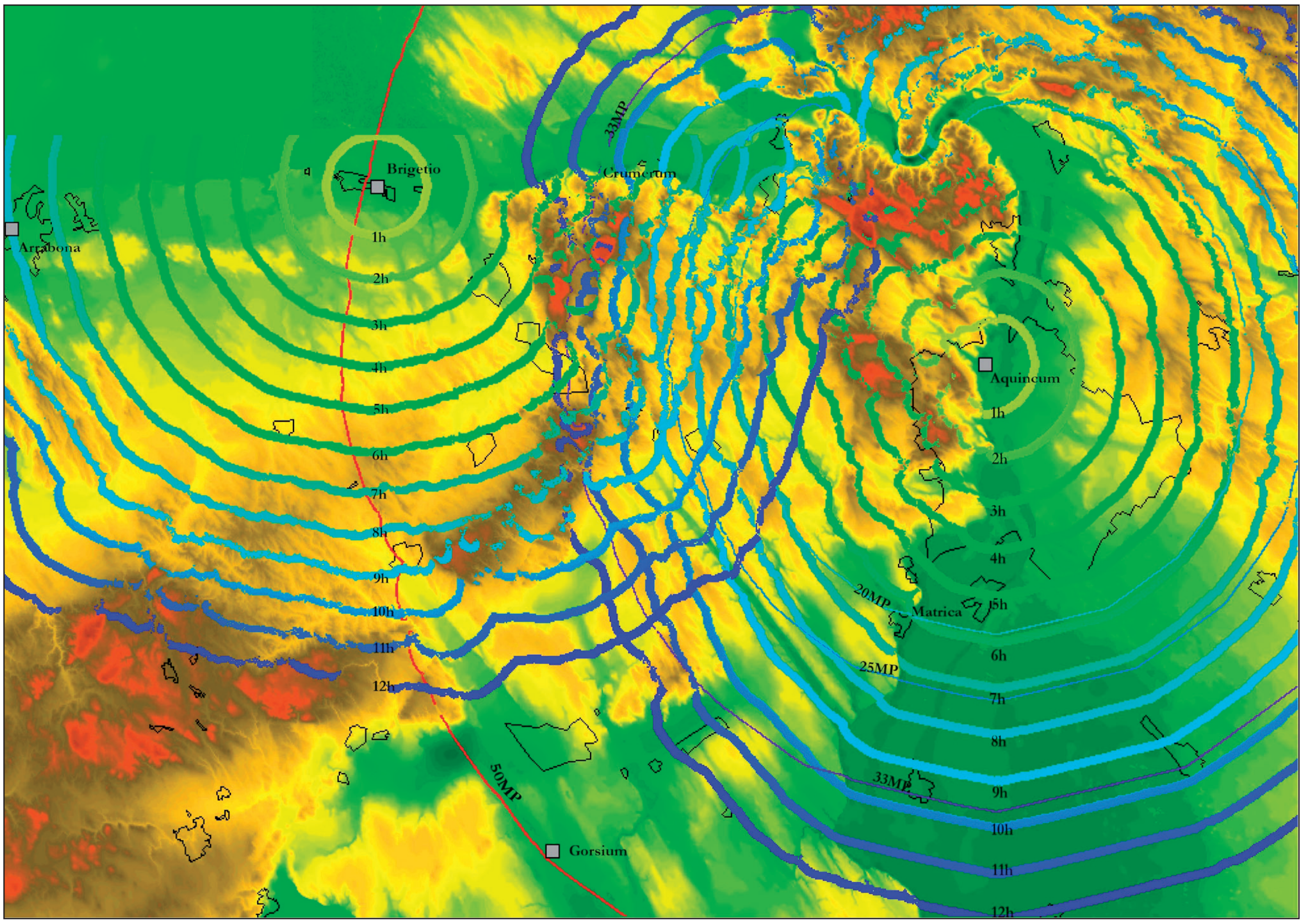

Fig. 4. Time-zones calculated with Tobler's hiking form.

(Budapest) and *Brigetio* (Komárom-Szőny) we can see, while traveling south along the "Limes Road" on a rather flat territory, we can manage 25 MP within 7 hours (at 5km per hour average speed). In case we are heading to the west from Aquincum, coming 25 MP takes 9 hours, which equals 30MP on plane territory. To overcome 30 MP on hilly ground it would take 11–12 hours.

The following question arises: if we assume that the stations (*mansiones*) were at regularly repeating distances from each other – and were in fact a day's walk away – then who was primarily targeted with the information of *Itinerarium Antonini*?

Based on some presumptions this summary from the 3rd century AD was written for the travellers of the imperial post or courier service (*cursus publicus*), but there is no evidence yet.

At first we have to clear on how to define "a day's walk". People were keeping track of lengths of roads and distances of localities largely by time measures until the mid-nineteenth century. Authors of country descriptions and topographies wrote how many hours it takes to get from one place to another, and larger distances were given in numbers of "day's walks". The idea of measuring distance by miles only slowly became generally accepted, and our roads were provided with milestones relatively late. The question is whether it was possible that in the Roman Empire, despite the numerous milestones, time-based counting was more widely prevalent, and if the data was converted into miles only for the needs of an official "timetable"?

How many hours did it take to complete a day's walk? We can probably exclude travel after dusk, since we have numerous data on how difficult it was to keep bandits away from roads.[5] There is only the period between dawn and dusk, left which is shorter in winter and longer in summer. From the yearly times of dawn and dusk, it is clear that we talk about 8 to 16 hour time frames. If we consider the time of resting, this will be reduced to 6–14 hours a day. Using the averages of these data is not favorable:

5 Gangs of bandits operated mostly in the countryside or on the frontiers of the empire where there was little government opposition or where local magistrates were responsible for policing (Strabo 16.2.18–20; Josephus, B.J. 1.304–14). Likewise Bulla Felix, a well known bandit who plundered throughout Italy at the beginning of the 3rd century AD (Dio Cassius: 77.10.5; cf. SHA, Sev. 18.6).

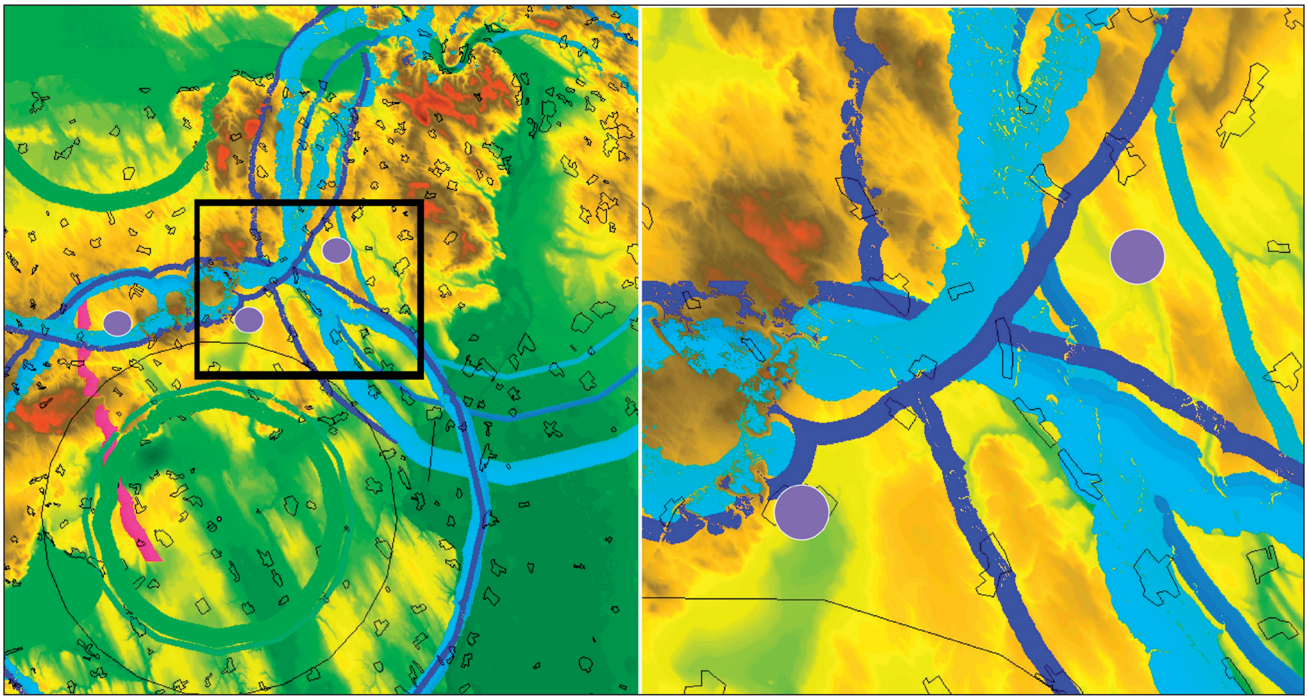

Fig. 5. Hypothetical settlemet localization with time and relief distance buffers.

during winter months there is not more than 8 hours of daylight. If we consider an interval of 6–8 hours daily, that is more acceptable already in theory for both winter and summer months.

If we study the speed data will see the following. Men: the well paced average walking speed is five kilometers per hour, but if we look at walking performances of a legion, will see the most outrageous data in Plinius (Nat.Hist 7.84): Tiberius makes 200 MP during a day when rushing to Drusus dying on the Rhein. According to this, given 24 hours a day, it would have been a 12.5 kilometers an hour performance, meaning they ran the whole distance, which is obviously impossible. At the same time, if we presume 7.5 kilometers per hour, this can be accepted as a strained march. If we study the performance of a riding courier, we have to assume he was in a hurry, so he trotted. The speed of a trotting horse is around 18–48 kilometers per hour, 48 kilometers per hour counts as full or race gallop. If we would like to make an estimate of the speed of carrier vehicles, we shall take the speed of a slowly walking man, which is 3 kilometers an hour.

If we consider once again the “izoTEMP” areas based on several speeds, we will get the time limits that belong to the 25–30 MP per hour data. According to this, 30 miles a day is a result of a 7 hour walk at the speed of 7.5 kilometers per hour (or 5 MP per hour). Depending on the landscape a day’s walk can even be less, for example 25 MP.

This corresponds to the rate of the strained march of an infantry unit, or to the speed of a mounted *militantes*, who, according to Speidel (Speidel 2004) were travelling along the *via militaris* and *via publica* routes with special permission and requisition rights in order to provide supplies for the army. There are available written sources on these requisitions (Borhy 1998, 114; Tacitus: Annales II.59.).

Thus, the mileage data (which they used as a template) corresponds to the speed of light cavalry, a surprisingly round number, 5 MP per hour.

The speed of 5 MP an hour among the data in Itineraium Antonini is the most common figure, the 30-25-20-15 mileage data occur most frequently. Most probably we can count with a generalization in these sources. The round numbers used here come from the inner parts of the province, which may not have been fully explored. At the same time we have to consider the landscape dependent deterioration of distance data. If we accept 30 MP as a day’s walk (and 15–20 MP would be half a day’s walks), we shall agree with the Itinerarium Antonini not using numbers of miles, but rather intervals of time.

4. The test area

An example to be studied in more detail is a settlement referred to as FLORIANA, which appears both on the Aquincum-Savaria and on the Brigetio-Sopianae route, but which has not yet been located the Itinerarium Antonini.

Fig. 5 shows a potential, but hypothetical localization of this settlement. The research showed that mileage data here are unfortunately uncertain (Tóth 1975), and we have to count on the loss of one or two settlements. In this area the 8-15-20 MP records occur quite often. It means the stations here should be within half a day's walking distance. If we take the neighboring settlements mentioned in the three closest sources (those that are archaeologically well identified), and draw half a day's areas, we will see that starting from the three settlements there will be an intersecting point which is at a day's walk from all three of them.

The settlement being a day's walk away from the three localities would be an ideal one, however this analysis could be just an aid to reduce the territory, which should be researched intensely using archaeological methods.

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