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SPACE, LANDSCAPES AND SETTLEMENTS IN BYZANTIUM

Studies in Historical Geography of the Eastern Mediterranean

Presented to
JOHANNES KODER

Andreas Külzer – Mihailo St. Popović (eds.)

DPP
DIGITISING PATTERNS OF POWER

AKADEMSKA KNJIGA

TABULA IMPERII BYZANTINI

VIENNA – NOVI SAD
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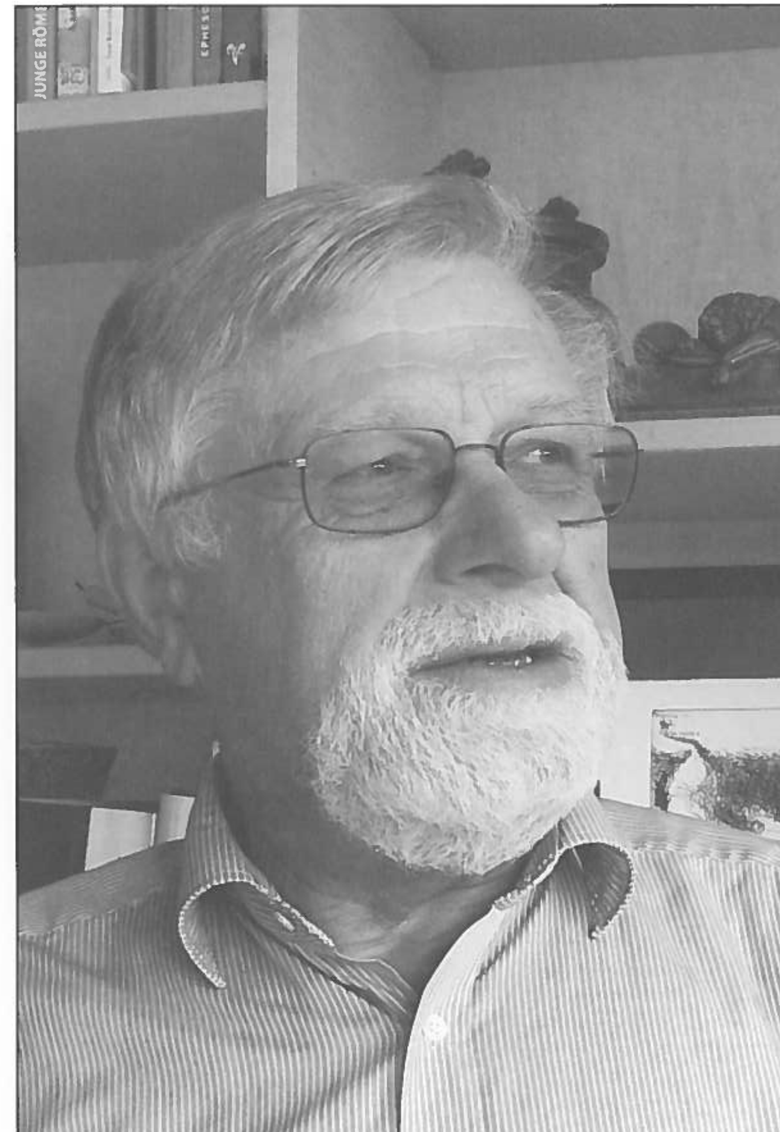

Johannes Koder

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Studies in Historical Geography of the Eastern Mediterranean

XVI

DAVID SCHMID, MIHAILO ST. POPOVIĆ,
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FROM THE *VIA EGNATIA* TO PRILEP, BITOLA AND OHRID:

a Medieval Road Map based on Written Sources, Archaeological Remains and GIScience

1. Introduction

No civilization without roads! This statement was true in Ancient times and it is still true today. The Roman Empire relied on its road network for its military campaigns as well as for trading activities and the mobility of its citizens, goods and ideas. The same is for example true for Napoleonic France, Germany during the Industrial Revolution or nowadays the European Union. Roads, whatever their quality and state might be, may they be dirt tracks or modern highways, were always shaped by the terrain, their envisaged function as well as their history and *vice versa*.

In this joint article[1] we will present a succinct history and systematic categorisation of the road network as well

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[1] This article derives from scholarly results achieved in the projects *Digitising Patterns of Power (DPP): Peripherical Mountains in the Medieval World* (Digitising Patterns of Power, <http://dpp.oeaw.ac.at/>, 16.6.2017) within the programme "Digital Humanities: Langzeitprojekte zum kulturellen Erbe" (DH 2014/10) and *Tabula Imperii Byzantini* (*TIB*) (Tabula Imperii Byzantini, <http://tib.oeaw.ac.at/>, 17.6.2017) as Long Term Project at the Institute for Medieval Research (IMAFO) of the Austrian Academy of Sciences in Vienna. The order of the names of the authors follows the order of their contribution to this article.

as a Least cost path (LCP) Model in and for a specific part of Byzantine Macedonia[2]. Both aforesaid scholarly aspects – roads and landscape – as well as the promotion of young academics have always been an essential element of the teaching and research agenda of Professor Dr. Johannes Koder at the University of Vienna and the Austrian Academy of Sciences.

Our approach within this article is as follows: firstly, we will provide a short topographical description of the area of research, which is the triangle of Ohrid – Bitola – Prilep in Byzantine Macedonia. Then, we will establish a theoretical categorisation of the hierarchy of roads[3] and apply it on our written source material, which is constituted by three medieval Serbian charters issued by the Serbian king Stefan Uroš IV Dušan for the Monastery of the Holy Mother of God in Treskavec in the years 1334/35, 1343/44 and 1344/45 (*fig. XVI-1*). Secondly, the source based evidence will be compared to archaeological data acquired during two field trips by Mihailo St. Popović and Peter Soustal of the *Tabula Imperii Byzantini* (*TIB*)[4] in the area of research in the years 2008 and 2016. Thirdly and finally, a LCP model of the route between Ohrid, Bitola and Prilep will be implemented in order to illustrate the usefulness of GIScience in this very field[5].

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2 Cf. on the definition of Byzantine Macedonia in detail: Koder, Johannes, Macedonians and Macedonia in Byzantine Spatial Thinking, in: John Burke–Roger Scott (eds.), *Byzantine Macedonia. Identity, Image and History. Papers from the Melbourne Conference July 1995*. Melbourne 2000 (*Byzantina Australiensia* 13), 12–28.

3 Hereby following for example the approach of: Belke, Klaus, Roads and Travel in Macedonia and Thrace in the Middle and Late Byzantine Period, in: Ruth Macrides (ed.), *Travel in the Byzantine World*. Aldershot 2002, 73–90.

4 Cf. Tabula Imperii Byzantini (TIB), <http://www.tib.oeaw.ac.at/>, 17.6.2017.

5 Cf. on such an approach for example the following publications: Popović, Mihailo St.–Jubanski, Juilson J., On the Function of "Least-

2. Topography

Byzantine Macedonia, whose northern part forms today's (Former Yugoslav) Republic of Macedonia, reached essentially from Skopje in the North to Thessalonica in the South and from Ohrid in the West to Philippi in the East[6].

The northern part consists geographically of a highland in the centre, surrounded by the mountains of Šar in the North, the Korab, Dešat, and the Jablanica in the West, the Kožuf, Nidže and the Belasica in the South and Maleševo in the East. The centre is dominated by the mountains of the Jakupica[7].

The country can be divided into four main areas: the valley of the river Vardar, the plain of Pelagonia, the Ovče

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Cost Path" Calculations within the Project *Tabula Imperii Byzantini* (*TIB*) of the Austrian Academy of Sciences: a Case Study on the Route Melnik-Zlatolist (Bulgaria), *Anzeiger der philosophisch-historischen Klasse der Österreichischen Akademie der Wissenschaften*, 145. Jahrgang / 2. Halbband (2010), 55–87; Popović, Mihailo St.–Breier, Markus, Tracing Byzantine Routes – Medieval Road Networks in the Historical Region of Macedonia and Their Reconstruction by Least-Cost Paths, in: *Proceedings of the "16th International Conference on Cultural Heritage and New Technologies"*. Wien 2011, 464–475 (cf. <http://www.stadtarchaeologie.at/wp-content/uploads/eBook_CHNT16_Part4.pdf>, 16.6.2017).

6 Jordan, Peter–Partl, Florian, Makedoniens verkehrsgeographische Position in Südosteuropa, in: Walter Lukan–Peter Jordan (eds.), *Makedonien. Geographie, Ethnische Struktur, Geschichte, Sprache und Kultur, Politik, Wirtschaft, Recht*. Wien 1998 (*Österreichische Osthefte. Zeitschrift für Mittel-, Ost- und Südosteuropaforschung* 40), 39–63, here 43.

7 Stoimilov, Aleksandar, Grundzüge der Raumstruktur der Republik Makedonien, in: Walter Lukan–Peter Jordan (eds.), *Makedonien. Geographie, Ethnische Struktur, Geschichte, Sprache und Kultur, Politik, Wirtschaft, Recht*. Wien 1998 (*Österreichische Osthefte. Zeitschrift für Mittel-, Ost- und Südosteuropaforschung* 40), 9–37, here 9.

Polje and the area of the Lakes Ohrid and Prespa[8]. The valley of the river Vardar, the plain of Pelagonia and the area of the Lakes Ohrid and Prespa are zones with important traffic routes. The *Via Egnatia*, which connected Constantinople to Rome via Thessalonica, Ohrid, Apollonia and Dyrrachium respectively, ran through the last two aforesaid zones, while the valley of the river Vardar connected the *Via Egnatia* with the *Via militaris*, the route from Constantinople to Belgrade, via Thessalonica and Niš. Both routes were of the highest importance to the Romans, the Byzantines and the Ottomans[9].

The plain of Pelagonia spans from Florina in northern Greece via Bitola near the Greek-(FYR) Macedonian border to Prilep. The surrounding mountains are the Jakupica in the North, the Babuna in the North-East, the Selečka in the East and the Bušova in the West[10].

The Lakes of Ohrid and Prespa lie in the border region of today's Albania, Greece and the (Former Yugoslav) Republic of Macedonia. This region is separated from the plain of Pelagonia by the Bušova, the Bigla and the Pelister Mountains. In the North of the Lakes lie the Bigla and the Stogovo Mountains, and in the West the Jablanica

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8 Stoimilov, *Grundzüge*, 10–15.

9 Jordan–Partl, Makedoniens verkehrsgeographische Position, 42–44. Cf. the following selected publications on the *Via Egnatia* and *Via militaris*: Tafel, Theophilus L. Fr., *De via militari Romanorum Egnatia qua Illyricum, Macedonia et Thracia iungebantur*. Tubingae 1842 (reprint London 1972); Jireček, Constantin J., *Die Heerstrasse von Belgrad nach Constantinopel und die Balkanpässe. Eine historisch-geographische Studie*. Prag 1877 (reprint Amsterdam 1967); Popović, Mihailo, *Von Budapest nach Istanbul. Die Via Traiana im Spiegel der Reiseliteratur des 14. bis 16. Jahrhunderts*. Leipzig (2nd edition) 2010.

10 Cf. on the topographical situation: Generalkarte von Mitteleuropa, 1 : 200,000 (Bundesamt für Eich- und Vermessungswesen in Wien 1970), Blatt Skopje; Generalkarte von Mitteleuropa, 1 : 200,000 (Bundesamt für Eich- und Vermessungswesen in Wien 1966), Blatt Bitola.

Mountains. The Galičica Mountains separate Lake Ohrid from the Lakes Prespa. The Bigla Mountains form together with the Pelister Mountains and the Galičica Mountains two bottlenecks, which facilitate the journey from Ohrid via Resen to Bitola[11], while the northern shores of the Lakes Ohrid and Great Prespa define at the same time the southern limits of the plain of Resen[12].

3. The Sources

The core of this article is based on a well-defined group of written sources, which consists of three medieval Serbian charters issued by the Serbian king Stefan Uroš IV Dušan for the Monastery of the Holy Mother of God in Treskavec in the years 1334/35, 1343/44 and 1344/45. Their most recent scholarly edition was undertaken by Lidija Slaveva and Vladimir Mošin in 1981[13]. A fourth charter, the date of which is unknown, was examined, but dismissed as a compilation based on the fundamental research of the Serbian historian Djordje Bubalo[14].

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11 Cf. below, chapter *Least cost path (LCP) Modelling*.

12 Generalkarte von Mitteleuropa, 1 : 200,000 (Bundesamt für Eich- und Vermessungswesen in Wien 1970), Blatt Skopje; Generalkarte von Mitteleuropa, 1 : 200,000 (Bundesamt für Eich- und Vermessungswesen in Wien 1966), Blatt Bitola.

13 Treskavec I (ed. Л. Славева–В. Мошин, Првата грамота на Стефан Душан за манастирот Трескавец од 1 септември 1334 до 31 август 1335 година, in: *Споменици за средновековната и поновата историја на Македонија* 4. Скопје 1981), 77–92; Treskavec II (Л. Славева–В. Мошин, Втората Душанова грамота за манастирот Трескавец од крајот на 1343 и почетокот на 1344 година, in: *Споменици за средновековната и поновата историја на Македонија* 4. Скопје 1981), 113–126; Treskavec III (Л. Славева–В. Мошин, Третата Душанова грамота за манастирот Трескавец од околу 1344–1345 година, in: *Споменици за средновековната и поновата историја на Македонија* 4. Скопје 1981), 143–153.

14 Бубало, Ђорђе, За ново, критичко издање трескавачких хрисовуља краља Душана, *Стари српски архив* 7 (2008), 207–229.

3.1 Roads in the Charters of Treskavec

The three charters from 1334 to 1345 mention various roads, mainly in the boundary descriptions of those villages, which were donated by the Serbian king Stefan Dušan to the Monastery of Treskavec. This fact illustrates the importance of roads for the mental mapping of the inhabitants of a specific area and highlights their function as remarkable and unique lines to draw property boundaries[15]. The aforesaid charters mention in total 23 times a *drum* or a *putь*, which are the Slavonic terms for "road"[16]. These roads were often named after the village or town, to which or from which they ran, for example the *putь Kučkovĕnьskogo* (the road from / to Kučkovĕne)[17] or the *hraštanski putь* (the road from / to Hraštani) (cf. *fig. XVI-2*)[18]. Others have names with a special and / or unique topographic characteristic, for example the *prisadьsky putь*[19], which ran over the pass of Prisad to the North-East of Prilep.

[15] Cf. on the issue of mental mapping in Byzantium for example: Della Dora, Veronica, *Landscape, Nature, and the Sacred in Byzantium*. Cambridge 2016; Veikou, Myrto, Space in Texts and Space as Text: A New Approach to Byzantine Spatial Notions, *Scandinavian Journal of Byzantine and Modern Greek Studies* 2 (2016), 143–175.

[16] Cf. on the Byzantine and Serbian typology of roads: Belke, Klaus, Roads and Travel in Macedonia and Thrace in the Middle and Late Byzantine Period, in: Ruth Macrides (ed.), *Travel in the Byzantine World*. Aldershot 2002, 73–90, here 86–90; Popović, Mihailo St., Altstraßenforschung am Beispiel des Tales der Strumica bzw. Strumešnica in spätbyzantinischer Zeit (1259–1375/76), in: Миша Ракоција (ed.), *Ниш и Византија. Осми научни скуп, Ниш, 3–5. јун 2009. Зборник радова VIII*. Ниш 2010, 417–432; Шкриванић, Гавро, *Путеви у средњовековној Србији*. Београд 1974, 16–19.

[17] Treskavec II, 115; Treskavec III, 150.

[18] Treskavec III, 150.

[19] Treskavec I, 83; Treskavec II, 119; Treskavec III, 145.

Very interesting is the fact that some roads bear the names of specific ethnic groups, who seem to have lived near or used the respective roads to transit the region of Prilep. In the aforesaid charters we come across two nomadic peoples, namely the Petchenegs (*putь penĕška*)[20] and the Cumans (*kumanskoga putь*)[21]. Also a road near Florina bears an ethnic name, i.e. the *putĕ vlaškego* ("the Road of the Vlachs") between Kladorrachi (Kladoruby) and Proti (Klьbasnica) in today's Greece[22]. Finally, there is the so-called "Imperial Road" (*carev drum*)[23], which had a significance as a main artery for trade and military movements. Some of them may be Ancient Roman roads, which were also continued to be used by the Byzantine Empire in regions and provinces, into which the Serbian kings and tsars had expanded their realm.

The localisation of this exclusively source based evidence on roads can only be an approximation, and only then, if the provided context and description proves to be sufficient for an unambiguous interpretation. These descriptions in the sources are for example formulations like "which runs near to the village of", "which is near to the possessions of" or "which crosses the river of". However, these localisations have a certain degree of fuzziness, being founded on microtoponyms, which could have sustained, vanished or have been relocated since the 14th century. For some roads we only possess the evidence that

[20] Treskavec II, 116; Treskavec III, 151.

[21] Treskavec III, 144; Cf. on this issue also: Shukurov, Rustam, The Byzantine Turks: An Approach to the Study of Late Byzantine Demography, in: *L'Europa dopo la caduta di Costantinopoli: 29 maggio 1453*. Spoleto 2008, 73–108.

[22] Treskavec II, 122; Treskavec III, 148; Also cf. Бубало, Ђорђе, *Влахо епископ или влахоепископ*, *Зборник радова Византолошког института* 39 (2001/2002), 197–220; Kravari, Vassiliki, *Villes et villages de Macédoine occidentale*. Paris 1989, 280f.

[23] Treskavec II, 121; Treskavec III, 147.

they must have existed and led from a certain village to a neighbouring village. Some of the mentioned roads can be traced on the basis of later sources, e.g. diaries, travel accounts or reports of the 19th and 20th centuries, which we have done in the case of the *prisadьsky putь*, which connected Prilep and Veles. Nowadays, this road is still used as a local road by the indigenous population (e.g. woodcutters, cf. below, chapter *Archaeological Remains of Roads in Situ*).

Based on the aforesaid three charters from the 14th century we are able to discern four zones of transportation, namely around the villages of Krivogaštane, Ōbrъšani with Běla Crъkva, Galičane to the South of Prilep and one zone between Maly Mramorane and Dupijačani to the North of Prilep. In a boundary description of a property of a certain abbot called Kalinikъ (maybe of the Monastery of Treskavec itself) from the year 1344/45 roads are mentioned near Dupijačani: one road ran from the watermill of a certain Radiman, bypassing the area named Gorkъ, to the property of a certain Vasilij and finally ended in the *putь dušьnički* in the direction of Mramorane, which is the second road mentioned in this paragraph of the charter[24]. The road near Krivogaštane is the so-called *putь krivogaškego*[25]. Near Ōbrъšani and Běla Crъkva we find the so-called *putь peněška*, which is the aforesaid "Road of the Petchenegs", and finally the *putь ōbrъšanskego*[26]. Near Galičane is a so-called "old road" (*do staroga puti galičkoga*), which could mean that there also existed a "new road" near Galičane, and the *putь hraštanskego*[27]. In this area, near the today's villages of Krivogaštane, Bela Crkva, Obršani and Galičane, lay the village of Kučъkověne, which cannot be

24 Treskavec III, 144.

25 Treskavec II, 115f.; Treskavec III, 150.

26 Treskavec II, 116; Treskavec III, 150.

27 Treskavec II, 115f.; Treskavec III, 150.

exactly localised and which was the starting point of the *putь Kučьkovanskogo* mentioned in the charters of 1343/44 and 1344/45[28].

In the immediate vicinity of Prilep itself there is only one (municipal) road mentioned, which led from the town to the Monastery of Treskavec (*putь isь Treskavьca, izь Trěskavьca putь gradьsky*)[29]. The road over the pass of Prisad is mentioned in all three charters in the boundary descriptions of the villages of Homorane and Nebreěgovo, which both lie in the Babuna mountain range[30].

Between the towns of Prilep and Tetovo lies the village of Vlъče, which also gave its name to the *putь vlьčevski*. It may have connected the plain of Pelagonia with the region of Polog. This road is exclusively mentioned in the charter of 1344/45[31].

In Polog itself another road can be found, the "Imperial Road" (*carev drum*) near Polaticъ, which appears in the charters of 1343/44 and 1344/45[32]. Unfortunately, neither the road nor the village can be exactly localised[33].

The "Road of the Cumans" (*ōtь kumanskoga puti*) and the "Lower Road" (*do dolnega druma*) are examples for roads, which cannot be localised, because they have not been connected to specific microtoponyms in the sources. However, the context of the written source suggests that both roads were to be found near the village of Dupijačani[34].

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28 Treskavec II,115; Treskavec III, 150.

29 Treskavec I, 79; Treskavec II, 114.

30 Treskavec I, 83; Treskavec II, 119; Treskavec III, 145.

31 Treskavec III, 147.

32 Treskavec II, 121; Treskavec III, 147.

33 Kravari, *Villes*, 316.

34 Treskavec III, 144f.

3.2 Archaeological Remains of Roads in Situ

Most fascinating and puzzling is the fact that the aforesaid roads, which are attested in the charters of the Serbian king Stefan Uroš IV Dušan for the Monastery of the Holy Mother of God in Treskavec, cannot be found *in situ*, i.e. the respective landscape, today. Hereby, our analysis is based on systematic field trips, which were conducted by Mihailo St. Popović and Peter Soustal in September 2008 and in June 2016 for the *TIB* volume 16 "Macedonia, Northern Part" within the Long Term Project *Tabula Imperii Byzantini* (*TIB*) of the Austrian Academy of Sciences[35].

The only exception is the *prisadьsky putь*, which is named after the pass of Prisad and which connects the valley of the river Vardar (i.e. Veles) as well as of the river Babuna (via the place Izvor) with the plain of Pelagonia (i.e. Prilep) (cf. *fig. XVI-2*). This road is not only attested in the medieval charters, but also in travel accounts or reports of the 19th and 20th centuries. The renowned Austrian diplomat and historian Johann Georg von Hahn (1811–1869) reports for example:

> "Drei Stunden von Welesa erreicht der Weg das Rinnsal der Babuna bei der Vereinigung ihrer beiden Arme. [...] Wir zogen daher das Rinnsal des südlichen Babunabaches aufwärts durch ein breites, fruchtbares Thal, in welchem etwa drei Viertelstunden von jenem Chane das Dorf Iswor liegt, welches Kiepert an die Mündung der Babuna in den Wardar versetzt, und erreichten in einer weiteren Stunde den Babuna Chan, [...] Von ihm an verengt sich das Thal sehr allmählich, und wird etwa eine Stunde vor dem Wezir-Chan, unserem Nachtlager, zu einem ziemlich steil aufsteigenden Waldthale. [...] Der Weg vom Chane zu dem Passsattel ist anfangs nicht schlechter, als der bis zum Chane; er blieb eine holperige, mit grossen Steinen gepflasterte türkische Strasse in vernachlässigtem Zustande, aber je höher wir kamen, desto unwegsamer wurde er für die Wagen [...] Wir ritten also bis zu dem auf der Kuppe des Passes gelegenen Wachthause vor, [...] Wie der Weg auf dem Osthange der Babuna sich bis zum Passsattel in einer Thalfalte hinaufzieht, so senkt er sich auf dem Westhange in einer ähnlichen in die Beckenebene von Prilip [sic!] hinab, doch mit dem Unterschiede, dass die letztere Strecke eine Stunde lang ist, während man die acht Stunden von Welesa bis zum Passsattel beständig ansteigt."[36]

35 Tabula Imperii Byzantini (TIB), <http://tib.oeaw.ac.at/index.php?seite=status&submenu=tib16>, 25.6.2017.

During the Balkan Wars 1912/13 the Serbian army used the same road in order to advance against Ottoman Prilep: "Die mittlere Kolonne, 3 Infanterie- und 1 Kavallerie-Division, die Hauptkräfte, war über Köprülü (Welesch) auf Prilip (Perlepe) in Marsch gesetzt. Sie hatte am 4. November bei Han Abdi Pascha, am 5. bei Karaul Prisat, auf Paßhöhen stärkeren Widerstand zu brechen. Am Abend des 5. stand sie vor dem von den Türken geräumten Prilep."[37]

The German army reconstructed and upgraded this road during the First World War in order to supply its troops on the Salonica Front, which is described by the German zoologist Franz John Theodor Doflein (1873–1924) as follows:

36 Hahn, Johann Georg von, *Reise von Belgrad nach Salonik: nebst vier Abhandlungen zur alten Geschichte des Morawagebietes*. Wien 1868, 173–175.

37 N. N., Die serbische Armee im Kriege des Balkanvierbundes, *Allgemeine schweizerische Militärzeitung* 51 (1913), 406–409, here 406.

"Seitdem Monastir in die Hände der Feinde [i.e. the Allies] gefallen war, spielte Prilep eine wichtige Rolle als Hauptstadt im Westteil der mazedonischen Front. […] So waren hauptsächlich zwei Pässe seit altersher als Zugangsstraßen nach dieser Stadt üblich. Beide waren jetzt für die Versorgung der Front ausgebaut worden, der Babuna- und der Pletwarpaß, die vom Wardartal nach Südwesten nach Prilep führten. […] Zu meinem ersten Besuch in Prilep wählte ich im Juni 1917 den Weg über den Babunapaß, wobei Veles den Ausgangspunkt darstellte. […] Über die Paßstraße ging ein regelmäßiger starker Verkehr von Lastfuhrwerken und Kraftwagen. Um diesen zu bewältigen, war im Laufe der Zeit die Straße immer besser ausgebaut worden; […] Die Straße von Veles nach dem Babunapaß ging zuerst geradeaus südlich an der Topolka entlang, um dann über eine Höhe hinweg die Babuna zu erreichen, welche bei Izvor direkt aus Süden in einem breiten Tal dem Gebirge entströmt. […] Bei Izvor verläßt die Straße das Tal und beginnt an der Babuna entlang ins Gebirge aufzusteigen. […] Bei der Weiterfahrt nahm die Paßstraße immer mehr den Charakter einer Hochgebirgsstraße an. […] Vom Paß [scilicet Prisad] aus, der in der Höhe von 1060 m lag, ging es steil in das Tal hinunter, an dessen Ende die Stadt Prilep liegt."[38]

During our field trip in June 2016 we documented remarkable sections of the German road, which is surprisingly well preserved (*figs. XVI-3, XVI-4*) and which is still used by the indigenous population as a local road in order to transport wood and timber. Thus, the *prisadьsky putь* has a continuity at least from the Middle Ages until our time.

[38] Doflein, Franz, *Mazedonien – Erlebnisse und Beobachtungen eines Naturforschers im Gefolge des deutschen Heeres*. Jena 1921, 448–455.

Franz Doflein mentions the road over the pass of Pletvar (*fig. XVI-2*)[39], which we cannot find in the aforesaid medieval charters. It connected the valley of the river Vardar (from Gradsko) with the plain of Pelagonia and must have already existed in the Middle Ages. Boban Petrovski surmises that Timurtaş, the Beylerbey of Rumelia, left the town of Serres in the spring of 1385, marched with his army via Dojran to Demir Kapija and then traversed the pass of Pletvar in order to conquer Prilep and Bitola. After that he led his army on the *Via Egnatia* to Ohrid, which he also captured[40].

Moreover, we used the western road in 2008 and the eastern road in 2016 during our field trips to hike to the Monastery of the Holy Mother of God in Treskavec (*fig. XVI-2*). In both cases we came across substantial remnants of the respective roads (*figs. XVI-5, XVI-6*), which we are not able to date due to the lack of archaeological excavations and finds[41].

In 2008 we also found remnants of a road, which connected the village of Kostinci to the Monastery of Zrze running in East-West direction as well as traces of a road

[39] Cf. above and: Doflein, *Mazedonien*, 468–471. See also: Stankovska, Ljubica, Za etimologijata na imeto na seloto Pletvar (Prilepsko), *Glasnik Institut za Nacionalna Istorija* 46/1 (2002), 95–101.

[40] Petrovski, Boban, Ottoman Military Campaign in 1385: Itinerary and Goals, in: Синиша Мишић (eds.), *Власт и моћ. Властела Моравске Србије од 1365. до 1402. године*. Крушевац 2014, 287–304, here 290–297.

[41] Cf. on the roads and the Sacred Landscape of the Monastery of the Holy Mother of God in Treskavec: Смолчић Макуљевић, Светлана, Сакрална топографија манастира Трескавца, *Balcanica* 35 (2005), 285–322; Smolčić Makuljević, Svetlana, Two Models of Sacred Space in the Byzantine and Medieval Visual Culture of the Balkans: The Monasteries of St Prohor of Pčinja and Treskavac, *Jahrbuch der Österreichischen Byzantinistik* 59 (2009), 191–202; Смолчић Макуљевић, Светлана, Цркве и приложници у трескавачким хрисовуљама краља Душана, *Зограф* 40 (2016), 73–84.

between the villages of Brailovo and Desovo, both in the plain of Pelagonia (*fig. XVI-2*). Again a dating could not be undertaken due to the lack of archaeological evidence *in situ*. Finally, there is also an old road between the villages of Podmol and Bonče, which we documented in 2016 (*fig. XVI-7*).

4. The *Via Egnatia* and Least cost path (LCP) Modelling

If we turn from the plain of Pelagonia to the area of the Lakes Ohrid and Prespa, we realise immediately the importance of the settlements of Struga, Ohrid, Resen and Bitola, which is attested by written as well as archaeological sources throughout the centuries as being an integral part of the *Via Egnatia*[42].

[42] Cf. the following selection of studies on the *Via Egnatia* with further bibliography: Avramea, Anna, Land and Sea Communications, Fourth–Fifteenth Centuries, in: Angeliki E. Laiou (eds.), *The Economic History of Byzantium. From the Seventh through the Fifteenth Century, Volume 1.* Washington, D. C. 2002, 57–90; Битракова-Грозданова, Вера, *Via Egnatia* помеѓу *Lychnidos* и *Pons Servilii* (Нови археолошки докази), in: *Макропроект "Историја на културата на Македонија". Археолошките откритија на почвата на Македонија.* Скопје 2008 (*Прилози за истражувањето на историјата на културата на почвата на Македонија* 18), 529–540; Fasolo, Michele, *La Via Egnatia I. Da Apollonia e Dyrrachium ad Herakleia Lynkestidos.* Roma 2005 (*Viae Publicae Romanae* 1); Fasolo, Michele, La *via Egnatia* nel territorio della Repubblica di Macedonia, in: Cesare Marangio–Giovanni Laudizi (eds.), *Παλαιὰ Φιλία. Studi di topografia antica in onore di Giovanni Uggeri.* Galatina 2009, 601–612; Филипоски, Тони, Прашањето за проодноста на западниот дел од патот Via Egnatia (Драч–Солун) во втората половина на IX век, in: Васил Гюзелев et al. (eds.), *Пътуванията в средновековна България.* Велико Търново 2008, 110–119; Gunaropulu, Lukretia–Chatzopulos, Miltiades B., *Les milliaires de la voie égnatienne entre Héraclée des Lyncestes et Thessalonique.* Athènes 1985; Hammond, Nigel G. L., The Western Part of the Via Egnatia, *The Journal of Roman Studies* 64 (1974), 185–194; Koytcheva, Elena, Civitates et Castra on Via Militaris and Via Egnatia: Early Crusaders' View, *Revue des Études Sud-Est Européennes* 44/1–4 (2006), 139–144; Лилчиќ, Виктор, Античка патна мрежа, in: Димче Коцо et al. (eds.), *Археолошка карта на Република Македонија. Том I.* Скопје 1994, 113f.; Лилчиќ, Виктор, *Via Egnatia* Лихнид – Ресен, in: *Макропроект "Историја на културата на Македонија". Археолошките откритија на почвата на Македонија.* Скопје 2008 (*Прилози за истражувањето на историјата на културата на почвата на Македонија* 18), Скопје 2008, 541–550; Lilcik, Viktor, Via Egnatia in the Republic of Macedonia, in: *Via Egnatia Revisited. Common Past, Common Future. Proceedings VEF Conference, Bitola, February 2009.* Driebergen 2010, 24–32; Murphey, Rhoads, Patterns of Trade along the Via Egnatia in the 17th Century, in: Elizabeth A. Zachariadou (eds.), *The Via Egnatia under Ottoman Rule (1380–1699). Halcyon Days in Crete II. A Symposium Held in Rethymnon, 9–11 January 1994.* Rethymnon 1996, 171–191; Oikonomidès, Nicolas A., The Medieval Via Egnatia, in: Elizabeth A. Zachariadou (eds.), *The Via Egnatia under Ottoman Rule (1380–1699). Halcyon Days in Crete II. A Symposium Held in Rethymnon, 9–11 January 1994.* Rethymnon 1996, 9–16; Stoianovich, Traian, A Route Type: the Via Egnatia under Ottoman Rule, in: Elizabeth A. Zachariadou (eds.), *The Via Egnatia under Ottoman Rule (1380–1699). Halcyon Days in Crete II. A Symposium Held in Rethymnon, 9–11 January 1994.* Rethymnon 1996, 203–216.

The (scholarly) interest in the *Via Egnatia* is still alive today as it was in the past. The embodiment of today's interest is for example the *Via Egnatia Foundation*, which organised amongst others a conference entitled "Via Egnatia Revisited. Common Past, Common Future" in Bitola in February 2009[43]. The interest in the *Via Egnatia* in the past is best attested by archival material, which is preserved in the Austrian Archaeological Institute (Österreichisches Archäologisches Institut) of the Austrian Academy of Sciences in Vienna and which was published for the first time in 2015[44]. Three letters, which were written

[43] Cf. on the *Via Egnatia Foundation* (*VEF*): <http://www.viaegnatia-foundation.eu/>, 19.6.2017.

[44] Popović, Mihailo St., Das Herrschaftsgebiet des Zaren Samuel im Mittelalter und dessen Erforschung zwischen 1890 und 1918,

by August Ritter von Kral (1869–1953), then vice consul of the Austro-Hungarian Empire in Monastir (Bitola), to the Ministry of Foreign Affairs in Vienna as well as to Friedrich August Otto Benndorf (1838–1907), the founder of the Austrian Archaeological Institute (1898), in 1898/99, contain meticulous reports on the activities of Russian archaeologists in the Vilayet of Monastir (Bitola).

What we learn from Kral's letter dated to 3 November 1899 on the scholarly research concerning the *Via Egnatia* is that:

> "[...] H.[err] Balaščeff[45] behauptet, diese römische Strasse [i.e. the Via Egnatia] sei vom Südufer des Ohridasee's (bei Pogradec[46] oder Sv. Naum[47]) über Lin[48] westlich (aber nicht durchs Šcumbithal) gegen Elbassan gezozen [sic!]. Die Bezeichnung Lagus Lychnidus stamme von Lin, welches der Hauptort am See gewesen sei, nicht die spätere Feste Ohrida. [Auf meiner Reise nach Elbassan hörte ich von Albanesen, die alte Via Egnatia sei stellenweise sehr gut erhalten und hätte südlich von Struga[49] nach Brzešti und Sopot geführt. Sopot ist eine im obersten Gostimathale, sehr

in: Васил Гюзелев–Георги Н. Николов (eds.), *Европейският Югоизток през втората половина на X – началото на XI век. История и култура*. София 2015, 277–298, here 291–298.

45 Georgi Dimitrov Balasčev (1869–1936), historian and archaeologist.

46 Today the town of Pogradec in Albania, on the southern shore of Lake Ohrid.

47 Today the Monastery of Sveti Naum in the (Former Yugoslav) Republic of Macedonia, on the southern shore of Lake Ohrid.

48 Today the Lin Peninsula in Albania, on the western shore of Lake Ohrid.

49 Today the town of Struga in the (Former Yugoslav) Republic of Macedonia, on the northern shore of Lake Ohrid.

> hoch gelegene Ruinenstadt, heutzutage unbewohnt, an welche sich alte Sagen knüpfen.] [...]"[50]

Apparently, Georgi Dimitrov Balasčev thought that the *Via Egnatia* came from Pogradec or Sveti Naum, ran along the western shore of Lake Ohrid via the Lin Peninsula and then turned to the West, but did not follow the valley of the river Shkumbin to reach Elbasan. His hypothesis has been disproved in the meantime[51].

Although a vast variety of secondary literature has been published on the *Via Egnatia*, some parts of its route still remain obscure, for instance the section between Ohrid and Resen. The archaeologist Viktor Lilčikj Adams has argued for a multi-layered approach to this question and stated rightly that: "[...] a serious scholarly reconstruction requires new detailed field and cabinet archaeological research with modern research methodologies and adequate sophisticated field and office equipment."[52] The same scholar distinguishes for the section Ohrid – Resen between a summer and a winter road[53] (*fig. XVI-8*). The summer road led from Ohrid to Velgošti and via the mountain of Istok (1661 m altitude) and the village of Petrino to Resen, which is the most direct and shortest way between Ohrid and Resen[54]. The winter road offers three variants: The first ran from Ohrid via Kosel, Opejnca, Zavoj, the pass of Bukovo (1207 m altitude) to Resen, which is the longest and safest section. The second variant connected Ohrid, Leskoec, circumvented the elevation of Bigla (1228 m altitude) to the South-East of Opejnca, crossed the pass

50 Cf. Popović, *Herrschaftsgebiet*, 295f.

51 Cf. the bibliography in footnote 42.

52 Lilcik, *Via Egnatia*, 25.

53 Lilcik, *Via Egnatia*, 28. Cf. also: Fasolo, *La Via Egnatia*, 241–254; Fasolo, *La via Egnatia nel territorio*, 607–609.

54 Lilcik, *Via Egnatia*, 28.

of Bukovo and reached Resen via Izbište. The third led from Ohrid to Leskoec, Skrebatno, Ilino and Resen[55].

A multi-layered approach would substantially help to provide a scholarly basis, which in turn would facilitate the preference for one of the aforesaid three variants of the winter road. Firstly, additional, unpublished archival material – like Kral's reports – could shed more light on the preferred usage of one of these routes in the Early Modern period.

Secondly, modern maps could help to bridge the gap and to facilitate a reconstruction. A good example for a useful pictorial source are the famous Austrian maps on the scale of 1 : 200,000, which were produced by the *k. k. Militär-Geographisches Institut*[56]. In addition, the Viennese archives preserve invaluable records of reconnaissance undertaken

[55] Лилчиќ, *Via Egnatia Лихнид – Ресен*, 542f.; Lilcik, *Via Egnatia*, 28f. Cf. also: Lilčik, Viktor, Via Egnatia Lychnidus-Resen, *Macedonian Heritage* 18 (Skopje 2002), 33–44.

[56] Cf. on the history of the *k. k. Militär-Geographisches Institut*: Almer, Franz, Das k.u.k. militärgeographische Institut, *Communications in Asteroseismology* 149 (2008), 75–82; Messner, Robert, Das Wiener Militärgeographische Institut. Ein Beitrag zur Geschichte seiner Entstehung aus dem Mailänder Militärgeographischen Institut, *Jahrbuch des Vereines für Geschichte der Stadt Wien* 23/25 (1967/1969), 206–292; Messner, Robert, *Das kaiserlich-königliche Militärgeographische Institut zu Mailand. L'imperiale regio Istituto Geografico Militare a Milano. 1814–1839. 25 Jahre österreichische Militärgeographie in Italien.* Wien 1986; Ponstingl, Michael, „Der Soldat benötigt sowohl Pläne als auch Karten." Fotografische Einsätze im k. (u.) k. Militärgeographischen Institut zu Wien. Teil I/ Teil II, *Fotogeschichte. Beiträge zur Geschichte und Ästhetik der Fotografie* 81 (2001), 39–56 and 83 (2002), 53–82. The relevant map sheets in the present case are: Generalkarte von Mitteleuropa, 1 : 200,000 (Bundesamt für Eich- und Vermessungswesen in Wien 1940), Blatt Elbasan; Generalkarte von Mitteleuropa, 1 : 200,000 (Bundesamt für Eich- und Vermessungswesen in Wien 1966), Blatt Bitola.

by the *k. k. Militär-Geographisches Institut* in South-East Europe during the 19th century. Since the 1870s Austro-Hungarian officers had set out for expeditions through the Balkan Peninsula in order to map routes between settlements and to sketch hachures of the terrain in preparation of the aforesaid maps on the scale of 1 : 200,000[57]. The value of the records of reconnaissance from the 1870s lies without doubt in the fact that they documented the pre-industrial condition of routes in South-East Europe. Their analysis has shown that Austro-Hungarian officers visited Ottoman Rumelia in the year 1873[58] and that they surveyed the route between Ohrid and Bitola via Resen on 17/18 May 1873[59]. What we learn on the basis of the hachures is that the Austro-Hungarian expedition used the aforesaid summer road, which led from Ohrid to Velgošti and via the mountain of Istok and the village of Petrino to Resen.

[57] Cf. in detail: Popović–Jubanski, *Function*, 55–87; Popović, Mihailo St., *Historische Geographie und Digital Humanities. Eine Fallstudie zum spätbyzantinischen und osmanischen Makedonien.* Mainz-Ruhpolding 2014 (*Peleus, Studien zur Archäologie und Geschichte Griechenlands und Zyperns* 61), 122–148.

[58] The whole collection of records is entitled: "Uibersichts [sic!] Skelett der im Jahre 1873 in der Türkei bereisten Routen und der dazugehörigen à la vûe Aufnahms-Blätter, die arabischen Ziffern bezeichnen die zugehörigen Blätter". It comprises the southern part of Albania, the south-western part of the (Former Yugoslav) Republic of Macedonia and the northern part of Greece.

[59] These drawings are preserved in: Austrian State Archives / Österreichisches Staatsarchiv (Vienna), Kriegsarchiv, B III c 19-03, Blätter 8, 9, 10. It is interesting to note that the Austro-Hungarian expedition came to Lake Ohrid from the South via Korçë and reached Sveti Naum, which is in accordance with the outline of the route of the ancient *Via Egnatia* proposed by the historian and archaeologist Georgi Dimitrov Balasčev.

At this point I would like to include a small case study on the accuracy of the hachures. My analysis of their accuracy was enabled by the software *MapAnalyst*[60]. Its main purpose is to compute distortion grids and to illustrate the geometrical accuracy of old maps by using pairs of control points on an old map and on a new reference map. I applied the software successfully on two of the three hachures, namely on the sheets 8 and 10[61]. Sheet 8, showing the city of Ohrid and the eastern shore of Lake Ohrid, has a Standard Deviation of 1,165 m and a Mean Position Error of 1,648 m, which manifests itself in the respective distortion grid (*fig. XVI-9*). Sheet 10 depicts the route between Resen and Bitola. Here, the Standard Deviation is 963 m, while the Mean Position Error amounts to 1,361 m. Displacement Vectors are shown in *fig. XVI-10*. They provide vector lines, which start at a point in the analysed map, and end at the position, where the point would be if the analysed map were as accurate as the modern reference map. The longer the vector, the less accurate the point. Since at least five control points are needed for the analysis of a map, sheet 9 illustrating the route between Ohrid and Resen could not be evaluated, because it provides only three usable points (*Reznia*, *Bohuno*, *Krusje*). So, unfortunately, the crucial hachure, which could enlighten the obscure section between Ohrid and Resen from the viewpoint of transportation history, provides only limited data.

That is why another method deriving from GIScience is implemented in the last part of this article by Markus Breier, namely "Least cost path" calculations. The aim and

[60] MapAnalyst, <http://mapanalyst.org/>, 21.6.2017. See also: Jenny, Bernhard–Hurni, Lorenz, Studying Cartographic Heritage: Analysis and Visualization of Geometric Distortions, *Computers & Graphics* 35 (2011), 402–411 (with extensive bibliography).

[61] Austrian State Archives / Österreichisches Staatsarchiv (Vienna), Kriegsarchiv, B III c 19-03, Blätter 8, 10.

function of Least cost path modelling is best explained by the following quotation from the bibliography:

> "Archaeologists, however, often do not know the exact route of transportation links because for much of history transport did not involve the construction of specialised infrastructure such as roads and artificial waterways. Even where it did, such infrastructure may not have been preserved. Under these circumstances GIS [i.e. Geographic Information Systems] can be used to predict transport routes by deriving least-cost paths from an appropriate accumulated cost-surface. Of course, prediction of 'lost' routes is not the only use for least-cost paths: they can be compared to known routes in order to help understand the location of those routes."[62]

Least cost path calculations are used in the following to replicate / predict the route between Ohrid, Resen, Bitola and Prilep, and, thus, to complement the existing written sources, archaeological evidence and maps. Based on the aforesaid multi-layered approach a Least cost path model is put into existence, which links the area of the Lakes Ohrid and Prespa to the aforesaid triangle of Ohrid – Bitola – Prilep.

MIHAILO ST. POPOVIĆ

[62] Conolly, James–Lake, Mark, *Geographical Information Systems in Archaeology*. Cambridge 2006 (*Cambridge Manuals in Archaeology*), 252. The author of this part of the article has successfully proved the usefulness of this approach in particular and of the Historical Geographic Information Systems (HGIS) in general for the fields of Byzantine Studies, South-East European Studies as well as Historical Geography and has elaborated several case studies: Popović, *Historische Geographie*, 10–30 (with extensive bibliography).

5. Least cost path (LCP) Modelling

Computer science, statistic methods and mathematical models had a great impact on research in the Humanities in the last decades. In times of Digital Humanities, even historiography can benefit to some extent from methods developed for other research disciplines. Examples are research questions dealing with Historical Geography. When trying to answer geographical questions, historians can use some of the tools and methods which geographers use. One set of tools are Geographic Information Systems (GIS), which are also applied to a remarkable extent in Archaeology[63]. These are computer systems which are designed to store, analyse and present geographical data.

One function often implemented in GIS are Least cost paths, which are paths from point A to point B, choosing the most efficient route across the landscape. These wayfinding algorithms can also be used to create digital representations of probable courses of roads, where no archaeological evidence exists.

To show the possibilities and limits of such digital reconstructions, Least cost path (LCP) models were calculated for the road between Ohrid and Bitola as well as for the road between Bitola and Prilep.

Computer models can never calculate historical facts, only more or less likely possibilities. The results of the calculations depend on many factors. Foremost, the completeness, accuracy and suitability of the input data has a large impact on the usefulness of the result. One of the biggest issues regarding the input data is the temporal aspect. Most of the available geodata represents the current landscape. Data representing historical conditions is hardly available. Even if old maps of the area of research are available, it can be quite a challenge to georeference and digitise these maps, so that their data can be used

[63] Cf. in general: Conolly–Lake, *Systems*.

in a GIS. Furthermore, with most maps drawn before the development of modern geodesy, this is unfeasible. As a consequence, only proxy data is available for the medieval landscape, be it current geodata or data deriving from maps from the late 16th / early 17th century onwards.

Not only the quality and date of the input data has an impact on the outcome of LCP. The included cost factors and their weighting determine the result even more. The cost factors reflect those factors which humans use to decide where they go or where they create a path. The most important factors are distance and slope. How long do I have to walk and how steep is the way? Therefore, these two are included in almost any LCP analysis which is trying to model human movement through the landscape. This leads to a natural deterministic model of movement. To counter this tendency, attempts are made to include the social landscape and cultural aspects into LCP models[64]. Since this is a complex issue with many difficulties, most LCP analyses conducted by archaeologists are based on slope, some extending this with viewshed analyses and even incorporating visibility into their models[65].

The analytical "view from above" of the GIS-analyses works well for present day applications, such as determining the most efficient route of a new road. When historical roads are modelled, however, this "view from above" is not very helpful, since it does not represent the perception of the landscape in historical times.

Despite of all these shortcomings, LCPs can be useful explorative approximations to historical paths. However, "Least cost paths are idealized patterns, not based on real

[64] White, Devin Alan–Surface-Evans, Sarah L. (eds.), *Least Cost Analysis of Social Landscapes*. Salt Lake City 2012.

[65] Herzog, Irmela, Least-Cost Paths – Some Methodological Issues, *Internet Archaeology* 36 (2014), <http://intarch.ac.uk/journal/issue36/herzog_toc.html>, 22.6.2017.

paths used in the past"[66]. It shows, where paths could potentially have been. It cannot be a positive proof, unless archaeological evidence supports the model. When interpreting the results, one has to keep the limitations of this method in mind.

The potential of these kinds of models is shown in this section of our article by conducting a LCP calculation for the road between Ohrid and Bitola and between Bitola and Prilep. The calculations were done with the GIS software ESRI ArcGIS 10.3 and are based on freely available geodata.

The model described in this article is primarily slope based. Denecke states that medieval routes tended to follow the relief, staying roughly at the same height[67]. Therefore, height above sea level was added as cost factor. Rivers and lakes were included as obstacles.

Slope, however, has to be handled carefully, since it is a direction dependent (anisotropic) cost factor (*fig. XVI-11*). The effective slope varies with the direction in which a sloped area is crossed, and not on the slope itself. The energy cost is therefore dependent on the effective slope. The height above sea level on the other hand is independent of the direction (isotropic).

Furthermore, the relation between slope in degrees and the energy expenditure when walking is not linear. The least energy is used when walking downhill 4°– 6°. The energy expenditure increases on level terrain and increases non-linear on uphill slope. It also increases on a

[66] Branting, Scott, *Seven Solutions for Seven Problems with Least cost pathways*, in: Alan Devin White–Sarah L. Surface-Evans (eds.), *Least Cost Analysis of Social Landscapes*. Salt Lake City 2012, 209–224, here 212; cf. also: Scarf, Philip, Route Choice in Mountain Navigation, Naismith's Rule, and the Equivalence of Distance and Climb, *Journal of Sports Sciences* 25/6 (2007), 719–726.

[67] Denecke, Dietrich, *Wege der historischen Geographie und Kulturlandschaftsforschung. Ausgewählte Beiträge*. Wiesbaden–Stuttgart 2005, 455f.

downhill slope. Van Leusen[68] developed a formula based on energy expenditure of an average adult at a walking speed of 4.8 km/h. These calculations will be the basis for determining the anisotropic cost. In order to balance the weight of the other cost factors, the energy expenditure is multiplied by 0.5 for the least cost calculation. It is not possible to enter the formula itself in ArcGIS. Therefore, a lookup table has to be created. The values are calculated for slopes from -30° to 30° in steps of 2.5°. Effective slopes greater than 30° are excluded from the calculation, since this would be far too steep for a viable road.

5.1 Data used for Calculations

The data used for this model is freely available. For the elevation data – and the derived slope data – the Shuttle Radar Topography Mission (SRTM) data is used[69]. The SRTM data is an elevation model with a horizontal resolution of 30 m, which is available for the whole surface of the Earth.

Regarding the hydrography the watercourses and lakes from the Vector Map Level 0 (Vmap0, formerly known as Digital Chart of the World) are used[70]. This dataset is compiled by the National Mapping Agency of the USA and is in the public domain. The geometry of the data is generalized for a scale of 1 : 1,000,000. Therefore the data has to be adjusted to the DEM, so that the two datasets are consistent. These adjustments have to be done manually in ArcGIS. Furthermore, the dataset on the watercourses consists of line representations of the rivers, with no width recorded

[68] Leusen, Pieter Martijn van, *Pattern to Process*. PhD, Rijksuniversiteit Groningen 2002.

[69] CGIAR – Consortium for Spatial Information (CGIAR-CSI), <http://srtm.csi.cgiar.org/>, 22.6.2017.

[70] VMAP0, <http://www.mapability.com/info/vmap0_intro.html>, 22.6.2017.

in the dataset. As the Least Cost algorithms can only use raster data as input, the rivers had to be converted from vector data into raster data. To prevent artefacts during this conversion, the rivers are changed from line representations to polygon representation with a general width of 60m assigned. The LCP algorithm would interpret these artefacts as places where the river could be traversed very easily (*fig. XVI-12*).

5.2 Data Classification and Algorithms

The ArcGIS algorithm, used to calculate cost distance, calculates the effective slope automatically. Therefore, it is not necessary to derive the slope from the DEM in a separate step. However, the factors contributing to the isotropic cost have to be classified and combined into a single cost of passage map before the execution of the cost calculations.

The height above sea level is an important additional factor. A purely slope based LCP results in a less plausible model of the road, especially when a mountain range has to be crossed. The height was coded as a cost multiplier according to the following table:

Height above Sea Level	Cost Factor
0m – 1000m:	1
1000m – 1200m:	2
1200m – 1400m:	3
More than 1400m	5

Lakes were assigned a cost factor of 100, effectively making them barriers. Rivers were assigned a cost factor of 10, making them hard, but not impossible to traverse (the available data is lacking information on whether a river is fordable or not).

In order to get the final cost of passage map, the three layers (height above sea level, rivers, lakes) were multiplied with the ArcGIS raster calculator. For the slope, no reclassification was necessary, because the ArcGIS algorithm only needs a DEM. The slope and effective slope is calculated internally.

The calculation of LCPs in ArcGIS is achieved with two tools included in the software. Both tools, path distance and cost path, have to be used to calculate LCPs. Path distance is the more complex tool and has to be used first to create a so-called accumulated cost surface. The accumulated cost surface is calculated for a starting point (or area), using isotropic and anisotropic cost factors. It is a raster where each cell has a cost value assigned. This value represents the cost it takes to reach this cell from the starting point[71]. The path distance tool uses the cost of passage map for the isotropic cost and uses a DEM to calculate the slope based anisotropic cost.

Once this accumulated cost surface is created, the tool cost path can find the route with the least cost from another point (or area) to the starting point. This route is then the final LCP.

5.3 Cartographic Representation

The result of the GIS calculations are rasterized paths, which, dependent on the resolution of the input data, can be jagged to some degree. Furthermore, multiple lines at the start or end point can occur. Therefore, a conversion to vector based lines and some cartographic generalisation, like smoothing of the lines, can be necessary to achieve an appropriate cartographic representation of the path.

71 Douglas, David H., Least-Cost Path in GIS Using an Accumulated Cost Surface and Slopelines, *Cartographica: The International Journal for Geographic Information and Geovisualization* 31/3 (1994), 37–51.

However, there is also the issue of uncertainty. As the model is only an approximation – an idealised pattern – and not the representation of a real line, a crisp visualisation of the path can be misleading. Crisp shapes are interpreted as exact results. Fuzzy shapes, on the other hand, are easily interpreted as uncertain and imprecise[72]. To make the inherent uncertainty visible, the LCP on the map shown in this article is widened to a broad corridor (*fig. XVI-13*), and the edges of this corridor are blurred. The road was likely within this corridor, but where exactly, cannot be determined by the model. Regarding the second part of this article it can be stated that the section of the LCP model between Ohrid and Resen corresponds to the aforesaid third variant of the winter road (namely from Ohrid via Leskoec, Skrebatno and Ilino to Resen).

MARKUS BREIER

6. Conclusion

Least cost paths are viable models that can help to understand historical transportation networks. Thus, they have the capacity to complement the thorough analysis of the surviving written sources, the archaeological evidence *in situ* and published as well as unpublished maps. Because every "model is only as good as the input data and the ways in which those data are managed"[73], surveys in the area of research are crucial in order to acquire substantial and significant geodata (i.e. GPS-waypoints, GPS-tracks).

[72] MacEachren, Alan M.–Robinson, Anthony–Hopper, Susan–et al., Visualizing Geospatial Information Uncertainty: What We Know and What We Need to Know, *Cartography and Geographic Information Science* 32/3 (2005), 139–160.

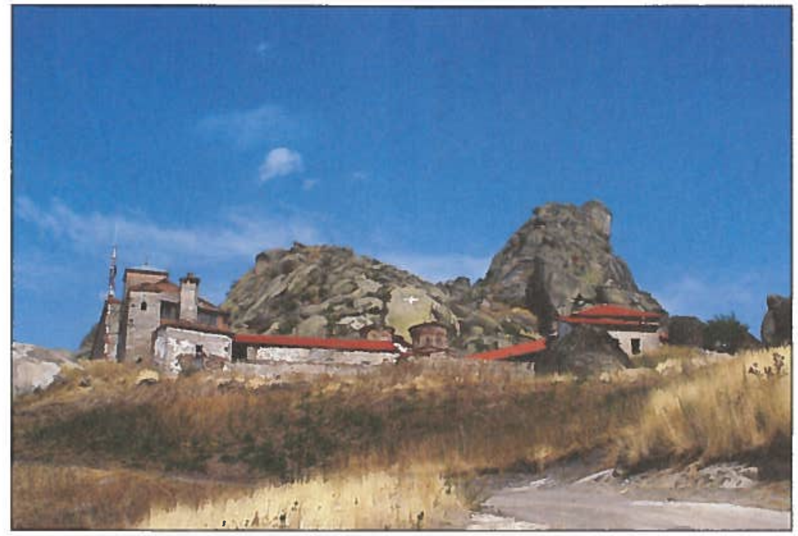
[73] Chapman, Henry, *Landscape Archaeology and GIS*. Stroud 2006, 107.

The model presented in this article is viable and can be a good approximation to the road between Ohrid and Bitola and Bitola and Prilep. However, it has to be noted, that the result is an idealised representation, not necessarily the real course of the road. Various uncertainties (e.g. present day data, uncertain locations of historical landmarks) also have to be considered when the results are interpreted.

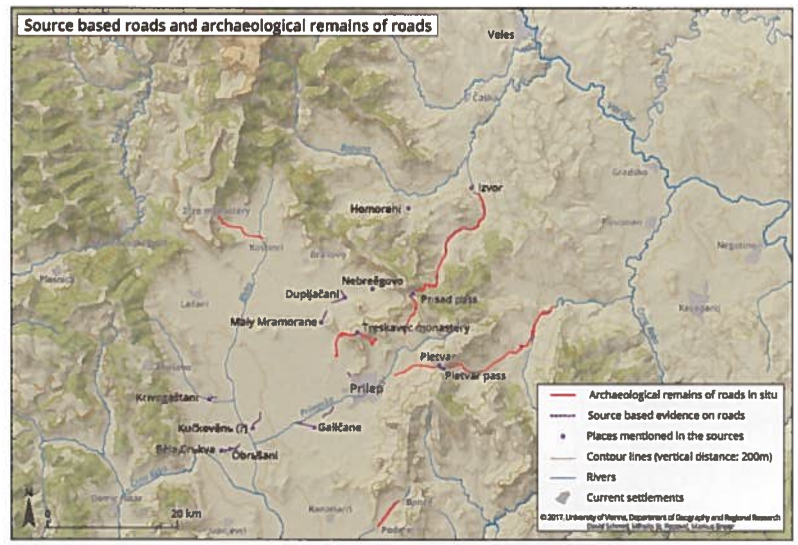
Nonetheless, computer generated models like Least cost paths can lead to new insights regarding historical landscapes. The integration of social, political and economic factors as well as agent-based methods like view-shed might further enhance the viability of these models. These factors, however, are difficult to formalise, so that they can be used within a GIS.

The hereby presented multi-layered approach shall serve as an impulse for similar studies on other essential transportation routes and zones, which connected different peoples in the past and still connect them today in a united Europe.

XV-19: Das westliche Hinterland von Konstantinopel. Külzer, Ostthrakien, Thematische Karte 1:800.000 (Ausschnitt).

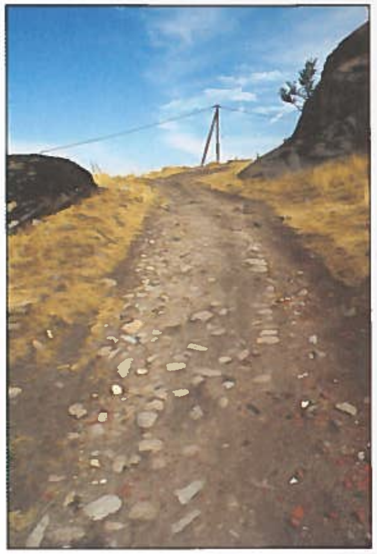


XVI-1: The Monastery of the Holy Mother of God in Treskavec from the South (M. St. Popović, *TIB* 16, 2008)



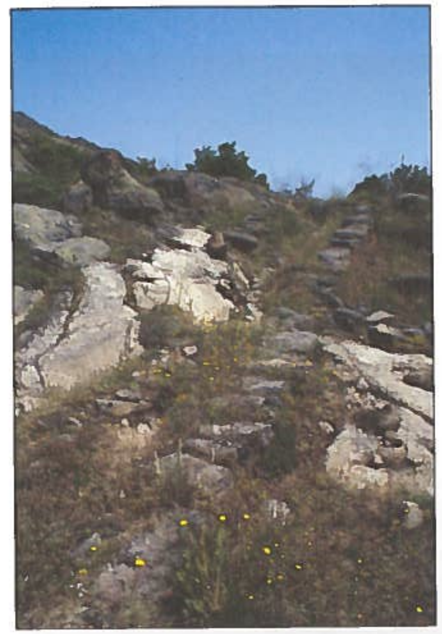
XVI-2: Source based Roads and Archaeological Remains of Roads

XVI-3: The German Road from WW I over the Pass of Prisad (M. St. Popović, *TIB* 16, 2016)



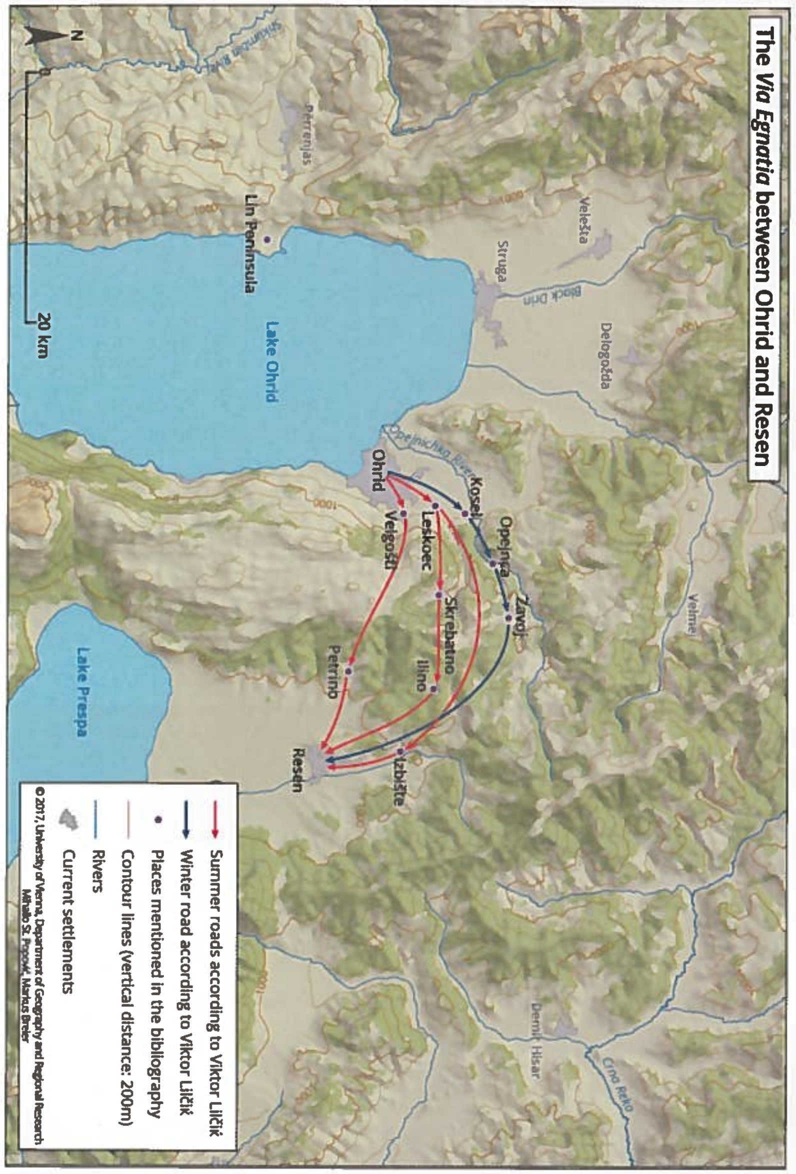
XVI-5: The Western Road to the Monastery of the Holy Mother of God in Treskavec (M. St. Popović, *TIB* 16, 2008)

XVI-4: The German Road from WW I over the Pass of Prisad (M. St. Popović, *TIB* 16, 2016)

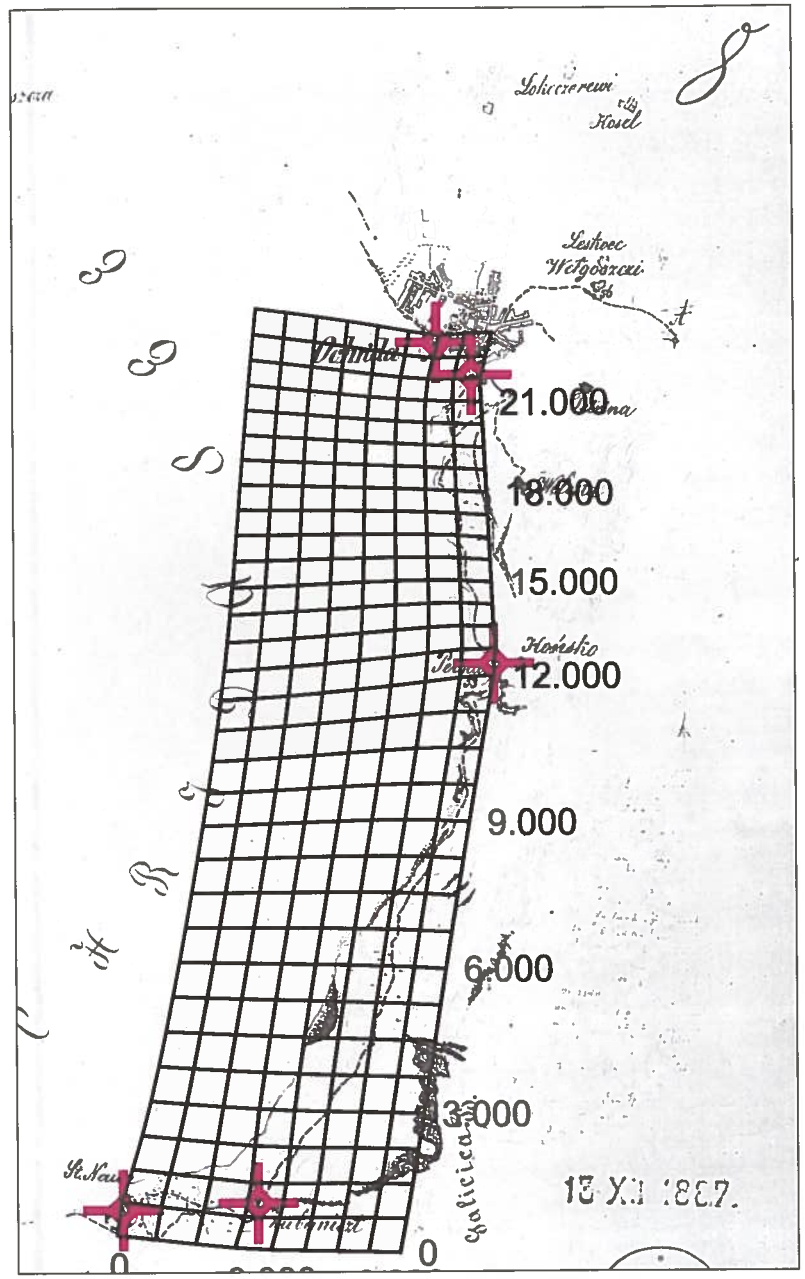


XVI-6: The Eastern Road to the Monastery of the Holy Mother of God in Treskavec (M. St. Popović, *TIB* 16, 2016)

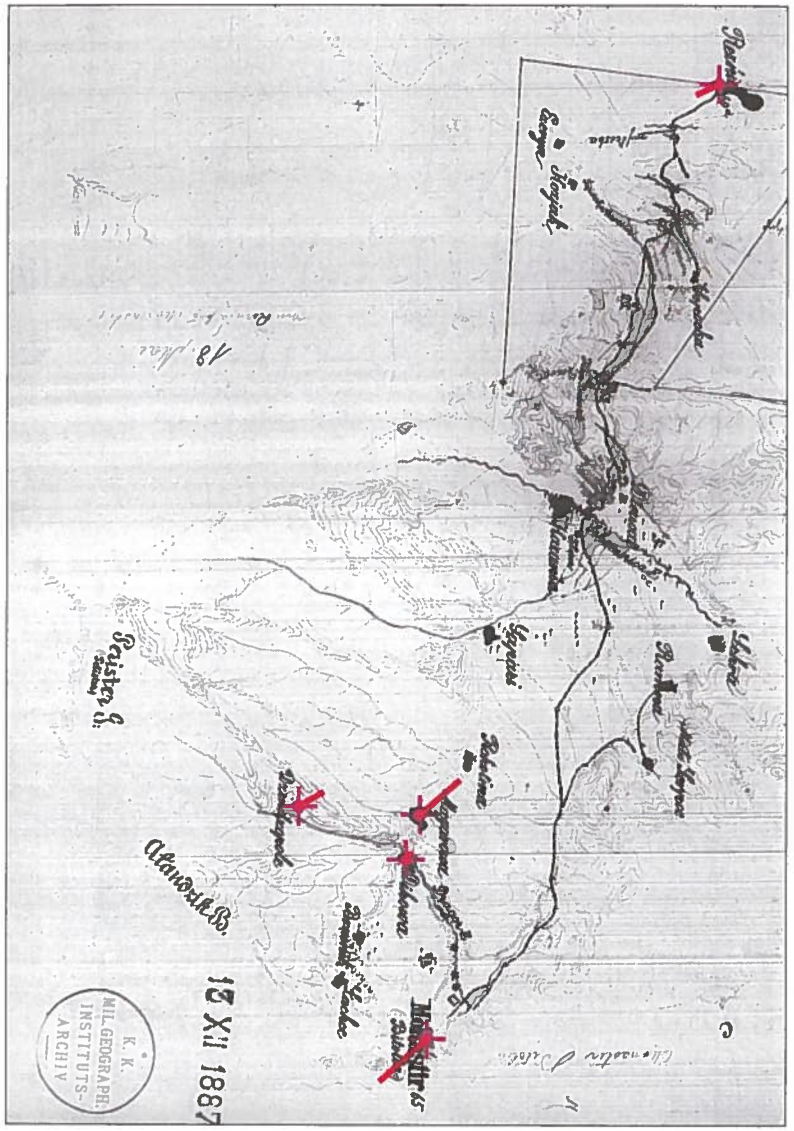
XVI-7: The Old Road between the Villages of Podmol and Bonče (M. St. Popović, *TIB* 16, 2016)



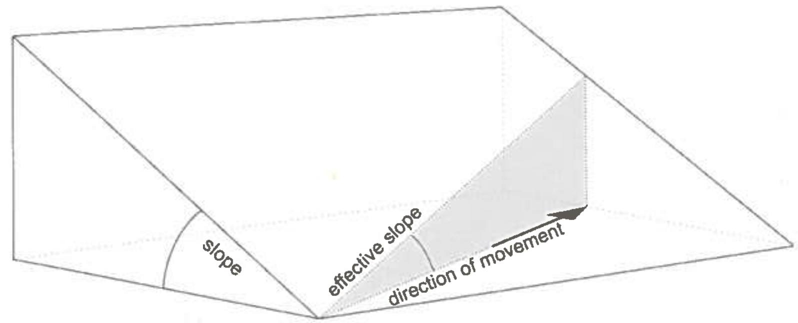
XVI-8: The Via Egnatia between Ohrid and Resen



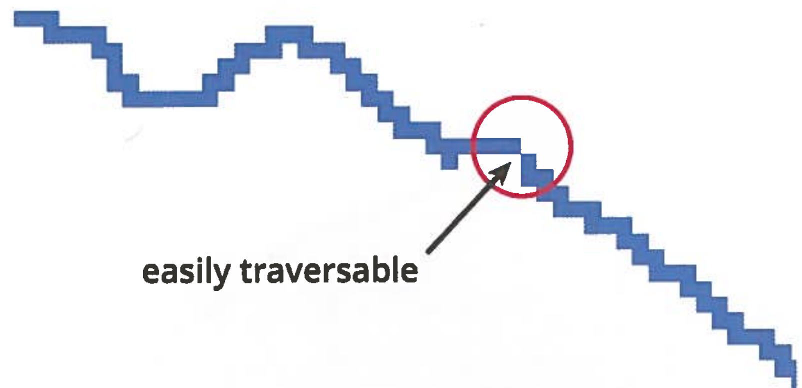
XVI-9: The Analysis of the Austro-Hungarian Hachure on the Area of Ohrid [Austrian State Archives / Österreichisches Staatsarchiv (Vienna), Kriegsarchiv, B III c 19-03, Blatt 8]



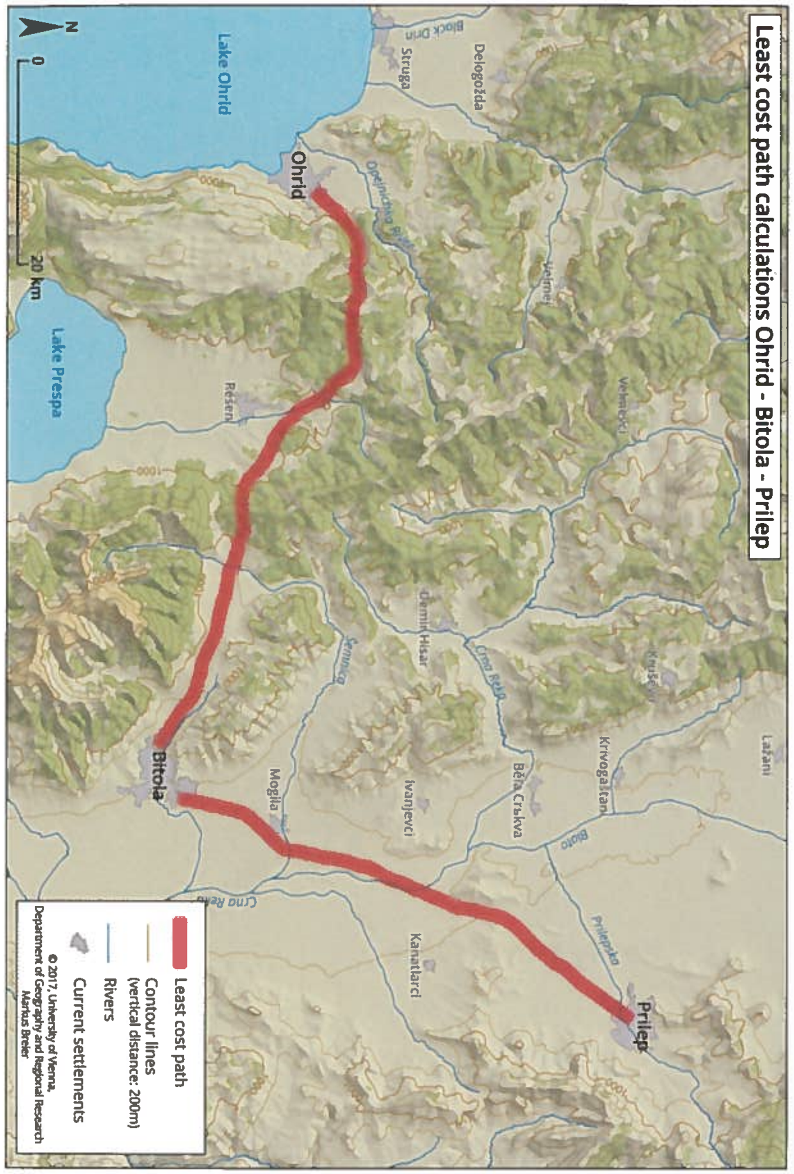
XVI-10: The Analysis of the Austro-Hungarian Hachure of the Area between Resen and Bitola [Austrian State Archives / Österreichisches Staatsarchiv (Vienna), Kriegsarchiv, B III c 19-03, Blatt 10]



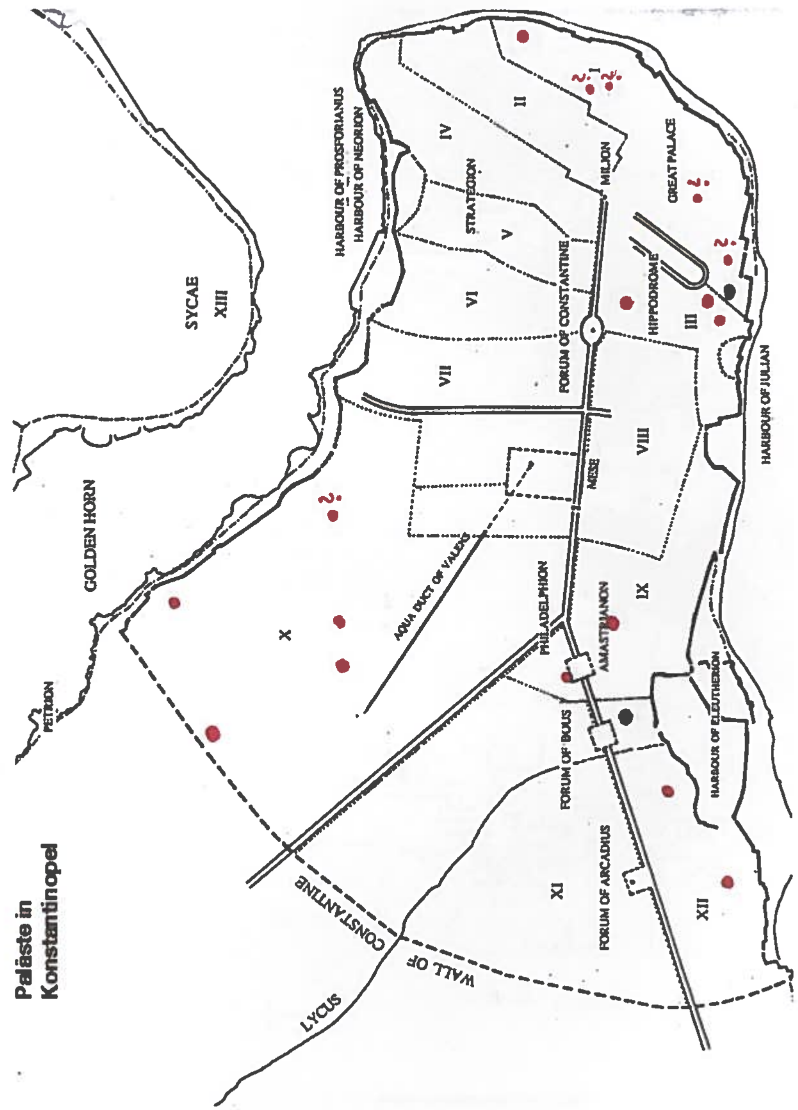
XVI-11: Slope and Effective Slope (M. Breier, 2017)



XVI-12: Artefacts of the Conversion to Raster Data.
In Diagonal Direction, Rivers are no Barrier at these Points
(M. Breier, 2017)



XVI-13: Least cost path Calculations Ohrid - Bitola - Prilep



XVII-1: Paläste in Konstantinopel