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The Anina (Steierdorf) coal mining district in Banat (Romania) on some old geological maps (1850–1884)

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Abstract

The paper presents some old geological maps from the nineteenth century (1850–1884) related to the Anina (Steierdorf) coal mining district – stored in the Library of the Geological Survey of Austria (*Geologische Bundesanstalt*): the manuscript map *Steierdorf Banat* (~1850); *Spezialkarte des mittleren Theiles des Banater Gebirgszuges* (1857); *Banater Domäne: enthaltend den vormaligen k. k. aerarischen Montan-Complex nebst den Staats. Herrschaften Oravicza und Bokschan: Geognostische Karte* (1860); *Geologische Karte von Steierdorf im Banat* (1867[?]); *Geognostische Übersichtskarte des Kohlenbergbau Terrains von Steierdorf* (1872[?]). The aim of this study is on the one hand, to offer a brief survey on the historical cartographic overview of the maps with special respect to the geological mapping activity concerning Anina (Steierdorf) region (or in a wider sense, the Banat Mountains) in the mid-nineteenth century. On the other hand, the paper summarizes the cartographic analysis of the maps, which has been made using MapAnalyst software application in order to test their cartographic accuracy, as well as to make possible (or easier) the geo-referencing process. This analysis, together with the study of the geological content of the maps is necessary when the goal is to test their reliability for the present researches. We have distinguished two phases in the geological mapping of the Anina (Steierdorf) region before the 3rd Military Survey (1884). The first phase contains the maps plotted before the 2nd Military Survey (1864), which represent a larger area on an approximate scale of 1:100,000. The second phase contains the maps compiled between the 2nd and the 3rd Military Survey (1864–1884) which represent a smaller area (only the Anina Anticline) on a scale of 1:10,000. We have observed a progress in the representation methods and nomenclature of geological content in time, as well as a significant improvement in the cartographic accuracy of the maps belonging to these two phases (improvement in the precision of their scale and orientation, as well as a decrease in the displacement errors).

Die Publikation behandelt einige alte geologische Karten aus dem neunzehnten Jahrhundert über die Kohlebergbauregion Anina (Steierdorf). Folgende Karten befinden sich an der Geologischen Bundesanstalt (Österreich): die Manuskriptkarte *Steierdorf Banat* (~1850); *Spezialkarte des mittleren Theiles des Banater Gebirgszuges* (1857); *Banater Domäne: enthaltend den vormaligen k. k. aerarischen Montan-Complex nebst den Staats. Herrschaften Oravicza und Bokschan: Geognostische Karte* (1860); *Geologische Karte von Steierdorf im Banat* (1867[?]); *Geognostische Übersichtskarte des Kohlenbergbau Terrains von Steierdorf* (1872[?]). Das Ziel dieser Studie ist einerseits eine kurze Übersicht über die kartographische Geschichte dieser Karten zu geben, insbesondere die geologische Landesaufnahme der Region Anina (Steierdorf) (oder im allgemeinen Sinne der Gebirgregion Banat) betreffend. Andererseits fasst diese Publikation eine kartographische Analyse dieser Karten zusammen. Die Karten wurden mit der Software MapAnalyst auf ihre kartographische Genauigkeit analysiert womit eine Georeferenzierung ermöglicht wird. Diese Analyse, zusammen mit der Untersuchung des geologischen Inhaltes dieser Karten, wird benötigt um eine Aussage zu deren Zuverlässigkeit für aktuelle Analysen machen zu können. Wir konnten zwei Phasen in der geologischen Landesaufnahme der Region Anina (Steierdorf) vor der dritten topographischen (Franzisko–Josephinische) Landesaufnahme (1884) erkennen. Die erste Phase beinhaltet Karten, die vor der zweiten topographischen (Franziszeischen) Landesaufnahme (1864) ausgearbeitet worden. Diese umfassen eine größere Region auf einer Skala von ungefähr 1:100.000. Die Karten der zweiten Phase wurden zwischen der zweiten und der dritten topographischen Landesaufnahme (1864–1884) erstellt. Diese Karten umfassen ein kleineres Gebiet (nur die Anina Antiklinale) auf einer Skala von 1:10.000. Eine zeitliche Entwicklung der Darstellungsmethoden und der Nomenklatur der geologischen Inhalte ist festzustellen. Ebenfalls hat sich in dieser Zeit die kartographische Genauigkeit (Skalen- und Dislokationsgenauigkeit) erheblich verbessert.

1. Introduction

Geological maps are special-purpose thematic maps, which allow the geological orientation and cognition of a certain area (Brezsnyánszky, 2007; Oldroyd, 2013). They show, on topographic base maps, information regarding the petrographic composition, structure and stratigraphic succession (succession in time) of the geological features at and under land surface. Beyond the fact that they represent an important part of our cultural (thematic cartographic) heritage, old geological maps – like old maps in general – are increasingly used as sources of information for historical studies (Jenny and Hurni, 2011, www.mapanalyst.org), especially due to the rapid development of GIS software and applications. At the same time, old geological maps are essential sources of information about the geological knowledge characteristic to a specific time.

The study of the old geological maps is extremely important not only for their role in the history of geological mapping, but also from a practical point of view. In order that an old geological map can be a reliable source of information for present researches, both its geological content and cartographic accuracy must be analysed. Therefore, the exploration of the mathematic elements of their topographic basis (either geodetic datum/projection, or the graticule subsequently computed using a GIS software or application) makes possible (or easier) the geo-referencing process, which would be more difficult using control points defined by content. With geo-referenced geological maps, further GIS applications can be performed: e.g. extraction of geological information (data); overlapping geo-referenced geological maps from different periods, or combining them with other geoinformation datasets (e.g. SRTM datasets (Werner, 2001; Timár et al., 2003)) etc. Therefore, the study of the geological content of the map together with the investigation of the cartographic accuracy makes possible the analysis and comparison of old geological data with modern ones, and consequently the tracking of the evolution of geological knowledge in time (Korodi and Hofmann, 2016).

The aim of this paper is to present some old geological maps from the nineteenth century (more precisely: 1850–1884) showing the Anina (Steierdorf) coal mining district, with special respect to the historical cartographic background, to the geological content (especially the legend) of the maps, as well as to their cartographic analyses. The studied maps are: the manuscript map *Steierdorf Banat* [Anina Banat](***, ~1850); *Spezialkarte des mittleren Theiles des Banater Gebirgszuges* [The geological map of the middle part of the Banat Mountains] (Kudernatsch, 1857a); *Banater Domäne: enthaltend den vormaligen k. k. aerarischen Montan-Complex nebst den Staats. Herrschaften Oravicza und Bokschan: Geognostische Karte* [Banat district: comprising the imperial and royal mountain territory complex, beside the state one. The mining region Oraviţa and Bocşa: geognostic map] (*** [Foetterle], 1860); *Geologische Karte von Steierdorf im Banat* [Geological map of Anina in Banat] (Roha, 1867a[?]); *Geognostische Übersichtskarte des Kohlenbergbau Terrains von Steierdorf* [Geognostic map of the Anina coal mining region] (***, 1872[?]). All these maps are stored in the Library of the Geological Survey of Austria.

The area of the Anina (Steierdorf) coal mining district (in a wider sense the area of the historical region of Banat of Temes) was mapped in 1881–1882 by the 3rd Military Survey (Jankó, 2007: 92). The general map series on a scale of 1:75,000 (*Spezialkarten* (Jankó, 2007:101–102)) – derived from the original map sheets on the scale of 1:25,000 mainly by reducing their scale and by methods of cartographic generalization – published in 1884 served as accurate basis for the second systematic, sheet-by-sheet geological mapping, in this area for the following geological thematic maps: the manuscript maps *Zone 25 Col. XXV Kudritz und D.-Oravica* (***, ?) and *Zone 25 Col. XXVI. Krassova und Teregova 1:75,000* (***, ?), as well as *A Magyar korona országainak részletes geológiai térképe 1:75 000:Temeskutas* [The detailed geological map on a scale of 1:75,000 of the lands of the Hungarian Crown] (Telegdi Roth et al., 1909) and *Krassova és Teregova* (Telegdi Roth et al., 1903). Therefore, the accuracy analysis and the geo-reference of these geological map sheets is equivalent to the analysis and geo-reference of the topographic map sheets of the 3rd Military Survey which has already been done and published (Biszak et al, 2007, www.mapire.eu). The geological maps that we study in this paper have not been based on topographic surveys; thus our aim is to analyse these geological maps, plotted before the 3rd Military Survey (1884).

2. Geology of the investigated area

The Anina mining district, famous for its coal mining, is located in the South-Western part of Romania, Caraş-Severin County, in the historical province of Banat of Temes. In the nineteenth century it was part of the Habsburg Monarchy, as well as of the Austro–Hungarian Monarchy (as part of the Hungarian Kingdom). In that period, its name was *Steierdorf–Anina* in German, and *Stájerlakanina* in Hungarian (Szabó, 2003: 51).

In geological terms, the Anina coal mining area belongs to the Median Dacides, more precisely to the Getic Nappe, including both the crystalline basement and the Mesozoic sedimentary cover. The economically significant sediments (namely coal and bituminous shales) of Anina and its surroundings are represented by Lower Jurassic (Liassic) continental and paralic deposits (Săndulescu, 1984).

The Anina coal mining area is located along the Anina Anticline, oriented approximately North–South, with Lower Jurassic coal bearing strata along both of its flanks (Popa, 2005; Kędzior and Popa, 2013). This anticline belongs to the central area of the Reşiţa Basin with Lower Jurassic–Late Cretaceous sediments (Popa, 2005), also known as the Reşiţa–Moldova Nouă sedimentary zone (Kędzior & Popa, 2013; Csiki-Sava et al, 2016), the largest sedimentary basin of the Getic Nappe (Murgoci, 1905; Săndulescu, 1984). During the Alpine: Austrian and Laramian orogenic phases, these deposits were folded and faulted along a series of important alignments oriented approximately North–South (Popa, 2005). The coal bearing sediments are represented by the Steierdorf Formation, Hettangian–Sinemurian (Early Jurassic) in age (Bucur, 1991, 1997; Popa and Kędzior, 2008), also famous for the richness and high diversity in Early Jurassic fossil plant species (counting more than 120 taxa), and extremely valuable for paleobotany, as well as for the paleobotanical heritage. The Early Jurassic paleobotanical material from Anina has been collected and studied in details since 1850 (Krasser, 1917; Langer, 1945; Semaka, 1962; Popa, 2005; Popa & Meller, 2009). The Steierdorf Formation, which is a detritic, continental formation, unconformably overlays the Late Paleozoic formations of the

Reşiţa Basin or the crystalline basement, and is conformably overlain by the black, bituminous shales of the Uteriş Formation, Pliensbachian–Middle Toarcian (Early Jurrasic) in age (Bucur, 1991, 1997; Popa and Kędzior, 2008; Popa and Meller, 2009). In some parts of the coal-bearing beds a direct contact of volcanic rocks with some black and brownish alterations of the sediment is known (Roha, 1867b:70; Hussak, 1881, 1885) (see Figure 5: "*Melaphyr, Porphyr*"). Both the coal and the bituminous shales were extracted for more than 200 years from the same mines (Popa et al., 2010). The Anina Anticline is separated by a set of longitudinal faults, and its western flank is fragmented by transverse faults (Kędzior & Popa, 2013). All mining coalfields from Anina with their open cast mines or pits come up along the flanks of this anticline (Popa, 2005; Kędzior & Popa, 2013).

The most important coalfield in Banat was discovered in 1790 in Steierdorf by a woodcutter, Mathias Nikolaus Hammer (Kudernatsch, 1850; Roha, 1867b; ***, 1893; Reimann, 2002). The coal extraction began two years later, in 1792 in Steierdorf (Roha, 1867b; Reimann, 2002), the coal found here being probably of the very first rank in the Habsburg Empire (Foetterle, 1865), but also in Europe, as it turned out later, in 1837 (Roha, 1867b; Kókai, 2010). Several mining fields were given in concession to private entrepreneurs, then, in 1846 the mines were taken over by the Imperial Treasury (*Montanaerar*) (Kudernatsch, 1850; Roha, 1867b; Kokai, 2010). In 1855 the mining assets from Anina (Steierdorf), as well as the entire Banat domain were bought by Austrian Railways Co. (*k. k. priv. Österreichische Staatseisenbahngesellschaft*) (Roha, 1867b; Kókai, 2010). This private multinational Austrian–French railway company used its own mines to supply the mineral resources required for the construction of the Szeged–Timişoara–Baziaş (Szegedin–Temeschwar–Baziasch, Szeged–Temesvár–Báziás), as well as other railway lines (Brezsnyánszky, 1996). Giving the concession of the entire mining and metallurgical assets of the Banat mountainous region to the Austrian Railways Co., has opened a new chapter in the history of mining industry in Banat (Kokai, 2010), facilitating significantly the development of the economy of Banat in 1855–1920. Thus the mountainous region of Banat became one of the largest industrial complexes in the Austro–Hungarian Empire in that period (Reimann, 2002; Gräf, 2011).

3. Historical cartographic overview and sources of research

The detailed and systematic geological mapping of the Habsburg Monarchy started in the mid-nineteenth century, and the Imperial and Royal Geological Institute (*k. k. geologische Reichsanstalt*) founded in Vienna in 1849, as well as the Royal Hungarian Geological Institute (*Magyar Királyi Földtani Intézet*) founded in Budapest in 1869 had a key role in this activity (Brezsnyánszky and Turczi, 1998; Barczikayné Szeiler et al., 2009; Pentelényi and Síkhegyi, 2012). At that time, the major goal of these institutes was the unified and systematic geological surveying and mapping of the entire Habsburg Monarchy (Schnabel at al., 1999) in a period when the needs of raw materials increased significantly due to the economic boom of the Monarchy, which required science-based geological researches (Pentelényi and Síkhegyi, 2012). For an efficient extraction of raw materials, the Court Chamber set a high value on scientific researches and geological mapping. This is also proved by the fact that the Imperial and Royal Geological Institute obtained permission to use the (otherwise) secret topographic map sheets (actually their simplified sketches) of the 2nd Military Survey on a scale of 1:28,800 for the geological mapping activity. Nevertheless, the geological map sheets on a scale of 1:28,800 have remained as manuscripts; they have never been published (Pentelényi and Síkhegyi, 2012).

The first systematic, sheet-by-sheet geological mapping activity of the Habsburg Empire started in 1851 (Haidinger, 1859) based on the deduced detailed maps of the 2nd Military Survey on a scale of 1:144,000 (*Spezialkarten* (Jankó, 2007: 76–80)). The geological mapping of the parts of the Monarchy belonging to the Hungarian Kingdom was limited at first mostly to the areas rich in raw materials (Barczikayné Szeiler et al., 2009), and it was performed by the Imperial and Royal Geological Institute, as well as by the Royal Hungarian Geological Institute (from 1869). However, in the Hungarian Kingdom (including also the historical province of Banat), this map series hasn't been completed, its compilation was interrupted after 1880 (because in the meantime the geological surveying for the second systematic geological mapping on the scale of 1:75,000 begun), and the missing map sheets haven't been finished (Barczikayné Szeiler et al., 2009). Although the mining districts of Banat – important from economical, as well as strategic point of view – represented a great interest for the Court Chamber, and two geological map sheets: *Versecz* (Vršac, Werschetz, Versec), as well as *Fehértemplom–Kubin* (Bela Crkva–Kovin, Weißkirchen–Kubin) on a scale of 1:144,000 have been completed in the district of South Banat, a map sheet showing Anina and its surroundings hasn't been compiled. Still, the Anina coal mining area, as well as other mining districts of Banat were intensively surveyed in the mid-nineteenth century, all the more so because the geology of this area hadn't previously been studied in details (Kudernatsch, 1855a; Roha, 1867b), since Banat was liberated from the Turkish rule later (in 1718, the Treaty of Passarowitz). This interest in researching the geology of the mining districts of Banat is also demonstrated by the fact that a manuscript geological map (Figure 1) showing Anina and its wider surroundings (***, ~1850) was plotted around 1850, according to the catalogue of the Library of the Geological Survey of Austria. The absence of the Baziaş–Oraviţa (Baziasch–Orawitz, Báziás–Oravicabánya) railway, which was opened later in 1856, confirms this approximate dating.

The map (Fig. 1) represents the area between Anina and the Danube on a paper with the dimensions 45x61 cm. The scale and the orientation aren't written on the map (the catalogue indicates a scale of 1:28,800, but the details of the map and

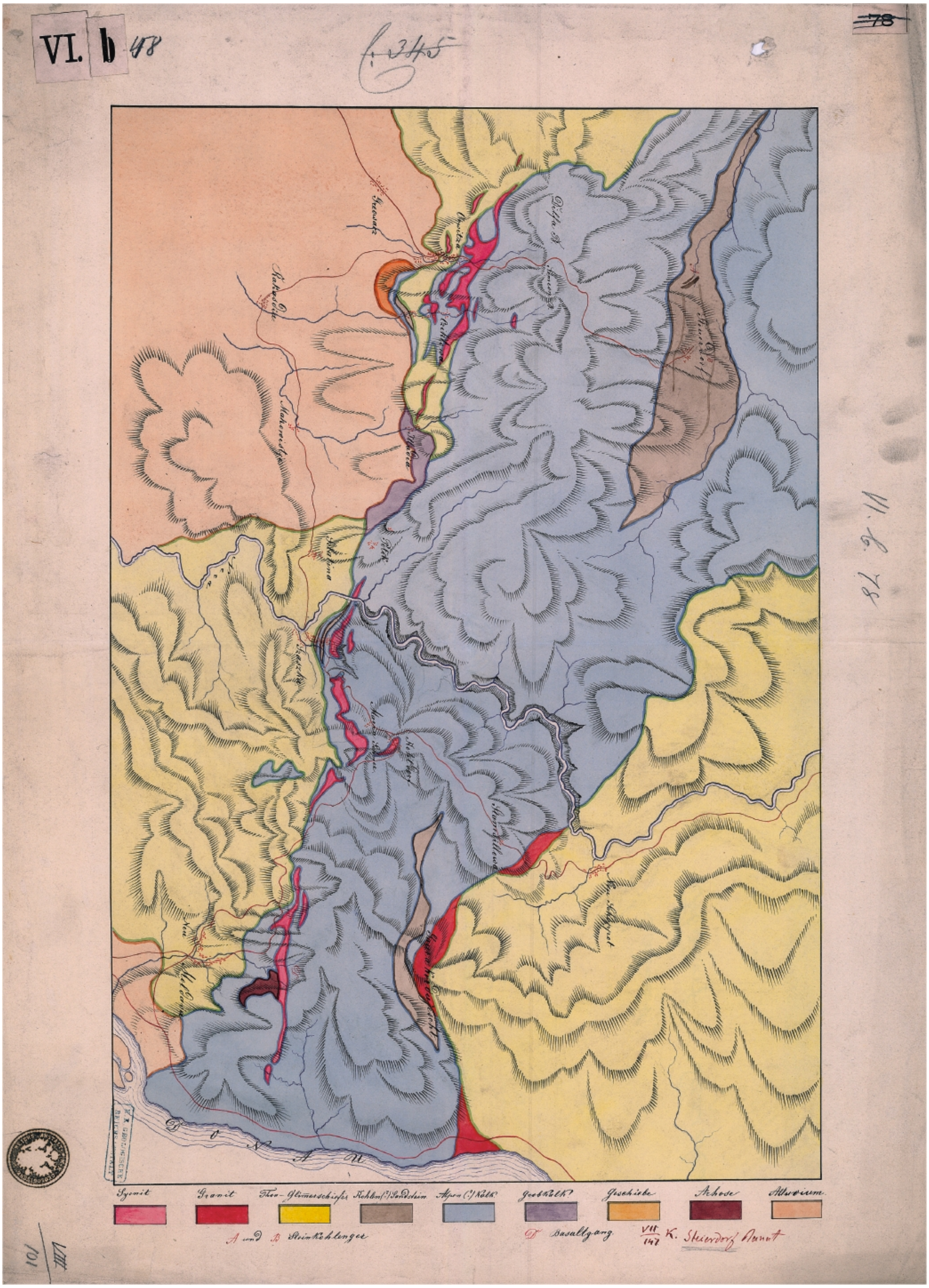

Figure 1: *Steierdorf Banat* (***, ~1850). Source: Library of the Geological Survey of Austria.

our calculations contradict that; see subchapter 4.1.). The representation methods of the geological content reflect an early geological map, more precisely a petrographic map with some stratigraphic information characteristic for the first half of the nineteenth century; therefore we can conclude that the map had probably been edited before 1849, consequently before the foundation of the Imperial and Royal Geological Institute. However, we couldn't find any data concerning the possible author of the map. The legend distinguishes 9 rock types and stratigraphic units by using different colours, as well as a mixture of lithological and stratigraphic connotations. The map is a "nontectonic" map, without any tectonic elements indicated on it.

In addition to the systematic, sheet-by-sheet geological mapping of the Habsburg Empire, also local large-scale mapping was carried out in the second half of the nineteenth century, particularly in mining areas (Brezsnyánszky, 1996). In Banat, this large-scale geological mapping activity was performed principally for the Austrian Railways Co.

In the Anina coal mining area the geological surveying and mapping activity was carried out generally by such accomplished geologists (employees of the Imperial and Royal Geological Institute, as well as of the Austrian Railways Co.) as Johann Kudernatsch (1819–1856) – geologist of the Imperial and Royal Geological Institute (1850–1852) and mining assistant director (*Bergverwaltersadjunkt*) in Steierdorf (1853–1855), Franz Foetterle (1823–1876) – chief geologist of the Imperial and Royal Geological Institute (1849–1876) and mi-

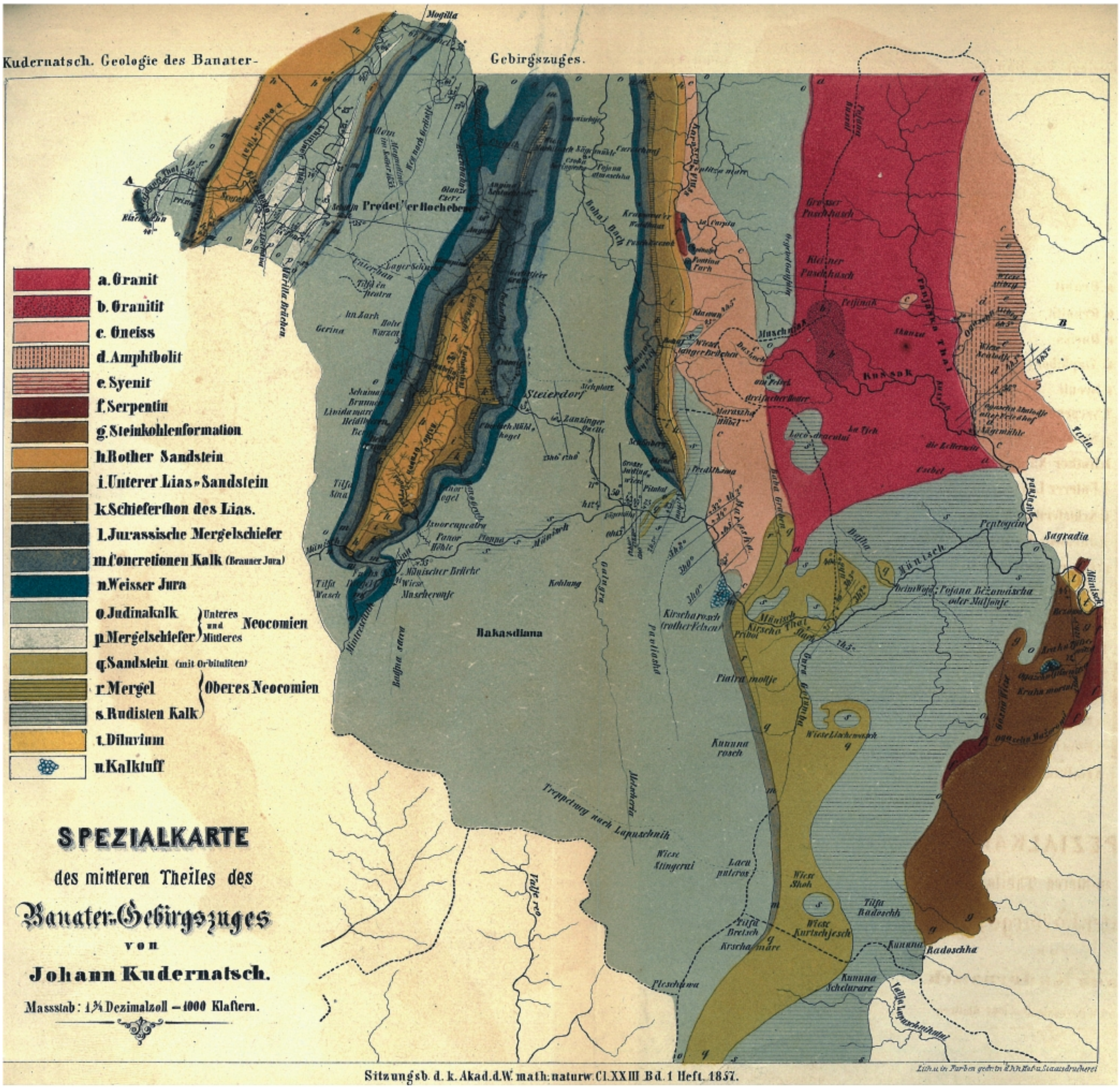

Figure 2: *Spezialkarte des mittleren Theiles des Banater Gebirgszuges* (Kudernatsch, 1857a). Source: Library of the Geological Survey of Austria.

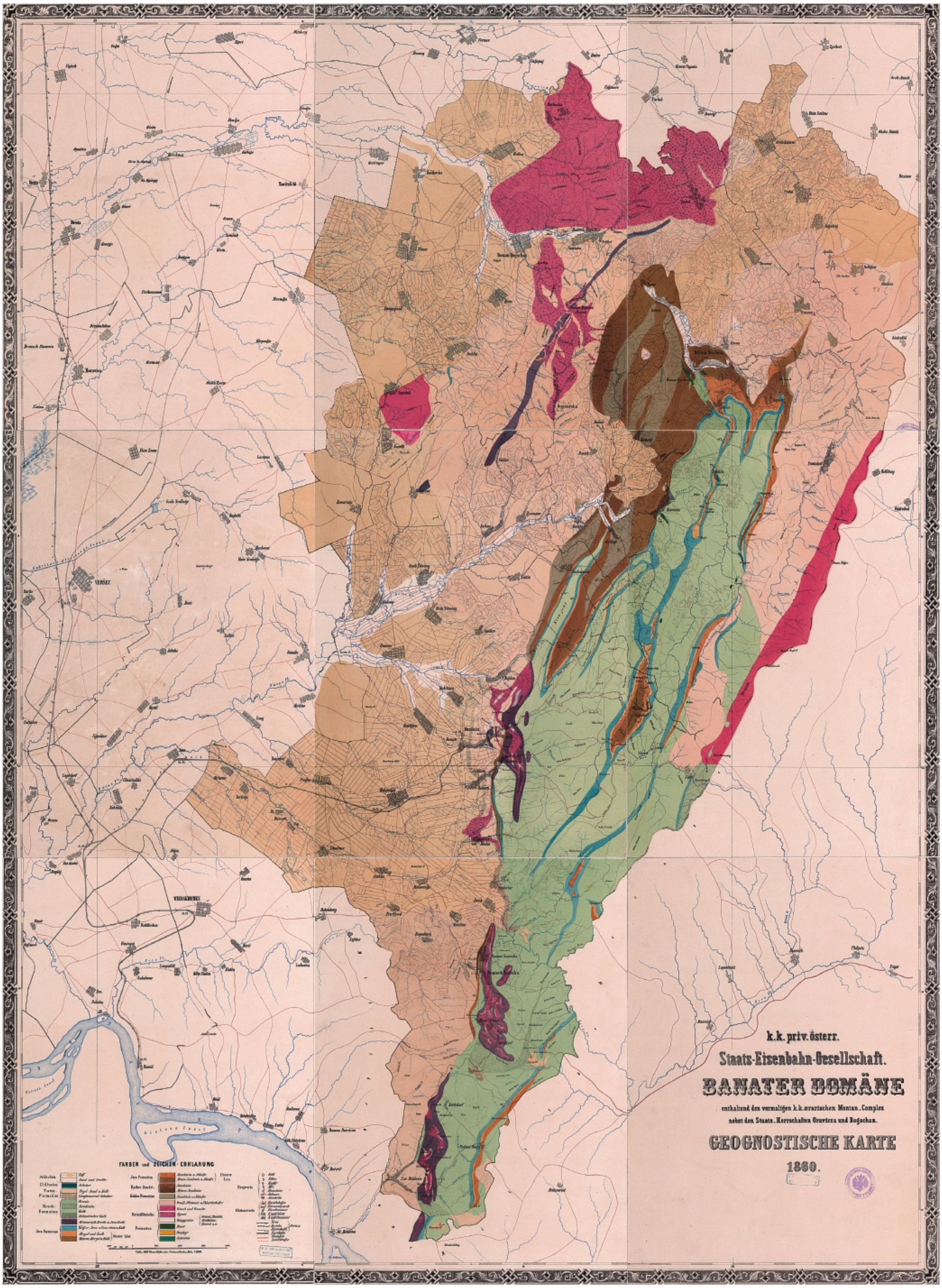

Figure 3: *Banater Domäne: enthaltend den vormaligen k. k. aerarischen Montan-Complex nebst den Staats. Herrschaften Oravicza und Bokschan: Geognostische Karte* (*** [Foetterle], 1860). Source: Library of the Geological Survey of Austria.

ning counsel (*Bergrat*), Ferdinand Lidl von Lidlsheim (1829–1915) – geologist of the Imperial and Royal Geological Institute (1851–1855) and mining engineer in Steierdorf (1855–?), Franz Xaver Schröckenstein (1832–1901) – geologist and mining engineer (*Merkscheider*) in Steierdorf (1857–1860?), Benedikt von Roha (?–?) – mining director-general (*Oberverwalter*) in Steierdorf (1864–1880?), Dionys Štur (1827–1893) – chief geologist of the Imperial and Royal Geological Institute (1850–1892), as well as its director (1885–1892) etc.

Johann Kudernatsch, who had been working in Steierdorf even before the foundation of the Imperial and Royal Geological Institute (1849), published in that time not only several technical plans, but also several geological profiles in the Banat Mountains, including a cross-section in Steierdorf area (Kudernatsch, 1848). In 1855, Kudernatsch carried out detailed geological surveying and mapping in the middle part of the Banat Mountains, more precisely in the area of Steierdorf and its surroundings. As a result of this work, he presented at the Imperial and Royal Geological Institute a geological map, as well as a detailed description of the geology of this area (Kudernatsch 1855a,b). In the next year, Kudernatsch completed this work and presented the final version of the map at a meeting of the Imperial Academy of Science. The geological map of the middle part of the Banat Mountains (*Spezialkarte des mittleren Theiles des Banater Gebirgszuges*) (Kudernatsch, 1857 a) (Fig. 2), as well as the detailed geological description related to it (Kudernatsch, 1857b) were published post-mortem in 1857.

The representation of the Oravița–Anina railway (opened in 1863) on the geological map by Kudernatsch could be misleading in its dating, but we have to mention that the position of the planned (or under construction) railway differs from the track realized later (cf. the sheet of the 2nd Military Survey from 1864 at www.mapire.eu). The map represents the surroundings of Anina (the middle part of the Banat Mountains) on a paper sized 22x22 cm. Its scale is defined as 1 and ¾ decimal inch equal to 1000 Vienna fathoms (numerically: 1:411,429), but the details of the map and our calculation disprove that.

The legend of the geological map by Kudernatsch distinguishes 20 different rock types and stratigraphic units by using different colours, patterns, and symbols (letters), as well as stratigraphic terms and stratigraphic subdivisions, using the stratigraphic time scale classification, although the formations being arranged in an inverse order (the oldest formations are listed at the top, while the youngest formations at the bottom of the legend). At the same time the cartographic representation of tectonic elements on the map is noteworthy, Kudernatsch referring to the existing systems of faults and foldings in his detailed descriptions (Kudernatsch, 1855a; Kudernatsch, 1857b) too, and also illustrating these with several figures and cross-sections (Kudernatsch, 1855a; Kudernatsch, 1857b). The map also indicates the attitude of geological features with strike and dip symbols.

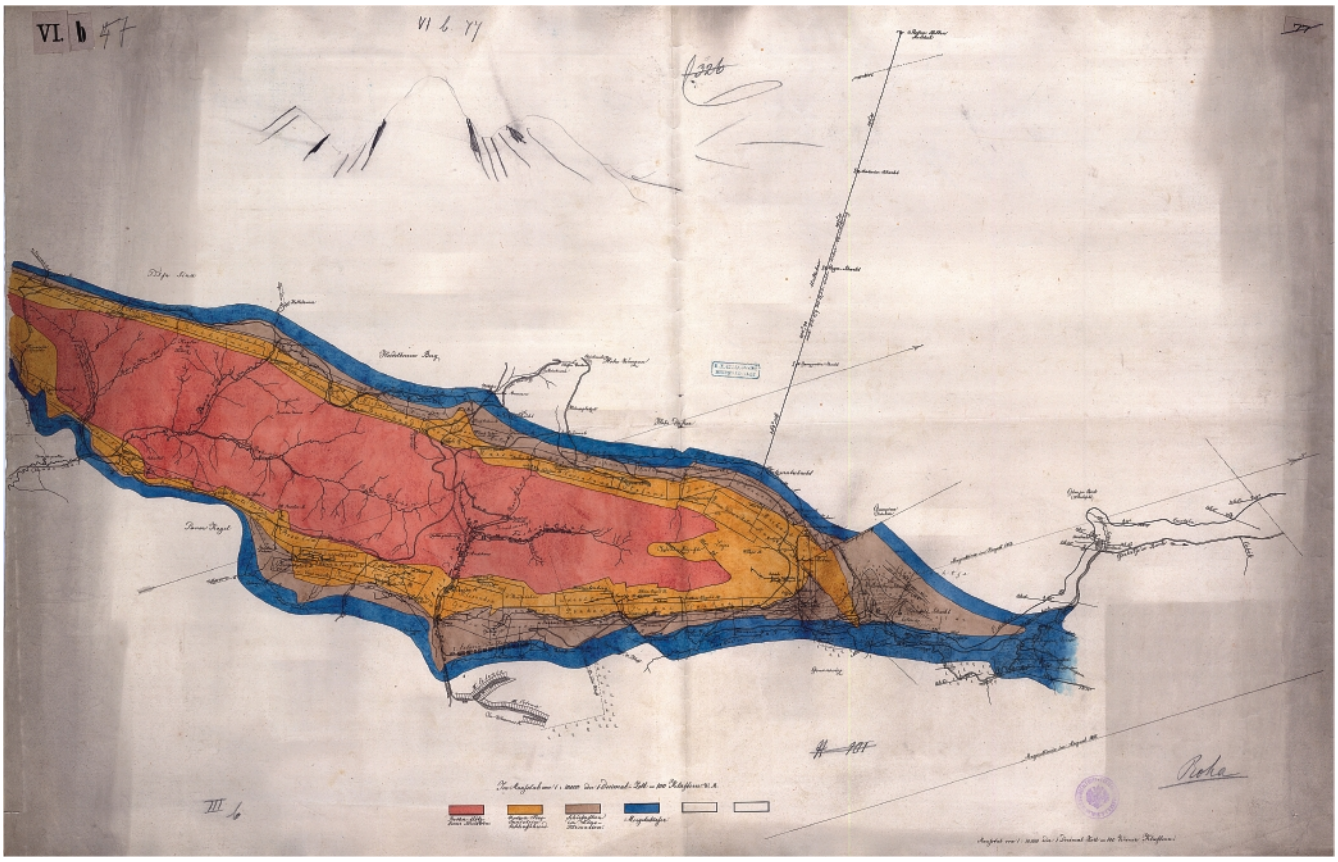

Figure 4: *Geologische Karte von Steierdorf im Banat* (Roha, 1867a[?]). Source: Library of the Geological Survey of Austria.

In any case, the map, as well as the geological descriptions connected to it can be considered landmark works in the geology of the Banat Mountains, which remained for decades some of the most important reference works for upcoming researches and geological mapping works, since they have been cited very often.

In 1860 the Austrian Railways Co. published a general "geognostic" map of the Banat district (*** [Foetterle], 1860) (Fig. 3) on a scale of 1:72,000 (1 inch is equal to 1000 Vienna fathoms) showing the mining region between Oraviţa and Bocşa (Bokschan, Boksánbánya). The railway Oraviţa–Anina is represented with a broken line, in the same position as on the map by Kudernatsch (1857a), different from the track realized later. The map consists of 9 sheets, the dimension of each paper being 40x50 cm (the map frame: 34x42 cm). The represented major towns are Vršac and Bela Crkva in Serbia (today), as well as Anina, Oraviţa, Moldova Nouă (Neu-Moldowa, Újmoldova), Reşiţa (Reschitz, Resicabánya), Bocşa and Deta (Detta, Detta) in Romania (today). The map has a graticule drawn at every 10 minutes; longitudes are given for the prime meridian of Ferro. This map was actually edited by Foetterle (based on the geological mapping work of the mining engineer Fabianek), who carried out an overall geological surveying of the area a year before (Foetterle, 1860a,b; Stur, 1870), and who convinced the director-general of the Austrian Railways Co., Carl Duboque, about the necessity of a geological mapping beside the drilling of the entire Banat district (Foetterle, 1860b). The legend of the map distinguishes 25 different rock types and stratigraphic units – arranged in geological time line – by using different colours and patterns, being relatively very detailed stratigraphically, indicating in some cases the stratigraphic subdivisions. It also shows the locations of the most important mines, furnaces and smelting-works. We can also notice that the map relied to a considerable extent on the previous geological researches and mapping of Kudernatsch, and it also made a significant contribution to Foetterle's further research work and geological mapping (Foetterle, 1860b). Foetterle and his co-authors used this map, as well as the previous maps and geological researches of Amie Boué (1794–1881), Paul Partsch (1791–1856), Johann Kudernatsch, and the Austrian Railways Co. in editing the overall geological map of Banat (Wolf et al., 1861) on a scale of 1:288,000 (Foetterle, 1862a,b).

At the same time several valuable, large scale (on a scale of 1:10,000, as well as 1:5,000) geological maps were plotted in this period for the Austrian Railways Co., showing the region of iron ore and coal occurrences from Banat, consequently not only the Anina coal mining area, but also the area of Oraviţa, Moraviţa (Moravicza, Temesmóra), Dognecea (Dognatschka, Dognácska), Moldova Nouă, as well as Resiţa (Brezsnyánszky, 1996).

In 1867, Benedikt von Roha published in the *Jahrbuch der k.*

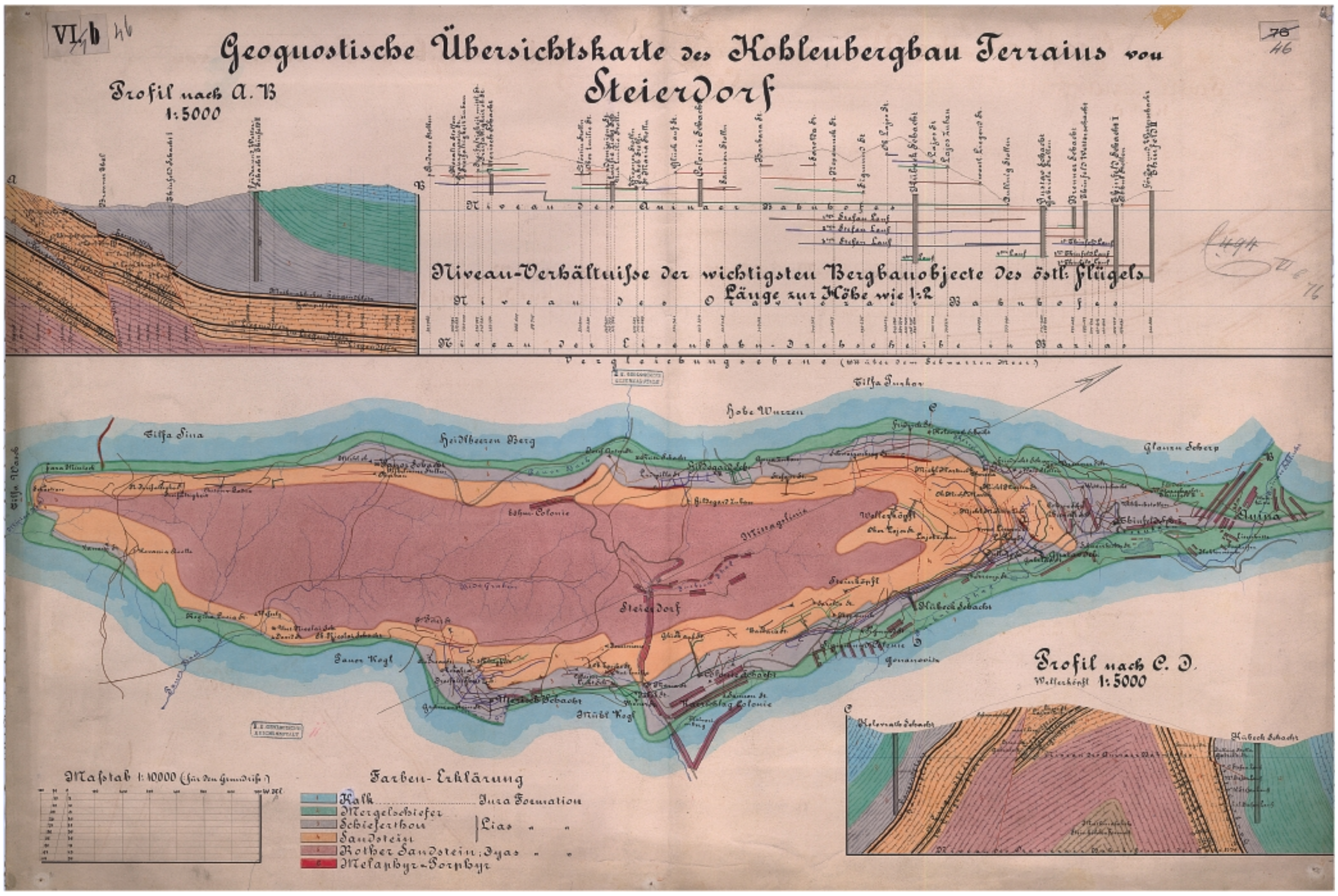

Figure 5: *Geognostische Übersichtskarte des Kohlenbergbau Terrains von Steierdorf* (***, 1872[?]). Source: Library of the Geological Survey of Austria.

k. geologische Reichsanstalt a paper related to the coal- and ironwork's complex from Anina–Steierdorf, based on the description of Franz Xaver Schröckenstein and Josef Kracher (managing director of the oil distillery in Steierdorf, *Betriebsleiter der Oelhutte zu Steierdorf*) (Roha, 1867b). Roha attached to this article a map on a scale of 1:10,000 showing in detail the Anina Anticline, as well as four geological profiles, and he also mentioned that the work and the map by Kudernatsch (Kudernatsch, 1857a,b) are noteworthy in the issue of the general geological and geotectonical relations of the Banat Mountains. The hand-coloured manuscript map (Roha, 1867a[?]) (Fig. 4) stored in the Archives of the Geological Survey of Austria in Vienna is catalogued as being plotted in 1867, also by Roha. We can find on the map the line indicating the 1855 magnetic North, and the railway opened in 1863 in the correct position, therefore we suppose that the map was edited after 1863. It represents the surroundings of Anina and it has a dimension of 106x68 cm. Its scale is 1:10,000 (numerically written on the map) – but the annotation showing that 1 decimal inch is equal to 100 Vienna fathoms (numerically: 1:72,000) is faulty. The map shows a North arrow towards 73° clockwise, too. Compared to the map by Roha published in his article (Roha, 1867b), the manuscript map has a different topographic base, it doesn't contain the geological profiles, it shows the Anina Anticline with a different orientation, and uses other terms for geological formations. Nevertheless, we can notice the fact that both maps have the same geological conception with very similar geological contacts, and both maps represent the tectonic elements on a high level (for that time), and the locations of the mines (both the open cast mines and pits). The manuscript map by Roha (1867a[?]) was probably compiled with another goal than the map published, the first one with the principal aim of mining land registration, while the second one being rather a geological map.

Another manuscript map on a scale of 1:10,000 representing the Anina Anticline (Fig. 5) was plotted for the Austrian Railways Co. (Brezsnyánszky, 1996) with the title *Geognostische Übersichtskarte des Kohlenbergbau Terrains von Steierdorf* (***, 1872[?]). The catalogue of the Library of the Geological Survey of Austria indicates 1872 as the year of publication. The correct position of the railway opened in 1863 proves this approximate dating. The map is printed on a paper sized 92x 63 cm, and shows a North arrow towards 65° clockwise. Harald Lobitzer and Zdeněk Kukal (2010) suppose that the map – which is very similar to the maps by Roha (Roha, 1867a[?],b) – was compiled by the mining engineer, Ferdinand Lidl von Lidlsheim. Nevertheless, we couldn't find any concrete evidence in the publications of the Imperial and Royal Geological Institute which confirms this assumption. In any case, the map is more elaborated and meticulous, and it has another topographic base, but its geological conception is very simi-

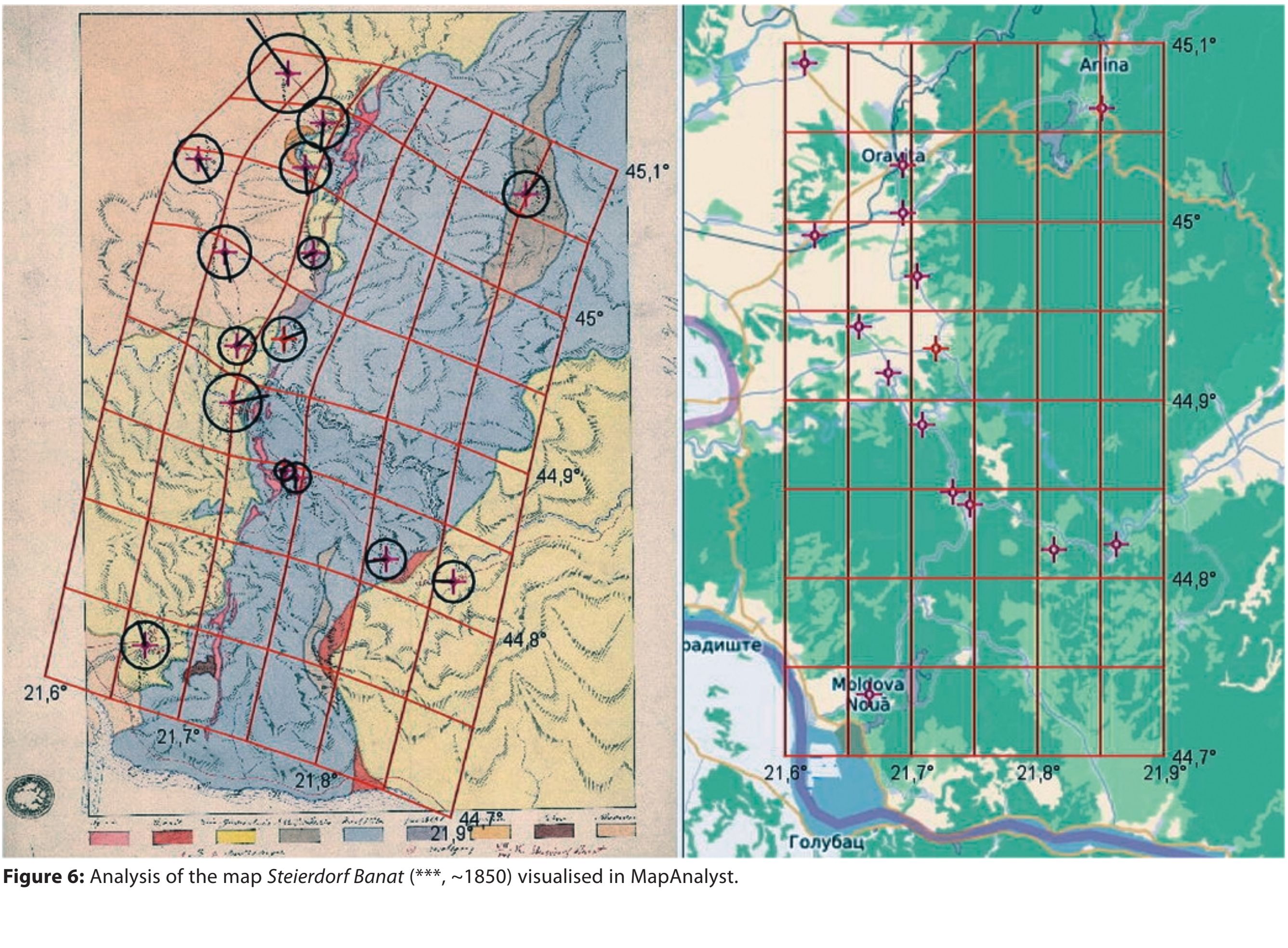

Figure 6: Analysis of the map *Steierdorf Banat* (***, ~1850) visualised in MapAnalyst.

lar to the map by Roha (Roha, 1867a[?]). Two geological cross-sections on a scale of 1:5,000 are also attached to the map, which visualise in details the geological relationships of strata, as well as the folding elements and faults. At the same time, the map illustrates the level of the most important mining objects, relative to the Anina railway station level.

However, we can notice the fact that these last two large scale maps reflect an extremely precise and high level geological mapping activity, exceeding considerably the level of the maps from this period. At the same time, the cartographic representation of tectonic elements is noteworthy (Brezsny-ánszky, 1996).

After the Austro–Hungarian Compromise in 1867, more precisely after the foundation of the Royal Geological Institute in Budapest (1869), the geological mapping of the Hungarian Kingdom (and obviously of the historical province of Banat) came under the competency of the Royal Hungarian Geological Institute (Brezsnyánszky et al., 1999). These were the times when the second systematic, sheet-by-sheet geological mapping activity of the Austro–Hungarian Monarchy started, based on the map series of the 3rd Military Survey on a scale of 1:75,000 (Spezialkarten (Jankó, 2007:101–102)). The map sheets of the series "*Geologische Karte*" were published continually between 1885 and 1914. The Hungarian sheets, belonging to the series with the title "*A magyar korona országainak geológiai térképe 1:75000*" were published using Hungarian labelling and legend (Jankó, 2007:102). All these map sheets, as well as the explanatory notes attached to them were published in German too. However, these maps represent another phase in the geological mapping activity, and they are not the subject of this paper due to the fact that they used the topographic map sheets of the 3rd Military Survey, therefore their accuracy analysis is less problematic. In a further publication we would like to present the geo-referencing methods, as well as the analysis of the relationship of these old maps to current geological map of this area.

4. Cartographic analysis

4.1 Methods

In general, for an accurate geo-referencing of a map it is important to know or to assess its geodetic basis, especially as what regards the projection, geodetic datum and prime meridian used. Nevertheless, the maps we studied didn't use the topographic surveys, consequently they couldn't have used projections and geodetic datums. Only one of them (*** [Foetterle], 1860) has a graticule drawn, which proved to be completely useless for geo-referencing. Therefore, the georeferencing of these maps is limited to the interpolation of a grid onto them and the running of the gridlines and especially our calculations show the accuracy and reliability of the maps.

We made the cartographic analysis of the maps using the MapAnalyst (version 1.3) software application (Jenny and Hurni, 2011, www.mapanalyst.org). As new reference map we used the Open Street Map (www.openstreetmap.org), or – if it hadn't enough details – we resorted to the current Romanian topographic maps on a scale of 1:25,000. The control points were given at the intersections of roads, brooks, and railways. The MapAnalyst software computes three kind of transformations (Helmert-4-Parameters, Affine- 5-Parameters, as well as Affine-6-Parameters transformations) calculating the scale and the rotation of the grid, as well as the displacement vectors of the control points.

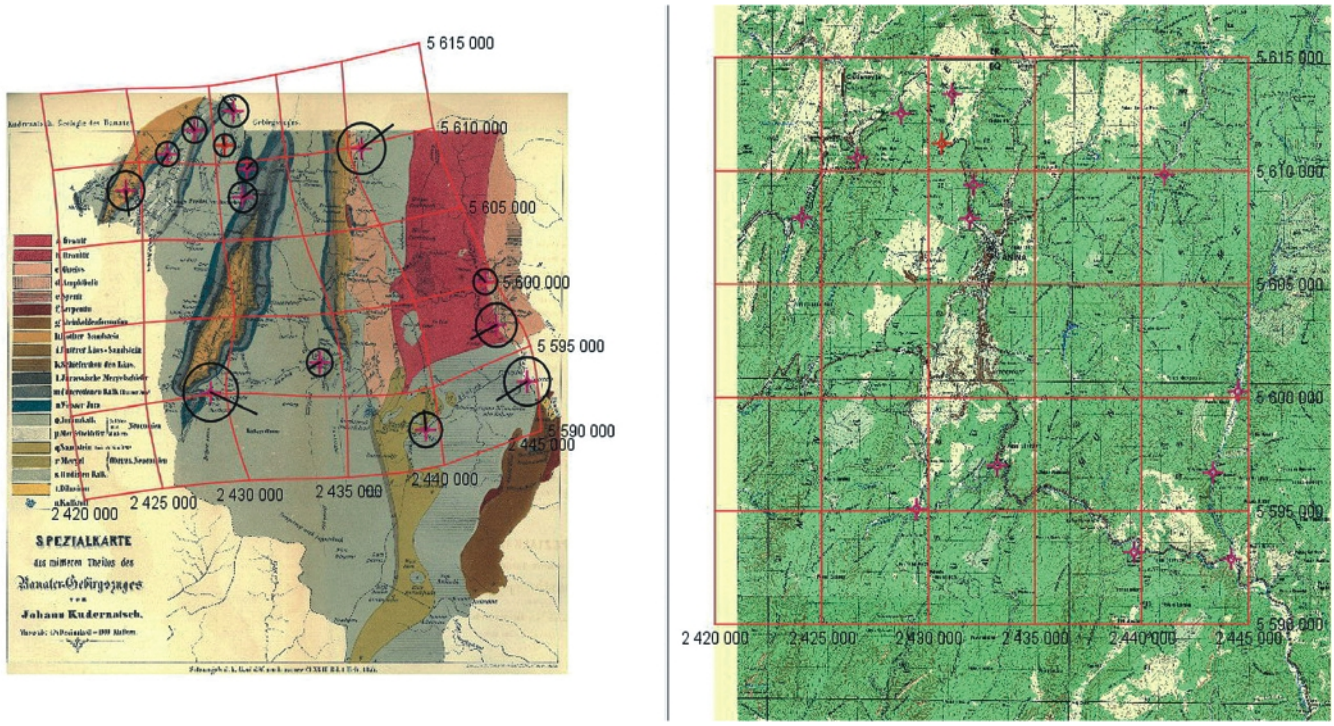

Figure 7: Analysis of the map by Kudernatsch (1857a) visualised in MapAnalyst.

The Open Street Map uses the Mercator projection, which has considerable linear distortion at this latitude, equal with 1/cos(latitude). If we use the Open Street Map as new reference map, the software solves this problem, but when we use another map rectified in the same projection, we have to correct it. Hence, we used a correction factor of cos(45°) = 0.707, since the latitude of Anina is 45° 05'.

One of the maps studied, the general "geognostic" map of the Banat district (*** [Foetterle], 1860) has a map graticule drawn on, therefore we analysed its map projection too.

4.2 Results

The results of our computing with the help of the MapAnalyst software application are summarized and visualized in the Table 1, as well as in Figures 6 to 11. Table 1 contains data concerning the number of control points and the type of the new reference map used for the accuracy analysis of each map studied, as well as the statistical indicators and errors obtained after the transformation (e.g.: the corrected scale of the maps, rotation, standard deviation, mean position error).

In the Figures 6 to 10 we can see the old maps on the left side of the images, where the red network represents the interpolated graticule, and the displacement vectors and circles are located around the control points. The new reference map with the real position of the grid and of the control points is on the right side of the images. For the Open Street Map (OSM) the coordinates are the geographical ones (WGS84), for topographic maps the datum/projection of the coordinates is the WGS84/Mercator.

Analysing the map graticule of the general "geognostic" map

Map	Number of control points	New reference map	Corrected scale	Rotation	Standard deviation (m)	Mean position error (m)
Steierdorf Banat (~ 1850)	15	OSM	1:90,300 – 1:105,000	17–21° clockwise	1315–1445	1860–2043
The map by Kudernatsch (1857a)	14	topographic	1:102.900– 1:121,600	6–12° clockwise	1042–1109	1473–1569
Banater Domäne […] (1860)	19	OSM	1:72,900– 1:74,000	4–5° clockwise	1145–1155	1620–1634
The map by Roha (1867[?])	15	topographic	1:9750– 1:10,050	83–84° clockwise	44–47	62–66
Geognostische Übersichtskarte des Kohlenbergbau Terrains von Steierdorf (1872[?])	12	topographic	1:9,900– 1:9,950	64–65° clockwise	48–50	68–71

Table 1: The accuracy analysis of the maps.

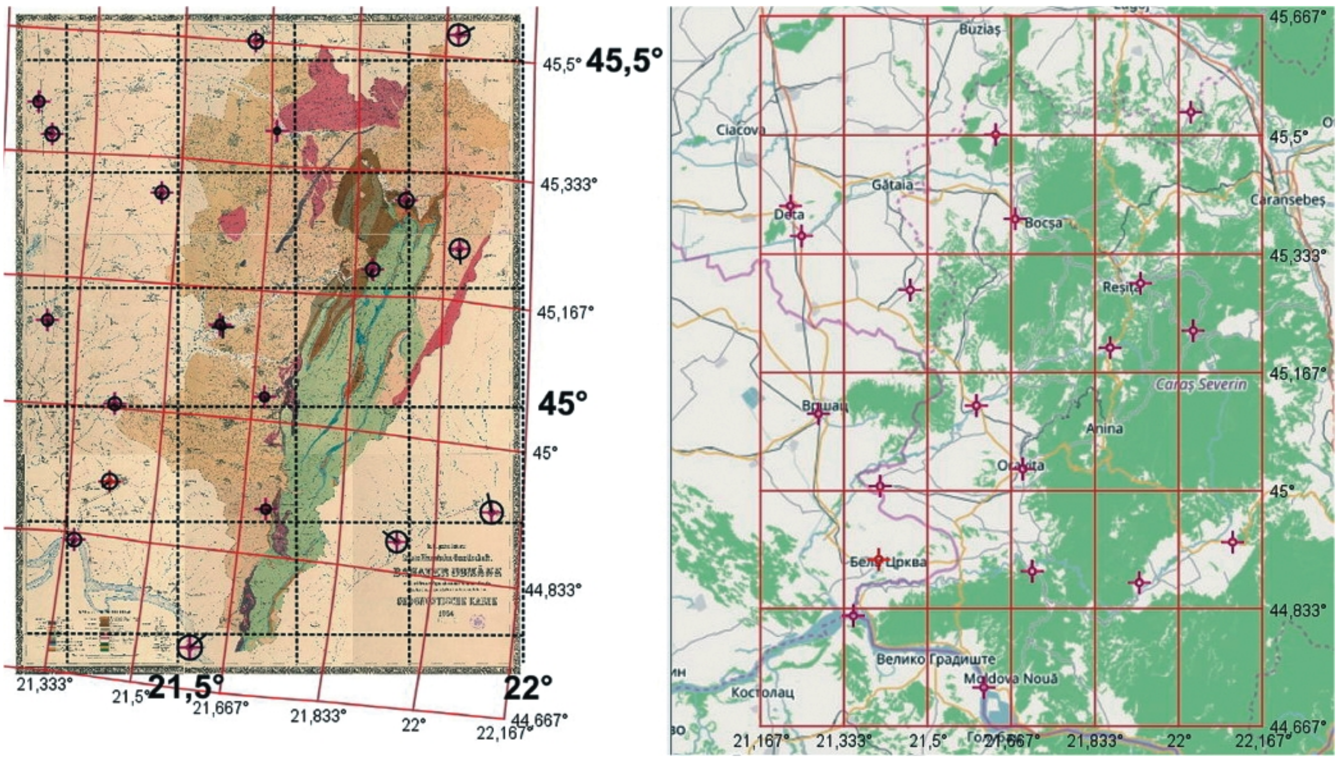

Figure 8: Analysis of the map *Banater Domäne […]* (*** [Foetterle], 1860) visualised in MapAnalyst.

of the Banat district (*** [Foetterle], 1860) (Fig. 8), we have observed that the network is almost a square grid (the 10 minutes distance between the meridians is 225±6 mm, between the parallels is 225±3 mm).

There isn't any unambiguous increasing/decreasing in the distances between the parallels, moreover the meridians aren't equidistant lines; thus the differences must be due to significant drawing errors. Due to square graticule, the projection of the map could be mainly the Equidistant Cylindrical Projection with the Equator as standard parallel (Snyder, 1987: 90–91). In the case of this projection the meridians are true to scale, therefore the 10 minutes (18,532 m) differences on a scale of 1:72,000 should be 257 mm, instead of 225 mm, consequently it cannot be the Equidistant Cylindrical Projection.

Another possibility could be the Cylindrical Equal-Area Projection with two standard parallels (Snyder, 1987: 76–85). However, this hypothesis proved to be false too: the product of the relative scale factors along meridians (k = 0.87), respectively along the 45° parallel (h = 1.24) is 1.08 (and not 1). Consequently it turns out that in editing the map the author just simply drew squares, with a diagonal line almost true to scale (318 mm equal to 22,700 m which means a scale of 1:72,000 with an error less than 1%). Thus, if we expand the squared network, the graticule refers to a particular "Equidistant" Cylindrical Projection, with the standard parallel at 29° (so, the relative scale factor along the 45° parallel is 1.144) though with meridians which are not true to the scale (the relative scale factor along the meridians is 0.874). For a regional map, this projection would be a really bad choice, because in reality on this latitude (45°) the proportion of the distances between parallels, as well as meridians is 18,532/13,104 = 1.414; and using this map projection the value would be completely different, namely 225/225 = 1. This significant discrepancy would cause a spectacular horizontal expansion and vertical reduction, which isn't proved at all by our analysis made with MapAnalyst application. Therefore, our conclusion is that the meridians and parallels were drawn without any accordance to reality. Fortunately, the map content has no accordance with this strange network: thus, the map could be geo-referenced only by the content and not by the network (see Fig. 8), where the drawn network of the map is represented with black broken lines and larger size numbers. It is spectacular that the displacement errors of the network points are multiple of the control points–.

4.3 Discussions

Summarizing the results, we can distinguish two phases in the geological mapping before the 3rd Military Survey (1884). The first phase (from around 1850 until 1864) contains the maps plotted before the 2nd Military Survey, namely the following: *Steierdorf Banat* (***, ~ 1850); *Spezialkarte des mittleren Theiles des Banater Gebirgszuges* (Kudernatsch, 1857a); *Banater Domäne: enthaltend den vormaligen k. k. aerarischen Montan-Complex nebst den Staats. Herrschaften Oravicza und Bokschan: Geognostische Karte* (*** [Foetterle], 1860). These maps represent a larger area (the first map the area from Anina to the Danube; the second one the wider surroundings of Anina; more precisely the middle part of the Banat Mountains; while the third one the whole mining district). Their scale is at about 1:100,000 (on the first map the scale is unwritten; on the second it is written faultily; and on the third one it is written correctly but with an unusable graticule). Their scale became more precise (on the first two maps its fluctuation is at about 20%, on the third one it is at about 1%). The preci-

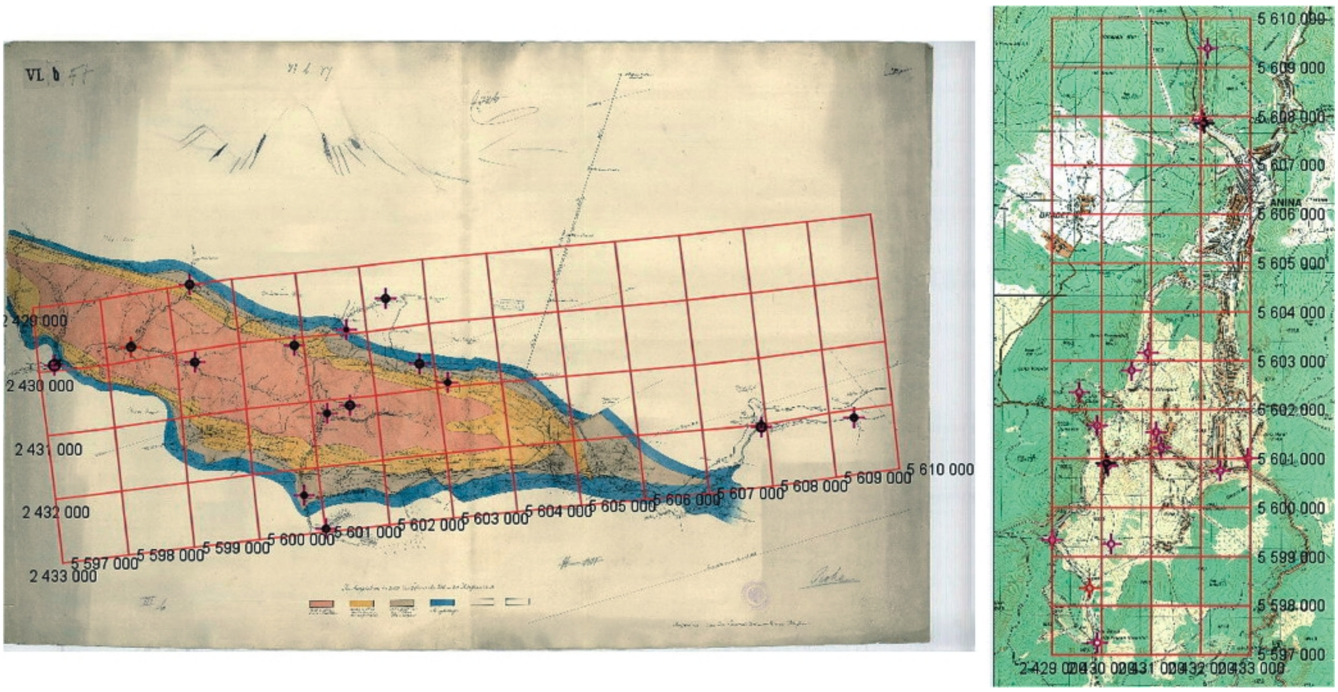

Figure 9: Analysis of the map by Roha (1867a[?]) visualised in MapAnalyst.

sion of their orientation also became better and better, the errors decreased from at about 20° to 4°. Their displacement accuracy is 1–2 km (in reality), that is 1–2 cm (on the map).

The second phase (1864–1884) contains the maps compiled between the publication of the topographic map sheets of the 2nd and the 3rd Military Survey, namely the following: *Geologische Karte von Steierdorf im Banat* (Roha, 1867a[?]); *Geognostische Übersichtskarte des Kohlenbergbau Terrains von Steierdorf* (***, 1872[?]). These maps represent a smaller area (both of them only the Anina Anticline). Their scale is larger (1:10,000), its lettering (writing) is still contradictory to the first one, but is already correct on the second one. The variation of the scale is negligible (less than 1%). The orientation of the first map is faulty (with 10°), while in the case of the second one it is accurate (the error is less than 1°). Their displacement accuracy is at about 50 m (in reality), that is 0.5 cm (on the map).

In any case, we can observe not only the progress in the representation methods and nomenclature of the geological content of the maps (in the beginning the petrographic-type map is characteristic, then the stratigraphic conception is more and more reflected, and the structural elements are also present), but also a significant improvement in their cartographic accuracy. The purpose of our cartographic analysis was to test the cartographic reliability of the maps studied, which can be easily geo-referenced by using the interpolated coordinates.

5. Conclusions

The mathematic base of the geological mapping significantly improved between 1850 and 1884. The scale of the maps increased from a medium scale of approximately 1:100,000 to the large scale of 1:10,000; the scale variation decreased from 20% to 1%. The orientation errors of the maps diminished from 20° to less than 1°, while the horizontal errors of the content decreased from 1–2 cm to less than 0.5 cm (on the map). Concerning their reliability, we have to be careful with the earlier maps, plotted between 1850–1864 (scale, orientation written faultily, useless graticule, displaced content items), while until the end of the period studied, such high-level geological maps were edited which almost suit the requirements of the contemporary topographic maps (accurate scale and content).

Old geological maps are part of our thematic cartographic heritage, therefore their study is important in the perspective of the history of geological mapping. At the same time, old geological maps are sources of information for historical studies, especially in those areas where the outcrops are scarce. In any case, for an old geological map to be a reliable source of information for present researches, it is required to take into consideration on the one hand the accuracy of the geological content, and on the other hand its cartographic accuracy. Therefore, the geo-referencing of the old geological maps together with the common analysis of the geological content, as well as the cartographic accuracy make possible the overlapping of several maps from different periods, in order to analyse and compare their geological data and conception reliability.

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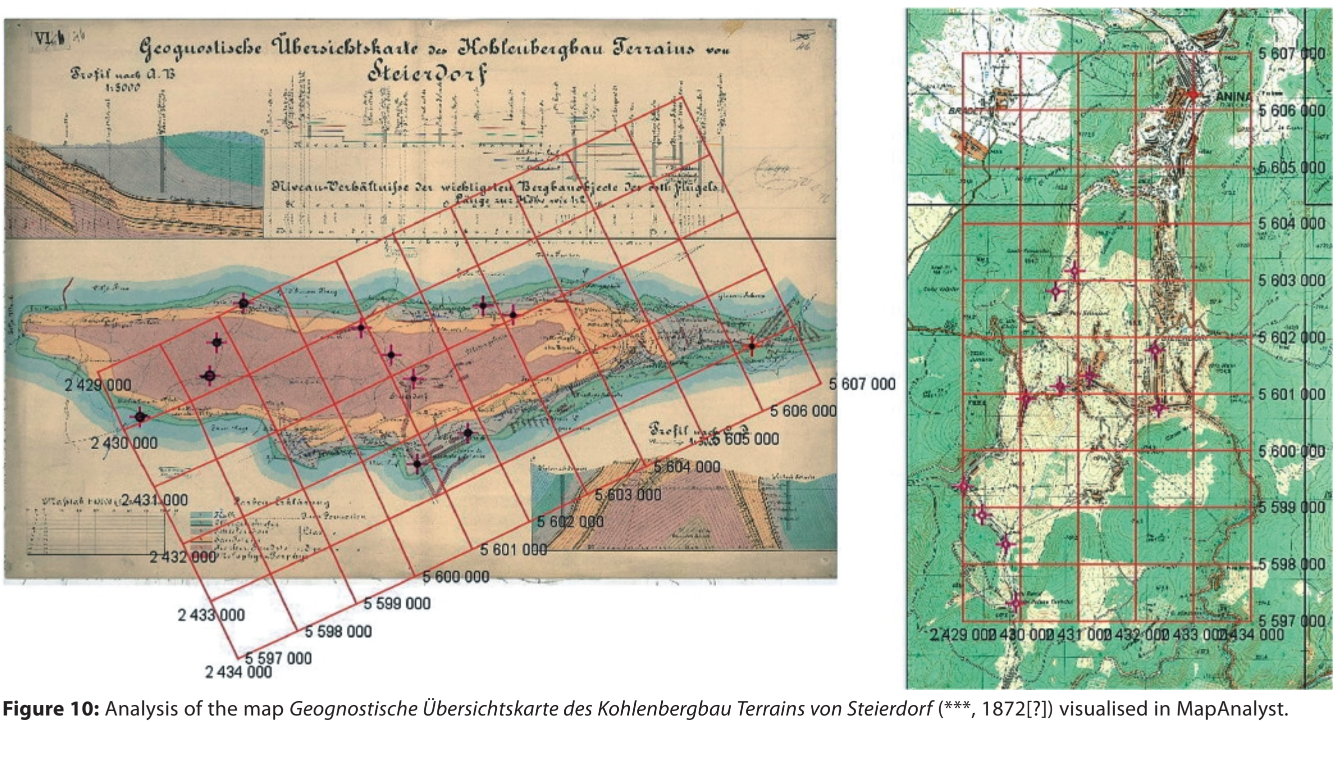

Figure 10: Analysis of the map *Geognostische Übersichtskarte des Kohlenbergbau Terrains von Steierdorf* (***, 1872[?]) visualised in MapAnalyst.

Scientific Society of Transylvania for the constructive advice concerning the geological content of the maps. The authors also thank Júlia Molnár Galaczi, teacher of English at the Reformed Theological High School in Cluj-Napoca, for overviewing the English version of the manuscript.

In elaborating the article Enikő Korodi was responsible for the historical cartographic overview, as well as for the geological aspects of the maps, while Zsombor Bartos-Elekes made the exploration of the mathematic elements of their topographic basis, as well as the cartographic analysis of the maps (the authors contributed equally to this paper). Ionel Haidu took part as supervisor in this work, and helped to improve the article.

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References

Barczikayné Szeiler R., Gyalog L., Hegyiné Rusznyák É., Viktor Zs., Orosz L., Pentelényi A., and Síkhegyi F., 2009. A földtani térképezés 140 éve – Térképválogatás a XVIII. századtól napjainkig. MÁFI kiadás – DVD, Budapest.

Biszak S., Timár G., Molnár G. and Jankó A., 2007. Digitized maps of the Habsburg Empire – The Third Military Survey. Arcanum DVD, Budapest.

Brezsnyánszky K., 1996. Austro–Hungarian geological mapping before 1869. In: Dudich E. and Lobitzer H. (eds.), Advances in Austrian–Hungarian Joint Geological Research, Budapest, pp. 25–32.

Brezsnyánszky K., 2007. Geological maps. Nova Acta Leopoldina NF 94, 349, 71–79.

Brezsnyánszky K. and Turczi G., 1998. Geological Maps – from Litography to GIS. Földtani Közlöny, 128(1), 145–156.

Brezsnyánszky K., Dudich E. and Schedl, A., 1999. Ungarn. In: Hofmann, T., Die geologische Untersuchung des Kaiserreiches. In: Bachl-Hofmann, C. et al. (red.), Die Geologische Bundesanstalt in Wien: 150 Jahre Geologie im Dienste Österreichs (1849–1999). Wien, Böhlau, pp. 125–129.

Bucur, I.I., 1991. Proposition pour une nomenclature formelle des depots paleozoiques et mesozoiques de la zone de Reşiţa-Moldova Nouă (Carpathes Meridionales, Roumanie). Studia Universitatis Babeş Bolyai, seria Geologie, 36, 3–14.

Bucur, I.I., 1997. Formaţiunile mesozoice din zona Reşiţa-Moldova Nouă, Cluj-Napoca, 214 pp.

Csiki-Sava, Z., Kędzior, A., Pieńkowski, G. and Popa, M.E., 2016. Hettangian tetrapod burrows from the continental Steierdorf Formation at Anina, Western Romania. Geological Quarterly, 60(2):395–406. http://dx.doi.org/10.7306/gq.1278

Foetterle, F., 1860a. Geologische Aufnahmen und untersuchungen im Felde: Banat [fingierter Titel]. Verhandlungen der k. k. Geologische Reichsanstalt, 112–113, Wien.

Foetterle, F., 1860b. Geologische Aufnahmen und untersuchungen im Felde: Verbreitung der alten Steinkohlenformation im Banate und der illyrisch- und roman-banater Militärgrenze [fingierter Titel]. Verhandlungen der k. k. Geologische Reichsanstalt, 146–147, Wien.

Foetterle, F., 1862a. Vorlage der geologischen Übersichtskarte des Banates und der Illyrisch- und Roman-Banater Militärgrenze. Verhandlungen der k. k. Geologischen Reichsanstalt, 1861/1862, 62, Wien.

Foetterle, F., 1862b. Kurze Mittheilung über die Lagerungsverhältnisse der Kohlenführender Liasformation im Banate [fingierter Title]. Verhandlungen der k. k. Geologischen Reichsanstalt, 1861/1862, 214–215, Wien.

Foetterle, F., 1865. Besuch der Steinkohlenwerke zu Fünfkirchen, Drenkova, Steierdorf und Reschitza. Verhandlungen der k. k. Geologischen Reichsanstalt, 15, 118–119, Wien.

Gräf, R., 2011. Contribuţii la istoria industrială a Banatului Montan. Presa Universitară Clujeană, Cluj-Napoca, 298 pp.

Haidinger, W. 1859. Ansprache gehalten am Schlusse des ersten Decceniums der Kaiserlich–königlichen Geologischen Reichsanstalt in Wien am 22. November 1859. K. K. Hof– und Staatsdruckerei, Wien, 37 pp.

Hussak, E. 1881. Pikritporphyr von Steierdorf, Banat. Verhandlungen der k. k. Geologischen Reichsanstalt, 1881, 258–262, Wien.

Hussak, E. 1885.Ueber Eruptivgesteine von Steierdorf im Banat. -Verhandlungen der k. k. Geologischen Reichsanstalt, 1885, 185–186, Wien.

Jankó A., 2007. Magyarország katonai felmérései 1763–1950. Argumentum, Budapest, 196 pp.

Jenny, B. and Hurni, L., 2011. Studying cartographic heritage: Analysis and visualisation of geometric distorsions. Computers & Graphics, 35/2, 402–411.

Kędzior, A. and Popa, M.E., 2013. Sedimentology of the Early Jurrasic terrestrial Steirdorf Formation in Anina, Colonia Cehă Quarry, South Carpathians, Romania. Acta Geologica Polonica, 63/2, 175–199. http://dx.doi.org/10.2478/agp-2013-0007.

Korodi E. and Hofmann, T., 2016. Historical cartographic overview and cartographic analysis of the geological map of Transylvania by Hauer (1861). Geographia Technica, 11/1, 44–53. http://dx.doi.org/10.21163/GT_2016.111.06

Kókai S., 2010. A Bánság történeti földrajza, 1718–1918. A Bánság helye és szerepe a Kárpát-medence földrajzi munkamegosztásában. Nyíregyházi Főiskola Turizmus és Földrajztudományi Intézete, Nyíregyháza, 421 pp.

Krasser, F., 1917. Männliche Williamsonien aus dem Sandsteinschiefer des Unteren Lias von Steierdorf im Banat. Kaiserliche Akademie der Wissenschaften in Wien Mathematischnaturwissenschaftliche Klasse Denkschriften, 93, 1–14, Hölder, Wien.

Kudernatsch, J., 1848. Skizze der Geologischen Verhältnisse im Banat. In: Haidinger Berichte, 4. In: Berichte über Mittheilungen von Freunden der Naturwissenschaften in Wien, 4, 456–469, Wien.

Kudernatsch, J., 1850. Die Neuen Bergbau-Unternehmungen im Banat. Jahrbuch der k. k. Geologischen Reichsanstalt, 1, 705–718, Wien.

Kudernatsch, J., 1855a. Beiträge zur geologischen Kenntniss des Banater Gebirgszuges. Jahrbuch der k. k. Geologischen Reichsanstalt, 6, pp. 219–253, Wien.

Kudernatsch, J., 1855b. Geologische Verhältnisse in der Umgebung von Steierdorf im Banat. Jahrbuch der k. k. Geologischen Reichsanstalt, 6, Sitzung am 18. December 1855, pp. 905–906, Wien.

Kudernatsch, J., 1857a. Spezialkarte des mittleren Theiles des Banater Gebirgszuges. In: Geologie des Banater Gebirgszuges (vorgelegt in der Sitzung am 8 Mai 1856). In: Sitzungsberichte der kaiserlichen Academie der Wissenschaften Matematisch–Naturwissenschaftliche Classe, 23, pp. 39–148.

Kudernatsch, J., 1857b. Geologie des Banater Gebirgszuges (vorgelegt in der Sitzung am 8 Mai 1856). In: Sitzungsberichte der kaiserlichen Academie der Wissenschaften Matematisch–Naturwissenschaftliche Classe, 23, pp. 39–148.

Langer, J. 1945. Über einige Stücke der Liasflora von Steierdorf und der Keuperflora von Lunz. Jahrbuch der Geologischen Bundesanstalt, 90, 21–33.

Lobitzer, H. and Kukal, Z., 2010. Der Ischler Geologe Ferdinand Lidl von Lidelsheim – Eine späte Würdigung. Jahrbuch der Geologischen Bundesanstalt, 150/3–4, 463–462.

Murgoci, G.M., 1905. Sur l'existence d'une grande nappe de recouvrement dans les Carpathes meridionales. Comptes rendus de l'Académie des sciences, 7, 31, Paris.

Pentelényi, A. and Síkhegyi, F. 2012. Hazai földtani térképeink topográfiai alapjai. In: A MÁFI évi jelentése 2010. Budapest, pp 81–95.

Popa, M.E., 2005. Aspects of Romanian Early Jurassic Paleobotany and Palynology. Part VI. Anina, an exceptional localty. Acta Paleontologica Romaniae, 5, 375–378.

Popa, M.E. and Kędzior, A., 2008. High resolution paleobotany and sedimentology of the Steierdorf Formation, Reşiţa Basin. In: Bucur, I.I. and Filipescu, S. (eds.), Annual scientific session "Ion Popescu Voiteşti".Cluj University Press, Cluj-Napoca, pp. 57–59.

Popa M.E. and Meller B., 2009. Review of Jurrasic Plants from the Anina (Steierdorf) Coal Mining Area, South Carpathians, in the Collection of the Geological Survey of Austria. Jahrbuch der Geologische Bundesanstalt, 149/4, 487–498, Wien.

Popa M.E., Kędzior A. and Fodolică, V., 2010. The Anina Geopark: preserving the geological heritage of the South Carpathians. Rev. Roum. Géologie, Tomes 53–54, pp. 109–113, 2009–2010, Bucureşti.

Oldroyd, D., 2013. Maps as pictures and diagrams: The early development of geological maps. Geological Society of America Special Papers, 502, 41–101. http://dx.doi.org/10.1130/2013.2502(04).

Reimann, R., 2002. Das Aufblühen eines von Natur aus reichen Landes: Über Geschichte, Berg- und Hüttenwesen des Banater Berglandesin den Jahren von 1718 bis 1920. Res. Montanarum, 29, 35–44.

Roha, B., 1867a[?]. Geologische Karte von Steierdorf im Banat. Manuscript map, scale: M = 1:10,000.

Roha, B., 1867b. Der Kohlen- und Eisenwerkscomplex Anina–Steierdorf im Banat: nach den Beschreibungen der Herrn Franz Schröckenstein, Markscheider zu Steierdorf, und J. Kracher, Betriebsleiter der Oelhütte zu Steierdorf mitgetheilt. Jahrbuch der k. k. Geologischen Reichsanstalt, 17, 63–76, Wien.

Semaka, Al., 1962. Observaţii asupra florei Toarcian–Aalenianului din Banat. Dări de seamă ale Comitetului Geologic, LXVI, 225–237, Bucureşti.

Săndulescu, M., 1984. Geotectonica României. Editura Tehnică, Bucureşti, 336 pp.

Schnabel, W., Matura, A. and Pistotnik, J., 1999. Geologische Landesaufnahme. In: Bachl-Hofmann, C. et al. (red.), Die Geologische Bundesanstalt in Wien: 150 Jahre Geologie im Dienste Österreichs (1849–1999). Böhlau, Wien, pp. 186–193.

Snyder, J.P., 1987. Map Projections – A Working Manual. United States Government Printing Office, Washington, 385 pp.

Stur, D., 1870. Beiträge zur Kenntniss der Dyas– und Steinkohlen-formation im Banate. Jahrbuch der k. k. Geologischen Reichsanstalt, 20, 185–200.

Szabó M.A., 2003. Erdély, Bánság és Partium történeti és közigazgatási helységnévtára. Pro-Print Könyvkiadó, Csíkszereda, 714 pp.

Telegdi Roth L., Schafarzik F., Adda K., Böckh J. and Gabrovitz K., 1903. A Magyar korona országainak részletes geológiai térképe 1:75 000: Krassova és Teregova. Map, scale: M = 1:75,000. Magyar Királyi Földtani Intézet, Budapest.

Telegdy Roth L., Halaváts Gy. and Pitter T., 1909. A Magyar korona országainak részletes geológiai térképe 1:75 000: Temeskutas és Oravicabánya. Map, scale: M = 1:75,000. Magyar Királyi Földtani Intézet, Budapest.

Timár G., Telbisz T. and Székely B., 2003. Űrtechnológia a digitális domborzati modellezésben – SRTM adatbázis. Geodézia és Kartográfia, 55/12, 11–15.

Werner, M., 2001. Shuttle Radar Topography Mission (SRTM), Mission overview. Journal of Communication (Frequenz), 55, 75–79. http://dx.doi.org/10.1515/FREQ.2001.55.3-4.75

Wolf, H., Foetterle, F., Štur, D. and Tietze, E., 1861. Geologische Übersichtskarte des Banat. Manuscript map., scale: M = 1:288,000, Wien.

***, ~1850. Steierdorf Banat. Manuscript map.

*** [Foetterle], 1860. Banater Domäne: enthaltend den vormaligen k. k. aerarischen Montan-Complex nebst den Staats. Herrschaften Oravicza und Bokschan: Geognostische Karte. Map, scale: M = 1:72,000. k. k. priv. Österreichische Staats–Eisenbahn–Gesellschaft.

***, 1872[?]. Geognostische Übersichtskarte des Kohlenbergbau Terrains von Steierdorf. Manuscript map, scale: M = 1:10,000.

***, 1893. Geschichtlicher Rückblick auf die Entwicklung des Steierdorfer Kohlenbergbaues (im Banate) von seiner Entstehung bis zur Gegenwart. Oesterreichische Zeitschrift für Berg- und Hüttenwesen, 41, 620–622, 627–630, Manz, Wien.

***, ?. Zone 25 Col. XXV. Kudritz und D.-Oravica 1:75,000. Manuscript map, scale: M = 1:75,000.
***, ?. Zone 25 Col. XXVI. Krassova und Teregova 1:75,000. Manuscript map, scale: M = 1:75,000.

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