

„BABEȘ-BOLYAI” UNIVERSITY, CLUJ-NAPOCA
THE FACULTY OF ENVIRONMENTAL SCIENCES

**EVOLUTION OF GEOLOGICAL KNOWLEDGE AS SEEN IN SPECIFIC
PUBLICATIONS FROM EIGHTEENTH AND NINETEENTH CENTURY
REGARDING INNER-CARPATHIAN AREA OF ROMANIA**

**PhD Thesis
(Summary)**



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**Scientific coordinator:
Prof. PhD Vlad A. Codrea**

Cluj – Napoca

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INTRODUCTION

Essential in the historical evolution of a knowledge field is the answer to one question: when this scientific discipline became an independent science, with strict research objectives with its own specialized teaching and research institutions.

Although the concept of geology, in the modern sense is first used in the seventeenth century in a 1657 publication about earthquakes and minerals, "*Geologia norvegica*" by *Mikkel Pederson Escholt* which emphasize some basic ideas regarding Earth constitution, stratigraphy, geologic time scale, comparative anatomy of current living creatures and the ones of the past, we can say that geology as a scientific discipline was individualised only at the end of the eighteenth century.

In Romania, over time, knowledge and use of "stones" have evolved gradually challenging one another, and the social implications in society's development is demonstrated by archaeological works revealing important data and discoveries. Since prehistoric times, there is evidence of processed river gravel, flint, and other local rocks, in order to obtain tools. Limonite was used as a dye in Banat, hematite for ornaments, amber as the cornerstone of healing, worship and beauty. The first metal that led to metallurgy was copper and on Romanian territory was known from Early and Middle Neolithic. In Transylvania this easy workable metal was extracted from copper deposits in the Apuseni Mountains. Workshops for iron processing were discovered in Grădiștea Muncelului and presumably the ore came from Ghelari or Teliuc.

Another useful mineral substance exploited from ancient times in our country was salt, many deposits being found in the studied area. Late antiquity and medieval times are documented for the use of local resources for building materials, extracting copper from local deposits for making ornaments and iron for making agricultural tools, production of ceramic objects.

In Transylvania, the accumulation of geological knowledge was slow even if it has all that rich deposits of precious metals that attracted particular attention to foreign scientists.

Geological research conducted over time within Romania's Inner-Carpathian area of were exposed in various scientific works, whether published monographic works, or articles in professional periodicals. For locating these papers in terms of their date and place of publication an important part have the bibliographical works, as those of Franz Toula¹, Ion Simionescu² and

¹ *Uebersicht über die geologischen Literatur der Balkanhalbinsel und des Orients*, published in C.R. IX Congr. Géol. Internat. de Vienne, 1903

The Geological Bibliography of Romania, published by the Romanian Geological Institute, of which the first volume was issued in 1926 and conducted by David Roman and Alexandru Codarcea.

This thesis addresses historical, geological and physical-geographical issues, specific to the studied region, the evolution of geology concept and geological research universally and locally, in our country

The main objective is to bring again to the attention of the scientific community old geological publications and documents published in Europe in the eighteenth and nineteenth century, existing in the Central University Library "Lucian Blaga" Cluj collections. These works reflect the main stages of geological knowledge development within the Inner-Carpathian area of Romania. The documents are either monographic works and maps with internationally recognized scientific value, mentioned in the geological literature as important landmarks in the history of this discipline or less mentioned documents and even omitted from the scientific circuit.

The area referred to in this work include, from a physico-geographical point of view, the Transylvanian Depression, adjacent areas of the Pannonian Basin and the Western Carpathians (Apuseni Mountains).

The study of these documents have sought mainly to highlight and detail the information and also reveal novel aspects of the research of local personalities.

Early information on mineral riches of Transylvania, especially on precious metals, appear in historical works, made by foreign explorers, scholars and scholars concerned with natural sciences or by various administrative officials. The first notes on the scientific nature aspects of geology for Transylvania begin to appear only in the seventeenth century. In the eighteenth-century specific publications for Inner-Carpathian area of Romania is much richer with the issue of a series of works having technical-mining and geological-scientific background.

The nineteenth century geological papers described in this thesis present the achievements of distinguished scientists and those of amateurs interested in the promotion and development of geological research in East European area. A reference work is the monograph *Geologie Siebenbürgen* (1863) with Franz Ritter von Hauer and Guido Stache authors, a very comprehensive work, new geological data at the time, some still valid today.

A Romanian adapting of this publication is performed in 1883 by Basiliu Basiota, judge in Alba Iulia, a geology amateur. His study was *Western Mountains of Transylvania, a geological study upon Metal Mountains of Transylvania*. This study, undocumented in bibliographies of other

2 Geology of Romania: geological literature, considerațiuni generale asupra tectonice și stratigrafiei României. În: *Publicațiunile Fondului Vasile Adamachi*, tom IV (1906-1910), p. 37-66, București.

geological works about the Apuseni Mountains, is another novel aspect of this paper, as well as some personal correspondence documents of the famous Geology professor at the University of Cluj, Antal (Anton) Koch who had great contribution in popularizing the study of Transylvania's geology topic in different scientific meetings at European level.

Geological exploration started in the eighteenth and nineteenth centuries on the Habsburg Empire territory, experienced some decline under the influence of the Napoleonic Wars. In Transylvania geological studies were conducted more by foreign scientists (French, British, Swiss). Between 1710 and 1850 the Vienna Imperial Court granted the mining industry more attention than any other branch of industry and geological literature of the time took into account in particular the topics of mineral location. Some geological studies authors were written by travel enthusiasts (German, Italian, Norwegian, Dutch, French, British) or official messengers.

In the chapter dealing with eighteenth and nineteenth centuries geological maps of Transylvania are highlighted those existing in B.C.U. "L. Blaga"'s collections. These maps were of utmost importance in achieving further geological maps of Romania. They were scanned and stored in digital format and printed by courtesy of B.C.U. "L. Blaga"'s management.

Geological publications of seventeenth to nineteenth centuries in the extent of Romania's Inner-Carpathian area has a special importance for the evolution of geological knowledge of the Romanian territory. In this paper we have considered both their comparative study and making available representative scanned works.

I. HISTORICAL BACKGROUND - SOCIO-POLITICAL ISSUES

Transylvania's past is quite difficult to study and interpret because, although since ancient times it had a well established geographical individuality, as a historical entity the region had different extents. As voievodship of Hungary (from the Middle Ages until 1541) Transylvania included in its' boundaries a well limited area between the Apuseni Mountains and the Eastern Carpathians. Then the Transylvanian principality (after 1541) includes Banat, Crisana and Maramures, this latter acception of Transylvania being close to the currently public meaning.

The work *History of Transylvania* published by the Romanian Cultural Institute, for example, in an attempt to set a history timetable of the region took into account certain official changes, important for the ruling elite.

Apuseni Mountains favorable geographical framework allowed the development of human communities in this region since prehistoric times. The first inhabitants main occupation was farming and grazing, but also mining in mineral-rich areas (in Eneolithic and Bronze Age). The economic importance of this region, especially the south side, resulted in a well documented steady living from the Iron Age and a continuous increase with the rise of the Dacian state, whose political leaders, from Burebista to Decebal, were able to properly assess the economic and strategic value of the area.

At the turn of the second millennium Carpathian territory was conquered by Hungarians and organized in the so-called comitate, including the counties of Alba, Bihor and Turda. There are local structures (kniazates, principalities, country) led by Romanian feudal lords, belonging to noble families with small and medium status (eg Candea family of Lupşa and family Moga of Zarand). Hungarian authorities send to Apuseni Mountains Saxon and Szeklers miners, established in the Aries valley at Abrud, Rimetea, Baia de Aries, Rosia Montana. These colonists along with the native population contributed to natural resources exploitation and defend the territory against migratory peoples.

In the eighteenth century, after integration into the Habsburg Empire, there were many rebellions in Transylvania in order to achieve feudal obligations cutoffs (uprising led by Horea in 1784-1785) and then in nineteenth century to eradicate social and national oppression (the 1848-1849

revolution, when Avram Iancu led resistance movements in the Apuseni Mountains against Hungarian army).

The Great Union of December 1-st, 1918 determined the application of legislative measures, ensuring economic and political unification to completely integrate peacefully the new provinces. During the period 1918-1920 have been established regional bodies for transition: Country's Parliament and the Ruling Council of Transylvania, Union Committees for Bessarabia and Bukovina. Involvement of the monarchy and especially of King Ferdinand in the union increased and enhanced the prestige of Romania at the European level and worldwide, promoting the affirmation of national culture and recruiting Romanian values based on criteria approved in all Western European countries since the eighteenth and nineteenth centuries.

The beginning of the twentieth century brought great enthusiasm in Romanian spirituality circles and in Transylvania began spectacular intellectual transformation, as the institutional framework was created for the necessary academic development: the establishment of a Romanian university in Cluj, University of Dacia Superior, as a priority of Transylvania's Leading Council. Since higher education in Romanian was a special goal since the 1848, the aim of these Transylvanian institutions was to become prestigious in Europe as a center of culture and modern science.

II. GEOLOGY AND THE GEOGRAPHICAL BACKGROUND OF INTRACARPATHIAN REGION

Romania's Inner-Carpathian territory as a geostructure falls in the Carpathian area (folded structure in the Alpine orogenesis), domain corresponding to the Eurasian plate³ active edge. This area along with the Precarpathian region (or Carpathian foreland) contains all major geological units of our country's territory. Geographically, Romania's Inner-Carpathian area corresponds to Transylvanian Depression and neighbouring areas of the Pannonian Basin, and the Western Carpathians (Apuseni Mountains).

II.1 Internal depressions and their neighbouring areas

Transylvanian Depression

As a geostructure it is surrounded by the three Romanian Carpathians branches: Eastern Carpathians, Southern Carpathians and Western Carpathians. The terrain is a plateau in the

³ Eurasian and Afro-European Plates are the two main tectonic plates that resulted from Pangea at the end of Hercinic Cycle.

northwest and in the center and southern part is hilly and plain. The main rivers are Mures and its main tributaries, Tarnave, Ampoi, Aries, in the center and Somes with its tributaries in the north. The geological structure (Fig. 1), taking into account the interpretation that the Transylvanian basin became a separate block after Transylvanian-Pannonian microplate division, during Laramic Neocretacic paroxysm, consists of: a folded metamorphic basement with Mesozoic sedimentary cover and tertiary post-tectonic cover of 4000 meters thick

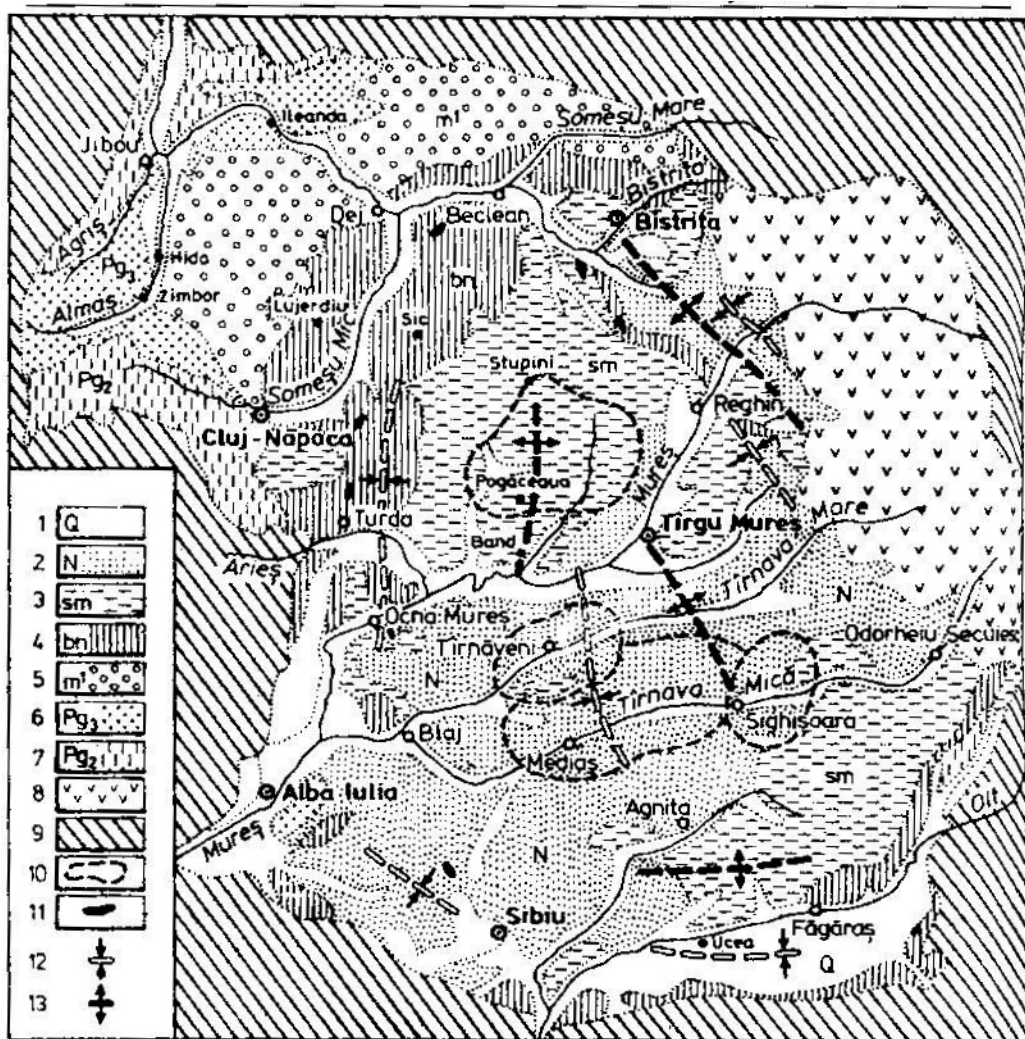


Fig. 1: Geological map of the Transylvanian Depression (Mutihac et. Col., 2007)

Neighbouring areas of Pannonian Depression

Pannonian Depression has a similar evolution and structure as Transylvanian Depression, with a prelaramic basement whose limits can not be fully established in our country. The eastern limit is in Arad-Timisoara area, and the northern limit is Carei-Secueni area.

The Badenian sea that covered this depression extended to the eastern part of Carpathian structures covering the edges, having inserts in the valleys of the three Cris. The neighbouring depressions have their own geostructure, essentially differentiated by the fact that they have been folded in the Alpine orogenesis, unlike the Pannonian basin whose basement has remained stable. Specific facies is present here: Pannonian Facies of Sarmatian-Pliocenian age, which has a rich endemic fauna.

Adjacent areas present a geomorphologic aspect of plain. These areas in order, from North to South, are: Baia Mare Depression, Simleu Depression – most extended one, Borod Depression, Beius Depression, Zarand Depression, Faget Depression, Lugoj Depression, Oraviței Depression (Mutihac, et. Col., 2007).

II.2 Apuseni Mountains

These mountains are situated to the west from the Eastern and Southern Carpathians arc, being part of the studied territory and closing the triangle form in which lies the Transylvanian Depression.

Their position is north of the river Mures, west limit is the Western Plain and east limit the Transylvanian Depression, with some high areas in the west, bordering adjacent depressions. There are two main structural units: the Northern Apuseni Mountains and the Southern Apuseni Mountains which are the result of the evolution of a rift type area and the Pannonian block continental margin.

III. GEOLOGICAL RESEARCH TILL 1939

III. 1 The concept of geology on a universal level ⁴

Prehistory and Antiquity

During a long and sometimes difficult evolution – for we know now that the destiny of humanity reaches back in time to the Toumaï⁵ (*Sahelanthropus tchadensis*) and *Orrorin tugenensis*⁶ –, the people of primitive communities realized very early – *avant la lettre* – the necessity to obtain some basic geological knowledge in order to be able to distinguish and use the most suitable materials for weapons and tools, and also to adorn later their sacral places, where they worshiped their idols.

The Middle Ages and the Renaissance

During this period,⁷ most civilizations were announcing the development of modern science, universally spread .

The scientific knowledge heritage of Antiquity survived the collapse of the Roman Empire, due to Byzantium and arab schools of Damascus and Baghdad which translated the Greek works. The Jews also translated the works (more or less complete) from Arabic to Hebrew, and in the twelfth century they were translated from Hebrew into Latin, thus giving back to the West what was left of the Greek heritage.

Birth and development of modern geology

The notion of *geology* was used only in the seventeenth century for the first time in its modern sense with the publication in 1657, in Oslo. Mikkel Pederson Escholt's *Geologia Norvegica* (*Geology of Norway*) is a work that addresses to earthquakes and minerals.

In the eighteenth century, naturalists ideas and discoveries were still confronted by the Church, and only after 1789, with the French Revolution, Earth Sciences became emancipated and considerably diversified. Nevertheless, some exceedingly important events and discoveries from

4 Morărescu Gabriela, Codrea Vlad, "Geological Research in Inner-Carpathian Romania up to the 19th Century".

În: *Philobiblon*, 14 (2009): 229- 249.

5 Brunet Michel et al., "A new hominid from the upper Miocene of Chad, central Africa". În: *Nature* 418 (2002): 145-151.

6 Brigitte Senut, Martin Pickford, „The geological and faunal context of Late Miocene hominid remains from Lukeino, Kenya”. În: *Comptes Rendus de l'Academie des Sciences, Series IIA - Earth and Planetary Science* 332/2 (2001): 145-152.

7 *Istoria generală a științei. Vol. I: Știința antică și medievală de la origini la 1450* (1970), București: Editura Științifică, p. 430.

this period can be reviewed. Two very different theories regarding the origin of rocks and minerals, neptunism and plutonism dominated geology of the eighteenth century.

In 1775 was established the neptunism school led by the German mineralogist Abraham Gottlob Werner. Their theory was based on the idea that the origin of all rocks was in the water of seas and oceans. Concentrated particularly on sedimentary rocks, Werner issued some erroneous conclusions regarding the origin of volcanic and metamorphic rocks, but prepared a "stratigraphic profile" of Earth's mantle rocks, without specifying their age, thus creating the notion of geologic timeline. Werner described in his model primary series, granites and gneisses, and three sedimentary series succeeding them.

During the nineteenth century, amid the fruitful dispute between plutonists and neptunists, some basic principles of modern geology were established through fundamental scientific works. Independent disciplines were successively separated: mineralogy, petrography and mineral deposits. Research in these disciplines was facilitated by the development at the turn of two centuries of other related sciences: chemistry, physics, zoology, botany, mechanics .

III.2 Geological research in Romania

Over time, knowledge and use of "stones" have gradually evolved in Romania, conditioned each other, with social implications in the development of society.

In the early days of The Middle Ages metal processing craft began to separate from extracting ores. Because there was a lack of iron throughout Europe, on Romanian territory iron smiths began to seek it in limonitic ores and then in hematite and magnetite ores. In rudimentary furnaces metal was extracted from iron ore to get the necessary material.

Another useful substance extracted in our country from ancient times was salt. Using the salted water springs man obtain a solid mass that was exchanged for other products - process used in Cacica - Suceava since the fourth millennium BC. During migration salt extraction still existed: 62 salt massives were discovered in Transylvania and Banat in seventh to ninth centuries at Moresti, Cipau, Unirea, Noşlac, as Gepid settlements and close to Turda and Ocna Mures mines as Avar settlements. Outside the Carpathians migratory peoples settled also around the salt mines and salt springs. The main salt mines were in Turda, Ocna Mures Sinpaul, Ocnele Mari, but in the following centuries exploitation was intensified in Ocna Dej, Cojocna, Uioara, Sic.

Late antiquity and medieval times findings indicate use of local resources for construction materials like dacitic tuff in Dabaca fortress – ninth-tenth centuries, extracting copper from local deposits to make adornments and iron for agricultural tools, production of ceramics, both

hand-made pottery and the wheel pottery, prevalent in tenth and eleventh centuries, making glass beads in Tibiscum (Jupa) - Banat and Dierna (Orsova).

Written records of geological findings in Romania can be found as notes in the works of *Nicolaus Olachus* (1535) and *Dimitrie Cantemir* (1716). As for Transylvania, *Georgius Vette* observations on vertebrate debris and emissions of methane were published by *Henricus Vollgnad* in the Imperial Academy of Sciences publication Vienna (1676, 1677).

The first general geological map of Romania (except some regions of Dobrogea and Muntenia) was drawn in 1806 by the Polish geologist *Stanislaw Staszic*, apprentice of A. G. Werner and other European geologists.

The first mineralogy publication in Romanian (written, however, with Cyrillic letters) was published in 1837, being an adaptation of I. Reinhard's textbook (issued in Heidelberg in 1883) by *Iacob Cristian Stanislau Cihac*.

In the second half of the 19th century, the evolution of geological sciences in Romania was influenced by the appearance of new international scientific research methods, and, on a national level, by the development of science, culture and education during the reigns of Alexandru Ioan Cuza and King Carol I (in Walachia and Moldavia united and renamed Romania), as well as the increase of geological research directed by the Imperial Institutes of Vienna and Budapest (for Transylvania and Banat). In the Romanian principalities, the establishment of the universities of Iași (1860) and Bucharest (1864) were also of a tremendous importance⁸.

In Transylvania, the progress of mineralogical studies was stimulated already in the last decades of the 18th century by the establishment of the mineralogical section of the Museum of Sibiu founded by Baron von Brukenthal, governor of Transylvania. As curator of this museum, *Johann Ludwig Neugeboren* published considerable contributions on the gold bearing deposits of the Metalliferous Mountains and the Neogene fossils of Transylvania (1836–1862). Furthermore, in 1855, the dean *Johann Michael Ackner* (councillor and correspondent of the Geological Institute of Vienna) published the work *Mineralogie Siebenbürgens*⁹, synthesizing the data obtained in the first half of the 19th century.

8 Dan Rădulescu, Radu Dimitrescu, *Cercetarea geologică a pământului românesc în a doua jumătate a secolului XIX și primele decenii ale secolului XX* (The Geological Research of the Romanian Land in the Second Half of the 19th and the First Decades of the 20th Century), *Academica: revistă de știință, cultură și artă*, New series, 24 (2004): 58

9 Michael J. Ackner (1855): *Mineralogie Siebenbürgens: mit Geognostischen Andeutungen*, Hermannstadt: Druck und Verlag von Theodore Steinhaussen, 392 p.

III.3 Geological research in Inner-Carpathian Romania

The results of geological research made in the Inner-Carpathian area of Romania in the course of time have been presented in different scientific writings issued either as monographs, or as articles in periodical publications. In order to find out these papers place and date of publication of great help is to review specialized bibliographical works.

Such general works on the geological literature dealing with Romania are the old bibliographic catalogues made by *Franz Toula* (*Uebersicht über die geologischen Literatur der Balkanhalbinsel und des Orients*, published in C.R. IX Congrès Géologique International de Vienne, 1903) and *Ion Simionescu* (*Geologia României: literatură geologică; considerațiuni generale asupra tectonicei și stratigrafiei României* – The Geology of Romania: Geological Literature; General 1 Michael J. Ackner, *Mineralogie Siebenbürgens: mit Geognostischen Andeutungen* (Hermannstadt: Druck und Verlag von Theodore Steinhaussen, 1855), 392. *Philobiblon Vol. XIV-2009* 241 Considerations on Romania's Tectonics and Stratigraphy, 19101), Bucharest, 1910.). In the regional bibliography of Hungary, compiled by *Antal Bődör* and *István Gazda* in 1944 there are bibliographical data referring to all scientific domains, organized according to the regional division of Hungary in the period 1527–1940 (*Magyarország honismereti irodalma 1527–1940* – The Historical, Geographical Literature of Hungary 1527–1940).

Another very important reference work in Romanian geology is *Bibliografia geologică a României* (The Geological Bibliography of Romania), a publication of the Geological Institute of Romania, whose first volume was issued in 1926. This work was compiled by *David Roman* and *Alexandru Codarcea*, and contains a part of the geological literature and of other related sciences referring to Romania.

In Transylvania, geological knowledge has been slowly accumulated, although her rich precious metal deposits in particular drew the attention of foreign researchers.

In addition to the historical “writings” which describe the rich mineral deposits of Transylvania, scientific works began to be issued in order to support those interested in exploiting these useful resources. For example, in the aid of pyrotechnists *Breviculus pyrotechnicus memoriae artificium in ea re commendatus* (1697)¹⁰ written by *Bálint Frank* was published in Sibiu. In 1717, also in Sibiu, the first treatise on mineralogy, geology, ores and mining in Transylvania was issued: *Auraria Romano-Dacica*, written by Gubernial Councillor *Sámuel Köleséri de Keres-Eer*.

10 *Industria minieră a județului Cluj: monografie (Mining Industry of Cluj County)* (1972), Cluj: [s.n.], p. 40-45.

Valuable information on the exploitation of salt mines in Turda, Cojocna, Ocna Dejului, Ocna Sibiului, Sic and Praid were comprised in mineralogist *Johann Fridwaldszky's Mineralogia Magni Principatus Transylvaniae*, issued in Cluj in 1767.

The mineralogist and metallurgist *Ignatz Edler von Born* had an important role in promoting the knowledge on Transylvania's mineral richness. He was a great Enlightened scholar born in Alba Iulia, whose "letters" written after a journey in Banat discussing the mineralogy of Transylvania and Banat were published in German in Frankfurt and Leipzig, and later on also translated to French, English, and Italian (1774: *Briefe über mineralogische Gegestände auf der Reise durch das Temeser Banat, Siebenbürgen, Ober- und Nieder-Ungarn*)¹¹. He also published in 1783 an article on stibine crystals in Transylvania entitled *Nachricht vom gedigenen Spiessganzkönig in Siebenbürgen* in the journal *Abhandlungen einer Privatgesellschaft in Böhmen* in Prague.

In 1774 the first monographic description referring to the cave of Fânațe in Apuseni Mountains (*Elek Nedetzky: Funacza Pestere seu antri Funacza dicti historico physica relatio concinnata ab Alexio Nedetzky de Eadem, qui ipsius antrum hocce lustravit anno 1772, die 19 Octobris, 1–36, Viennae*)¹² was published.

The geographical regions of Transylvania and Banat were the subject of *Franz Griselini's* later (1780) published "attempt of political and natural history": *Versuch einer politischen und natürlichen Geschichte des Temesvarér Banats*, his work being translated to Romanian as well. In the same year, *Johann Ehrenreich von Fichtel* published in Nuremberg a book in two sections, the first containing reports on fossils found in Transylvania, the second additions to the history of rock salt and salt mines in Transylvania (*Beiträge zur Mineralgeschichte von Siebenbürgen. I. Nachrichten von den Versteinerungen des Grossfürstentums Siebenbürgen. II. Geschichte des Steinsalzes und der Salzgruben in Siebenbürgen*). The same author described later (1791) the Transylvanian Mountains in his *Mineralogische Bemerkungen von den Karpathen* published in Vienna.

Hager Johann Daniel wrote a work on the occurrence of native gold in Transylvania: *Über das Vorkommen des Goldes in Siebenbürgen* (1797), and *Balthasar Hacquet* one on the salt mines of Transylvania and Galicia: *Ueber die Salzberge in Siebenbürgen und Galizien* (1794, in *Moll's Jahrbücher der Berg- und Hüttenkunde*, Prague).

11 Mineralogul și metalurgistul I.E. von Born, născut la Alba Iulia, în urma unei călătorii prin Banatul Timișului realizează această lucrare pe teme mineralogice care, în următorii ani este tradusă și în alte limbi: engleză, franceză și italiană

12 Tiberiu Jurcsák, Rozalia Poliș, Doina Ignat, Mihai Șerban, Elisabeta Popa: „Date privind fauna fosilă a Peșterii Urșilor (Munții Bihor)”. În: *Nymphaea: Folia naturae Bihariae*, VIII-IX (1980-1981): 161-162.

Jens Esmark published in Freiberg in 1798 his observations on mineralogical themes made during journeys in Hungary, Transylvania and Banat (*Kurze Beschreibung einer mineralogischen Reise durch Ungarn, Siebenbürgen und das Banat*)¹³.

At the turn of the 18th and 19th centuries Aiud was an important Transylvanian scientific centre; its fame reached far and wide, a fact proved also by a 18th century manuscript preserved in the Bethlen Documentary Library in this town¹⁴.

In the first decades of the 19th century many foreigners travelling in Transylvania published works focused on geology: *François Sulpice Beudant* (1822): *Voyage minéralogique et géologique en Hongrie pendant l'année 1818*, *Ami Boué* (1831): *Coup d'oeil d'ensemble sur les Carpathes, le Marmorosch, la Transylvanie, etc.*, *Lill von Lillienbach* (1833): *Journal d'un voyage géologique fait à travers toute la chaîne des Carpathes en Bukovine et en Transylvanie*.

The western part of Apuseni Mountains (Bihar Mountains and Codru Moma Mountains) was studied between 1858 and 1862 on the initiative of Hungary's Habsburg Governor (Albrecht Archduke), the results of this research being compiled in *Adolf Schmidl's* work *Das Bihar-Gebirge* published in 1863. This work reflects a synthetic conception in the survey of a region, including multidisciplinary investigations (on geomorphology, geology, biogeography, economic geography, and history), emphasizing a modern form of research, being a reference work in the study of the karst in Bihar Mountains¹⁵.

In Transylvania in the 19th century, mineralogical research focused on the known gold and silver deposits of the Apuseni Mountains (*František Pošepny*, *Anton Koch*), on the deposits of Bucovina (*Franz Herbich*), the sulphur in Călimani Mountains (*Fülöp Jakab Kremnitzky*), and the iron deposits in Banat. *Zsigmond Szentpétery* investigated the mafic rocks of Trascău, Metaliferi, Drocea and Perșani Mountains, and *Gyula Szádeczky* the felsic rocks of Vlădeasa Mountains¹⁶. Coal began to be used in metallurgy, which led to the intensification of scientific research on these resources (*Johann Kudernatsch* – 1867, *Roth von Telegd* – 1890).

13 Lucrare în care se fac observații atente asupra multor localități de munte din Transilvania și o descriere geologică generală a acestora.

14 Vlad A. Codrea, Gabriela R. Morărescu, Forray Erzsébet: „Un catalog manuscris din perioada de început a Muzeului de la Colegiul Bethlen Gábor, Aiud”. În: *Elanul: revistă de cultură editată de Asociația culturală „Academia Rurală Elanul” și Școala „Mihai Botez” din Giurcani, com. Găgești, jud. Vaslui*, nr. 72 (2008):1, 12-13.

15 Liviu Vălenaș: „Considerații asupra informațiilor documentare despre carstul Munților Apuseni în lucrarea „Das Bihar-Gebirge” (1863) de A. Schmidl”. În: *Nymphaea: Folia naturae Bihariae*, VIII-IX (1980-1981): 549-560.

16 Dan Rădulescu, Radu Dimitrescu: „Cercetarea geologică a pământului românesc în a doua jumătate a secolului XIX și primele decenii ale secolului XX”, În: *Academica: revistă de știință, cultură și artă*, Serie nouă, nr. 24(2004): 59.

The middle of the 19th century marked a development in the investigation of Neogene volcanism of the Carpathians. For the Inner-Carpathian region the genetic relationship between lode mineralization and volcanic rocks was proved, laying thus the scientific basis for a new prospecting activity of these deposits. When the University of Cluj was founded (1872), Anton Koch was invited from Budapest to be a professor of geology, since the main aim of his scientific research was to obtain geological information on the central unit of Transylvania, and to make a geological synthesis¹⁷. In this extensive monograph published in two volumes (1894, 1900) former publications written by other geologists (e.g. *Karl Hofmann*, *Ferenc Pávay-Vajna*, *János Böckh*) were referred to. In the volume describing the Palaeogene, Koch outlined a series of correlations with formations from the Paris Basin, mainly based on lithology¹⁸.

Károly Herepei, a geologist who published in 1865 a work accompanied by a geological sketch, made the first detailed description on the morphology and geology of the Transylvanian Depression's Southwestern region¹⁹. Later on (1896), he added new data to this work, writing a new chapter referring to the geology of Alba County. This was the first part of the county's monograph published in Aiud²⁰.

Palaeontology made the Romanian territory well known, Transylvania's fossiliferous areas becoming reference points for the international literature of the field (*Johann Ludwig Neugebauer*, *Franz Hauer*).

Salt is a treasure of Inner-Carpathian Romania. It was exploited much before any thorough scientific research was made. The first scientific information on this resource dates back to 1780 (*Ignatz Edler von Born*). *František Pošepny* around 1870 made research on salt, and beginning with the 20th century, it has been investigated by many geologists both theoretically and economically.

17Ioan. Al. Maxim: "Câteva considerațiuni asupra valorii actuale a lucrării lui Anton Koch - Formațiunile terțiare ale Bazinului Transilvaniei I. Paleogenul, 1894. II. Neogenul, 1900". În: *Studia Universitatis Babeş- Bolyai. Series II:Geologia-Geographia*, 1959, 1: 7-22.

18 Cristina Fărcaș, Vlad Codrea: „Evolution of knowledge on Paleogene formations from the NW border of the Transylvanian Basin”. În: *Studii și cercetări, Geologie – Geografie Bistrița*, 9 (2004): 13-46.

19 Iustin Gherman: "Cercetări geologice în colțul de SW al depresiunii Transilvaniei (între Valea Stremțului și Valea Ampoiului)". În: *Revista Muzeul Mineralogic-Geologic al Univesrității din Cluj la Timișoara*, vol. VII (1940-1941): 3.

20 Herepei Károly, Gáspár János: „Alsófehér vármegye földrajzi és földtani leirása”. În: *Alsófehér vármegye monografiája*, I kötet, (Nagy-Enyed: Cirner és Lingner Könyvnyomdája, 1896): 103-183.

III.4 Geological research in Inner-Carpathian area, reflected in 18th and 19th centuries literature, from the collections B.C.U. "Lucian Blaga" Cluj

Georgius Vette²¹ was one of the first scientists who had geologically relevant contributions and published two studies in 1676: *De draconibus Carpathicis et Transsylvanicis* referring to vertebrate fossils from Transylvania and illustrating the skull of a cave bear and *De aquis ardentibus*, practically the first testimony of the methane presence in Sibiu outskirts, outlining the existence of „burning waters”, most probably near Copșa Mică²².

In 1697 **Frank Bálint**²³ translated and published in Sibiu, Conrad Haas's manuscript which is a "guide" with practical examples in pyrotechnics to help workers in mining, especially firestarters, important work to train future workers in Transylvanian salt mines, in specially schools set up but much later, from 1780 to 1790.

Sámuel Köleséri²⁴ is the author of what is considered as the first published work on technical topics about Romanian territory²⁵ *Auraria Romano-Dacica* (Fig. 2). The work was published in 1717 at Sibiu and it describes mineralogy, geology, mining deposits of the principality of

Transylvania. In this valuable publication, the author pays particular attention to the location of gold mines in the territory and capture the historical aspects of the exploitation and processing gold since the Roman times.

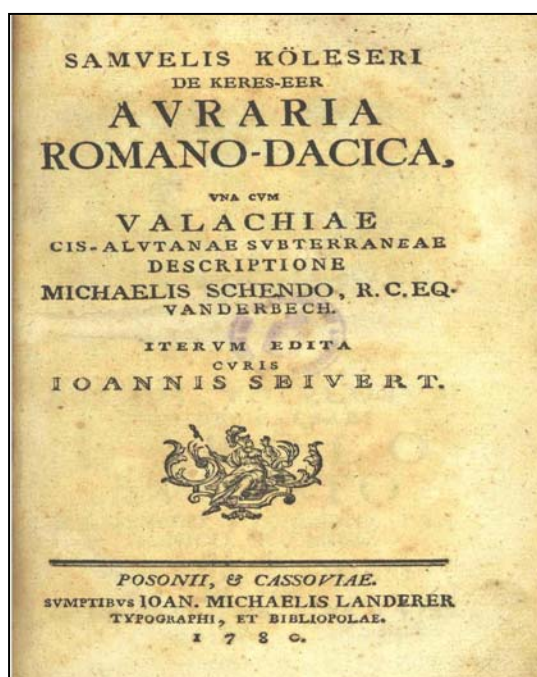


Fig. 2 : Sámuel Köleséri: *Auraria Romano-Dacica*, ediția 1780 (BCU- 189905)

21 Georgius Vette (1645-1704): chimist și naturalist sibian.

22 Emil Pop, „Vechi note naturaliste despre România”, *Analele Academiei Române, Memoriile Secțiunii Științifice*, Seria III, XVIII (1943), 5: 76-77.

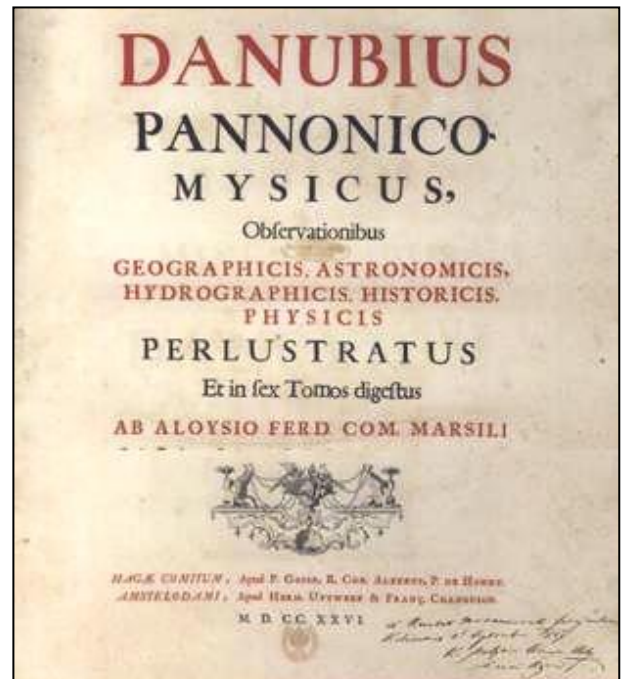
23 Valentin Franck von Franckenstein (1643-1697), sibian, poet și traducător din limba germană (*Allgemeine Deutsche Biographie*, Volumul 7, Leipzig 1877, p. 263–264).

24 Sámuel Köleséri (1663-1732), consilier gubernial; a studiat teologia, filosofia și medicina în Olanda și a fost numit medic șef și supervisorul minelor în Transilvania.

25 Tataru S., Khiell O.: "Auraria romano-dacica de Samuel Koleserius". În: *16th International Congress of the History of Science, Proc. B: Symposia*, (1981).

The same phenomenon described by *Vette, appa ardens*, is recorded also later in 1726 by **Luigi Ferdinando Marsigli (lat.Marsilius)** in Medias area, at Bazna. Scientific observations he gathered in twenty years in the Habsburg Empire were used to achieve his most important work on the Danube, *Danubius Pannonico – Mysicus* (Fig. 3), a 6 volumes encyclopedia, richly illustrated with 300 plates, which had a great importance in the development of European science and culture.

Fig. 3: Luigi Ferdinando Marsigli: *Danubius Pannonico - Mysicus*, 1726
(BCU – Opere de artă 34)



The manuscript of this work was prepared for printing by *Johann Christoph Müller*, at Nuremberg, working version appeared in 1700, the work itself was proposed to be printed in 1704. Only after two decades in 1726, this work is published in Amsterdam and The Hague and components make up a map atlas to be published in 1744.

In 1767 **Johann Fridvaldszky** publishes in Cluj his work: *Minero-Logia Magni Principatus Transilvaniae* (Fig. 4). Valuable information about operating the mines from Turda, Cojocna, Ocna Dej, Ocna Sibiului, Sic and Praid are presented and also data about metals, semimetals,



sulfides, rocks and waters of the Great Principality of Transylvania are found in it.

Fig. 4: Johann Fridvaldszky: *Minero-Logia Magni Principatus Transilvaniae*, 1767 (BCU – 58114)

The famous mineralogist and metallurgist **Ignaz Edlen von Born**²⁶, undertook in 1770, a study tour in Hungary, Transylvania and Banat. After the tour he sent to his friend, the German geologist Johann Jakob Ferber, letters in which he recounts those observed in these areas: geography features, natural resources, local customs and culture of the people. These letters were first published in Germany, in Frankfurt in 1774, under the title: *Briefe über Mineralogische Gegenstände, auf seiner Reise durch das Temeswarer Banna Siebenbürgen, Ober - und Nieder Hungarn*. They were translated then into English, Italian and French. The French version, *Voyage minéralogique fait en Hongrie et en Transylvanie, 1780* (Fig. 5) - translated and annotated by Antoine Grimaldi Monnet, the general inspector of mines in France and of the Royal Academy of Sciences in Stockholm and Turin, was a valuable source of information for professionals of that time.

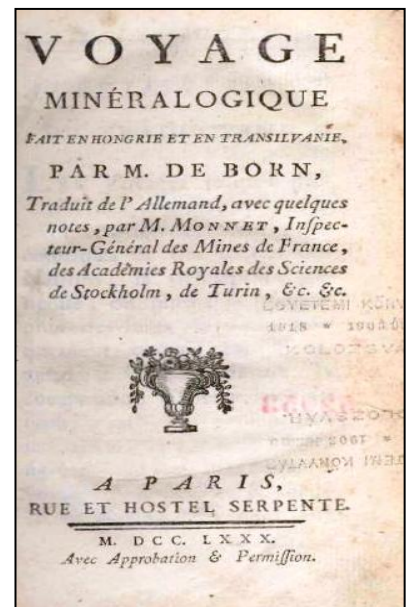


Fig. 5: Ignaz Eldlen von Born:

Voyage minéralogique fait en Hongrie et en Transylvanie, 1780
(BCU: 52053)

Another passionate for natural sciences study of territories belonging to the Habsburg Empire, is **Francesco (Franz) Griselini**²⁷ who published in 1780 in Vienna, the work: *Versuch einer Politischen und naturlichen Geschichte des Temeswarer Banats in Briefen en Standespersonen und Gelehrte. Zweiter Theil: Naturliche Geschichte des Bannats. Beschaffenheit des Flaschen Landes. Gebirge, mit ihren Mineralien und Fossilien: Mineralische Wasser und Brunnen, in verschiedenen Gegenden; besonders die berühmten herkulischen Bäder zu Mehadia*. work that was designed into two distinct parts: the political history and the natural history of Banat, having

²⁶ Ignaz Edlen von Born (1742-1791), urmează colegiul iezuit la Viena și studii juridice la Praga, dar se dedică cercetărilor din domeniul științelor naturale (mineralogie, chimie, geologie) care vor rămâne ca preocupări primordiale, până la moartea sa.

²⁷ Francesco Griselini, savant italian născut la Veneția, pasionat de studiul științelor umaniste și ale naturii

a correspondence format, letters addressed to distinguished both military and political leaders and scholars with whom he had personal or scientific relationships²⁸.

Johann Ehrenreich von Fichtel²⁹, Transylvanian Treasury adviser at Sibiu provided important information for the geological research in Transylvania. Karl Alfred von Zittel³⁰ considered him in his work *Geschichte der Geologie und Palaeontologie bis Ende des 19 Jahrhunderts* (*History of Geology and Palaeontology to the end of nineteenth century*) published in 1901, as one of the most gifted stratigraphy researchers dedicated to geological study of the Austro-Hungarian Empire territory.

At the turn of the 18th and 19th centuries, Aiud was an important Transylvanian scientific centre; its fame reached far and wide, a fact proved also by a 18th century manuscript preserved in the Bethlen Documentary Library in this town³¹. A detail still remained obscure to the public - and paradoxically, to a part of museographers - is that from the existing natural sciences museum collections in Romania, the Natural Sciences Museum of Aiud is undoubtedly the oldest. The beginnings of this museum is linked to a core collection, mainly minerals, fossils and antiquities, mentioned in the manuscript *Catalogus Raritatum et Benefactorum* (Fig. 6)³² kept by **Ferenc László Benkő Nagy**, since 1796. This document was preserved in the Bethlen Documentary Library of Aiud since the 18th century.



Fig.6: A part of the title page of the manuscript *Catalogus Raritatum et Benefactorum*, in hard cover

28 Grisileini face deseori referire în scrisorile sale la scrierile lui Ignaz von Born și ale lui Johann Jacob Ferber.

29 Johann Ehrenreich von Fichtel (1732-1795), născut la Pressburg (Bratislava de azi), consilier al tezoreriei transilvănene la Sibiu în 1769.

30 Karl Alfred von Zittel (1839-194), paleontolog german.

31 Vlad A. Codrea, Gabriela-Rodica Morărescu, Forray Erzsébet: „Catalogus Raritatum et Benefactorum, un manuscris reprezentativ din perioada de început a Muzeului de Științele Naturii din Aiud”. În: *Hermeneutica Bibliothecaria – Antologie Philobiblon* – vol. IV (2009), p.166-176.

32 Benkő Ferenc, Nagy László (1796): *Catalogus Raritatum et Benefactorum*, [manuscris], Aiud, 47 p.

In the last decade of the 18th century **Jens Esmark**³³, a Danish geologist, undertook a travel in Europe between 1791 and 1797 (almost 6 years), in order to collect different minerals from different locations. He visited the territories belonging currently to the Czech Republic, Slovakia, Austria, Hungary, Poland, Romania and draw some reports on these trips. In 1798, his work *Kurze Beschreibung einer mineralogischen Reise durch Ungarn, Siebenbürgen und das Bannat* is published in Freiberg, a description of his mineralogical trip through Transylvania and Banat.

Stanisław Staszic³⁴ the great Polish scholar, wrote a series of four reports on the geology of Poland and the neighboring regions in the years 1806-1809. He draw a general geological map of Central and Eastern Europe, which includes a part of Romania and is considered one of the first large-scale maps of Europe: *Carta geologica totius Poloniae, Moldaviae, Transilvaniae, et partis Hungariae, et Valachiae. Inventa per Staszic anno 1806. Hoffmann delin.¹ Frey Sculpt.*³⁵ (Geological map of Poland, Moldova, Transylvania and part of Hungary and Wallachia). A particularly important role in the bibliography used for Transylvanian territory by Staszic were the work of Fichtel, *Mineralogischen Bemerkungen von der Karpathen* considered to be the first mineralogical work of the country.

French mineralogist **François Sulpice Beudant**³⁶ began his geological journey through the Kingdom of Hungary in 1818 at the expense of the French Government. In 1822 he published a work in three volumes accompanied by a map volume, which will get his recognition in the European scientific world: *Voyage minéralogique et géologique, en Hongrie, pendant l'année 1818* (BCU 83435). Beudant starts the journey as deputy director of the imperial cabinet of mineralogy, to collect samples to develop mineralogical collections of the cabinet and to study volcanic formations and their associated metal deposits in Hungary. Chapter XIV is devoted to Transylvania and Banat (Fig.7). Before his departure from Paris, he reviewed information about Transylvania while trying to gather as much data on this this region as he could, compared with what was already known about Hungary.

33Jens Esmarck (1763-1839), expert danez în montanologie și profesor de mineralogie, adept al neptunismului.

34 Stanisław Staszic (1755-1826), had a teological career, then studied Natural Sciences in Paris; he is one of the founders og Polish Enlightenment.

35Algimantas Grigelis, Zbigniew Wojcik, Wojciech Narebski, Leonora Živilė Gelumbauskaitė, Jan Kozak, Stanisław Czarniecki: „The first large geological map of Central and Eastern Europe (1815)”. In: *Geologija* - Vilnius, Vol. 50(2008), No. 2(62), p.125–134. (After 1816 printed version, Warsaw)

36 François Sulpice Beudant (1787-1850), mineralog francez, profesor de matematică și fizică, cu preocupări asupra studiului geologiei și științelor conexe acesteia încă din 1814.

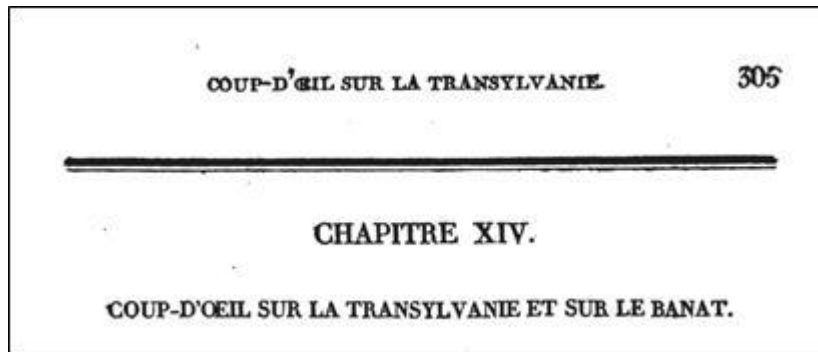


Fig. 7: F.S. Beudant: *Coup-d'oeil sur la Transylvanie et sur le Banat*, 1822

Another travel enthusiast, being interested in Roman archaeological sites in Transylvania and collecting various mineral and fossil encountered was **Johann Michael Ackner**³⁷ from Sighisoara, which between 1832-1847 has made many journeys to the ancient Roman Empire, often accepting to organize in his parish meetings for various scientific organizations. Observations have resulted in articles and scientific papers published in various journals or books (*Antiqua Musei Parisiorum monumenta*, 1809; *Geologisch-palaeontologische Verhältniss des siebenbürgischen Grenzgebirges längs der Kleinen Walachei*, 1851; *Beitrag zur Geognosie und Petrefactenkunde des Südöstlichen Siebenbürgens: vorzüglich der Schichten aus dem Bereich des Hermannstädter Bassin*, 1854 ; *Mineralogie Siebenbürgens* (Fig.8), 1855).



Fig. 8: J. M. Ackner: *Mineralogie Siebenbürgens*, 1855 (BCU 190401)

³⁷ Johann Michael Ackner (1782-1862), a urmat cursurile gimnaziale la Sighișoara și Sibiu, iar studiile în filosofie le-a început la Colegiul reformat din Sibiu.

Observations and results of palaeontological and mineralogical research are published by Ackner, between 1851-1853, in a series of articles in Transylvanian Society for Natural Sciences of Sibiu magazine *Verhandlungen und Mitteilungen des Siebenbürgischen Vereins für Naturwissenschaften zu Hermannstadt* [= Debates and communications in Transylvanian Society for Natural Sciences of Sibiu] The fossils found in these study trips are specified and various mineralogical observations (eg formation of "spheres of sandstone" (*Sandsteinkugelbildung*) today called "concretiuni de Feleac").

Adolf A. Schmidl³⁸ led an expedition between 1858-1862, initiated by the governor of Hungary at that time, Archduke Albrecht, aiming to research the western Apuseni (Bihar Mountains and Codru-Moma Mountains). Unlike other members of the expedition, which published their results separately, Schmidl includes in his work, in addition to the synthesis of research results, the topography of Professor Josef Wastler³⁹. In his *Das Bihar-Gebirge: an der Grenze von Ungarn und Siebenbürgen: mit einer geodätischen Abhandlung, Karte, Panorama und Höhlen-Plänen von Josef Wastler, Professor am Joanneum zu Gratz und Ansichten von R. Wirker*, published in Vienna in 1863, research is grouped by geomorphology, geology and biogeography and economic geography, ethnography and history. A. Schmidl's work has the quality to be the first speleological inventory of Bihar Mountains, proving its author's synthetic thinking, addressing multidisciplinary research methodology as it ranks among the "revolutionaries" of the nineteenth-century scientific researchers. Although he was adept of lithological contact only karst circulation theories, he has the merit of having understood the concept of karst system (although not using it under that name) from a hydrogeological point of view, calling several karst systems Bihar Mountains and Forest-Moma Mountains were research confirmed the following years.

Franz Ritter von Hauer and **Guido Stache**'s work *Geologie Siebenbürgens* (Vienna, 1863 – BCU 65940 ; 99814), called by Ion Al. Maxim⁴⁰ a *milestone* in geological research of Transylvania is of great importance not only for presenting the geological structure of the region, but especially for establishing the link between the structure and the logical, natural development of the phenomena leading to geological units genesis of the perimeter investigated.

38 Adolf (Anton) Schmidl (1802-1863), profesor de geografie la Universitatea din Viena, cu o constantă preocupare în studiul fenomenelor carstice.

39 L. Vălenaș: „Considerații asupra informațiilor documentare despre carstul Munților Apuseni în lucrarea "Das Bihar-Gebirge" (1863) de A. Schmidl". În: *Nymphaea: Folia naturae Bihariae*, vol. VIII-IX (1980-1981), p. 549-560.

40 Ion Alexandru Maxim (1902-1968), doctor în geologie cu carieră didactică universitară la Cluj (1922-1968)

Edward Albert Bielz⁴¹ had the initiative to achieve this monograph as president of the Transylvanian Society of Natural Sciences based in Sibiu, scientific association that financed the monograph's printing. *Geologie Siebenbürgens* contains a series of new geological data at the time, some still available today, which gives it a great level of originality⁴².

An adaptation of this publication in Romanian language was made in 1883 by **Basiliu Basiota (Bașotă)**⁴³, a geology amateur, having legal training, but a great passion for travel, geography and history. He undertook a trip in the Apuseni Mountains in 1859, then published a series of papers and articles, highlighting the beauty and natural riches of these mountains. His research study, *Munții apuseni ai Transilvaniei seau Studiu geologicu asupra structurei muntiloru metalici ai Transilvaniei* (Fig.9), published in Blaj in 1883, in a time when there have been great advances in field geology in the world due to the emergence of new research methods of mineral substances. This has influenced the development of science and education and thus, the evolution of geological sciences and specialized higher education.

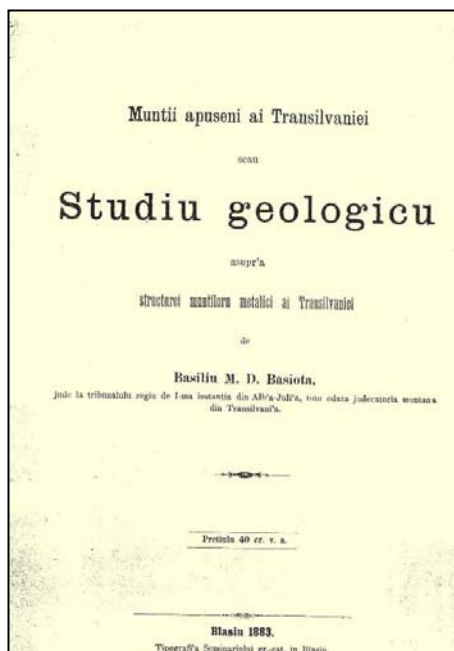


Fig.9: Basiliu Basiota: *Studiu geologicu...*, 1883 (BCU 178775)

41 Eduard Albert Bielz (1827-1989), om de știință sibian, care l-a însoțit pe F. Hauer în unele călătorii pe teritoriul transilvan, cu scopul cercetării din punct de vedere geologic al acestuia

42 Idem

43 Basiliu Basiota (1836-1906) face parte din rândul oamenilor de seamă ai ținutului Năsăudului, fiind descendentul unei vechi familii boierești din Botoșani refugiată în Valea Someșului în timpul domniei lui Duca-Vodă (1665-1683).

Being passionate about travel, geography and history, Basiliu Basiota, published after 1875 a series of papers and articles highlighting and commenting on general problems of environment and natural phenomena, but also works that highlight the beauty and natural riches of these lands, especially the Apuseni Mountains.

A great contribution in geological research Transylvanian territory and the development of geological education university of Cluj had the famous geologist, petrography, mineralogy and paleontology professor, **Antal (Anton) Koch**⁴⁴, appointed in 1872 at the Department of Mineralogy and Geology of the newly established University of Cluj and director of the Geological Institute. He was appointed Doctor Honoris Causa in 1874 and served as Rector in academic year 1891-1892. He contributed to the work of various specialized congresses, with exposures on the geology of Hungary and Transylvania, showing geological maps published for this area by other authors.

Antal Koch was the most active member of the Department of Natural Sciences of the Transylvanian Museum Society, managing to clarify some issues related to the geological evolution of Transylvania and to help complete The Collection of the Mineralogy and Geology Museum at the University of Cluj⁴⁵.

Contributions to the study of tetrapods fossils (especially dwarf dinosaurs) from Transylvania start to be published in the late nineteenth century by the aristocratic adventurer, a passionate for paleontology: Baron **Franz Nopcsa**⁴⁶. His main research field was dinosaurs, and brought new taxonomic concepts for determined Dinosauria species, different from those of his contemporaries.

The beginning of the new century was characterized by a special movement in all groups of Romanian spirituality in Transylvania. Here have worked great personalities of the natural sciences and geology, recognized worldwide: Gheorghe Munteanu Murgoci, Ion Popescu-Voitești, Emil Racovita. The professors of the University of Cluj proposed systematic and diverse scientific activities were concerned in the highest degree of methodological attitude of scientists and the enrichment of scientific research instruments.

44 Antal (Anton) Koch (1843-1927), profesor de geologie la Universitatea din Cluj; a publicat peste 200 de lucrări științifice: monografii, studii, articole în publicații periodice de specialitate din țară și străinătate, făcând parte din colectivul de redacție a unora dintre acestea (*Földtani Közlöny* din Budapesta – 1871-1873, și *Orvos és Természettudományi Értesítő* din Cluj – 1879-1895).

45 Vanek Ferenc: „Koch Antal”. În: *Hivatás és tudomány: az erdélyi múzeum-egyesület kiemelkedő személyiségei, Kolozsvár: Erdélyi Múzeum-Egyesület, 2009, p. 283-339.*

46 Franz Nopcsa (1877-1933), născut într-o familie de aristocrați maghiari, în apropierea Hațegului, la Săcel, studiază la Universitatea din Viena începând cu anul 1898, preocuparea lui principală fiind paleontologia vertebratelor; a ocupat funcția de director al Institutului Geologic al Ungariei, în intervalul 1925-1928.

IV. OLD GEOLOGICAL MAPS, SIGNIFICANT FOR ROMANIA'S INNER-CARPATHIAN AREA

The **geological map** is a special document that currently is an essential source of information to address issues involving the use of Earth resources, according to the risks and natural conditions in the area of interest. It is absolutely necessary to know the geological structure, distribution and typology of existing basement rocks and tectonic elements in a given region: land use planning, location of industrial and civil objects, starting development projects and transport systems of hydrological works and not the least the exploitation of mineral resources available.

The geological map is in fact a quadro-dimensional system of data, the fourth dimension being the geological time, absolutely necessary to accurately assess the situation of natural elements and environmental and socio-economic risk factors. The interpretation of a map is not only locating geological formations or structures, but also understanding their characteristics at the time of their formation. A geological map implemented in electronic format (digitized map) completed with geographical information systems (GIS) is an interactive way to make interpretations of extremely varied and complex issues.

The intense activity of mapping carried out mainly in the nineteenth century and very different variants of using color to represent rocks, the second International Congress of Geology in Bologna in 1881 established their need for standardization. This standard is used in general by Europeans, as American geologists are using U.S. standard established in the same year (1881) by the USGS director at the time, John Wesley Powell.

The European standard has become a necessity because as language barriers and geopolitical situation in Europe in seventeenth and eighteenth centuries led to very diverse scientific approaches, from a scientific community to another. Thus, the strongest scientific communities have communicated and published the results of their work in English, French, German and Italian.

For Romania, there were numerous geological maps made in Transylvania, Banat and Bukovina, which were published several in a series of geological maps at different scales - 1:75.000, 1:200.000 and 1:350.000, but the first geological map of Romania, of greater importance, was drawn to the scale of 1:175 000 and published in 1898, edited by Gregory Stefanescu. Until 1918, the Geological Institute (established in 1906) was occupied to draw the geological map of Romania, 1:50.000 sheets, most detailed series of maps, which is the subject of a still ongoing project. Many sheets were completed, but due to World War I, printing them all was a big problem. In 1921, I.P. Voitești, printed a geological map of united Romania, scale 1:500.000,

and between 1936-1959, The Geological Institute of Romania coordinated completion of this map, and several editions were printed at the same scale, as an integral part of the geological map Earth. The evolution of geological maps making for Romania, in the last years were printed geological maps at 1:100.000 and 1:200.000 scales, the latter covering the entire territory of Romania.

IV.1. Administrative maps of Transylvania

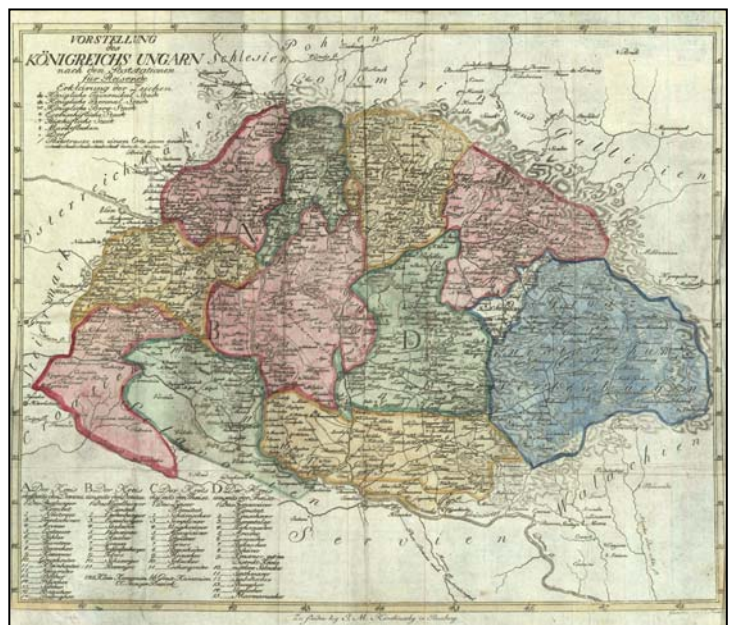
Transylvania was reflected over time in various graphical representations, first in the form of the administrative and geographical maps, by the foreign travelers and nature enthusiasts, passionate for the history and nature of eastern parts of Central Europe, parts of the great empires.

Here are some examples:

Map drawn in 1579 by **Wolfgang Lazius**, *Hungariae descriptio*.

Map drawn by **Johann Matthias Korabinszky** (Fig.10), in 1786, included in his work: *Geographisch-historisches und Produkten-Lexikon von Ungarn, in welchem die vorzüglichsten Oerter des Landes in alphabetischer Ordnung angegeben, ihre Lage bestimmt, und mit kurzen Nachrichten, die im gesellschaftlichen Umgange angenehm und nützlich sind, vorgestellt werden: mit einer Postkarte, durch deren Beyhilfe man sich einen vollständigen Ideal-Atlas dieses Reichs selbst entwerfen kann.* On this map are located the main post stations of the time, very useful for travelers who arrived on these lands.

Fig. 10: Vorstellung des Königreichs Ungarn nach den Poststationen für Reisende. (J.M. Korabinszky)

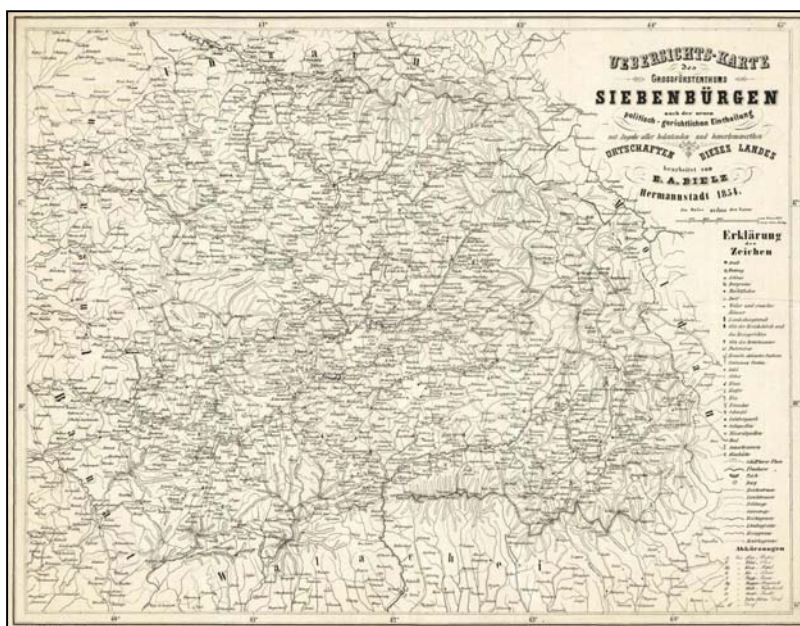


An administrative division of the Habsburg Monarchy and lithographic representation can be seen in **E.K. Frühwirth's** map (Fig. 11), where Transylvania is part of Hungary, the boundaries being set on line Carpathian Mountains (Southern and Eastern) (1830?).



Fig.11: Taschen Postmeilen Karte der Oesterr. Monarchie (1830?), versast und lithographirt von E.K. Frühwirth

In 1854, **Eduard Albert Bielz**⁴⁷ Sibiu published a map (scale 1: 846,000) representing an overview of the Principality of Transylvania in the new political-legal division, indicating also the important locations of mineral resources in this territory: *Uebersichts-Karte des Grossfürstenthums Siebenbürgen, nach der neuen politisch-gerichtlichen Eintheilung, mit Angabe aller bedeutenden und bemerkenswerthen Ortschaften dieses Landes* (Fig.12).



47 Eduard Albert Bielz (1827-1898), om de știință născut la Sibiu, autorul principalei monografii a Principatului Transilvaniei, *Handbuch der Landeskunde von Siebenbürgen*, publicată în 1857

Fig.12: E.A. Bielz: Uebersichts-Karte des Grossfürstenthums Siebenbürgen, nach der neuen politisch-gerichtlichen Eintheilung, mit Angabe aller bedeutenden und bemerkenswerthen Ortschaften dieses Landes, 1854

IV.2. Geological maps for Transylvania, 18th –19th centuries

Among the first geological maps is the mineralografic one: *Mappa Mineralographica* (Fig.13), published in volume three of Count **Luigi Ferdinando Marsigli's** work, *Danubius Pannonico – Mysicus* (1726), in the vloume with the title: *De Mineralibus circa Danubium Effossis: Necnon Aquâ Abrafis, & eum deductis*, second part, *De Mediis Mineralibus, Lapidibus ac Metallis*.

Fig.13: Mappa Mineralographica
(L.F. Marsigli: Danubius
Pannonico Mysicus, 1726, Vol. 3)



The first general geological map for Romania, (except some areas of Dobrogea and Muntenia) can be considered *Stanislaw Staszic's* map published in 1806, actually one of the first large-scale maps of Europe. Staszic, a Polish geologist, along with other European geologists - have received from German geologist Abraham Gottlob Werner the task to map geologically Europe. The map of Staszic (Fig.14) - *Carta Geologica totius Poloniae, Moldaviae, Transylvaniae et partis Hungariae et Valachiae*, sc. 1:325000 – is different from other maps published at the end of eighteenth century and the beginning of nineteenth century by the fact that its author introduces a new symbolism style (lines, dots and symbols for geomorphology perspective, colors and numbers to emphasize the petrographic and mineralogical character of the basement).

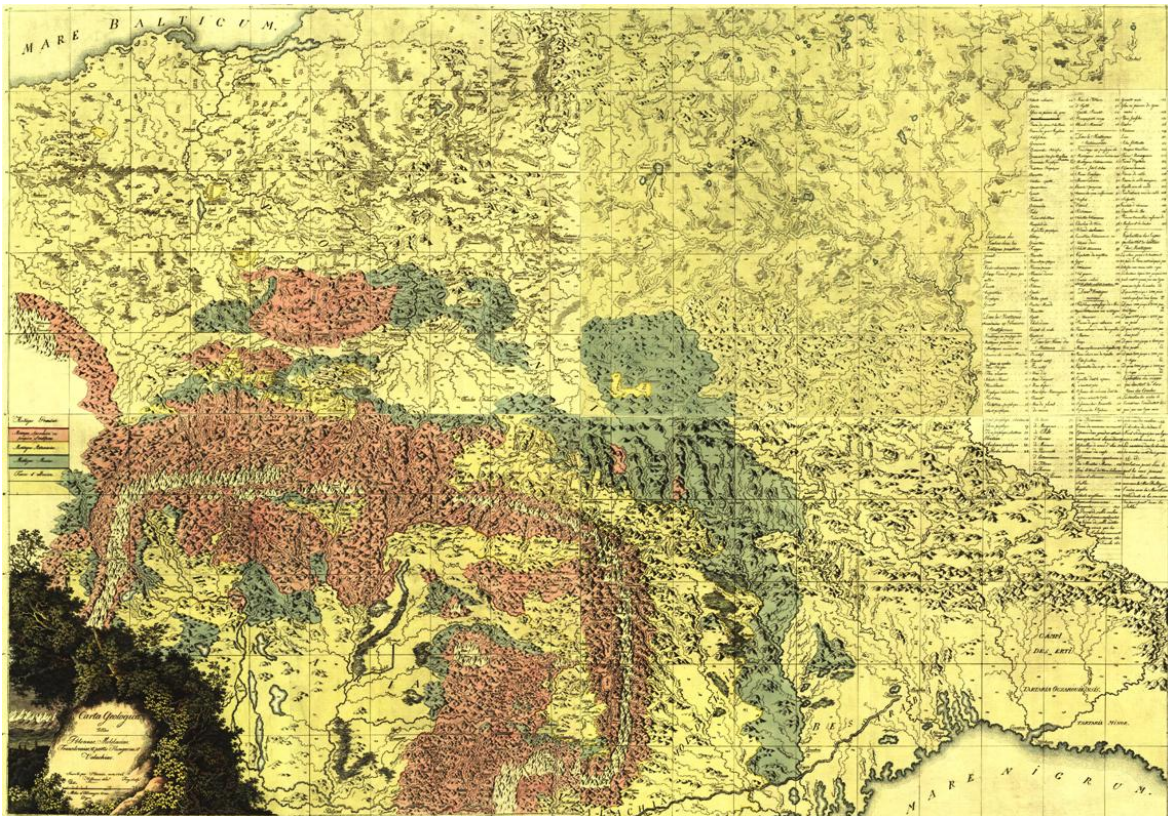


Fig.14: Carta Geologica totius Poloniae, Moldaviae, Transylvaniae et partis Hungariae et Valachiae, 1806

Although it appeared after Staszic's map, the map drawn by F.S. Beudant has long been considered by European scientists as the first published geological map of parts of Hungary, Transylvania and neighboring territories (Fig.15). It accompanies the work of the same author, *Voyage minéralogique et géologique, en Hongrie pendant l'année 1818 (Tome 1-2: Relation historique. Tome 3: Résumé géologique. Tome 4: Atlas)*, made with the original purpose of describing and studying Hungarian volcanic formations and associated metal deposits.

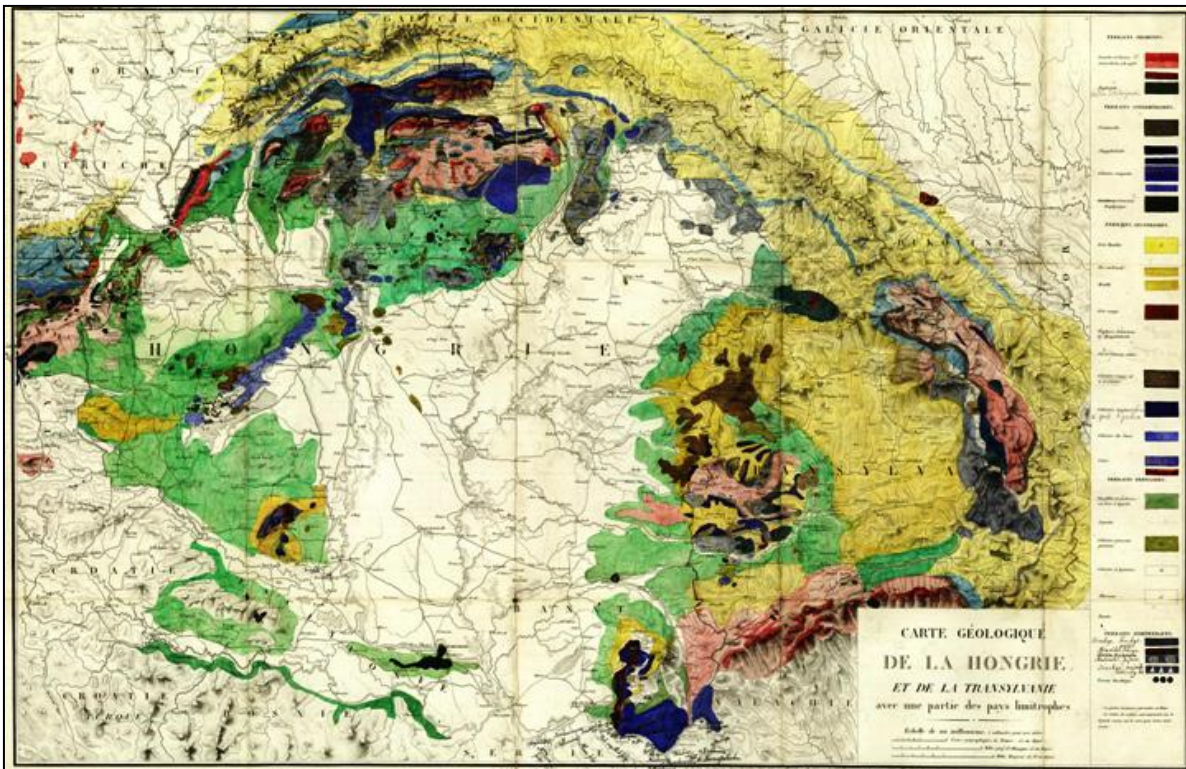


Fig.15: F.S. Beudant: Carte géologique de la Hongrie et de la Transylvanie avec une partie des pays limitrophes, 1822

In the second part of the nineteenth century, geological investigations have focused primarily on exploring areas where useful minerals were present, their delineation and exploitation conditions, especially for rocks and minerals with great economic importance in mining and construction. In this respect, Wilhelm Haidinger, as the first director of the Imperial Institute of Geology, has initiated detailed geological surveys and conducted elaboration of well documented geological maps for the Empire territory. In 1845, Haidinger gathers several research results and mapping from scientists, thus making the first systematic geological map of the Austrian Empire, 1:864.000 scale: *Geognostische Uebersichts Karte der oesterreichischen Monarchie*. Among the authors: François Sulpice Beudant, Ami Boué, Christian Leopold von Buch, Ernst Heinrich Karl von Dechen, Bernhard von Cotta, Johann Grimm, Carl von lilienbach Lille, Paul Partsch, etc. In this map is included the Inner Carpathian territory of our country and in the legend are explained symbols and colors used.

Karte der geognostischen Verhältnisse des Grossfürstenthum Siebenbürgen. **Eduard Albert Bielz**, 1854 is the geological map (inspired by the one by Partsch, but with reference only to Transylvania) who accompanies the administrative one, carried on at the same scale, but with the mineral areas reported and minerals explained in the legend.

In his *Mineralogie Siebenbürgens: mit Geognostischen Andeutungen: eine vom Vereine zur Beförderung der siebenbürgischen Landeskunde gekrönte Preisschrift*, published in 1855 but

initiated in 1844, **Ackner** describes minerals discovered in Transylvania, enclosing at the end a map that is a copy of Bielz map, describing the same way minerals as well as administrative elements of the studied localities: *Andeutungen der geognostisch-oryktognostischen Verhältnisse Siebenbürgens*.

Franz Ritter von Hauer, Wilhelm Haidinger's successor as head of the Imperial Geological Institute, presented in 1865 at the Agriculture Expo in Cologne and then in 1866 in Vienna, The General Geological map of Austro-Hungarian Empire (Geologische Karte der Übersichts-Österreichische-Ungarischen Monarch) one of the most comprehensive geological maps of Central Europe at that time, published afterwards between 1867 and 1874 in various editions (scale 1:576.000). The background of this map were the work diaries of various members of the Institute⁴⁸, collected between 1850-1865 (as recorded on the studied map), first under the direct coordination of W. Haidinger and then of his successor F.R. von Hauer.

Another product of F. Hauer geological mapping is also a map published around 1876, scale 1:2 016 000 which used the same color scheme, and for the Inner-Carpathian territory one can observe the carefully representation of existing units: *Geologische Karte von Österreich-Ungarn auf Grundlage der Aufnahmen der k.k. Geologischen Reichsanstalt*.

The renowned geologist and professor from Cluj, Antal Koch, exposed at the Millennial Congress of Mining, Metallurgy and Geology in Budapest in 1896 a geological map of Hungary edited by **A. Semsey**: *Carte Géologique de la Hongrie*⁴⁹ that shows "deposits of precious metals, ores, iron ore, salt and other minerals that can be sold, exploited or under exploration, within the countries belonging to the Hungarian Crown." At the same event was shown and the map *A Magyar Korona országai területén mivélésben és feltárófélben levő nemesfém, ércz, vaskö, köso és egyéb értékesithető ásványok előfordulási helyei*, based on official data obtained from the captains of the mining area, drawn by **J. Böckh** and **A. Gesell** and that led later to the realization of mining districts map at a different scale (1: 800 000).

Geological research started in the eighteenth and nineteenth centuries on the Habsburg Empire territory, experienced some decline during the Napoleonian Wars, as well as the entire economy, and geological studies were conducted more by foreign scientists (French, English, Swiss).

48 Sunt consemnați pe hartă, ca membri contributori la realizarea sa: Ferdinand Freih. Andrian, Johann Czjžek, Franz Fötterle, Frans Ritter von Hauer, Ferdinand Ritter von Hochstetter, Johann Jokély, Johann Kundernatsch, Ferdinand Lidl, Markus Vincenz Lipold, Edmund von Mojsisovics, Melchior Neumayr, Karl Maria Paul, Karl Peters, Heinrich Prinzing, Ferdinand Freih. von Richthofen, Urban Schloenbach, Guido Stache, Ferdinand Stoliczka, Dionys Stur, Heirich Wolf, Victor Ritter von Zepharovich.

49 Titlul în lb. germană: Geologische Karte von Ungarn, (BCU H48/38).

Between 1710 and 1850 the Vienna Imperial Court granted the mining industry more attention than any other branches of industry, geological literature of the time taking into account the particular topics on mineral location, authors of geological studies were travel enthusiasts (German, Italian, Norwegian, Dutch, French, British) or official messengers. One of the reasons for increased interest in geology and mining, ore mining can be considered to be the establishment of one of the oldest institutions in the world stock market: Wiener Börse (1771 - Wiener Börse)⁵⁰, during Empress Maria Theresa, in order to issue and create a market for government bonds.

În a doua parte a secolului al XIX-lea începe aplicarea proiectului inițiat de Institutul Geologic Imperial, de topografiere și cartare geologică a cât mai multor porțiuni din teritoriul monarhiei, acest lucru declanșând realizarea hărților geologice în primul rând pentru localizarea formațiunilor aparținând Cuaternarului, hărți cu o mare importanță în evoluția cercetării geologice nu numai la nivelul Imperiului ci și la nivelul întregului continent european.

In the second half of the nineteenth century begins implementation of the project initiated by the Imperial Geological Institute, for surveying and geological mapping of many parts of the monarchy. This initiative triggered the implementation of geological maps to locate primarily formations belonging to Quaternary, maps of great importance in the evolution of geological research not only of the Empire but also of the entire European continent.

50 T.Gaudenyi, M. Jovanovic....

V. CONCLUSIONS

Geological knowledge evolved over time from observations of the practical interest in using the underground mineral resources (river stone, metal ores, salt, coal) for the prosperity of communities or for a scientific approach.

All issues concerning knowledge of geological structures, distribution and typology of existing rocks in the basement, describing minerals and fossils found in the research areas were addressed first in a theoretical and subjectively way by those interested in these issues. Many of them were scholars, trained in other fields, but having a great passion for travel and natural science.

Geological publications from the eighteenth and nineteenth centuries containing geological aspects of the Romanian Inner-Carpathian area reflect the evolution in time of such an interest in this part of Europe developed by scientists and scholars, foreign and domestic.

Revealing the historical aspects of the investigated territories resulted in accumulated knowledge in various domains: geographical, sociological, demographic and ethnic, petrographic and mineralogical composition of the formations encountered, the last of great importance in detecting and locating targets that were designed to ensure the economic future of society. Details obtained from experiments and field practice, professional representation on maps made across Europe, have contributed to the enrichment of very valuable information sources for use of mineral resources of the Earth.

Trying to achieve the objective of this thesis has proven to be a challenge, because most of the documents to be investigated were written in less accessible languages: Latin, German, Hungarian. I began by extracting the titles of these "landmarks" in the geology of Romanian Inner-Carpathian area from the first volume of the publication of Romania Geological Bibliography (publication of the Geological Institute of Romania), the rich bibliography of geological monograph *Geologie Siebenbürgens* (Hauer and Stache, 1863) and traditional catalogs of the Central University Library "L. Blaga" Cluj. Exploring these catalogs: systematic catalog - geology, natural science, topographic catalog - Transylvania, Cluj, Banat, but mostly special collections catalog, where I found the old and rare titles of publications and maps (administrative, geographical and geological) allowed me to access and study in more detail the documents mentioned and less circulated or even omitted from the circuit (Catalogus Raritatum

et Benefactorum - from the library of Aiud or *Studiu geologicu asupr'a structurei muntiloru metalici ai Transilvaniei* of geology passionate Basiliu Bașotă).

Library catalogs from Eötvös Loránd University (ELTE) in Budapest and visiting a part of the special collections helped me verify the historical and bibliographical data on publications studied.

The discovery and investigation of documents from personal archives of Professor Antal Koch Cluj, at the Museum of Paleontology at the University "Babes-Bolyai" was a real opportunity to bring to the attention of the scientific community novel aspect of life and work of this great scientist .

From old periodic publications with articles and studies containing geological data, I analyzed in detail a number of Romanian and German titles, such as Mineralogical Geological Museum magazine of Cluj University and *Verhandlungen und Mittheilungen des Vereins für Naturwissenschaften zu siebenbürgischen Hermannstadt*. There are many other periodicals with titles with such works, written mainly in German and Hungarian, which are expected to be investigated at a later stage. The language barrier, the large amount of information material and necessary period of time study and analysis of these articles were factors that led to this decision.

Given the multidisciplinary content of many publications, followed by a documentary analysis, we restricted the study only to those with significant geological aspects, while trying to point out the geological data and information on the area of interest.

Passages from the studied publications that we found they are of geological interest, important data for the location of geological structures or useful substances deposits have been scanned to be accurately shown to the interested reader. Geological maps have been scanned also, this process being difficult as some of them were on several sheets (and the topography was often not the same for the same map sheets - eg. Staszic map, drawn up in 1806), in an attempt to provide a collection of old geological maps in electronic form, easy to be addressed by interested researchers.

As the study of documents that form the basis of this thesis research was going forward, I prepared a synoptic table that allows an overview of the geological research characteristics in historical periods considered, the evolution of the concept of geology and reference works published at that time, inserting in the context specific publications in Romanian Inner Carpathians area.

To point out the first scientific observations relevant to the geology of the area of Transylvania, we included also the seventeenth century as period of time in the evolution of geological knowledge and concepts. In that time the notion of "geology" was already used in a modern sense, scattered observations appeared, sometimes poorly documented and lacking a scientific method of research, explanations of natural phenomena described especially in religious writings. Most scientists of those times had theological training, and their writings were influenced by religious concepts.

At European level this century is marked by the emergence of key ideas in the field of geology, on the constitution of the Earth (René Descartes, Mikkel Pederson Escholt, Athanasius Kircher, Robert Boyle, GW Leibniz, William Whiston), mineralogy (Robert Boyle), water sources of rivers (Pierre Perrault), notions of stratigraphy (Nicolas Steno), a better knowledge of fossils and comparative anatomy terms of existing and fossil plants (Robert Hooke). In Inner-Carpathian Romania only now appear the first geological writings. These are observations of Georgius Vette from 1676, reporting about the presence of methane gas near Sibiu and the vertebrate fossils in the area - fossil bones of so-called "dragons", *Draco volans*, which actually proved to be the remains of cave bear, *Ursus spelaeus*.

In the eighteenth century, *geology* has been seen as independent scientific discipline, with the first attempts to systematize known data. During this period happened the move from abstract speculation to logical reasoning based on direct observation of natural phenomena. Although naturalists studies were still influenced by the Church teachings, natural sciences were developing rapidly, as geological research did. Prospecting ores criteria are highlighted by M.V. Lomonosov in 1757, rocks are classified into four major orders -these orders referring to the age of these rocks: primary, secondary, tertiary and quaternary (G. Arduino, 1759). The first materialistic theory about Earth formation was made (G.-LL Buffon, 1749-1788), and the two theories that dominate this century about the origin of rocks and minerals: neptunism (A.G. Werner, 1775: origin of all rocks is in the water of the seas and oceans), and plutonism (J. Hutton, 1795: conditions of formation of rocks are endogenous determined) were launched. Stratigraphic column was developed by A.G. Werner in 1775 and the geological cycle was defined by J. Hutton in 1795.

Against this background, many geological works about Inner-Carpathian area were published on petrographic and mineralogical description of the studied area, paleontological descriptions, but also on practical issues (mining history, administrative and economic issues affecting the mining industry). They highlight the location of mines and minerals existing in those areas, and as

examples some graphical representation can be given: the geographical map of Grisellini - *Tabula Bannatus Temesiensis*, mineralographic map of Marsigli - *Mappa Mineralographica* with location and special signs and distinct symbols for gold, salt, copper, and iron deposits.

Written in the early eighteenth century, the paper of gubernial advisor Sámuel Köleséri, *Auraria Romano-Dacica* (1717), is entitled to be called the first technical publication for Romania, which captures the historical aspects of the exploitation and gold processing in Transylvania, emphasising location of gold mines in this territory. Sámuel Köleséri was one of the mineral specimens donors from Transylvania for large collections of its kind in Europe (eg the collection of John Woodward of the Sedgwick Museum in Cambridge there are specimens of cinnabar and native antimony in Transylvania).

Johann Fridvaldszky - *Minero-Logia Magni Principatus Transilvaniae* (1767), paper containing historical aspects of precious metals mines in Transylvania of a Jesuit priest with a passion for mineralogy. These data were next to geographical, administrative and ethnical ones, and based primarily on accounts of local mines employees - the main reason to be later criticized by Ignaz Edlen von Born, who also wanted to meet him but to clarify some aspects.

A novel aspect in presenting the 18-th century's publications is the general presentation of the catalog manuscript of the first natural science collection in the country, *Catalogus Raritatum et Benefactorum* (1796) by Ferenc Nagy and László Benkő and stored in the Bethlen Documentary Library of Aiud.

Works presented in this thesis contain petrographic and mineralogical details and a accurate location of mines in the areas studied, mineralizations and fossils found, geological terminology used throughout Europe those days:

- Luigi Ferdinando Marsigli: *Danubius Pannonico Mysicus - Description du Danube* (1726), in whose volume three aspects of mineralogy are included for areas to the north of Danube and examples of useful mineral deposits in Transylvania;
- Ignaz Eldlen von Born: *Voyage minéralogique fait en Hongrie et en Transilvanie* (1774, 1780), which had a special role in promoting information about mineral riches of Transylvania across Europe; also an article on stibine crystals in Transylvania published in May 1783 „*Nachricht vom gedigenen Spiessglanzkönig in Siebenbürgen*” that appeared in "Ab. einer Privatgesellschaft in Böhmen "in Prague;
- Francesco Grisellini: *Versuch einer Polilischen und naturlichen Geschichte des Temeswarer Banats in Briefen en Standespersonen und Gelehrte. Zweiter Theil: Naturliche Geschichte des Bannats. Beschaffenheit des Flaschen Landes* (1780), a work containing a geographical map, descriptions of Banat's geomorphology, petrographic

composition of this land, minerals in the area and location of their main operating mines; here we find a reference to the use of peat from the lowland area of Banat as fuel instead of wood to protect forests in the area;

- Works published in 1780, 1791 respectively, on the fossils of Transylvania, the history of salt extraction and description of Transylvania's mountains, having as author the Transylvanian treasury adviser, Johann E von Fichtel.: *Beytrag zur Mineralgeschichte von Siebenbürgen* - volume 1: *Nachricht von den Versteinerungen des Grossfürstenthums Siebenbürgen* and volume 2: *Geschichte des Steinsalzes und der Steinsalzgruben im Grossfürstenthum Siebenbürgen* - and *Mineralogische Bemerkungen von den Karpathen*;
- Jens Esmarck: *Kurze Beschreibung einer mineralogischen Reise durch Ungarn, Siebenbürgen und das Bannat*, (1798), with details and descriptions of rocks and minerals in the mining districts of the Banat and gold-bearing mountains of Transylvania.

Publications of the nineteenth century are distinguished by this century's scientists approach with a method of detailing the knowledge accumulated by their predecessors and making graphic, geological maps specific to certain parts of Central and Eastern Europe. We have thus included some territory of Romania (except for some areas of Dobrogea and Muntenia) in Stanislaw Staszic's map (1806), considered the first large geological map of Europe, and François Sulpice Beudant's geological map printed in 1822 which includes also Transylvania . In the following years a series of rich geological and mineralogical maps were drawn by foreign and local geologists and mineralogists, formed at high schools in Vienna and Budapest and monographic works of particular importance in the Romanian geological research were written:

- Johann Michael Ackner: *Antiqua Musei Parisiorum monumenta* (1809) *Geologisch-palaeontologische Verhältnis des siebenbürgischen Grenzgebirges längs der Kleinen Walachei* (1851), *Mineralogie Siebenbürgens* (1855) and articles from Transylvanian Society for Natural Sciences of Sibiu magazine, *Verhandlungen und Mitteilungen des Siebenbürgischen Vereins für Naturwissenschaften zu Hermannstadt*;
- Adolf A. Schmidl: *Das Bihar-Gebirge: an der Grenze von Ungarn und Siebenbürgen*, which has the quality to be the first Speleological inventory of Bihor Mountains;
- Franz Ritter von Hauer and Guido Stache: *Geologie Siebenbürgens* (1863), "milestone" in geological research of Transylvania, a work containing a number of new geological data at the time (some still available), which gives it a high degree of originality;
- Nopcsa Franz, with his first scientific paper of paleontology, *Dinosaurierreste aus Siebenbürgen: Schädel von Limnosaurus transsylvanicus nov.gen. et spec.* (1899),

describing this new species of herbivore dinosaur, which opens the series of papers of this "pioneer" in the European paleobiological research, which managed to combine systematic data with complete reconstruction of the dinosaurs and to correlate these with geological surveys, stratigraphy and evolutionism.

The original contribution of this thesis about publications from the 19-th century is revealing to the geological community certain documents, such as:

– Some documents from the personal archive of renowned geologist, and specialist in petrography, mineralogy and paleontology, Antal (Anton) Koch, consisting of letters, official addresses, drawings and sketches that show thoroughness and seriousness of the famous scientist in his research themes and his promptitude in responding to work tasks, but also to requests from other people interested in geological aspects of Transylvania.

– *Munții apuseni ai Transilvaniei seau Studiu geologicu asupr'a structurei muntiloru metalici ai Transilvaniei* published by a lawyer with a passion for geology, Basiliu Basiota, printed in Blaj in 1883. This study, even if written by an amateur who took over and adapted largely from the German text of Hauer & Stache's work *Geologie Siebenbürgens*, has great significance primarily due to the language in which it was written, Romanian, making it accessible to a wider category of people interested in the process of extracting metals from the Apuseni Mountains. This author published also some articles in popular periodicals of those times, having some socio-economic aspects, and also bringing to the forefront of knowledge environmental problems, the efficient exploitation of soil and subsoil riches of Transylvania.

The research performance of previous centuries scientists and the possibility of having access to their specialized scientific publications created an effervescence in Romanian spirituality circles of the late nineteenth and early twentieth century. It is in this century that in Transylvania took place spectacular evolution of Romanian intelligentsia, through the creation of the institutional framework necessary for academic development: the establishment of a Romanian University in Cluj, existing as an institution of higher education since 1872, but teaching in Hungarian. Development of higher education in Transylvania helped scientific research grow in general, and geology also.

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