Geological Research in Inner-Carpathian Romania Up to the 19th Century

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Keywords: history of geology, Inner-Carpathian Romania, publications, natural sciences

Abstract
Though Transylvania's rich gold and silver deposits have attracted foreign people's attention, geological information was rather slowly accumulated here. In the 19th century, the geological research of Romania's Inner-Carpathian region, comprising mainly the historical provinces of Transylvania and Banat were in a way directed by the geological institutes of Vienna and Budapest. A considerable contribution to geological research was made by autochthonous scholars gathered around the University of Cluj. They investigated precious metal, complex sulphides, iron, or salt deposits.

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The original historical roots of geological research in Romania might be eventually found in the primitive attempts of those who wished to obtain knowledge on the diversity of mineral substances in their natural state and on the modality of their use in different activities. This 'origin' is attested in the writings of Greek and Latin historiographers referring to mining activities in the Carpathian countries at that time. For example, the first record on the exploitation of gold in the Apuseni Mountains was made by **Herodotus** in his description of Darius I's war against the Scythians in 514 BC. We can also mention the first autochthonous authors who, much later, referred to the rich mineral resources of Romania. These authors were **Nicolaus Olahus** – in his work *Hungaria* written in 1535 – and **Dimitrie Cantemir** – in his

Descriptio Moldaviae from 1716, in which he referred to the rich resources of salt, iron ores and alluvial gold.[1]

If we take into consideration the geological-structural units of Romania, the Inner-Carpathian region of this country is bordered on the south and the east by the orogenic Carpathian belt, which is in contact with the platforms of the foreland area.[2] In the context of historical provinces and regions, the discussed territory would correspond to Transylvania, Banat, Crişana, and Maramureş.

The evolution of Romanian geology had had two – from the point of view of their span – unequal periods until the creation of the unitary national state: the first, a very long one, lasted from the antiquity to the beginning of the 18th century; the second comprised the 18th century and the first half of the 19th. In the second period, in addition to the informational, scientific aspect of geology, its 'practical task' also occurred: to estimate the useful constituents of the Earth's crust by elaborating and interpreting different hypotheses and theories. Moreover, this was the age when the global progress of science amply widened the investigation methods of minerals and rocks.[3]

In order to describe adequately the evolution of geological research in the territory of Romania in general and in the Inner-Carpathian area in particular, it seems to be necessary to make a short review of the concept *geology* and its evolution in the course of time, both on universal and national level, especially in the first part of the 19th century. We are going to highlight the events which led to the appearance and development of this science, the moments when the laws and basic principles of the domain were elaborated, and the most important contributions by the personalities involved in the different research activities.

[1] Dan Rădulescu and Radu Dimitrescu: "Începuturi ale cercetării geologice în spațiul românesc" (The Beginnings of Geological Research in the Romanian Territory), *Academica: revistă de ştiinţă, cultură şi artă* (Academica: Scientific, Cultural and Artistic Journal), New series, 23 (2004): 61.

[2] Vasile Mutihac, Maria Iuliana Stratulat, and Roxana Magdalena Fechet, *Geologia României* (The Geology of Romania) (Bucureşti: Editura Didactică şi Pedagogică, 2004), 11–12.

[3] Rădulescu, Dimitrescu, "Începuturi ale cercetării...", 63.

Geology – the evolution of the concept on a universal level

Prehistory and antiquity

In the course of a long – for we know now that the destiny of humanity reaches back in time to the Toumaï (*Sahelanthropus tchadensis*)[1] and *Orrorin tugenensis*[2] – and sometimes difficult evolution, the people of primitive communities very early – *avant la lettre* – realized 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 embellish later their sacral places, where they venerated their idols.

In the Palaeolithic, man discovered and used flint without having proper notions of petrology – in the scholarly sense of the word –, and he used some fossils as decorative objects without knowing the meaning of palaeontology.

In the Neolithic, as the name shows, cut stone was substituted for polished stone, the first metals were discovered, and clay was also widely used for making some objects of use, or of art, and also as building material. The first data on metals and the mining of some metal bearing deposits were recorded in the Middle East, beginning with the mining of copper in Iran (5th millennium BC), followed by those of tin, iron, gold, and lead.

The first, more elaborated geological (palaeontological) observations were made by the Greeks in the 6th century BC, when **Pythagoras** and **Xenophon** of Colophon discovered on the rocks of Paros Island the imprint of laurel leaves and fragments of marine mollusc shells far away from the seashore. This made them affirm that in the past these lands may have been covered by some seas, which later vanished. In the 5th century BC **Herodotus** mentioned the continuous change of the Earth's crust in the course of time and **Empedocles** studied the Etna volcano during its eruption. **Aristotle** and **Theophrastus** made similar observations in the 1st century BC; the latter writing also the first book with observations on the minerals known at that time. In the 1st century BC, the famous geographer **Strabo** described the *Nummulites* (*nummulus*

[1] Brunet Michel et al., "A New Hominid from the Upper Miocene of Chad, Central Africa", *Nature* 418 (2002): 145–51.

[2] Brigitte Senut and Martin Pickford, "The Geological and Faunal Context of Late Miocene Hominid Remains from Lukeino, Kenya", *Comptes Rendus de l'Academie des Sciences, Series II A – Earth and Planetary Science* 332/2 (2001): 145–152.

= coin; a fossil group of large foraminifera, with coin-like tests, from where the vernacular name "petrified little coins" originates) and showed the possibility that Vesuvius might be a volcano. Otherwise, the eruption of this volcano in 79 BC was described (although the causes of this destructive phenomenon were not discovered) by the Roman writer **Pliny the Young** in his famous letters to his friend, the historian **Tacitus**.

In the 1st century AD, the Roman philosopher, **Lucius Annaeus Seneca** made observations on gems, stating that these are usually to be found in the gravel carried by the rivers.[1] In the same age the first seismoscope was constructed in China (based on a pendulum system – year 132 AD).

The Middle Ages and the Renaissance

The scientific heritage of the Antiquity survived the fall of the Roman Empire due to the Byzantine Empire and the Arabian schools of Damascus and Baghdad which translated the Greek works. The Jews also translated these works (more or less completely) from Arabic to Hebrew, and, in the 12th century, these were translated from Hebrew to Latin, restoring thus to the Occident what had remained from the Greek heritage.

Abu Ali ibn Sina, a Persian scholar also known as **Avicenna** (980–1037), elaborated a treaty on rocks, in which he formulated different mineralogical descriptions and observations, issuing even a theory on the formation of mountains as well.

In the 13th century, while oppressed by the church, the scientific activity in the Occident was renewed. The French **Albert the Great** made observations on fossils and laid the bases of biogeography, in which he emphasized the influence of the environment on living organisms. The Rector of Paris University, **Albert of Saxony**, in 1357, published the work *De coelo et mundo*, in which he discussed the effect of erosion and the slow, but continuous vertical movement of the continents (now called isostasy). In the 15th century, a series of Italian scholars, among them **Leonardo da Vinci**, made different observations and enounced hypotheses on the origin of fossils.

In the first decades of the 16th century, the German naturalist **Georg Bauer (Agricola)** – considered the father of mineralogy and iron metallurgy – studied mineralogy, chemistry, geology, metallurgy, and

[1] *Dicţionar cronologic al ştiinţei şi tehnicii universale* (Chronological Dictionary of Universal Science and Technique) (Bucureşti: Editura Ştiinţifică şi Enciclopedică, 1979), 259.

mining. The first theory on the process of lode mineralization formation and the first systematic description of minerals were associated with his name. In his work entitled *De natura fossilium* (1546) he introduced the term *fossil*; and *De re metallica* (1556) was the first richly illustrated reference work on mineral techniques and the processing of metals.[1]

The birth and development of modern geology

The notion *geology* was first used in its modern sense in **Mikkel Pedersön Escholt**'s work *Geologia Norvegica* discussing earthquakes and minerals, issued in Oslo in 1657. Otherwise, in the 17th century some essential ideas in geology referring to the structure of the Earth and the water sources of rivers, as well as terms of stratigraphy appeared, the subdivisions of the geological time were devised, fossils became better known, and notions of comparative anatomy in relationship to actual plants and fossils were introduced.

In England, **Robert Hooke** (a forerunner of transformism who also initiated the building of a British museum for exhibiting collections of minerals, rocks and fossils) made the first observations of comparative anatomy regarding the similarities between fossil and actual plants. He also tried to understand the nature of the separating walls of ammonites' shells. In his *Micrographia* (1665) he gathered many biological observations and introduced also the notion of *cell* too (the vegetal cells he studied reminded him of monks' small rooms called *cellula*).

In 1669, Danish anatomist and naturalist, **Niels Stensen** (also known as **Nicolas Steno** or in Latin as Nicolaus Stenonis) published his work *De solido intra solidum naturaliter contento dissertationis prodromus*. In this work the main, still valid principles of stratigraphy are defined:

- the principle of overlapping strata – that states lower strata are older than the upper ones;
- the principle of original horizontality of strata – according to which even if the strata are perpendicular or somewhat dipping as compared to their present horizontality, they were initially horizontal;
- the principle of lateral continuity – according to which the constituent material of strata would have been continuous at the surface of the Earth unless a solid body broke their continuity;

[1] "Géologie", *Encyclopaedia Universalis*, Corpus 10, (2004): 322.

- the principle of cross-cutting discontinuities (the cross-cutting relationships between strata) – which means long gaps in the process of sedimentation produced by tectonic and/or erosive events occuring in the meantime.

In this same work **Steno** formulated the first basic law of geometrical crystallography, known simply as *Steno's law*, or *Steno's law of constant angles* which states that the angles between the corresponding faces of crystals are constant for a mineral species.

In the same period, **Erasmus Bartholinus** in his work *Experimenta crystalli islandici disdiaclastici* pointed out the cleavage of crystals and some of their physical characteristics and the English physicist **Robert Boyle** used for the first time the term mineralogy in its modern sense.

In 1674, **Pierre Perrault**'s *De l'origine des fontaines* was issued. This work demonstrates that underground waters are the result of rainwater percolating into the ground. The same problem was tackled later by the mathematician and astronomer **Philippe de la Hire** and the Abbot **Edmé Mariotte** in 1686. The latter also made some calculations regarding this issue.[1]

Studying the optical characteristics of calcite, Dutch physicist **Christiaan Huygens** imagined for the first time (in 1690) the inner network of crystals. In 1693 German philosopher and mathematician **Gottfried Wilhelm Leibniz** in his *Protogaea* (issued integrally only in 1749) attributed the origin of the Earth to the cooling and solidifying of melted material, as well as to the deposition of the solid parts contained by watery solutions.

In the 18th century, the naturalists' ideas and discoveries were still attacked by the Church. Only after the French Revolution in 1789 did Earth Sciences become emancipated and considerably diversified. Nevertheless, some exceedingly important events and discoveries can be enumerated from this period. The discovery around 1705 of ice interleavings in the soil of Siberia marks the beginning of *cryopedology* (valorised only in the 20th century). Robert Hooke laid the bases of *paleoclimatology*, discovering the existence of turtle fossils characteristic to tropical regions in England, a fact which demonstrates the change in the Earth's climate in the course of time.

In 1715, astronomer **Edmund Halley** tried to determine the age of the Earth relying on the hypothesis that the salinity of the seas and

[1] *Dicţionar cronologic...*, 261.

oceans had changed in the course of time due to the levigation of salts from the continents by watercourses.

In this age some writings referring to the Romanian territory were also published. In *Descriptio Moldaviae* (1716) **Dimitrie Cantemir** presented in detail and in a scientific manner the extraction of alluvial gold, the phosphate deposits, salt mines, and the fossil fish remains in Moldova. Furthermore, in Transylvania the first work of mineralogy referring to this region was issued in 1717, written by the general supervisor of mines, **Sámuel Köleséri**.[1]

In 1749, the work *Histoire de la Terre* by French naturalist **Georges Louis Leclerc de Buffon** – a forerunner of modern evolutionism – was published; it formulated the first materialist conception of the Earth's formation (stellar hypothesis or the theory of catastrophism). **Mikhail Vasilyevich Lomonosov** published in 1763 *On the Earth's Strata*, in which he presented criteria for prospecting mineral deposits: the mineralization of waters, the specific colour of mineral outcrops, and their specific vegetation.

1775 was the year when the Neptunian School led by German mineralogist **Abraham Gottlob Werner** was founded. This school considered that all rocks originated from the water of seas and oceans. This renowned professor of Freiberg Mining Academy also formulated the term *geology* to denominate an independent science.[2]

In England, in 1795 **James Hutton**'s *Theory of the Earth* was released, which marks the beginning of the Plutonian School. This book stated that rocks had been formed endogenously; it also defined the geologic cycle.

The 19th century

The period 1790–1880 was decisive for geological research, since many fundamental scientific works presenting the basic principles of modern geology were published in this interval, all of them based on the disputes between Neptunists and Plutonists.

In this period the bases of experimental geology were laid (1801–1805, **James Hall**), the world's first geological society was

[1] S. Köleseri de Keres-Eer, *Auraria Romano-Dacica* (Cibinii, 1717), 243.

[2] Árpád Hadnagy and Árpád Lorberer, "Geologul Stanislaw Staszic şi importanţa activităţii sale pentru cunoaşterea geologică a României" (The Geologist Stanislaw Staszic and the Importance of His Activity for the Geological Knowledge of Romania), *Nymphaea: Folia naturae Bihariae*, VIII–IX (1980–1981): 534.

founded in London (1807), the first scientific geological map of a country was printed (1815). This was the map of England on a scale of 1:316,000 edited by **William Smith,** the "*Father of English Geology*", who emphasized the importance of stratigraphic principles and the determinant role of the relative age of fossils in attributing a new content to the geological maps.[1] In this same age the chemist **Jakob Berzelius** classified minerals according to their chemical composition (1819), and in 1820, **Friedrich Mohs** devised the scale of mineral hardness consisting of ten steps, still used nowadays.

In 1821–1824 **Georges Cuvier**'s *Recherches sur les ossemens fossiles* was issued in several volumes, thus being laid the bases of modern palaeontology and comparative anatomy. Cuvier's observations in this work referring to the mammoth remains in Romania, even after a century and a half, have great actuality.[2] Scottish geologist **Charles Lyell** introduced in 1825 the term metamorphism, and in 1830, in his work entitled *Principles of Geology*, launched the theory of uniformitarianism (also known as the "principle of Lyell's actualism"), according to which all past changes on the surface of the Earth were similar to present processes.

The notion of geochemistry was created in 1838 by Norwegian scientist **Victor Moritz Goldschmidt**, and then developed as a science by the Russians **Vladimir Ivanovich Vernadsky** and **Alexander Yevgenyevich Fersman**. Later, in 1847, the English engineer **William Henry Barlow**, who discovered the presence of telluric currents (spontaneous currents in the Earth's crust) perfected the electrometric geophysical prospecting methods.[3]

In 1861, French geologist **Jules Marcou** published the geological map of the world on eight sheets, representing the different types of rock as well. In the same year, in Bavaria the remains of the primitive bird *Archaeopteryx* were discovered, having both reptile and avian anatomic features.

German geologist **Bernhard von Cotta** classified rocks for the first time in 1862 as igneous, metamorphic, and sedimentary, this classification being still in use.

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[1] Idem.
[2] Vlad Codrea, *Rinoceri şi tapiri terţiari din România* (Tertiary Rhinoceroses and Tapirs from Romania), (Cluj-Napoca: Presa Universitară Clujeană, 2000), 12.
[3] William Murray Telford, L. P. Geldart, Robert E. Sheriff, *Applied Geophysics* (Cambridge: Cambridge University Press, 1990), 302.

The end of the 18th and the beginning of the 19th century thus marks the individualization of geology as a worldwide science, the transition from the simple inventory of the substances forming the Earth's crust to the elaboration of laws and principles, theories and hypotheses. Great qualitative changes were made in science in this period: analyses intensified and became refined, new natural scientific branches were developed ever more distanced from theology and metaphysics. In this time **Charles Darwin**'s work *On the Origin of Species* was published, two chapters of the book being dedicated to geology: *On the Imperfection of the Geological Record* and *On the Geological Succession of Organic Beings*. This work had an exceptional role in the materialist approach to natural sciences.

Geology in Romania

In Romania geology has a rich tradition. We have already mentioned **Nicolaus Olahus**'s (1535) and **Dimitrie Cantemir**'s (1716) works. For Transylvania we should also mention **Georgius Vette**'s observations referring to the remains of vertebrates and methane gas emissions in this historical province. These observations were published by **Heinrich Vollgnad** in publications of the Imperial Academy of Sciences in Vienna (1676, 1677).

The richness of the historical Romanian countries was, however, mentioned by most of the historians who wrote about these regions, such as **Anton-Maria Del Chiaro** (1718), **Jean Louis Carra** (1777), **Franz Joseph Sulzer** (1782), **Andreas Wolf** (1805).

Geological data occured in the travel notes of **Balthasar Hacquet** (who published four volumes in Nuremberg between 1790 and 1796, in which he enumerated fossils, minerals and stratigraphic successions), **I. I. N. Huot** (who participated in Count Anatole Demidoff's 1837 expedition to Southern Russia, Crimea, Walachia and Southern Moldova), and **Mihalie de Hodocin** (who made in 1855 an inventory of Moldavia's mineral resources).

The first general geological map of Romania (except some regions of Dobrogea and Muntenia) was drawn in 1806 by Polish geologist **Stanislaw Staszic** taught by A. G. Werner and other European geologists. Werner triggered the launching of geological cartographic activities in Germany, devising the conventional signs and colours for the representation of the geological formations from different ages; they form still, with some changes, the basis of the conventional signs of

geological cartography. Under his guidance the first European geographers – Staszic among them – were entrusted with drawing geological maps of large European territories. Staszic's map – *Carta Geologica totius Poloniae, Moldaviae, Transylvaniae et partis Hungariae et Valachiae*, scale 1:325,000 – was annexed in 1815 to the book *O ziemorództwie Karpatów i innych gór i równin Polski* (The Genesis of the Carpathians and Other Polish Mountains and Plains). It differed from the maps published at the end of the 18th century and the beginning of the 19th (in which the geological signs were not separated from geomorphological and topographical ones) due to the fact that Staszic introduced a new system of signs (lines, points and symbols of perspective for geomorphology, colours and numbers to emphasize the petrographic and mineralogical character of the basement).[1]

The first mineralogy book 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 Iaşi (1860) and Bucharest (1864) were also of a tremendous importance.[2]

In Iaşi the first Head of the Geology Department was **Grigore Cobâlcescu**, the author of the first geological work in Romanian: *Calcariul de la Răpidea* (The Limestone from Răpidea) (1862). In this study, Cobâlcescu made a series of observations which are still valid nowadays, such as the establishment of the lithological sequence of the Moldavian Plateau's northern edge; he observed the reduced salinity of the sea in which a part of these deposits accumulated; he referred to the

[1] Hadnagy, Lorberer, "Geologul Stanislaw Staszic...": 533–534.

[2] Dan Rădulescu, Radu Dimitrescu, "Cercetarea geologică a pământului românesc în a doua jumătate a secolului XIX şi 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 ştiinţă, cultură şi artă*, New series, 24 (2004): 58.

upper Medium Miocene, though there were no similar terms in the literature of that age at that time; he mentioned an aquifer, which could be used to supply Iaşi with water. In addition, he also drew the geological map of Vaslui County, which is the first Romanian geological map.

In 1886, in recognition of his merits, he was elected as member of the Romanian Academy, his inaugural speech (held in 1887) bearing the title *On the Origin and Deposits of Oil in General and in Particular in the Carpathians*. In this work he described the geological formations where oil was to be found in the Carpathians and Subcarpathians, pointing out the relationship between tectonics and oil-bearing deposits. Regarding the genesis of oil, he defended the mineral, inorganic-Plutonic conception.

The work that made him acknowledged as an important scientist was published in 1883 (*Geological and Palaeontological Studies on Some Tertiary Regions of Romania*). This work describes the studies he made on deposits with *Congeria*, on the Sarmatian deposits, the salty formations, and the Oligocene deposits in the Eastern Carpathians, as well as the mud volcanoes. From a palaeontological viewpoint, he described one hundred Sarmatian and Pliocene (naturally, in the sense in which the Pliocene was understood at that time) fossil species, among which a new genus (*Psilodon*) and several new species. In the same work, as well as in other writings, he outlined quite precisely the Oligocene horizons in the Eastern Carpathians, and established the age of menilite formations comparing them with the Ileanda strata of the Transylvanian Depression.[1]

In Bucharest, the first professor of geology was **Gregoriu Ştefănescu** who laid the bases of Romanian geological education and (theoretical and applied) and research activity, being among the first scientists to popularize geology for the general public. Under his lead, the first geological state institution, the Geological Office of Romania began its activity; also at his request the first geological map of the whole country was accomplished on a scale of 1:200,000. From the Geology Department led by Gregoriu Ştefănescu the **Department of Mineralogy and Petrography** was divided in 1894, headed by **Ludovic Mrazec** until 1937. This brilliant scientist erected the theory of diapirism and founded in 1906 the **Geological Institute of Romania**. Under the aegis of this

[1] Liviu Ionesi, *Sculptori în piatra timpului. Geologia ieşeană şi alţi geologi români* (Sculptors in the Stone of Time. Geology in Iaşi and Other Romanian Geologists) (Iaşi: Editura Universităţii „Alexandru Ioan Cuza", 2007), 9–19.

institute the first International Oil Congress took place in Bucharest (1907).

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*,[1] synthesizing the data obtained in the first half of the 19th century.

The development of higher education in Transylvania also contributed to the development of scientific research, including geology. The University of Cluj, since its establishment in 1872 as a Hungarian language university, has undergone several changes, being officially attested as the third Romanian university on October 1st, 1919 by Decree No. 4031. Some outstanding natural scientists and geologists worked there, such as Gheorghe Munteanu Murgoci, Ion Popescu-Voiteşti, and Emil Racoviță.

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. If we want to find out the place and the data when these scientific works were published, the specialized bibliographical works are a great help.

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: literatura geologică; considerațiuni generale asupra tectonicei şi 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.

Considerations on Romania's Tectonics and Stratigraphy, 1910[1]), Bucharest, 1910.). In the regional bibliography of Hungary, compiled by **Antal Bödör** 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.

Among the first authors with relevant contributions for geology we should mention the Sibiu (Hermannstadt) citizen **Georgius Vette** (1645–1704), named by **Heinrich Vollgnad** „*vir satis integer, ac alias fide non indignus, amicus meus perdilectus, Georgius Vette, Pharmacopoeus Cibiniensis*".[2] He published three contributions: *Observatio CLXX. D. Henrici Vollgnad. De draconibus Carpathicis et Transsylvanicis*, *De aquis ardentibus* (both published in 1676), *Rariora quaedam naturae sive luxuriantis sive ludentis exempla* (1677). If the latter is a purely botanical work, the former two are of real geological interest, since the first one refers to the vertebrate fossils from the caves in Transylvania, and the second is practically the first work to mention the methane gas in the same province, pointing out the "burning waters" occurring in the neighbourhood of Sibiu, probably near Copşa Mică.

[1] Ion Simionescu, "Geologia României: literatura geologică; consideraţiuni generale asupra tectonicei şi stratigrafiei României", *Publicaţiunile Fondului Vasile Adamachi*, *IV. (1906–1910)* (1910).

[2] Emil Pop, "Vechi note naturaliste despre România" (Old Naturalist Notes on Romania), *Analele Academiei Române, Memoriile Secţiunii Ştiinţifice* (Annals of the Romanian Academy, Memoirs of the Scientific Section), Series III, XVIII (1943), 5: 76–77.

"Adriatica" block, Bucharest
(Photograph by Bianca Petcu)

Starting perhaps from **Vette**'s data, **Luigi Ferdinando Marsigli** in his 6 volume work[1] described anew the same phenomenon – "*appa ardens*" – in the neighbourhood of Mediaş, at Bazna.

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)[2] 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**.

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. This contribution presents the metals, semimetals, sulphides, rocks, and waters to be found in the great Principality of Transylvania. In the period when the salt mining system began to improve (1780–1790), a school network was established around these mines (among them the salt mines in Cluj County), with the main role to instruct the future salt miners. These schools laid great emphasis on learning German language, but reading and writing, as well as a little arithmetic were also taught in them.[3]

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*). He also published in 1783 an article on stibine crystals in Transylvania entitled

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[1] Luigi Ferdinando Marsigli, *Description du Danube, depuis la montagne de Kalenberg en Autriche, jusqu'au confluent de la rivière Jantra dans la Bulgarie: contenant des informations géographiques, astronomiques, hydrographiques, historiques et physiques* (La Haye: Swart Jean, 1744), vol. 3., 49–51. Referred to by Pop, "Vechi note naturaliste...".

[2] *Industria minieră a județului Cluj: monografie* (Mining Industry in Cluj County: A Monograph) (Cluj: [s.n.], 1972), 40–45.

[3] Idem.

Nachricht vom gedigenen Spiessglanzkönig 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*)[1] 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 natürlischen 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.

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

Other observations on mineralogical themes made during journeys in Hungary, Transylvania and Banat were published by **Jens Esmark** in Freiberg in 1798 (*Kurze Beschreibung einer mineralogischen Reise durch Ungarn, Siebenbürgen und das Banat*).[2]

At the turn of the 18th and 19th centuries Aiud was an important Transylvanian scientific centre; its fame reached far and wide, a fact

[1] Tiberiu Jurcsák et al., "Date privind fauna fosilă a Peşterii Urşilor (Munții Bihor)" (Data on the Fossil Fauna in the Cave of Bears (Bihor Mountains)), *Nymphaea: Folia naturae Bihariae*, VIII–IX (1980–1981): 161–162.

[2] This work makes thoughtful observations on several Transylvanian mountain localities, and it gives a general geological description of these.

proved also by a 18th century manuscript preserved in the Bethlen Documentary Library in this town.[1]

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 chaine des Carpathes en Bukovine et en Transylvanie*.

The bourgeois-democratic revolution of 1848–1849 was the beginning of a period of great change in Transylvania's economic and social structures, implying thus also the further development of mining industry. Therefore, regional achievements were made in this domain. There was a peculiar interest in the geology of the Inner-Carpathian region, the finding of economically valuable substances and their ownership, and also in production modalities. For example, in Cluj County the production of salt, precious metal and iron ore, coal, and useful rocks continued. Researchers interested in geology published scientific monographs or articles in scientific journals at first in Budapest and Vienna, later on in Cluj and in other Transylvanian localities. These were independent studies, or activity reports of some scientific societies' specialized sections.

The western part of Apuseni Mountains (Bihor 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 Bihor Mountains.[2]

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[1] Vlad A. Codrea, Gabriela R. Morărescu, and Forray Erzsébet, "Un catalog manuscris din perioada de început a Muzeului de la Colegiul Bethlen Gábor, Aiud" (A Manuscript Catalogue from the Beginnings of the Museum in the Gábor Bethlen College, Aiud), *Elanul* (The Élan) 72 (2008): 1, 12–13.

[2] Liviu Vălenaş, "Consideraţii asupra informaţiilor documentare despre carstul Munţilor Apuseni în lucrarea *Das Bihar-Gebirge* (1863) de A. Schmidl" [Considerations on the Documentary Information on the Karst of the Apuseni Mountains in the work *Das Bihor-Gebirge* (1863) by A. Schmidl], *Nymphaea: Folia naturae Bihariae*, VIII–IX (1980–1981): 549–560.

Sibiu, besides Braşov and Sighişoara, was one of the important Transylvanian centres of naturalist thinking, which had already been present in this region in the second half of the 18th century. This Transylvanian borough, which later became the most important scientific centre of the region, had the advantage of being the administrative capital of the province, thus having substantial financial support from some of the governors. Better quality educational and research activities were also available there (personalities of European renown were brought to the town to occupy important academic positions and to lead research activities).

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. The mafic rocks of Trascău, Metaliferi, Drocea and Perşani Mountains were investigated by **Zsigmond Szentpétery**, and the felsis rocks of Vlădeasa Mountains by **Gyula Szádeczky**.[1] 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).

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 synthesis.[2] 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

[1] Rădulescu, Dimitrescu, "Cercetarea geologică...", 59.

[2] Ioan Alexandru Maxim, "Câteva consideraţiuni asupra valorii actuale a lucrării lui Anton Koch – Formaţiunile terţiare ale Bazinului Transilvaniei I. Paleogenul, 1894. II. Neogenul, 1900" (Some Considerations on the Present Value of Anton Koch's Work – Tertiary Formations of the Transylvanian Basin I. Palaeogene, 1894. II. Neogene, 1900), *Studia Universitatis Babeş-Bolyai, Series II: Geologia-Geographia*, 1 (1959): 7–22.

the Palaeogene, Koch sketched a series of correlations with formations from the Paris Basin, mainly based on lithology.[1]

The first detailed description on the morphology and geology of the Transylvanian Depression's South-western region was made by geologist **Károly Herepei**, who published in 1865 a work accompanied by a geological sketch.[2] 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 Aiud.[3]

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 from theoretical and economic points of view.

Naturalist preoccupations in Transylvania reached some kind of maturity in the first half of the 19th century, which made necessary the creation of an organized framework for research activities in this domain. Thus in 1841 the Society for Researching Transylvania was founded with a history and a natural sciences section, the latter being led by **Michael Bielz**. He took the necessary steps in Vienna to establish an exclusively naturalist society, and in September the much sought for authorization was obtained. Because of the Revolution of 1848 and the events triggered by this, the new society (*Siebenbürgischer Verein für*

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[1] Cristina Fărcaş, Vlad Codrea, "Evolution of Knowledge on Paleogene Formations from the NW Border of the Transylvanian Basin", *Studii şi cercetări, Geologie – Geografie Bistriţa* (Studies and Research, Geology–Geography, Bistriţa), 9 (2004): 13–46.

[2] Iustin Gherman, "Cercetări geologice în colţul de SW al depresiunii Transilvaniei (între Valea Stremţului şi Valea Ampoiului)" [Geological Research in the South-western Corner of the Transylvanian Depression (Between Stremţ Valley and Ampoi Valley)], *Revista Muzeului Mineralogic-Geologic al Universităţii din Cluj la Timişoara* (The Review of the Mineralogical-Geological Museum of the University of Cluj in Timişoara), vol. VII (1940–1941): 3.

[3] Herepei Károly, Gáspár János, "Alsófehér vármegye földrajzi és földtani leirása" (The Geographical and Geological Description of Lower Alba County), *Alsófehér vármegye monografiája* (The Monograph of Lower Alba County), I vol., (Nagy-Enyed: Cirner és Lingner Könyvnyomdája, 1896): 103–183.

Naturwissenschaften zu Hermannstadt = The Transylvanian Society for Natural Sciences in Sibiu) was established only a year later, in May 1849.

The society was dissolved a century later by the communist regime, however its activity resulted in some important collections of natural history, a prodigious number of publications (95 volumes containing the debates and papers of the Society), and last but not least in the creation of the Museum of Natural History (opened in 1895).[1]

The founding members of the society were scientists or enthusiastic dilettantes having different professions related to the different branches of biology, geology, geography and medicine (pharmacists, professors, priests, physicians, and civil servants). Among these forerunners of Transylvanian naturalist thinking the most distinguished were: **Johann Ludwig Neugeboren** in palaeontology, **Johann Michael Ackner** in mineralogy and palaeontology, **Eduard Albert Bielz** in geology and palaeontology, **Michael Bielz** in malacology, **Ferdinand Schur** and **Gustav Kayser** in botany, **Karl Fuss** in entomology, and **Ludwig Reissenberger** in meteorology.

Towards the end of the 19th century some works by amateur geologists were published, for example the popular paper written in Romanian by the lawyer **Basiliu Basiota** (Başota) for common people (*Studiu geologicu asupr'a structurei muntiloru metalici ai Transilvaniei*, 1883 – A Geological Study on the Structure of the Metallic Mountains of Transylvania).[2] This is a popular Romanian language adaptation of the first geological synthesis on Transylvania entitled *Geologie Siebenbürgens,* and published by Austrian geologist **Guido Stache** together with **Franz Ritter von Hauer** in Vienna in 1863. This detailed work on Transylvania's geology is very often cited even today due to its authors' vision on the geological formations and structures in this region.

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[1] Gheorghe Ban, "Rolul determinant al Societăţii Ardelene pentru Ştiinţele Naturii din Sibiu privind cercetarea, tezaurizarea şi valorificarea patrimoniului de istorie naturală" (The Determining Role of the Transylvanian Society for Natural Sciences in Sibiu Regarding the Investigation, Preservation, and Valorisation of the Natural Historical Heritage), *Der Siebenbürgische Verein für Naturwissenschaften zu Hermannstadt = Societatea Ardeleană pentru Ştiinţele Naturii din Sibiu (1849-1949): volume omagial* [The Transylvanian Society for Natural Sciences in Sibiu (1849–1949): Commemorative Volume, (Sibiu: Hora, 2003), 19–24.

[2] Gabriela R. Morărescu, Vlad A. Codrea, "Un entuziast uitat: Basiliu Basiota" (A Forgotten Enthusiast: Basiliu Basiota), *Elanul* 67 (2007): 1, 6–8.

This period brought considerable progress to world geology, as well as new theoretical approaches and the application of some new, specific methods in the research of useful mineral substances. This had a beneficial influence on the development of this science and of the academic education in Cluj.[1]

The development of Earth sciences needed centuries of observations and reflections, and later on more and more precise research. The real progress of these sciences had been impossible – as otherwise the development of most scientific domains – until they abandoned the old dogmas and ideas, fully benefiting from the contributions of other sciences such as mathematics, physics and chemistry which have known an exceptional emancipation.

As Ion Simionescu highlighted in the introduction of his bibliographical work published in 1910: "Out of all natural science branches, geology was the most popular; foreigners and Romanians made efforts to know the structure of our country from a purely scientific, or a practical point of view. The obtained results were published in different journals, so that many of them remained unknown to those who would have been interested in them."[2]

Translated by Ágnes Korondi

[1] Vlad A. Codrea, Gabriela R. Morărescu, "Basiliu Basiota şi aurul Apusenilor" (Basiliu Basiota and the Gold of the Apuseni Mountains), *Dacoromania*, 35 (2008): 72–76.
[2] Ion Simionescu, "Geologia României...", 37.