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THE GOLD MUSEUM OF BRAD. CHARACTERIZATION AND CLASSIFICATION OF NATIVE GOLD SAMPLES AND OF OTHER MINERALS

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București, 2013

Contents

Introduction

The Gold Museum of Brad is unique among other museums in Romania and, as far as we know, even in Europe. The museum includes absolutely unrepeatable and invaluable samples. EThe samples were collected in Romania and from all around the world. A special display is dedicated to mineral species described for the first time in Metaliferi Mts. and in Romania, in general: nagyagite, sylvanite, native tellurium, krennerite, semseyite, fizelyite, rhodonite, alabandite, *etc.* The museum belongs to ”MINVEST” – Deva mining company.

After 1990, when everybody expected a period of openness in the history of the Museum, of uncovering of its ”wonders”, the building and the institution iteself were on the verge of being lost, of remaining forever closed to visitors, of being remembered only from anecdotal facts. Fortunately and owing to the courage and commitment of several people devoted to mining and geology (the mayor of Brad – Florin Cazacu and general managers Sorin Copăescu and Sorin Găman), today the Gold Museum has a new and improved appearance. In this respect, starting with October 2011, a team of experts from the University of Bucharest (professors Gheorghe C. Popescu, Gheorghe Ilinca and Antonela Neacșu) together with specialists from MINVEST – Deva (Grigore Verdeș, Ana Ursoi and Georgeta Dulgheru) have worked on the revaluation and classification of the gold and mineral ”treasure” of the museum. A special mention has to be granted to Mr. Alexandru Nicolici – general manager of SAMAX, for his important material and logistic support.

Figures 1.1-1.3, 2.1-2.4, 3.2, 3.18, 3.19, 4.1, 5, 6.1, 7.1-7.4; 3.4, 3.6, 3.13, 3.14, 3.21, 3.27, 3.31, 3.33; 3.17, 3.23-3.25 were reproduced by kind permission of the authors cited in each caption: Tămaș-Bădescu (2010), Ciobanu et al. (2004) and Wollmann (2010).

1. Brief History

The Gold Museum of Brad was born from various mineral, rock and mining tool collections belonging to mining companies from the end of the 19th century. Several such collections were mentioned by various authors involved in the research of gold deposits around Brad. For example, in a report written in 1910-1911 by Friedrich Schumacher on the ore deposits owned by “Ruda-12 Apostoli” company, a mineral collection with about 200 specimens of gold was mentioned. Later, the author added over 160 samples of minerals and rocks to this collection.

Starting with 4th of July 1912, the collection could be visited by people outside the company, and many agree that this should be considered the birth date of the Gold Museum of Brad. Through the care of the technical and engineering staff, many of them educated in Germany. The collection has been added with new gold specimens from the ore deposits around Brad or from the “Golden Quadrilateral” of the Metaliferi Mts., under administration of „MICA” company between 1920 and 1948. Other mineral samples from ore deposits of Romania or from all around the world have entered the Museum through exchanges and donations. On 14th of June 1948, the assets of „MICA” company were nationalized. At that time, the mineralogical and geological collection included 992 samples of native gold, 383 mineral samples, 53 rock samples, as well as ore processing reagents, mining models, mining devices, old mining tools (some of them from the Roman period), all testifying for the special care of the technical and geological staff to preserve objects of museum value. It is worth mentioning the decisive role of professors Toma Petre Ghiţulescu, Valeriu Luca and Viorel Brana.

Following the year 1948, the collection has continued to grow with samples from Metaliferi Mts. or from other geological units of Romania and from abroad. The collection has always belonged to mining companies based in the Brad region. Today, it is owned by S.C. “MINVEST” S.A. Deva and includes 1305 samples of native gold, 1087 mineral samples, as well as numerous archaeological and mining objects which plead for a more than 2000 year old mining activity in the region.

2. Collections and exhibitions

The expositional heritage of the Museum consists of samples collected by geologists and miners who worked in various mines of Metaliferi Mts. (about 80% of the specimens originate in the Brad region, especially Musariu and Brădişor deposits). The great majority is represented by native gold and other gold-bearing minerals (*e.g.* over 100 telluride samples). The gold-bearing samples are grouped according to ore deposit and metallogenic criteria. Besides, three separate rooms of the Museum gather mineral samples from various Romanian and foreign occurrences, arranged in systematic order.

The four rooms reserved to gold-bearing samples host unique specimens such as those containing crystals of over 1 cm or fine-granular, skeletal aggregates. These spectacular examples of native gold have often been compared with natural forms or have inspired various metaphoric names: „The Map of Great Romania”, „The Sitting Hen”, „The Polar Bear”, „The Cannon of Avram Iancu”, „Eminescu’s Writing Plume”, „The Lizard”, „The Little Dog”, „The Fern”, „The Dragonfly”, „The Eagle”, „The Magic Bird”, *etc*. One extremely rare specimen, called „The Ballerina” is an unique assemblage of several gold dodecahedral crystals. The top crystal is almost perfect with all the twelve faces readily visible. It lies on a pile of less perfect crystals, in a quasi-parallel arrangement. Two of the most beautiful samples resemble a lizard shape. One of them weighs 4.5 g and was presented in 1937 at the Universal Exhibition in Paris. For the time of its exposure, the sample was insured for 2 million pounds.

Upstairs, there are several rooms for exhibiting old tools and devices used in gold extraction, such as hydraulic stump crushers, built of hard wood, wooden or metal gold pans, as well as a replica of the famous mine carriage which is considered to be the oldest of the kind in the world and whose original version is exhibited at the Mining Museum in Heidelberg – Germany.

Numerous samples illustrate a variety of assemblages between native gold and quartz, calcite, baryte, fluorite, clay minerals, native arsenic, *etc.*

There are many samples with gold, silver and lead tellurides from the famous ore deposits of Săcărâmb, Stănija, Baia de Arieş, Roşia Montană, Boteş, Căraci, *etc*., all belonging to the „Golden Quadrilateral”.

The Gold Museum of Brad has served both as means of popularizing knowledge about one of the most important part of the Romanian underground wealth – the gold in the Metaliferi Mountains, and as repository of the national and universal mineral heritage, mainly of *the minerals first described in Apuseni Mts*. Numerous such samples are unique, witnessing for the *locus tipicus* of numerous minerals in the Metaliferi Mountains. Thus, *nagyágite* was described in 1769 by Scopoli under the name of *minera aurifera nagyagensis*, while its present name was given by Haidinger in 1845 after the village of Nagyág, currently Săcărâmb. *Sylvanite* was described in 1790 by Ignaz von Born who called it *or blanc de Offenbanya* – Baia de Arieş; later, in 1835, the mineral got his present name from Necker, alluding to Latin name of Transylvania. *Native tellurium* was discovered in 1783-1785 by Müller von Reichenstein, at Faţa Băii, near Stănija, and called *metallum problematicum*; the name *tellurium* was given by Klaproth after the research carried out during 1798 and 1802. *Stützite* was described for the first time by Schrauf, at Săcărâmb, in 1848. *Krennerite* was discovered by Krenner also at Săcărâmb, in 1877, and named *bunsenine*; later it was renamed by von Rath in honor of its discoverer. Another first occurrence at Săcărâmb was that of *muthmannite*, found in 1911 by Zambonini. *Tellurite* was discovered in 1798 by Esmark, at Faţa Băii; the mineral was named *gebles Spiess-Glaserz* and renamed to its actual form by Heidinger, in 1845. *Museumite* was described in 2004 by Bindi and Cipriani in a sample from Săcărâmb. *Pseudobrookite* was discovered by Anton Koch, in 1848, at Uroi Hill, near Simeria.

The Gold Museum of Brad was included as a field trip stop of all major national and international scientific events concerned with the geology of Apuseni Mts., with gold or other resources of the western and north-western part of Romania. **One such moment was the International Symposium of Economic Geology organized by Society of Economic Geology of Romania, on 13-16 September 2012. The event was dedicated to the Centennial of the Gold Museum and was attended by experts from seven countries. On this occasion, the prestigious geologist Petre Toma Ghiţulescu, one of the leading researchers of the Metaliferi Mountains, has been awarded the title of Honorary Citizen of the City of Brad.**

The Museum will become again a touristic landmark of Brad, and a major reference of the Apuseni Mts. heritage.

In the future, the Museum must answer two basic requirements. One is about its scientific character, both in terms of gold as a mineral and natural resource, and as a repository of minerals belonging to national and universal heritage (native tellurium, sylvanite, nagyágite, stützite, *etc.*). A second one would concern the local, regional, national and international tourism.

3. Evaluation of the mineral collection

In this new stage in the life of the Museum, several aspects were taken into account.

1. Verification of the initial mineral diagnosis of samples
2. Description of the mineral physical features: size, weight, *etc*.
3. Identification of new mineral characteristics
4. Verification of the gold content
5. The museum value of the exhibited samples
6. Photographing the samples
7. Digital storage of mineral sample data

In order to achieve these goals, various non-destructive means of observation have been used: magnifiers, microscopes, electronic scale and other measurement devices.

The evaluation of samples has covered two aspects: the first was to verify the gold content of the samples using non-destructive procedures, and the second was to assess the value of museum specimens, both of the gold-bearing samples and of the specimens without gold.

As a result, most of the names of gold samples have been changed with the aim of updating the mineralogical, morphological and metallogenic nomenclature.

In the mineralogical section of the Museum, a special attention was given to the **mineral formula**. Numerous such formulae have changed recently due to the advance gained in chemical and structural investigation methods. The modifications concerned mainly the minerals with complex composition, such as sulfosalts or phylosilicates, *etc.* A good example is that of **nagyàgite, a complex gold telluride which has been known with an undecided chemical formula ($Pb_5Au(Te,Sb)_4S_{5\text{-}8}$(?). Recently, the chemical formula of nagyàgite has been determined exactly to (Te,Au)Pb(Pb,Sb)S_2, so that the new formula was written on the specimens label. Other minerals have undergone similar procedures.**

In order to obtain a more detailed description of the samples, several less conventional methods have been used, such as X-ray fluorescence spectrometry which allowed the evaluation of gold and silver content as well as the identification of gold in samples where the presence of this metal was less conspicuous.

A very useful information regarding native gold is its Ag content. Old technological analyzes have identified the varying silver content in native gold from various deposits of the Apuseni Mountains and in general, from various other provinces with significant gold metallogenesis. However, no such data on native gold samples in the Museum were available. In this respect, we turned to experts from the National Institute of Physics and Nuclear Engineering "Horia Hulubei" Bucharest, namely Dr. Bogdan Constantinescu and Dr. Daniela Cristea-Stan, who conducted non-destructive analyzes of gold *vs.* silver ratio, using a portable X-MET 3000TX XRF spectrometer, designed to investigate alloys, soils, geological samples and archaeological artifacts. XRF measurements were performed on more than 200 samples. Au-Ag composition was normalized to 100% in order to compare the variation of Au/Ag in various metallogenic fields. It is likely that the presence of other minerals than native gold, such as gold-silver-bearing tellurides and/or antimony compounds has influenced some measurement results.

The Au:Ag ratio represents an index of native gold quality and of the genetic conditions. Therefore, correlation diagrams were drafted for each metallogenic unit. For instance, in Brad-Săcărâmb metallogenic district, the Au:Ag ratio is relatively uniform (45% to 90% gold, and 55% to 10% silver). Instead, in the metallogenic node of Barza there is a marked difference between Valea Morii ore deposit (75% to 90% Au) and Musariu (60% to 70% Au).

Gold-bearing mineral assemblages were investigated by macroscopic and microscopic observation of each sample.

Over 100 samples were investigated through X-ray powder diffraction techniques which allowed the identification of new minerals in the collections of the Museum (RE-apatite at Valea Morii; altaite, coloradoite, dyscrasite, tellurantimonite, hessite, calaverite, nagyágite, goldfieldite at Hărţăgani; petzite, coloradoite, muthmannite, tetradymite, tellurantimonite, petzite, dyscrasite, phlogopite, chamosite at Stănija; tetradymite and tellurantimonite at Baia de Arieş).

Many such newly described minerals were referenced in the collection catalogues under the generic name of *tellurides*, however without discerning any particular phase in this rather large mineral group. Many of these tellurides *have been described for the first time in occurrences from the Metaliferi Mts.*

The nomenclature of minerals has also been updated either for cases of synonymy (*e.g. xantophyllite?* or *seyberite?* which represents in fact *clintonite*; *roettisite* was considered a valid mineral species, but in fact, represented a serpentine mixture with antigorite and Ni-chrysotile, *etc.).*

The actual museum value of the samples with or without gold was assessed through comparison with the values accepted on the international market and posted on various Internet pages, such as *Rocks, Fossils, Minerals – eBay*. Obviously, our own experience has been involved in this evaluation, taking into account also the scientific value and thr absolute rarity of the samples. On this basis, some specimens on the Gold Museum of Brad could be evaluated at over 500,000 $.

4. Photography

The photographic record of the samples hosted by the Gold Museum of Brad has been achieved with high-performance equipment: two 12 Mp, dSLR cameras (Nikon d700 and Nikon d300) with high resolution lenses, tripod, backgrounds and appropriate lighting devices (up to seven 180-400Ws Elinchrome strobe lights, up to six portable Nikon SB-800, SB-900 and SB-R200 flash lights), various light modifiers (soft-boxes, grids, cones, *etc.*)

The photographing regime was adapted to the effective size of the sample and to the required degree of detail in order to depict particular crystallographic aspects. Numerous small-sized samples were photographed using a laborious "focus stacking" technique – that is, shooting up to 30 images and different focus distances and digital recomposition of the entire image. Thus, some microscopic, almost invisible details could be enhanced.

The photographic documentation of the Museum aimed both at obtaining a visual inventory of the collection to be used in the digital data base, but also to fully reflect the beauty of the samples and to allow the printing of advertising materials such as booklets, views, posters, internet page *etc*. The photographs have sufficient resolution to stand enlargements up A0 format, without major quality loss. Approximately 40,000 exposures have been taken during the research and evaluation campaign. All the mineral images presented in this book represent samples from the Gold Museum.

5. Classification of samples

Several criteria were taken into account for the classification of the samples in the Gold Museum of Brad: mineralogical, metallogenic and regional.

The mineralogical criterion seems the most appropriate for the mineralogical section of the Museum. The samples here were arranged and classified according to the chemical-structural system of Strunz (1941-1994) – *the symmetric classification*. Thus, the specimens were grouped in the following order: **native elements, sulfides-sulfosalts and similar compounds, halides, oxides-hydroxides, carbonates, sulfates, arsenates, phosphates, vanadates, iodates, borates, silicates, organic compounds.**

A new feature added to the new configuration of the Museum was that each display has a 200/50-80 cm illustrated explanatory poster. For the mineralogical section, 17 posters were drafted to contain a more detailed view of each exhibited mineral. Typically, the poster contains information about: name, chemical formula, system of crystallization, diagnostic features, and occurrences in Romania and worldwide. A special display was reserved for minerals firstly described in Romania (Fig.1).

The samples with native gold and gold- or gold-silver-bearing tellurides were classified according to the regional criterion, that is, in Romanian and foreign occurrences (South Africa, North America, South America, *etc*). According to the **metallogenic criterion**, the Romanian samples were grouped on the basis of hierarchical **metallogenic criterion**: **province, subprovince, district, sector, field/node** (Fig. 2) .

Fig. 1. Example of explanatory plate in the mineral section

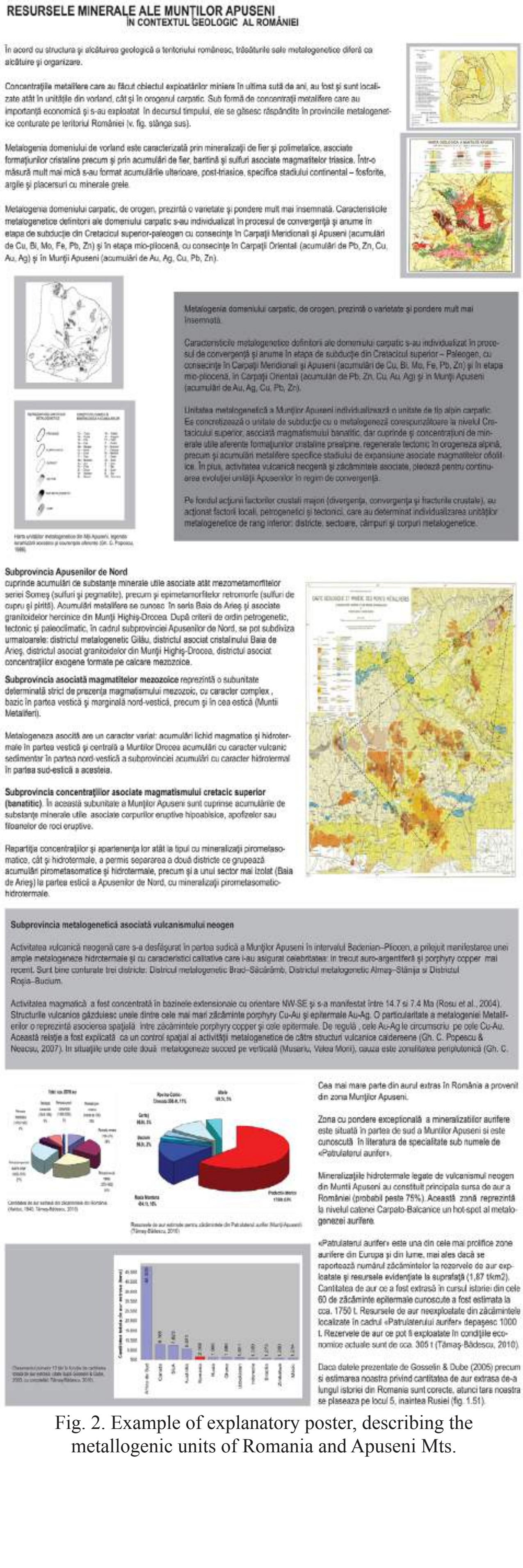


Fig. 2. Example of explanatory poster, describing the metallogenic units of Romania and Apuseni Mts.

For instance, in the case of Apuseni Mts., the **metallogenic classification** is expressed in the form of maps and explanatory notes, describing the Metallogenic Subprovince of the Metaliferi Mts., the Au-Ag-Cu metallogenic districts (Brad-Săcărâmb, Zlatna-Stănija, Roşia-Bucium, Baia de Arieş), as well as geological sections in the ore deposits for which the museum samples are representative (Fig. 3).

For the native-gold section of the Museum, 24 posters have been drafted. For the entire Museum, a total number of 41 explanatory posters were drafted, amounting approx. 60 m^2.

6. Digital storage of sample data

The entire mineralogical, geological and metallogenic data concerning the Gold Museum has been digitally stored in order to make it accessible to the museum staff and to the public. A comprehensive inventory table has been drafted with data on: inventory number, name of sample, content/chemical formula, sample description (weight, size, *etc.*), location and museum value.

Also, for each source deposit, short descriptions of the relevant metallogenic units (node, field, sector, district) were made. For samples sourced abroad, a summary was made of each gold deposit in the country of origin.

These activities were intended to bring the Gold Museum to European and world standards of mineralogical museums.

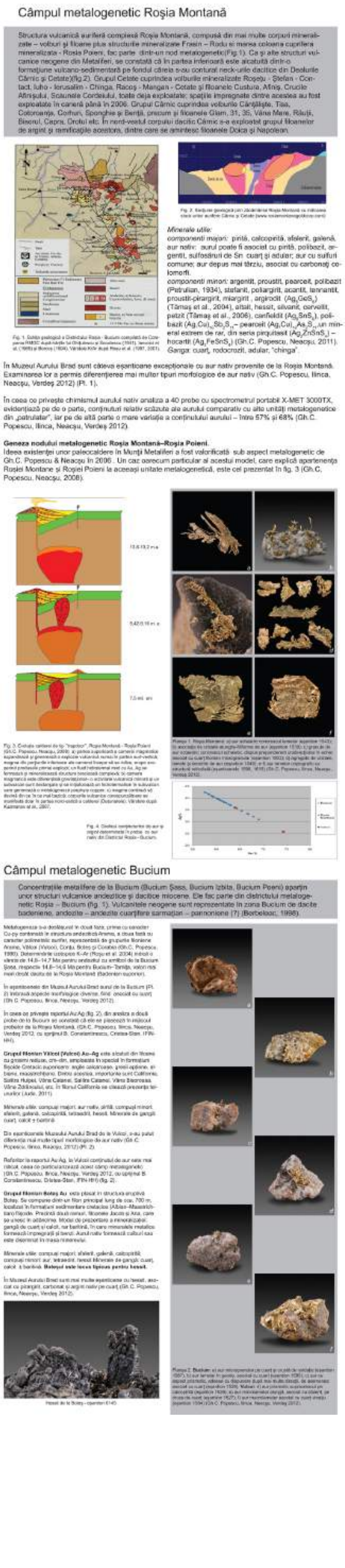


Fig. 3. The explanatory plate attached to the native gold samples from Roşia-Bucium district; general and mineralogical characterization

Metallogenic context and classification of native gold and Au-Ag-mineral samples in the Gold Museum of Brad

1. Historical highlights of gold mining in Romania

In all likelihood, our ancestors – the Dacians have played an important role in the world history of gold mining. Many documents dealing with this subject have been published by numerous authors, including Roman *et al.* (1982), Fodor (2005), Baron (2006), Wollmann (2010, 2013), *etc*.

It seems that gold mining activity over the present territory of Romania dates from about the same time with the gold mining in Mesopotamia and Egypt. In those days, the local inhabitants, mined gold from river alluvia.

The archaeological research by radiocarbon measurements conducted by Cauuet *et al.* (2002) (in Popescu *et al.*, 2007) in the Roșia Montană (Alba county), showed that the mining of veins in this deposit began sometime between the 3rd and 1st centuries BC. A number of other archaeological remains support the idea that the Dacians knew and mined several gold veins in the Apuseni Mountains and in the Baia Mare area. Many archeologists argue that during the pre-Roman period, gold was extracted mainly from river alluvia and less, or none, directly from the primary deposits. References by Herodotus and Pliny the Elder are strong arguments in this respect, although there are only few archaeologically documented sites of Dacian alluvial mining (Figure 1.1). Ancient chroniclers estimated that the Romans captured massive amounts of gold and silver from Dacia. The amount of gold brought by the Romans from this newly conquered province was estimated at approx. 165 t with approx. 331 t of silver. This large amount of gold captured by the Romans led to an approx. 10% decline in the price of gold on the Roman market, to be one of the first collapses of gold value in the history of mankind.

Gold production of the Roman Empire grew stronger due to the opening of mines in Dacia and generated the first inflation in history. It has been estimated that during the Roman occupation, which lasted 165 years, the Romans extracted from Dacia about 500 t of gold. Until around 1600, the gold mines in the Apuseni Mountains and in the Baia Mare are produced approx. 20% of the gold mined worldwide (Haiduc, 1940).

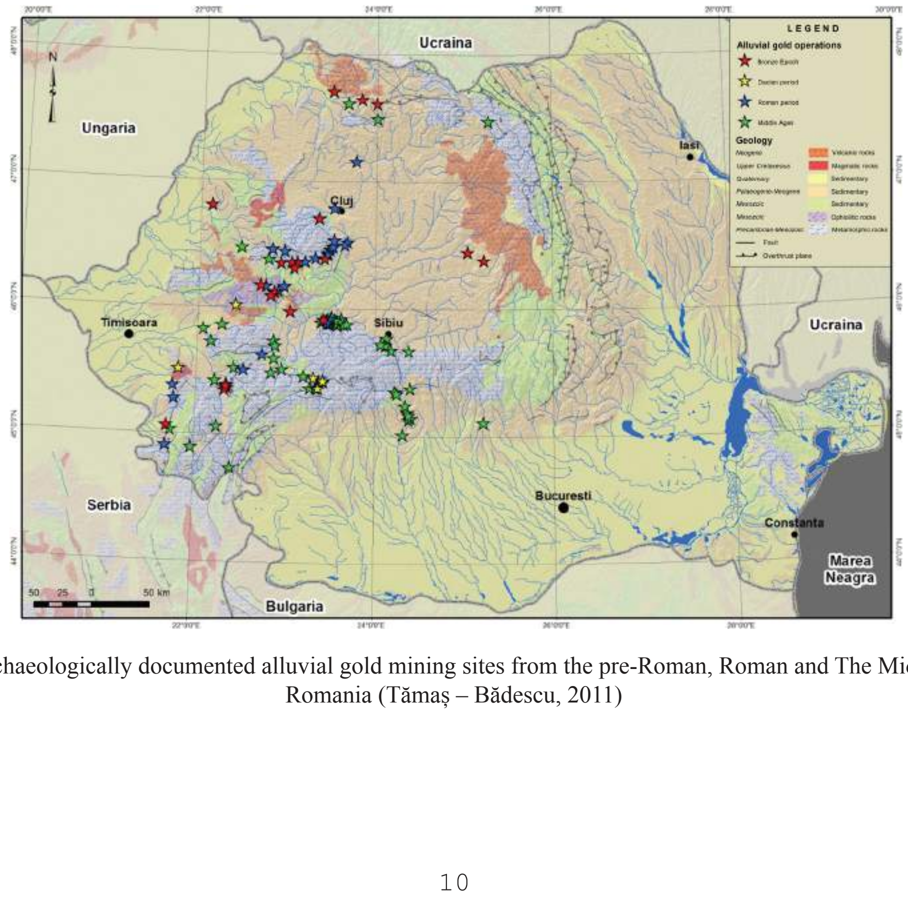


Fig. 1.1. Archaeologically documented alluvial gold mining sites from the pre-Roman, Roman and The Middle Ages in Romania (Tămaș – Bădescu, 2011)

Between the World Wars, the history of gold mining in Romania is related to “MICA” company (Brad), which was the main Romanian producer of gold and the most important mining company engaged in the extraction of precious metals from the Central and South-East Europe, between 1920 and 1948. The company had concessions on most deposits in the Apuseni Mountains.

During the communist period, gold ore mining activity has been intense, but during its last years, the productivity was low and operating costs were high. There is no official data available on the gold production of Romania before 1989, but an average annual production of about 3 t gold could be estimated (Fig. 1.2).

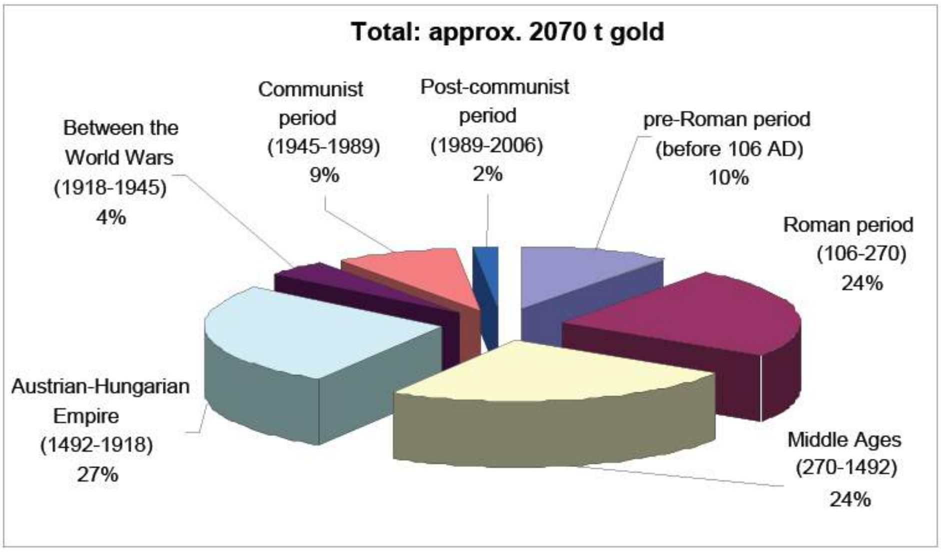


Fig. 1.2. Estimate of gold amount extracted from ore deposits on the territory of Romania (data after Haiduc, 1940, with additions by Tămaș-Bădescu, 2010)

The first Mining Law in post-communist Romania was enforced in 1998. As a result, numerous foreign exploration and mining companies manifested their interest for investing in the mining sector of Romania, especially in the “Golden Quadrilateral” of the Apuseni Mountains, Eastern Carpathians (mainly in the Baia Mare area), Banat Mountains, *etc*.

Based on data published by Haiduc in 1940 on the amount of gold extracted in different historical periods until 1938, and on an estimate the amount of gold extracted after 1938, Tamaș-Bădescu (2010) believes that the overall gold amount mined throughout history was of about 2069 t gold (Fig. 1.3). Much of this quantity came from the Apuseni Mountains (”Golden Quadrilateral”), one of the most prolific gold provinces in the world, especially in what concerns open-pit mining. The Apuseni Mountains alone yielded 1,600 t of gold.

Gosselin & Dube (2005, in Tămaş-Badescu, 2010) published a ranking of gold producing countries throughout history. South Africa ranked first, followed by Canada, the United States and Australia. Gold production of each of the three later countries was about 6-8 times lower than the total output of South Africa.

The amount of gold that was extracted throughout history of Romania was 2069 t, ranking our country into the fifth position after the major gold producers in the world: South Africa, Canada, United States and Australia, and surprisingly, ahead of Russia (Fig. 1.3).

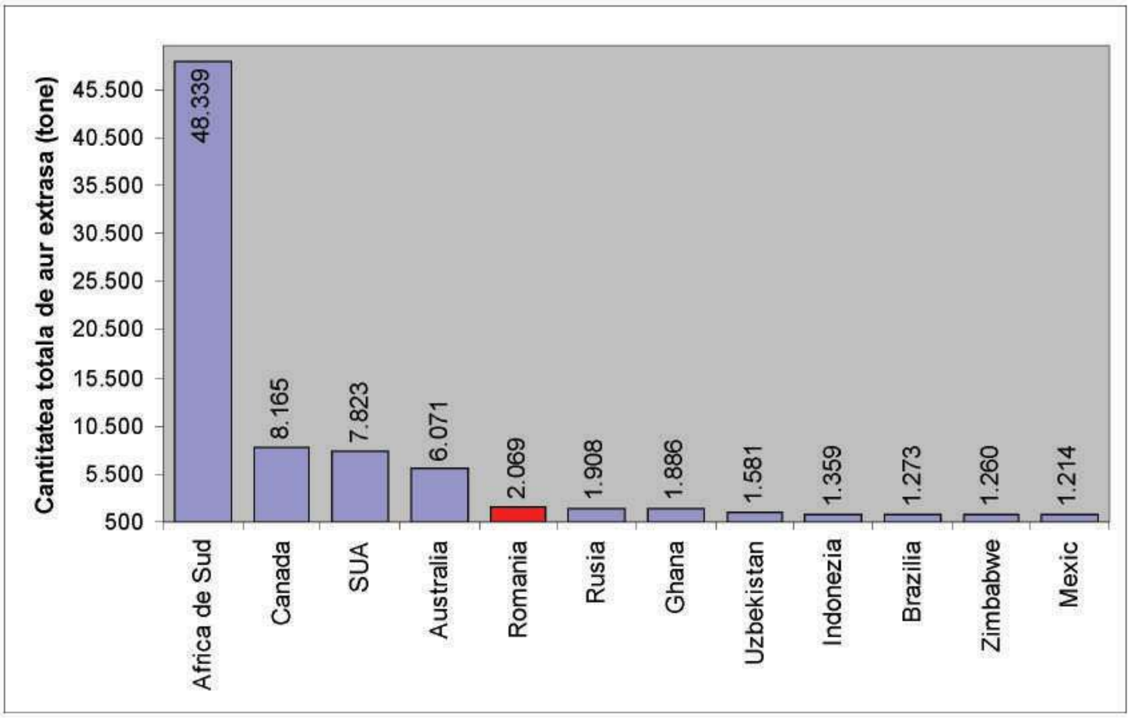


Fig. 1.3. The first 12 gold-producing countries, based on the total amount of gold extracted (data after Gosselin & Dube, 2005, with additions by Tămaș-Bădescu, 2010)

2. Overview of the gold mining in Romania

In Romania, there are over 140 known deposits and occurrences in which gold is the main useful metallic element, and more than 90 fields in which gold is present as a byproduct. Most gold deposits and occurrences in Romania are associated with the Neogene volcanism from the southern part of the Apuseni Mountains and the East Carpathians (Baia Mare district) and are of epithermal and porphyry copper type.

Across Romania, the banatitic magmatism, which played an important role in the gold metallogenesis for the rest of Carpatho-Balkan chain *e.g.* Serbia and Bulgaria) (Fig. 2.1) had a subordinate role (Banat and Apuseni metallogenic subprovinces) in the formation of the gold deposits themselves. In Romania, we know also many areas of mineralization associated with shear zones, which economically, qualify for the time being only as simple occurrences. Recent or fossil alluvial deposits in Romania were an important source of gold for the ancient inhabitants of these territories.

2.1. Gold deposits in the Metaliferi Mountains

The gold deposits in the Metaliferi Mountains represented the main gold source of Romania (probably, over 75% of the total gold mined throughout history originate from this area) (Fig. 2.2).

At the scale of the entire Carpatho-Balkan belt, his unit represents an anomaly of the gold metallogenesis and it remained one of the most prolific gold mining areas in Europe and in the world. The historical amount of gold extracted from the 60 known epithermal deposits in the Golden Quadrilateral was about 1750 t (Fig. 2.2).

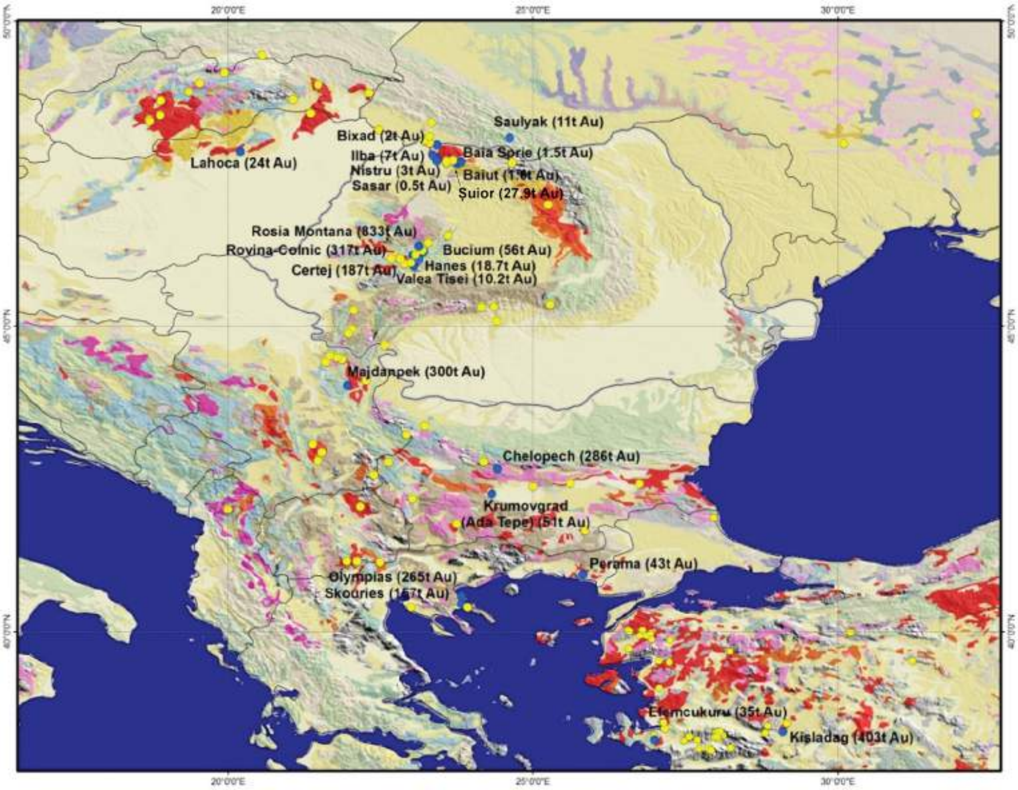


Fig. 2.1. The location of gold deposits in the Carpatho-Balkan chain. Known deposits are represented by yellow dots whereas deposits under exploration are shown in blue. Figures in the brackets represent the total amount of gold in reserves and outlined resources (Tămaş-Bădescu, 2010)

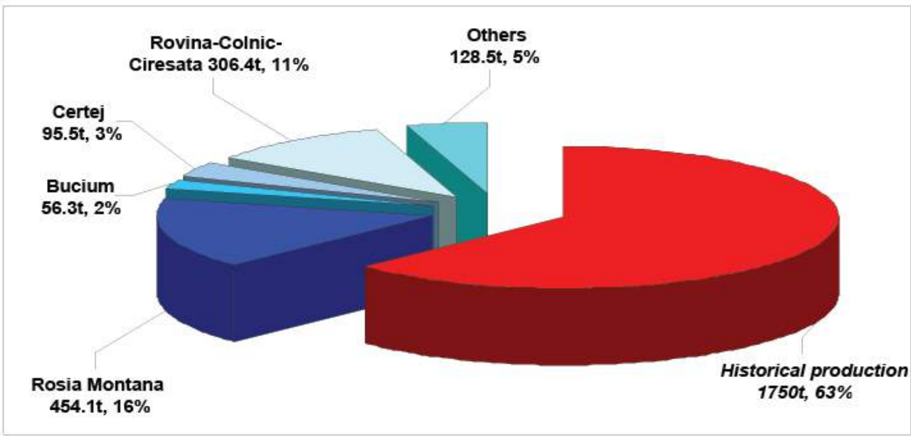


Fig. 2.2. Estimated gold resources of the deposits in the Golden Quadrilateral (Apuseni Mountains) (Tămaş-Bădescu, 2010)

The Golden Quadrilateral contains 14 known mineralized porphyry copper systems which are spatially associated with mineralized epithermal systems. Gold is present within porphyry copper deposits in concentrations sometimes reaching approx. 1 g/t.

2.2. Gold deposits in the Gutâi Mountains

Baia Mare is the most important polymetallic metallogenic district in Romania and one of the most impressive of the kind in Europe.

It is estimated that approx. 125 t gold were extracted from over than 20 mineralized structures within the Baia Mare district, throughout history. However, this amount is likely to be underestimated, if we consider that over 20 t gold were extracted during 1875-1993, from Cavnic metallogenic field alone (Marias, 2005). Kouzmanov et al. (2005) believe that the Baia Mare district still contains approx. 33.6 t unexplored gold (Fig. 2.3).

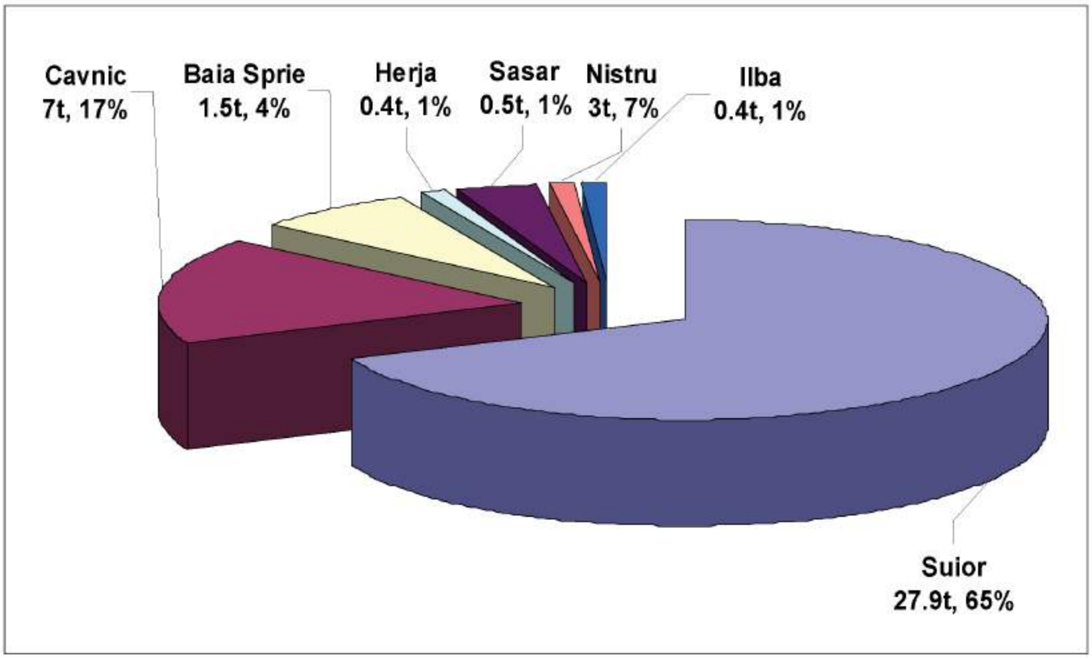


Fig. 2.3. Estimated gold resources for various metallogenic fields in Baia Mare district (Gutâi Mountains) (Tămaș-Bădescu, 2010)

2.3. Gold deposits related to Upper Cretaceous (banatitic) magmatism

The Upper Cretaceous magmatism in Banat and Apuseni Mountains played an important role in the Pb-Zn and with (± molybdenum) metallogenesis of Romania, but in terms of gold abundance, its role was relatively minor.

Gold is present in most banatitic deposits and occurrences of *porphyry copper*-type mineralization, or in contact metasomatic and hydrothermal metallic accumulations, but not a major constituent thereof. However, in the past, some deposits related to banatitic magmatism were mined for gold.

2.4. Gold deposits and occurrences related to shear zones

Over two thirds of the shear zone-related gold occurrences in Romania are located in the Carpathians, and the rest in the Apuseni Mountains (Fig. 2.4). Many occurrences of this type have been subjected to small scale operation in the past. The gold content in known occurrences is quite low (seldom over than 2 g/t). Abundant arsenic creates additional problems for the ore processing.

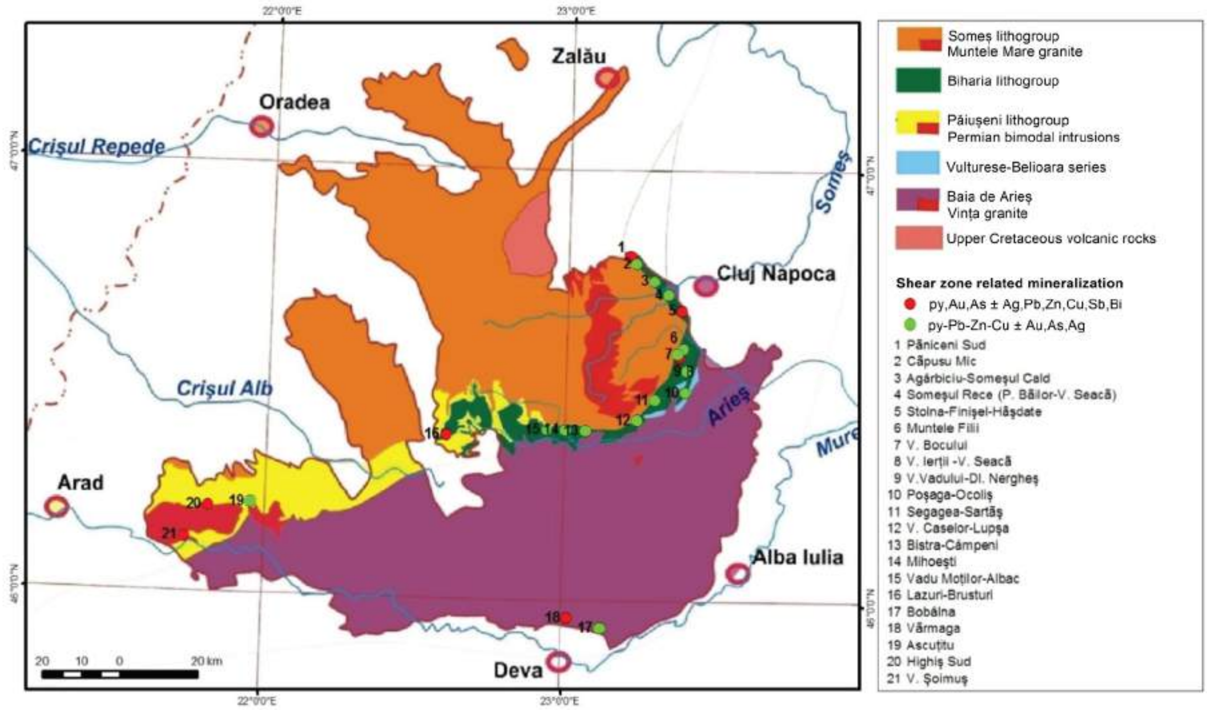


Fig. 2.4. Gold occurrences associated with shear zones in the Apuseni Mountains (Tămaş-Bădescu, 2010)

3. The metallogenic subprovince related to the Neogene volcanism in Metaliferi Mountains

As mentioned earlier in this Guide, the **metallogenic classification** of samples is expressed specifically in arranging the gold specimens based on their original metallogenic units, starting with the Baia de Arieș district where maps and explanatory notes depict the Metaliferi Mountains subprovince and its Au-Ag-Cu metallogenic districts: Brad-Săcărâmb, Zlatna-Stănija, Roșia-Bucium, Baia de Arieș. Maps, geological sections and other geological and mining elements are used to characterize the ores from which these samples originate (Fig. 3.1).

The Badenian-Pliocene volcanic activity that took place in the southern part of the Apuseni Mountains, produced a broad gold-silver and *porphyry copper* metallogenesis, with a remarkable hydrothermal specificity and with quality characteristics that have early ensured its celebrity. Pre-Tertiary crustal fractures that were reactivated in the Neogene, especially those oriented NW-SE, led to the formation of intracontinental basins such as: Brad-Săcărâmb, Zlatna-Stănija, Roșia Montană-Bucium and Mureș Valley (Fig. 3.2).

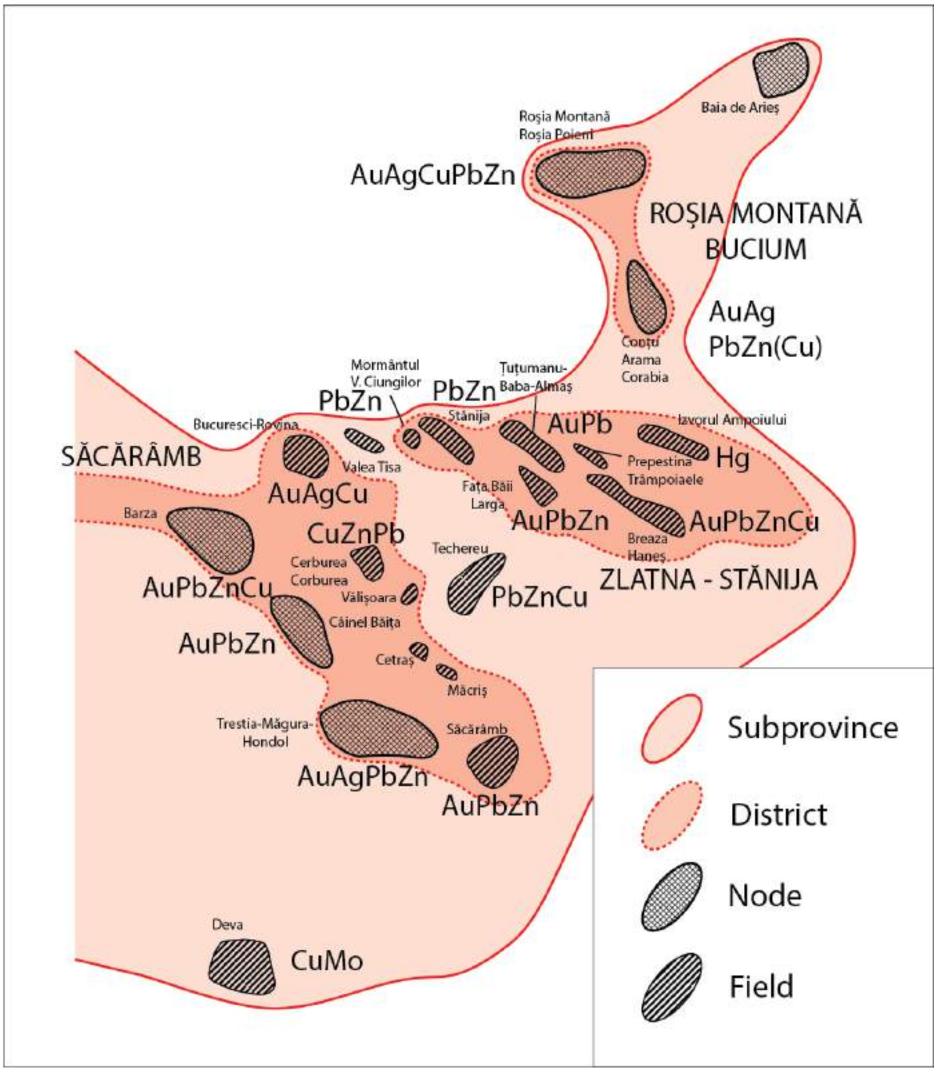


Fig. 3.1. The Neogene metallogenic subprovince of Southern Apuseni Mountains (Popescu, 1986)

The Neogene metallogenesis is characterized by gold-silver veins and stockworks, closely associated with volcanic structures and followed by copper porphyry deposits related to subvolcanic intrusions. The Neogene period has been characterized by an overall geodynamic regime of subduction, where primary roll-back of the subducted slab and secondary phenomena, like slab break-off and the development of slab windows, could have contributed to the evolution, location and type of volcanic activity. Structural features developing in the overlying lithosphere and visible in the Carpathian crust, such as transtensional wrench corridors, block rotation and relay structures due to extrusion tectonics, have probably acted in focusing hydrothermal activity. As a result of particular events in the geodynamic evolution and the development of specific structural features, mineralization formed during fluid channelling within transtensional wrench settings and during periods of extension related to block rotation (Neubaer et al., 2005).

Museum samples were arranged in accordance with this metallogenic classification. Separate displays group specimens from deposits/occurrences organized based their original districts, starting from north-eastern corner of the subprovince, through the central metallogenic subunits, and then to the south-western part of the “Quadrilateral”.

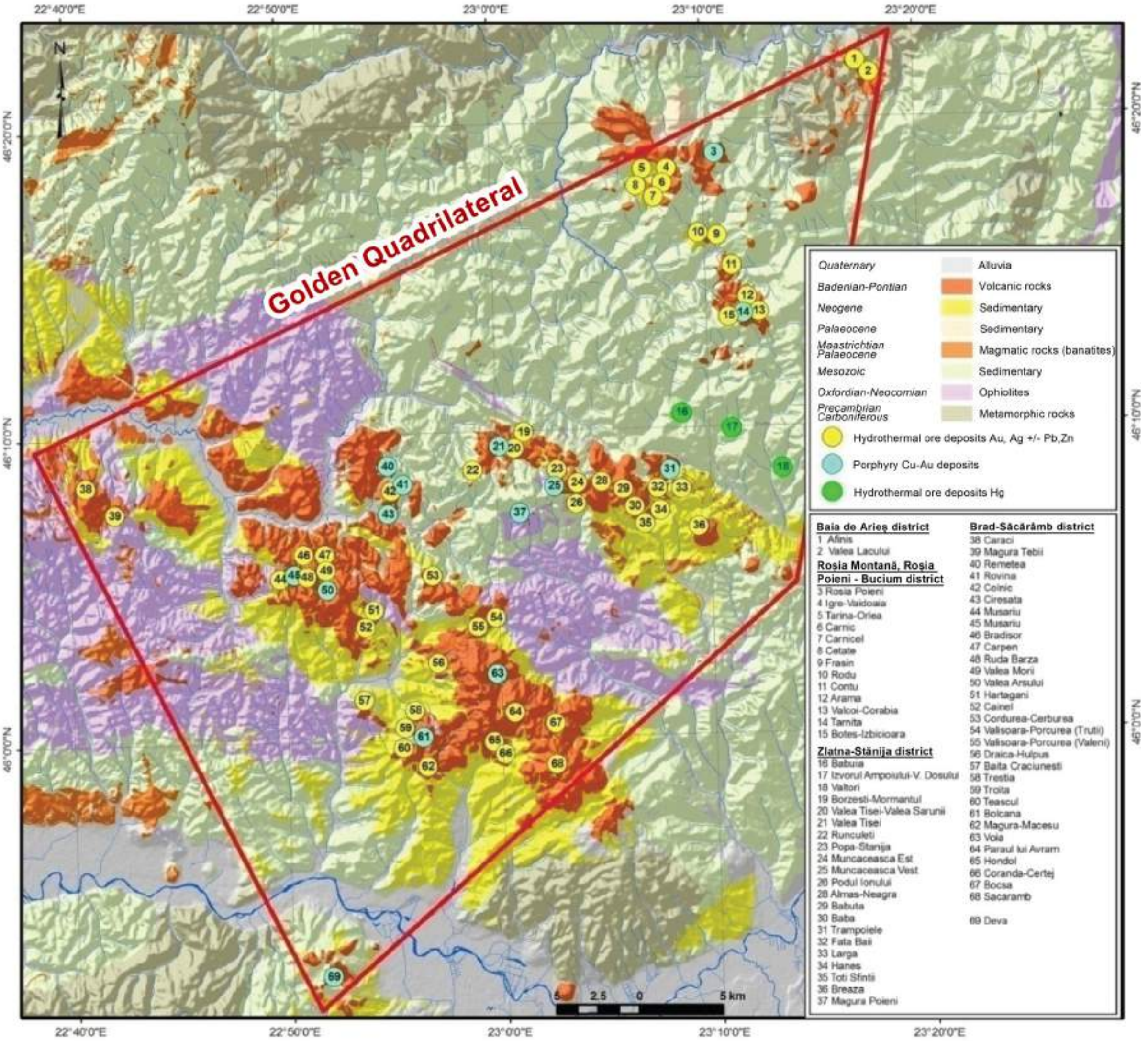


Fig. 3.2. Ore deposits and occurrences within the Golden Quadrilateral (Apuseni Mountains) (Tămaş-Bădescu, 2010)

3.1. Baia de Arieş metallogenic node

Metallogenic classification: In several works on the Neogene metallogenesis in the Apuseni Mountains, this unit ranks as ”mining group” (Brana, 1958), ”district” (Ianovici *et al.*, 1976b, Ianovici and Borcoş, 1983) or as a part of the Bucium-Roşia Montană-Baia de Arieş district (Borcoş *et al.*, 1983, Berbeleac, 1998). The last two classifications are based on the common action of similar metallogenic factors. However, assigning the rank of metallogenic node seems more appropriate (Popescu, 1986), due to the fact that Baia de Arieş represents a magmatic and metallogenic concentration on a relatively constrained space (Fig. 3.2), with an intense polymetallic and gold metallogenesis, materialized by two metallogenic fields: Afiniş and Ambru (Fig. 3.4, Fig. 3.6).

Baia de Arieş is the *locus tipicus* for sylvanite $AuAgTe_4$. Gold telluride veins are located in the eastern and south-eastern part of the Afiniş structure.

The gold samples from Baia de Arieş are prevalently lamellar (sample 2120) or skeletal (Plate I); gold is frequently associated with quartz (samples 2121, 2120). One of the nicest native tellurium samples in the Museum comes also from Baia de Arieș (Fig. 3.3)

Fig. 3.3. Native tellurium, Baia de Arieş

Two native gold samples from Baia de Arieş were analyzed with the X-MET 3000TX portable spectrometer, yielding 66.4% and 74.7% Au, 16.1% and 18.1% Ag; contents of 15.6% and 6% Fe were also detected.

Afiniş metallogenic field (Fig. 3.4). Mineralization is related to Barza hornblende ± pyroxene andesite intrusions and consists of stockworks 1 and 7 and of veins located on the SE fringe of the Afiniş column. Gold mineralization locates in the breccia bodies 1 (Concordia), 2 (Combinat), 3 (Aeraj), Ştefana, Crăişor, Nicolae and 4, together with numerous other veins (Ecaterina, Noroc Nesperat, Ion, *etc.*) (Fig. 3.4).

The mineralization from Baia de Aries-Afiniş is particular in the context of the Apuseni Mts. Metallogenesis, due to the presence of gold-bearing arsenopyrite, and subordinately, of gold and sulfides.

Sylvanite samples in the museum show constant association with microgranular and skeletal gold (samples 7, 21, 2120), with fine tablets of baryte, sometimes zoned (samples 25, 30, 36), with marcasite, altaite and tellurantimonite (sample 15) or with tetradymite, altaite, krennerite and clay minerals (palygorskite, illite) (Plate I).

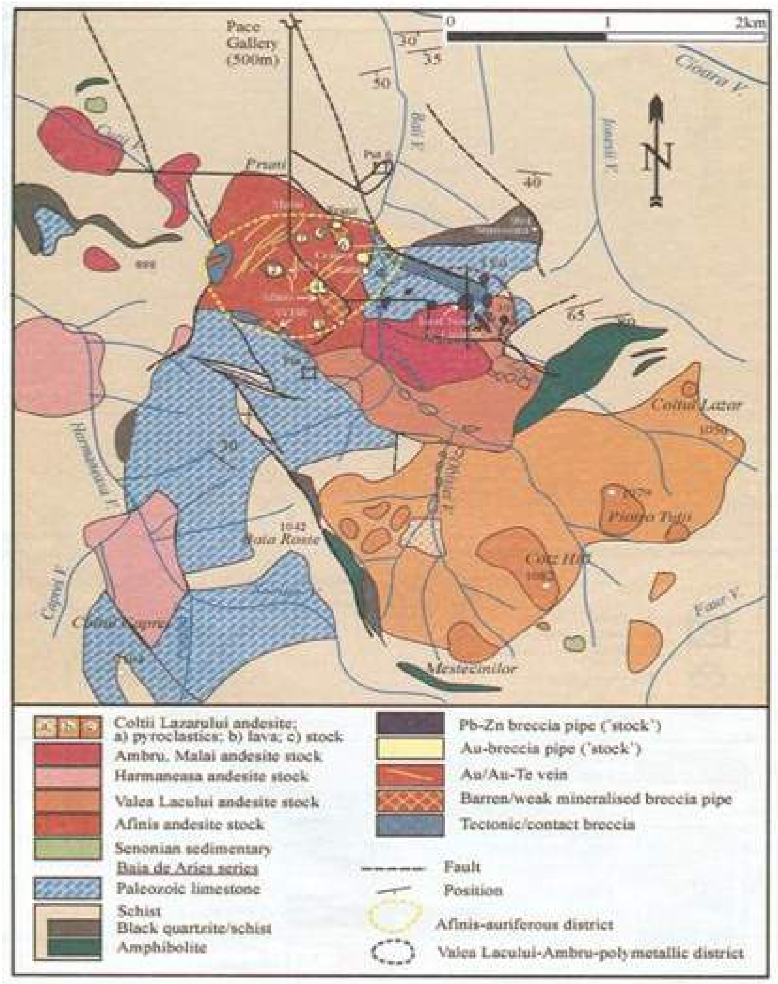


Fig. 3.4. Geologic map of Baia de Arieş metallogenic node (Ciobanu *et al.*2004)

The X-ray diffraction investigation carried out on several samples in the museum, allowed the determination of: **tetradymite, palygorskite, illite.**

Ambru metallogenic field. The mineralization is spatially associated with hornblende-biotite quartz andesites (Ambru and Mălai type), and builds several lenses and hydrometasomatic bodies, or irregularly shaped breccia; more seldom, veins occur in various positions with regard to the schistosity of crystalline limestones. The mineralized bodies 1-11, Iosif, Iosif Nou, Plumbul Nou, Valea Lacului, Feredeu, Buturoasa, Pleşu, Baia Roşie, *etc*., have variable shapes, textures and dimensions (Fig. 3.5).

Economic geology and mining history of Baia de Arieș metallogenic node

Gold deposits of Baia de Arieş have been mined since Roman times. In the 13th century, gold mining was growing at Zlatna and Baia de Arieş, where no less than 36 furnaces for ore melting were in operation (Tripşa *et al.*, 1981, in www.romanit.ro). The first geological observations and descriptions of local geology belong to von Cotta (1861), I. Grimm (1867), Pošepny (1876), Horn (1896), Grigore (1938-1944 – unpublished). Later there were the works of Ghiţulescu and Socolescu, published in 1936 and 1941, with special reference to Baia de Arieș.

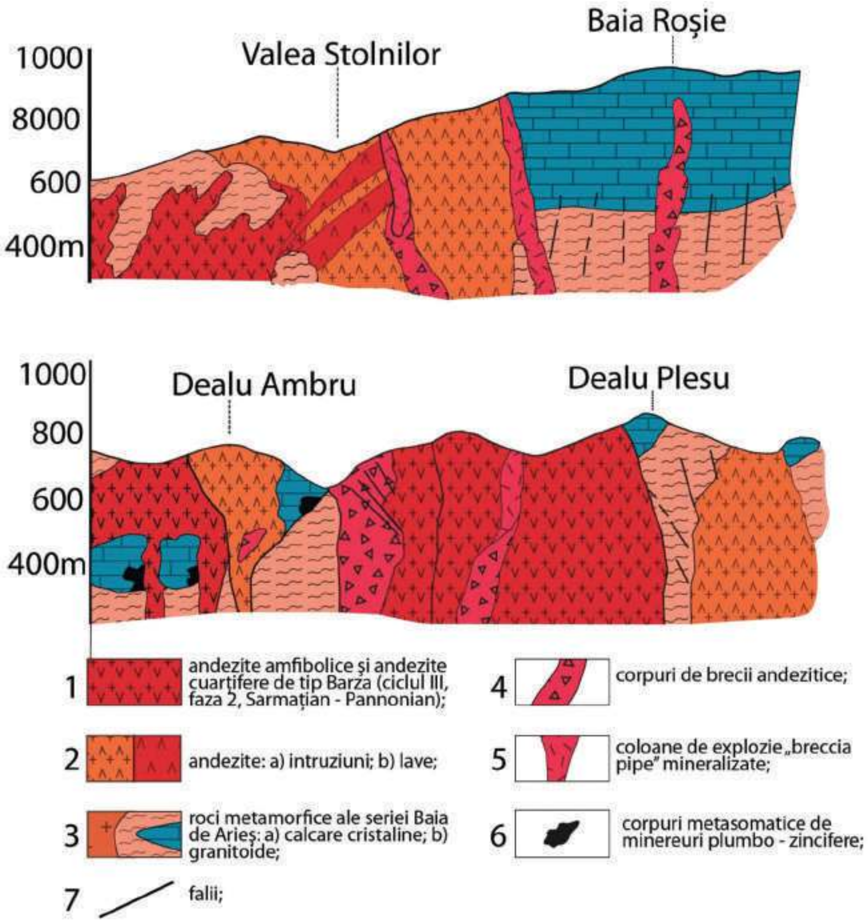


Fig. 3.5. Geological sections through the mineralized volcanic structures of Baia de Arieș metallogenic node

Recent historical and mining research (Wollmann, 2010) in hardly accessible mine galleries from Baia de Arieş (Dealul Vânăt, Dealul Afiniş, Dealul Băilor, Baia Roşie, *etc*.) confirmed the extent of mining in this area since, starting with the 16th and 17th centuries. Numerous artifacts such as old mining lamp lights, chisels, jars for oil storage. Two of the galleries contained a rail system equipped with guiding rods and a large ladder carved from a tree trunk.

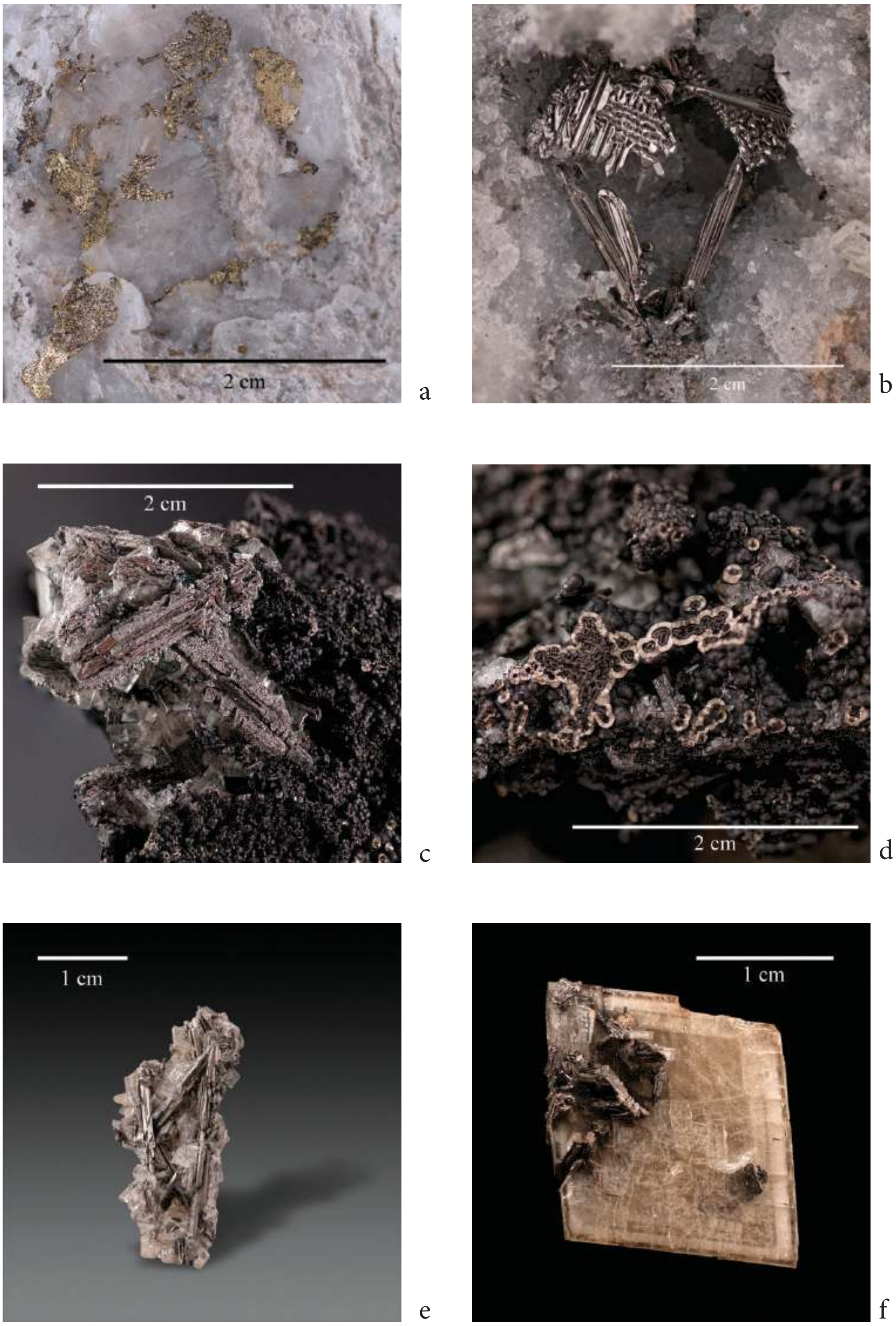


Plate I. Samples from Baia de Arieș in the museum: a) skeletal gold and sylvanite (sample 7); b) aggregates of skeletal sylvanite (sample 21); c-d) sylvanite associated with altaite, tellurantimonite and marcasite (sample 15); e-f) sylvanite associated with baryte (samples 25, 36)

The interest for tellurium has increased worldwide since the 2000s, due to its possible to use in the manufacturing of solar panels of "lower cost solar electricity" type. With view to the fact that in Romania there are no analytical data on the economic contents of tellurium in ore deposits, excepting the ore waste dumps from Săcărâmb (Popescu *et al.*, 2010), a problem arises on future research of telluride ore deposits and waste ore dumps from the perspective of economic recovery.

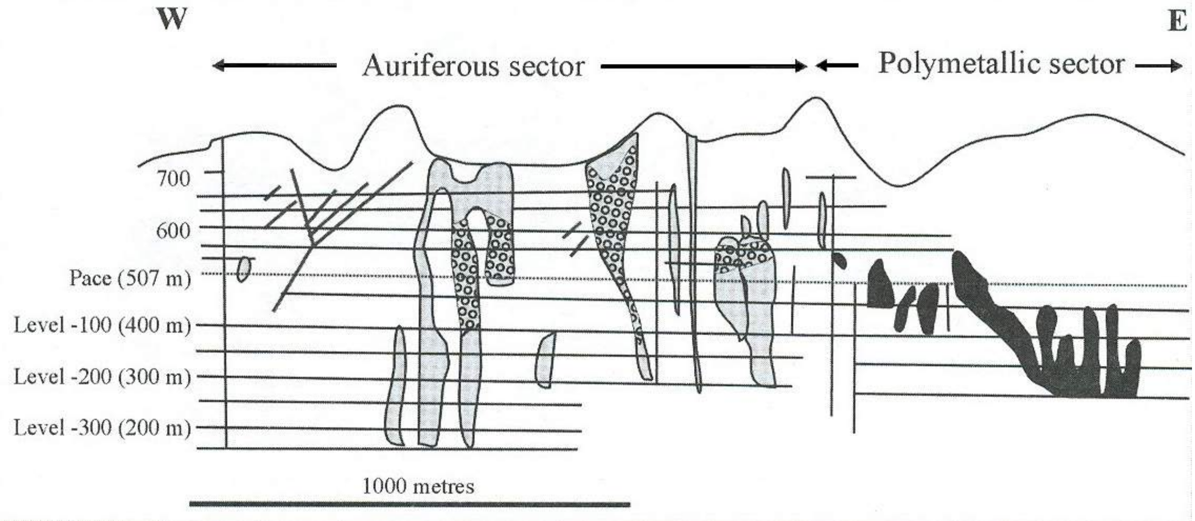


Fig. 3.6. Schematic cross-section through the metallogenic node of Baia de Arieş, depicting the morphology and the vertical extent of mineralized bodies (Ciobanu *et al.*2004)

3.2. Roşia-Bucium district

The geological space of the Roșia-Bucium district is represented by the Roşia-Frasin Neogene basin, whose formation was controlled by crustal fractures oriented NW-SE.

3.2.1. Roşia Montană-Roşia Poieni metallogenic node

It represents one of the most important metallogenic concentrations, not only in the Roșia-Bucium district, but also at the scale of the entire Metaliferi Mts. Subprovince. The node groups two mineralized structures which have been renowned ever since the Antiquity – Roșia Montană and Roșia Poieni (the first *porphyry copper* structure ever mined in the Southern Apuseni Mts., starting with the late 70s) (Fig. 3.7).

Roşia Montană metallogenic field

The field is composed of various mineralized bodies – stockworks and veins, closely associated with, and spatially controlled by the Roşia Montană complex volcanic structure.

Significant gold-silver accumulations concentrated in the breccified spaces and they were subjected to mining starting from the Roman period. The most significant mineralized bodies are located in Cetate and Cârnic hills, each of them forming an independent group of mineralized bodies (Fig. 3.8).

Cetate group contained the mineralized stockworks Roşeţu-Ştefan-Contact, Iuho-Ierusalim-Chinga, Racoş-Mangan-Cetate and Custura, Afiniş, Crucile Afinişului, Scaunele Cordeiului veins, all depleted to date; the remaining mineralization is located in the impregnated space between the depleted stockworks. This low-grade mineralization was subjected to open pit mining until 2006. Within the breccia, the hydrothermal assemblage consists of quartz, rhodochrosite, "chinga" – a siliceous formation, pyrite, chalcopyrite, sphalerite, galena, gold.

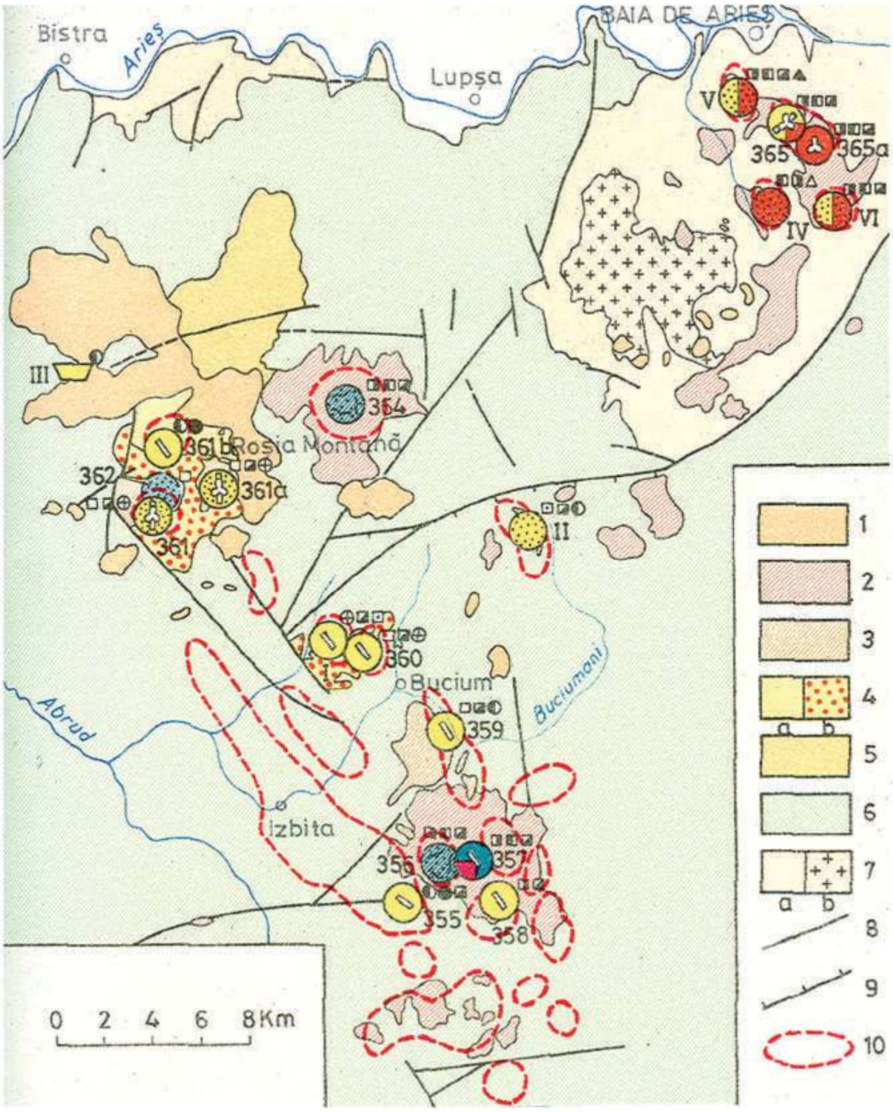


Fig. 3.7. Geological map of Roşia-Bucium district and of Baia de Arieş metallogenic node (after Borcoş *et al.*, 1983 *Harta resurselor minerale ale României*, IGR). 1. Detunata basaltoid andesites (Pliocene); 2. Rotunda hornblende-pyroxenes andesites and Şurligata quartz andesites (Pannonian); 3. Barza hornblende-pyroxenes andesites and Săcărâmb quartz ± biotite andesites (Sarmatian, Pannonian); 4. Miocene-Pliocene sedimentary (a) volcano sedimentary sequences (b); 5. Paleogene sedimenary; 6. Cretaceous sedimentary; 7. Pre-Alpine crystalline formations (a), Granitoides (b); 8. Faults; 9. Thrusts; 10. Metallogenic structures inferred from geophysical data. Metallic accumulations: I. Rodu; II. Valea Berzei; III. Vârtop (Au, Ag alluvial; Pliocene); IV. Valea Socilor (Pb, Zn ± Au, Ag as hydrothermal impregnations; Miocene); V. Valea Cuţii (Au, Ag ± Pb, Zn; Miocene); VI. Valea Obârşiei (Pb, Zn ± Au, Ag, hydrothermal impregnations; Miocene). 355. Vâlcoi (Au, Ag; hydrothermal; Miocene); 356. Bucium-Tarniţa (Cu, Au, Fe; *porphyry copper*; Miocene); 357. Bucium-Arama (Cu, Au, Ag, Pb, Zn; hydrothermal; Miocene); 358. Corabia (Au, Ag; hydrothermal; Miocene), 359 Conţu (Au, Ag ± Pb, Zn, Cu; hydrothermal; Miocene); 360. Frasin (Au, Ag ± Pb, Zn; hydrothermal; Miocene); 361. Roşia Montană (Au, Ag; hydrothermal; Miocene); 361a. Roşia Montană-Cârnic (Au, Ag; hydrothermal; Miocene); 361b. Roşia Montană-Ţarina (Au, Ag; hydrothermal; Miocene); 362. Roşia Montană-Dl. Cetate (Au, Ag; hydrothermal; Miocene); 364. Roşia Poieni (Cu; *porphyry copper*; Pliocene); 365. Baia de Arieş-Afiniş (Au, Ag ±P b, Zn, Cu; hydrothermal; Miocene); 365 a. Baia de Arieş-Ambru (Pb, Zn ± with ± Au, Ag; hydrothermal-metasomatic; Miocene)

Seen through its subdivisions, the district is an obvious metallogenic alignment, with two, clearly distinguishable metallogenic nodes: Roşia Montană-Roşia Poieni (NW) and Bucium-Conţu-Arama-Corabia (SE) (Fig. 3.2 and 3.7).

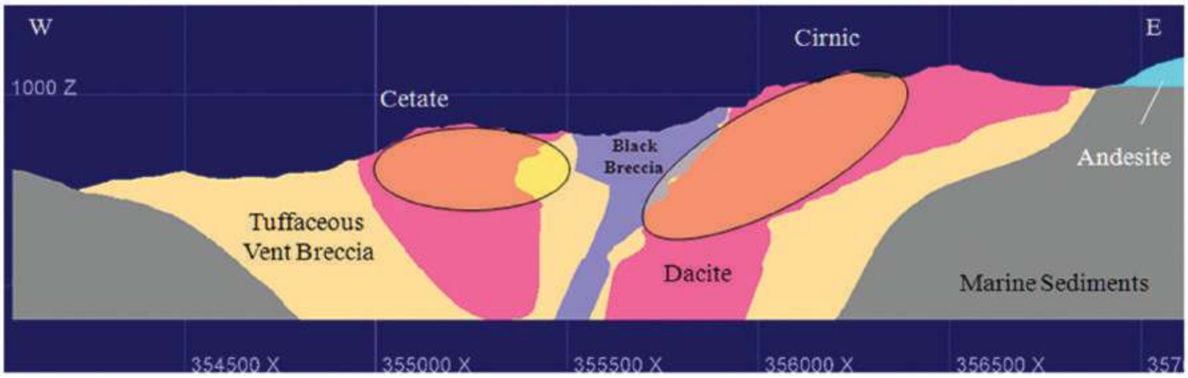


Fig. 3.8. Geological cross-section through Roşia Montană ore deposit, depicting the location of gold stockworks Cârnic and Cetate stockworks (www.rosiamontanagoldcorp.com)

Cârnic group contained the stockworks Cănţălişte, Tisa, Cotoroanţa, Corhuri, Sponghie and Benţă, as well as the veins Glam, 31, 35, Vâna Mare, Răuţii, Bisorul, Capra, Drotul, *etc*.

Mineralogically, Roşia Montană is not as famous as other gold deposits in the Apuseni Mts., *e.g.* Săcărâmb, Stănija, Baia de Arieş, yet ranks as the *locus tipicus* for the new mineral *alburnite* -$Ag_8GeTe_2S_4$, recently approved by the IMA (Tămaș *et al.,* 2013). However, the native gold specimens, the size and beauty of its ”mine flowers” are the pride of many mineralogical collections around the world

In Brad Gold Museum there are several specimens with native gold from Roșia Montană (Plate II). The following morphological types were distinguished: lamellar intergrowth of skeletal gold (1543), cryptographic gold with reticulated structure (1598, 1615), aggregates of gold crystals, lamellae and dendrites (1545), partially skeletal gold grown on vein-shaped quartz, associated with galena and chalcopyrite (1915), microgranular gold intergrown with microcrystalline quartz (2130), gold intergrown with carbonates (1901), assemblage of elongated gold crystals (1539), graphic gold developed prevalently in one direction and associated with vein-shaped microgranular quartz (1900, 1903, 1939), granular gold, sometimes aggregated in skeletal textures (1540, 1617).

A number of 40 samples of native gold from Roşia Montană were analyzed by means of the X-MET 3000TX portable. Results show relatively low contents of gold as compared with other metallogenic units in the „Golden Quadrilateral”, but also a larger range of variation in these contents: between 57% and 68% (Fig. 3.9).

During the last two years, together with a group of physicists from I. F. I. N. – „Horia Hulubei”, we carried out an ample research of the native gold from Romania’s classic occurrences, in order to document the sources of gold found in ancient archaeological artifacts.

During this research we found in a polished section from with native gold from Roșia Montană (the sample belonged to the ”Petrulian Collection” – Department of Mineralogy, Faculty of Geology and Geophysics, Bucharest), two tin sulphosalts. One of them was canfieldite (Ag_8SnS_6) (Popescu, Neacșu, 2010) which forms an isomorphous series with argyrodite (Ag_8GeS_6), already determined at Roşia Montană (Tămaş *et al.*, 2004). Another interesting occurrence in the gold-quartz-carbonate intergrowth, was of an extremely rare mineral from the pirquitasite (Ag_2ZnSnS_4) - hocartite (Ag_2FeSnS_4). Within the same band of gold, tightly associated with quartz and carbonates, in which canfieldite occurs, we identified argentite (achantite) Ag_2S and a member of the polybasite-pearceite series $(Ag,Cu)_{16}Sb_2S_{11}$-$(Ag,Cu)_{16}As_2S_{11}$.

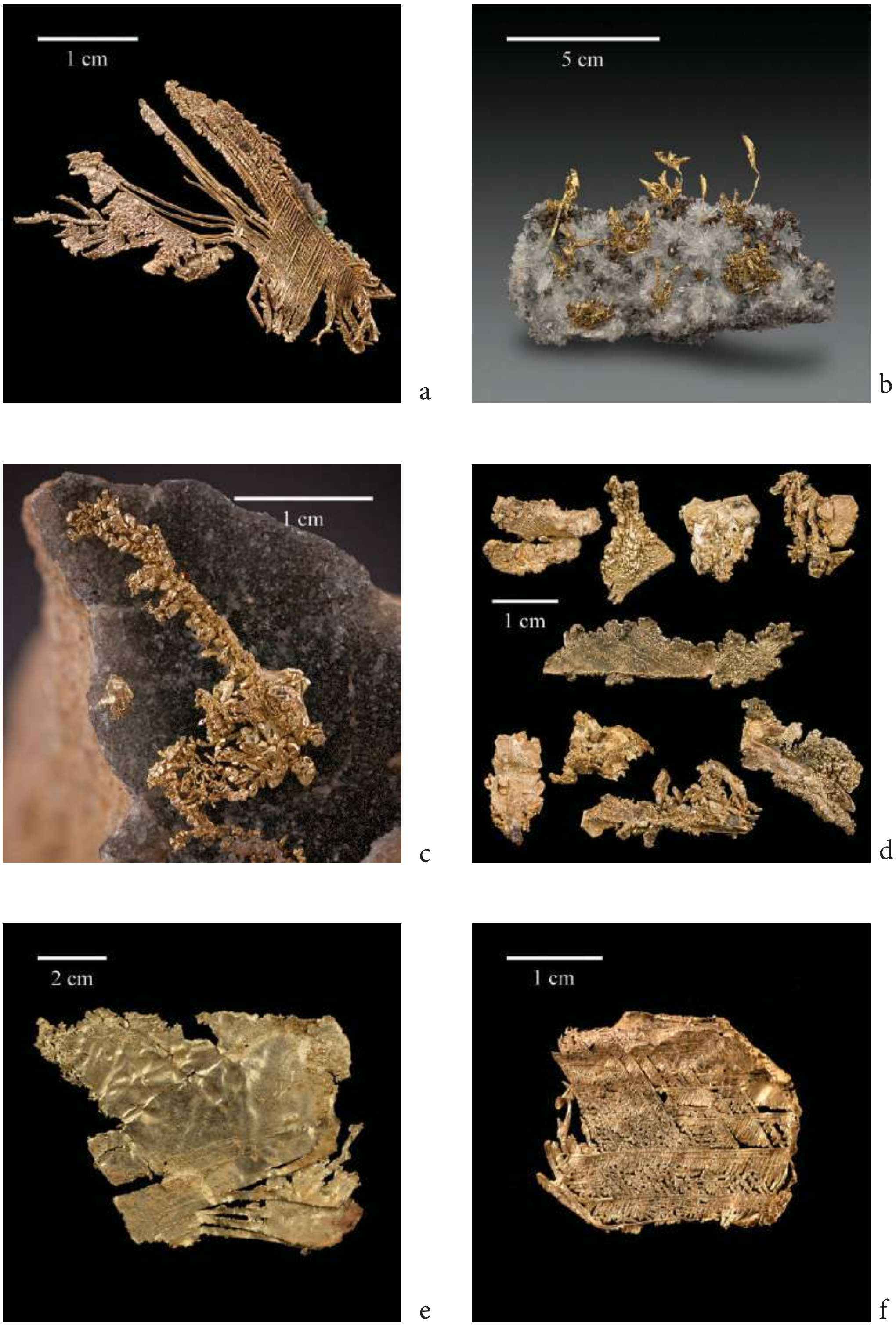


Plate II. Roşia Montană: a) skeletal intergrowth of lamellar gold (sample 1543); b) assemblage of elongated gold crystals (sample 1539); c) graphic gold developed prevalently in one direction associated with microgranular vein-shaped quartz (sample 1903); d) aggregates of gold crystals, lamellae and dendrites (sample1545); e-f) graphic gold with reticulated texture (samples 1598, 1615)

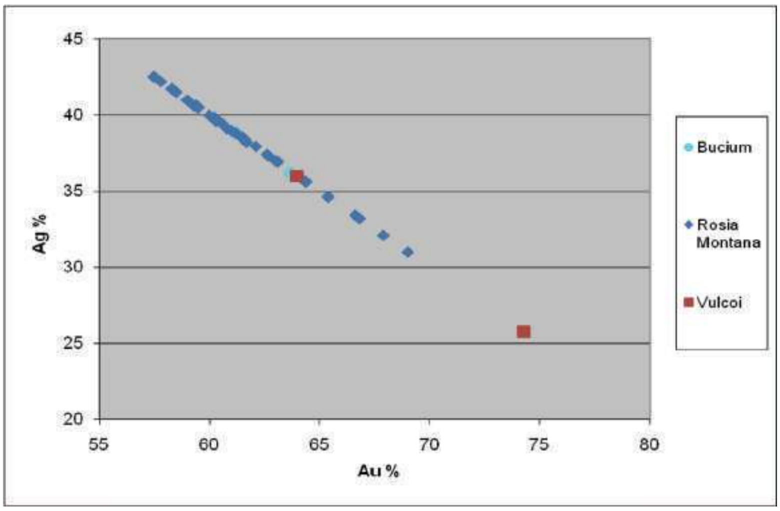


Fig. 3.9. Gold vs. silver ratio in the native gold samples from the Roșia – Bucium district

The microscopic study revealed the existence of two types of gold: a predominant Ag-rich gold of whitish-yellow color, which intergrowths with the majority of other minerals from within the "gold zone", and a cleaner-yellow colored gold, less frequent and mainly associated with carbonates. The former type is older in the mineral succession and associates with pyrite, polybasite, argentite, canfieldite, quartz and adularia, whereas and the second, newer one is associated only with colomorphous carbonates.

Regarding the formation of the Roșia Montană - Roșia Poieni metallogenic node, which is a heterochronous *porphyry copper* and gold-silver structure, in the recent years another explanation emerged which admits the existence of resurgent paleocaldera that would assign Roşia Montană and Roşia Poieni to the same metallogenic unit, as depicted in Fig. 3.10.

Late, other resurgent calderas were found in other areas of the South Apuseni Mountains (Metaliferi Mountains) which functioned as complex volcanic structures with early acid eruptions placed in a concentric pattern; first eruptions were followed by intermediary episodes (Fig. 3.11). Within these calderas, each eruption stage was accompanied by a hydrothermal event which remobilized deep-seated, pre-concentrated mineralization.

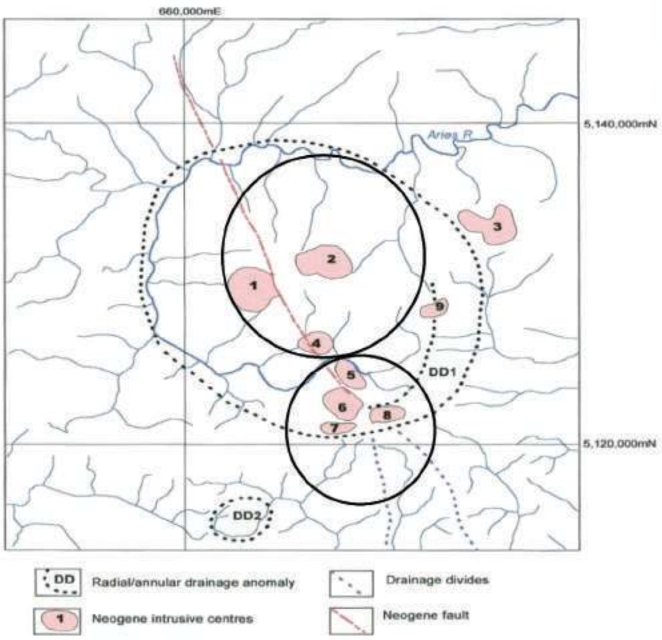


Fig. 3.10. Hypothetic outline of the Roșia-Bucium paleocaldera and of the mineralized structures within Roșia-Bucium district (O´Connor *et al.*, 2004), later added by Popescu & Neacșu (2006) with the resurgent paleocalderas Roșia Montană - Roșia Poieni - Frasin and Bucium, as inferred from the relation between the *porphyry copper* + gold-silver metallogenesis and the volcanic activity: 1. Roşia Montană, 2. Roşia Poieni, 3. Baia de Arieş, 4. Rodu-Frasin, 5. Bucium-Arama, 6. Bucium-Tarniţa, 7. Boteş, 8. Vulcoi-Corabia, 9. Geamăna

Economic geology and mining history of Roşia Montană metallogenic node. The ore deposit contains an estimated mineable geological resource of approx. 215 Mt of ore, with an average grade of 1.46 g/t Au and 7.10 g/t Ag (Tămaş-Bădescu, 2010).

Roşia Montană is the first gold deposit mined since the Antiquity and ranks as the largestgold deposit Europe. Roşia Montană witnessed the transition from mine digging by fire and water or chisel and hammer methods, together with improving drainage, collection and pumping of water from the underground works (Tămaş-Bădescu, 2010). The wax tablets found here, were in fact, mining regulations stating for an intense mining activity during the Roman period.

The specific features of the ore deposit favored underground mining in huge exacavations named *corănzi*. Such chambers ”are in continuous succession, both horizintally and vertically, and the connecting adits (…) are just like a maze” (Brana, 1958). At *Cetate* the deposit is in the form of stockworks, N-S oriented veins, with eastward or westward 75-80^{o} inclination, ”chair” veins with 45° tilt and cross-veins (Crucea Contactului, Afiniş, Cosor, Copil Manel, Bătrâna 1, 2, Chingii, Cordeiului, Cărămizi, Şuluţiu) oriented E-w and areas of impregnation. The southern extremity of the 134-214 veins, along the contact between dacite and sedimentary formations, the Glam vein is developed, where back in 1962, a gold lump of 3 kg. was found in the 60m horizon 60 (785 m) (Sântimbrean *et al.*, 2006).

Open pit mining began in 1970 and in 1984 the entire ore production was achieved by the surface methods. The pit bottom was at 873 m (Iuliana) in 2006 (Sântimbrean *et al*., 2006).

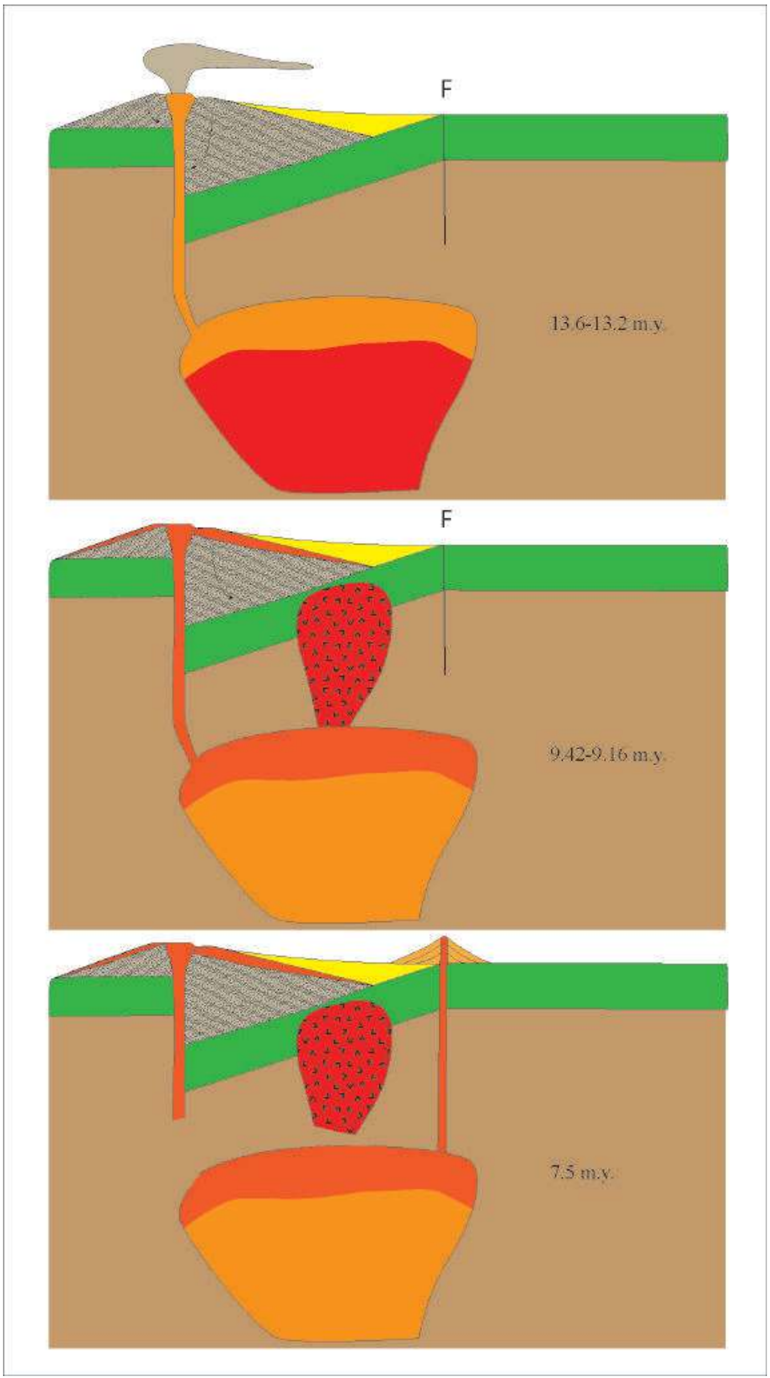


Fig. 3.11. The evolution of the ”trapdoor” type caldera at Roşia Montană - Roşia Poieni (Popescu, Neacşu, 2008): a) the upper part of the magmatic chamber expands and generates a strong volcanic explosion in the south-western part; magma from lower portions start to rise, covering the products of the first explosion; a mixed hydrothermal fluid with Au, Ag is generated and mineralizes the complex breccia structures; b) the magmatic chamber is segregated by gravity – a minor volcanic activity and a subvolcano are generated together with a hydrothermal pulse within the subvolcano, generating the porphyry copper metallogenesis; c) magma continues to become more and more basic; volcanic bodies occur only in the north-eastern part of the caldera (Detunatele). Ages after Kuzmanov *et al.*, 2007

The *Cârnicel Massif*, located south of Cetate and Cârnic, has an altitude of 985 m. The mineralization occurs as NS, NNW-SSE oriented veins, with 75-80^o E or W inclination, and stockworks oriented NS, such as: Cobori, Colopari, Arini, Mestecani, Flanken. Ore bodies were opened and mined in the past, along Corna Valley, through the galleries David, Râpa, Terezia, Mestecani, *etc*., resulting in voids, some quite significant such as Mestecani.

In 1997, the Romanian Government decided that unprofitable mining operations must be gradually shut down. Romania's gold production diminished as the mines were closed. The operation at Roşia Montană ended in June 2006.

The geological research program undertaken by Roşia Montană Gold Corporation S.A. (RMGC) resulted in a *geological resource* of approx. 313.5 Mt of ore, to be extracted approx. 247.5 t gold (Tămaş-Bădescu, 2010).

Within Roşia Montană metallogenic field, four main mineralized areas were outlined: Cetate, Cârnic, Orlea and Ţarina-Jig-Văidoaia. RMGC obtained a mining concession for 4282 ha. The mining project provides the extraction of gold ore for a period of 16 years, resulting in approx. 247 t Au and 899 t Ag. The ore would be subjected to cyanide processing (the *carbon in leach* method). Four open pits are envisaged each of approx. 100 ha. The tailings resulted from gold and silver processing will be stock-pilled in a tailings dam of 250 Mt extending over 100 ha, behind a 180 m high dam built from waste rock (Tămaş-Bădescu, 2010).

Table 3.1. Comparison between resources/reserves estimated before and after 1989 in the Roşia Montană ore deposit (Tămaş-Bădescu, 2010)

		Estimation by state own companies (before 1989)	Estimation by RMGC (2009)
Geological resources	Ore (Mt)	27.693	214.931
	Au (g/t)	0.8	1.46
	Ag (g/t)	10	6.88
	Au (t)	22.1544	313.446
	Ag (t)	613.522	1479.485
Mineable resources	Au (g/t)	0.79	1.15
	Ag (g/t)	9.95	4.18
	Au (t)	21.877	247.543
	Ag (t)	275.545	898.661

Table 3.2. Summary of estimated reserves for the Roşia Montană ore deposit (Gabriel Resources Ltd. , 2009 in Tămaş-Bădescu, 2010)

Reserve category	Ore	Average grade		Metal	
	Mt	Au (g/)	Au (Moz)	Au (Moz)	Ag (Moz)
Proven	113.8	1.62	8.96	4.68	20.1
Probable	101.1	1.28	4.56	3.27	8.8
Total	214.9	1.46	6.89	7.94	28.9

3.2.2. Bucium metallogenic node

The metallic concentrations from Bucium (Bucium Şasa, Bucium Izbita, Bucium Poieni) belong to Miocene andesitic and dacitic volcanic structures which are part of the Roşia-Bucium metallogenic district (Fig. 3.12). The Tertiary volcanic rocks in Bucium area are represented by Badenian dacites and Sarmatian-Pannonian (?) andesites and quartz andesites (Berbeleac, 1998).

The metallogenesis developed in two phases, the first with a prevalent copper-pyrite character, in the andesitic structure of Arama, and the second, with gold-polymetallic character, represented by the vein groups Arama, Vâlcoi (Vulcoi)-Boteş and Corabia. Due to the structural control of the vein fractures, both along the NW-SE crustal fault and towards the volcanic structures on the same alignment, several vein groups have formed in these metallogenic nodes: Arama, Conţu, Corabia and Boteş (Popescu, 1986).

Isotopic K-Ar determinations (Roşu *et al.,* 2004) pointed to 14.8–14.7 Ma for the Bucium Şasa amphibole bearing andesite, and 14.8-14.6 Ma for Bucium-Tarniţa, both older than that of the Roşia Montană dacite (Upper Badenian). The metallogenic activity started in Upper Badenian with veins, stockworks and breccia pipes hosting the epithermal *low sulfidation* gold mineralization (Bucium Şasa) and continued during Upper Sarmatian-Pannonian with the formation of *Cu-Au porphyry* accumulations (Bucium-Tarniţa).

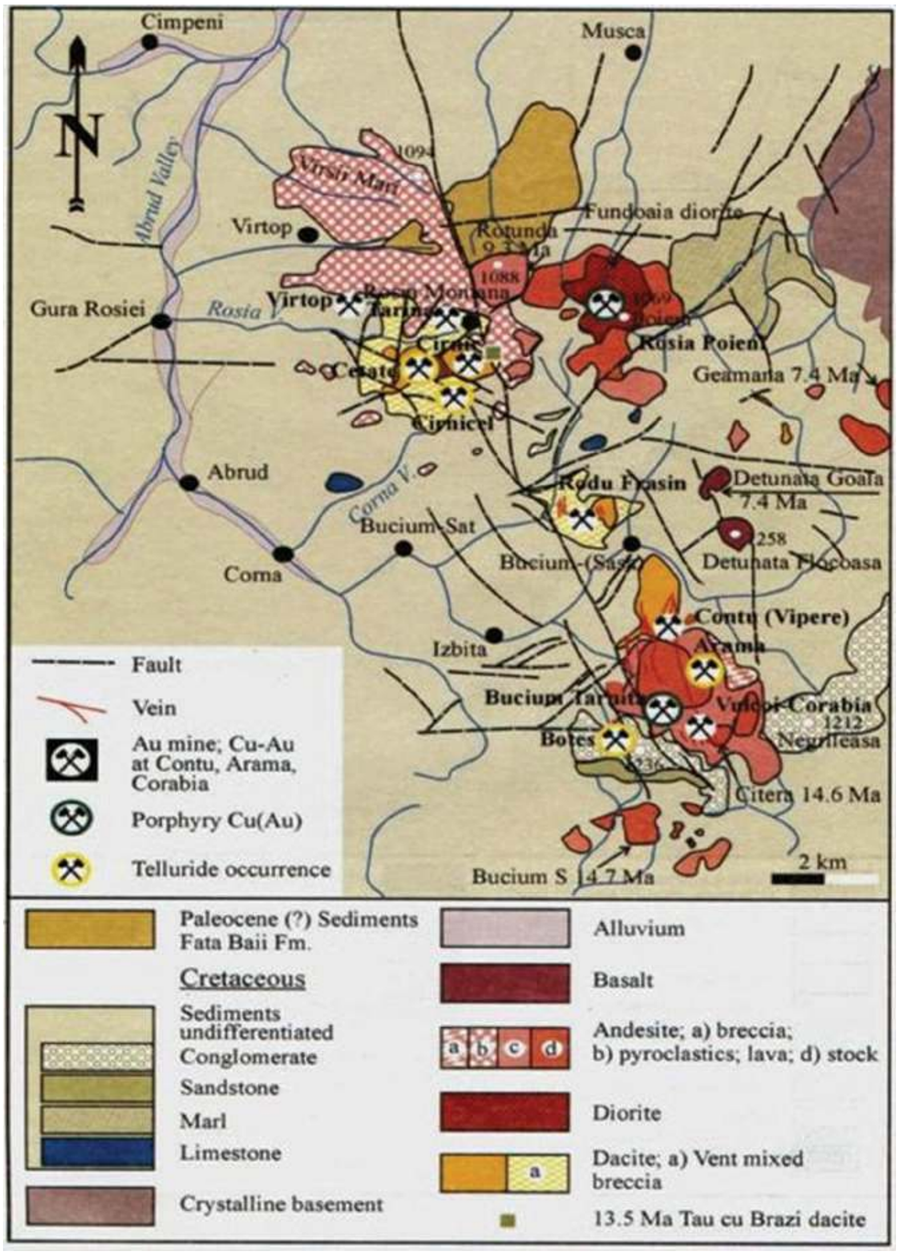


Fig. 3.12. Geological sketch of Roșia-Bucium district compiled by RMGC after the maps of Ghițulescu and Socolescu (1941), Ianovici *et al.*(1969) and Borcoș (1994). K/Ar ages, after Roșu *et al.*(2004)

Arama vein group consist of several fractures around the large Arama vein which extends over 3 km and forms, together with its south-east prolongation, the Corabia vein, one of the most important vein structures in the Metaliferi Mts., with over 10 km in length. The *native gold* occurs seldom, as nests or threads or fine grains associated with late quartz. Gold has also been described on several vein branches at the Sf. Treime level.

In Brad Gold Museum, the gold specimens from Bucium (Plate III) display lamellar gold associated with quartz (1528, 1585), or as prismatic, uni- or multidirectional aggregates also associated with quartz (1528, 1587). The Au:Ag ratio for two samples from Bucium falls in the middle of the Roşia Montană range, thus suggesting similar characteristics (Fig. 3.9).

Conțu vein group is located along the northern extension of the Arama vein group, within the Conțu dacitic body and along its western contact. The group consists of Vipera, Vâna Băii, Grațiu, Mocșii, veins, a.o. (Popescu, 1986). Other smaller veins are oriented N-S, N20^{o} E or NW (Jude, 2011).

Corabia vein group is located in the Corabia igneous structure (1349 m) which crosscuts Maastrichtian sedimentary formations (alternating sandstones and marls). The group consists of branched out veins from the Corabia vein, all sharing a common NW-SE orientation, located westwards to the main vein (Butura, Ieruga, Scursura, Petru and Pavel). The whole group extends over 1.5 km in length. The upper veins have the same NW-SE and extend over 1 km, *e.g.* Surduci, Răchita, Letului.

Vâlcoi (Vulcoi) vein group is located in Vâlcoi (Vulcoi) hill, westwards of Corabia, and consists of several thin veins such as: California, Salitra Hulpei, Vâna Catanei, Salitra Catanei, Vâna Bisoroasa, Vâna Zdrâncului, *etc*. Tellurides were cited in the California vein (Jude, 2011).

The mineralization occurs as: veins of banded quartz, impregnations, pyrite, sphalerite and gold nests. Sometimes, gold grains are of the size of a hazelnut (Bisoroasa, Salitra Catanei).

In the samples from Vulcoi gathered in the Brad Gold Museum, one could distinguish the following morphological variations (Plate III): macrolamellar gold associated with bluish quartz (1584); prismatic gold overgrown on chalcopyrite (1529); prismatic lamellar gold in quartz microgeodes (1525-1531); elongated microlamellar gold associated with sphalerite, in geodes (1527).

At Vulcoi, the Au:Ag ratio is significantly higher than in other metallogenic units (Fig. 3.9).

Boteș vein group is located in the Boteș igneous structure (1230 m) which crosses through Maastrichtian sedimentary formations. It consists of a main vein of approx. 700 m which passes westwards of Boteș peak (alt. 1336 m). The vein is oriented NNW-SSE, with eastwards 60-70^{o} dip. The vein has two branches: Jacob and Ana veins which reunite at greater depths.

Boteș is the *locus tipicus* for hessite. In the Brad Gold Museum there are more specimens containing hessite: some display a lamellar and prismatic shape with botryoidal terminations, associated with pyrargyrite, carbonate and native silver on quartz (145a); others have hessite lamellae with skeletal terminations (148) or lamellar hessite with skeletal margins, on quartz (2192) (plate IV).

Economic geology and mining history of Bucium area*.* The first significant historical moment took place on the 1st of May 1859, when two mining regulations were enforced and approved through a ministry order on 14th of December 1859. One of them was the *Statute of the Abrud-Roșia Montană mining area*, accompanied by the *Maximilian Ordinance for the mining area within the borders of Vulcoi, Corabia and Bucium villages***.**

In 1922, through the unification of 12 mining associations which owned significant concessions in Frasinul hills and at Dâmbul Meselor, within Bucium village, the new mining society ”Industria Aurului” was founded, with assets amounting 10,000,000 lei.

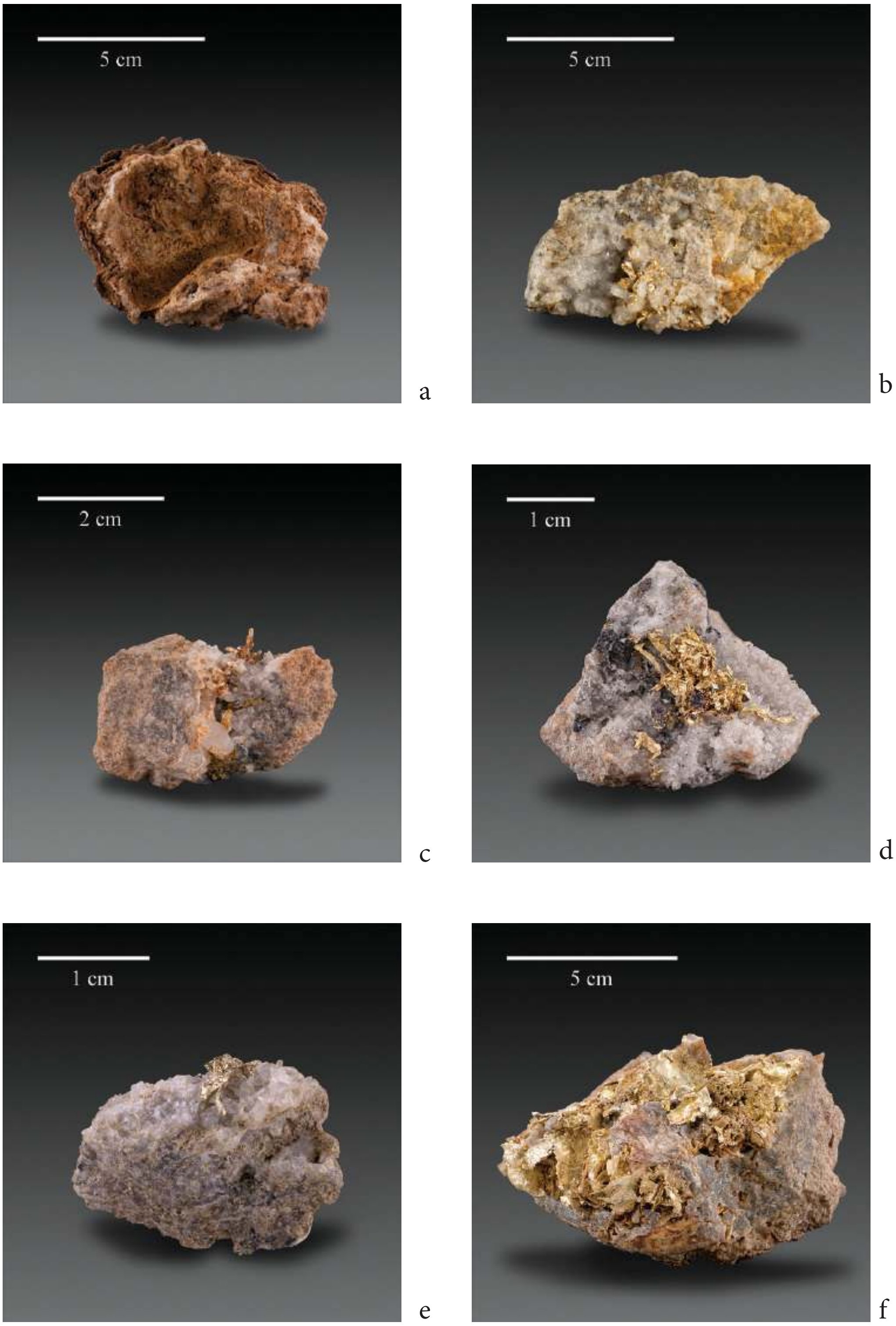


Plate III. Bucium: a) microgranular gold on quartz and oxidation crust (sample 1587); b) lamellar gold in geode, associated with quartz (sample 1585); c) gold with prismatic aspect, oriented after multiple directions, associated with quartz (sample 1528). Vulcoi: d) prismatic gold overgrown on chalcopyrite (sample 1529); e) macrolamellar gold associated with bluish quartz (sample 1584)

Plate IV. Boteș: a), b) lamellar and prismatic hessite with botryoidal margins, associated with pyrargyrite, carbonate and native silver on quartz (sample 145a); c) hessite with skeletal endings (sample 148); d) lamellar and skeletal hessite on quartz (sample 2192)

The fame of Boteş ore deposit comes from the high frequency of native gold concentrations (Ghițulescu, Socolescu, 1941). Haiduc (1940) reviewed the main mining zones in the ”Golden Quadrilateral” and mentioned Boteș ore deposit with grades up to 4-5 g/t gold.

The ”Industria Aurului” company mined its concessions with its own employees until 1937. Later, and until the nationalization on 11th of June 1948, the mines were leased to various individual tenants who used hydraulic stump crusher for primary ore processing. The annual production was handed to the ”Exchange office” in Abrud and the wet ore concentrate to the Metallurgical Works in Zlatna.

3.3. Zlatna-Stănija metallogenic district

Several famous gold deposits belong to Zlatna-Stănija metallogenic district: Au (Breaza), polymetallic-Au (Haneș, Muncăceasca Vest, Stănija), *porphyry copper*-Au (Stănija, Muncăceasca Est) and Hg (Izvorul Ampoiului and Valea Dosului).

The metallogenesis of this district, as in the case of Brad-Săcărâmb, is hosted by volcanic structures located along tectono-volcanic alignments. The difference is made by the prevailing NW-SE and subordinate WSW-ENE orientation of alignments in Zlatna-Stănija, which is better expressed in the central parts of the district (Fig. 3.13).

Other differences regard the subdivisions of this unit, as compared with Roșia-Bucium and Brad-Săcărâmb. Whereas in these two units, the metallogenic units rank mostly as *nodes* and/or *fields*, in Zlatna-Stănija one has to consider the obvious linear metallogenesis in correlation with the tectono-volcanic alignments already mentioned. Thus, the following metallogenic alignments can be distinguished (Popescu, 1986): Haneş-Breaza, Prepeștenia-Trâmpoiele, Tuţumanu-Baba-Almaş, Neagra-Dealul Ungurului-Stănija.

3.3.1. Prepeștenia-Trâmpoiele metallogenic alignment. It is somewhat less extended (3.5 km) and located north-eastwards from Haneş-Breaza alignment, crossing the sedimentary and volcanic formations of the basin, while the northern half crosses the Mesozoic sedimentary formations.

Fața Băii vein field (Fig. 3.14) represented a small gold and sulfides ore deposit, yet of considerable scientific because this is the *locus tipicus* for **native tellurium** and **tellurite**. The most important veins found and mined here were the following: Prepeștenia, Cucuruz, Querendus, Alpha, Beta, Delta, Zeta and 37. The veins are predominantly made of quartz and sulfides and are crossed by fissures with pyrite, sphalerite, galena and stibnite, together with lately formed tellurides (krennerite, nagyágite, frohbergite, native tellurium) sulfosalts (tetrahedrite, tetradymite, jamesonite) as well as gold and realgar. Gold was found as fine disseminations, or nests reaching up to few kilograms – as in case of Beta vein. Sometimes it occurs in shapes resembling corn grains which inspired the name given to this vein: *Cucuruz (popular, regional name for corn)*.

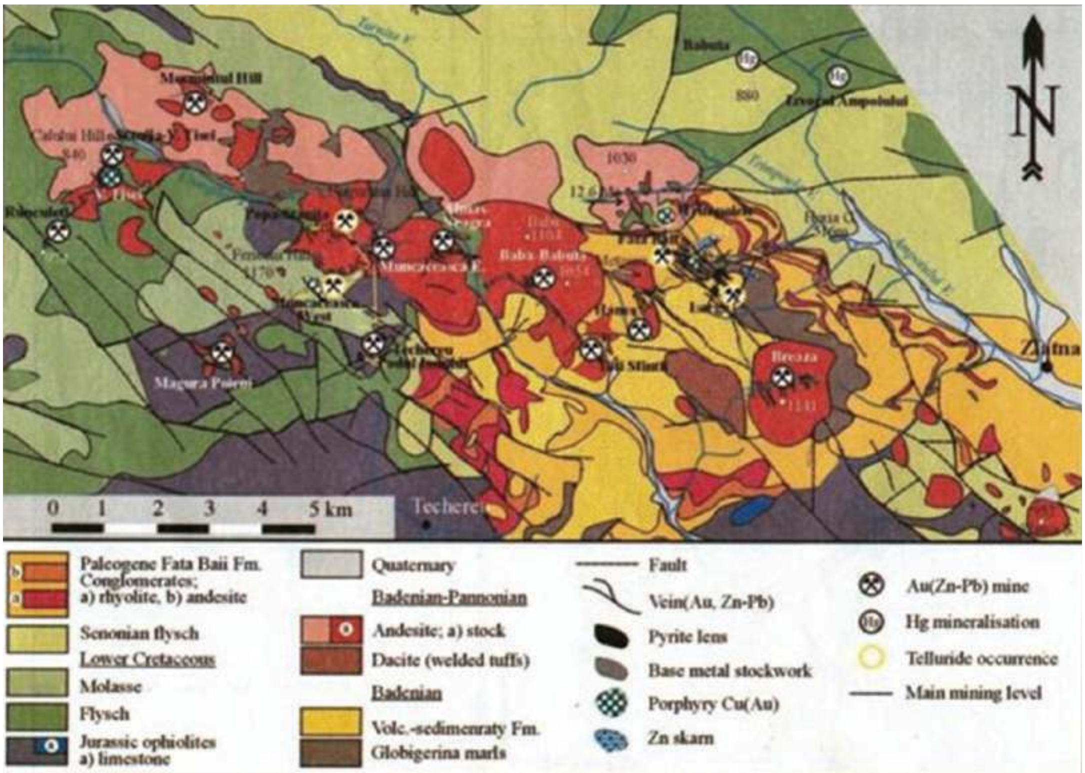


Fig. 3.13. Geological map of Zlatna-Stănija district (Ciobanu *et al.* 2004)

The morphology of native gold from Fața Băii (Plate V) is dominantly skeletal-dendritic, with crystals of gold often covered by secondary Fe hydroxides: skeletal gold in vein-shaped quartz with sulfides (1422), dendritic gold intergrown with pyramidal quartz in a vein geode (1423), dendrites and skeletal gold with pellicles of Cu secondary minerals on a quartz geode (1551), skeletal and lamellar gold intergrown with quartz, with pellicles of iron hydroxides (1594), skeletal and partially lamellar gold, associated with sulfides, in quartz geode (1835) and skeletal gold in a quartz geode, with sphalerite (1554).

The Au:Ag ratio at Fața Băii ranges between 62.5 and 68.9%, that is, higher than Stănija, but lower than Stănija Runculeți (Fig. 3.15).

Tuţumanu-Baba-Almaş metallogenic alignment is parallel to the previously described alignment, and located north-westwards from it (Fig. 3.13). It consists of Tuţumanu, Baba, Băbuţa and Almaş ore deposits

Almaş metallogenic field represents the most important metallogenic field of Țuțumanu-Baba-Almaș alignment and is formed of two vein groups located in the north-east part of the Neagra volcanic structure (Fig. 3.13).

The gold samples from Almaș (Plate V) are very diverse and cover the entire range from fibrous to granular isometric: lamellar gold in carbonates within breccia (1386, 1831), microgranular gold with quartz, in sphalerite (1407), microgranular gold in quartz, outlined by sphalerite with gold inclusions, in a mass of quartz with pyrite and arsenopyrite (1408), microgranular gold intergrown with sphalerite in hydrothermal quartzite (1409, 1838), gold intergrown with quartz included in sphalerite, as part of the breccia with cockade texture (1412), vein with quartz, sphalerite and microgranular gold, in hydrothermally altered breccia with pyrite and carbonates (1413, 1414), microgranular gold intergrown with sphalerite in hydrothermal quartzite (1415), dendritic gold with incipient lamellar habit (1823, 1825), microgranular gold with sphalerite, pyrite and quartz with pellicle of iron hydroxides (1829), dendritic gold with quartz geode (1832), microgranular gold with sulfides, sphalerite and galena, on quartz, and carbonate geodes (1834), granular skeletal gold with dendritic aspect (1836), microgranular gold with sulfides, quartz and rhodochrosite (1837).

The Au:Ag ratio at Almaş is relatively low, ranging between 61.6 and 65.9%, somewhat similar with the native gold from Fața Băii (Fig. 3.15). However, at Stănija, the ratio is higher, pointing to the highest fineness in the entire „Quadrilateral".

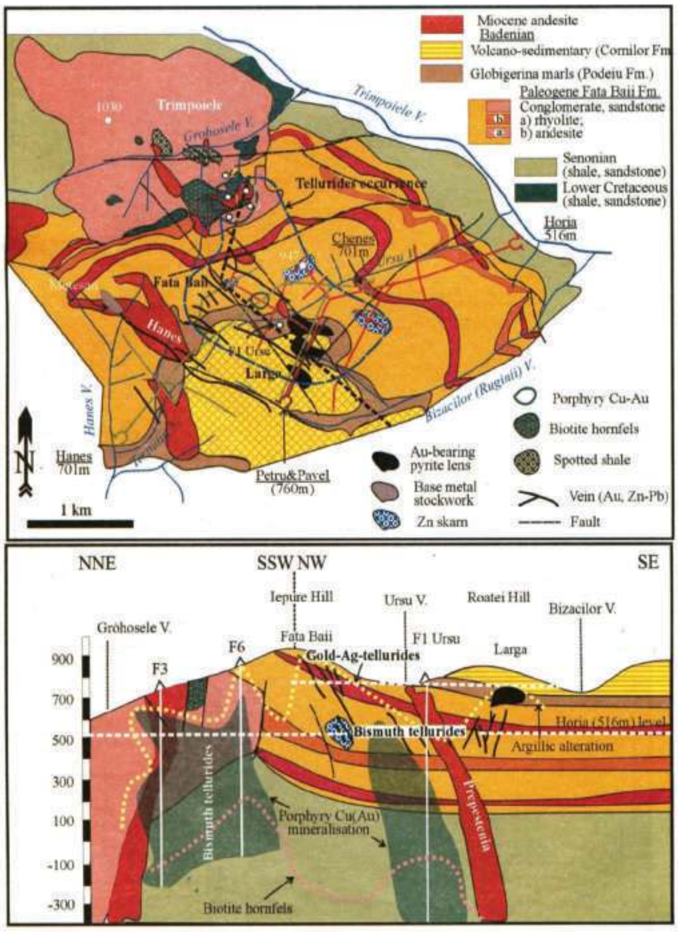


Fig. 3.14. Geological map and cross section of the Fața Băii-Larga vein field (Ciobanu *et al.*, 2004)

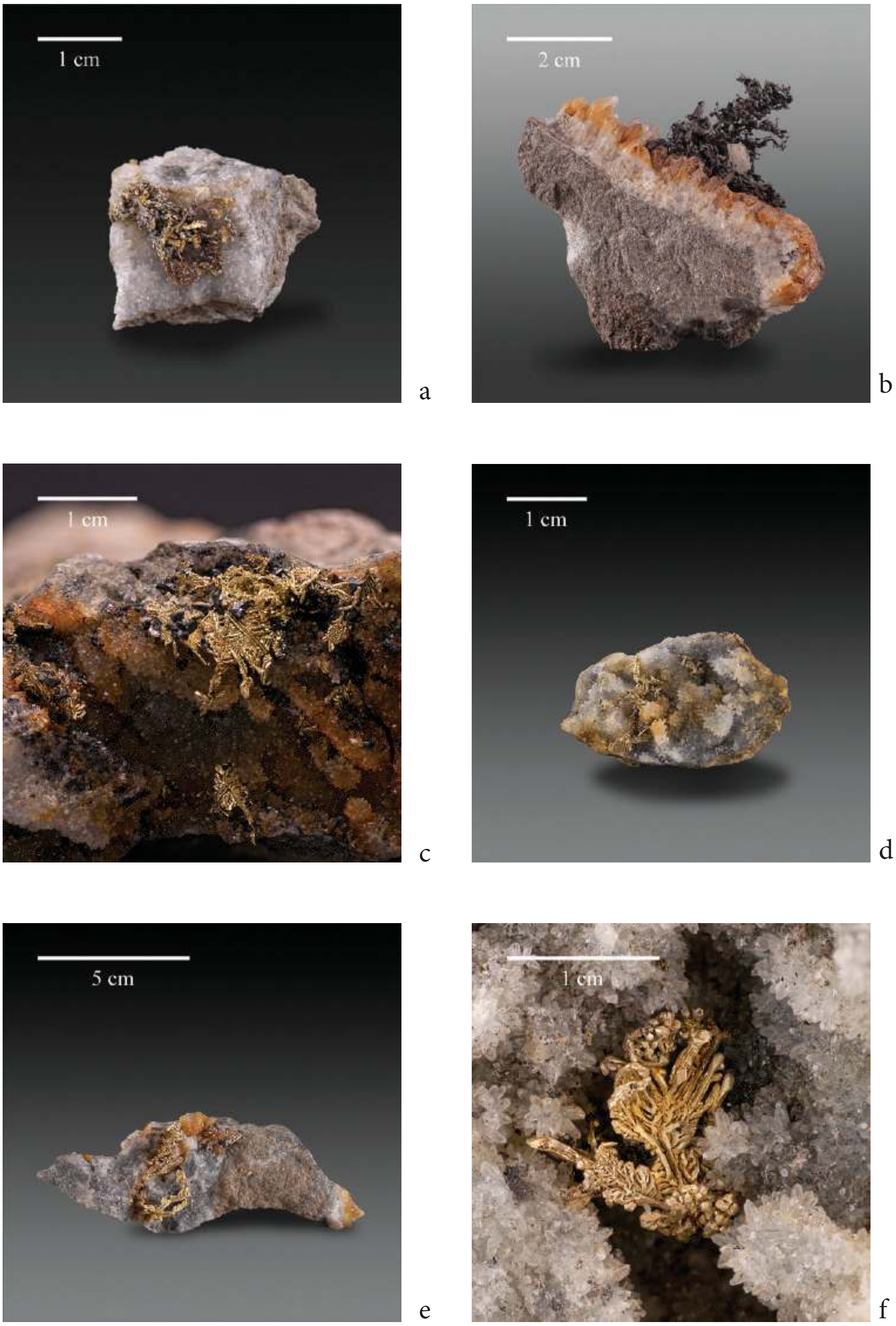


Plate V. Fața Băii: a) dendrites and skeletal gold with pellicles of secondary Cu minerals on quartz geode (sample 1551); b) skeletal and lamellar gold intergrown with quartz, with pellicles of iron hydroxides (sample 1594); c) skeletal and partially lamellar gold, associated with sulfides, in a quartz geode (sample 1835). Almaș: d-e) dendritic gold with incipient lamellar habit (samples 1823, 1825); e) granular skeletal gold with dendritic aspect (sample 1836)

Neagra-Dealul Ungurului – Stănija metallogenic alignment. The metallogenesis of this alignment is gold-silver and is under spatial control by NW-SE fractures and by the volcanic structures located along this alignment. The most significant vein fields are: Muncăceasca Est, Muncăceasca Vest and Stănija.

Stănija (Popa) metallogenic field is represented by an important group of veins hosted by the main andesitic body in Ungurului hill (Fig. 3.16). There are several veins in this group: Ana, Ludovica, Grofoaia, Lazăr, Fortuna, Aurel, Grațiela, Sfânta Treime, Iulius, Ieronim, Budac, all NW-SE oriented, mined in their upper parts for gold, and for polymetallic-gold ores in depth.

The Vilanela vein has a breccious texture and includes galena, sphalerite, altaite and native gold (Popescu, 1986), in calcite gangue, or fluorite in the upper parts **(fluorite from Stănija is also displayed in the Brad Gold Museum and deserves attention due to its perfect octahedral shape, its extremely nice color and in general, its special museum value; these samples are located in the mineralogical section of the museum);** Sf. Treime vein group: gold, pyrite, sphalerite, chalcopyrite, stibnite, quartz, calcite; Ludovica vein: zeolites (laumontite and stilbite).

The Au:Ag ratio measured in native gold samples from Stănija is by far, the highest (Runculeți samples) from Zlatna-Stănija district, thus confirming older data. However, there are also samples with very low gold percent (Fig. 3.15) which gives this metallogenic field a particular note.

The morphology of native gold from Stănija (Plate VI) is extremely diverse: quasi-lamellar gold, associated with quartz and clay minerals (pyrophyllite?), with friction plane aspect (1383); macrolamellae of gold, associated and intergrown with quartz (2266, 2269, 2271); skeletal gold in interlaced nests, within geodes with microgranular quartz (1397); gold associated with tellurides, quartz, carbonates and sulfides (berthierite?) (1385); grains of gold in quasi-parallel pattern, in argillized rock, with altaite and pyrite (1389); microgranular gold , disseminated in a hydrothermally altered, cockade textured rock, with successive layers of marcasite, sphalerite, clay minerals, carbonates, surrounded by pyrite and sphalerite (1391); dendritic gold in small nests, on quartz, within a vein of aragonite? (1393); microgranular gold in lamellar aggregates, associated with pyrite and altaite, within strongly argillized rock – nacrite (1395); lamellar-prismatic gold associated with carbonate (2137); finely grained gold with sulfides and tellurides in banded quartz (1877); concretionary gold, associated with altaite and sulfides, on quartz, fluorite and carbonate (1988).

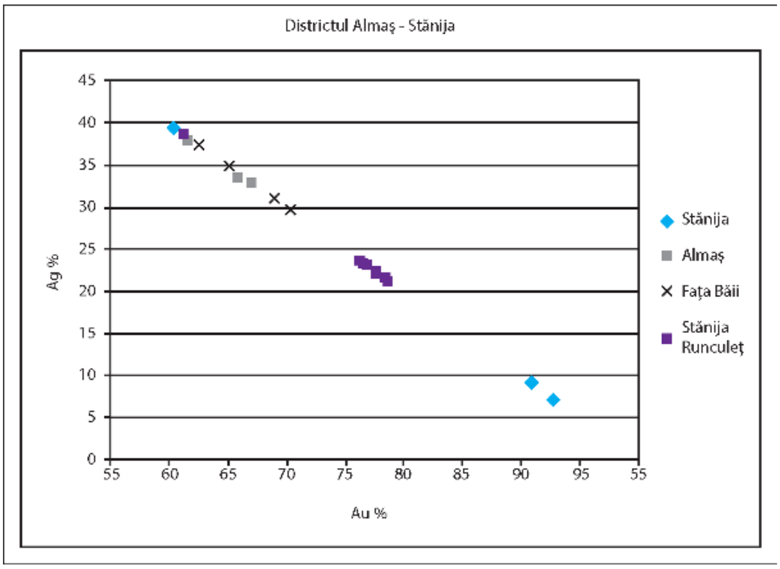


Fig. 3.15. The Au/Ag ratio in samples of native gold from Almaș, Fața Băii, Runculeț and Stănija ore deposits

Economic geology and mining history of Zlatna-Stănija district. The gold deposits in Zlatna have been mined ever since the Roman period. The city of Zlatna was the center of Roman mining authority and the meeting place of the *procuratores aurariarum dacicarum.* The importance of Zlatna is revived in the 18th century, but ample mining had been developing in the region ever since the 13th century when no less than 36 metallurgical furnaces were in operation at Zlatna and Baia de Arieş (Tripşa *et al.*, 1981 in www.romanit.ro).

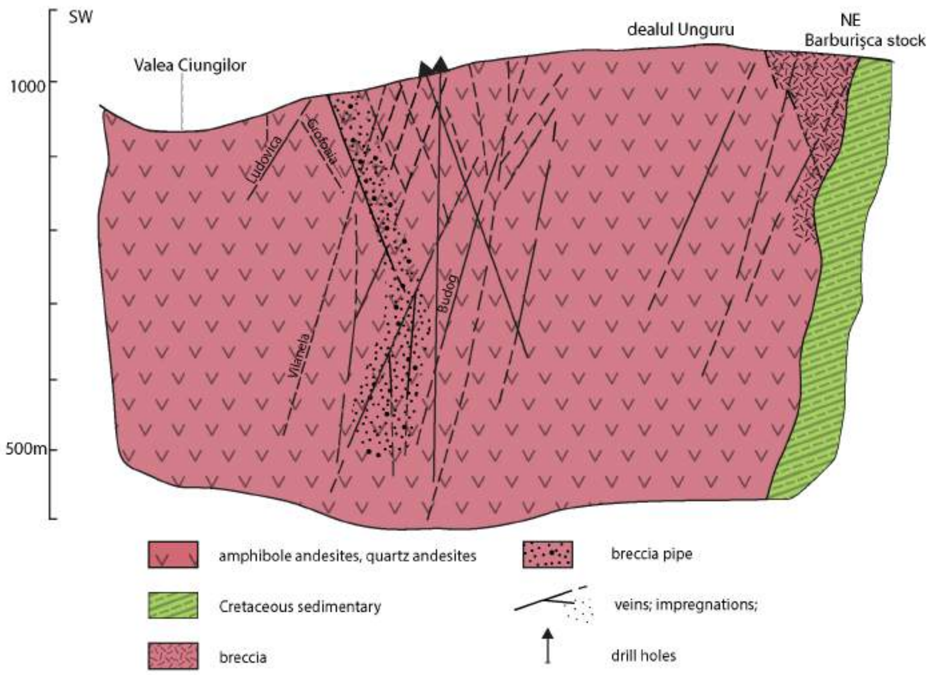


Fig. 3.16. Geological cross section through the mineralized structure of Stănija (redrawn after Borcoș *et al.*, 1961, 1962 în Ianovici, Borcoș 1983)

In the 18th century, numerous join-stock companies called *societates urburiales or Gewerkschaft* developed in the Zlatna mining region (Neamțu, 1970 in Baron, 2006). In 1747, the headquarters of the Mining Directory, the Mining Court and the Superior Precious Metals Exchange Office and a company for selling mercury were settled here. In 1783, there were already three operational smelters in Zlatna, and in 1838 the region witnessed the first steam-powered machine ever used in Romania. The machine was used at the silver smelters and was produced by „Punshon & Fletcher" from Vienna.

Following the shut-down of the Certej and Baia de Arieș smelters and starting with 1880, the Metallurgical Works in Zlatna remained the only one to process the gold-silver ore input from over 400 mining operations. As early as 1879-1889, in Zlatna, pyrite ore and smelter byproducts were processed by means of various acids. The head of the Chemical Division, Anton Hauch invented a new metallurgical procedure, later patented all over Europe. In 1896 a Pilz furnace replaced the old smelters (Fig. 3.17, Wollmann, 2010) and in 1918, the core of the works as the metallurgical division where gold, silver, copper and various ore concentrates from state owned and private operations from all across Apuseni Mts. were extracted.

At the end of the First World War, in 1919, all the mining and metallurgical assets owned by the Hungarian state in Transylvania, including the Metallurgical Works in Zlatna, were taken over by the Romanian state, through *Regia Întreprinderilor Miniere and Metalurgice ale Statului din Ardeal (R.I.M.M.A)*.

The role of Zlatna plant was essential for the existence of Au-Ag mining in Apuseni Mts. Region, after the Unification of Transylvania with Romania. Until 1939 this was the only metallurgical plant of its kind in the area and between 1940 and 1945 it supplied for the loss of Firiza de Jos plant in Baia Mare. The Metallurgic Works in Zlatna had a processing capacity of 6,000 tons/year and it processed concentrates from state owned and small private operations in the Apuseni Mts. Until 1939, the plant also used the ore input of "MICA" company (Baron, 2006). The gold and silver production rose continuously from 114.2 kg gold and 208.4 kg silver in 1933, to 202.8 kg gold and 1769.76 kg silver in 1938.

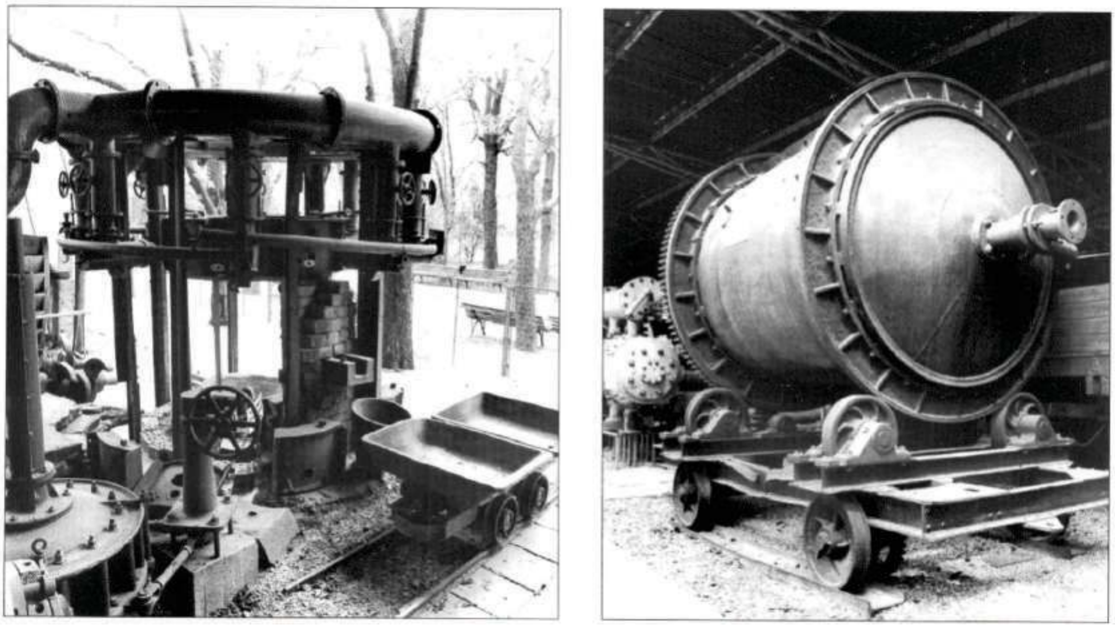


Fig. 3.17. The circular "Pilz"-type furnace in Zlatna, Technical Museum "Ing. Dr. D. Leonida", Bucharest (Wollmann, 2010)

3.4. Brad-Săcărâmb metallogenic district

The metallogenic district of Brad-Săcărâmb (Fig. 3.18) is the largest territorial unit of the metallogenic subprovince associated with Neogene volcanics in the Apuseni Mts. Structurally, this is a post-tectonic basin which fragments the eastern part of the Drocea-Techereu ophiolitic massif and the Mesozoic sedimentary formations. The dominant fracture system which determined the present configuration of the basin is oriented NW-SE. This newer system of fractures intersected with the older WSW-ENE or EW system, thus resulting in areas of minimum resistance in the crust and favoring the flow of magma to the surface. Thus, a number of complex volcanic systems developed, in connection with the accumulation of gold, silver, and *porphyry copper* mineralization.

Many of these complex structures are characterized by collapsed central sectors, clearly outlining areas with calderean character, as is the case of Barza, Caraci, Corburea-Cerburea, Vălișoara, Cetraș, Măcriş, Săcărâmb and Căinel.

An important feature of this district is the grouping of metallogenesis in *nodes*. The metallogenic node of Barza is the most important metallogenic concentration of the Brad-Săcărâmb district. It consists of auriferous and subordinately polymetallic vein groups, or mineralized *porphyry copper* belonging to Barza stratovolcano.

This feature enables the simple separation in metallogenic fields when mineralization is confined to a single volcanic structure (Caraci, Căinel, *etc*.) and in groups of metallogenic fields and nodes, when mineralization is located in complex volcanic structures: Barza, Trestia-Măgura, *etc*.

Plate VI. Stănija: a) native gold with friction plane aspect (sample 1383); b-d) gold as macrolamellae, associated and intergrown with quartz (samples 2266, 2271, 2269)

From a spatial point of view, one can separate metallogenic fields of the south-western margin of the basin (Caraci, Barza, Căinel, Băiţa, Trestia-Măgura) and those located on the north-eastern fringe of the basin (Bucureşci-Rovina, Duba, Corburea-Cerburea, Vălişoara, Măcriş-Cetraş).

3.4.1. Caraci (Căraciu) metallogenic field

Caraci (Căraciu) ore deposit encompasses the vein mineralization located northwards of Caraci peak. It develops as a vein system covering approx. 800 m/200 m, with five main veins and their ramifications. The veins are NW-SE and WNW-ESE oriented and have several hundreds of meters in length, and up to 1 m in width (Fig. 3.19). The mineralization occurs in a depth interval of approx. 250 m. The radiogenic data suggest that the second volcanic phase characterized by the hornblende andesites, took place at approx. 12.5 Ma (Jude, 2000).

The gold samples from Caraci (Plate VII) are less diverse when compared with other occurrences and consist of: gold lamellae on carbonates, partially covered by pellicles of iron hydroxides (1440), lamellar gold with pellicles of iron hydroxides, intergrown with vein-shaped quartz (1444, 1856), dendritic gold (1854), dendritic lamellar gold in andesitic fissure (1982), nest of lamellar gold in vein (1981).

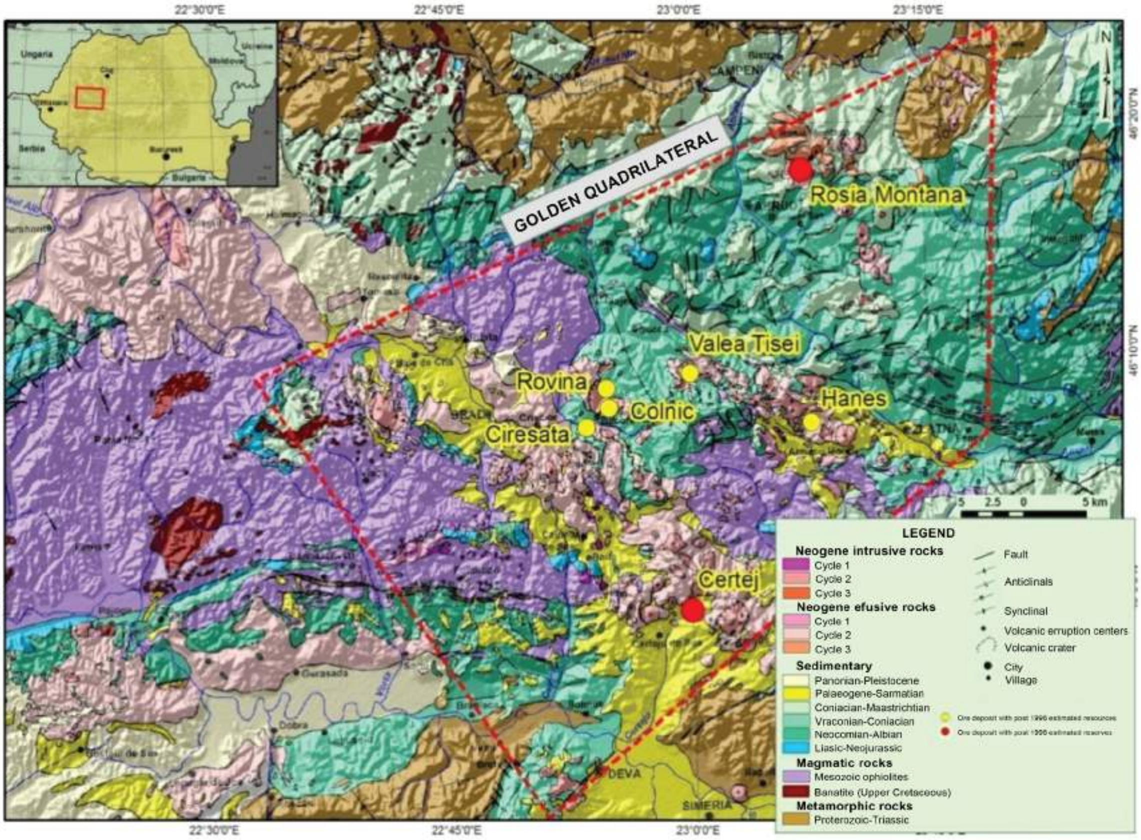


Fig. 3.18. Location of Brad-Săcărâmb district in the Southern Apuseni Mts. and in the "Golden Quadrilateral". Mining projects developed after 1990 are indicated (Tămaş-Bădescu, 2010)

The Au:Ag ratio at Caraci is the lowest recorded for Brad-Săcărâmb district, with values ranging from 48.8 and 57.4 (Fig. 3.22).

3.4.2. Barza metallogenic node

The Barza metallogenic node represents the most important metallogenic concentration in the entire district. It is related to the interaction between the NW-SE and E-W fracture systems (Fig. 3.21). The node consists of groups of gold and subordinately polymetallic veins as well as of *porphyry copper* columns belonging to Barza volcano with andesitic lava flows and pyroclastites (Fig. 3.20).

Barza vein field represents the landmark unit of the metallogenic node and consists of gold veins which have been mined for hundreds of years (Ruda-Barza, Măgura, Brădişor, Valea Morii Veche), but also of *porphyry copper* accumulations discovered in 8th decade of the last century (Musariu Nou and Valea Morii Nouă). The main vein group in Barza vein field is Ruda-Barza, located on the south-west margin of Barza andesitic pillar and in the neighboring Smereciu volcanic neck (Berbeleac, 1998).

Samples with native gold from the vein group Ruda (in the upper part of Barza structure) (Plate VII), range among the following morphological types: microgranular gold intergrown with rhodochrosite, quartz and sulfides (1458, 1460), skeletal gold in geodes, with quartz and sphalerite (1462, 1468, 1474), lamellar gold intergrown with calcite (1469), lamellar gold, partially dendritic intergrown with carbonates and baryte (2214, 2215), dendritic gold (2223), 120 gold plates, sometimes with dendritic texture, and having one side covered in silica (2318), quartz with gold powder (1476).

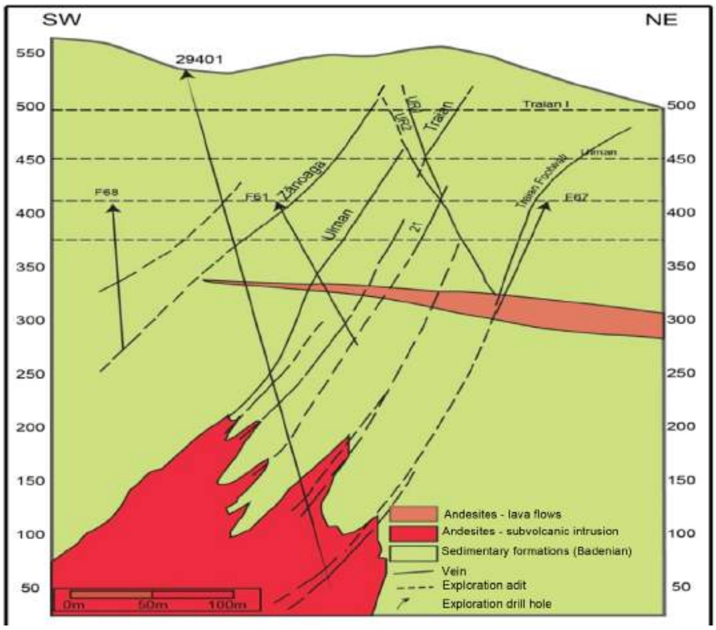


Fig. 3.19. Geological cross section Caraci ore deposit (Tămaş-Bădescu, 2010)

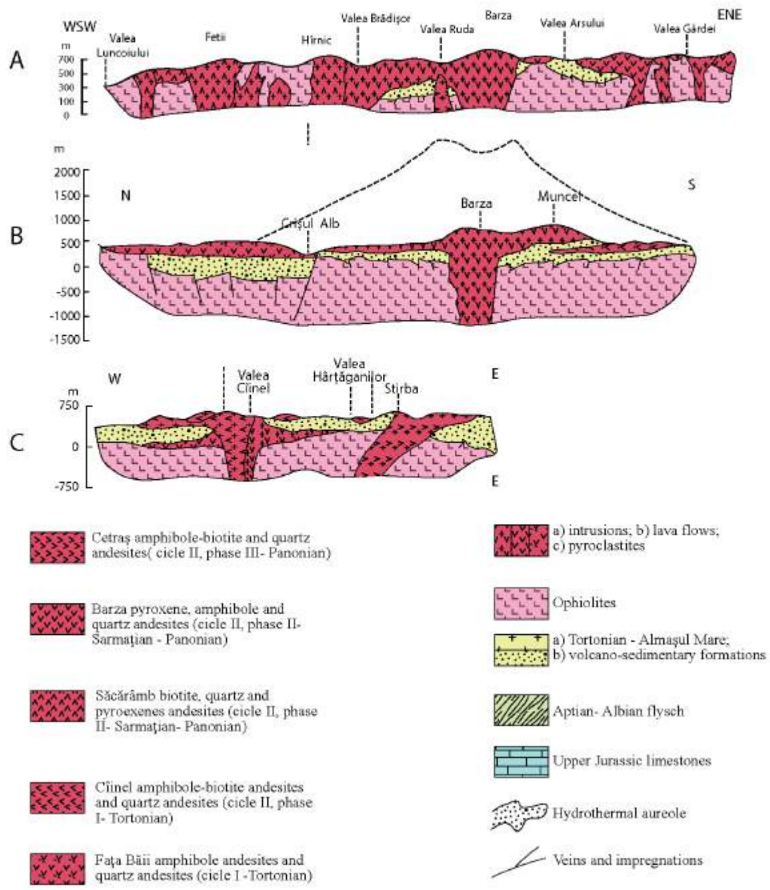


Fig. 3.20. Neogene volcanic structures in Barza metallogenic node. A) Geological cross-section through the central part of the node; B) Barza stratovolcano; C) Căinel-Măgura Băii composite volcano (redrawn after Ghiţulescu and Borcoş, 1966, in Ianovici *et al.*, 1969)

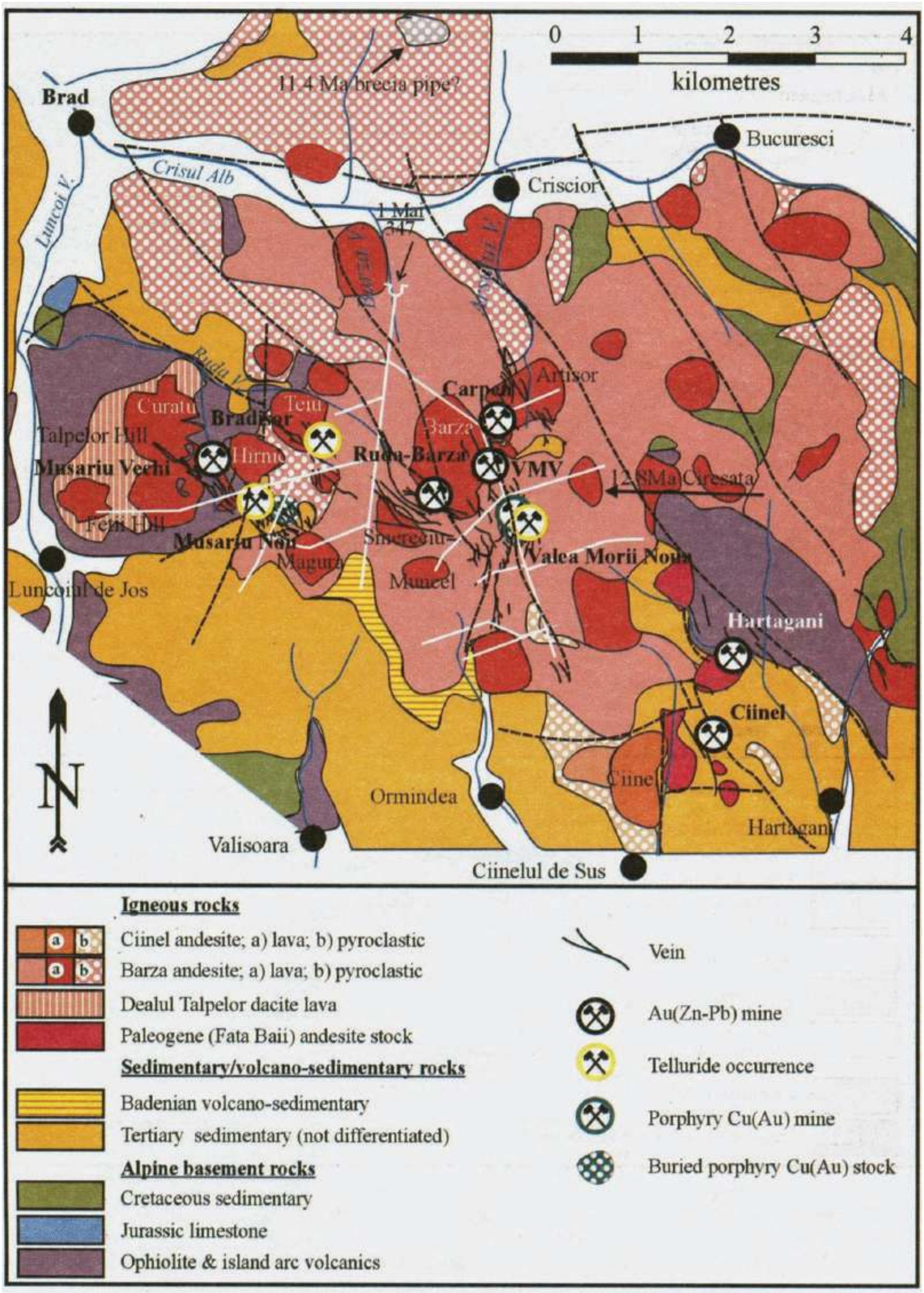


Fig. 3.21. Geological map of Barza metallogenic node, depicting the gold deposits (Ciobanu *et al.*, 2004)

The Au:Ag ratio for Ruda falls in the middle range of Barza metallogenic node (Fig. 3.22), between Valea Morii (highest) and Carpen (lowest).

Economic geology and mining history of Ruda-Barza vein group. The Ruda-Barza ore deposit, together with „Ruda 12 Apostoli" mine are remnants of the oldest gold mining activities ever carried out in the area (Fig. 3.23, 3.24). Many mine adits were dug by chisel, as far back as in the Roman period.

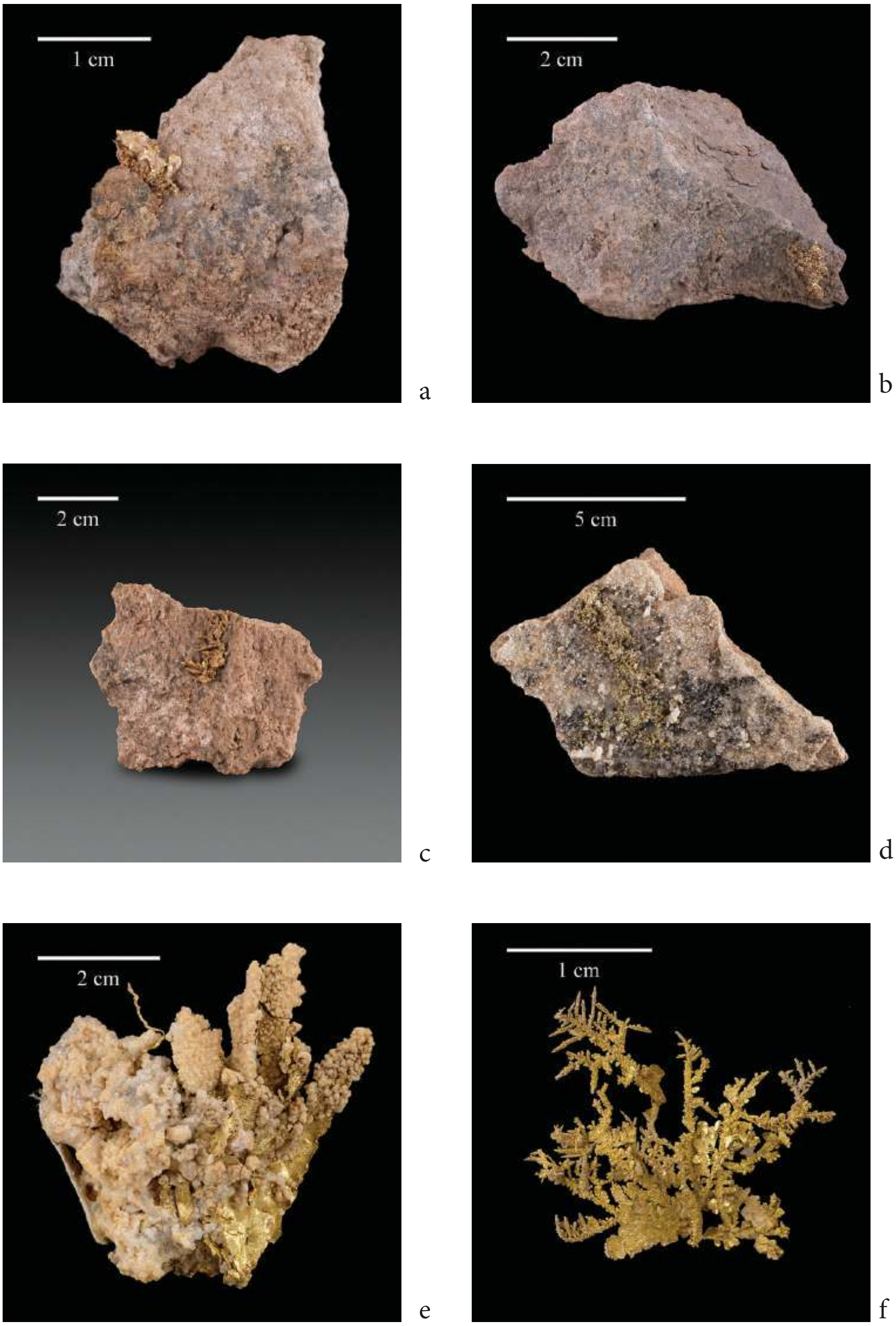


Plate VII. Caraci: a) dendritic gold (sample 1854); b) lamellar gold with pellicles of iron hydroxides intergrown with vein-shaped quartz (sample 1856); c) dendritic lamellar gold in andesitic fissure (sample 1982). Ruda: d) skeletal gold in geode, with quartz and sphalerite (sample 1474); e) lamellar gold, partially dendritic intergrown with carbonates and baryte (sample 2215); f) dendritic gold (sample 2223)

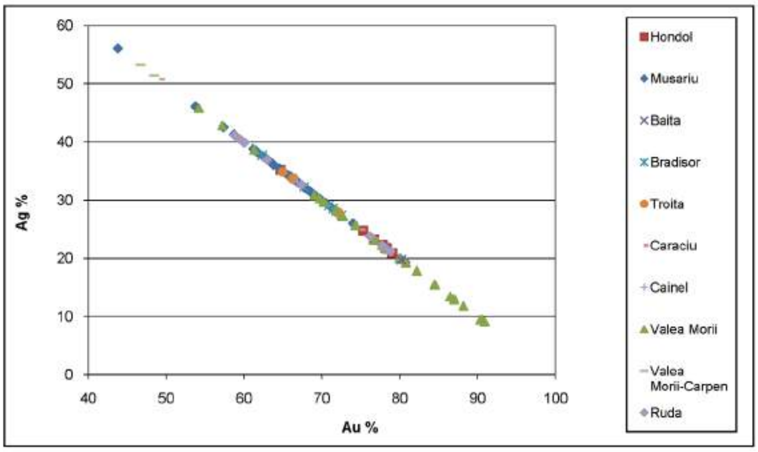


Fig. 3.22. Variation of Au/Ag ratio in various ore deposits of Brad-Săcărâmb district

In 1898, one of the most modern gold ore processing plants was built at Gurabarza (Fig. 3.25). The hydraulic stump crusher hall was 120 m long and 26 m wide and had 18 operational Californian stumps and copper plated amalgamation tables on massive concrete muffling pedestals. The plant had a processing capacity of approx. 200,000 t ore/year, with two ore flotation lines able to process 40,000 t ore/year. The pyrite cyanidation line had a capacity of 10,000 t ore/year, whereas the gold electrolytic refinery, could process approx. 6000 kg fine gold/year. The plant also had facilities for special processing of ores with visible gold. The total output of the plant ranged from 2300 and 3000 kg/year (Baron, 2006, after Ghițulescu and Socolescu, 1941).

Fig. 3.23. Valea Ruzii, "The Roman Stairs"; photograph from 2008 (Wollmann, 2010)

Fig. 3.24. Brad, mining carriage from the 16th-17th century, German Museum of Mining, Bochum (Wollmann, 2010)

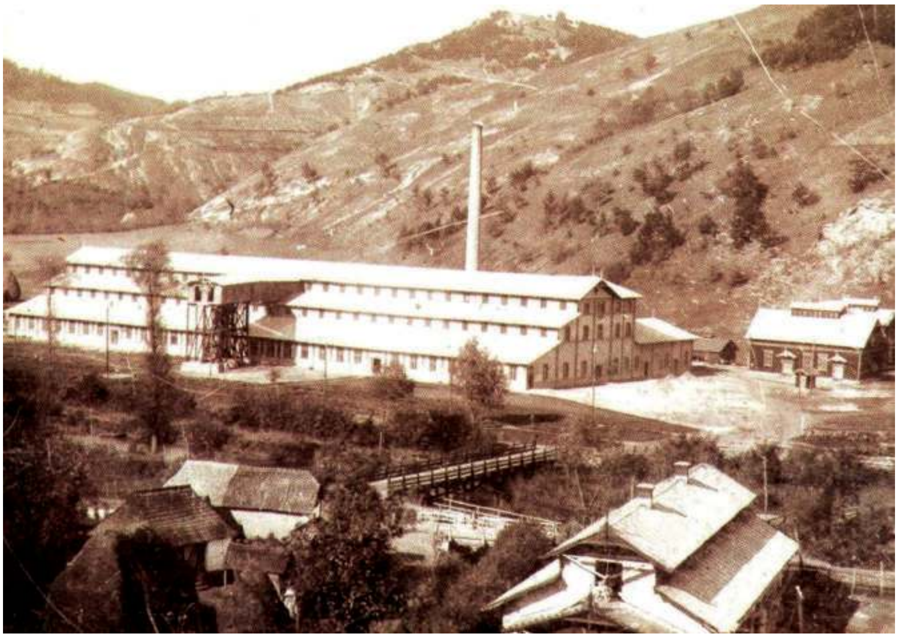


Fig. 3.25. The Central Processing Plant at Gurabarza in its first year of operation: 1898-1899 (Wollmann, 2010)

Brădișor ore deposit is located westwards of Ruda, between Teiul and Hârnicul hills (Fig. 3.21). It consists of the Brădișor vein group, once extremely rich in gold, especially in 25/37, 41, I and II roof and Ana veins (and branches). The vein fill was quartz associated with gold-bearing sulfides; the central part of the veins hosted native gold in quartz and kaolinite gangue (Popescu, 1986). Native bismuth, tellurides and native tellurium were also quoted in this occurrence (Brana, 1958, Borcoș *et al.*, 1964, Berbeleac, 1998).

With all the scarcity of "free", visible gold at Brădișor, the Gold Museum Brad still holds an impressive number of such samples which allowed both a comprehensive morphological classification and the determination of the gold vs. silver content. Thus, the following morphological types could be separated (inventory number in parantheses): microgranular and dendritic-lamellar gold intergrown with baryte, quartz and sphalerite (1144); microgranular skeletal gold, finely intergrown with quartz, carbonate and sulfides (1175); microgranular gold with sulfides and quartz in radiary aggregates (1169); microgranular and thread-like gold intergrown with quartz, carbonate, baryte and iron hydroxides (1185); microgranular gold on grainy-radiary quartz and sphalerite (1764); microgranular gold intergrown with sulfides and quartz (1779); skeletal and moss-like gold (1774); skeletal and moss-like gold on quartz with native tellurium? (1168); skeletal and moss-like gold, interlaced with lamellar baryte (1176); skeletal gold intergrown with quartz ("anthill") and submillimetric tablets of baryte (1941); skeletal and lamellar gold interlaced with quartz (1948); dendritic and skeletal gold invaded by iron hydroxides, and intergrown with quartz and sulfides (2252); dendrites of gold in geode of microgranular quartz on baryte (2324); dendritic and lamellar gold on microgranular quartz and gypsum (2325); dendritic lamellar gold and pyrargyrite (1177); dendritic gold in the geodes of a quartz (1186); dendritic and lamellar gold with white and black, zoned baryte and pyrite (1187); and dendritic lamellar gold in geode of quartz and sulfides (1193); grains of gold on tetrahedrite and sphalerite (1744); lamellar and dendritic gold in geodes of chalcedony, microgranular quartz and baryte, sometimes with pellicles of iron hydroxides (1542); vein quartz ore with impregnations of pyrite, micronic gold and epsomite (1753); lamellar gold on quartz in argillized rock (1775); lamellae of gold interlaced with thread-like gold and chalcedony (1949); lamellar gold with sulfides in geode of grey quartz (1954); lamellar and dendritic gold with pellicles of iron hydroxides on quartz (2058); lamellar gold partially covered with pellicles of iron hydroxides in white quartz (2149).

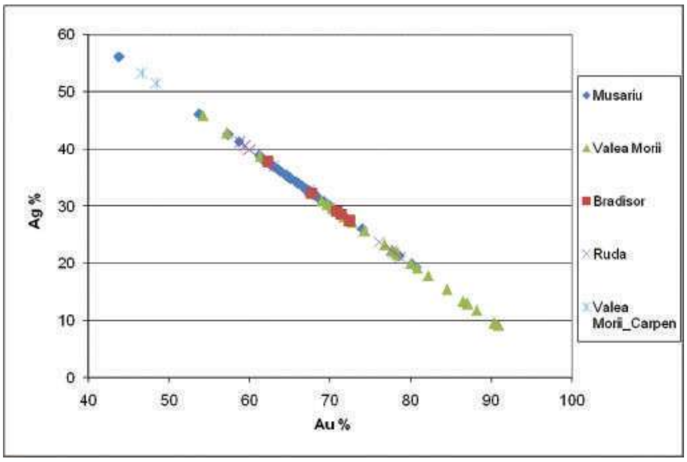


Fig. 3.26. Variation of Au/Ag ratio in samples of native gold in various ore deposits in Barza metallogenic node

The Au:Ag ratio for Brădişor locates in the middle area of the Barza metallogenic node, with a tendency towards higher values (Fig. 3.26).

Musariu mineralized structure.

The vein network at Musariu (Fig. 3.27) locates in the south-west part of Hârnicul andesitic chimney (705 m), on the territory of Ruda village (*rudar* = goldsmith). The old mined veins locate in the ophiolitic rock complex and within the andesitic intrusive body. The veins have frequent thinning and discontinuity zones and are outlined by impregnations with occasional richer metal grades (Clara, Carpen, Elena) (Popescu, 1986). The optimal north-west area (Musariu Vechi) develops upwards until under the tree roots, and towards SE (Musariu Nou), descends under the last mining level (-180 m, under 1 Mai-Victor gallery). The veins from Musariu Nou (Elena pit) get thinner above 1 Mai (Victor) gallery (Brana, 1958).

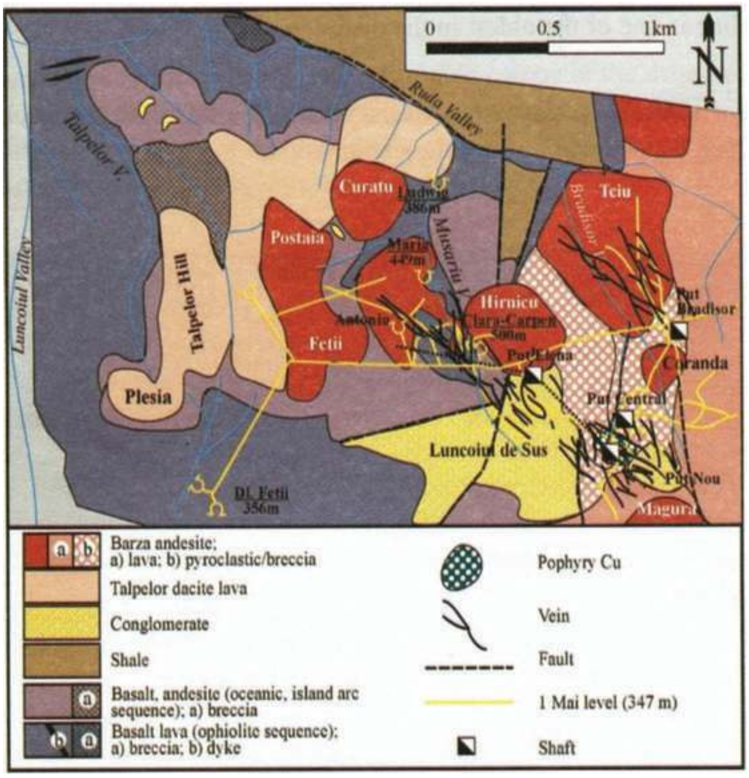


Fig. 3.27. Geological map of Musariu (after Ciobanu *et al.*, 2004)

The mode of occurrence of the mineralized area may be described as follows:

Musariu Vechi: Veins with native gold, quartz, calcite, baryte, kaolinite. Native gold occurs as impregnations, nests and rich concentrations, sometimes reaching kilogram size (Popescu, 1986). “Free gold occurs as leafs, threads, moss-like aggregates, on crusts of quartz, tissues of gold leafs, invaded by calcite, threads covered in calcite crystals, gold threads covered by leafs of gold, gold leafs covered by native arsenic” (Brana, 1958).

Musariu Nou: Veins with native gold as lamellae and flakes disseminated in quartz, baryte and gypsum, in an assemblage with galena, sphalerite, chalcopyrite, marcasite, arsenopyrite, tetrahedrite, sylvanite, realgar, native arsenic (Popescu, 1986). The Cu-Au mineralization forms stockworks and impregnations in the potassic zone (Fig. 3.28) and contains: magnetite, hematite, pyrite, veinlets of chalcopyrite, together with chlorite, epidote, quartz; sometimes pyrrhotite, sphalerite and subordinate ilmenite, rutile, bornite, tetrahedrite, galena, marcasite, arsenopyrite occur (Vlad, 1983).

Relying on the number of specimens exhibited in the museum, on their unique beauty, and on the fact that almost all the famous museum samples come from Musariu, then this is by far the best represented gold deposit in Brad. Musariu is the true ”king” of the gold deposits in Romania, and most probably one of the ”kings” of all gold deposits worldwide.

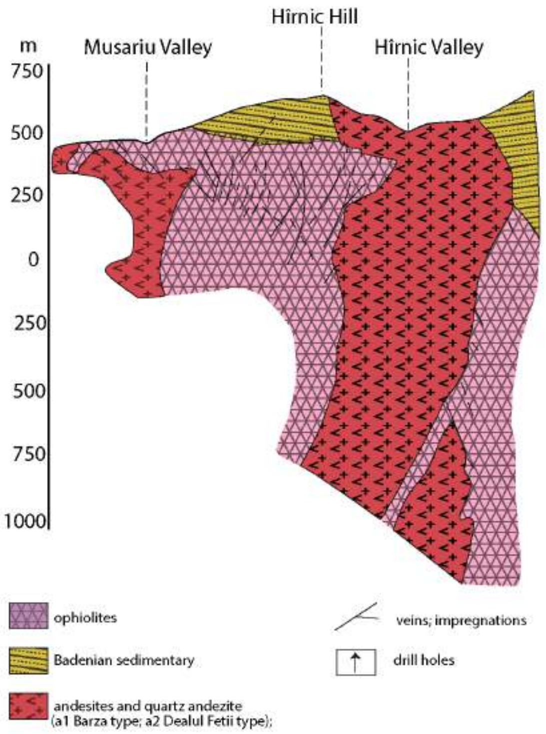


Fig. 3.28. Geological cross section through Musariu Nou metallogenic field (redrawn after Ghițulescu and Borcoș, 1976 in Ianovici and Borcoș, 1983)

The predominant morphological feature of native gold from Musariu is the lamellar habit (Plates VIII-X), but subordinate skeletal-dendritic and especially the granular-isometric habits, do also occur. Many forms are mixed and in relation with other minerals in the assemblage: lamellar–skeletal or lamellar–dendritic. Thus, the following types may be described at Musariu: lamellar gold intergrown with carbonates on sphalerite (C.60); lamellar and dendritic gold on quartz with oxidized siderite (C.98); lamellar subcentimetric gold associated with subhedral sphalerite (C.101); Paste-up of lamellar gold, with dendritic fringes and triangular growth patterns, partially covered by crusts

of iron hydroxides (C.104); Paste-up of lamellar gold with dendritic terminations and growth excrescences (C.107); reddish lamellar gold associated with sulfides and calcite on quartz geode (1200); gold macrolamella marginally intergrown with quartz, on geode of microgranular quartz, microlamella with dendritic pattern (1274); macrolamella with overgrown quartz, dendritic gold and sphalerite (1196); "the Polar Bear" – macrolamellar gold with dendritic patterns (1203); lamellar gold associated with scalenohedral calcite on microgranular quartz and sulfides (gold micrograins on two edges) (1237); macrolamellar gold intergrown with calcite and sulfides (1260); lamellar gold, quartz, colomorph arsenic and sphalerite (1261); assemblage of lamellar gold, yellow sphalerite and with scalenohedral calcite (C.46); microlamellar gold rarely associated with calcite, siderite, gypsum and sulfides (1224); lamellar gold with crust of arsenic (1257); microlamellar gold intergrown with centimetric lamellar fusiform excrescence – "Eminescu's writing plume" (1306); lamellar gold with intersertal texture on quartz (1343); lamellar strip of de gold with dendritic excrescence and carbonate overgrowth (1331); gold lamellae with skeletal fringes and conspicuous triangular patterns (1348); lamellar gold with intersertal texture on quartz – "the Salamander" (1619); lamellar subcentimetric gold intergrown with microgranular quartz (2004); lamellar gold associated with black calcite on sphalerite (2005); macrolamellar gold with carbonates and pellicles of iron oxyhydroxides and friction grooves (1329); macrolamellar gold on crust of quartz (1578); lamellar gold – "Horea's spear" (2089); lamellar-dendritic gold with concretionary native arsenic on carbonates (C.18); dendritic lamellae de gold intergrown with hollow dolomite scalenohedra (C.27); lamellar gold dendritic on quartz – "the Sitting Hen" (1206); paste-up of 55 de lamellae of dendritic gold from an initial marcasite sample which decomposed (1201); lamellar and dendritic gold with a twinned calcite scalenohedron from a vein with gold, quartz and sulfides (1221); lamellar dendritic gold intergrown with quartz and sulfides (1254); lamellar dendritic gold, intergrown with calcite and enveloped in globular native arsenic (1258); lamellar gold, sometimes dendritic, in geode of crustiform quartz (1577); lamellar dendritic gold intergrown with microgranular quartz and enveloped in globular native arsenic (1602); microlamellar and dendritic gold on o geode of quartz ("Snake head") (1330); lamellar and dendritic gold associated with zoned calcite (1655); dendritic lamellar gold in calcite geode (1662); gold in microlamellae with overgrowth of quartz partially enclosed in calcite scalenohedra (1706); lamellar gold on crustiform quartz with sulfides (2239); group of gold macrolamellae with coarse overgrowth quartz crust (2263); lamellar dendritic gold, intergrown on crustiform quartz – "the Stegosaurus" (2281); aggregate of gold minilamellae – "the Leopard" or "the Lioness" (10001); aggregate of gold lamellae – "the Rhino" (10002); intergrowth of lamellar and skeletal gold with subhedral calcite (2037); reddish lamellar gold intergrown with micrógranular bipyramidal quartz (2020); local accumulation of lamellar gold intergrown with calcite, on quartz and sulfides, with iron hydroxides (2041); concretion of lamellar gold with scalenohedral calcite (2042); lamellae of gold associated with quartz, on crustiform quartz with sphalerite (2216); lamellar gold intergrown with quartz and sulfides (2220); lamellar, vivid yellow gold, with overgrown de granular quartz – „the Nicest Gold" (2303); lamellar and skeletal gold associated with quartz and carbonate (1332); tissue of compact gold lamellae and quartz with marcasite (1342); skeletal and lamellar gold in barite interspaces (1583); skeletal gold lamellae with crystals of tetrahedrite and quartz (C.42); skeletal gold lamellae intergrown with calcite on microcrystalline quartz – "the Map of Romania: Transylvania and the Carpathians" (C.44); skeletal lamellar gold with microcrystalline quartz (C.89); skeletal lamellar gold – "the Dragon" (C.97); skeletal gold, partially lamellar, in a cylinder-shaped concretion, with fringes of skeletal gold, intergrown with zoned barite (1208, 1209); skeletal gold, sometimes lamellar, with centimetric, curved, lamellar excrescence – "the Feathered Helmet" (1307); skeletal lamellar gold, grown on crustiform-tabular quartz (1326); nest of dendritic and lamellar gold on microgranular quartz and sphalerite (1328); elongated concretion of lamellar and dendritic gold, with quartz (1309); skeletal and lamellar gold on crustiform quartz (2063); lamellar and dendritic gold associated with quartz and sulfides in a geode (2119); zoomorphic lamellar and skeletal gold, with local overgrowths of – "the Duck" (2235); zoomorphic lamellar and skeletal agglomerations of gold with hydroxide pellicles – "the Dog" (2236); subcentimetric granular

and skeletal gold on quartz (1300); vein of skeletal gold on calcite (1282); zoomorphic intergrowth of skeletal gold (minilamellae and dendrites) – "the Lizard" (1310); skeletal gold (1340); aggregates of skeletal gold (up to 10 cm long), partially lamellar, in quartz geode, with carbonates (1341); skeletal gold intergrown with quartz, and sphalerite (1478); skeletal gold intergrown with sulfides associated with baryte (1483); string-like skeletal gold on microgranular quartz (2036); skeletal gold intergrowth – "the Cannon of Avram Iancu" (2278); skeletal gold intergrown with microgranular (scalenohedral) calcite and sphalerite on quartz crust (2299); skeletal microgranular gold intergrown with dolomite on quartz and sulfides (2288); skeletal dendritic gold intergrown with calcite scalenohedra grouped in star-shaped aggregates (2302); skeletal gold intergrowth with sphalerite, dolomite and quartz (C.49); skeletal microgranular gold marginally intergrown with quartz – "the V sign" (1233a); skeletal gold with bipyramidal quartz (1579); thread-like and skeletal gold intergrown with quartz (1581); skeletal microgranular gold, intergrown with sulfides and oxidized carbonates, in breccia matrix (C.95); granular skeletal gold on o ferruginous crust (1240); agglomeration of skeletal granular gold, on crustiform quartz (1241); dendritic gold intergrown with carbonates on microcrystalline quartz, followed by lamellar baryte (1314); dendritic and microlamellar or skeletal gold, intergrown with carbonates and sphalerite, on quartz (C.56); moss-like gold intergrown with siderite, on crustiform quartz (C.75); moss-like gold intergrown with siderite, on crustiform quartz (C.76); densely microdendritic gold, intergrown with carbonates and secondary minerals with sulfur efflorescenses (1199); dendritic gold with baryte and carbonates (1216); granular skeletal and dendritic gold in a quartz geode (1233); microgranular gold intergrown with quartz, sulfides and scalenohedral calcite having the edges powdered with gold (tri-edged gold micrograins) (1246); scalenohedra with three edges powdered with microcrystalline gold (1249); microconcretion of skeletal and lamellar gold intergrown with quartz (1284); dendritic and microlamellar gold in geode with euhedral quartz, alternating with layers of sulfides (1347); dendritic lamellar gold on geodes of prismatic quartz with pyrite and partially zoned quartz (1316); thread of gold, overgrowth of gold crystals and quartz (1352); thread of gold with marginal aggregate of quartz (1354); intergrowth of gold and baryte on sulfides (1482); felt-like gold intergrown with sphalerite (1497); felt-like gold intergrown with baryte and sulfides (1498); reddish skeletal, lamellar and dendritic gold, with three lamellar prominences (1643); quartz vein with skeletal gold (1712); black, tuft-like agglomeration of skeletal gold (with pellicles of oxyhydroxides) (1725); V-shaped veinlet with skeletal gold intergrown with sulfides (1715); dendritic and lamellar gold in minigeode of quartz (1717); microgranular gold intergrown with quartz in the middle of a quasi-concentric texture with chalcopyrite and calcite – "the Great Romania" (1317); assemblage of gold dodecahedra on quartz and sulfides – "the Discobolos" or "the Ballerina" (1535); dendritic and partially lamellar subcentimetric gold associated with zoned baryte (2017); granular-isometric intergrowth of gold in quartz geode, with pellicle of iron hydroxides (2029); biomorphic gold as dendritic intergrown lamellae – "the Dragonfly" or "the Fern" (2264); zoomorphic intergrowth of dendritic and lamellar gold – "the Lizard 2" (2277); gold intergrown with native arsenic and calcite (1600); fine dendritic gold on quartz and sphalerite (2245); moss-like gold intergrown with siderite, on crustiform quartz (C.90); native moss-like gold on quartz (112); concentric layers of calcite on a gold thread (1214); globular native arsenic with dendritic gold on quartz and calcite scalenohedra (1253); crust of colomorphous arsenic intergrown with black calcite scalenohedra around quartz and gold intergrowth (1264); zoned globular arsenic globular with calcite envelope and layers of iron hydroxides (1267); colomorphous arsenic on crustiform quartz intergrown with skeletal gold (1268); gold ore in chalcedony, associated with dolomite (1312); twinned calcite scalenohedra with spherical voids filled with native arsenic (1607); black calcite on spherules of native arsenic with crusts de quartz associated with sphalerite, rare lamellae of gold with pellicles of iron hydroxides (2007); globular arsenic with zoned texture intergrown with calcite (2164); black calcite with crust of globular native arsenic (2169).

The Au:Ag ratio at Musariu lies in the middle of the interval described for Barza metallogenic node (Fig. 3.26), but several values tend to the lower ratio area.

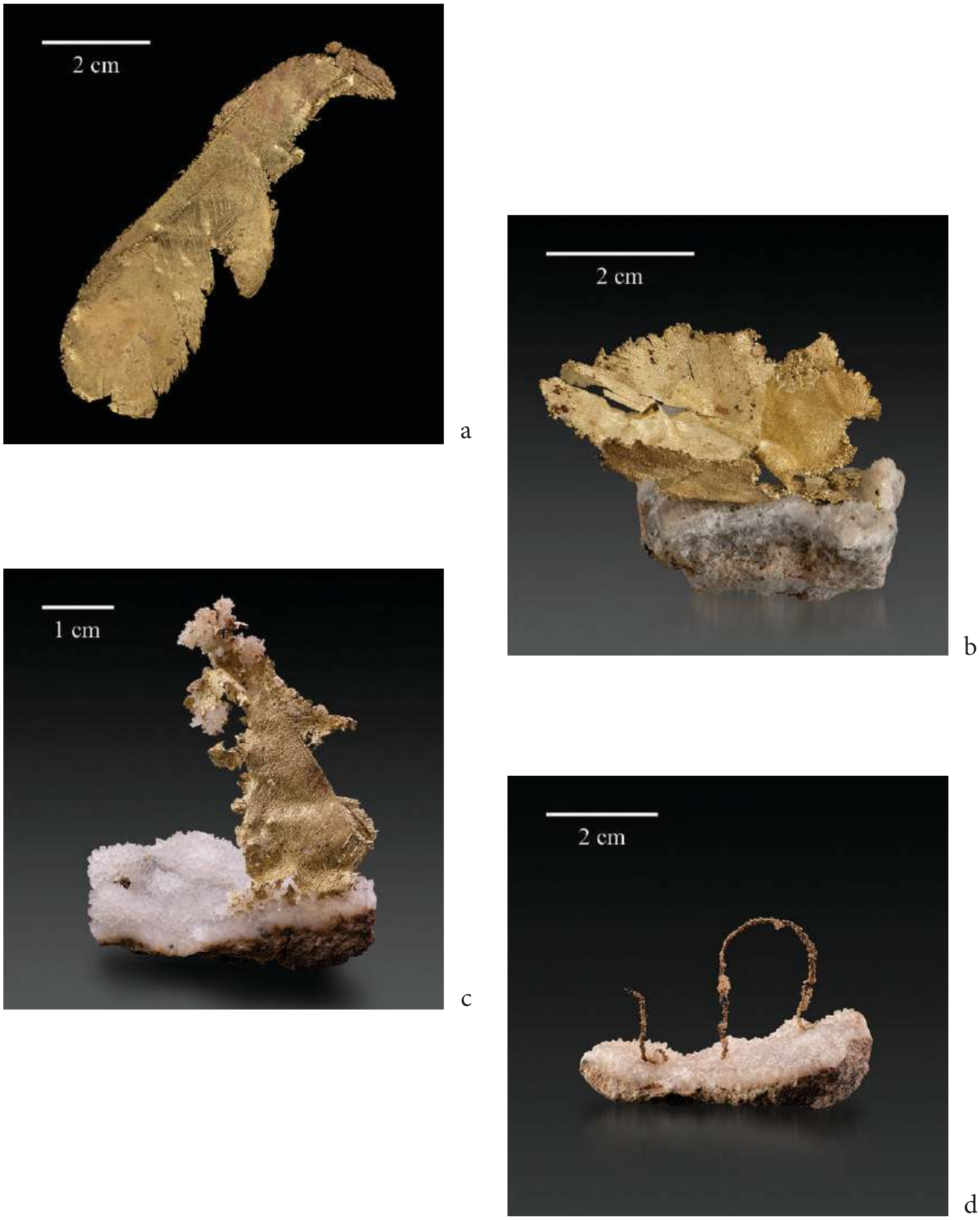


Plate VIII. Musariu: a) “the Polar Bear” – macrolamellar gold with dendritic patterns (sample 1203); b) lamellar and dendritic gold on quartz – “the Sitting Hen” (sample 1206); c) macrolamella of gold marginally intergrown with quartz, on geode of microgranular quartz, macrolamella with skeletal pattern (sample 1274); d) crystals of native gold, aggregated as threads on quartz, in association with sphalerite (sample 1350)

Plate IX. Musariu: a) microlamellar gold intergrown with centimetric lamellar excrescence – “Eminescu’s writing plume” (sample 1306); b) intergrowth of skeletal gold – “the Cannon of Avram Iancu” (sample 2278); c) microgranular gold intergrown with quartz in the middle of a quasi-concentric texture with chalcopyrite and calcite “The Great Romania” (sample 1317); d) zoomorphic intergrowth of skeletal gold (minilamellae and dendrites of gold) – “the Lizards” (samples 2277, 1310)

Economic geology and mining history of Brad mining area. The mining region around Brad is formed of the mining districts of Ruda-Barza, Valea Morii-Valea Arsului and Musariu-Dealul Fetii. It gained importance after 1840, through the settlement of „Ruda 12 Apostoli” Association, taken over after 1884 by the mining company „Harkot’sche Bergwerke und Chemischen Fabriken zu Schwelm und Harkoten, Aktiengesellschaft zu Gotha”, which invested in the area and turned the gold mining into a profitable business until the years of the First World War (Wollmann, 2010).

After World War I, modern and extensive mining works were executed at Musariu. The main galleries were: Hârnicu – employed as airway towards the end of the operation, Musariu and Trei Crai – inaccessible, Sf. Anton – which gave access to a secondary deposit, Ludwig and Maria, which served for secondary access (Baron, 2006).

a

b

Plate X. Musariu: a) assemblage of gold dodecahedra on quartz and sulfides – “the Discobolos” or “the Ballerina” (sample 1535); b) biomorphic gold as dendritic lamellae – “the Dragonfly” or “the Fern” (sample 2264)

The length of the operating field at Musariu is 1800 m, 100-200 m (sometimes 400 m) wide and 400 m high. The vein thickness varies from a few centimeters to a few meters. The mining galleries opening this deposit describe a true maze and start from Elena shaft, dug under the supervision of A. Sieber, in 1911, and from Puțul Nou shaft. The optimal mineralization area of the Musariu vein network has the form of an oblique column, oriented NW-SE direction and developed around Henrieta shaft, through Clara, Elena and Carpen. The NW end is called Musariu Vechi. These veins were rich in upper parts of the deposit, whereas Carpen vein has been mined to the surface. Old documents mentioned that on 6th of November 1891, at the intersection of Clara and Carpen veins, at Maria horizon, 55 kg of free gold were found (Brana , 1958).

Data from the archive of "MICA" company indicates a mineralization dominated by visible native gold, which accounted for 70 % of the operation output. The remaining annual production of 30 % was about 70,000 t ore, which meant a production of approx. 1000 kg gold (Baron, 2006).

3.4.2. Valea Morii metallogenic field

The Valea Morii ore deposit contains the mineralization located southwards of Criscior, in Valea Arsului, Valea Gârdei and Cireșata, and consists of two vein groups: Valea Morii Veche, on the eastern and south-eastern fringes of Barza neck (Fig. 3.21), in Sarmatian quartz andesites, breccia and Lower Miocene sedimentary, and Valea Morii Nouă, associated with the andesite-microdiorite subvolcanic body of same denomination, rooted in the ophiolitic formations; towards surface, where it intersects Badenian formations and Barza stratovolcano, it tends to become splay. The ore deposit is crossed by a fissure and mineralized fracture system, with N-S orientation, concordant with the long axis of the structure.

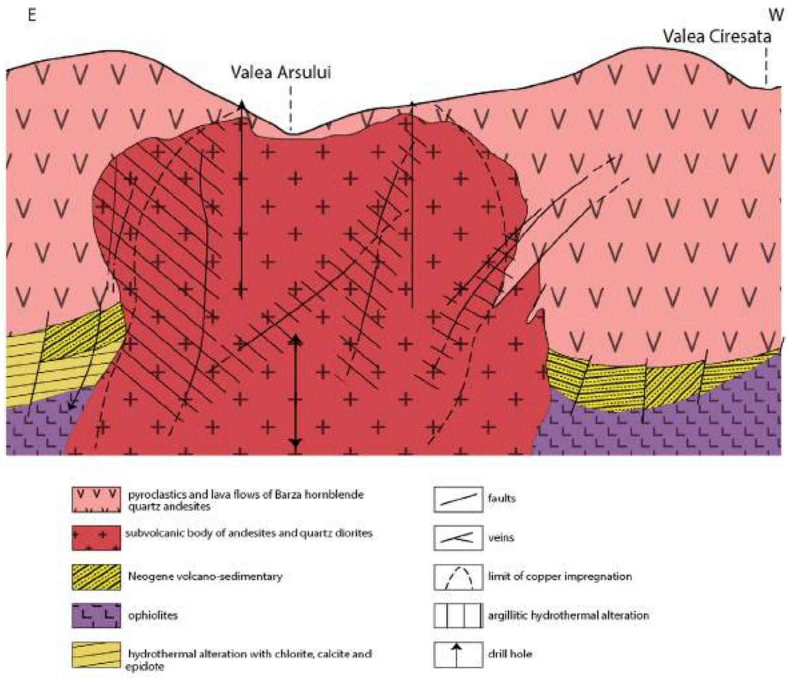


Fig. 3.29. Geological cross section through Valea Morii Nouă ore deposit (redrawn after Ghițulescu, in Ianovici *et al.*, 1969)

Valea Morii Veche vein group consists of exhausted Au-Ag ± Pb, Zn veins (Francisca, Hermina, Tuliu, Filonul Nou, Filonul B, Liegendtrumm I and II) and their ramifications. The veins had a high content of native gold, associated with galena and chalcopyrite.

Valea Morii Nouă vein group (Fig. 3.29) represents the southward extension of the above mentioned group, together with which reaches a total north-south length of over 2 km, 300-400 m wide, and 0.1-1 m thick (Berbeleac, 1998). The northern half contains a *porphyry copper* mineralized column. The gold and sulfide veins have been known since a long time, but the most significant were: 10 Antoniu Plumb, 10, 9 and 8, 7, 82 vein group, B and Cireașa. The ore contains "free" gold, sphalerite with gold inclusions, galena, chalcopyrite, quartz, baryte and clay minerals. The gold rich zones are depleted.

There are numerous samples of native gold from Valea Morii in the Gold Museum, many of them with predominant lamellar morphology (Plate XI): lamellar gold with pellicle of iron hydroxides, at the bottom of a quartz intergrowth (1090); lamellar gold, partially with pellicles

of iron hydroxides and quartz overgrowths (1091); lamellar gold with quartz overgrowths on one side and oxides and sulfides on the other side, all grown on quartz geode (1096); lamellar gold with pellicles of iron hydroxides enclosed in sphalerite (1107); lamellar, dendritic and skeletal gold, on quartz (1110); lamellar and skeletal gold, intergrown with iron hydroxides, on crust of quartz (1111); microlamellar gold on fissures in calcite (1127); lamellar gold on bluish quartz vein (1114); lamellar and skeletal gold on white quartz (1163); lamellar and prismatic gold intergrown with bipyramidal quartz – "The Little Boat" (1537); lamellar gold with pyramidal tetrahedral excrescences (1538); lamellar gold, partially dendritic, on quartz (2227); lamellar-dendritic gold on quartz – "Victory" or "The Eagle" (2228); lamellar, granular, dendritic and skeletal gold, sometimes as agglomerations (2254); lamellar gold associated with lamellar baryte and quartz (2256); lamellar gold with triangular patterns and quartz overgrowth (2265); lamellar, marginally dendritic gold, with triangular patterns (1790); lamellar gold with quartz overgrowths (1970); lamellar-dendritic gold with pellicles of iron hydroxides, on a quartz geode (1118); aggregate of lamellar gold partially dendritic, partially covered by pellicles of iron hydroxides (1817, 1819); lamellar and dendritic gold intergrown with sulfides on quartz (2226); dendritic lamellar gold intergrown with quartz (2273); lamellar-dendritic gold with quartz overgrowth (2276); lamellar and fibrous gold intergrown with calcite (2182); dendritic and lamellar gold, intergrown with sphalerite in dissolution voids of a crustiform quartz (2301); dendritic gold intergrown with dolomite on quartz and sulfides (2300); lamellar-dendritic gold with zoomorphic aspect, intergrown with sphalerite – "The Cobra" (1088); dendritic, lamellar, compact gold, intergrown with quartz (1089); gold on friction plane, precipitated along friction grooves (1092); skeletal and lamellar gold in compact aggregate (1097); skeletal gold intergrown with quartz and iron hydroxides (1112); skeletal gold intergrown with microgranular euhedral quartz, in the voids of a crustiform quartz (2181); skeletal and lamellar gold in compact aggregates (1976); skeletal, partially lamellar gold intergrown with sphalerite, on euhedral quartz (2225); dendritic gold (2024); dendritic-lamellar gold intergrown with baryte, with pellicles of iron hydroxides, on microcrystalline quartz (1131); microgranular dodecahedral gold, associated with crustiform intergrowths of quartz and sulfides (1149); microgranular and lamellar gold in vein with yellowish sphalerite and white-violet quartz (1152); microgranular and lamellar gold in bluish quartz at the bottom of violet quartz aggregate (1153); gold in bluish quartz at the bottom of amethyst geode (1154); granular euhedral gold in quartz geode (1532); granular, euhedral, millimetric gold, intergrown with skeletal galena (1547); millimetric grains of gold intergrown with sphalerite (1548, 1612, 1985, 1962); dendritic gold associated with quartz, sphalerite and tetrahedrite in a geode (1597); powder of skeletal gold on sphalerite (1963); zoned and lamellar gold, with overgrowths of iron hydroxides, on quartz geode (1143); gold-sphalerite-quartz-carbonates assemblage; lamellar-dendritic gold in vein ore with sphalerite and carbonates (1151).

The Au:Ag ratio at Valea Morii is located towards the rich-end of the variation range for Barza metallogenic node (Fig. 3.26).

Economic geology and mining history of Valea Morii metallogenic field. The Valea Morii-Hărțăgani mine was operated through Francisca, Hubanec, Antoniu and Ferdinand galleries, located on both slopes of Arsului Valley. In 1930, Antoniu gallery, derived from 1 Mai (Victor) gallery, intercepted the 7, 8, 9, 10 (Antoniu) and Plumb veins. Neither of these veins crop out.

- *The 10 (Antoniu) vein* is considered one of the richest veins in Romania (Jude, 2011), yielding over 7000 kg, or even more, according to other sources, *i.e.* 12.000 kg gold. The vein is located in propylitic and partially kaolinitic andesites, and had an initial 600 m in length long, and 50–60 cm in width. The vein was mined across 7 horizons (210 m). The mineralogy includes quartz, amethyst and rare calcite gangue, "free" gold, especially between 1 Mai (Victor) and III (+ 90 m) galleries, but also galena, sphalerite, chalcopyrite and tetrahedrite**. The Museum hosts several samples from this vein, in the form of bunches of gold crystals, up to 3-4 mm.** Below the level of 1 Mai (Victor) gallery, the gold content was much lower (Brana, 1958).

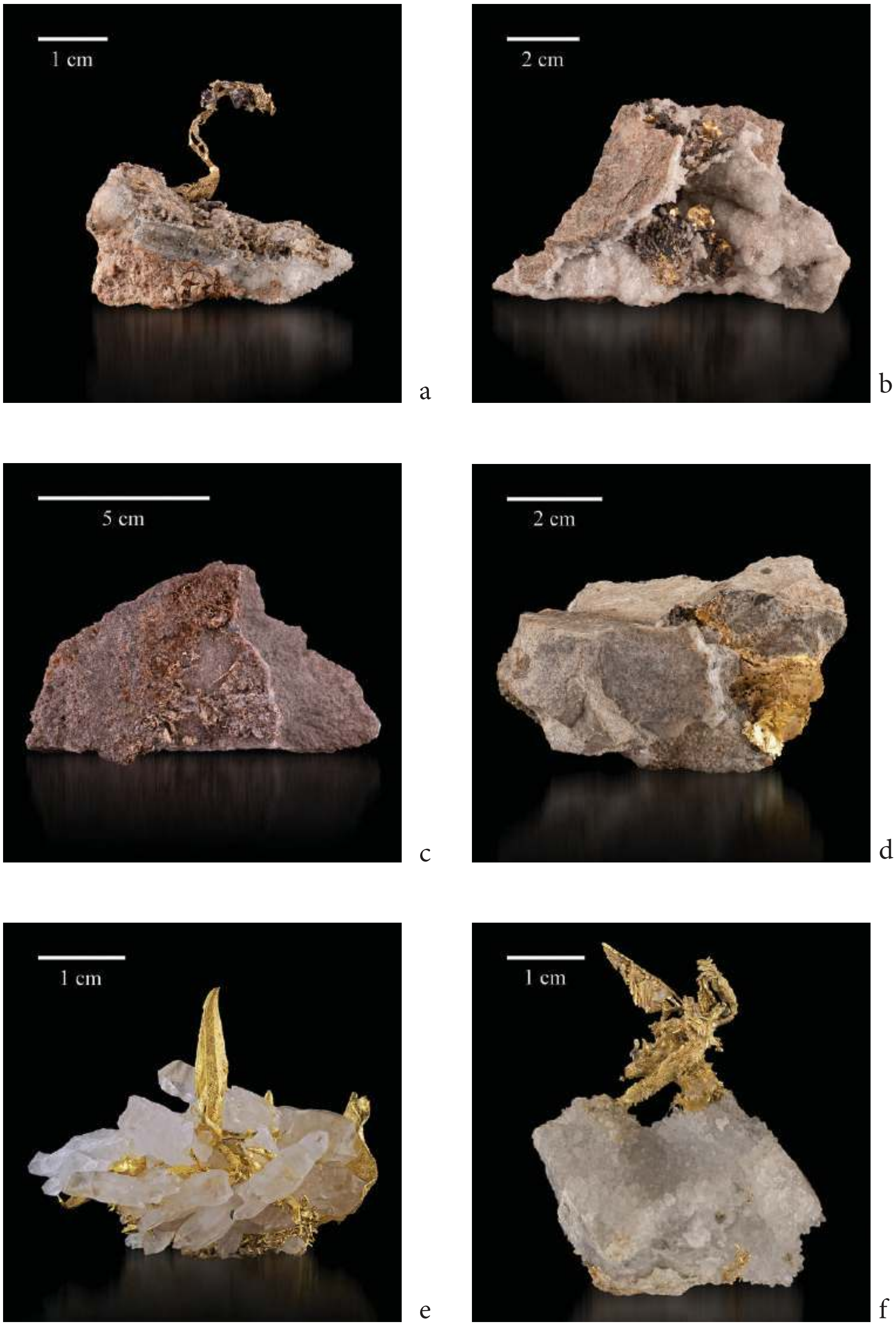


Plate XI. Valea Morii: a) lamellar-dendritic, zoomorphic gold intergrown with sphalerite – "The Cobra" (sample 1088); b) lamellar gold, partially covered with pellicles of iron hydroxides and quartz overgrowths (sample 1091); c) lamellar, dendritic and skeletal gold, on quartz (sample 1110); d) lamellar gold on a vein of bluish quartz (sample 1114); e) lamellar and prismatic gold intergrown with bipyramidal quartz – "The Little Boat" (sample 1537); f) skeletal and lamellar-prismatic gold on quartz – "The Eagle" (sample 2228)

- *The Plumb vein* is known on a length of 600 m, and has roughly the same mineralogy as 10 Antoniu vein, but is richer in sulfides. It was mined in the upper parts where the gold content was higher. The 8, 9, 10 Plumb veins contained a reserve of over 1 million t of ore, yielding annually approx. 35000-58000 t ore, at an average grade of 15-30 g/t gold and approx. 1000 kg gold/year (Baron, 2006, after Ghițulescu and Socolescu, 1941).

As the fame of the 10 (Antoniu) and Plumb veins diminished, the importance of the lower horizons of the Ilie Pintilie (Petru and Pavel) mining field increased, especially through a new transversal NE gallery dug from 1 Mai (Victor) gallery, which opened several gold veins up to 0.2-3 m. These veins yielded large amounts of amalgamable ore.

On 1st of August 1948, the administration of the mining operations owned by "MICA", including Valea Morii, was taken over by Brad Regional Directory (Baron, 2006).

3.4.3. Căinel-Băiţa-Hărţăgani metallogenic node

It contains the mineralized structures in the basin of Băiţa Valley. The structures are aligned along a NW-SE fracture system located on the south-west limit of Brad-Săcărâmb Basin. The metallogenic activity resulted in three major mineralized fields: Căinel, Băiţa and Draica.

Căinel Ag-Au Metallogenic field is hosted by Căinel compound volcano which was formed during two volcanic phases: Fața Băii andesites and Căinel andesites, respectively.

X-ray diffraction investigation of samples from Căinel metallogenic field has helped in identifying several new mineral occurrences: pyrargyrite, calaverite (sample 1364); tetradymite, altaite, krennerite, sylvanite (sample 2193).

The museum samples from Căinel contain both native gold and native silver: microgranular gold on quartz (1058); microgranular skeletal gold with pellicles of iron hydroxides in vein quartz and small geodes with gold microlamellae (1358); microgranular gold on quartz with sphalerite (1359); lamellar gold (1844); gold lamellae on argillized rock, partially covered by iron hydroxides with quartz (1846); microgranular and lamellar gold associated with quartz, yellowish sphalerite and nacrite (1848); lamellar and granular gold with pellicles of iron hydroxides in quartz veinlet (1977, 1978). In their majority, the samples contain in turn native silver. Căinel is in fact, *the most silver-rich occurrence in the entire* "Golden Quadrilateral" (Fig. 3.30). The following samples from Căinel were observed to contain native silver: native silver threads in calcite geode, with silver sulfosalt borders, pyrite and dolomite (1362); silver wires in calcite geode (pagoda-shaped twin) with argentite and pyrite (1363); native silver and argentite in geode with dolomite and calcite and silver sulfosalts (pyrargyrite) (1364); fibrous silver with dolomite in quartz and sulfides vein (1366); felt-like silver in geode with dolomite and quartz with argentite and common sulfides (1367); thread-like silver in geode with dolomite, sulfides and microgranular gold (1371); felt-like native silver in geode with carbonate, argentite, common sulfides and quartz (1374); silver wire in geode with quartz and carbonates with galena and yellowish sphalerite (1845); sulfides, dolomite, microgranular baryte and sporadic native silver wires (1843).

Băiţa Au-Ag metallogenic field consists of mineralized veins and breccia controlled by a NW-SE fracture system located in the rooting area of Băiţa volcano.

The mineralization is rich in sulfides (transparent sphalerite, galena intergrown with quartz), pyrargyrite, argentite and native gold (Popescu, 1986).

In the Museum, the native gold is represented by specimens with gold nests, small lamellar crystals associated with baryte, galena and sphalerite on microgranular quartz in geode (1933), or microgranular gold with sulfides and carbonates, intergrown on quartz (1935).

Hărţăgani-Căinel metallogenic field. Hărţăgani village belongs to Băiţa commune, Hunedoara county. Here, „the kaolinized occurrences" have been investigated with Elisabeta, Baia la Nuc, *etc.* galleries. The host rock of the mineralization is represented by andesites intruded in ophiolites, which extend towards NW to Cireşata area.

Fig. 3.30. Wire-shaped native silver. Căinel

As a result of the X-ray diffraction measurements the following new mineral occurrences were identified for Hărțăgani field: altaite, tellurantimonite, petzite, calaverite, hessite, tellurite, nagyágite, discrasite, coloradoite, goldfieldite.

In the museum display reserved to Hărțăgani ore deposit, there are several specimens with visible native gold and tellurides (Plate XII): lamellar gold in manganese carbonate, associated with sulfides and tellurides (calaverite?) (95); gold intergrown with sulfides (pyrite, sphalerite, galena), tetrahedrite and tellurides (98); sulfides and tellurides (altaite, coloradoite, discrasite) disseminated on argillized rock with carbonates (102); tetrahedrite, galena and tellurides (tellurite, calaverite, nagyágite) in argillized rock (5129); pyrite, galena, sphalerite, tetrahedrite, hessite, calaverite, marcasite (5130).

Curechiu-Hărţăgani mine. North of Coasta Mare, on the territory of Curechiu and Hărţăgani villages, the exploration works carried out by "MICA" company have revealed a lens-shaped ore deposit with native gold and tellurides (petzite, and rarely, calaverite). "Free" gold occurs in pyrite diaclases (Brana, 1958). **Samples from Curechiu hosted by the Museum: breccia with carbonates, sulfides and tellurides (altaite, coloradoite), discrasite (101); geode with dendritic lamellar gold in quartz vein (1373); sphalerite, tetrahedrite, carbonates, rarely pyrite and quartz (5114); sphalerite, galena, chalcopyrite, pyrite, quartz, chalchanthite with tellurides (altaite, krennerite), sulfosalts (tetrahedrite, enargite) with pellicles of iron hydroxides and clay minerals (5115); gold ore with sulfides in zoned texture (5118).**

Economic geology and mining history of Căinel-Băița metallogenic node. Of the 22 mine adits from Ormindea-Căinel-Măgura Băii region, the most significant one was Principesa Georgina (Căinel), dug in 1884. Between 1892 and 1897 the mining was extensive, yielding 13,500 t of ore, at an average grade of 30 g/t Au and 210 g/t Ag. The production reached 730 t of concentrated ore, 436 kg gold, of which, about 75% "free" gold. A ramification of the gallery extended all the way to Măgura Băii (Baron, 2006).

In 1940, Haiduc wrote that the mining area around „Ruda 12 Apostoli" vein group, located between Brad, Luncoiu de Sus, Luncoiu de Jos, Ormindea, Căinelul de Sus, Hărţăgani, Bucuresci, Criscior and Tărăţel, at a grade of 4-35 g/t gold, is one of the most significant in the "Golden Quadrilateral" where the average grade is around 10 g/t Au. In Băiţa deposit, the gold content reached 7 g/t (Baron, 2006).

Băiţa mine is located at approx. 20 km north of Deva. Systematic workings were carried out since 1887, when Henrich (Crăciunești) gallery encountered several veins, of 2000 m in length. The 800 m long Şuhaida vein, was the most important; it is hosted by breccia "around a chimney of rhyolites, where a stockwork has formed (...) where sometimes, nests rich in "free" gold could be found". The deposit has been extensively exploited through the Hartman pit, which reached up to 210 m below the main gallery (Brana , 1958).

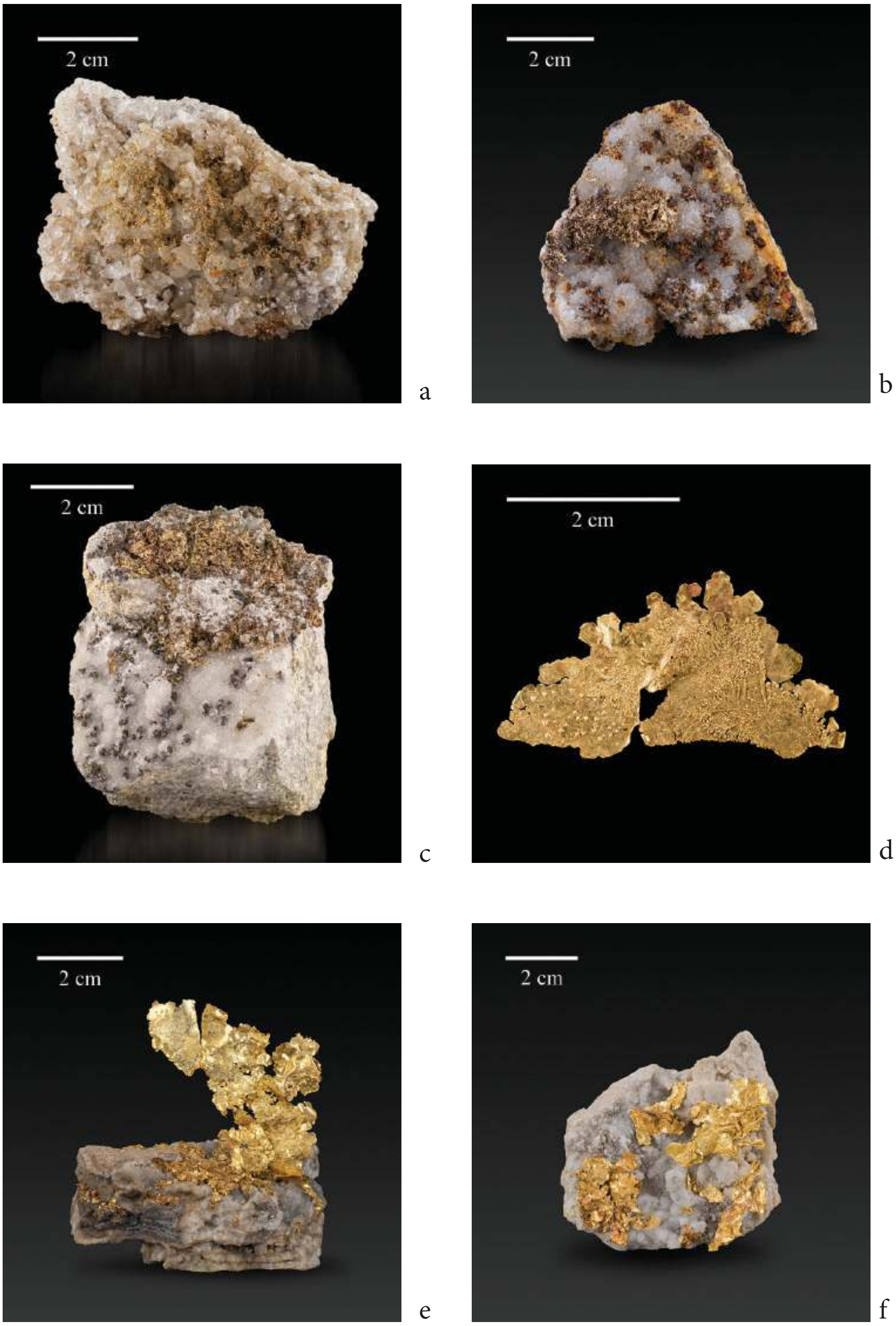


Plate XII. Hărţăgani: a) lamellar gold in manganese carbonate associated with sulfides and tellurides (calaverite?) (sample 95); b) gold intergrown with sulfides (pyrite, sphalerite, galena), tetrahedrite and tellurides (sample 98); c) sulfides and tellurides (altaite, coloradoite, discrasite) disseminated in argillized rock with carbonates (sample 102); Hondol: d) gold lamellae with pyramidal excrescences (sample 2279); e) gold macrolamellae de gold with pyramidal excrescences of variable size and density (sample 2286); f) macrolamellae de gold with pyramidal excrescences on chalcedony (sample 2287)

3.4.4. Trestia-Măgura-Hondol metallogenic node

Represents an ample metallogenic episode, favored by the tectonic and structural environment developed at the intersection of NW-SE and E-W fracture systems, where an intense intrusive and extrusive activity took place. The volcano emission centers are oriented along NW-SE and E-W. The mineralization associated with the volcanic structures within this metallogenic node may be divided into two metallogenic fields: Troiţa-Măgura and Hondol-Băiaga-Bocşa (Popescu, 1986) (Fig. 3.31).

Troiţa-Măgura metallogenic field. The mineralization is predominantly gold-silver and subordinately gold-polymetallic, partly copper. The spatial control is exerted by a N-S tectono-volcanic alignment. Trestia, Magdana, Troiţa, Măceşu-Măgura are among the numerous vein groups in this metallogenic field (Popescu, 1986).

*Trestia Au vein group***.** It is located at the contact of the andesitic body in Runcu Hill with the ophiolitic formations and has a NNW-SSE direction. A particular case is represented by the lens-shaped body of pyrite, sphalerite and galena in Runcu Hill, formed as a result of a hydrometasomatosis on behalf of Jurassic limestones in contact with ophiolitic formations.

The gold content in the native gold of Hondol is higher in comparison with that of Troița (Fig. 3.32).

The samples from Trestia in the Gold Museum show: dendritic, granular gold, with sphalerite, on quartz (2133); microlamellar and skeletal gold with pellicles of iron hydroxides, in a quartz geode (2143); dendritic and lamellar gold intergrown with sphalerite, on quartz (2156).

Troiţa Au vein group. It consists of two vein systems of ample extension and with significant metal contents. The veins contain areas with rich ore located at the intersection of two vein systems which form this vein group. In the enriched zones, the native gold intergrowths with quartz, in a characteristic assemblage (Popescu, 1986).

Several samples from Troița show the following features: microgranular gold intergrown with microcrystalline quartz, sphalerite and galena + lamellar zoned baryte (1582); nest with skeletal-lamellar gold with bipyramidal quartz, on quartz granular (1930); nest of lamellar gold with sulfides, in pyramidal quartz geode (1931); dendritic lamellar gold intergrown with quartz and sulfides (1932); lamellar gold with stibnite on microcrystalline quartz (1934).

Hondol vein group. Several old mining works are still visible in the mining zone, especially on Coranda-Teiul Hill. Of the seven main galleries, only Regina gallery and Carol and Împărătesc pits yielded favorable results, through the discovery of veins with "free" gold, sulfides and sometimes realgar and orpiment. These works were mined down to 80 and 106 m. Other veins were rich in mineralization with native gold and sulfides in a compact quartz gangue (Baron, 1958, 2006).

The gold samples from Hondol are especially beautiful (Plate XII): lamellar gold with pyramidal excrescences e (C.35); lamellar gold on milky quartz and dendritic gold intergrown with sulfides (1696); gold lamellae with conspicuous pyramidal excrescences (2279); lamellar gold with pyramidal excrescences, mounted on quartz (2280); gold macrolamellae with pyramidal excrescences of variable size and density (2286); gold macrolamellae with pyramidal excrescences on chalcedony (2287).

Economic geology and mining history of Trestia-Măgura-Hondol metallogenic node. Few kilometers south-east of Băiţa a mining center existed around a group of veins which were mined separately until 1888, when they were taken over by the „Goldbergbau Füszed-Trestia" company (Baron, 2006). In 1958, Brana mentioned the Troiţa-Trestia-Topliţa mine, with five significant fields: Trestia, Magdana, Troiţa, Piţiguş and Măceşul. The company carried out important mining works, especially along Grimm transversal gallery which spanned along 3000 m and opened the veins of Trestia, Troiţa, Piţiguş and Măceşul groups. The vein length was of approx. 600 m.

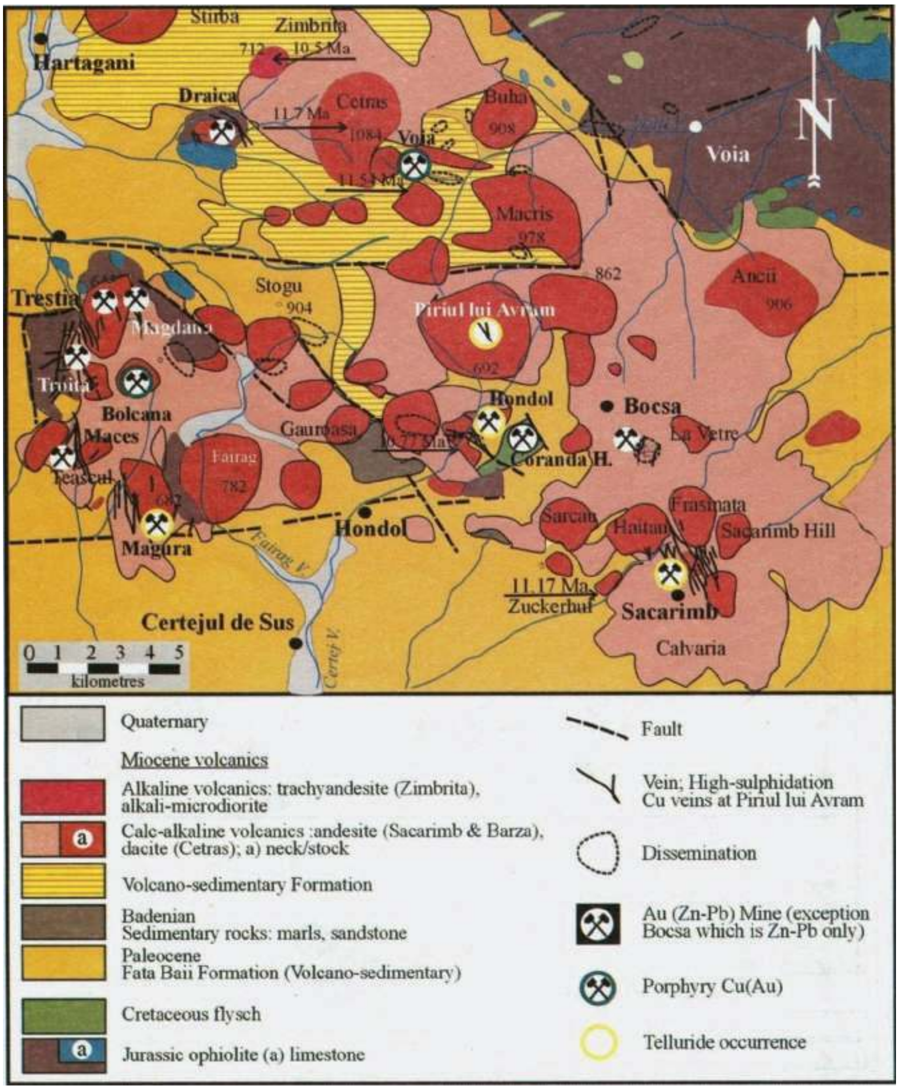


Fig. 3.31. The geological map of Trestia-Hondol metallogenic node and of Săcărâmb vein field, compiled from various sources (Ciobanu *et al.*, 2004)

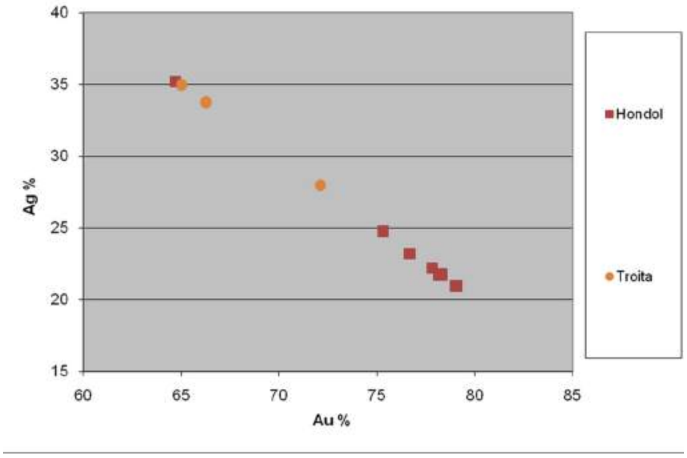


Fig. 3.32. The variation of Au/Ag ratio in native gold samples from Trestia-Hondol metallogenic node

3.4.5. Săcărâmb metallogenic node. The regional position of Săcărâmb metallogenic field is controlled by an intersection of two fracture systems oriented NW-SE and E-W. The distribution of veins is controlled by the morphology of the andesitic pillar which represents the core of the caldera structures. Several adventive eruption centers are still conspicuous in the relief of Haitău, Frăsinata and Săcărâmb hills (Fig. 3.33). The volcanic activity products consist of amphibole andesites, pyroxene andesites and biotite ± pyroxene andesites.

The Săcărâmb ore deposit was discovered in 1740 and actual mining operation began in 1745. The total length of the mining works was of about 150 km. The metallogenesis from Săcărâmb has become famous due to its mineralogical peculiarities, especially of its richness in tellurides.

Săcărâmb is the *locus tipicus* for: krennerite $(Au,Ag)Te_2$, muthmanite $(Ag,Au)Te$, nagyágite, $Pb(Pb,Sb)S_2(Au,Te)$, petzite Ag_3AuTe_2, stutzite $Ag_{5-x}Te_3$, krautite $Mn^{2+}As^{5+}O_3(OH)\cdot H_2O$, alabandite MnS. Minerals such as frohbergite $FeTe_2$, tellurantimonite TeSb and tellurite Te_2O were for the first time described in Romania, at Săcărâmb.

The ore deposit consists of four vein groups oriented in a rectangular pattern: Nepomuc and Magdalena-Carolina groups, oriented NE-SW, and Longhin-Antelonghin and Ertzbau groups, with NW-SE orientation. There are 12 Longhin veins and 21 Antelonghin veins. The veins have anastomozing ramifications which intersect in the upper part of the deposit (Fig. 3.33).

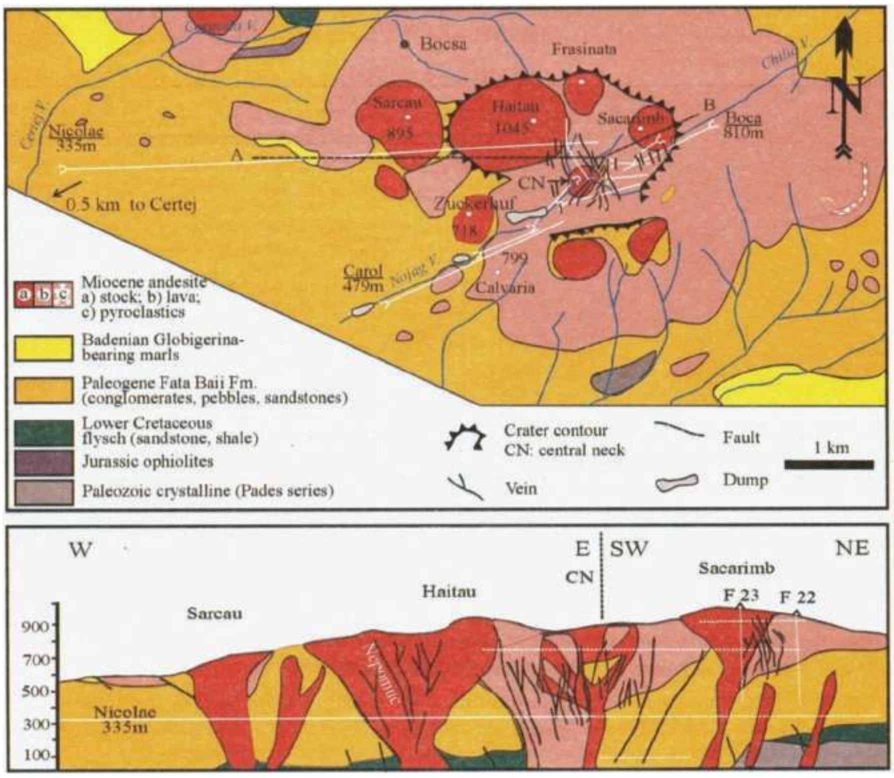


Fig. 3.33. Geological map and cross-section through Săcărâmb ore deposit (after Udubaşa *et al.*, 1992, Berbeleac *et al.*, 1995, in Ciobanu *et al.*, 2004)

The native gold samples from Săcărâmb display a clear image of the typical minerals from this ore deposit (Plate XIII): nagyágite, sylvanite and alabandite. The gold is less spectacular and frequent at Săcărâmb: microgranular and microlamellar native gold in nests, disseminated in silica, with carbonates, with petzite and calaverite (2095); petzite, calaverite, krennerite and lamellar native gold (2098); microlamellar gold on quartz, alabandite and microgranular gold (2097); nests of gold and tellurides (calaverite, krennerite, nagyágite) (2110). Nagyágite – which identifies itself with Săcărâmb, is the best illustrated by spectacular specimens: nagyágite intergrown with vein-

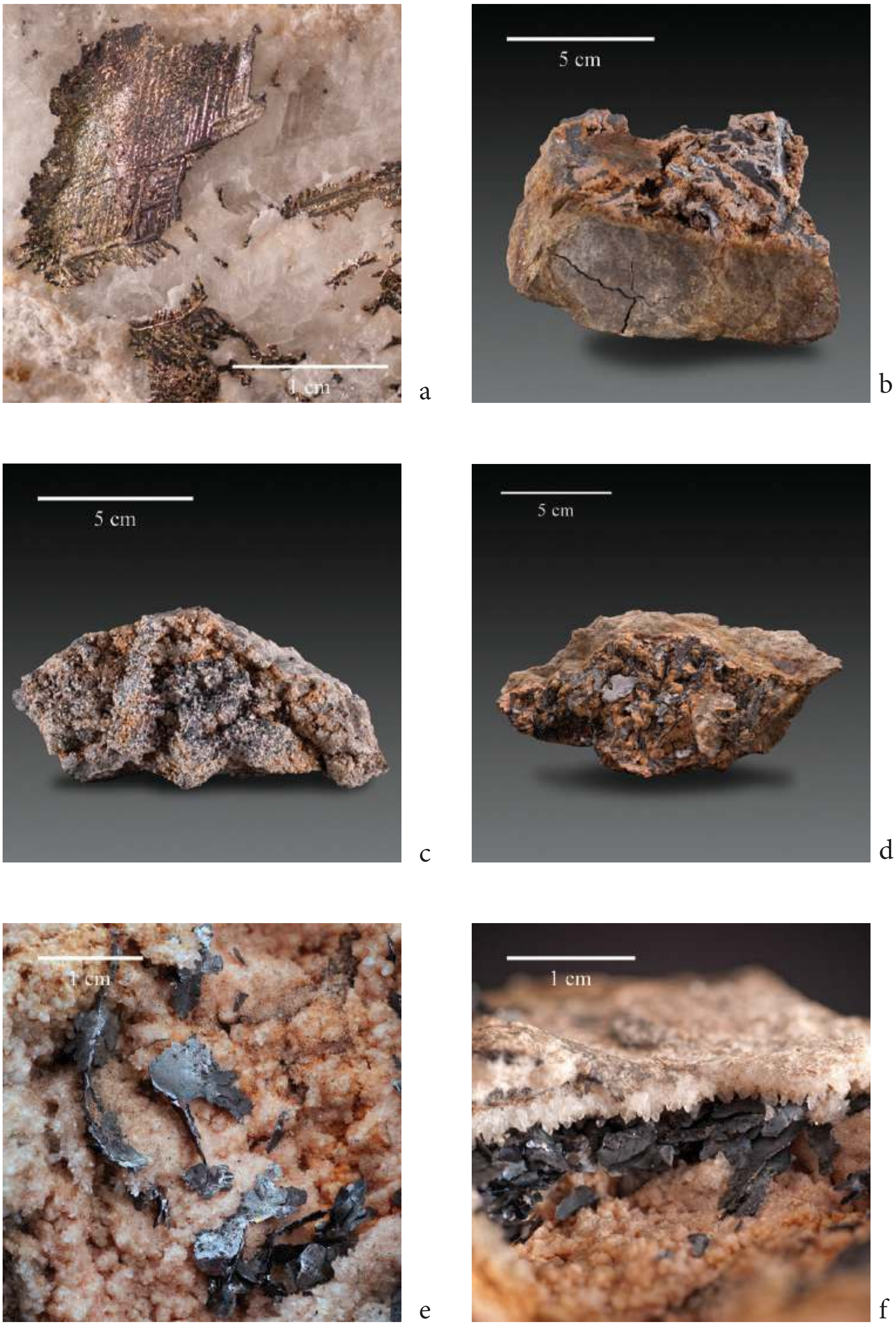


Plate XIII. Săcărâmb: a) prismatic crystals of sylvanite, on quartz crust (sample 8); b) nagyágite intergrown with vein-shaped rhodochrosite (sample 2074); c) finely lamellar nagyágite intergrown with rhodochrosite, quartz and sylvanite (sample 2075); d) lamellar nagyágite with rhodochrosite and quartz (sample 2076); e) and f) lamellar nagyágite and rhodochrosite (sample 2077)

shaped rhodochrosite (2074); finely lamellar nagyágite intergrown with rhodochrosite, quartz and sylvanite (2075); macrolamellar nagyágite on quartz intergrown with sphalerite (2079); lamellar nagyágite intergrown with rods of sylvanite and gold (2081); lamellar nagyágite, alabandite and rhodochrosite (2083); nagyágite, sylvanite, rhodochrosite with spotted texture (2084); lamellar nagyágite with quartz (2086). The second most-frequent telluride at Săcărâmb is sylvanite, also represented by nice specimens, especially in what concerns its association with other tellurides: prismatic sylvanite in carbonatic vein, with nagyágite, petzite and microgranular gold (2090, 2092); prismatic crystals of sylvanite, on quartz crust (8); veinlet with sylvanite, petzite, nagyágite in hydrothermally altered andesite, intergrown with quartz (2091); sylvanite, krennerite, petzite, intergrown with quartz (2093). Alabandite was also found to have its *locus tipicus* at Săcărâmb (Udubașa *et al.*, 2002), but unfortunately, the Museum owns only one sample of this rare sulfide, that is sample 2085: alabandite and quartz with tellurides (calaverite, krennerite).

***Economic geology and mining history of Săcărâmb metallogenic field*.** Starting with the mid 18th century, mining has become the main activity in Săcărâmb. The starter of the mining activity was Ludwig von Born, a retired artillery officer and owner of Certej-Hondol mine, and father of famous mineralogist Ignaz von Born (Wollmann, 2010). Ludwig von Born was involved in the settlement of mining stock company. The operation began with Buna Vestire (Maria Veche) gallery, from which approx. 14 kg gold and 19 kg silver were extracted in 1748 alone. By the end of the same year, after von Born's death, her spouse offered at no charge to Empress Elisabeth of Austria, 16 "kuxen" (shares), which was decisive for the continuation and future of mining at Săcărâmb, which went uninterruptedly until the World War II. The Imperial Family later bought another 22 "kuxen", whereas the state, bought through the Montanistische Aerarium, 32 "kuxen". In 1748 the mining operation at Săcărâmb became state owned, and the Aeraric clerks got involved in the monitoring of works. Thus, as early as 1748 the digging of Maria Nouă gallery begun, with the aim to open as many mining fields as possible. During the late 18th century, the state faced serious competition from the private enterprises who opened a series of galleries in Valea Strâmtă (Baron, 2006).

In 1835, the *Superior Technical Mining School* has been settled at Săcărâmb. The school continued to function until World War II. Numerous experts of repute taught here, such as Johann Grimm who published in 1839, at Vienna, a manual destined for the students of Săcărâmb, and Josef Franzenau (1802—1862), professor of natural sciences and one of the most reputed butterfly collectors in Transylvania. Franzenau was awarded with the highest imperial distinctions for its outstanding merits as chief administrator of the mines. After Frazenau's death, his pupils erected a cast iron monument at Govăjdia, in Hunedoara County.

In 1796, Felix Franzenau invented the pressurized ore washing machine and built an animal traction winch in order to spare the human force.

In 1797, Munteanu Urs(u) invented a machine for gold ore washing by means of a barreled lift wheel; he also improved the hydraulic stump crushers, by adding an extra gear (Wollmann, 2010).

At the end of the World War I, in 1919, all the mining and metallurgical assets owned in Transylvania by the Hungarian state passed into the property of the Romanian state which operated the mines through *Regia Întreprinderilor Miniere and Metalurgice ale Statului din Ardeal* (R.I.M.M.A), which included the gold mines at Săcărâmb. According to the *Mining Statistics of Romania for the year 1921* (Baron 2006), *The State Service for Metallic Mines Săcărâmb* was one of the main precious metal producers in Romania.

The first regular hydraulic stump crushers in Transylvania were built at Săcărâmb, in the 19th century. By the end of the 20th century, similar stumps were in operation at Certej. After World War I the mine was in a disastrous situation, with a production of only 7.723 kg gold in 1919, to reach 19.955 kg gold, only by 1927. As early as 1928 attempts were made to extract gold from the quartz low grade ore from Zlatna Metallurgical Plant and from the mining waste dumps. As long as the underground operation developed in high grade ores of over 50 g/t, it was obvious that the mining waste dumps had much lower gold contents and that the residual ore was highly altered, thus making it improper for processing. The studies carried out in 1932 on methods of gold extraction from waste dumps found that the best ore processing procedure was the flotation of a low-grade waste material mixed with fresh, low-grade gold ore. Therefore, in 1935 the stumps were replaced with a modern flotation built at Certej, with a processing capacity of 250 t/day and fed with a mixture of 30 % fresh ore, 30 % tailings and 40 % waste dump material.

The gold production rose from 68.963 kg gold in 1932 to 274.912 kg gold in 1935. By the beginning of World War II the production reached approx. 300 kg gold and approx. 500 kg silver/year (Baron, 2006), at an average grade of 7, 3 and 2 g/t Au and 25, 11 and 4 g/t Ag in flotation, tailings and waste dump, respectively.

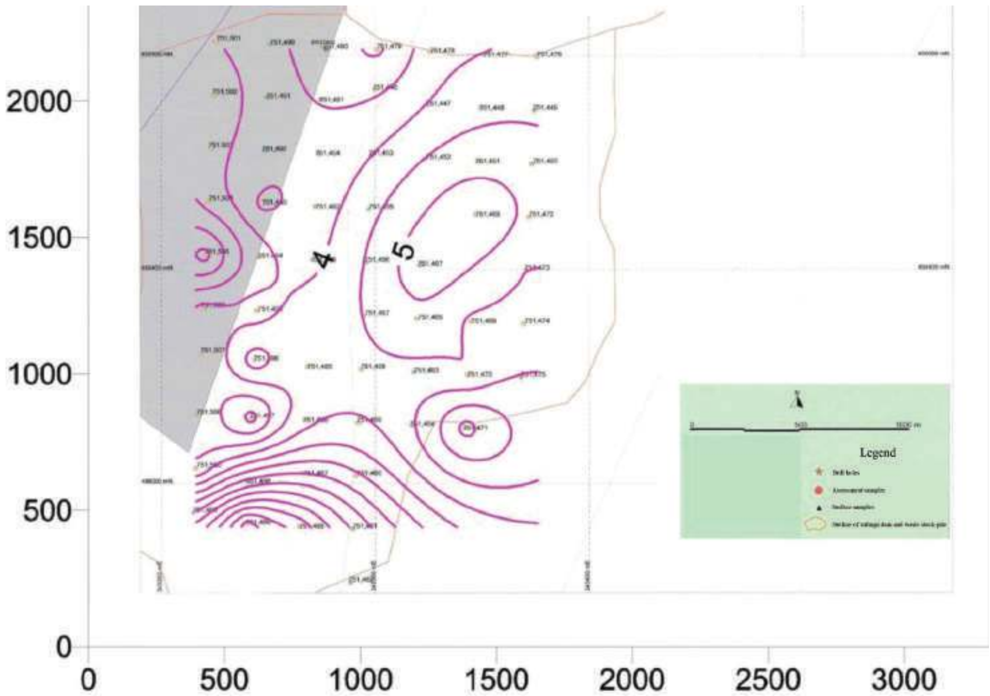


Fig. 3.34. Map of tellurium distribution in the damaged tailings pond of Certej

In 1940 R.I.M.M.A became „Minaur" and, after the loss of north-west part of Transylvania, continued to operate with the mines from Săcărâmb, Roșia Montană, Valea lui Stan and Zlatna Metallurgical Plant.

The ore reserves of Săcărâmb deposit in 1940 amounted approx. 546.862 t, with an average grade of 3.34 g/t gold and 9.72 g/t silver. In 1948, the production reached 1,698.476 t, at 2.18 g/t gold and 10.11 g/t silver (Baron, 2006).

The production was discontinued in the 80s of the last century, and the industrial buildings, including the gate of the main gallery were destroyed. An inscription from 1765, marking the opening of the main drainage gallery Iosif and its call bell are preserved at the Mining Museum in Certeju de Jos. Instead, the entrance building of the gallery Francisc Iosif (Sector I) in Certeju de Jos has not collapsed yet, and waits for restoration. There are no ongoing projects aiming at the conservation of the industrial heritage related to gold mining in Săcărâmb-Certej area (*e.g.* the cableway used for ore haulage from the former Iosif gallery either to the processing plant in Certeju de Jos or to the old plant equipped with up to date „Klockner- Humboldt-Deutz" machines, or the new plant which was destroyed in 1971, in the catastrophe which led to the collapse of the tailings dam (Wollman, 2010). The significant quantities of tellurium make the ore refractory to cyanidation.

Starting with 2005, the worldwide interest for tellurium increased, due to its possible use in the manufacture of "lower cost of solar electricity" solar panels.

Until recently, tellurium stirred only scientific-mineralogical interest, with no preoccupation for assessing the tellurium resources of Romania. Tellurium began to be regarded as having some economic relevance only in 2005 when CdTe was for the first time used by the American company "First Solar" to build photovoltaic panels.

Some years ago the tellurium resource of Săcărâmb has been assessed Udubașa & Udubașa, 2004) on the basis of the Au:Te ratio in the most widespread tellurides occurring across the ore deposit (nagyágite and sylvanite), which yield a ratio of 1:2. According to this rather speculative evaluation, during 1746 and 1941, Săcărâmb mine produced approx. 60 t Te which added to the 30 t Au, 55 t Ag extracted from veins spanning over 300 km. The entire Te quantity was deposited in mine waste dump stockpiles and in underground fillings.

With the aim of outlining the areas of interest for tellurium and of assessing the possibilities to mine and process tellurium resources, a research program was started in 2008. The program focused not only on Săcărâmb, but on other areas in the Metaliferi Mts., namely Larga-Faţa Băii, Baia de Arieş, Căinel-Băiţa (Popescu, Neacşu, 2008).

Based on chemical analyses carried out at Certej, the Au:Te ratio in the sediments of the damaged tailings pond 0.25, whereas in the case of the mining waste dumps, 0.35, that is well above the theoretical value (Fig. 3.34). According to these new data, and based on an average Au:Te ratio of approx. 0.3 for all the mining areas at Săcărâmb, a resource of approx.. 85.7 t Te could be estimated (Popescu *et al*. 2010).

4. Baia Mare metallogenic district

Baia Mare represents the most important polymetallic metallogenic district of Romania and one of the most impressive metallogenic districts of Europe.

The mineralization is predominantly polymetallic, but the mineralized structures often have a vertical zonning, with an upper gold-silver-rich level. The metallogenic sectors with a marked gold character are Săsar and Dealul Crucii, especially Valea Roşie vein structure (Săsar sector) (Fig. 4.1).

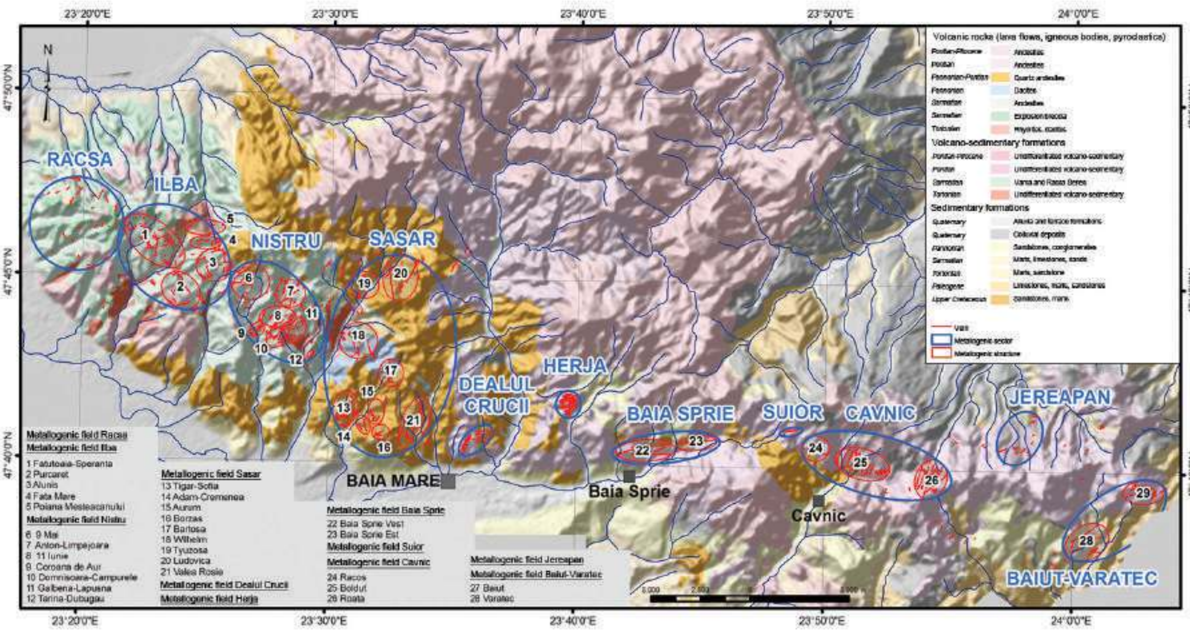


Fig. 4.1. The vein fields in the metallogenic district of Baia Mare (Tămaș-Bădescu, 2010)

The museum samples with native gold from Baia Mare come from Săsar and Dealul Crucii ore deposit: **dendritic gold in geodes of calcite, baryte and quartz (1516); lamellar-dendritic gold in quartz geode with baryte (1517); thread-like and lamellar gold with quartz and dolomite with pyrite, sphalerite**

(1518); gold associated with pyrite and sphalerite in bluish quartz (1519); microgranular gold associated with quartz in microgeode (1520); nest of lamellar-dendritic gold in quartz and baryte geode (1521); microgranular and dendritic gold intergrown with microgranular quartz (1590); gold ore with silica and carbonates ("invisible" gold) (1591); gold interlaced with pyramidal quartz and dolomite (1592); veinlet of quartz with impregnations of sphalerite, pyrite and thread-like gold (2123); lamellar gold with pellicle of iron hydroxides in hydrothermally altered rock (2126); microgranular gold intergrown with euhedral quartz associated with sulfides (2127); granular gold dispersed on iron hydroxides in baryte-bearing altered rock (2131); geode of quartz with sulfides and thread-like gold (2132, 2134); microgranular dendritic gold in quartz (2151); dendritic and partially lamellar gold on chalcedony crust (2153); agglomeration of lamellar and dendritic gold on geode with chalcopyrite, pyrite and sphalerite on quartz (2159); geode of thread-like gold associated with dolomite, quartz and sulfides (2161).

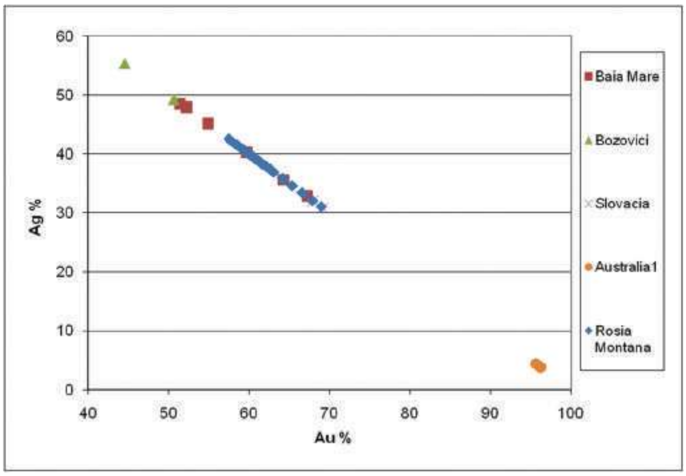


Fig. 4.2. Variation of Au:Ag ratio in native gold samples from Baia Mare district, compared with other metallogenic units in Romania and other countries

The diagram in Fig. 4.2 show that the native gold from Baia Mare is among the richest in silver.

5. Other sources of native gold from Romania in Brad Gold Museum

Among samples from "classic" occurrences, 15 specimens in the museum represent native gold from Bozovici. The samples are abundant in milky-white quartz, with traces of almost totally limonitized sulfides, chlorite, carbonates and native gold, consistent with the source geological environment, that is a shear zone related mineralization.

Over two-thirds of the mineralized areas related to shear zone environments in Romania, are located in the South Carpathians (Fig. 5), whereas the rest, are spread across Apuseni Mts.

Numerous such deposits were mined at a small scale in the past. The gold content of the mineralization is relatively low, rarely over 2 g/t, and etremely unevenly distributed. Moreover, the volume of such deposits was much too low for a profitable operation. Arsenic is ubiquitous and abundant in all occurences, which is prone to create environmental and ore processing issues.

The samples in the museum have the following features: nests of lamellar gold on pyritized quartz (2122); quartz and nests with micronic gold, chlorite and limonite (2187); gold ore with „invisible gold" (2199); quartz, chlorite and „invisible gold" (2200).

The X-ray spectrometry indicated a relatively low gold content in the samples from Bozovici. In fact, this is a characteristic of the shear zone related areas in the south Carpathians.

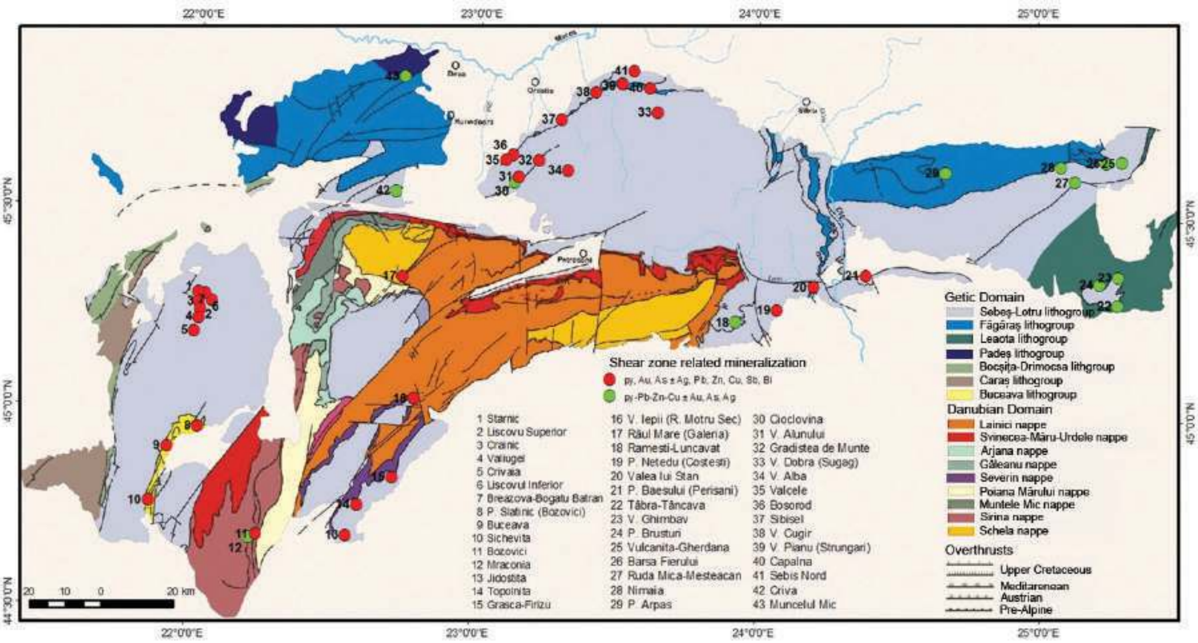


Fig 5. Shear zone related mineralized areas in the South Carpathians (Tămaş-Bădescu, 2010)

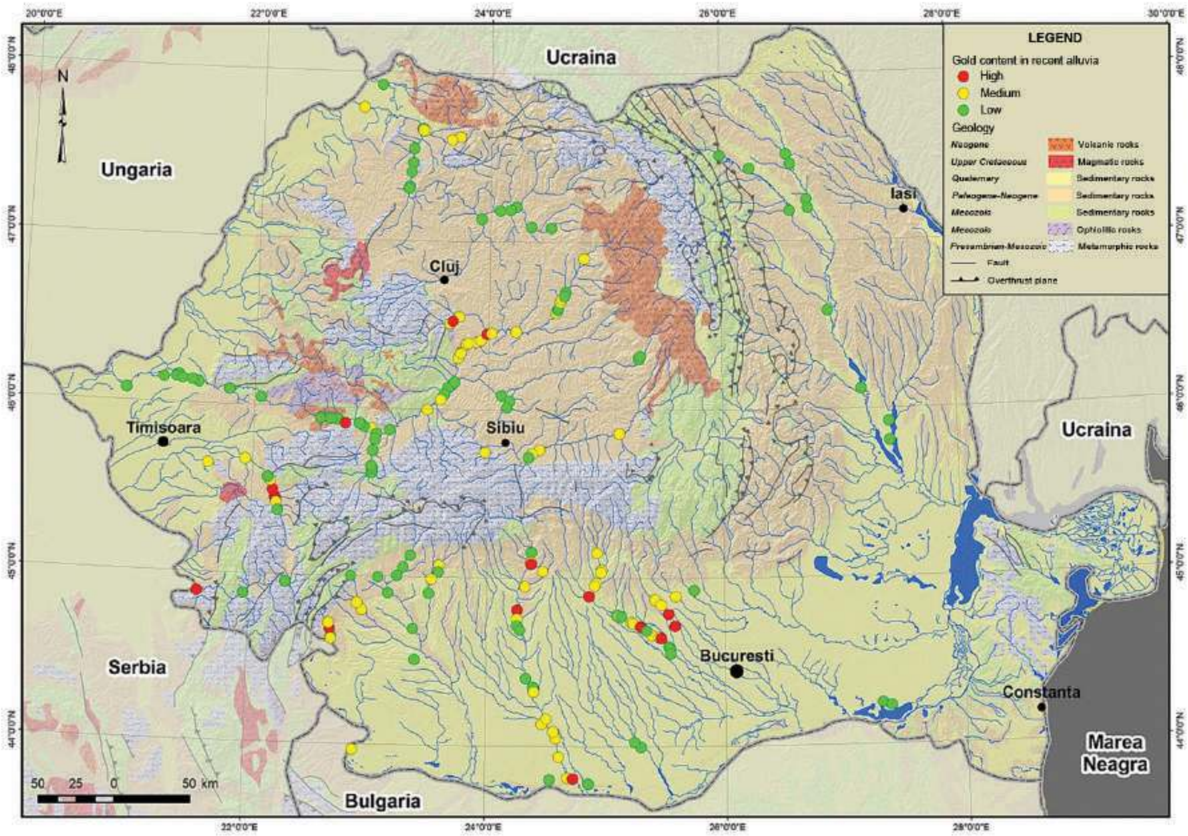


Fig. 6.1. Alluvial gold occurences mined over the territory of Romania (Tămaş-Bădescu, 2010)

6. Alluvial gold occurences

The Romanian geological literature seldom refered to areas with alluvial gold. The Map of Mineral Substances of Romania, published by the Romanian Geological Institute in 1984, only five areas with alluvial gold resources are mentioned: Pianu – on the northern boundary of Sebeș Mts.; Cibin Olt, on the northern boundary of South Carpathians; Râureni, on the southern limit of the South Carpathians; Arieș Valley in Apuseni Mts.; Nera/Bozovoci zone in Banat Mts.

For sure, such occurences are mcuh more numerous. As mentioned earlier in the text, the gold extraction from alluvia has been relatively widespread across Romania. Such activities started in the pre-Roman period and continued with intermitence, until the dawn of the 20th century. In 2010, Tămaș-Bădescu compilled data from numerous sources and identified over 125 occurences of alluvial gold which have been mined along history across the territory of Romania (Fig. 6.1).

The diagram in Fig. 6.2 suggest the higher gold content of the samples from Pianu and Valea Oltului, in comparisson with Valea Țebei and Serbia. The former two have the same source (Getic shear zones), whereas the later are of Alpine hydrothermal origin.

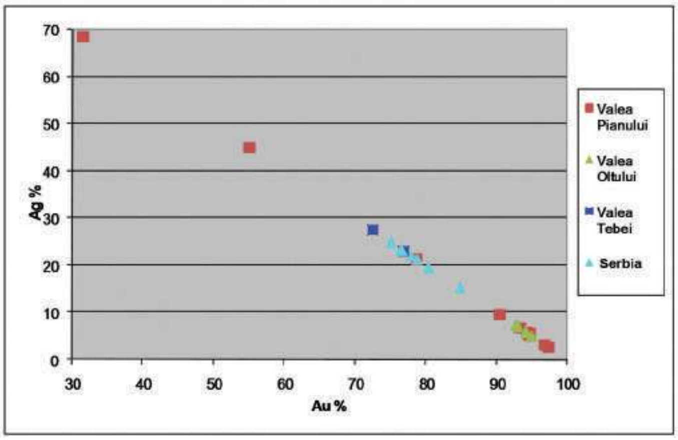


Fig. 6.2. Variation of Au:Ag ratio for the alluvial gold in Romania and Serbia

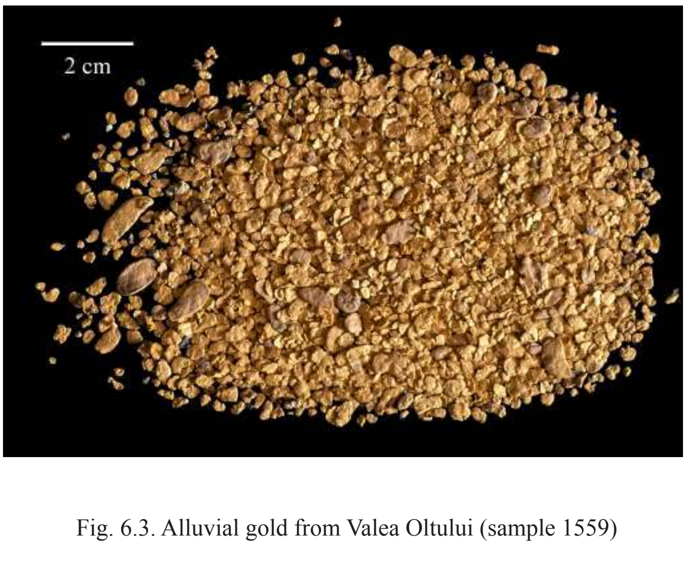


Fig. 6.3. Alluvial gold from Valea Oltului (sample 1559)

7. Gold from occurrences across the world in Brad Gold Museum

It is difficult to asses the total amount of gold in all the ore deposits worldwide. The *U. S. Geological Survey* and *The Gold Institute* estimated that along history, between 152,000 and 196,000 t have been mined, and that 33,000 t to 102.500 t are still unextracted (Fig. 7.1). The total amount of gold on the planet coud be somewhere between 185,000 t and 298,500 t (Tămaș-Bădescu, 2010).

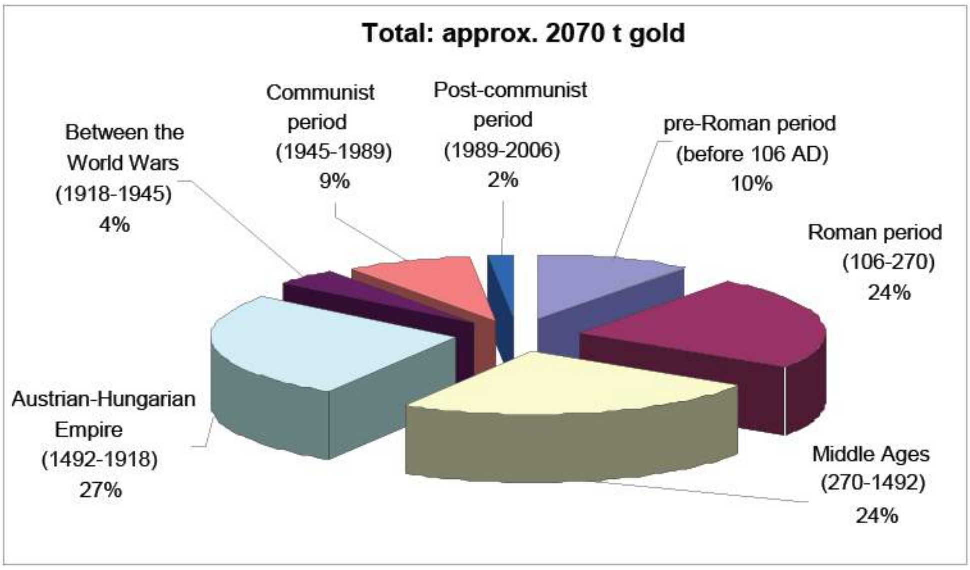


Fig. 7.1. World resources of gold in 2003 (Tămaș-Bădescu, 2010, data after The Gold Institute, 2003)

The gold ore deposits in the world are related mostly to older or newer orogeneous areas of the planet. The distribution of ore deposits in these orogenic areas is uneven in what regards both their frequency and sizes (Fig. 7.2). The gold deposits concentrate mainly in the central-south zone of the Rocky Mts. in North America, in the central zone of Andes Mts. in South Africa, in the Witwatersrand in South Africa, in West Australia, *etc*. Small and rich deposits are more frequent thant the large, low grade ones.

With regard to the total amount of gold (in mined, discovered reserves and resources), the small and medium are more frequent than the large and very large deposits (Fig. 7.2) (Tămaş-Bădescu, 2010).

The data after Arribas (2000) show that approx. 50% of the gold located in the major deposits of the planet (over 5 million ounces ≈ 156 t gold) is found in in the paleoplacers of Witwatersrand basin, 12% in epithermal deposits, 10% in *porphyry copper*-gold deposits, 12% in sedimentary deposits (including approx. 4% of the gold in Carlin type deposits), 9% in green schists related deposits, and the rest of 7% in other types of deposits (Fig. 7.3) (Tămaş-Bădescu, 2010).

The best known examples of fossil gold placers consists of gold and uranium bearing conglomerates of Lower Proterosoic age. The main deposits occur in the gold district of Witwatersrand in South Africa, in the Blind River area on the northern shore of Lake Huron (Canada) (traces of gold only) and Serra de Jacobina, Bahia (Brasil).

Other occurences are known in West Africa and West Australia. The host rocks are polymictic conglomerates in a matrix rich in pyrite, sericite and quartz. The gold and uranium minerals (mainly uraninite) occur in the matrix and in other minerals of the detrital rock.

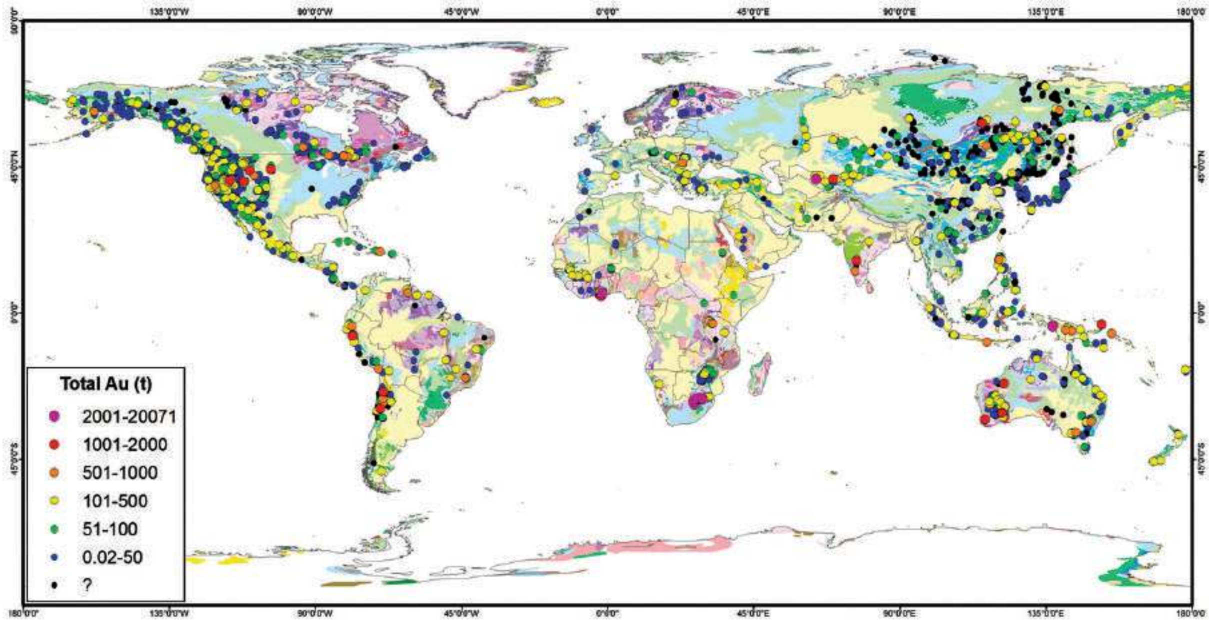


Fig. 7.2. Gold deposits worldwide. The figures indicate mined reserves and discovered resources/reserves (Tămaș-Bădescu, 2010)

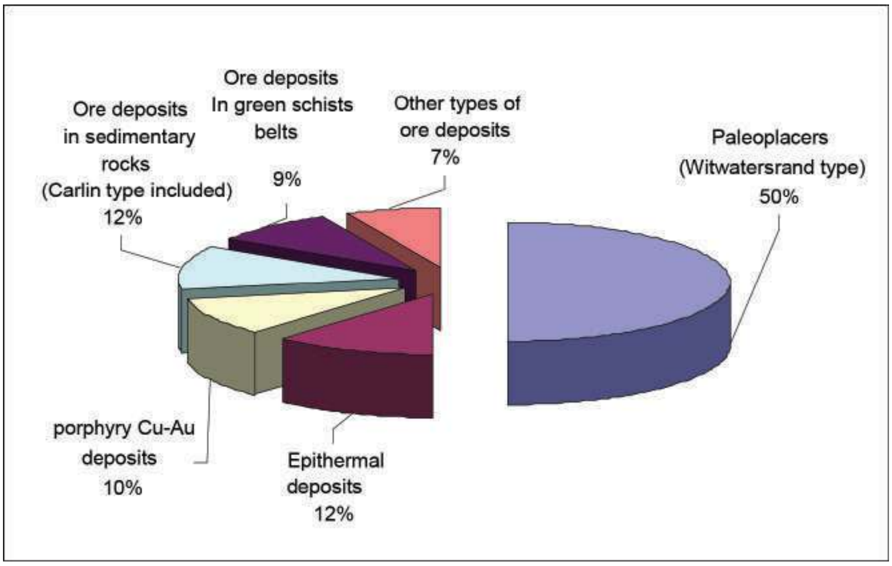


Fig. 7.3. Distribution of gold among Earth's major deposits (Arribas, 2000 in Hedenquist, 2006) (Tămaş-Bădescu, 2010)

Within Witwatersrand gold district(Fig. 7.4) the mineralized bodies seem to have formed at the edge of an intracratonic or intramontaneous lake, or continental sea, relatively close to the metal source areas. The gold and uranium deposits in Witwatersrand basin form one of the largest metallogenic units in the world. The industries developed around this phenomenal resource have made South Africa the main gold producer in the world. It is estimated that from the total 110,000 t gold ever mined on Earth, approx. 43,500 come from Witwatersrand, that is, around 40% of the total gold production. The deposit still has 45% of the total known reserves around the Globe, namely, an exceptional 22,000 t reserve at over 7.5 g/t gold. The mines near Johannesburg, where the gold-bearing conglomerates rise to the surface are the most productive, contributing with approx. 48% to the total production of the basin. The gold field East Rand is the second most productive area with over 24% of the total output. West Wits Line (Carletonville) field contributes with 19.3%, followed by Free State (18.5%) and Klerksdorp (12.3%).

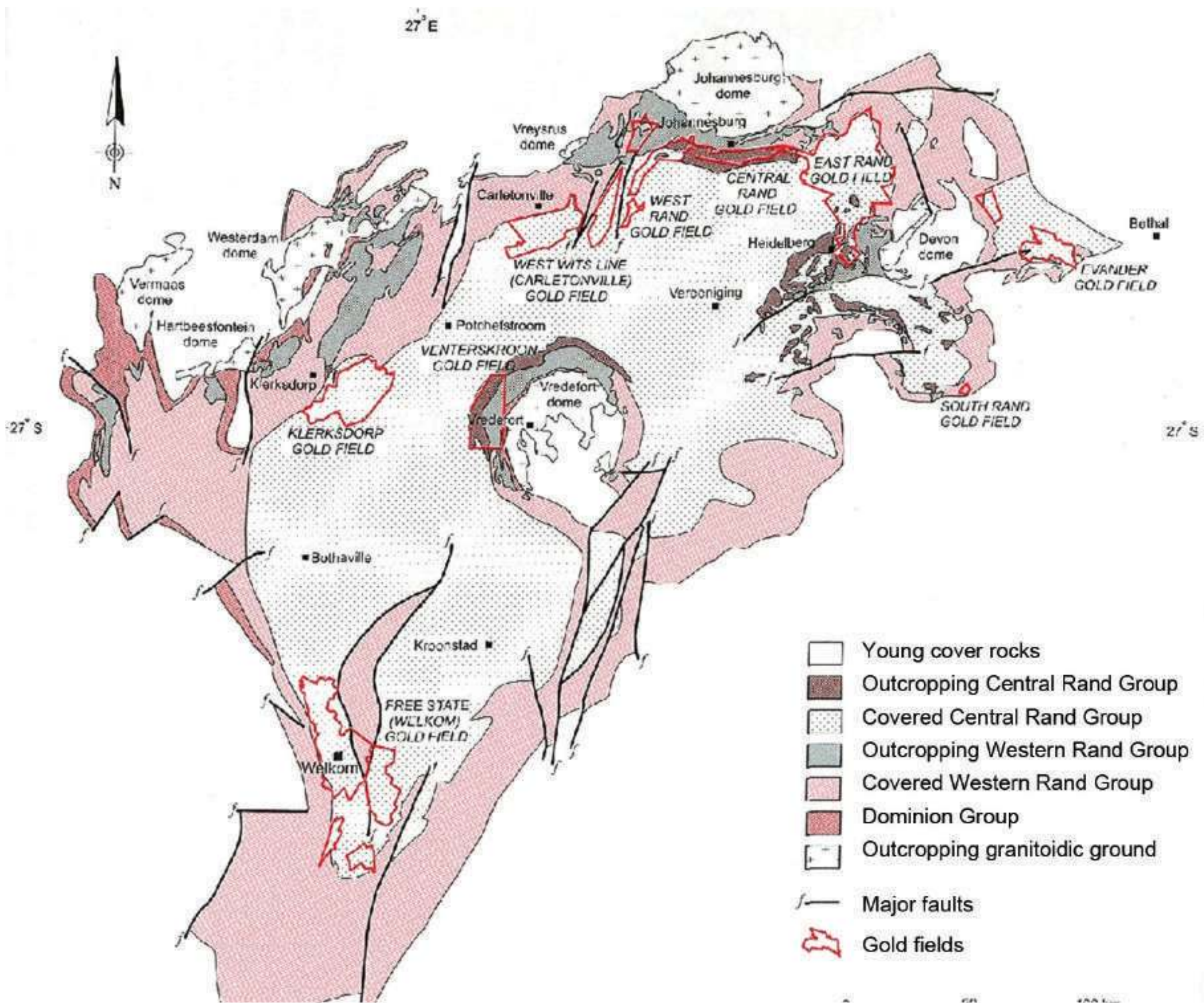


Fig. 7.4. Geological map of Witwatersrand basin with its main gold fields (Pretorius, 1986 in Popescu *et al.*, 2007)

The huge amount of pyrite and uraninite in these conglomerates has aroused controversy mainly due to the fact that the two minerals are uncommon for detrital deposits under present atmospheric conditions. In the Lower Proterozoic, when these deposits were formed, the Earth's atmosphere was probably much lower in oxygen; the rapid accumulation and burial of clastic sequences with pyrite and uraninite, have favored their concentration in the form of ample ore deposits.

There are several samples in the displays of Brad Gold Museum which illustrate nearly all the major types of gold ores in the world (gold-bearing conglomerates, epithermal ores and ores related to shear zones), as well as the major world producers of gold (South Africa, the United States, Canada).

Thus, the samples from Serbia illustrate shear zone-related gold deposits: skeletal lamellar gold in sulfide dissolution voids (1508); thread-like gold with pellicle of iron hydroxides, associated with microgranular quartz and pyrite (2158). The samples from din Slovakia are representative for the epithermal type: gold associated with sphalerite in quartz, from Natália vein, Rozália mine, Hodrusa-Hámre (2327). Samples from the United States and Canada also belong to the epithermal type: microgranular sylvanite in syenite, Colorado (1501); sylvanite intergrown with fluorite (1502); microgranular gold with calaverite in hydrothermally altered rock (1503); lamellar gold in quartz (1504); native lamellar gold associated with petzite (1505); granular-microlamellar gold and petzite (1506); microgranular dendritic gold in nests, associated with tellurides, in layers of chlorite and krennerite, in hydrothermally altered quartzite (Kirkland Lake) (1500). Samples from Algeria originate in shear zones: gold in nest of malachite associated with Alpine quartz (2201); gold in

Alpine vein quartz (2202, 2204); lamellar gold with quartz (2205); lamellar-dendritic gold in quartz (2206); skeletal-granular, columnar gold, in sulfide dissolution voids, in quartzite (2213). The gold from Chile is microlamellar and comes from the oxidation zone of a copper deposit (2326). Most of the foreign samples in the Museum come from South Africa – Witwatersrand district; sterile low grade metamorphic conglomerates (190, 193, 194); sterile polymictic conglomerate (196), well sorted and clearly laminated conglomerate, with interstitial pyrite (198); drill cores with sterile conglomerates (199, 200, 201); highly transformed sterile conglomerate, with intense silicification and chloritisation (203); polymictic gold-bearing conglomerate with quartz-pyrite matrix (204); nodule of twinned pyrite around clast (205); polymictic gold-bearing conglomerate, with gold, pyrite, quartz, interstitial chlorite (206); gold-bearing pyrite and native gold in metaconglomerate (207); gold-bearing conglomerate with oxidized interstitial pyrite (1192); polymictic gold-bearing conglomerate with interstitial quartz and gold-bearing pyrite; some perfectly rounded and glassy clasts, suggest a possible meteor impact (2189); conglomerates with sulfides, chlorite, quartz around clasts (2190); highly oxidized conglomerate (2191); relic clasts in a botryoidal mass of iron hydroxides.

Characterization of samples in the mineral collection of the Gold Museum of Brad

1. Introduction

Minerals are components of rocks and ores that make up our planet. They are the foundation of life, the substratum used by plants and animals to thrive and survive. By definition, minerals are chemical compounds (sometimes native elements and alloys), with well-defined crystalline structure, formed exclusively by natural (geological) processes which took place in the Earth's crust and in the solid shells of other planets.

Every mineral has a **name** which stands for both the chemical composition and for the crystal structure. For example, the calcium carbonate – $CaCO_3$ – forms two important minerals: *calcite* – crystallised in the trigonal system and *aragonite* – crystallised in the orthorhombic system.

About 4000 minerals are known, but only about 100 are common. The chemical-structural duality of minerals gives them specific properties (composition, colour, hardness, lustre, *etc.*) which allow both their identification and use in various human activities. The study of minerals id covered by the science of **Mineralogy** which is closely related to **Petrology** and **Metallogeny** – the fundamental core disciplines of Geology. It is for this reason that by its dawn, Geology was often called the science of the Mineral Realm.

The position and role of Mineralogy in the context of geosciences (after Popescu, 1995)

With the exception of native mercury, all other minerals posses an ordered, periodic and symmetrical arrangement of atoms and molecules which is characteristic for the crystalline state. Under certain conditions, rarely fulfilled, the internal structure is reflected by regular polyhedral external forms. The same mineral may present very different polyhedral shapes. In terms of symmetry, crystalline minerals are grouped into seven crystallographic systems with 32 possible symmetries.

The study of crystalline symmetry takes into account mainly the internal structure, the orderly and regular arrangement of atoms and molecules in a mineral. Due to their extremely small dimensions, these embodiments are not directly accessible to human vision, not even with the most sophisticated electro-optical instruments. However, we can deduce the nature of these structures by analyzing the interaction between minerals and X-rays

The properties of minerals. The specific characteristics of minerals - derived from their chemical composition and how they crystallize – allow their identification and the determination of the role they played in various geological processes. Moreover, the properties of minerals recommend the practical use of these substances in everyday life. For example, the extreme hardness of diamond – the natural carbon cubic polymorph recommends the use of this mineral as an effective abrasive. Often, based on mineral properties, mankind manufactures various materials with useful properties. For example, foliated crystals of mica (muscovite and biotite) have been used in the past as thermal insulators. Galena – a lead sulphide - was one of the first semiconductors known to man. Its structural model and features given by the presence of certain impurities, have subsequently served for the creation of transistors and diodes.

For a more precise recognition of minerals, numerous properties such as morphology, gloss, colour, transparency, hardness, cleavage, specific gravity, magnetism, radioactivity, luminescence, solubility, *etc.* are used in practice. A great deal of diagnostic properties of minerals is studied by means of the polarizing microscope.

Crystal habit. The external morphology of crystals is characterised by: habit, perfection of forms and intergrowths. The crystal habit reflects the tendency of preferential growth in one or more directions. The following types of habit are common:

- **isometric** - equal development in all directions
- **prismatic, columnar, acicular or fibrous** - increasingly pronounced development of in one direction
- **tabular, lamellar** or **foliated** - progressively pronounced development after two directions.

Natural crystals will only rarely yield well developed, perfect forms. The museum is one of the few places where such specimens can be seen. The cramped space of most mineral forming environments, often lead to the accretion and tight intergrowth of crystals. Most of the time, this accretion is heterogeneous and irregular, but in some cases, several crystals of the same species may intergrow symmetrically to form the so-called twins.

Mineral colour. The colour of natural compounds is subject to numerous influences, including the presence of transitional metals (Cu, Cr, Fe, Ni, *etc.*), the existence of finely dispersed impurities (allochromatism) crystal lattice defects, colloidal mixtures, *etc.*

Mineral colours are often compared to the colour of common objects or substances: *e.g.* milky-white, brass-yellow, lead-gray, chocolate-brown, *etc.* Sometimes there is an important difference between the colour of a mineral in a compact state and the colour of the same mineral, but in a crushed or powdered state. For example, pyrite - FeS_2, is yellow when compact, but black when powdered.

Transparency. Denotes the light-transmitting qualities of a mineral. Depending on the degree of transparency, minerals with large crystals are divided into: transparent, semi-transparent (translucent) and opaque.

Hardness. Mineral hardness depends on the strength of atomic bonds. In mineralogical practice, hardness determination is made by scratching one mineral with another. To assess the relative hardness of minerals, the Mohs' scale was adopted, that is, a succession of ten common minerals where each mineral scratches the preceding ones: 1. TALC; 2. HALITE, GYPSUM; 3. CALCITE; 4. FLUORITE; 5. APATITE; 6. ORTHOCLASE ; 7. QUARTZ; 8. TOPASE; 9. CORUNDUM; 10. DIAMOND.

Cleavage is the ability of crystals and crystal grains to detach following certain crystallographic directions. This property is linked specifically to the internal structure of minerals. Depending on the quality of the cleavage, the following types are often quoted:

1. **Perfect cleavage** – crystals unwind after continuous and large planes.
2. **Good cleavage** – sharp-edged but relatively small flat fragments
3. **Poor cleavage** – difficult to see; the mineral fragments, usually show cracks and uneven surfaces.
4. **Imperfect (absent) cleavage** – the mineral divides into irregular fragments, in random directions.

In most cases, minerals are too small and too tightly intergrown to be examined with the naked eye. For this reason, one of the most important tools is the mineralogical research is the polarizing microscope by which allows to observe textural and essential optical characteristics of a mineral. To this purpose, minerals are cut to a thickness of 0.02 mm and then observed either in transparency or in reflection.

2. Native elements

Only a limited number of chemical elements are found as natural minerals, and many of them are known only in small accumulations. Some elements such as native gold, native silver, native copper, carbon (with the two polymorphs: diamond and graphite), and native sulphur exist only rarely in large enough quantities to form deposits.

Native metals - gold, silver, and copper have many similar physical properties, such as high density, malleability and dendritic habit. Native elements are each composed of one kind of atom, while other minerals are composed of two or more components. The most common elements are native gold – Au, silver – Ag Copper – Cu, sulphur – S, Diamond – C, graphite – C, Bismuth – Bi, and mercury – Hg.

Sulphur – S – orthorhombic. Name derives from Latin – *sulphur*.

Native sulphur – Sicily

There are many sulphur occu-rrences known in Romania: secondary sulphur in polymetallic ores at Baia Sprie, Cavnic, or in gold ores at Roșia Montană and Săcărâmb; sedimentary sulphur in Miocene sulphuric or saline deposits at Dărăbani, Târgu Ocna, Govora, Matița, Turda and Copăceni (associated with celestine). The best known occurrence of this type is Pucioasa, where sulphur-rich layers reach 2-5 m in thickness. The most important soplhatarian deposit and the one at Gura Haitii, Călimani Mts. where native sulphur occurs in lenses of 5-6 m which were partially mined. A recent sulphur deposit related to thermal waters is the one in the volcanic cave at Turia, genetically related to the Neogene volcanics in Covasna. In other countries, significant sulphur occurrences are those in the Pre-Carpathian

Basin in Poland (Machow) and Ukraine (Rozdol). Europe is host for the famous solphatarian sulphur deposits in Italy (Pozzoulli, Solfatara, Etna, *etc.*), Spain (Corub), Greece. Also famous are the deposits in the United States (Utah – Cove Creek, California – Napa, Yellowstone) and in Japan or Mexico.

Diamond – C – cubic. Name originates in the ancient Greek - *adamas* – invincible, adverting to its exceptional hardness – 10, on the Mohs scale.

Diamond has various morphological and colour aspects. Most frequently it has a well defined crystal shape, either octahedral or cubic, but sometimes it may occur as irregular grains or crystal fragments. For instance, the biggest diamond in the world – Cullinan (3106 carats), represents a fragment of octahedron. Colour is also variable: colourless, gray, blue, pink, green, yellow, orange, violet, brown to black, very seldom red. Diamond is the most expensive mineral in the world. Its value is measured in carats: 1 carat – 0.2 g, which is the equivalent of a lens grain.

Diamond has been known since ancient times, with the first specimens arriving in Europe back in the VI-V centuries, B.C. Later, Plinny the Elder (23-79 A.D.) mentioned diamond among the precious stones which most probably originated in India where they had been mined for centuries. India is the place where numerous famous diamonds have been discovered: The Great Mogul (787.25 carats, found in 1650), Orloff (189.62 carats, found in 1680), Hope (blue, 45.52 carats), Florentine (yellow, 137.27 carats). Starting with 1714, diamonds have been discovered also in Brazil. Later they were found in South Africa which remained for a long time the largest diamond supplier of the world. Famous diamonds come from here, such as Cullinan which adorns the British Crown, Excelsior (995.2 carats, found in 1893), and Jubilee (pink, 650.8 carats, found in 1895). Such diamonds were extracted from the well renowned kimberlite formations or from diamond-bearing sediments. Major producers of today are Russia and China. Diamond has not been found in Romania.

Graphite – C – hexagonal. Name comes from ancient Greek, *graphein* – writing.

Graphite represents the hexagonal polymorph of carbon, and it is chemically closely related to diamond which is the cubic modification. It occurs as platy crystals, with hexagonal shape, sometimes columnar or as grains, radiary or compact masses. Its characteristic property is the black, shiny-gray colour and its low hardness which, for a long time, recommended it as the main natural material for pencil manufacturing. Graphite is relatively widespread, mostly in metamorphic formations formed on behalf of carbon-rich material.

Graphite – Sri Lanka

In Romania, graphite occurs in several metamorphic sequences of the Carpathian chain. Economic deposits are known only in the South Carpathians, on Jiețului Valley (Cătălinu, Ungurelaș). The pre-graphitic form – “meta-anthracite” is also well known in the Schela Formation, at Schela-Gorj where it associates with pyrophyllite and chloritoide.

Worldwide, the most important accumulations of superior graphite are known in England (Borrowdale), Norway (Arendal), Finland (Pargas), Russia (Ural Mts., Irkutsk), United States (Massachusetts, Connecticut, Pennsylvania).

Gold – Au – cubic. Name derives from Old English, *geolo* – yellow.

Many historians agree that gold was the first metal known by man. Gold was used for manufacturing jewels which initially had a sacred character, but later it became the most important symbol of wellness and power.

Lamellar gold on quartz - Musariu, Brad

Over 140 gold occurrences are known in Romania, and many of them have been gold mining areas. The most important area with gold deposits in Romania is the south part of Apuseni Mountains, an area mentioned in the geological literature as the “Golden Quadrilateral”. The gold deposits of Apuseni Mountains represented the main gold source of Romania (perhaps, well over 75%). Here, the gold mining activities are well over 2000 years old.

In Metaliferi Mountains, the most famous ore deposits are those at Baia de Arieş, Roşia Montană, Bucium, Stănija, Breaza, Musariu, Valea Morii, Ruda-Barza, Corabia, Brădişor, Hondol *etc.*

Worldwide, gold has been extracted from numerous places. The major gold producers are: South Africa – with approx. 30% of the total gold ever extracted in the world, Australia – which yielded the biggest gold nuggets known to date (68. 26 kg -1857 ; 71.03 kg -1869 ; 92 kg – 1872), United States – where gold played an essential role, not only through the California gold placers (where a 35 kg. nugget was found near Sacramento, but also through Colorado (with the famous Cripple Creek), Nevada (with the famous Carlin deposit), Dakota (Homestake), Alaska (with the big Klondike deposit) and many other places throughout the North America. Canada is in its turn a major gold producer – the second in the world, mostly due to the famous gold deposits in Ontario (Porcupine, Kirkland Lake) and Quebec (Bousquet, Val d'Or).

Silver – Ag – cubic. Name derives from the Old English word *seolfor* – silver.

Native silver - Freiberg, Germany

Silver is one of the first precious metals used in coin manufacturing. History offers numerous examples of silver jewellery in many ancient civilisations such as Egyptian, Chaldean, Persian, Phoenician, Chartaginian, Roman and later, Spanish.

Romania recorded numerous references for silver, but most frequently it occurs only as microscopic grains. The most widespread type of occurrence is in the form of wires grown on quartz (Săsar, Valea Roşie, Ormindea, Vălişoara), on sphalerite (Hărţăgani), on pyrargyrite (Stănija) or on baryte (Oraviţa). Millimetric crusts and wires were also mentioned at Câinelu de Sus whereas submillimetric crystals of silver were found at Dealu Crucii and Baia Sprie.

A special mention is deserved by the relatively frequent electrum occurrences – a natural alloy of silver and gold – at Roşia Montană, Musariu, Herja and Baia Sprie, where it can be found as microscopic inclusions in sulphides.

Some exceptional silver concentrations have been recorded in the form of blocks weighing several tons in the United States (Arizona, Nevada, Michigan, Alaska), Canada (Ontario, British Columbia). Mexico, Chile, Bolivia and Peru are also important producers in South America. Other important occurrences are in Australia, Japan, Russia (Altai Mts.) and Kazakhstan. In Europe, there are several famous silver deposits: Schneeberg (silver wires of up to 40 cm), Freiberg, Mansfeld, St. Andreasberg and Wittichen – Germany; Kutná Hora, Jákimov – Czech Republic; Banská Štiavnica – Slovakia, and Kongsberg (silver blocks of up to 100 kg) in Norway.

Bismuth – **Bi** – trigonal. Name derives probably from the German word *Weissmuth* – white mass, describing the general aspect of this metal.

Native bismuth is rare. It occurs as isolated crystals, frequently twinned, dendritic or in foliated aggregates. In Romania, bismuth is frequent especially in deposits related to Upper Cretaceous magmatic rocks, in Banat (Oravița, Ocna de Fier, Dognecea) and at Băița Bihor. It has been mentioned also in relation with to shear zones in Leaota and Căpățânii, or at Lipova where it is associated with galena and cobaltite. In Europe, bismuth was described at Dobšina in Slovakia and at Podulky in Ukraine.

Copper – **Cu** – cubic. Name derives from the Latin word *cuprum* – meaning "metal from Cyprus".

Native copper - Arizona, United States

Native copper is widespread in deposits of various ages and origins. It normally occurs in association with malachite, azurite, chalcocite and cuprite, in the oxidation zone of copper deposits.

There are three commoner forms of native copper: dendrites (Moldova Nouă, Pătârș near Lipova, Pojorâta, Sândominic-Ciuc), octahedral (Bălan, Sândominic) or cubic crystals (Deva), as well as lamellae of various sizes (Cârlibaba, Deva, Săcărâmb). Outside Romania, copper occurs in many countries: Hungary (Rudabánya), Poland (Szczawnica), Slovakia (Špania Dolina), Ukraine (Beregove), Russia (Nijni Tagil), Italy (Monte Catini), United Kingdom (Cornwall), Australia (New South Wales – Broken Hill), Chile (Adacollo), Bolivia (Corocoro), Mexico (Sonora), United states (Massachusetts, Connecticut).

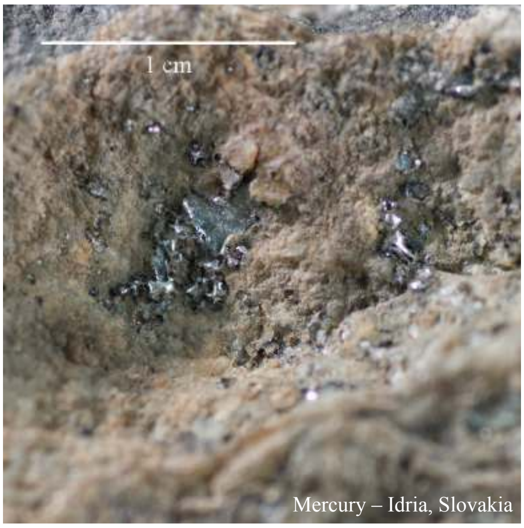
Arsenic – **As** – trigonal. Name originates in the Aramaic word *(al) zarniqa* or in the Persian word *zarnikh*, meaning "yellow pigment", imported into Greek as *arsenikon*. Some sources relate the name to the similar Greek word *arsenikos* meaning "male", "masculine" or "potent", based on the belief that metals had different sexes.

Although, arsenic is a rare mineral, it is relatively widespread in the ore deposits of Meta-liferi Mts. It occurs as reniform aggregates, sometimes reaching tens of centimetres, or as concentric crusts enveloping gold-bearing quartz (Musariu, Hondol, Stănija).

Arsenic - Musariu, Brad

It has also been described as globular aggregates with rhodocrosite, quartz, Au and Ag tellurides (Săcărâmb). Rarely, arsenic has been mentioned in Gutâi Mts. (Baia Sprie, Cavnic) and in the Banatitic area (Oravița).

Abroad, arsenic is known in Hungary – relatively rarely, in the form of crusts or microscopic inclusions in native bismuth, in Slovakia – as black films or globular aggregates in quartz geodes, associated with stibnite (Zlatá Baňa). It has been also described in Germany (Freiberg, Annaberg), Czech Republic (Jachymow), Norway (Kongsberg), Chile, Mexico, United States, Russia.



Mercury – Idria, Slovakia

Mercury – **Hg** – the only mineral in liquid state. Name comes from god *Mercury* in the Roman mythology.

Mercury has a tin-white to whitish gray colour, metallic lustre and appears as tiny spherical drops.

In Romania it has been quoted in older works as minute spherules associated with cinnabar (Izvorul Ampoiului – Metaliferi Mts., Lemnea and Estelnic – Ciuc Mts.).

Abroad, mercury is known especially in Slovenia (Idria), Spain (Almaden), Italy (Monte Amiata), Peru (Juan Cavelica), United States (New Almaden, New Idria).

3. Sulphides, sulphosalts and similar compounds

Sphalerite (Zn,Fe)S – cubic. Name derives from Greek *sphaleros* meaning treacherous, misleading, to suggest its variable colour from colourless to reddish brown, yellow, green and black.

Sphalerite – Trepča, Serbia

Sphalerite is widely known in Romania, throughout a multitude of occurrences (well over 70), with extremely diverse crystal morphologies: crystals in vein ore bodies (Herja, Baia Sprie, Cavnic, Rodna, Toroiaga, Stănija, Rușchița), compact masses (Baia de Arieș, Hondol, Săcărâmb, Valea Blaznei, Boița, *etc*).

The chromatic variety is well expressed, too. Thus at Fața Băii – Metaliferi Mts., sphalerite is yellow or even colourless, at Roșia Montană – is green or reddish yellow, at Baia de Arieș is brown or greenish, whereas at Herja is black (due to high iron content).

Outside Romania, sphalerite is known especially in Germany (Freiberg, Altenberg, Hagendorf), Czech Republic (Příbram), Poland (Lagota, near Baligród – spherulites), Slovakia (Banská Štiavnica), Switzerland (Binnental), Serbia (Trepča), Spain (Picos de Europa, Santander), United States, Australia, Peru.

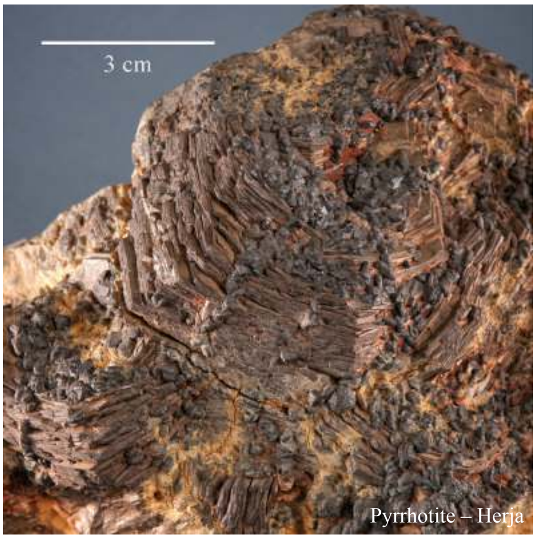
Nickeline NiAs – hexagonal. Name derives from the main metal contained - nickel, (Beudant, 1832).

In Romania, several nickeline occurrences have been cited: in serpentinites (South Banat – Tișovița, Eibenthal, Plavișevița) associated with pyrrhotite, pentlandite and secondary magnetite. It has also been described in the hydrothermal Co-Ni-Bi-Ag-U mineralisation of Leaota where it is associated with maucherite, millerite and gersdorfite, and in the shear zone of northern Sebeș Mts., at Cioclovina and Căpâlna, in association with millerite, ullmanite and zoubekite.

In other countries, nickeline is known at Wolfach, Bieber and Annaberg in Germany, at Jachimov in Czech Republic, at Dobšina in Slovakia, and at Cobalt in Canada.

Pyrrhotite $Fe_{1-x}S$ – monoclinic and hexagonal. Name derives from Greek *purrotes* – brass-like colour (Breithaupt, 1835).

Pyrrhotite is one of the most widespread minerals in Romania (over 50 occurrences). It develops in magmatic environments, in association with ultrabasic rocks – together with chromium spinel, pentlandite and chalcopyrite (Southern Banat – Iuți, Sebeș Mts., Breaza – in the north part of Eastern Carpathians), in skarn deposits (Moldova Nouă, Sasca Montană, Oravița, Ocna de Fier, Băișoara), in hydrothermal formations (veins and metasomatic – Herja, Băiuț, Toroiaga, Rodna, Țibleș) and even in sedimentary formations (Schela-Gorj, Jitia – Curvature Subcarpathians). The most spectacular forms are those from Herja – near Baia Mare, where tabular aggregates in the shape of a rose or columnar aggregates, often transformed into marcasite. Smaller dimensioned crystals were found also at Săcărâmb, Rodna and Băiuț. In other countries, pyrrhotite was mentioned in Czech Republic (near Uhreský Brod), Hungary (Nagybörzsöny, Recsk), Slovakia (Pernek, Pezinok, Rožňava, Smolník), Ukraine (Rakhiv, Vyshkove, Beregove), Germany (Freiberg, Bodenmais, Horbach), Serbia (Trepča), Canada (Sudbury).



Pyrrhotite – Herja

Millerite NiS – trigonal. Name comes from the English mineralogist *W. H. Miller* (1801-1880), (Heidinger, 1845).

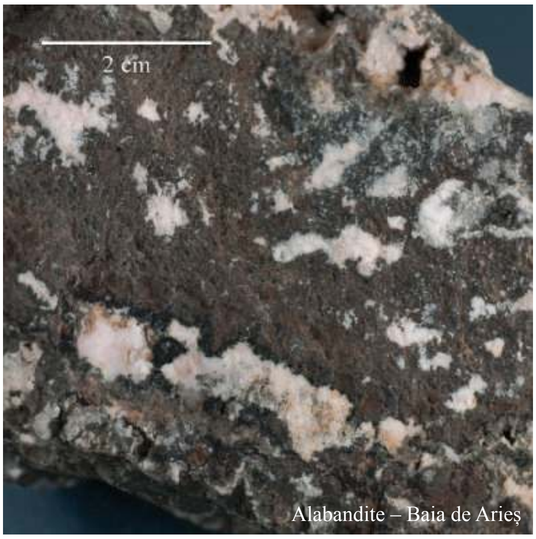
In Romania, millerite has been mentioned only in few occurrences such as the serpentinites in Sebeș Mts., where it is associated with pentlandite, in Leaota Mts., within the nickel-cobalt mineralisation at Stoenești - Dâmbovița Valley, in association with maucherite, nickeline, gersdorfite and ankerite, as well as in the Eastern Făgăraș Mts., at Valea Nimaia and Valea Rușească.

Worldwide, is known in several places such as Germany (Freiberg, Schneeberg, Siegerland, Oberlara), Hungary (Helesfa, Perkupa), Slovakia (Rožňava, Ladmovce), Canada (Sudbury) *etc.*

Millerite – Germany

Alabandite MnS – cubic.

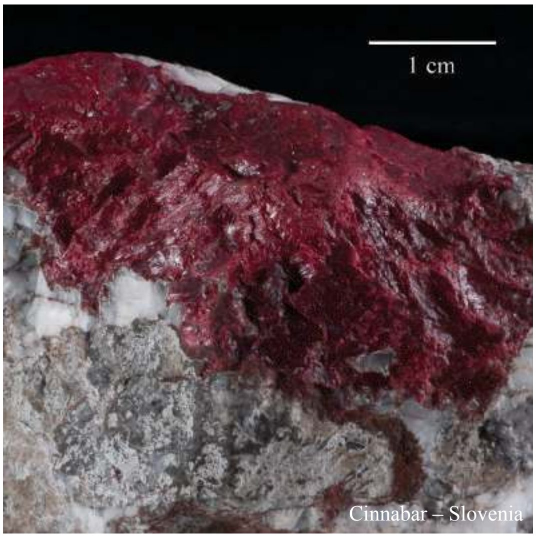
Alabandite was described as a new mineral at Săcărâmb Franz-Joseph Müller von Reichenstein, in 1784, who called it ”schwarze blende”. The name ”alabandite” was given by Beudant in 1832, based on the works of del Rio on a similar mineral found in Mexico. The first chemical analysis was carried out by Arfvedson in 1822, who used a material collected at Săcărâmb (Udubașa *et al.*, 2002). Thus, the true *locus tipicus* for alabandite is Săcărâmb and not Alabanda in Turkey which stands rather as a type locality for almandine (Karsten, 1800). Other alabandite occurrences are: Baia de Arieș, Căraci and Roșia Montană in Metaliferi Mts. as well as Cavnic in Gutâi Mts.



Alabandite – Baia de Arieș

This rare mineral has also been described in Bulgaria (Obroshiste), Peru (Morococha), United States (Arizona-Tombstone) and Germany (Voberg – Fe-alabandite).

Cinnabar HgS – trigonal. Seemingly, the name *kinnabari* was firstly used by the Greek Theophrastus, 315 B.C., but it designated more than one distinct substance. Other sources suggest that the word comes from the Persian *shangarf* or the Arabic *zinjifrah*, both of uncertain origin, but comparable to the Sanskrit word *sugara.*

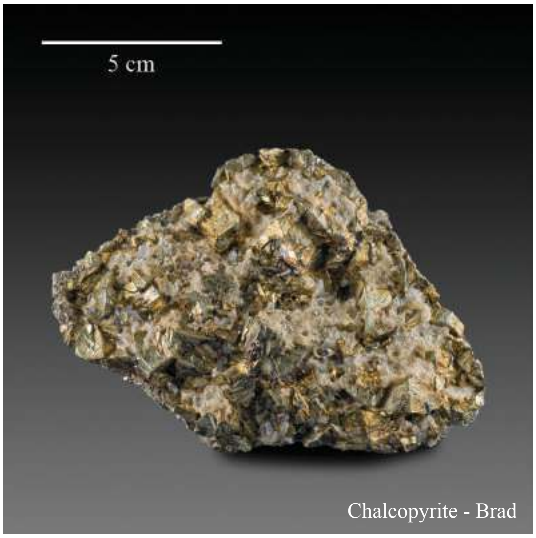


Cinnabar – Slovenia

There are two significant cinnabar occurrences in Romania: Izvorul Ampoiului – Metaliferi Mts. and Sântimbru Băi – Harghita Mts. Other places where cinnabar has been described are: Ilba, Baia Sprie, Cavnic and Băiuț – Gutâi Mts., and Musariu, near Brad.

Worldwide, the most renowned occurrences are in Spain (Almaden), Slovenia (Idria), Russia (Nikitowka), United States (Terlingua, New Almaden, New Idria) and China (Wanshanchang).

Chalcopyrite CuFeS – tetragonal. Name comes from the Greek terms *khalkos* – copper and *pyrites* – stone which strikes fire (Henckel, 1725).



Chalcopyrite - Brad

This is one of the most widespread sulphides in Romania as it occurs in more than 110 places of various geological origins. Chalcopyrite is the main economic source for copper. The best looking samples have been collected in the hydrothermal veins related to the Neogene volcanic rocks in Maramureș (Cavnic, Poiana Botizei, Baia Sprie, Băiuț, Toroiaga), in Metaliferi Mts. (Bucium, Boteș, Troița), or in porphyry copper deposits - Deva, Bolcana, Roșia Poieni, Bucium Tarnița. Very interesting occurrences are those from the crystalline schists where chalcopyrite is tightly intergrown with pyrite (Bălan, Burloaia, Măgura, Baia de Aramă).

Around the world, chalcopyrite is also one of the commonest sulphides; it occurs in Germany (Siegerland, Rammelsberg, Freiberg, Annaberg, Mansfeld), Great Britain (Cornwall), Spain (Rio Tinto), Serbia (Bor), Slovakia (Bansca Štiavnica), Norway (Sulitjelma), Sweden (Falun), Russia (Turinsk, Norilsk, Talnach), Canada (Sudbury), United States (Montana-Butte; Maine-Bingham; Arizona-Clifton-Morenci), Chile (Chuquicamata, Braden, Escondida), Peru (Yanacocha), Zambia (Mufulira), *etc.*

Bornite - Eisenfeld, Germany

Bornite Cu_5FeS_4 – orthorhombic. The name comes from the famous Austrian scholar Ignaz von Born (1742-1791) (Heidinger, 1845).

Bornite covers more than 25 occurrences in Romania, most frequently associated or intergrown with chalcopyrite and/or chalcocite and replaced by covellite in supergeneously altered ores. It is an important source of copper. It has a complex genesis: magmatic, pneumatolithic, secondary hydrothermal. Significant bornite volumes are related to skarn deposits at Sasca Montană, Oravița, Băița Bihor; to hydrothermal veins – Bucium, Ilba; to porphyry copper deposits – Deva, Bolcana, Bucium-Tarnița; to oxidation zones – Altân Tepe, Bălan.Outside Romania, bornite has been cited in Slovakia (several localities in Metallic Mts. Spišsko-Gemerské), Germany (Mansfeld – copper-bearing sedimentary schists, Wittichen, Neubulach), Sweden (Norberg), Great Britain (Cornwall-Redruth – nice crystals), United States (Montana –Butte), Namibia (Tsumeb).

Orpiment As_2S_3 – monoclinic. Name comes from Latin *aurum* – gold and *pigmentum* – coloured, due to its golden hues (Agricola, 1546).

There are approximately ten occurrences cited in Romania, of which the most important are those in Moldova Nouă (crystals of up to 1-3 mm), Săcărâmb, Baia Sprie (globular aggregates of 4-6 mm), Cavnic (crystals and aggregates of up to 12 mm), Covasna (where orpiment occurs in association with aragonite and realgar), Băiuț and Băița (lamellar crystals), Băița Bihor, Sasca Montană.Abroad, orpiment has been mentioned in Slovakia (Tajov), Ukraine (Soymy, Petros), Hungary (Recsk), Georgia (Loukhoumi), United States (Utah-Mercury), Russia (Yakutia-Minkiule, where a crystal of 30 kg and 60 cm in length was discovered), Germany (St. Andreasberg in Harz Mts.), Switzerland (Imfeld, Binnental).

Realgar As_4S_4 – monoclinic. From the Arabian term *rahj al ghar* – cave dust (Wallerius, 1747).

Realgar shares practically the same occurrences with orpiment. The most interesting cases are those of Moldova Nouă – where prismatic crystals of about 3 cm were described, Baia Sprie and Cavnic – crystals of up to 4-5 cm (associated with arsenic, stibnite, sphalerite and baryte) and Săcărâmb – the largest crystals in Romania (5 cm), in association with baryte, quartz and ankerite. Realgar occurrences outside Romania are roughly those mentioned for orpiment.

Realgar – Baia Sprie

Stibnite Sb_2S_3 – orthorhombic. Name derives from Greek term *stibi* – antimony black (Haidinger, 1845).

Stibnite is rather widespread in Romania, yielding one of the most spectacular mineral specimens, especially in the vein deposits of Baia Mare metallogenic district. The most beautiful specimens were found at Baia Sprie (acicular crystals of up to 20 cm, tightly intergrown with tabular baryte); Băiuț (short prisms aggregated within superb bunches, or tabular crystals of up to 7 cm in length); Herja (prismatic crystals of about 5 cm in length, often in radiary layouts) and Poiana Botizei (short prismatic crystals of up to 5 cm in length).

In Metaliferi Mts. stibnite was described at Baia de Arieș, Fața Băii, Musariu, Troița and Coranda- Hondol.

Abroad, stibnite was mentioned in Germany (Harz-Wolfsberg, Westphalia-Casparizeche), Slovakia (Kremnica, Zlata Baňa, Dúbrava), Russia (Khardarkan, Ouspensk), China (Henan Province) and Japan (Ichinokawa mine).

Stibnite – Baia Sprie

Berthierite $FeSb_3S_4$ – orthorhombic. Name comes from the French chemist *P. Berthier* (1782-1861) (Haidinger, 1827).

Berthierite – Baia Sprie

The mineral is somewhat similar to stibnite, but the crystals are smaller and yield a low intensity reaction with KOH. In Romania berthierite occurs mainly in Baia Mare metallogenic district, at Herja and Baia Sprie, where it forms radiary aggregates of crystals reaching 10-15 cm.

At Roșia Montană, berthierite forms concentric aggregates associated with tetrahedrite. It also occurs at Dealu Crucii near Baia Mare and in Țibleș Mts.

Worldwide, the mineral has been mentioned at Freiberg (Germany), Auvergne (France), Zlatá Idka, Poproč (Slovakia), Příbram (Czech Republic), Japan, Peru, Chile, Bolivia, *etc.*

Pyrite FeS_2 – cubic. Name comes from Greek: *pyrites* – able to strike fire.

Pyrite is the most widespread sulphide in the world and also in Romania. It occurs in all types of geological formations of magmatic, metamorphic and sedimentary origin, but the most significant occurrences are those related to sulphide deposits, of mainly hydrothermal origin. The most common form is anhedral, as in the sulphide deposits related to crystalline schists, where it develops as quasi-concordant lenses, often associated with quartz, chalcopyrite and chlorite: East Carpathians (Burloaia, Fundu Moldovei, Leșu Ursului and Bălan), South Carpathians (Vețel, Lișava). Euhedral pyrite occurs mainly in the vein sulphide deposits, where it displays either the classical cube shape (Țibleș, Rodna Veche) or the pentagonal dodecahedron (Bucium-Arama, Vălișoara, Fața Băii, Roșia Poieni). A remarkable feature of pyrite is the extreme morphological diversity; for example, at Dognecea (skarn deposit), more than 200 forms were described, whereas Deva (porphyry copper deposit) stands with 15 distinct crystal morphologies.

Pyrite – Bucium

Pyrite is abundant in Germany (Rammelsberg, Meggen, Elbingerode), Italy (Brosso, Elba Island), Greece (Xante – cubes of up to 50 cm), Switzerland (Saint-Gothard), Spain (numerous deposits Huelva, Rio Tinto, Tharsis, Pena del Hiero), Norway (Grong, Sulitjelma), Sweden (Falun), Russia (Ural Mts.), Czech Republic (Příbram), Slovakia (Banska Štiavnica), France (Saint-Bel), Mexico (Sonora-Arizpe),United States (Colorado-Central City; Pennsylvania – French Creek).

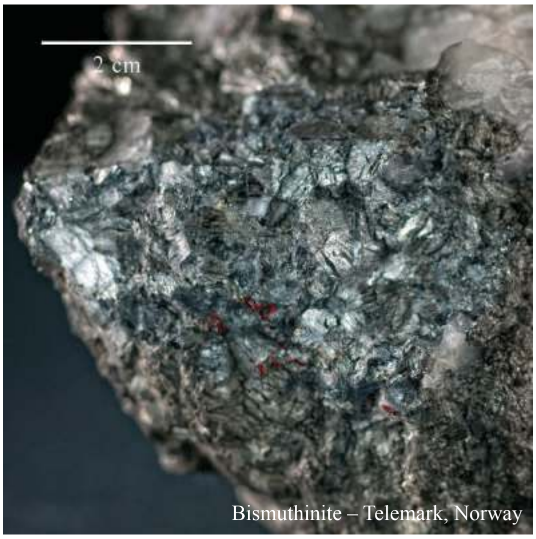
Marcasite FeS_2 – orthorhombic. Name derives from the Arabic or Moorish name of pyrite or of other similar minerals of uncertain origin (Haidinger, 1845).

Marcasite has been quoted in relatively numerous occurrences in Romania (over 50). Most frequently, forms on behalf of pyrite and pyrrhotite. The most illustrative example is that of marcasite from Herja where pyrrhotite, especially when occurring in „rose”-shaped aggregates, is partially or totally substituted by marcasite. Extremely interesting cases are those of Baia Sprie and Săcărâmb, where marcasite replaces calcite. Remarkable concretionary masses of spheroidal or columnar marcasite occur at Valea Roșie, Baia Sprie and Săcărâmb. Stalactitic marcasite was found at Băiuț and Roșia Montană.

Marcasite is relatively widespread in the world. Often, it is associated with cinnabar, galena, sphalerite, pyrrhotite and pyrite. It was quoted in Germany (Clausthal, Freiberg, Wiesloch), Czech Republic (Komňa, Bánov, Komořany), Slovakia (Banská Štiavnica, Kremnica), Poland (Myślenice, Krosno, Lesko), Hungary (Nagybörzsöny, Recsk, Rudábanya), Russia, United States, Mexico, Chile, *etc.*

Marcasite – Musariu, Brad

Bismuthinite Bi_2S_3 – orthorhombic. Name comes either from the German term *Weisse Masse* – white mass, to remind of bismuth – the main metallic component (Geoffroy, 1753), or from the Latin *bisemutum* – a term used by Paracelsus as early as the XVI-th century.



Bismuthinite – Telemark, Norway

In most cases, the name bismuthinite has a generic character and refers to intermediate members of the isomorphous and polysomatic series bismuthinite Bi_2S_3 – aikinite $CuPbBiS_3$. The exact identification of a certain intermediate member of this series – based on the Bi:Cu+Pb ratio is impossible to achieve by simple macroscopic or microscopic observation. To this purpose, much more sophisticated determinative methods are used aiming at establishing the chemical composition and the crystal structure. The intermediate members of the bismuthinite-aikinite series are also called „bismuthinite derivatives" and are among the most widespread bismuth minerals and important economical source for this metal The most significant occurrences in Romania are at Băița Bihor, Ocna de Fier (where bismuthinite derivatives associate with tremolite and wollastonite), Oravița-Ciclova, Sasca Montană, Baia Borșa, *etc.*

Molybdenite MoS_2 – hexagonal. Name derives from the Greek word *molubdos* – lead, suggesting the colour resemblance with lead (Hielm, 1782).

Molybdenite – Băița Bihor

Molybdenite is relatively widespread in Romania. It occurs in various types of mineralisation, from hydrothermal veins (Ditrău-Jolotca, Săvârșin, Almaș-Săliște, Teregova, Țibleș, Ilba, Baia Sprie), porphyry copper deposits (Roșia Poieni, Musariu Nou, Bolcana-Troița, Deva) to skarn-related occurrences (Băița Bihor, Sasca Montană, Moldova Nouă, Mraconia — west of Orșova).

In other countries, molybdenite is cited in various types of assemblages such as cassiterite and wolframite-bearing pegmatites in Norway (Stavanger), Russia (Ural Mts.), Germany (Bayerischer Wald). Nicely shaped crystals were found in the United States (Edison, New

Jersey), sau Canada (Wakefield, Québec). Hydrothermal occurrences are known in the United States (Questa, New Mexique, Climax - Clorado, and Bingham - Utah), Australia (New South Wales), whereas molybdenites in scheelite-bearing skarns were cited in Russia (Tyrny Auz) and Maroc (Azegour). Pneumatolithic accumulations are known in Czech Republic (Krušné Hory) and Mexico (Cananéa).

Cobaltite – Reichenstein, Austria

Cobaltite CoAsS – orthorhombic. Name comes from the main metal in the composition of this mineral, which in its turn derives from the German word *Kobalt* or *Kobold* – evil spirit (Beudant, 1832).

It is a rare mineral. In Romania it was described long ago at Oravița in association with native bismuth and alloclasite, and at Lipova with euhedral and twinned crystals grown on glaucodot. Recently, cobaltite was discovered also at Oița – Bistriței Mts., associated with gersdorfite, pyrite and chalcopyrite.

Abroad, cobaltite was mentioned in Slovakia (pentagonal dodecahedrons of about 7 cm, at Hnúšťa-Mútnic) and in Germany (Siegen, Annaberg, Schneeberg), Sweden (Boliden, Tunaberg).

Arsenopyrite FeAsS – monoclinic. Mineral name derives from *arsenic* and *pyrite*, even though arsenopyrite is structurally closer to marcasite – the orthorhombic counterpart of pyrite.

Arsenopyrite – Herja

Arsenopyrite is relatively frequent in regional metamorphic formations (Burloaia, Colbu), in skarn deposits (Sasca Montană, Oravița, Ciclova, Dognecea) and especially in hydrothermal veins (Ilba, Baia Sprie, Herja, Șuior, Băiuț, Toroiaga, Țibleș, Rodna, Hărțăgani, Breaza, Stănija, Bucium, Roșia Montană). It is relatively abundant in shear-related zones of the Getic Nappe in the South Carpathians (Valea lui Stan, Costești, Cioclovina, Jidoștița, Văliug). Often, arsenopyrite contains micronic inclusions of gold which unfortunately is very difficult to extract and raises serious environmental problems. The most important occurrences outside Romania are known in Germany (Freiberg, Altenberg, Zinnwald, Sulzburg, Wittichen), Austria (Mitterberg), Great Britain (Pen. Cornwall), Sweden (Boliden), South Africa, United States.

Gersdorffite NiAsS – cubic. Name derives from *von Gersdorff*, owner of Schladming mine (Austria), (Löwe, 1842).

This is a rare mineral in Romania; it was found in the pegmatites of Teregova (Banat) and in skarn-related deposits at Băița Bihor (where it had been described as "sommarugaite" – in fact, a gold-bearing gersdorffite, Udubașa *et al.*, 2002). Other known occurrences are those from Stoenești (Valea lui Dăniș - Leaota Mts. – where it appears together with maucherite, nickeline, millerite and ankerite; Popescu, 2003), in the lead and zinc mineralization in East Făgăraș Mts. and at Oița - Bistriței Mts. where it associated with pyrite, cobaltite and chalcopyrite. In other countries, gersdorffite was mentioned in Germany (Siegerland, Goslar), Slovakia (Dobšiná), Austria (Mitterberg, Schladming), Canada (Cobalt) and Bolivia.

Löllingite $FeAs_2$ – orthorhombic. Name comes from *Lölling* – a locality in Austria (Haidinger, 1845).

It is a rare mineral, only found as minute grains in the mineralised areas of Oravița, Sasca Montană and Ilba. It was also quoted in the metallic veins of Brusturi, Apuseni Mts., associated with arsenopyrite and in the pentametalliferous formation of Stoenești, Leaota Mts. In other countries, löllingite was quoted in Germany (St. Andreasberg, Sulzburg), Poland (Złoty Stok), Austria (Lölling, Schladming), Canada (Cobalt), Algeria (Belelieta), *etc.*

Maucherite $Ni_{11}As_8$ – tetragonal. Name comes from the German mineral collector *A. Maucher* (1879-1930). It was discovered before the first decade of the XX-th century, but the author of its first description remained unknown.

Maucherite – Valea lui Dăniș, Leaota

In Romania, maucherite was described for the first time at Valea lui Dăniș, in Leaota Mts. where it is associated with nickeline, millerite, gersdorffite and ankerite (Popescu, 1968). Later, the mineral was described at Băița Bihor, Valea Nimaia - East Făgăraș Mts. and at Căpâlna, in the north part of Sebeș Mts.

Ullmannite NiSbS – cubic. Name derives from the German chemist and mineralogist *J. Ch. Ullmann* (1771-1821) (Fröbel, 1843).

Ullmannite has only recently been discovered in Romania; the first occurrence is that of Valea Nimaia – East Făgăraș Mts. (Lupulescu & Damian, 1992), where it appears with siegenite, sphalerite, galena, proustite, tetrahedrite and pyrite; the second occurrence is at Cioclovina, where ullmannite is associated with proustite, pyrargyrite and zoubekite (Popescu & Șimon, 1995).

Abroad, ullmannite is mentioned only in few countries: Slovakia (Rožňava, Pezinok – Trojkrálová mine), Germany (Siegerland, Harzgerode, Löbenstein, Haiger), Austria (Waldenstein, Lölling), Italy (Sardinia).

Tetrahedrite $Cu_6Cu_4(Fe,Zn)_2(Sb,As)_4S_{13}$ – cubic. Name comes from its crystallographic shape – regular tetrahedron.

Tetrahedrite – Bucium

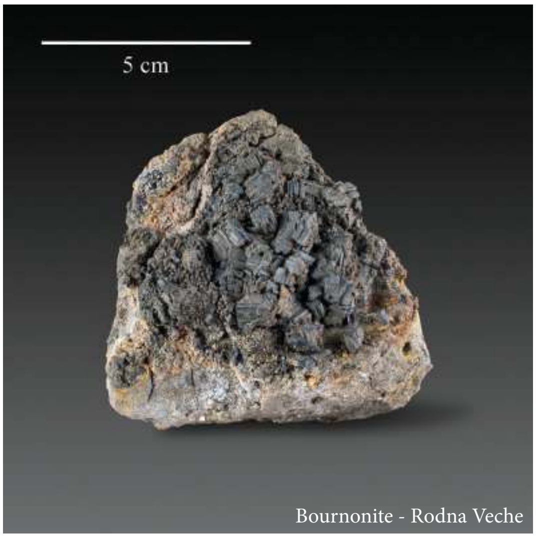
In Romania, tetrahedrite is relatively widespread, with over 50 occurrences. The best known is that of Cavnic where crystals exceeding 4 cm were found. Other deposits are: Herja – with a silver-bearing variety also known at Baia Sprie, but recently considered to be a distinct mineral – freibergite. Other occurrences are mentioned at Săcărâmb, Bucium, Boteș – also with big crystals of up to 4 cm, and Fața Băii.

Some occurrences reveal Bi-rich tetrahedrites (up to 24% annivite) such as those from Valea Seacă, Oravița and Băița Bihor (Ilinca, 1998).

Among the numerous occurrences worldwide, worth mentioning are those from Germany (Clausthal, Siegen, Annaberg, Freiberg – the type locality of freibergite), Czech Republic (Příbram), Austria (Schvaz), Great Britain (Liskeard), Russia (Berezovsk), United States (Idaho – Sunshine Mine).

Enargite Cu_3AsS_4 – orthorhombic. Name comes from the Greek word *enarges* – obvious.

Enargite is relatively rare. It is somewhat abundant in some porphyry copper deposits at Deva, Bucureșci-Rovina, Bucium-Tarnița or in hydrothermal vein deposits such as those from Pârâul lui Avram, Băița-Crăciunești, Săcărâmb, Bucium- Arama.



Bournonite - Rodna Veche

Around the world, enargite occurs in Germany (Wittichen, Hungary (Recsk), Slovakia (Dobšiná, Mlynky), Poland (Baligród), Serbia (Bor), Austria (Brilegg), United States (Montana – Butte), Peru (Morococha, Cerro de Pasco), Chile (Chuquicamata), Argentina (Famatina).

Bournonite $PbCuSbS_3$ – orthorhombic. Named after the French mineralogist, *J. L. de Bournon* (1751-1825).

Bournonite is relatively widespread in our country. It was described in about 20 occurrences, both in Gutâi Mts. and in Metaliferi Mts. (Udubașa *et al.*, 2002).

Cyclically twinned crystals were found at Cavnic, Rodna and Săcărâmb. Also mentioned at Baia Sprie, Dealu Crucii and Baia de Arieș.

Abroad, bournonite was described in Slovakia (Rožňava), Hungary (Gyögyösoroszi), Germany (Neudorf, Clausthal), Austria (Hütenberg), Bolivia (Machacamarca), Peru, Russia, *etc.*

Proustite – Saxony, Germany

Proustite Ag_3AsS_3 – trigonal. After the French chemist, *J. L. Proust* (1755-1826).

Proustite was reported at Săsar and Baia Sprie in association with pyrite, pyrargyrite, native silver and quartz. Also mentioned at Săcărâmb, Câinelu de Sus, Roșia Montană and at Tulgheș, Cârlibaba – East Carpathians.

In other countries, proustite was mentioned in Germany, Czech Republic, France, Chile (Chanarcillo – crystals of about 15 cm), Mexico, United States.

Jamesonite – Herja

Jamesonite $Pb_4FeSb_6S_{14}$ – monoclinic. It was named for Scottish mineralogist *Robert Jameson* (1774-1854).

Jamesonite is relatively rare in Romania, but occurs in several occurrences, of which, the most representative are Herja, Baia Sprie, Cavnic and Toroiaga. In an approximate language, jamesonite is called „plumosite" or „lead cotton". A peculiar type of occurrence is described by jamesonite forming fine inclusions in calcite and gypsum, yielding a general dark aspect (black or gray), such as in Herja, Hărțăgani or Stânceni – Călimani Mts. (Udubașa *et al.*, 2002).

In other countries, jamesonite was mentioned in Germany, Slovakia (Nižná Slaná – crystals of up to 50 cm), Hungary, Czech Republic, Sweden, Russia, Bolivia, Mexico, United States, Australia, Japan, *etc.*

Semseyite $Pb_9Sb_8S_{21}$ – monoclinic. Named after the Hungarian collector *Andor von Semsey* (1833-1923). Semseyite was first described at Baia Sprie (Felsőbánya) by Krenner, in 1881.

In the ores of Baia Sprie, semseyite forms rose-like aggregates, exceeding 5 cm in diameter, usually intergrown with galena. Other occurrences: Ilba and Herja (lamellar crystals exceeding 3 cm, grouped in sub-parallel aggregates), Cavnic, Băiuţ, Rodna and Toroioaga mine near Baia Borşa. Macaleț *et al.* (1994) identified semseyite at Puiu Suhărzel, East Carpathians, in a layered Pb-Zn ore deposit (Udubaşa *et al.*, 2002).

Semseyite – Herja

Also known in Slovakia: microscopic grains of semseyite were reported at Jasenie-Kyslá, Zlatá Baňa, Ozdín-Mládzovo, and at Dúbrava – associated with robinsonite, plagionite and heteromorphite. In Hungary, semseyite associated with galena occurs as microscopic grains or fan-shaped aggregates of thin crystals at Nagybörzsöny and Gyöngyösoroszi, (Nagy, 1986, in Udubaşa *et al.*, 2002). Elsewhere, it has been reported at Wolfsberg – Germany, and at Oururo in Bolivia.

Fülöppite $Pb_3Sb_8S_{15}$ – monoclinic. Named after the Hungarian lawyer, statesman and mineral collector *Bela Fülöpp*, (1863-1938).

The mineral was described for the first time at Dealu Crucii, Baia Mare, by Finály and Koch (1929). Fülöppite is a very rare mineral, usually occurring in platy or pyramidal crystals sometimes exceeding 3 mm in length), as in Dealu Crucii (Udubaşa *et al.*, 2002).

Fülöppite - Dealu Crucii, Baia Mare

In Slovakia, microscopic grains of fülöppite were observed at Dúbrava, in association with zinkenite (Chovan *et al.*, 1992 in Udubaşa *et al.*, 2002). It is also present at Ozdín-Mládzovo, together with other Pb-Sb sulphosalts (Mat'o & Mat'ová, 1994 in Udubaşa *et al.*, 2002).

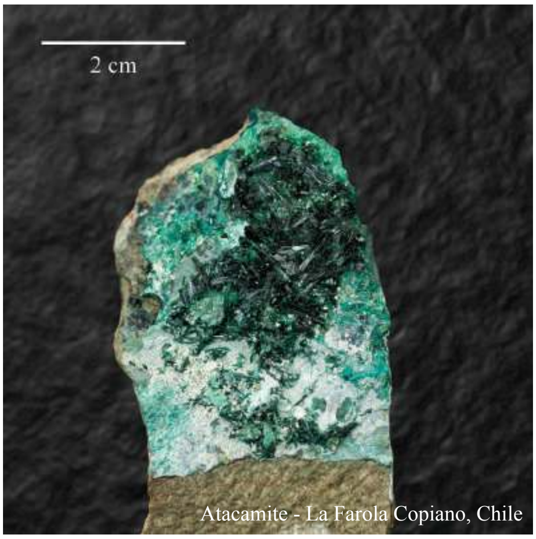
Pyrargyrite Ag_3SbS_3 – trigonal. Name derives from Greek words *pyr* and *argyros*, "fire-silver", in allusion to colour and silver content.

This is the most widespread silver sulphosalt. In Romania, it has been reported from more than 20 occurrences, of which the most representative are those at Dealu Crucii and Săsar, near Baia Mare, Băiţa-Crăciuneşti and Câinelu de Sus, in Metaliferi Mts. Other occurrences are at Baia Sprie, Băiuţ, Săcărâmb, Breaza, Stănija, Baia de Arieş.

Pyrargyrite - Himmelsfurst, Germany

Abroad, pyrargyrite was mentioned in polymetallic ore deposits from Germany (St. Andreasberg, Freiberg), Slovakia (Banská Štiavnica), Hungary (Rudabánya), Chile (Chanarcillo), Mexico (Zacatecas and Guanajuato), Peru, United States, Russia, Canada, *etc.*

4. Halides



Atacamite - La Farola Copiano, Chile

Atacamite $Cu_2^{2+}Cl(OH)_3$ – orthorhombic. Named after *Atacama* province in Chile, by Blumenbach in 1805.

It is a dark-green mineral, transparent, with vitreous to submetallic lustre, occurring as acicular or platy crystals, often grouped in spheroidal and fibrous aggregates. Atacamite is frequent in secondary accumulations developed on primary copper ore deposits. Atacamite deposits are known in Chile (Copiapo, Chuquicamata), Mexico (Baja California – Boleo), Namibia (Tsumeb), Italy (Vesuvius).

Fluorite - Stănija

Fluorite CaF_2 – cubic. Name comes from Latin *fluere* - colour (Napione, 1797).

Fluorite has been reported from more than 20 occurrences, mainly as an accessory mineral in acid igneous rocks or hydrothermal veins. The most significant places are in Moldova Nouă (pale green octahedra and yellow cubes); Cavnic (green, violet or colourless octahedra, as well as pink or violet spheroidal aggregates); Băiuț (violet or colourless crystals); Stănija (green, pink or pale blue crystals of variable habit, sometimes octahedra of up to 6 cm); Musariu (green octahedra of approx. 2 cm). Other occurrences are those at Sasca Montană, Oravița, Băița Bihor, Ocna de Fier, Ilba, Baia Sprie. More recently, fluorite was identified also in Leaota Mts. at Julești-Valea Fagului and at Tarna Mare.

Abroad, fluorite has been reported in numerous places: Germany (Freiberg – limpid, yellow crystals), Switzerland (octahedra in Alpine veins), Czech Republic, Slovakia (Banská Štiavnica), Poland, Great Britain, Italy, Bulgaria, Canada, United States, Australia, China, Mongolia, *etc.*

Halite - Hallstadt, Austria

Halite (salt) NaCl – cubic. Name derives from Greek words *hals* – salt and *lithos* - stone (Glocker, 1847).

Halite is among the oldest known and used mineral substances. During the Roman time, halite represented the most abundant resource of our territory. During the Middle Ages, salt was a true “currency”, due to the easy access to underground accumulations. The typical halite deposit occurs in the form of a “diapire” (term introduced by the Romanian geologist L. Mrazec in 1906), meaning a dome, a salt core penetrating the above layers of sandstone, marls and clays – that is much more brittle formations than salt. Romania has huge salt reserves which have been known and mined for centuries: Cacica, Târgu Ocna, Slănic Prahova, Ocnele Mari, Ocna Șugatag, Praid, Ocna Sibiului, Ocna Mureș, Ocna Dejului. Halite occurs rarely as crystals, mainly when it forms from natural brines, *e.g.* at Ocna Dejului, Slănic, and Ocna Sibiului. Large salt deposits are known all over the world: Germany (Stassfurt), Poland (Wieliczka), Russia (Solikamsk), United States, *etc.*

Sylvite - Stassfurt, Germany

Sylvite KCl – cubic. Named after the Dutch chemist *Sylvius de la Boe* (1614 – 1672), (Beudant, 1832).

Sylvite represents an isolated occurrence in our country: Găleanu mine near Târgu Ocna, where it is associated with halite, kainite, kieserite and picromerite. Abroad, sylvite occurs in Germany, Austria, Poland, Russia, United States, *etc.*, roughly the same deposits as those quoted for halite.

Kainite $MgSO_4 \cdot KCl \cdot 3H_2O$ – monoclinic. Named after the Greek word *kainos* - new (Zicken, 1865). Kainite is a very rare component of the evaporitic deposit of Târgu Ocna where it associates with halite, kieserite, sylvite and picromerite. Abroad, is to be found roughly in the same deposits where halite and sylvite occurs.

Carnallite $KMgCl_3.6H_2O$ – orthorhombic. Name derives from the German mining engineer *R. Von Carnall* (1804-1874) (Rose, 1856). It has been identified as microscopic grains at Găleanu mine near Târgu Ocna, where it associates with halite, sylvite, kainite and picromerite. For world-wide occurrence, see kainite.

Kainite, carnallite, kieserite - Stassfurt, Germany

Kieserite $MgSO_4.H_2O$ – monoclinic. Named after the president of Jena Academy, *D. G. Kieser* (1779-1826) (Reichardt, 1861). Occurs as bipyramidal crystals. It has a salty taste and dissolves in water. Occurrences in Romania are similar to those mentioned for carnallite and kainite.

Cryolite Na_3AlF_6 – monoclinic. Named from Greek words *kruos* – cold and *lithos* - stone (Abildgaard, 1799). Cryolite is a rare mineral of variable colour (white, gray, reddish-brown), translucent. It is relatively soft (Mohs hardness 2.5-3) and resembles anhydrite and baryte. Cryolite was reported only in Greenland, in the pegmatites of Ivigtut, in the United States, Russia and Nigeria.

Cryolite - Ivigtut, Greenland

5. Oxides

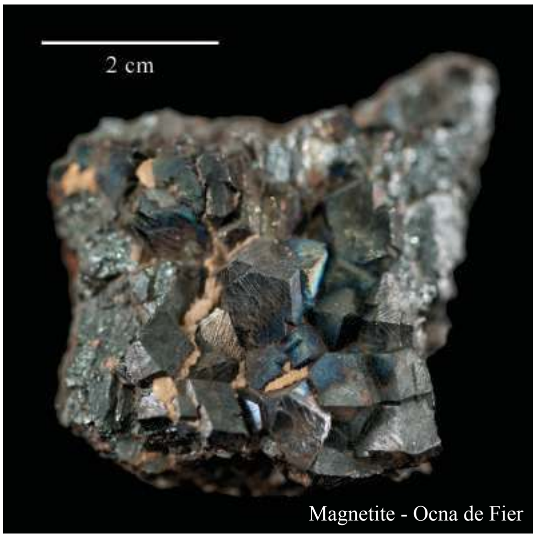
Chromite $Fe^{2+}Cr_2O_4$ – cubic. Name derives from the chemical composition. This is the main economical source for chrome.

Chromite - Pozanti, Turkey

Chromite is black to dark brown. It rarely occurs as well shaped crystals, more often massive, granular or as impregnations, compact masses or alluvial clasts.

There are numerous chromite occurrences in Romania, mainly associated with serpentinised ultrabasic rocks in South Carpathians, such as those of Precambrian age from Dealu Negru, Tițianu, Palaeozoic age from Southern Banat (Plavișevița, Tișovița, Eibenthal) or Mesozoic age (Urdele and Gura Văii). Similar rocks of Mesozoic age occur in East Carpathians at Breaza.

Magnetite $Fe^{2+}Fe^{3+}{}_2O_4$ – cubic. Name derived from Greek *magnes* – magnet (Haidinger, 1845).

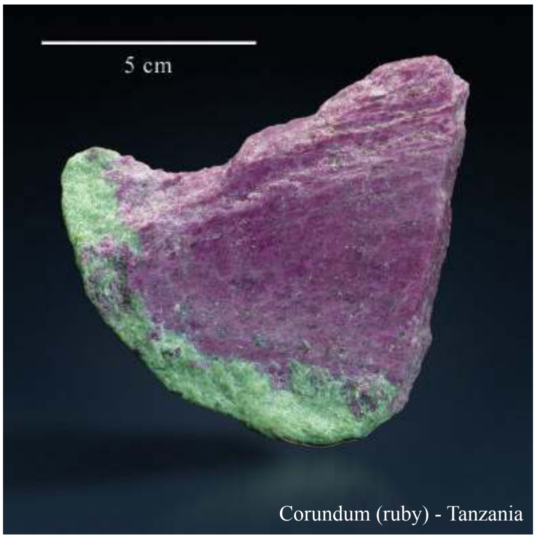


Magnetite - Ocna de Fier

Metallic mineral, with isometric, granular habit, one of the main sources of iron. Its main property is magnetism. There are over 100 occurrences in Romania, among which the most important are: Ocna de Fier (Banat), in skarn deposits, Căzănești, Ciungani, Almaș-Săliște, Cuiaș, Julița (Metaliferi and Drocea Mts.) in association with basic rocks, mainly gabbros. Secondary magnetite related to serpentinisation or chromite decomposition occur at Eibenthal, Tișovița, Plavișevița – Southern Banat); Dealu Negru and Tițianu – Sebeș Mts.; Rășinari – Cibin. Mts. As a result of thermal metamorphism of siderite, magnetite occurs at Rușchița in Poiana Ruscă Mts. Hydrothermal magnetite appears in porphyry copper deposits at Roșia Poieni, Bucium-Tarnița *etc.*

Worldwide, large magnetite deposits are found in Russia (Magnitogorsk, Kursk Magnetic Anomaly), Australia (Iron Monarch), Brazil (Itabira), United States, India.

Corundum Al_2O_3 – trigonal. Mineral name is of Indian origin: *kuruntam* - ruby (Estner, 1795).



Corundum (ruby) - Tanzania

Extremely hard mineral, 9th on the Mohs scale. Variable colour: colourless, blue (saphire), pink-red (ruby), brown, yellow, violet, bluish-green.

In Romania, corundum is known in the thermal aureole of various magmatic intrusions (Ditrău, Remeți, Băița Bihor, Pietroasa, Gilău) or in xenoliths found in andesites (Deva, Săcărâmb, Lipova) or rhyodacites (Julești-Valea Fagului, Bihor Mts.). Nice platy crystals are mentioned at Remeți (blue), Gilău (colourless, blue), Deva (blue), Săcărâmb (colourless).

In other countries, corundum was found in Germany, Czech Republic, Switzerland, Russia (Ural, Yakutia), Canada, United States, Australia, India, Afghanistan, South Africa, *etc.*

Cassiterite SnO_2 – tetragonal. Etymology: from Greek *kassiteros* – tin (Beudant, 1832).

This is an essential source of tin. It displays a brown, black, yellow or gray colour. Commonly it occurs as crystals, granular or radiary aggregates and rounded clasts. Cassiterite is hard (6-7 on Mohs scale), very dense (~6 g/cm^3) and insoluble in acids.

In Romania, cassiterite was mentioned only in as microscopic grains in various ores related to metamorphic rocks belonging to the Tulgheș Series (Burloaia, Fundu Moldovei, Leșu Ursului), associated with tourmaline, fluorite, topaz and lithium micas in Highiș Mts. or in the lithium pegmatites in Cibin Mts.

Abroad, cassiterite is relatively widespread. It is found in Germany (Altenberg, Zinnwald), Czech Republic (Cinovec), Great Britain (Cornwall), France (Bretagne), Russia, United States, Australia, Mexico and especially in the „tin belt" of Malaysia, Indonesia and Thailand.

Cassiterite - Czech Republic

Hematite - Elba, Italy

Hematite Fe_2O_3 – trigonal. Etymology: from Greek *haima* – blood (Pliny the Elder)

Hematite is one of the most important iron minerals. It has a greyish-black, reddish-brown or iron-black colour, especially when it occurs in compact masses. Often develops crystals, rose-like aggregates, scales, lamellae or oolites.

There are numerous hematite occurrences described in Romania. The most important accumulations are those hosted by the metamorphic rocks of Poiana Ruscă Mts. (Iazuri, Vadu Dobrii) and of East Carpathians (Cârlibaba, Giumalău). The "martite" paramorphosis consisting of magnetite, partially replaced by hematite, is specific to many skarn related deposits such as those at Ocna de Fier, Dognecea, Băișoara or to several regionally metamorphosed deposits in Căpățânii and Rodnei Mts. Beautiful crystals have been described in the altered andesites of Cucu Mountain – Harghita Mts. Lamellar crystals – the „specularite" variety were found at Iulia – North Dobrogea. Often, hematite is intergrown with chalcopyrite (Pătârș – Drocea Mts.), quartz (Cavnic) or with other common sulphides (Ilba, Baia Sprie, Herja).

Outside Romania, the main hematite occurrences are those already described for magnetite (see above).

Ilmenite - Norway

Ilmenite $FeTiO_3$ – trigonal. Named after *Ilmeni* Mts. In the Ural region (Russia).

The mineral forms an isomorphous series of limited miscibility with hematite. It is slightly magnetic and develops as quasi-tabular or granular forms. In Romania, though in minor quantities, ilmenite is a relatively common accessory mineral. Its presence is more conspicuous in the gabbros of Drocea Mts. Or in the veins of Ditrău Massif, as well as in the alluvia around Roșia Montană.

Worldwide, ilmenite is quite abundant in Germany, Switzerland, Great Britain, Norway, Russia, United States, Canada and represents an important titanium ore.

Goethite ”glasskopf” - Ocna de Fier

Goethite α-Fe^{3+}O(OH) – orthorhombic. Named after the German writer *J.W.Goethe* (1749-1832) (Lenz, 1806).

Goethite is a relatively common mineral. It displays a brown or black colour and a variable morphology: crystals, stalactites, earthy massive aggregates, radiary aggregates, oolites, concretions and pseudomorphoses various iron minerals.

In Romania, goethite is known from many occurrences, mainly of supergene or hydrothermal origin. Among the most spectacular occurrences are the “limonite” stalactites in the volcanoclastic “caves” of Călimani Mts. Often, goethite is found as a pseudomorph after pyrite (Băița Bihor, Moneasa and Țibleș) or marcasite (Cavnic), garnet (Ocna de Fier), siderite (Lueta, Baia de Arieș) and calcite (Oravița). Goethite is the major component of the Dogger ferruginous oolites in Munteana (Banat) or of the Paleogene ones in Căpușu Mic (Eastern Gilău Mts.) Goethite is a significant secondary iron ore in Poiana Ruscă (Ghelar, Teliuc).

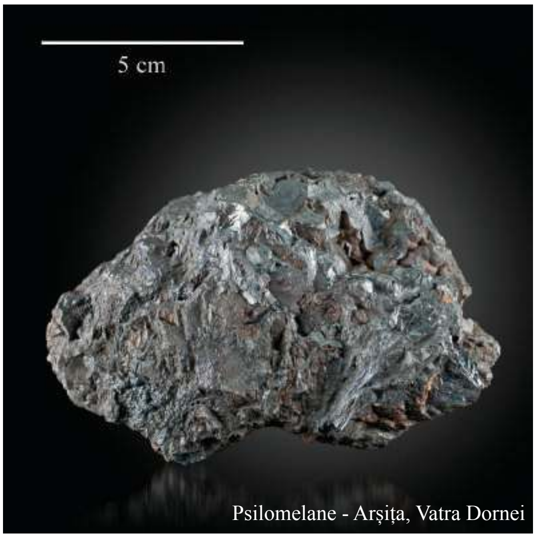
Manganite - Ildfeld, Harz Mts., Germany

Over the world, goethite is found in Germany, France (the Dogger minnettes of Alsace and Loraine), Great Britain, Russia, United States and Australia. Goethite is an important iron ore.

Manganite α-Mn^{3+}O(OH) – monoclinic. Etymology: after its chemical composition (Haidinger, 1827).

This is relatively rare manganese mineral. In Romania, occurs as a secondary mineral in various manganese ore deposits (Răzoare, Iacobeni, Delinești, Godinești, Șoimuș-Buceava and Moneasa).

Across the world, manganite occurs in Germany, Great Britain, Russia, Canada, Sweden, Australia, India, *etc.*



Psilomelane - Arșița, Vatra Dornei

“Psilomelane”-Romanechite $(Ba,H_2O)_2(Mn^{4+},Mn^{3+})_5O_{10}$ – monoclinic. Etymology (for psilomelane): from Greek *psilos* – glossy and *melas* – black (Haidinger, 1827)

Black, opaque, earthy mineral, often crypto-crystalline, with dendritic and even stalactitic aggregates. In Romania, it is assumed that romanechite represents as a supergene mineral in numerous Mn and Fe deposits, previously known as “psilomelane” occurrences. It is the case of various deposits in South or East Carpathians (Tolovanu) or of the residual Mn or Fe-Mn ores at Moneasa – Codru-Moma Mts., Pârnești – Highiș Mts., Godinești and Șoimuș-Buceava, Drocea Mts. Commonly, romanechite forms black crusts and associates with birnessite, pyrolusite, goethite.

Uraninite UO_2 – cubic. Etymology: after the metal *uranium* (Born, 1772).

Uraninite is black, gray and sometimes greenish. Occurs as crystals, massive, granular, earthy aggregates or even reniform shapes („pechblende” variety). Its main remarkable property is radioactivity.

Uraninite - Erzgebirge, Germany

In Romania, uraninite exists mainly as hydrothermal „pechblende”. It is the main mineral component in the uranium ore deposits of Băița Bihor, Ciudanovița and Mehadia – Banat, Crucea – Bistriței Mts. It is also common in the uranium accumulations of Leaota Mts., where it occurs as microgranular black masses, with coaly aspect, named „thuchoite” (from the major contained elements Th,U,C,H,O).

Worldwide, uraninite occurs mainly in the United States (Colorado), Canada (Blind River), Congo-Kinshasa (Shinkolobwe – the place wherefrom uranium used for the first atomic bombs was extracted), South Africa (Witwatersrand), Czech Republic (Jachymow – place of origin for the uraninite samples studied by Marie Curie – the material in which the chemical element radium was discovered, Pribram), France, Germany.

Quartz SiO_2 – trigonal. The name *quertz* was first used in an early 16th century anonymous publication in Germany „Eyn Nützlich Bergbüchlein”.

Quartz is one of the most widespread minerals in the Earth’s crust. It displays a whole variety of colours and crystallinities which is generically grouped under the term „silica”:

I. phanerocrystalline varieties: „rock crystal” – transparent, limpid, „ametist” – violet, „smoky quartz”, „pink quartz”, „morion” – black, „citrine” – yellow, „saphirine” - bluish, „tiger’s eye” – pseudomorph quartz after altered crocidolite, „hawk’s eye” – a partially silicified variety of the „tiger’s eye” pseudomorph, „cat’s eye” – a more translucent and brighter variety of „tiger’s eye”, „aventurine” – quartz with mica or hematite inclusions, „common quartz” – gray, milky white, „ferruginous quartz” – impregnated with iron oxides and hydroxides, *etc.*

II. cryptocrystalline varieties: named „chalcedony” or – based on peculiar textures – „agate”, or „onyx”.

In Romania, quartz is known in a large variety of geological formations and in numerous crystallographic forms. For instance, the Cretaceous sandstones of Maramureș are hosts for the famous „Maramureș diamonds” (small crystals of up to 5 mm, located in diagenentic diaclases). Alpine veins from metamorphic formations contain large quartz crystals, commonly associated with „adularia” (monoclinic K-feldspar), chlorite, epidote, *etc.* (*e.g.* Parâng, Plopiș, Rodna). Among these, the most impressive are the veins near Uricani-Șigleu or the quartz occurrences in the pegmatites from Voineasa, Teregova – South Carpathians and Muntele Rece – Apuseni Mts. Nice, perfectly transparent quartz crystals grown in spectacular geodes were found in the hydrothermal veins from Baia Mare metallogenic district and from the Golden Quadrilateral (*e.g.* Herja, Baia Sprie, Cavnic).

„rock crystal” – Uricani

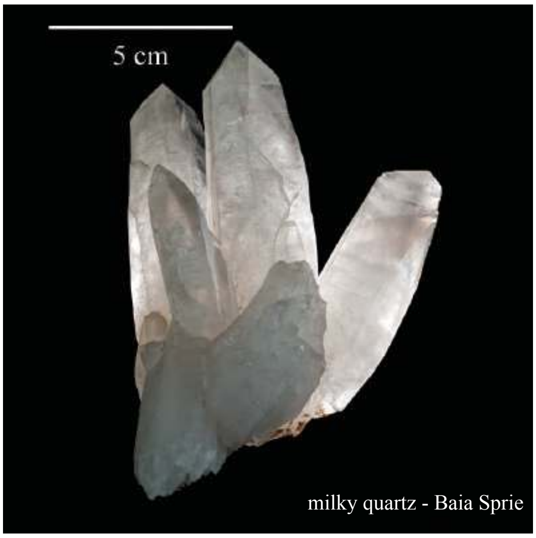
„ametist” – Brazil

pink quartz - Madagascar

„tiger’s eye” - Brazil

smoky quartz- Baia Sprie

„Maramureș diamonds”



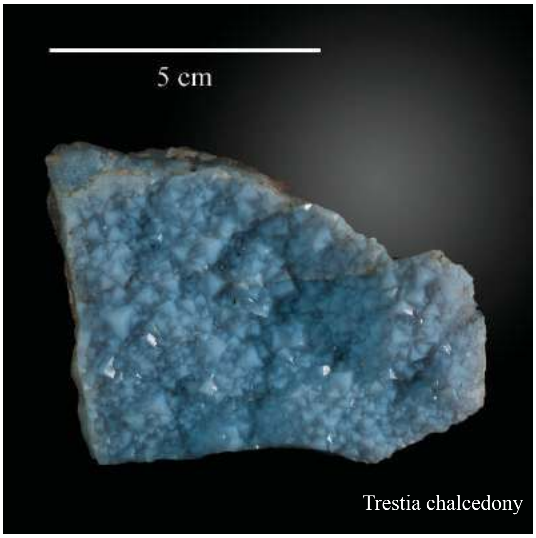
milky quartz - Baia Sprie

„citrine" – Brazil

Other hydrothermal occurrences display milky-white crystals or „ametist" (Săsar, Valea Roșie). The most impressive violet quartz crystals were discovered at Vălișoara – Metaliferi Mts. (up to 15 cm) and at Dognecea where they associate with garnets. Peculiar forms such as sceptre have been recently described at Baia Sprie. Dauphine twins were found in Vlădeasa Mts., whereas perfect Japanese coaxial twins were described at Ocna de Fier. Also famous are the centimetric bipyramidal quartz crystals in the rhyodacites from Roșia Montană.

„Chalcedony" is a microcrystalline form of silica, often occurring as veinlets, nests or small geodes, such as those in the basic rocks of Metaliferi Mts. (Techereu) and Trascău Mts.(Rîmetea), in the Upper Cretaceous granodiorites (Dognecea) or in the Neogene andesites (Căpușu Mic – Gilău Mts., Firiza, Trestia – near Cavnic, Băița, Vălișoara, Zlatna, Gura Văii, Roșia Montană – Metaliferi Mts.).

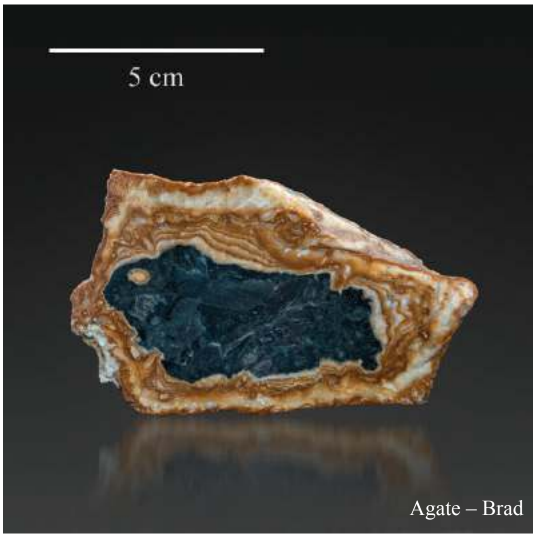
The colour of chalcedony varies from greenish to blue (Trestia) or reddish (Maramureș and Trascău). The most renowned occurrence is that of Trestia, described as early as the 18th century. Blue fragments of up to 20 cm may be found in soils and alluvia, or developed on andesitic pyroclastites. It occurs as reniform aggregates, rubanated crusts, or small geodes with cubic crystals of up to 3 cm. Such cubic crystals were considered to represent pseudomorphs after various minerals such as fluorite or galena, but recent studies (Ilinca, 2009) established that they represent quartz pseudomorphs after melanophlogite – a peculiar mixture of silica and organic matter – $(2\text{-}x)(CH_4,N_2).(6\text{-}y)(N_2,CO_3).Si_{46}O_{92}$.



Trestia chalcedony

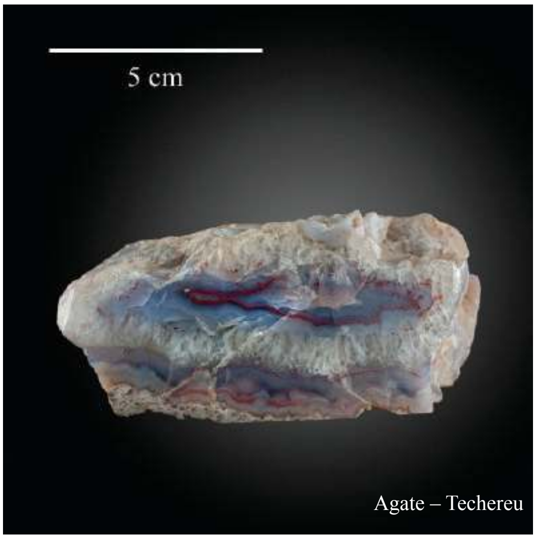
Trestia chalcedony

Agate – a microcrystalline variety of silica characterised by a parallel banded texture described by alternating and contrasting colours**.** Etymology: after river *Achates* from Southern Sicily.

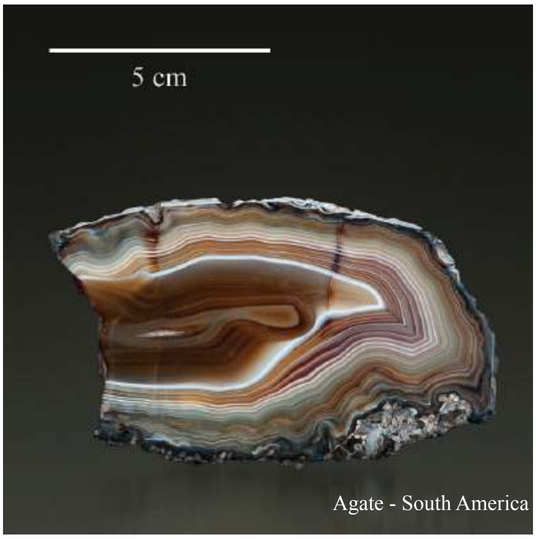


Agate – Brad

Agate – Mureș Valley



Agate – Techereu



Agate - South America

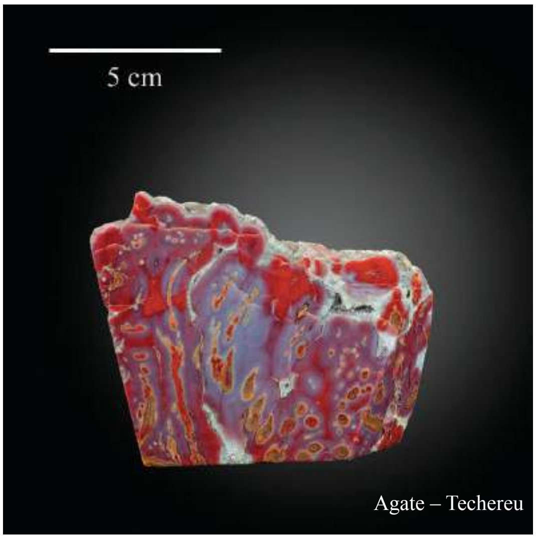
Onyx – same as agate, but with alternating layers forming a perfectly concentric, circular texture. Etymology: after the Greek word *onux* – nail.

Agate and onyx are frequent in volcanic areas. There are famous occurrences in Germany, Slovakia, Italy, Russia, China, India, Australia, *etc.* The largest and most beautiful agates and onyxes are found in Brazil and Uruguay. Nice samples exist also in Mexico and in the United States. In Romania, there are nice occurrences at Trestia, along Mureș Valley and at Techereu din Apuseni Mts.

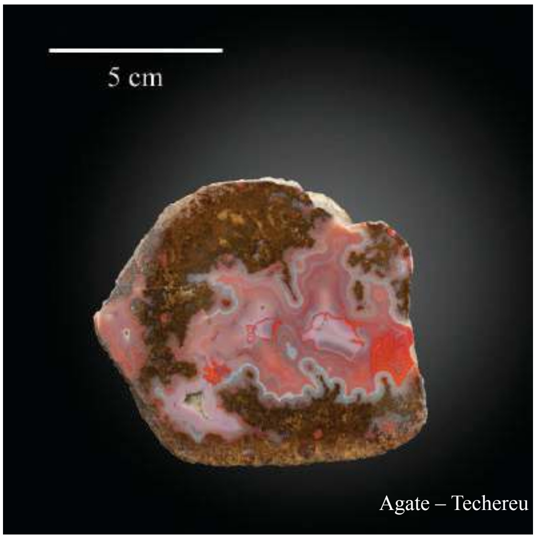
Opal SiO_2.nH_2O – amorphous. Etymology: from Sanskrit, *upala* – precious stone, jewellery.

Opal is amorphous silica, yet no anorganic substance could ever be entirely non-crystallised. Opal is in fact a „rock" consisting of microminerals, mainly silica polymorphs such as trydimite, cristobalite or quartz. To the naked eye, and even under the polarising microscope no crystalline properties are obvious, however.

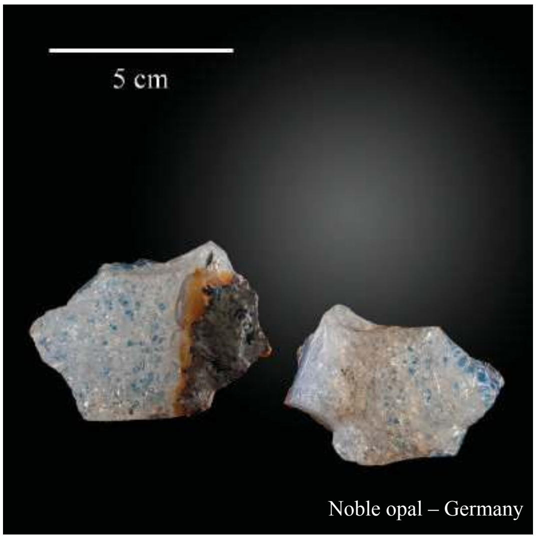
Opal occurs in various colours: white, yellow, reddish, brown, bluish, black, most often whitish, with a murky aspect. Morphology is specific to poorly crystallised materials: concretions, spheroidal shapes, rounded bunches, stalactites, oolites, earthy masses. Based on colour or structure, the following opal varieties may be distinguished:



Agate – Techereu



Agate – Techereu



Noble opal – Germany

Chrysopal - Techereu

- Noble opal: with a multicoloured characteristic opalescence;
- Fire opal: fire-red to hyacinth red;
- Milky-white opal;
- Common opal: yellowish, yellowish-brown, brown and black with resinous lustre;
- Woody opal: with remnant wood structure, preserved after pervasive silicification;
- Chrysopal: greenish;
- Hydrophane: matte, microporous, with splintering break, translucent when immersed into water;
- Hyalite; transparent like water, vitreous lustre;

In Romania, opal is common in many rocks, especially in volcanic terrains. The best known occurrences are at Techereu – Metaliferi Mts., Brad (near the Sanatorium) or along the Mureș Valley.

6. Carbonates

Carbonates compounds of metals and the anionic unit $[CO_3]^{2-}$. Structurally, the anionic unit consists of a C^{4+} ion placed in the centre of an equilateral triangle formed by three O^{2-} ligands which bond to the metals. There are over 230 carbonate species, but only 13 of them are widespread:

- the calcite group (trigonal – *R3m*): calcite - $CaCO_3$; magnesite - $MgCO_3$; siderite - $FeCO_3$; smithsonite - $ZnCO_3$; rodochrosite - $MnCO_3$;

- the dolomite group: dolomite - $CaMg[CO_3]_2$; ankerite - $Ca(F^{e2+},Mg)[CO_3]_2$;

- the aragonite group (orthorhombic – *Pmcn*): aragonite - $CaCO_3$; strontianite - $SrCO_3$; cerusite - $PbCO_3$; witherite - $BaCO_3$.

- monoclinic carbonates: malachite - $Cu_2^{+2}[CO_3](OH)_2$; azurite - $Cu_2^{+3}[CO_3]_2(OH)_2$

Calcite $CaCO_3$ – trigonal. Name derives from Latin *calcis* - lime.

Calcite is one of the most widespread minerals in Romania and in the world. Calcite is main mineral component of limestones, marls and marbles. Marble is an excellent decorative stone, used ever since the Antiquity. Many of the architectural „wonders" of the Ancient World were built with marble. This was also the material preferred by many famous sculptors in ancient Greece (*e.g.* Phidias, Myron) or during the Renaissance (*e.g.* Michelangelo).

Calcite – Brad

Calcite – Rușchița

Calcite – Musariu

Calcite – Cavnic

Calcite – Brad

Calcite – Brad

In Romania, there are several mountain chains with large marble lithons: Făgăraș, Sebeș, Parâng, Rodna, *etc.* Yet, the best known marble is that of Rușchița, which formed at the contact between magmatic intrusions of Upper Cretaceous age and Lower Palaeozoic crystalline limestones in Poiana Ruscă Mts.

Mineral collections – as the one you are just visiting, gather beautiful calcite samples with a great variety of forms and colours. Among the largest crystals ever found in Romania are those originating in the thermal aureoles of Moldova Nouă, Sasca Montană, Dognecea and Ocna de Fier and Băița Bihor. Beautiful specimens – commonly known as „mine flowers" – displaying a large variety of morphologies and colours, come from hydrothermal vein deposits in Gutâi Mts. and Metaliferi Mts.

In most such cases, calcite is associated with quartz, baryte, common sulphides (pyrite, sphalerite, galena, chalcopyrite). Peculiar black, gray, white or half black- half white spheres of calcite have been described at Herja (about 8 km from Baia Mare). Appealing specimens of calcite were also collected from Dealu Crucii (near Baia Mare) and Cavnic. In the later locality – where rhodochrosite - $MnCO_3$ is frequent - a very nice type of pink calcite has been collected.

In Metaliferi Mts., the most beautiful „calcite flowers" were found at Baia de Arieș (crystals of various shapes and sizes of up to 8 cm), Zlatna (crystals up to 4 cm). The calcite from Musariu ore deposit is sometimes associated with native gold and occurs as scalenohedral crystals. In some rare cases, it displays a very fine zoning which is enhanced by fine traces of gold. Calcite and aragonite are the main mineral component of stalactites and stalagmites in carstic caves. The caves hosted by carbonatic formations of Jurassic and Cretaceous age in Bihor Mts. (Piatra Altarului, Meziad, Peștera Urșilor), Vâlcan Mts. (Cloșani) and Parâng

Aragonite – Germany

Aragonite - Spain

(Muierii Cave) are among the most spectacular in the world. In almost all situations, calcite and aragonite associate with gypsum, vaterite and carbonate-hydroxylapatite (the so-called „dahlite”).

Aragonite $CaCO_3$ – orthorhombic. Etymology: after *Aragon* Province in Spain.

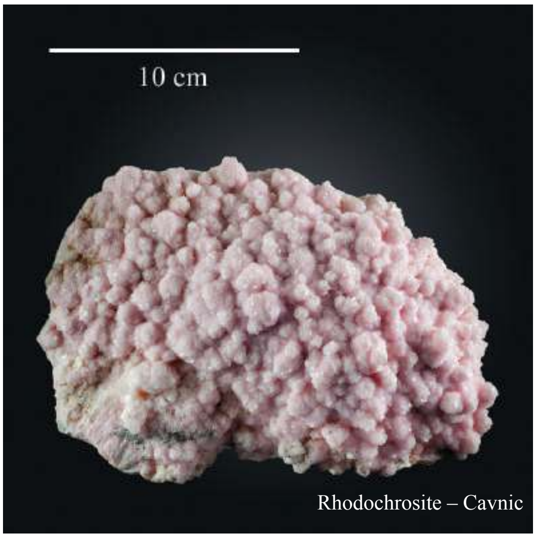
Aragonite is a polymorph of calcium carbonate, with lower symmetry than calcite. It occurs with a variety of colours: white, white-gray, colourless, yellow, brown-green, pink, purple, bluish, red, orange. Aragonite is mainly used as an ornamental rock.

In Romania, aragonite is relatively widespread, with almost 30 known occurrences. Commonly, it displays needle-like crystals (*e.g.* Moldova Nouă, Dognecea, Ocna de Fier and Băița Bihor). Sometimes is massive (*e.g.* Corund, Săcărâmb, Borșa and Băiuț) and hence, used for manufacturing various desktop accessories and ornaments.

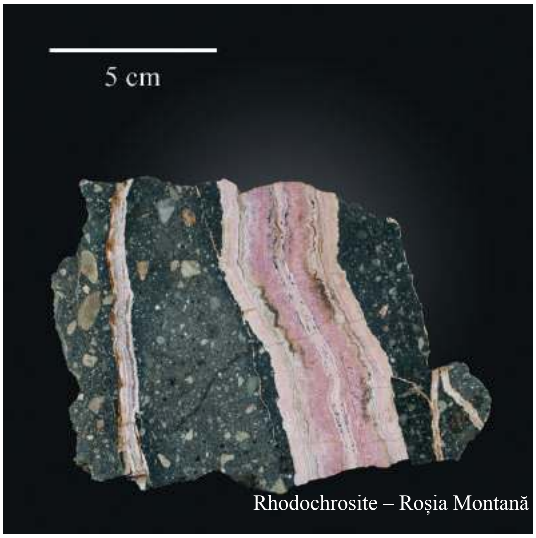
Aragonite is also common in carstic caves (*e.g.* Valea Rea – Bihor Mts., and some caves in Rodnei Mts.).

Rhodochrosite $MnCO_3$ – trigonal. The mineral name was introduced in 1800, when Lampadius carried out the first chemical analyses of samples from Cavnic (Kapnikbánya) (Hausmann, 1813). In fact, the mineral had been known before, but was not assigned with a precise chemical composition. For this reason, Cavnic could be considered the type locality for rhodochrosite.

Rhodochrosite is a relatively widespread mineral, described in over 30 occurrences. Significant amounts of rhodochrosite have been reported in the Mn and Mn-Fe layered ores from Iacobeni, Șaru Dornei, Oița, Dadu, Tolovanu, Broșteni, Delinești (East Carpathians), Bătrâna, Bretan, Pravăț, Leucuș, Foltea, Dealu Negru, Globurău (South Carpathians) and at Răzoare (Preluca Massif). In such occurrences, rhodochrosite is always fine-grained and it is intimately associated with rhodonite, spessartine and Mn-grünerite.



Rhodochrosite – Cavnic



Rhodochrosite – Roșia Montană

Many interesting occurrences are located in the hydrothermal veins related to Miocene volcanics in the Baia Mare metallogenic district and in Metaliferi Mts. Here, rhodochrosite is associated with calcite, and develops as fine-grained aggregates in the gold ores of Săsar or in the polymetallic veins at Baia Sprie and Cavnic. In Metaliferi Mts., there are numerous rhodochrosite occurrences, such as Crăciunești, Caraci, Valea Morii, Zlatna, Musariu and Bucium, especially in the gold ores associated with alabandite or gold tellurides. The geochemical triad Au-Te-Mn is characteristic to the Au and Te ores. Rhodochrosite forms fine-grained or reniform aggregates, with alternating layers of quartz, gold, chalcopyrite, chalcedony (Roșia Montană) or crusts and layers alternating with alabandite and calcite (Baia de Arieș). The most interesting occurrence is that of Săcărâmb, where large crystals of rhodochrosite (over 7 mm) are associated with nagyágite, alabandite, quartz and iron-poor sphalerite. Spheroidal pink aggregates of at least 1 cm, are also typical.

In Slovakia, rhodochrosite occurs in the hydrothermal veins of Banská Stiavnica and Hodruša-Hámre, as minute crystals, globular aggregates or massive infillings, associated with baryte, dolomite and Mn-bearing calcite. In Hungary, rhodochrosite is one of the dominant mineral phases in the Mn ores of Bakony Mts. (Urkút, Eplény). In Poland, rhodochrosite is relatively abundant in the diagenetic concretions hosted by Lower Triassic marls in the Carpathian flysch. In Ukraine, rhodochrosite is the main component of the Mn-silicate and carbonate ores from Chyvchyny, Rakhiv and Burshtyn. Other occurrences worldwide were mentioned in Germany (Freiberg, Neubulach), France (Les Cabannes), Peru (Pasto Bueno), United States (Colorado), *etc.*

Dolomite $CaMg[CO_3]_2$ – trigonal. Etymology: the name was given by Saussure in 1796, after the French mineralogist and geologist *D. de Dolomieu* (1750-1801).

Dolomite - Cavnic

Dolomite is among the most frequent carbonates. It occurs in various forms (rhombohedral crystals, and subordinately, prismatic and tabular) and colours (colourless – in the case of pure dolomite, gray, greenish, brown, yellowish-brown – mostly dependent on the iron content).

In Romania, dolomite is frequent in various sedimentary carbonate formations of the South Carpathians (especially in Poiana Ruscă Mts.), East Carpathians and Apuseni Mts. Dolomite crystals were also found in the hydrothermal veins of Metaliferi Mts. (Săcărâmb, Hărțăgani, Roșia Montană), Gutâi Mts. (Herja, Baia Sprie, Cavnic) or in pyrometasomatic ore deposits (Ocna de Fier).

Siderite $FeCO_3$ – trigonal. Etymology: name comes from Greek *sideros* – iron (Haidinger, 1845).

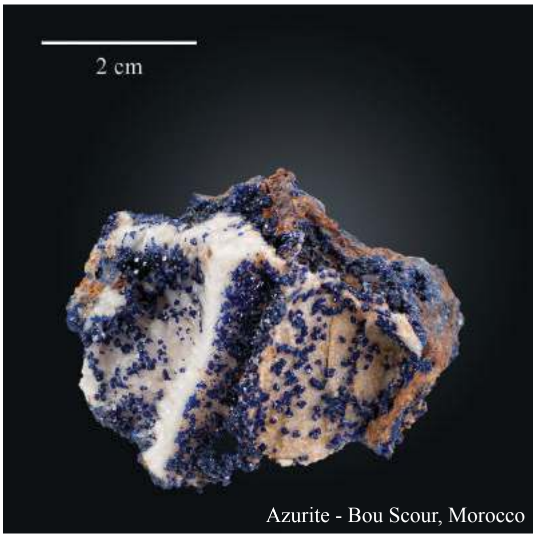
Siderite - Herja

In opposition with other carbonates and due to its chemical composition, siderite is always coloured in brownish hues. It displays numerous morphological aspects: well shaped crystals, massive, oolites, earthy masses, reniform aggregates, *etc.*

In Romania, siderite is known as a significant iron source at Teliuc, Ghelar, Vadu Dobrii (Poiana Ruscă Mts.) and at Delniţa (East Carpathians). As a gangue mi-neral, siderite was described in numerous places: as rhombohedral crystals at Săsar, Baia Sprie, Băiuț or reniform-spheroidal aggregates grown on stibnite or baryte, at Baia Sprie and Cavnic. Compact metasomatic masses of siderite, formed through the action of meteoric waters, are mentioned in the Miocene sedimentary formations of Lueta, Vlăhița, Mădăraș and Bodoc. Spheroidal masses called „spherosiderites” are well known in the Liasic sedimentary formations of Anina and Doman and in the Cretaceous flysch of the East Carpathians.

Azurite $Cu_2^{+3}(CO)_2(OH)_2$ – monoclinic. Name derives from Persian word *lazhward* – sky blue. The mineral was described in 1824, by Beudant. Azurite is mainly used as a pigment.

There are numerous azurite occurrences in Romania. It develops mainly as crusts and films over primary copper sulphides. Well shaped crystals have been described at Deva (<1 cm), Moldova Nouă (>3 mm); crusts, reniform aggregates and small columns grown on primary sulphides were also found. At Sasca Montană, in the Banatitic Province, authors have described the largest crystals known in Romania (up to 5 cm) along with globular and columnar aggregates; radiary aggregates occur at Dognecea and lamellar aggregates at Ocna de Fier. Interesting occurrences are also those from Delnița – Bistriței Mts., where large compact masses of azurite have been described. This could be one of the sources for the famous „Voroneț blue” used for painting the frescos of the well known monastery in Moldavia. Other occurrences are at Bălan, Baia Sprie, Bucium, Oravița, Lipova, and Băița Bihor, *etc.*



Azurite - Bou Scour, Morocco

Malachite $Cu_2(CO_3)(OH)_2$ – monoclinic. name comes from Greek *malache* – hollyhock. In Antiquity, mainly in Egypt, Greece and Roman Empire, malachite was intensely used as a precious stone and as a pigment for painting and make-up.

Malachite is frequent in numerous places in Romania. It is one of the most important secondary copper minerals.

The most significant amounts were found at Moldova Nouă (the best samples of reniform malachite); Sasca Montană (malachite, azurite and goethite crusts), Ocna de Fier (fibrous malachite grown on hematite and malachite pseudomorphs after cuprite); Băița Bihor (reniform and spheroidal aggregates of malachite associated with cerusite and hemimorphite - $Zn_2Si_2O_7(OH)_2.H_2O$.

Other occurrences: Lipova, Deva, Stănija, Ilba and Toroiaga.

Malachite - Congo

7. Sulphates

Baryte $BaSO_4$ – orthorhombic. Etymology: from the Greek word *barys* – heavy (Karsten, 1800).

Baryte is mostly an accessory mineral in the Earth’s crust. However, it is relatively widespread in Romania, either in magmatic formations – especially in hydrothermal veins, or in metamorphic and sedimentary environments.

In Romania, the best known accumulations are at Somova – North Dobrogea, where baryte formed through the metasomatosis of the brecciated Triassic limestones and at Ostra and Gemenea – Rarău Mts. where baryte is of hydrothermal origin. These were of some economical interest in the seventh and eighth decades of the last century and covered the baryte quantities necessary for the Romanian oil industry. However, the most spectacular specimens and „mine flowers” were found in the hydrothermal veins from Baia Sprie and Cavnic – Gutâi Mts. Such specimens display crystals of up to several centimetres with various colours: white, greys, greenish, bluish and even red.

Baryte - Musariu, Brad

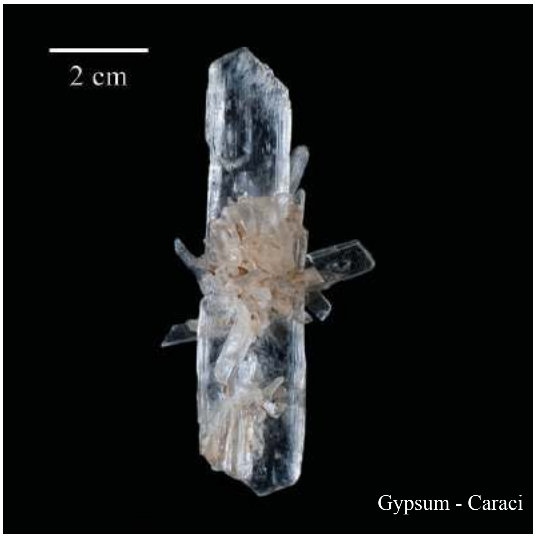
Red baryte - Baia Sprie

In Metaliferi Mts., is less frequent, but nice crystals were described at Troița and Băița-Crăciunești (bluish-gray, with sizes of up to 5-6 cm), Musariu (lamellar crystals, sometimes zoned, associated with native gold), Săcărâmb (fine, thin and transparent crystals associated with stibnite), Boteș (pseudomorphed by calcite), Roșia Montană, Baia de Arieș, Măgura and Deva.

In crystalline environments, baryte was cited in Poiana Ruscă Mts. (Ghelar, Teliuc, Luncani – associated with siderite, Muncelu Mic), in Bistriței Mts. (Cârlibaba, Ciocănești, Dadu, Oița, Tolovanu), Rodnei Mts. (Valea Blaznei, associated with cu quartz and cimrite - $BaAl_2Si_2(O,OH)_8.H_2O$) and Făgăraș Mts.(Poiana Mărului). In sedimentary formations, baryte was mentioned at Colțești near Turda – in sandstones, together with pyromorphite – $Pb_5(PO_4)_3Cl$, at Pleși near Râmnicu Sărat – in Miocene sandstones, together with rhodochrosite and common sulphides, and at Copăceni near Turda, associated with celestine in bituminous Miocene limestones.

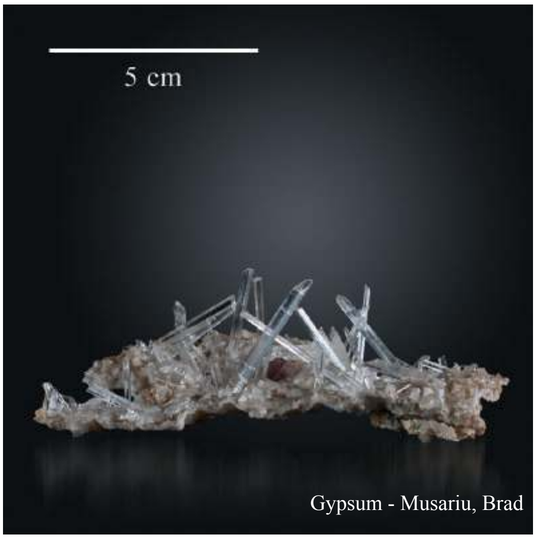
Gypsum $CaSO_4.2H_2O$ – monoclinic. Etymology: name derives from Greek *gypsos* – plaster or chalk.

Gypsum represents one of the economically important natural sulphates. It is mainly used in the cement industry – especially under the form of rigypsum.



Gypsum - Caraci

Gypsum - Musariu, Brad



Gypsum - Musariu, Brad

Gypsum - Cavnic

The most significant gypsum accumulations are located in the Miocene evaporites in the Transylvanian Basin and in the Precarpathian Depression. It occurs as white masses, sometimes as fine-grained aggregates named „alabaster”. At the same time, gypsum is among the most valuable mineral collection items, mainly due to its variable morphology, size and crystal quality. The most spectacular crystals were found at Cavnic where they can reach up to 80 cm. Smaller crystals were found at Baia Sprie, Băiuț, Roșia Montană, Săcărâmb, Musariu and Moldova Nouă. Gypsum was described also in the gangue of porphyry copper ores at Bolcana, Voia, Tălagiu and Moldova Nouă.

Anhydrite - Campangna, Italy

Anhydrite $CaSO_4$ – orthorhombic. Etymology: from the Greek *anhydros* – with no water, opposed to gypsum which contains water (Werner, 1803).

From a geological point of view, anhydrite occurs in three situations: syngenetic, primary in Triassic, Jurassic and Miocene formations; hydrothermal, associated with metallic veins – *e.g.* Cavnic; in porphyry copper deposits at Moldova Nouă, Voia, Bolcana and Tălagiu.

It usually occurs as fine-grained masses of white to gray colour.

Celestine - Montalien, France

Celestine $SrSO_4$ – orthorhombic. Name given after the Latin *coelestis* – celestial, pointing to its sky blue colour, (Werner, 1798).

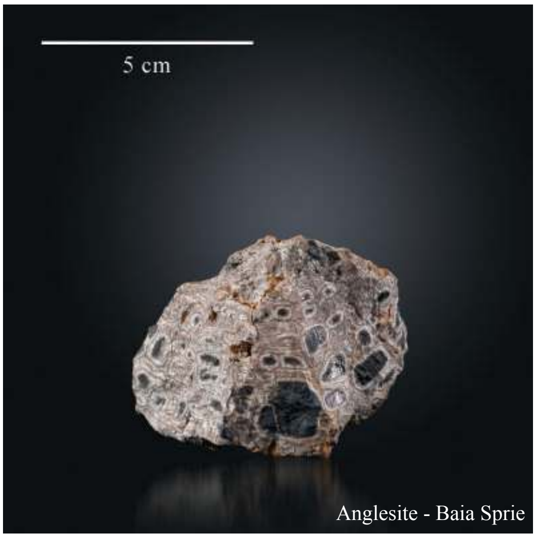
Celestine is a rare mineral. In Romania it occurs in skarns (*e.g.* at Băița Bihor), with hemimorphite ($Zn_4Si_2O_7(OH)_2 \cdot H_2O$) and gypsum, in sulphur-bearing sedimentary rocks (at Pucioasa) or in Lower Jurassic limestones (at Anina).

The most representative occurrence is Copăceni –Turda where celestine develops in Tertiary limestones. Here, celestine is white or bluish-white, and has a prismatic habit when grows in geodes. Similar occurrences were reported at Cheia, also near Turda and Sândulești, not far from Cluj-Napoca. Here, celestine shows well developed crystals of gray, bluish or even reddish colour and associates with gypsum. Also a sedimentary celestine was found at Ivăncăuți in Northern Moldavia where it associates with calcite and forms small lenticular bodies or veins in Badenian limestones. Celestine was also reported in Valea Rea Cave – Bihor Mts., with gypsum and anhydrite.

Worldwide, celestine occurs in Germany, Great Britain, Russia, Canada, Sweden, Australia, India, *etc.*

Anglesite $PbSO_4$ – orthorhombic. Name comes from *Anglesey* Island (Wales) (Beudant, 1832).

Anglesite is a secondary sulphate which occurs mostly as crusts and only rarely as crystals, in the oxidation zone of sulphide deposits. Such situations were met in: Baia Sprie, Rodna – Ţibleş Mts., Toroiaga, Gemenea and Stănija - Metaliferi Mts.



Anglesite - Baia Sprie

Crystal of various sizes and different colours were reported at Vișeu de Sus, Dognecea and Ocna de Fier. In the later occurrence, crystals of about 2 cm, associated with galena and other secondary minerals were reported.

Epsomite $MgSO_4.7H_2O$ – orthorhombic. Named after *Epsom* locality (Great Britain) where it was described for the first time (Beudant, 1824).

Epsomite- Brad

It is a rare mineral, with fibrous acicular habit, quoted at Cârlibaba where it was found on the walls of old mining works, in Iași region, as efflorescences, and at Tg. Ocna., in combination with potassium salts.

Older references mentioned epsomite in association with coal at Săsciri-Sebeș. “Zinkfauserite” from Baia Sprie is a variety of epsomite (Udubaşa *et al.*, 2002).

“Kalinite” (alum) $KAl(SO_4)_2.11H_2O$ – monoclinic.

Mineral of doubtful validity, soon to be discredited by IMA (International Mineralogical Association).

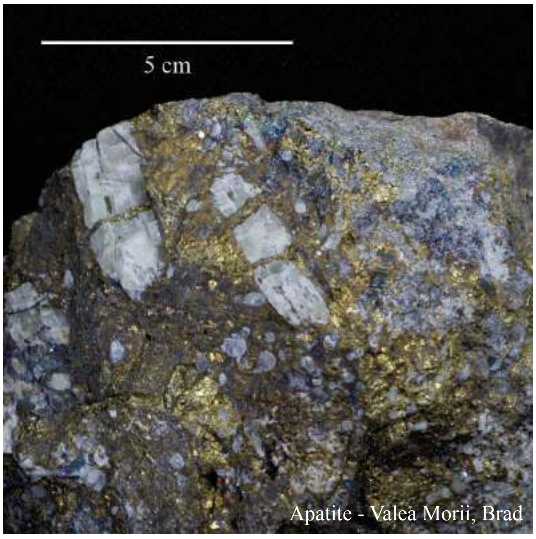
„Kalinite” is white, fine-grained and often occurs as efflorescences in the Miocene sandstones and clays at Filipeștii de Pădure, Șotânga and other localities in the Subcarpathian area. Also reported in mineral collections as an alteration product of samples containing coal.

„Kalinite” - synthetic

8. Phosphates

Apatite $Ca_5(PO_4)_3(OH,F,Cl)$ – hexagonal. Etymology: from Greek *apate* – deceptive, alluding to being hardly distinguishable from other minerals.

Apatite has a complex chemistry and the formula above is just generic. It has many varieties so that apatite is no longer recognised as an individual phase, but rather as a dense group of minerals.



Apatite - Valea Morii, Brad

Apatite occurs often as a phosphatic rock, used rawly as a fertilizer. Apatite is also used in the chemical industry for manufacturing softeners, cleaning powders, insecticides, in oil refinement and also in the food and ceramic industry.

In Romania, it is assumed that there are all members of the apatite group: carbonate-rich fluorapatite, hydroxylapatite, chlorapatite, fluorapatite, and even stronadelphite - a strontium apatite. There is no availability of analytical data that would allow a differentiated presentation of apatite occurrences, especially those referred to in older writings. In general, apatite is widespread , but most frequently it occurs in pegmatites (Răzoare, Teregova, Armeniș); in the alkaline complex of Ditrău; in hornfels (Ţibleş , Parâng Mts.); in copper polymetallic and gold deposits (Lipova, Baia de Arieș, Valea Morii); in manganese ores at Răzoare (carbonate-rich fluorapatite); in Ocna de Fier , with diopside; in the Alpine veins of Parâng Mts., associated with adularia and chlorite; in the metamorphic limestones of Runc, near Turda (previously described as "dahllite"); in various caves of Pădurea Craiului Mts. (Gălăşeni, Igriţa, Stracoș, Meziad) and in guano deposits and bone breccias.

Monazite - Ditrău

Monazite $(Ce,La,Nd,Sm,Gd..)PO_4$ – monoclinic. Etymology: from Greek *monazeis* – to be alone (Breithaupt, 1829).

Monazite is a rare mineral with a complex chemistry that led to the definition of a so-called monazite group which includes: monazite-(Ce), monazite-(La), monazite-(Nd), monazite-(Sm).

Monazite is tabular or prismatic, with colours ranging from yellow, reddish-brown, yellowish-green and even white. In Romania, occurs in the following geological environments: alkaline magmatic rocks (Ditrău Massif, north of Gheorgheni, Harghita County: monazite-(Ce) and monazite-(La)); shear zones in regional metamorphic areas: Grădiștea de Munte, Valea Pianu, in the north part of Sebeș Mts., Cibinului Valley and Turnişor – Cibin Mts.; in relation with polymetallic deposits, in the north part of Făgăraș Mts.; in manganese-bearing schists: Delinești – Semenic Mts., Răscoala – Sebeș Mts.

Vivianite $Fe_2^{+3}(PO_4)_2.8H_2O$ – monoclinic. Named after the English mineralogist *J.G. Vivian* (Werner, 1817).

Commonly, vivianite is prismatic or tabular, with colours ranging from colourless on fresh surfaces, to pale-blue, bluish-green, indigo-blue or even black. In Romania, vivianite occurs in hydrothermal environments and in sedimentary formations. The former category is represented by centimetric crystals in the sulphide veins of Herja-Baia Mare, Ilba – Gutâi Mts., Roșia Montană, Roșia Poieni (the largest crystals described in

Romania – about 30 cm^2) or in the pyrite mineralisation of Rodna and Moldova Nouă. The later type is outlined by vivianite found in the coal deposit of Căpeni – Baraolt Mts. and in carstic caves (Valea Rea).

Pyromorphite $Pb_5(PO_4)_3Cl$ – hexagonal. Name derives from the Greek words *pyr* – fire and *morphe* – shape (Hausmann 1813).

Pyromorphite belongs to the apatite group. It is a secondary minerals found in the oxidation zone of galena-bearing deposits. It may be green, yellow or brown.

In Romania, pyromorphite was described as an alteration product of galena occurring in brown reniform aggregates (Oravița), prismatic crystals (Dognecea, Ocna de Fier, Rușchița), or acicular and with a grass-like aspect (Băița Bihor). The largest crystals (>1 cm^2) were found at Ocna de Fier and Dognecea.

Turquoise $Cu^{2+}Al_6(PO_4)_4(OH)_8 \cdot 4H_2O$ – triclinic. Etymology: from the French word *turquoise* – Turkish, alluding to the type locality: Al-Mirsah-Kuh Mts. (Iran), a principal node in the way from Asia to Europe and believed to be in Turkey.

Turquoise has various colours: bright blue, sky-blue, pale-green, greenish-blue, *etc.* Morphologically, appears as a fine-grained material or in globular crusts, veinlets or massive aggregates.

Turquoise was highly appreciated by many populations: Aztecs, Tibetans, Ottomans, Persians, Chinese, *etc.*

Torbernite $Cu^{2+}(UO_2)_2(PO_4)_2 \cdot 8\text{-}12H_2O$ – tetragonal. Named after the Swedish chemist *Torbern Bergman* (1735-1784).

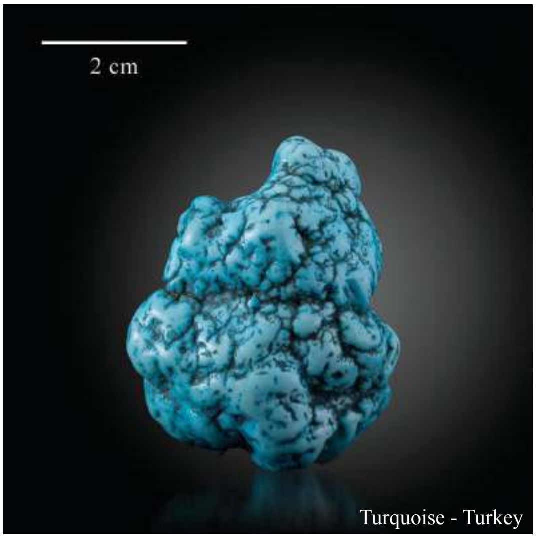
Torbernite shares the same crystal structure as another uranium mica - autunite.

In Romania, it is only assumed that torbernite would exist in several uranium deposits. Certain evidence exists for Rănușa – Bihor Mts. and Păiușeni, Slatina de Mureș – Highiș Mts.

Autunite $Ca(UO_2)_2(PO_4)_2 \cdot 10\text{-}12H_2O$ – tetragonal. Etymology: named after its type locality near *Autun*, France where it was described in 1852, as an oxidation product of primary uranium minerals hosted in granites, pegmatites and hydrothermal veins. Associated minerals: meta-autunite, torbernite, uranophane and sabugalite.

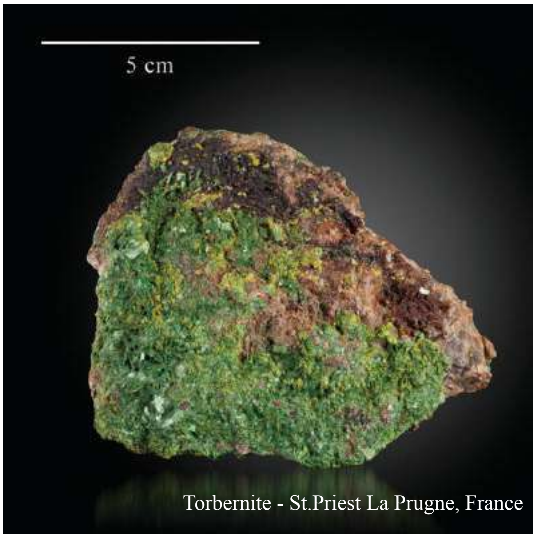
Vivianite - Roșia Poieni

Pyromorphite - Germany

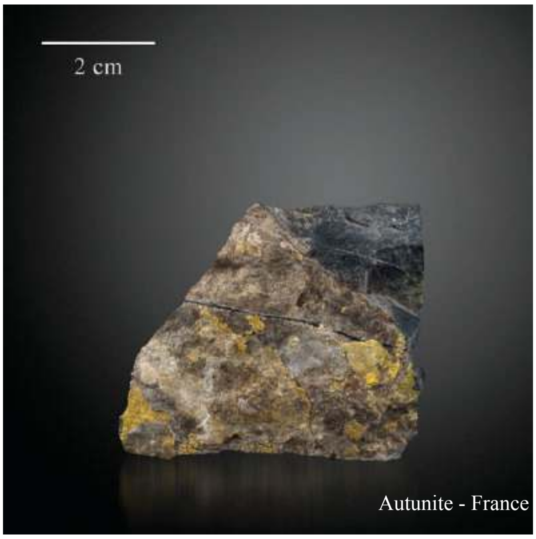


Turquoise - Turkey

In Romania, occurs in uranium deposits as an alteration product of „pechblende”, in Highiș Mts., East Carpathians and Bihor Mts.

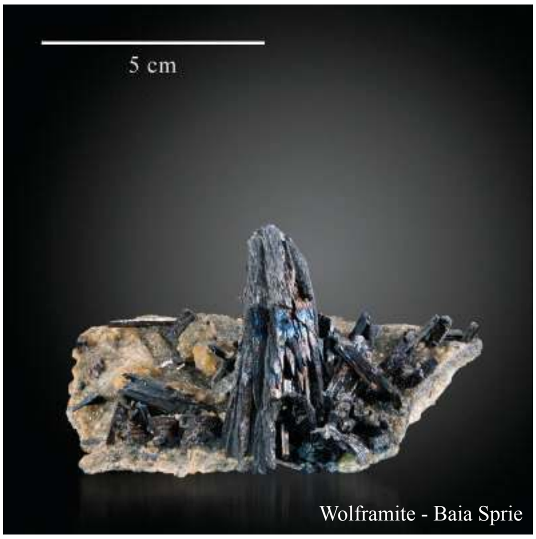


Torbernite - St.Priest La Prugne, France



Autunite - France

9. Tungstates, Chromates, Vanadates, Molybdates, Arsenates



Wolframite - Baia Sprie

Wolframite $(Fe^{2+},Mn)WO_4$ – monoclinic. A generic name for the intermediate members of the isomorphous series ferberite ($Fe^{2+}WO_4$) - hübnerite ($Mn^{2+}WO_4$).

The origin of the mineral name is disputable. Some sources say it derives from German words *Wolf* – wulf and *Hramn* – raven, whereas others (*e.g.* Agricola, 1546) quote *Wolf* and *Rahm* – froth, translated into Latin as *spumi lupi*, alluding to the fact that the tungsten ore interfered with the smelting of tin and was supposed to devour the tin (Breithaupt 1832). The German name of the chemical element *Wolfram* – tungsten is derived from the mineral name and not vice versa. The English name tungsten is believed to derive from Swedish terms *tung* – hard and *sten* – stone.

Ferberite was named after *M.R.Ferber* (Breithaupt 1863), whereas hübnerite was named after the German geologist *A. Hübner* (Riotte, 1865).

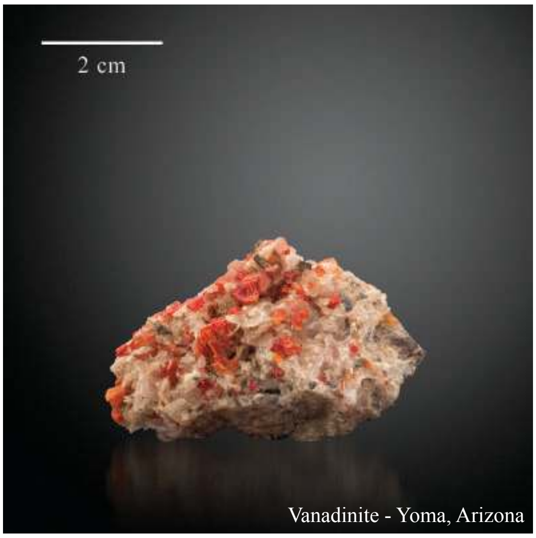
Scheelite - Baia Sprie

Generic wolframite and various representatives of the isomorphous series were mentioned in several localities of Romania: ferberite – previously described as "wolframite" – was mentioned at Oravița and Baia Sprie (the later occurrence provided numerous nice specimens to mineral collections and museums: prismatic and tabular crystals of approximately 20 cm). Hübnerite was mentioned in the manganese mineralisation of Bistriței Mts. and at Delinești – Semenic Mts.

Scheelite $CaWO_4$ – tetragonal. Named in honour of the German-Swedish chemist *Carl Wilhelm Scheele* (1742-1786).

Scheelite is the main economic mineral for tungsten. It has a light colour, high density (6.1 g/ cm^3) and specific bipyramidal habit.

In Romania, occurs as grainy aggregates or individual crystals in several skarn deposits – Sasca Montană, Ciclova, Oravița, Tincova – Poiana Ruscă Mts., Mraconia – Almăj Mts., Băița Bihor. As a mineralogical rarity, scheelite was mentioned also in the hydrothermal veins of Baia Sprie, Cavnic and Burloaia, near Baia Borșa.



Vanadinite - Yoma, Arizona

Vanadinite $Pb_5(VO_4)_3Cl$ – hexagonal. Name given from the chemical element *vanadium*.

Colour is brown, yellowish-brown, reddish-brown, yellow colour, but the mineral may appear also colourless. It has prismatic or globular habit. Vanadinite is a rare mineral.

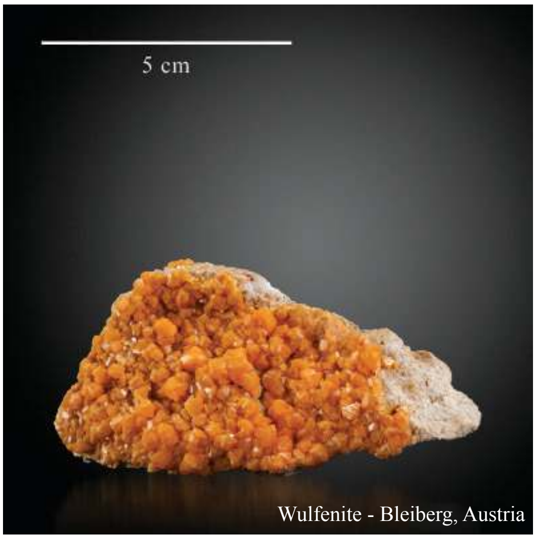
In the Carpathian area, it was mentioned only in Slovakia (Sidovo Valley – prismatic-acicular crystals (3 mm), in geodes, associated with quartz and calcite).

Crocoite – Berezovsk, Russia

Crocoite $PbCrO_4$ – monoclinic. The mineral was discovered in the Berezovsk ore deposit, near Ekaterinburg in Ural Mts., in 1766 and named by F. S. Beudant in 1832, after the Greek word *krokos* – saffron, alluding to its colour.

In Romania, crocoite was mentioned at Moldova Nouă, Rușchița and Băița Bihor, as a secondary mineral – tabular, orange crystals, associated with galena, cerussite and pyromorphite.

It was also found at Poiana Mărului and Șinca Nouă, Făgăraș Mts.



Wulfenite - Bleiberg, Austria

Wulfenite $PbMoO_4$ – tetragonal. Was described for the first time in 1845 at Bad Bleiberg, Carinthia, Austria and was named in honour of *Franz Xavier von Wulfen* (1728-1805), an Austrian mineralogist.

In Romania, wulfenite was described as a secondary mineral, associated with malachite and cerussite at Șinca Nouă – Făgăraș Mts., associated with cerussite and galena la Sasca Montană and with cerussite at Deva.

Also found at Băița Bihor –associated with hemimorphite, cerussite and chrysocola.

Erythrite - Schneeberg, Germany

Erythrite $Co_3(AsO_4)_2.8H_2O$ – monoclinic. The mineral was described for the first time in 1832 at Daniel mine, Schneeberg, Saxony and was named after the Greek word *erithros* – red.

Erythrite forms an isomorphous series with annabergite and hörnesite and belongs to the vivianite group. Erythrite has an indirect economical importance as the prospectors use it as a clue for cobalt and silver deposits.

It is a secondary mineral occurring in the oxidation zone of Ni-Co-As, deposits. It usually associates with skutterudite, cobaltite, *etc.*

In Romania, there are several occurrences cited: Ciclova, Oravița, Muncelu Mic, Săcărâmb, Băița (pale red radiary aggregates of about 2 mm in diameter).

The most important locality is at Valea lui Dăniș- Leaota Mts., where it develops as veinlets and/or crusts in primary cobalt minerals.

10. Silicates

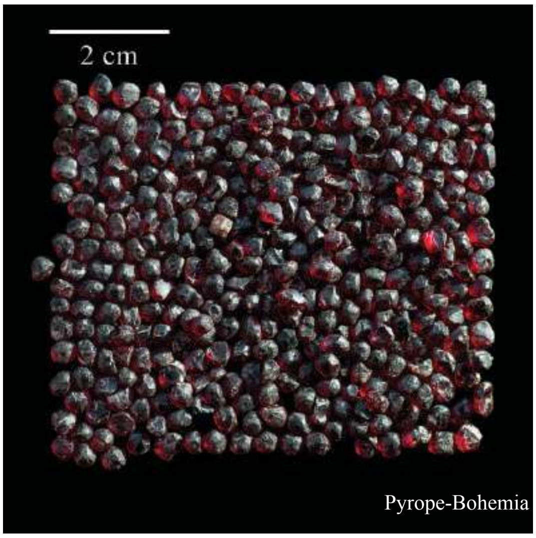
Garnets $X^{2+}{}_3Y^{3+}{}_2[SiO_4]_3$ – cubic.

Garnets represent a group of silicate minerals which have been used ever since the Bronze Age, either for its abrasive properties or as a precious stone. The name garnet was given in the 13th century and derives from Latin *granatus* – grain (Magnus, 1250).

Garnets have similar physical properties and crystal habit, but they could be very different in chemical composition. They form several isomorphous series involving: Mg,Fe,Ca,Al,Cr,V,Mn,Ti,Zr,Y. The main series are: Aluminous garnets – pyralspites: pyrope $Mg_3Al_2[SiO_4]_3$, spessartine $Mn_3Al_2[SiO_4]_3$, almandine $Fe_3Al_2[SiO_4]_3$, and Calcic garnets – ugrandites: grossular $Ca_3Al_2[SiO_4]_3$, andradite $Ca_3Fe_2[SiO_4]_3$, uvarovite $Ca_3Cr_2[SiO_4]_3$.

In Romania, garnets occur in magmatic rocks, especially in granites, pegmatites, in crystalline schists (*e.g.* micaschists with almandine), in skarns – mainly calcic garnets: Ocna de Fier, Dognecea, Oravița and Băița Bihor. Significant occurrences worldwide are those of Felbertal (Austria), Gladhammar (Sweden), Krupka (Czech Republic), Tennant Creek (Australia), Sells Mine (United States) *etc.*

Almandine - Norway



Pyrope-Bohemia

Andalusite Al_2SiO_5 – orthorhombic. Etymology: After *Andalusia* province (Spain) where it was discovered (Delametherie, 1789).

Andalusite is specific to metamorphic rocks. It occurs mainly in the mesometamorphic formations of South Carpathians (Godeanu Massif), in pegmatites (Plopiș Mts.) and in contact aureoles of Palaeozoic and Upper Cretaceous magmatites in Banat and Bihor; rarely, it occurs in subvolcanic rocks (*e.g.* Toroiaga). It was frequently found in alluvial deposits along Bistrița Gorjeană and Pianu Valley (Sebeș).

Andalusite - Tirol, Austria

Staurolite $(Fe,Mg,Zn)_2Al_9(Si,Al)_4O_{22}(OH)_2$ – monoclinic. Etymology: from Greek *stavros* – cross and *lithos* – stone, alluding to the cross-shaped twins the mineral often displays (Karsten, 1800).

It is a dense silicate mineral (3.5-3.6 g/cm^3), with high hardness (7-7.5), often in reddish-brown colours. Staurolite is of entirely metamorphic origin. In Romania, it is largely developed in the medium-grade metamorphic rocks of the Carpathians.

Well developed prismatic crystals (of 1-2 cm) occur at Răzoare – Preluca Massif, Vârful lui Petru – Sebeș Mts., Steflești Peak – Lotru Mts. Very large crystals, of up to 15 cm) displaying the cross-shaped twin, were discovered in the micaschists of Sălciua de Sus –Arieș Valley.

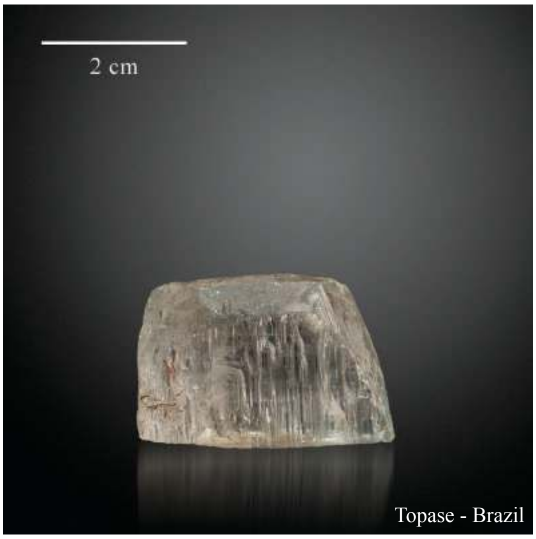
Staurolite - Bretagne, France

Kyanite Al_2SiO_5 – triclinic. Etymology: from Greek *kuanos* – blue, the typical colour of the mineral (Werner, 1790).

Kyanite is used economically as a highly thermal refractive material, with good acid resistance, and sometimes as a gemstone. It is a typical regional metamorphic mineral; the largest crystals (about 20 cm) were found in Sebeș Mts., in the north part of Făgăraș Mts., in the north part of Semenic Mts., in Lotru and Cibin Mts.

It has been mentioned also in alluvial deposits: *e.g.* Pianu de Jos or in the Oligocene Kliwa sandstone.

Kyanite - Tirol, Austria



Topase - Brazil

Topase $Al_2SiO_4(F,OH)_2$ – orthorhombic. Etymology: after *Topasos* Island in the Red Sea (Boodt, 1636).

One of the hardest minerals known (8 on Mohs scale). Used mainly as a precious stone. Various colours: colourless, yellow, golden yellow, pink, red, blue, violet, greenish and brown. In Romania, topase was identified long ago, in the micaschists of Cibin Mts.

More recently it was described in the spodumene-bearing pegmatites of Conțu. The typical mineral assemblage hosted by Palaeozoic granites of Highiș Mts. contains cassiterite and Li-mica.

Tourmaline - Madagascar

Tourmaline $(Na,Ca,K)(Al,Fe^{2+},Fe^{3+},..,Mg,Mn)_3(Al,Cr,Fe^{3+},V)_6(BO_3)_3[Si_6O_{18}](OH,F,O)_4$ – trigonal. Etymology: from Shingalese (one of the languages spoken in Ceylon) *turmali* – jewel.

Tourmaline is used in electronic and optical industry, but also as a gemstone. Tourmaline denotes a very complicated group of minerals, with 27 accepted phases, found in various geological environments. Its main representatives are schorl, dravite and elbaite.

In Romania, tourmaline occurs prevalently in pegmatites, in association with apatite, feldspars, quartz and muscovite (Teregova, Gura Râului, Parva, Someșu Rece, Răzoare). Elongated, white crystals of elbaite - $Na(Al_{1,5}Li_{1,5})Al_6(BO_3)_3[Si_6O_{18}](OH)_4$, occur in Metaliferi Mts. (Fața Băii, Larga), in altered rhyodacites.

Zoned grains of shorl - $NaFe_3Al_6(BO_3)_3[Si_6O_{18}](OH)_4$) and dravite - $NaMg_3Al_6(BO_3)_3[Si_6O_{18}](OH)_4$, reaching up to 5 cm, with colours ranging from dark green to yellow, have been described at Sasca Montană.

In other countries, tourmaline was reported in Germany (St. Andreasberg, Sulzburg), Poland (Złoty Stok), Austria (Lölling, Schladming), Canada (Cobalt), Algeria (Belelieta), *etc.*

Epidote - Knappenwand-Salzburg, Austria

Epidote $Ca_2Al_2(Fe^{3+},Al)Si_3O_{12}(OH)$ – monoclinic. Etymology: from Greek *epidosis* – addition, perhaps pointing to the fact that some of the mineral's prism faces in a crystal are larger than others (Haüy, 1801).

Epidote has raw-green to greenish-yellow colours. Sometimes it is used as a gemstone and cut in the shape of cabochon.

In Romania, epidote is relatively widespread, mainly as an accessory mineral in low-grade metamorphic rocks (Rodna, Semenic, Bistriței Mts., *etc.*), in hornfels (Ocna de Fier, Oravița, Moldova Nouă, Băișoara – Gilău Mts.).

It is also found in hydrothermally altered volcanic rocks around metallic vein deposits (Herja, Baia Sprie, Cavnic, Săcărâmb) or, in association with ferroactinolite, in porphyry copper (Deva, Bolcana, Bucium Tarnița, Roșia Poieni).

Vesuvianite $Ca_{10}(Al,Mg,Fe)_{13}Si_{18}O_{68}(O,OH,F)_{10}$ – tetragonal. Etymology: after Mount *Vesuvius* – the type locality (Werner, 1795).

Vesuvianite is specific to skarns where it occurs in association with garnets, diopside and calcite. In Romania, the most renowned occurrences are in Banat (Moldova Nouă, Sasca Montană, Oravița, Ciclova, Dognecea), Bihor Mts. (Băița Bihor, Pietroasa, Budureasa), Metaliferi Mts. (Vața de Jos), Parâng Mts. (Urdele, Găuri, Muntinu).

Vesuvianite - Pizzo, Italy

Dioptase $Cu^{2+}SiO_2(OH)_2$ – trigonal. Etymology: from Greek *dia* – through and *opsis* – vision (Haüy, 1801), alluding to the mineral's two cleavage directions that are visible inside unbroken crystals.

Dioptase was described for the first time in Europe at Băița Bihor where it occurred in crystals of gemstone quality. Deep green crystals of up to 2 mm were found in association with wulfenite, cerussite and hemimorphite. It has been mentioned also at Întregalde, near Alba Iulia, in the Cu-As mineralisation.

Dioptase - Congo

Zircon $ZrSiO_4$ – tetragonal. Etymology: from Persian *zargun* - gold colour. Old German jewellers used the term *Cerkonier* which later became *Circon*, that is, zircon (Werner, 1783).

Zircon is frequently used as a gemstone, especially when it forms perfectly shaped crystals. Many so-called small-sized diamonds are in fact zircons. The mineral is one of the main sources of zirconium.

In Romania, zircon is a typical accessory mineral in acid magmatic rocks – granites (South Carpathians) and intermediary magmatites – granodiorites and andesites. Pale-pink or yellowish crystals have been described at Ditrău in the nepheline syenites. Zircon was also mentioned in numerous metamorphic occurrences, especially those that are rich in biotite. It is frequently found in alluvia – Izvorul Mureșului, Merișani (Argeș), Glogova (Motru), *etc.*

Gehlenite $Ca_2Al(AlSi)O_7$ – tetragonal. Named after the German chemist *A.F.Gehlen* (1775-1815), (Fuchs, 1815).

In Romania, gehlenite was mentioned in association with garnets and vesuvianite, in the skarns of Oravița. Impressive tabular crystals were described at Vața de Sus - Măgureaua Vaței in skarns with wollastonite, „melanite" – Na and Ni-bearing andradite and vesuvianite. Crystal colour ranges from yellowish-green to bluish-gray.

Zircon - Brazil

Gehlenite - Valea Cerboaia

Rhodonite $CaMn_4Si_5O_{15}$ – triclinic. Etymology: from Greek *rhodon* – pinkish.

Since long ago, rhodonite was mentioned in the polymetallic-gold veins of Cavnic, but the mineral is much more widespread in the manganese schists of East Carpathians where it appears in association with rhodochrosite, spessartine, Mn-grunerite at Iacobeni, Dadu, Tolovanu, Oița, and in the South Carpathians – at Delinești, Pravăț and Globu Rău. At Răzoare, in Preluca Massif, it is associated with pyroxmangite, whereas at Băița Bihor, brown fibrous rhodonite occurs in association with rhodochrosite, bustamite, garnets and galena. Rhodonite is also present at Săcărâmb and Roșia Montană.

Rhodonite - Iacobeni

Beryl - Italy

Beryl $Be_3Al_2Si_6O_{18}$ – hexagonal. Etymology: from Greek term *berullos* which, after Pliny the Elder was a precious stone, green as the sea water.

This is the main source of beryllium. In ancient times, beryl was used for manufacturing optical lenses to build telescopes (such as emperor Nero's telescope).

Today, beryllium is used in preparing light alloys for aero spatial industry. Beryl also finds appreciation as gemstone especially when it forms varieties such as: emerald - green, aquamarine – greenish-blue to light blue, morganite vorobievite – pale to intense pink, doré beryl – golden yellow, heliodor – yellow to green-yellow, goshenite – colourless, transparent, „bixbite" (not to be confounded with the mineral bixbyite) – red.

In Romania, beryl occurs in pegmatites. The biggest crystals (about 30 cm) were found at Teregova. Greenish-blue to greenish-yellow crystals were described at Răzoare, and less often at Teregova. A newer beryl occurrence with greenish-whitish crystals of up to 5 cm was reported at Vidruța.

Wollastonite $Ca_3Si_3O_9$ - triclinic, monoclinic. Etymology: named after the English chemist *William Hyde Wollaston* (1766–1828).

When found in large quantities, wollastonite serves for manufacturing ceramic plaques and for preparing paint.

Wollastonite is typical for thermal metamorphism when it forms on behalf of limestones. Such is the case of nearly all wollastonite occurrences in Romania, most often related to Upper Cretaceous magmatism: Moldova Nouă, Sasca Montană, Oravița, Dognecea, Ciclova Montană, Rușchița, Brusturi, Pietroasa, and Băița Bihor where wollastonite forms radiary aggregates of up to 20 cm in diameter.

An interesting occurrence is represented by the high temperature skarns of Măgureaua Vaței – Metaliferi Mts., where crystals of up to 25 cm were found.

Wollastonite - Băița Bihor

Diopside Ca,$MgSi_2O_6$ – monoclinic. Etymology: from Greek words *dis* – twice and *opse* – face, alluding to the two ways of orienting the crystal prism. (Haüy, 1806).

Diopside is the end member of an isomorphous series with hedenbergite $CaFeSi_2O_6$.

The chromian variety is often used as a gemstone. In Romania, diopside was often reported both in contact and regional metamorphic environments – skarns and hornfels (Banat, Northern Apuseni Mts.) and amphibolites or crystalline limestones (Preluca, Parâng).

The most spectacular are the diopside bearing skarns of Ocna de Fier, Dognecea, Oravița, Ciclova and Băița Bihor – where crystals reach up to 10-12 cm.

Diopside - Băița Bihor

Spodumene $LiAlSi_2O_6$ – monoclinic. Etymology: from Greek *spodoumenos* – „burnt to ash", in reference to the greyish colour of first specimens described (Andrade, 1800).

Spodumene is sometimes a gemstone, especially the kunzite and hiddenite varieties.

Spodumene was described in the Getic Domain of the South Carpathians. It was reported at Teregova and Conțu – Cibin Mts. where it forms gigantic crystals of up to 50 cm. At Conțu, spodumene is accompanied by albite, quartz and rare phosphate minerals hureaulite, alluaudite, montebrasite, *etc.*

Spodumene - Cibin Mts.

Lazurite $(Na,Ca)_8Si_6Al_6O_{24}[(SO_4),S,Cl,(OH)]_{24}$ – cubic (orthorhombic, monoclinic, triclinic). Etymology: from Persian *lazhward* – sky blue. The mineral is often mentioned as *lapis lazuli* and it is known by man for over 7000 years.

Lazurite was used as an adornment stone by Egyptians, Babylonians, Greeks and Romans. Ancient Chinese took lazurite as a symbol for power. In 1828 lazurite was synthetically produced for obtaining the ultramarine pigment which had been previously prepared from lazurite powder, wax and oil.

Lazurite - Afghanistan

The most significant lazurite resources are in Afghanistan and in general, throughout Asia – Siberia – near Baikal Lake, in Pamir Mts., Pakistan, India and Myanmar. It is also mined in Angola, South Africa and Chile.

Objects and adornments made of lazurite are found in many famous museums in the world: Hermitage, in Skt. Petersburg, Palazo Pitti in Florence. The lazurite columns of St. Isaac cathedral in Skt. Petersburg are among the most beautiful works known. Lazurite has not been identified in Romania.

In other countries, lazurite was reported in Germany (St. Andreasberg, Sulzburg), Poland (Złoty Stok), Austria (Lölling, Schladming), Canada (Cobalt), Algeria (Belelieta), *etc.*

Cronstedtite- Herja

Cronstedtite $Fe^{2+}_2Fe^{3+}(Si,Fe^{3+})O_5(OH)_4$ - monoclinic, trigonal. Etymology: named after the Swedish mineralogist *Axel Fredrik Cronstedt* (1722-1765).

It is a rare mineral belonging to the serpentine group. In Romania, cronstedtite is typical for the Herja ore deposit – Gutâi Mts., where it occurs as blackish semi-spherical aggregates of high visual impact.

Tremolite $Ca_2Mg_5Si_8O_{22}(OH)_2$ – monoclinic. Etymology: named after its type locality – *Tremola* Valley, Italian Alps (Hoffner, 1790).

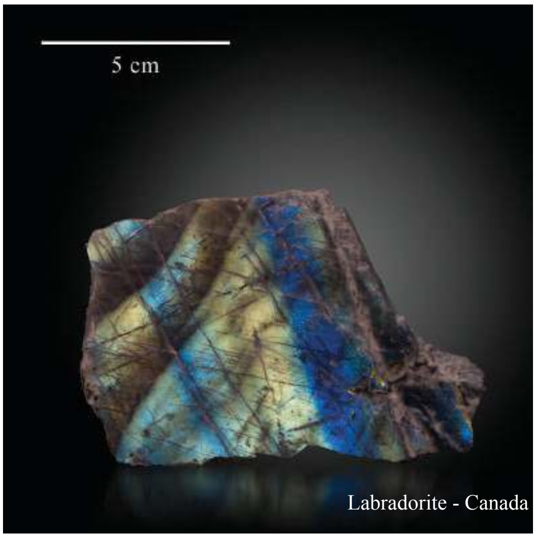
There are several tens of occurrences in Romania, most of them in ultrabasic rocks – where tremolite develops as an accessory mineral, in skarns and crystalline limestones.

Tremolit - Tirol, Austria

Often found as radiary, spherical aggregates – Ocna de Fier, Băița Bihor, or as solitary crystals (up to 7-8 cm) – Voșlăbeni, Rodna, Răzoare and Segagea – Gilău Mts. Other occurrences record veinlets of tremolite in crystalline limestones: Iara Valley – Gilău Mts., Turnu Roșu, Porumbacu de Sus – Făgăraș Mts.

Feldspars $(K,Na,Ca)[Si_2(Si,Al)AlO_8]$ - monoclinic, triclinic. Etymology: from German *Feldspat* – „with prominent cleavage from the field" (that is, "widespread", alluding to its high frequency in the Earth's crust).

Orthoclase - Voineasa



Labradorite - Canada

The most widespread feldspars belong to the potassic or orthoclase group – represented by three polymorphs of KSi_3AlO_8: orthoclase, sanidine and microcline and to the plagioclase limited miscibility isomorphous series between albite – $NaSi_3AlO_8$ and anorthite – $CaSi_2Al_2O_8$. Three major miscibility gaps develop in this series: peristerite, Bøggild and Huttenlocher, expressed by submicroscopic exsolutions between either of the end members and two insufficiently described intermediate phases: *e1* and *e2.* Feldspars occur in all types of magmatic and metamorphic rocks, and even in sedimentary rocks: conglomerates, sandstones, *etc.*

Certain rocks with abundant feldspars, such as pegmatites and syenites, are of some economic value. Finely ground feldspar is used as an amendment for eroded soils. The high aluminium content recommends feldspar for manufacturing special glasses, ceramics and even tooth paste.

Some feldspar varieties have been used as gemstones since very long ago. Thus, amazonite – the green feldspar – has the longest tradition in this respect. Amazonite was mentioned as early as the time of Ancient Egypt and was praised throughout the Middle East. Today, amazonite is intensely mined in United States, Russia, India, Ukraine and Brazil. Another valuable feldspar is adularia – colourless, well shaped sanidine, occurring in Alpine veins. Yellowish or reddish adularia – the Sun stone or bluish adularia – the Moon stone, has been used as gemstone since ancient times, in India. Today both varieties get extracted in the United States and Russia. Among the plagioclase feldspars, labradorite variety is used for manufacturing jewels and ornamental plaques.

In Romania, feldspars occur in numerous geological environments and in various types of rocks. Large quantities occur in pegmatites: microcline at Voineasa and albite in the spodumene bearing pegmatites at Conțu. Adularia is widespread in the hydrothermal rocks around Neogene gold deposits in both Metaliferi and Gutâi Mts. Feldspars are a major rock forming mineral of many magmatic and regional metamorphic rocks in our country.

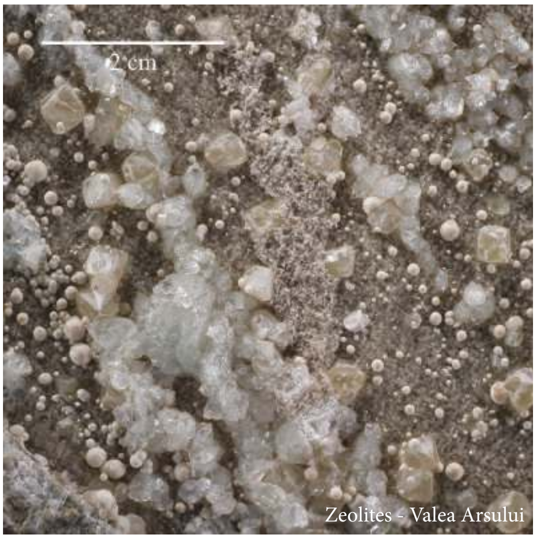
Sodalite $Na_8Al_6Si_6O_{24}Cl_{12}$ – cubic. Etymology: named in reference of the high sodium content, plus *lithos* – stone.

Used sometimes as a precious stone, due to its attractive colour – blue and less often green or pale-pink. Usually, polished as cabochon, rarely faceted.

Sodalite - Germany

Spread in the nepheline syenites of Ditrău as a partial or total replacement of nepheline. It occurs as well at Ogradena – Southern Banat. Sometimes occurring in blue veinlets across the syenite intrusion at Ditrău and Jolotca.

Zeolite group – Etymology: the term zeolite was introduced in 1756 by the Swedish mineralogist Axel Fredrik Cronstedt who observed that during heating, **stilbite** produced a large quantity of steam which was subsequently re-absorbed by the mineral. On this basis he named the material zeolite, after the Greek words *zeo* – to boil and *lithos* – stone.



Zeolites - Valea Arsului

Zeolites are natural hydrated alumosilicates of calcium, sodium, potassium, barium, strontium and sometimes magnesium and manganese. Zeolites have a microporous crystalline structure with high water absorbing capacity. They lose contained water gradually, by heating and thus, they are used widely as a water softener. Their multiple usages have led to zeolite artificial production at vast industrial scale. The mineralogy of zeolites is complex and dynamic. More than 50 species of zeolites are known to date. The most widespread and best known are: analcime, chabasite, clinoptilolite, heulandite, natrolite, phillipsite and stilbite. Several examples of zeolites exhibited in the museum will be described further on.

Analcime $NaAlSi_2O_6.H_2O$ - cubic, tetragonal, trigonal, orthorhombic, monoclinic, triclinic. Etymology: from Greek *analkimos* – weak.

Analcime is usually whitish-gray or colourless. In Romania, analcime has been identified in the monchiquite lamprophyres in the metamorphic terrains of Tulgheș - East Carpathians, and in the basalts of Poiana, Almașu Mare, Techereu – Metaliferi Mts., where it occurs as vacuoles and intergrowths with calcite, natrolite and heulandite. It has been also mentioned as the last precipitated phase in the mineral assemblage at Moldova Nouă.

Chabasite series $(Ca_{0,5},Na,K)_4[Al_4Si_8O_{24}].12H_2O$ – trigonal. Etymology: from Greek *chabazios* – one of the 20 species of stones mentioned in the poem Peri` li`qwn , ascribed to Orpheus, the legendary founder of the Orphic cult which flourished in early Antiquity.

In Romania, chabasite occurs as veins and small geodes in the Mesozoic basalts of Poiana and Techerău – Metaliferi Mts., together with heulandite. It has also been mentioned at Moldova Nouă, with stilbite, and as well, at Stănija and Valea Arsului – Metaliferi Mts. together with apophyllite. Another occurrence was described in Vlădeasa Mts.

Heulandite series $(Ca_{0,5},Na,K)_9[Al_9Si_{27}O_{72}].24H_2O$ – monoclinic. Etymology: the mineral was for the first time found as distinct from stilbite by A. Breithaupt in 1818, and named *euzeolite* – beautiful zeolite; later, H.J. Brooke who reached the same conclusion, named the material heulandite, in honour of mineral collector *H. Heuland* (1778-1856).

In Romania, heulandite was mentioned in andesites and basalts, mainly as a low-temperature hydrothermal product at Rîmetea near Turda and Poiana, Techerău – Metaliferi Mts., together with epistilbite; it has been quoted also at Căprioara – Lipova, where it occurs as reddish crystals.

Natrolite $Na_2[Al_2Si_3O_{10}].2H_2O$ – orthorhombic. Name comes from Greek *natros* – sodium and *lithos* – stone and was given by Martin Heinrich Klaproth in 1803.

In Romania, natrolite occurs as many other zeolites, in vacuoles where it is associated with calcite and analcime, in andesites and basalts from Techereu Massif – Metaliferi Mts., and in the Neogene volcanic rocks of Cavnic, Bolduț and Rupea. Also, as veinlets, associated with opal, chalcedony, quartz and clay minerals at Vorța – in the south-west part of Metaliferi Mts.

Stilbite series $(Ca_{0,5},Na,K)_9[Al_9Si_{27}O_{72}].28H_2O$ – monoclinic. Etymology: from Greek *stilbe* – lustre, in allusion to the pearly to vitreous lustre of the mineral.

In Romania, stilbite is one of the most frequently encountered zeolites, present in almost all low-temperature hydrothermal deposits. Lamellar crystals are quoted at Căzănești and Ciungani – Metaliferi Mts., radiary aggregates at Oravița, whereas spherical aggregates were described at Băița Bihor. Transparent and colourless crystals were identified at Valea Leucii near Hălmagiu, in association with phillipsite. White crystals in fan-like aggregates were found at Valea Morii near Brad, where it occurs with chabasite in andesite voids. Also quoted at Poieni – Vlădeasa Mts., Vorța and Furcșoara – Metaliferi Mts., and at Moldova Nouă where it replaces plagioclase or it forms pinkish crusts or fibrous veinlets in granitoids.

Muscovite $KAl_2AlSi_3O_{10}(OH)_2$ and Biotite $K(Mg,Fe)_3(Al,Fe^{3+})Si_3O_{10}(OH,F)_2$ – monoclinic. Etymology: after the name of *Moscow* (Dana, 1850) and after the French physicist *J. B. Biot,* respectively (1774-1862) (Hausmann, 1847).

These are essential minerals for many rocks: granites, granodiorites, diorites, andesites, dacites, hornfels, sandstones. The biggest crystals occur in the pegmatites of Rodnei, Gilău. Semenic, Sebeș and Lotru Mts.

The pegmatites in Voineasa contain huge, pseudo-hexagonal, euhedral crystals of up to 10 cm in width. Biotite is a typical mineral for the central – potassic zone of the porphyry copper deposits in Metaliferi Mts., *e.g.* Roșia Poieni, Bucium Tarnița, Deva, Bolcana.

Biotite, muscovite - Voineasa

11. Organic compounds

Amber. The name derives from Arabic *anbar* – yellow. The Romanian name "chihlimbar" seems to derive from Persian *kiahruba* – attracting straws, in allusion to its electrostatic properites. Amber is a fossil resin with specific properties.

Amber has an extremely complex chemical composition. Due to its chemical inertia and to its partial solubility in organic solvents, only a part of its composition is known to date. Several provisional chemical formulae for amber were given by Brydson (1999): $C_{10}H_{16}O$ and Frondel (1968): $C_{79}H_{10,5}O_{10,5}$.

Around the year 60 BC, Thales discovered the ability of amber to attract various light objects after being rubbed against a piece of canvas. The old Greek word for amber was *elektron* wherefrom electricity derives. This property – together with its ability to burn –placed amber among the magic stones.

There are numerous species and varieties of amber on all continents around the world: *succinite* – the most important species of amber, found on the shores of the Baltic Sea (from Latin *succinum* – the juice of trees), *simetite* from Simeto Valley, Italy , *birmite* – from Burma, *cedarite* – from Lake Cedar, Canada, *guayaquillite* – from Ecuador, *Dominican amber*, *Borneo amber, Alava amber* – from Spain, *romanite, rumanite* (from the name *Rumänite* given by Otto Helm, 1891) – the amber species found in Romania, near Buzău. Helm suggested this new name after seeing the chemical differences between this amber and the Baltic one.

Amber is a mixture of organic compounds with high molecular weight and their oxidation products. The colour ranges from yellow to brownish-red and black, with all intermediate possibilities. Colour is influenced by paleoclimatic and paleontologic features but also by the geological environment in which the already weathered resin, suffered the fossilisation processes.

Amber is a fossil resin produced by various Tertiary species (Banerjee *et al.*, 1999):

Amber – Baltic Sea

Coniferous: *Pinaceae*, *Taxodiaceae* (Sequoia, Taxodium) and *Cupressaceae*.

Angiosperms: *Hamamelidaceae* (Liquidambar), *Leguminaceae* (Hymenaea, Copaifera, *etc.*), *Burseraceae* (Commiphora, Boswellia, Protium).

Approximately 70% of the global amber production of adornments and art objects is covered by Poland, with 80.5% of this, originating in the Gdansk region. About 19% of the amber accumulations are located along the Russian shores of the Baltic Sea. Besides, a great deal of the amber being processed in Poland comes from Samland (Kaliningrad) Peninsula. The most important mine is that of Palmnicken (Yantarny), the first operation which was completely mechanised in 1930 and where reserves of at least 180,000 tones have been estimated.

References

Aballain M., Chambol P., Derec-Poussier F., Guillemin C., Mignon R., Pierrot R., Sarcia J.A. (1968) Index alphabetique de nomenclature mineralogique. Inventaires des Collections Nationales de Mineralogie. BRGM, 386 p.

Anastasiu N., Grigorescu D., Mutihac V., Popescu C. Gh. (2007) Dicţionar de Geologie, Ed. Didactică şi Pedagogică, Bucureşti, 347p.

Banerjee A., Ghiurca V., Langer B., Wilhelm M. (1999) Determination of the provenance of two archaeological amber beads from Romania by FTIR- and solid-state-Carbon-13 NMR Spectroscopy. Archäologisches Korrespondenzblatt, 29, heft 4. Verlag des Römisch-Germanischen Zentralmuseums, Mainz, 593-606.

Baron M. (2006) Din istoria mineritului aurifer în România 1918-1948. Ed. Universitas,Petroșani, 224 p.

Berbeleac I. (1985) Zăcăminte de aur. Ed. Tehnică, Bucureşti, 334 p.

Berbeleac I. (1998) Zăcăminte de plumb şi zinc. Ed. Tehnică, Bucureşti, 528 p.

Borcoș M., Gheorghiță I., Boștinescu S., Mătieș P. (1964) Considerații asupra unor manifestări magmatice Neogene cu caracter liniar în Munții Metaliferi și asupra structurii aparatului vulcanic Haneș. D.S. Com. Geol., 49, 33-40.

Borcoş M., Kraütner H.G., Udubaşa G., Săndulescu M., Năstăsescu S., Biţoianu C. (1983) Geological Atlas 1:1000000, Map of the Mineral Resources and explanatory note. Ministry of Geology, Institute of Geology and Geophysics, Bucharest.

Borcoș M. (1994) Volcanicity/metallogeny in the South Apuseni Mts. (Metaliferi Mts.), in Plate Tectonics and Metallogeny in the East Carpathians and Apuseni Mts., June 7-19 1994, M. Borcoș and Vlad Ș. editors, p 32-40, Bucharest.

Borcoş M., Vlad Ș., Udubaşa G., Găbudeanu B. (1998) Qualitative and quantitative metallogenetic analysis of the ore genetic units in Romania. Rom. J. Min. Dep., v. 78, special issue IGR Bucharest.

Brana V. (1958) Zăcăminte metalifere din România. Ed. Ştiinţifică, Bucureşti, 261 p.

Cioacă M.E. (2007) Studiul mineralizaţiei de cupru şi aur tip porphyry de la Bolcana, M-ții Metaliferi. Teză de doctorat, Bucureşti.

Ciobanu C., Găbudeanu B., Cook N.J. (2004) Neogene ore deposits and metallogeny of the Golden Quadrilateral, South Apuseni Mts., Romania, in IGCP 486 Gold-Silver-Telluride Deposits of the Golden Quadrilateral, South Apuseni Mts., Romania, Cook, N. J., Ciobanu, C editors.

Ďuďa R., Rejl L. (1990) Minerals of the World, Arch Cape Press, New York, 520 p.

Fodor D. (2005) Pagini din istoria mineritului; Ed. Infomin, Deva.

Ghițulescu T.P. (1934) Distribution de la mineralization dans les gisements d'age tertiaire de Transylvanie. Bul. Soc. Rom. Geol. II, 56-97.

Ghiţulescu T.P., Socolescu M. (1941) Étude géologique et minière des Monts Metallifères. An. Inst. Geol. Rom., 21, 181-464, Bucureşti.

Ghițulescu T.P., Borcoş M. (1966) Încadrarea funcțională a magmatismului alpin din Munții Metaliferi. St. Cerc. Geol. Geogr. Geof., s. Geol.,11, 367-379.

Haiduc I. (1940) Istoria aurului din Romania. Imprimeriile "Adeverul", București, 390 p.

Hedenquist J.W. (2006) Characteristics of Exploration for Epithermal Deposits: Background, and Relation to the Porphyry Environment. Workshop–0601, Sofia, Bulgaria. January, 12-13th 2006.

Ianovici V., Giuşcă D., Ghiţulescu T.P., Borcoş M., Bleahu M., Savu H. (1969) Evoluţia geologică a Munţilor Metaliferi. Edit. Acad. RSR, Bucureşti, 741 p.

Ianovici V., Borcoş M., Patrulius D., Bleahu M., Lupu M., Dimitrescu R., Savu H. (1976) Geologia Munţilor Apuseni. Edit. Acad. RSR, București, 631 p.

Ianovici V., Borcoș M. (1983) Mineral Deposits of Europe 2; South East Europe (Romania) Publ. Mineralogical Soc. and the Inst. Mining and Metallurgy, London.

Ilinca Gh., Ionescu C., Ghergari L. (2009) The chalcedony of Trestia, Maramureș (Romania) - Revisited. St. Univ. Babeș-Bolyai, Special Issue, MAEGS-16, 190-191.

Jude, R. (2000) Gold Mineralisation with Tellurides Related to the Neogene Volcanic Edificia of Caraci - Măgura Ţebei (Metaliferi Mountains, Romania). Revue Roumaine de Geologie, t. 44, 2000.

Jude, R. (2011) Ţara moţilor, Scurtă monografie. Ed. Universitaria, 171 p.

Kouzmanov, K., Ivăşcanu, P., O'Connor, G. (2005) Porphyry Cu-Au and epithermal Au-Ag deposits in the Southern Apuseni Mts.,Romania. Ore Geology reviews, Elsevier.

Kouzmanov K., von Quadt A., Peytcheva I., Harris C.R., Heinrich Ch.A., Roșu, E., Ivășcanu, P.M. (2007) Miocene magmatism and ore formation in the South Apuseni, Proceedings of the Ninth Biennial SGA Meeting, Dublin, "Digging Deeper" C.J. Andrew et al. editors,865-868.

Mandarino A.J., Back E.M. (2004) Fleischer, Glossary of Mineral Species, The Mineralogical Record Inc, Tucson , 309 p.

Mariaș, F. (2005) Metalogeneza districtului minier Baia Mare, model bazat pe sistemul hidrotermal Cavnic (Maramures); Evaluari comparative cu alte sisteme epitermale din lume; Ed. Cornelius, Baia Mare, 450 p.

Neubauer F., Lips A., Kouzmanov K., Lexa J., Ivăşcanu P. (2005) Subduction, slab detachment and mineralization: The Neogene in the Apuseni Mountains and Carpathians. Ore Geology Reviews 27, 13–44.

O´Connor G.V., Nash C.R., Szentesy C. (2004) The structural setting of the Roșia Montană gold deposit (Romania). Romanian Journal of Mineral Deposits, vol. 81, p.51-57.

Popescu Gh.C. (1986) Metalogenie aplicată şi prognoză geologică, Partea II, Tipografia Univ. Bucureşti, 316 p.

Popescu Gh.C. (1995) Quo vadis Geologiae? An. Univ. București, s. Geologie, t. XLIV,1995, 3-7.

Popescu Gh.C. (2003) De la mineral la provincie metalogenetică. Ed. Focus, Petroșani, 618 p.

Popescu Gh.C., Neacșu A. (2007) Relationship between gold and copper metallogensis in the Metaliferi Mts.- Romania. Ann. Şt. Univ. „Al. I. Cuza" Iaşi, Geologie, Tomul LIII, 2007, 71- 78.

Popescu Gh.C., Tămaş-Bădescu S., Tămaş-Bădescu G., Bogatu L., Neacşu, A. (2007) Geologia economică a aurului, Ed. Aeternitas, Alba Iulia, 536 p.

Popescu Gh.C., Neacșu A., Ilinca Gh. (2008) Mineralogy of Vivianite from Roşia Poieni; metalogenetic significance. Rom. J. Min. Dep., 83, 119-123.

Popescu Gh.C., Neacșu A. (2008) Tellurium mineralogy, resources, energetic implications. Rom. J. Min. Dep. and Rom. J. Min., v.83, 19-27, Ed. IGR si SGER, Alba Iulia.

Popescu Gh.C., Neacşu A., Cioacă M.E., Filipescu, D. (2010) The selenium and Se-minerals in the Săcărâmb ore deposit – Metaliferi Mrs., Rom. J. Min. Dep, v. 84, 120–123.

Popescu Gh.C., Neacșu A. (2010) Preliminary data on two tin-sulfosalts (canfieldite and pirquitasite) in Roşia Montană. Rom. J. of Earth Sciences, 85, issues1- 2, 2011, 35-43.

Rădulescu D., Dimitrescu R. (1966) Mineralogia topografică a Romaniei, Ed. Acad. R.S.R., 376 p.

Roman B., Sîntimbrean A., Wollmann V. (1982) Aurarii din Munții Apuseni. Ed. Sport-Turism, Bucuresti, 106 p.

Roşu E., Seghedi I., Downes H., Alderton D.H.M, Szakács A., Pécskay Z., Panaiotu C., Panaiotu C.E., Nedelcu L. (2004) Extension-related Miocene calc-alkaline magmatism in the Apuseni Mountains, Romania : Origin of magmas Schweizerische Mineralogische und Petrographische Mitteilungen 84, 153-172.

Sîntimbrean A., Bedelean H., Bedelean A. (2006) Aurul și argintul Roșiei Montane. Ed. Altip, Alba Iulia, 210 p.

Tămaş-Bădescu S. (2010) Contribuţii privind geologia economică a aurului în Romania. Ph.D. thesis, Bucureşti.

Tămaş C.G., Bailly L., Ghergari L., O'Connor, G., Minuţ, A. (2006) New ccurences of tellurides and argyrodite in Roşia Montană, Apuseni Mountains, Romania and their metallogenetic significance, The Canadian Mineralogist, 44, p. 367-383.

Tămaș C.G., Grobety B., Bailly L., Bernhardt H.-J., Minuț. A. (2013) Alburnite, IMA 2012-073. CNMNC Newsletter No. 15, February 2013; Mineralogical Magazine, 77, 1-12.

Udubaşa G., Ďuďa R., Szakáll S., Kvasnytsya V., Koszowska E., Novák M. (2002) Minerals of the Carpathians, S. Szakáll editor, Granit Prague, 479 p.

Udubașa G., Udubașa S.S. (2004) Au-Ag telluride deposits in the Metaliferi Mts; effects of local geology or of a "hydrothermal ichor". Rom. J. Min. Dep., 81, Special Issue, 39-46.

Vlad Ș.N. (1983) Geologia zacamintelor porphyry copper. Ed. Acad. Române, Bucureşti, pp156.

Wollmann, V. (2010) Patrimoniul preindustrial şi industrial în România, vol. I., Ed. Honterus, Sibiu, 356 p.

Websites:

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