National Research Program (Romania)

ALBURNUS MAIOR

Ancient Gold Mines of Dacia

Roşia Montană District

(Apuseni Mountains, Romania)

Report 2002

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Report 2002 – the team

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A miners team from Roşia Montană

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The French Archaeological Mission
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The Cârnic Massif

Since 1999, a French archaeological mission conducted by Béatrice Cauuet (archeologist of the C.N.R.S.) and made of researchers from the archaeological laboratories of U.T.A.H. (Le Mirail University of Toulouse) and of associate researchers, is being carried on at the site of Rosia Montana, an ancient mining town from Transylvania (in the north-west of Romania) in a partnership with geologists from the Geology-Mineralogy department of Babes-Bolyai University of Cluj-Napoca (Romania) and geologists from the Technical University of Munich (Germany). The objective of this mission is to give a full archaeological diagnosis on the state, nature, chronology and importance of the mining vestiges previous to the 20th century, but still conserved on the site from Rosia Montana. The French presence is justified by the fact that the U.T.A.H. studies, among other subjects, the mining archeology, a recent specialty, still ignored in Romania.

The diagnosis carried on in 2000, 2001 and 2002 belongs to a mining development project, on the site of Rosia Montana, handed in by the mining society, Rosia Montana Gold Corporation. It was part of a state of facts requested by the Romanian Ministry of Culture, previous to the negotiations in process on the acceptance of the mining project. This state of facts was meant to report on the patrimonial, architectural and archaeological potential of Rosia Montana, where a big part of the historical monuments at the surface or buried, is directly threatened by the mining project.

In the year 2000, the French mission was financed partly (60%) by France (the Ministry of Foreign Affairs and the U.T.A.H. Laboratory) and partly (40%) by Rosia Montana Gold Corporation, within the limits of the partnership convention signed by Le Mirail University of Toulouse and the mining Society involved in the project (Cauuet *et alii*, 2000). In the years 2000 and 2001, the French mission was financed by the U.T.A.H. Laboratory and the Rosia Montana Gold Corporation through annual conventions signed by the U.T.A.H. and the Romanian National Museum of History (Bucharest) (Cauuet *et alii*, 2001).

Research collaboration

During these three years, the French mission was made of a dozen of French researchers (mining archaeologists, independent speleologists, students). Mrs. Béatrice Cauuet, responsible for the archaeological research at the C.N.R.S., coordinates the ensemble of the operation and the diggings.

The French team was completed on the field with three geologists: a Romanian geologist, Mr. Calin Tămaş, two German geologists from the Technical University of Munich (Germany), Mr. Gerhard Lehrberger and Mr. Vladimir Ruttner, and for the laboratory work with two Romanian geologists from the Babes-Bolyai University of Cluj-Napoca, Mrs. Corina Ionescu (head of the Geology Department) and Mrs. Lucretia Ghergari (honored professor).

A forming of Romanian geologists in the mining archaeology is in progress and some exchanges of researchers are also carried on. In this perspective, the geologist from the Babes-Bolyai University (Cluj-Napoca), Calin Tămaş, was invited as a young researcher at Le Mirail University in Toulouse, from September to December 2000, thanks to a financing aid from the House of Human Sciences in Toulouse. Similarly, during the 2002 mission, four geology students of the Babes-Bolyai University, Bogdan Benea, Sorin Faur, Nicoleta Feier and Nuţu Groza, started their initiation in mining archaeology in connection with Calin Tămaş and the French team. More than that, the French team integrated during the whole mission a Romanian prehistoric-archaeologist, Romi Pavel, from the Museum of Deva.

The initial French-Romanian program on the ancient gold mines of Dacia in the north-west of Romania has two fields of study (Cauuet *et alii*, 2000, p. 42, fig. 1):

- the gold mines in alluvial deposits from the valley of Pianul (the Meridional Carpathians, in the south of Alba-Iulia)
- the gold mines in rock from Rosia Montana (the Apuseni Mountains, in the north-west of Alba-Iulia)

In 1999, the study was done first on the alluvial mines of Pianul (Cauuet *et alii*, 1999). The Rosia Montana sector was only fast explored with the assistance of A. Sintimbreanu, retired exploitation manager of the Romanian mining society, *Minvest*, still exploiter of the site. As we had announced in 1999, the site from Rosia Montana will soon be threatened with a re-exploitation/destruction on a large scale of the mine and of all the ancient vestiges (surface mines, subterranean mines, treatment workshops, Romanian mining villages, the ancient *Alburnus Maior*, sanctuaries, necropolis etc.), of the modern ones (medieval mining constructions and others from 17th to 19th century) and even a part of today's village with its ancient buildings (classified houses, churches etc.). This will also compel the villagers to emigrate to the western part of the site in a new place built by the new society, the *Rosia Montana Gold Corporation* (a branch of *Gabriel Resources Ltd*., a mining society from Vancouver, Canada).

Given the richness of the ancient mining vestiges still in place on the site of Rosia Montana and the fact that the constructions in alluvial deposits in the valley of Pianul are not threatened, in the years 2000, 2001 and 2002 we guided all our efforts on a preliminary study of the threatened site of Rosia. Nevertheless, the study on the Pianul sector was accelerated in May 2000 during a short mission of B. Cauuet, assisted by the geologists Calin Tămaş on the field and M. Calin Baciu in the laboratory (a three-dimensional geographical and topographical presentation of the studied area).

In the year 2001, on the site of Rosia Montana, the collaboration with the archaeologists' team from the museum of Alba-Iulia was carried on by distributing the areas to be explored:

- the French team concentrated on the mining vestiges from the surface, but especially the subterranean ones
- the Romanian team analysed the different archaeological sites from the surface, discovered by chance along the years (habitats, necropolis etc.)

Thus, each team produced a distinct account from that of the work carried on in the summer of 2000.

In 2001, taking into account the extension of the site and the number of vestiges to be studied, the ensemble of the project was placed under the responsibility of the Romanian National Museum of History from Bucharest and its representative, Mr. Paul Damian, preserver of the museum. The project was classified as a ”National cultural project of major interest” by the Romanian Ministry of Culture and by several teams of archaeologists and historians, coming from different organisms of the country (professors and preservers of museums from Bucharest, Cluj, Deva, Alba-Iulia etc.), in all, a dozen of teams invited to take part in the study of the ancient and medieval vestiges from the surface (habitats, necropolis, places of cult etc.) The superficial and subterranean mining vestiges were conferred to the mining archaeologists from Toulouse because of the special aspect that their study requires and because of the French specialization in this matter. The French team was asked for a complete inventory of the ancient mining vestiges still conserved on the site, next to a description and a classification of the vestiges by order of priorities. In 2000 and 2001, the massifs of Cetate and Cârnic had been completely exploited and two more digging areas were initiated (Cârnic 1 and 2 in Cârnic; Zeus and Gauri in Cetate).

In 2002, the digging operations concentrated on the south of the Cârnic massif (fig. 1). They were moved forward well to the centre of the massif on eight different sectors, but essential digging points couldn’t be found because of the lack of time during that mission (fig. 2 and 3). In 2003, two or three more months are necessary to really finish studying the Cârnic massif (fig. 4 and 5). A digging of the upper networks of the Southern Cârnic was carried on, followed by topographical lists of the networks. For the future, there are a few digging operations to be made in these new areas.

INTRODUCTION - GEOLOGY

The gold and silver deposits of Rosia Montana have been famous for a long time (fig. 6). Its richness and its long period of exploitation are well known. It has always attracted the world of scientists for geological and mining reasons or for archaeological interests. Even today, after the great geological discoveries of the New World (the Americas, Oceania) the deposit from Rosia Montana is still a giant among the deposits of precious metals due to its stock that exceeds 300 tons of metal gold. It is equally striking to notice the impressive total quantity of gold, about 1000 t Au, and of silver, about 3000 t Ag, that the original deposit contained and that such tonnages could have been concentrated in a very narrow perimeter.

The low sulfidation type of the deposit from Rosia Montana was described by Marza *et al.* (1997), Tămaş and Bailly (1998). Moreover, a metallogentic model has been recently suggested (Tămaş, 2002). It deals with a phreatomagmatic system (*maar-diatrème*) centred on the breccia structure from Cetate (fig. 7).

During the antiquity, the breccia structure from Cetate, which is outcropping especially in the massif of Cetate, was explored on the surface (see the Roman working places in the open air) and also in subterranean mining workings (*Cauuet et alii*., 2001). Besides the Cetate massif, in the Cârnic massif there are no important traces of ancient working places on the surface, they might be buried in the waste dumps. On the contrary, the prospecting of the year 2000 and the diggings of 2002 have started offering a view, incomplete for the moment, of the subterranean mining working places of Roman and pre-Roman times in this massif (see the results of the diggings). The size and the complexity of these subterranean works are still astonishing, two millenniums later, for the professional geologists, miners and archaeologists.

In comparison with the Cetate massif where the most important ore body was and still is the breccia from Cetate, in the Cârnic massif the ancient mining workings revolve around breccia structures of a smaller scale, around veins and their areas of intersection and areas of stockwork. During the year 2002, two already known perimeters, Cârnic 1 and Cârnic 2, have been re-examined in new points:

In Cârnic 1 : G2-Ch2, G12, G5-G9, P10 et Dep10 ;
In Cârnic 2 : G2, G4-G5, Gallery of the Stairs

New networks have been equally studied: Cârnic 2 to Cârnic 7, except from Cârnic 4, a network unexplorated yet. This last network (Cârnic 4) is still obstructed, because, being situated in a confined area, the air was polluted and there were no ventilations to make the work possible. But this network is yet very promising.

The geological study of the ancient mine of Cârnic was at first meant to recognize the type of ore. This purpose was achieved by using different research methods. A thorough geological cartography was drawn up thanks to the observations made on the mining workings starting from a topographical base provided by archaeologists. Further information is given by the complementary laboratory studies. Gold-silver holders[1] (table 1), observations and photos of thin sections [2] and polished sections[2, 3] gave more information on the types of rocks,

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[1] S.C. Rosia Montana Gold Corporation S.A., Rosia Montana, Romania.
[2] Babes-Bolyai University, Cluj-Napoca, Romania.
[3] Technical University of Munich, Germany.

hydrothermal alterations, type of ore, mineralogy and metal holders. Various gold panned concentrates showed us the abundance of gold in the ore bodies explored by the ancient miners (Dacians or/and Romanians).

Table 1
Au – Ag holders in the ancient mining workings of Cârnic in Rosia Montana

Sample	Au (g/t)	Ag (g/t)
334	0,61	13
342	0,16	7
351	122,59	145
393	55,13	43
396	0,65	3
400	0,34	8
404	1,68	17
426	0,3	5
429	0,23	2
433	1,84	8
447	1,09	11
458	0,21	7

The insufficient time for the research at the Cârnic massif in general and in particular for geology, did not allow to find a solution for the problem linked to the ancient subterranean networks of Cârnic discovered during the mission of the year 2002. For the future, the geological study must be taken again on various parts of the ancient mine in order to define more accurately various obscure details which are still waiting for solutions. This will mean answering certain questions that do not have an answer for the moment, questions linked to geology but that are also put to archaeologists. Indeed, they are waiting for complementary detailed data on the type of ore, the host rock, the ore holders as well as other, more thorough elements, in order to give a satisfactory answer to the mysteries that are still hidden in the heart of the massif and especially to understand the whole dynamics of the mine.

Cârnic 1

The mining network of Cârnic 1 is expanded between the elevations of the modern works 958 and 932 (fig. 8). About 1/3 of the surface of this network had been explored. There are three main sectors (fig. 9):
-the North-Western network, ranged on two levels, an upper and a lower one;
-the Eastern network, partially exploited;
-the Southern network, also only partially exploited.

The North-Western Network

The exploration of this north-western extremity of Cârnic 1 took place in the year 2000 and was carried on in three archaeological diggings: G1 gallery and the south-western half of G2 gallery (upper level) and Ch1 (lower level) on a surface limited at an archaeological digging of 1,50 x 4,50 m (Cauuet *et alii.*, 2000). This first phase of exploration had permitted the discovery of non-dated vestiges of wooden boards and laths, wooden coal (dating C14[4] , 110-245 AD, ref. *RM00 Cârnic 1 - G1*, see fig. 10) and fragments of Roman lamps (even the entire object) dating from the 2nd century AD. The mining working places of this North-Western network are ranged on two levels, linked by a rectangular well, P1, of about 2 m deep only (fig. 11).

<u>The Upper Level</u>

In the year 2002, the exploration of gallery G2 was finished in the upper level and carried on in two small exploitation chambers, Ch2 and Ch3, united and situated in the north side of G2 (fig. 12 and 13). Gallery G2 corresponds to two levels of galleries of trapezoidal section opened one above the other till they form a narrow *depilage* of 1,45 x 4,20 m (fig. 14 and 15). The direction of the digging is north-east/south-west, visible from the traces of tools (chisel) and the unevenness left on the walls by the successive operations of sectioning.

<u>Workings Topography</u>

In the north wall of G2, there are four lamp niches arranged in the face of the wall at every metre following an axis inclined downwards (fig. 16). They mark well the progress of the working place and the progressive deepening of G2, done starting with the north-west. The southern wall of G2 shows three lamp niches following an equally descending progress. The basement of the gallery is very irregular and it marks a breach/fissure(un creusement) in the shape of a hole in the direction of a first little bench which closes the gallery in the north-east. This 1 m wide and 0.75 m high bench, situated at the level of the opening towards Ch2, stretches till the inside of the chamber which it limits in the east/north-east. A second bench or

[4] Our radiocarbon dating are done by the French laboratory, Archéolabs, Le Chatelard, F – 38840 Saint Bonnet de Chavagne.

stair of 1.60 m wide and 1 m high ends G2 in ascending stairs till it reaches the place where it opens on the G3 gallery (fig. 17 and 18).

The G3 gallery, from where the miners arrived to the upper level, was cleared on a surface of only 1.60 m long. Almost entirely obstructed but situated in an area of important joints, the gallery received a support frame and it was left in this state for security reasons. On the other side of G3, it seems that huge modern workings of the *coranda* type had destroyed the ancient workings. The diggings were thus stopped there in that sector. Before enlarging in chambers Ch2 and Ch3 of the workings starting with the wall north of G2, the G3 gallery had followed an east-western direction. There is still a very clear trace of this progression on the ceiling of the areas of contact G2-G3. In the north wall suspended above Ch2, two lamp niches can be seen (fig. 19).

In the cleared part of the south-eastern wall of G3, an open part of the ancient G4 gallery can be seen at the level of the low bench that limits G2 in the north (fig. 17). After having been 0.50-1 m long, this G4 gallery was cut again by a huge modern *depilage* of 3.80 m wide and which meets a part of the wall inclined towards the south the lower level of the North-West working places of Cârnic 1. Even more westwards from the *depilage*, there is the 1.70 m long extremity of G4, parted into two working fronts. The quadrilateral proportions of the gallery are still well shaped at the ceiling. This G4 gallery was summarily cleared in order to be mapped out, it hasn't been explited (fig. 11).

The initial basement of G2 was preserved at its western extremity at the level of a high bench where an intact Roman mining lamp was found in the year 2000 (Cauuet *et alii*., 2000). Then the gallery was deepened until it formed a second level of gallery that became wider and slightly moved off towards the south-west in the direction of the exploration drift G1, explored in the year 2000.

Then, the exploitation that was following a mineralised vein forked in a right angle towards the south opening a high and narrow *depilage*, D1. It goes down to the depths gradually, on the south side, cutting tiers fallen down in stairs to the ceiling. After 4.20 m in length, this working place immersed in a short well of a rectangular section (1 x 2 m), 2 m deep at the maximum, which came out at the lower level of the north-western network (fig. 31).

At its north-east end, G2 opens in the north side in order to come out on two small exploitation chambers Ch2 and Ch3, a similar working place of an irregular form of 2 x 5.80 m and of 1.35 to 1.65 m high (fig. 20 and 21). The Ch2 chamber diminishes with 0.75 m in comparison with the basement of G3. The basement of the small chambers Ch2 and Ch3 is in the shape of a basin, the two areas being separated by a mass of rocks that comes out in the western part of Ch3. This mass of rocks left on the field shows that the digging of the workings is done starting from the ceiling. The wall rises in the western part where there is a unique lamp niche placed halfway on the wall (fig. 19).

Four stratigraphic sections were done in the upper level, one in G2, two in Ch2 and Ch3 and a diagonal one in Ch2, G3 and G4 (fig. 22).

<u>Stratigraphy St1-St1' (section taken in G2) (fig. 22):</u>

US 1: heterogeneous mobile layer built at 70% dacite fragments (diameter 0.5 to 5 cm) and at 30% clay pockets and sandy clay.
US 2: more compact layer, 30% of gritty silt and 50% of dacite blocks (diameter 15 to 30) with presence of wooden coal.
US 3: same type of layer as US 2 with clay pockets.
US 4: 60% gritty silt (diameter 0.20 to 0.50) and 40% of 5 cm long dacite fragments.
US 5: 20 % lemon and 80 % dacite fragments (diameter 0,20 to 5 cm), uniform layer.
US 6: 10 % sand clayey matrix and 90 % gravel intrusions, dacite blocks (diameter 10 to 15 cm) and grits (diameter 0,20 to 0,50 cm).
US 7: dense layer, 50 % sand clayey matrix, and 50 % dacite fragments intrusions (diameter 2 to 5 cm).
US 8: 20 % sand clayey matrix and 80 % dacite fragments intrusions (diameter 8 to 13 cm).
US 9: same type of layer as US 7.
US 10: (couche meuble), aired, 10 % sand clayey matrix, 90 % dacite fragments (diameter 5 to 18 cm).
US 11: dense layer, 10 % sand clayey matrix and 90 % dacite fragments intrusions (diameter 2 to 4 cm).
US 12: scree type layer, 10 % sand clayey matrix, 90 % heterogeneous dacite blocks and fragments.

Stratigraphy St2-St2’ (section taken at the entrance of Ch2) (fig. 22) :

US 1: compact layer of clayey sands stratified in layers coloured from beige to ochre.
US 2: compact layer, 60 % sand clayey matrix, 40 % dacite fragments intrusions (diameter 5 to 17 cm).
US 3: compact layer of clayey sands.
US 4: 40 % sand clayey matrix, 60 % dacite fragments intrusions (diameter 3 to 7 cm).
US 5: aired layer, 10 % matrix of gritty clay, 90 % dacite fragments intrusions (diameter 5 to 25 cm).
US 6: compact layer, 50 % sand clayey matrix, 50 % dacite intrusions (diameter 0,5 to 5 cm).

Stratigraphy St3-St3’ (section taken from the workings of Ch2, G3 and G4 on an north-west/south-east axis) (fig. 22) :

US 1: compact layer of clayey sands stratified in layers coloured from beige to ochre, including some dispersed blocks of dacite of a big diameter (7 to 90 cm long).
US 2: compact layer, 60 % sand clayey matrix, 40 % dacite fragments intrusions (diameter 5 to 20 cm).
US 3: compact layer, 50 % sand clayey matrix, 50 % dacite intrusions (diameter 0,50 to 5 cm).

Stratigraphy St4-St4’ (section taken at the entrance of Ch3) (fig. 22) :

US 1: compact layer of clay interstratified with clayey sands, alternance of layers coloured from beige to ochre.
US 2: compact clay layer, 60 % sand clayey matrix, 40 % dacite fragments intrusions (diameter 5 to 17 cm).

US 3: compact layer, 50 % sand clayey matrix, 50 % dacite intrusions (diameter 0,50 to 5 cm).

No archaeological artefacts, ceramics, wood or other vestiges were found in the filling of the different workings in the upper level explored in 2002.

Geology of Drift G2 and Chamber Ch2

The study of gallery G2, started in 2000, was finished during the mission of 2002. The preliminary geological examination done in 2000 was completed after the evacuation of the waste that was blocking almost entirely this gallery and the neighbouring chamber Ch2 (fig. 23). In the median sector, the gallery was dug in a breakable and sterile dacite. On the microscope, the rock appears extremely altered: potassium metasomatosis and phyllic alteration with adularia I and adularia II, illite, illite/montmorillonite. At the same time, the rock is fissured and in the fissures there is a filling of clayey minerals, iron hydroxide and in the axial part of the adularia (adularia II) (fig. 24).

On the north wall, at a short distance from sample 359 (taken from below a lamp niche), a silicification area starts and continues in the chamber (fig. 23). In this area, the rock is mineralised and harder because of the silicification. The microscopic examination shows the micro-brecciation of the rock (sample 360, fig. 25) and the hydrothermal filling. Towards the angle G2-Ch2, there are some important pyrite impregnations (sample 362) that completely change the colour of the rock (dark grey).

A spectacular and amazing dyke of *chinga*, of a medium width of 30 cm outcrops on a part of the basement and of the walls of the chamber Ch2 and at the eastern extremity of gallery G2. The body of the *chinga* is extremely homogenous and its limits with the host rock are very clear. Injections of chinga on a smaller scale often cross the host rock.

The position of the dyke of *chinga* is responsible for a brecciation of the host rock. For example, on the eastern wall of the chamber a dacite breccia with angular fragments and a *chinga* type matrix accompany the dyke of the *chinga*. In this satellite breccia of the *chinga* dyke, some pyrite and sphalerite, grey copper and gold can be seen on the microscope (sample 363).

It is possible that this injection structure also controlled the placement of the precious metals. On the north wall of gallery G2 there is a visible area of transition between the area of mineralised breccia (in the east of Ch2 and G2) and a horizontal vein explored especially in the north/north-east side of the chamber. The miners followed the *chinga* dyke in view of the interesting gold grades that are found especially in the breccia area surrounding this dyke and also in the fissures or veins that extends the breccia in the host rock.

The fluidised matrix, also called chinga, presents a superposed hydrothermal alteration (silicification and adularisation) and sulphide and oxide impregnations. It is obvious that this structure of an injection breccia dyke continues in chamber Ch2 of the Cârnic 1 mining sector and comes out in the upper levels of Cârnic 1.

The Lower Level

The diggings in this part of the lower network was resumed after the archaeological digging in the centre of the chamber Ch1 in 2000 (Cauuet *et alii*, 2000). They concentrated on a group of partially superposed galleries that could be seen in the south-west angle of the chamber (fig. 26).

Workings Topography

The east and south-east side of chamber Ch1 was reworked so many times by the Moderns that one cannot say where the ancient working places were. However, the west and the south-west preserved ancient workings cut with a chisel. The first working, G1, corresponds to a short gallery vertically dug from east to west (fig. 32). It presents a rectangular plan (1.25 m x 3m, 1.90 m high) and a characteristic trapeze shape. The basement of the gallery was re-dug in the shape of a 30 cm deep basin, where the infiltration waters are stocked. The ceiling of the working is marked by overturned tiers, the mark of a series of small working places (fig. 27).

At 1 m south of G11 and following the same south-west axis, another gallery, Ch12, opens (1.15 m x 3.75 m, 1.55 m high). It is linked to chamber Ch1 by a gallery oriented to the north-south, gallery G13, based on a 40º descending slope (fig. 26). The extremely irregular basement of G13 is marked by successive modifications (fig. 28). The south end of G13 opens in the west on a new working place, gallery G14, which couldn't be dug because of the lack of time (fig. 33).

This gallery also pierced from east to west is linked to G12 by an opening, so that the south wall of G12, the north wall of G14 and the west wall of G13 form a pillar (fig. 29 and 30). This is an example of the characteristic type of exploitation from Cârnic, where the opening of the galleries ends by forming chambers on pillars. The main orientation of the workings of this area is east-west, which is demonstrated by the orientation of the explored veins. Only one lamp niche was discovered in the lower network, and it is faces the well P1, in the middle of the chamber Ch2 (fig. 31).

Stratigraphy St1-St1' (taken at the entrance of G13) (fig. 27) :

US 1 : aired layer, of an ochre colour with traces of oxidation, 30 % sand matrix, slightly clayey, 70 % dacite fragments intrusions (diameter 1 to 20 cm).
US 2 : very compact level of circulation, heterogeneous layer coloured from light-grey to yellow, 90 % sand clayey matrix, 10 % dacite intrusions (diameter 5 to 10 cm).
US 3 : very aired layer, yellow-coloured, 30 % from sand clayey matrix to gritty, 70 % dacite blocks intrusions (diameter 5 to 20 cm). Presence of fragments of Roman lamps (canal lamp types) (Loeschke X type).
US 4 : the same type of layer as US 2 but the module of the dacite intrusions is smaller (diameter 1 to 3 cm).
US 5 : slightly aired layer, 70 % of sand clayey matrix, yellow-coloured, 30 % dacite fragments intrusions (diameter 5 to 15 cm).
US 6 : compact layer, heterogeneous, grey-yellow coloured, 80 % of sand clayey matrix, 20 % dacite fragments intrusions (diameter 2 to 5 cm).

US 7 : perturbed and aired layer, 20 % sand matrix (fine sand), slightly clayey, 80 % dacite fragments intrusions (diameter 1 to 30 cm).
US 8 : layer 90 % made of blocks of dacite of 10 to 40 cm in diameter covered by a sandy matrix (fine sands), very slightly clayey.
US 9 : layer almost exclusively made of dacite fragments covered in yellow compact clay (diameter 10 to 30 cm).

Stratigraphy St2-St2' (taken at the entrance of G12) (fig. 27) :

US 1 : aired layer, ochre-coloured, marked by a trace of oxidation, done by the fall in plates of the ceiling of the gallery.
US 2 : sand layer, heterogeneous, grey-yellow coloured, 90 % from sand matrix to gritty, 10 % dacite gravel intrusions (diameter 1 to 3 cm)
US 3 : aired layer made of 90 % of angular fragments (diameter 5 to 20 cm), packed in a sand matrix 10 % (sables fins).
US 4 : compact layer, 90 % sand clayey matrix coloured in beige (grits trapped in clay), 10 % gravel intrusions (diameter 1 to 5 cm).
US 5 : very compact level of circulation, heterogeneous layer coloured from light-grey to yellow, 90 % sand clayey matrix, 10 % dacite fragments intrusions (diameter 1 to 3 cm). The same layer as US 4 from the stratigraphy St1-St1' of G13.
US 6 : slightly compacted layer, 80 % clayey-sandy matrix to gritty, 20 % intrusions of fragments of dacite (diameter 5 to 15 cm).
US 7 : little compact layer, heterogeneous, coloured in grey-yellow, 50 % from sand clayey matrix to gritty, 50 % intrusions of small fragments of dacite (diameter 1 to 10 cm).

The diggings of G12 et G13 discovered fragments of Roman lamp (*firmalampen*), of the type canal lamp (fig. 34 and 35) and dating from 2nd century A.D. (Loeschke X model). Fragments of modern enamelled ceramics were equally found in this area (fig. 36). Finally, several wooden fragments, like a small board and wooden coal were found at the base of the layers. These elements were taken for radiocarbon analysis and two measures were obtained. For the small board (fig. 10):

- Ref.: *RM02 Cârnic 1 – Ch1 – G13 – US4*; measure: 2160 +/- 50 BP; highest probability range: 265 to -90 B.C.

For the wooden coal:

- Ref.: *RM02 – Cârnic 1 – G12*; measure: 1860 +/- 60 BP; highest probability range: 45 to 260 A.D.

The dating of the small board situates the cutting of the wood between the middle of the 3rd and the beginning of the 1st century B.C., that is, during Dacian times. The other dating situated between the middle of the 1st century and the middle of the 3rd century A.D. is more likely to be Roman. We are not very surprised to find Dacians in Cârnic, as, since 2000, we know that it is a possibility in Rosia Montana since the first dating of the 1st century AD (middle of the 1st century BC to end of the Ist century AD, 50 - 80) obtained for a mine propping in Tarina.

In any case, the date is early and this means an activity in two periods of time in this part of Cârnic 1. A first phase of crossing simple galleries during the Dacian epoch, then a deepening and an enlarging of the network of galleries during Roman times. Moreover, the modern stages disturb in their turn the pre-existing workings. (fig. 37).

The Eastern Network

At the beginning of July 2002, the research team was given a new impulse by the arrival of new French archaeologists on the field. A part of the researchers took care of finishing the diggings in progress in various areas, while another explored new digging places, especially in the Cârnic 1 network. A first attempt on a drowned sector, situated up the bent of sedimentary rocks of the modern level 932 had to be abandoned because of the dangers and disturbances (mud running) that this opening caused to the working team in P10 and Dep 10 (south working place of Cârnic) in the lower level. The examination was resumed in the network upwards and to level 958 (fig. 9).

Discovery of a New Network

In 958 drift, there are a lot of ancient networks, a quick visit of the places does not allow us to choose one in favour of another, as they are often re-cut by modern powder attacks. We were facing another handicap, that of the management of the excavations in a short period of time, that is, in three weeks' time. However, an inclined ancient climbing caught our attention and we would have started studying it if in the modern level 958 our interest hadn't been risen by two ancient galleries, opening, at 9.70 m high at least, on a chamber practically entirely resumed in modern times. Because of its altimetry height and its proximity to the Cârnic 1 working place, thus making a coherent ensemble, we decided to settle down there temporarily, not knowing yet the potential we had only perceived.

The first disadvantage of these workings was their accessibility. This encouraged us in our choice as, if there were networks behind the first metre seen from the chamber, it seemed obvious that they were no longer visited, thus not disturbed by the mineral seekers. Our first task was to get to these networks in order to check their archaeological interest and their extension. For this, we had to set a speleological equipment (ladder, ropes) vertically on 9.70 m, which was not easy to do because of the fields altered by the hydrothermal activity linked to the presence of veins and to the action of the running waters coming from the upper networks.

Finally, we got to the perceived networks, but only the lowest one, situated at 9.70 m, was visited, the other one situated at 2 m above was abandoned for the time being because of the great quantity of ferruginous concretions forbidding the setting of all the security measures. The lower network that opens directly on the east face of the wall of the modern exploitation *depilage* presents (fig. 38):

-a gallery, G5, oriented first at N111º on 3 m, then bending to N134º on 3.50 m. At 6.15 m, this work ends on a working place.

-on the south-west face of the wall at 1.35 m' distance from the above mentioned working place, a second gallery opens, G6, oriented at N31º, having an extension of only 1.35 m;

-this opening goes beyond, following the same direction on a length of 0.90 m in the shape of a descent cut in the shape of stairs in the rock till the workings intersection;

-from this point to the south-east, a gallery, G7, oriented at N130º. At 2.60 m' distance from its origin, the gallery is obstructed to the ceiling by concretions made of iron oxides;

-from the intersection point of this concretioned working, the descent continues in a slightly different direction (N45º). It has the same shape of stairs. At 2 m' distance, a quite deep ground-water layer stopped any progression. In this last part of gallery G6, there are two visible lamp niches situated on the western wall, 3 m from the basement.

The ensemble of recognized workings presents all the characteristics of an ancient digging without modern intrusion. During this visit, it was decided to dig and study this network in spite of the dangerous access to it, as the chance to find a flooded network preserving in good conditions archaeological vestiges, especially those made of wood, was worth the risk.

Equipment for the Access to the Network

The priority in the diggings of the basement of the discovered network is to pump out the water. But before, the access to this working place (+ 9.70 m) was to be made practicable and secure by cutting a way from the lower part of the chamber to the west, for the workers and the archaeologists. We had to clear the vestiges of an ancient gallery, perpendicular on the modern *depilage* in order to find the rock, permitting an easy access to a detachment which was re-cut to serve as a support casing. A parapet was set on the length of the *depilage* and at 1/3 m high.

In the direction of gallery G5, a small platform was set in order to receive a wooden stairs fixed in the rock using the anchoring points set during the exploration climbing. The wooden stairs (4 m) was not enough, we finished by setting in relay a cable stairs doubled by a parapet made of ropes, the whole being well linked. Once we had made the passage, we could start cleaning the network at the level 9.70 m obstructed by stalactites and by concretion stalagmites. During this clearing done in easier conditions, we saw in the north-east of the depilage, at a slightly higher level than gallery G5, another casing, G16, covered by half-concretionned detritus and reaching the middle part of a new ancient gallery, G15 (fig. 39 and 40).

Great Workings of Clearing

The newly discovered ancient gallery, G15, was coming from the north. Its entrance was exploited in the north part, at the level of the passage of a modern descent that crosses the upper side of the Cârnic 1 network. The work was shared between two teams, one working in the north to clear G15 from the descent as the other attacked the south side to clear the casing G16 suspended above the modern depilage, towards the inside of G15. It was soon obvious that there was a great deal of waste to be cleared at the north entrance of G15.

Thus, three protection dams were built in order to block or direct the excavations and to prevent them from falling in the lower circulation levels. After setting several wooden elements, the clearing was finished and the two sectors G15 and G16 were connected within one day. The clearing of G15 continued south from the depilage in order to prevent the falling of blocks in the north descent. This gallery was well preserved in spite of the modern crashes visible in the north.

Once the detritus was stabilized, the complete clearing of G15 was finished in the north descent following the eastern face of the wall. The height of the waste was of 3 m to the entrance because of the widening of the ceiling due to modern workings. Then, the obstruction became smaller in the direction of G16 finding the ancient ceiling again. The east side of the wall and a part of the west side were well preserved.

The clearing works had a double interest:
-to facilitate the understanding of the passage of the ancient gallery G15 by reading the remnant vestiges (basement- and walls);
-to facilitate the passage of the pumping material (pump, pipes and electrical cable) as well as the traffic of the people during the evacuation of the water and of the waste accumulated at the bottom of the flooded network G5-G6.

The Pumping Operation

The pumping of the Eastern network was done in two operations, because the first generating group used (material lent by the museum of Deva) was too weak for the pump. The operation was done using the generating group of the miners of the Catalina Monulesti network. At the bottom of the network there was only a thick mud that the pump couldn't evacuate and some waste. The height of the evacuated water was of 2.80 m, or about 11 m^3 (fig. 41 and 42).

The pumping made way for an inclined surface, G8, extremely concretionned, and for the ceiling of a gallery, G9, that was going in the direction of the descent to the G6 stairs. In the mud, the frame of a wooden winch appeared. There was no trace of modern exploration. An hour after the pumping, the water level did not rise so the diggings could start. They couldn't be achieved in 2002 because of the lack of time and this working in progress must be absolutely resumed in order to understand the purpose of this network.

Topography of the Drifts G15 and G16

In the direction of the modern descent situated in the top part of Cârnic 1, the eastern side, there is an inclined chamber that was filled up for almost 3 m high (dacite blocks of 0.50 to 20 cm diameter). At the bottom of this waste there is the ancient gallery G15 (fig. 43). Cut after 7.50 m in length by the modern *depilage* opened in the south-east, it continues in the direction of the G5-G6 network with a 5 m long cornice, called G16. This part of the gallery G16 was very much resumed by the Moderns. From the ancient state there is only the basement and 1 m of wall in the north-east at the contact with the access gallery G5. The only traces of ancient waste are stuck and concretionned to the north pillar of the chamber. The G15-G16 ensemble, of a total length of 10.50 m, was well linked to the protected network G5-G9 and had to be the way of access before the opening of the modern *depilage*.

The narrow way G15 shows today a very irregular shape (fig. 44). In its first half (3.50 m wide, 4 m long, maximum height of 3.30 m at the fallen ceiling) from the north side there is only the western wall left. It is marked by two cuts for the wooden elements and a lamp niche. The unstable Eastern wall was widened by the Moderns (traces of borer of 2.5 to 3 cm wide). In the south-east angle there is a 30 cm long prominence which still marks the ancient way of the old gallery. The basement of G15 couldn't be explored in 2002 because of the lack of time, the heights given are those above of the waste, that still mask it. The real dimensions of the ancient gallery G15 are found in the 3.50 m long segment of the south side before the resuming of the workings opened by the *depilage* (fig. 45).

The gallery has a classical model (1.35 m wide, 1.55 visible height), presenting a trapezoidal section. There are visible traces of tools (chisels) on the walls and the ceiling. The south side of G15 does not have any lamp niches, but a narrowing of the walls that changes the width to 0.80 m on 0.30 m in length. At the junction with the G16 cornice, the narrow way points out a

0.80 m high stairs in the middle of the gallery before taking a horizontal way. There is about 0.40 m of waste to be dug on the basement.

A narrow casing, G16, links G15 to G5 downwards, in a gentle slope (fig. 40 and 43). On the east wall, preserved best, there are successive marks from the north that show the beginning of a quadrilateral gallery and the opening of a filled gallery, completely concretionned. In the lower western part of the cornice, the modern *depilage* has a depth of at least 9.40 m, height measured on the waste gathered at the foundation. The direction of the hole in G15 and G16 appears to be in the north-south, but the carrying on of the study might produce surprises knowing that there are two concretionned galleries left unexploited, in the north-east/south-west direction for the one opening on G16 and south-east/north-west for G7 inside the network. The progress could also have come from the east.

Topography of the Network G5 to G9

The walls, the basement and the ceiling of the access drift to the Eastern site, G5, are almost entirely covered by concretions (fig. 46 and 47). Tools can be seen in the rare passages where the rock is uncovered. One of these places, situated near the entrance of G5 (the side of the *depilage*) on the south wall, is a witness of the direction of the cutting done from west to east (fig. 47 and 48). A second virgin area of concretion is the one where the lamp niches are, and this one stretches from the ceiling to about 1 m below. The examination of the wall couldn't be done because of the height and the lack of time (fig. 49).

Everywhere else, the network is so horizontal that the descending traversed part with the stairs has a width of a very compact iron dioxide, from 3 to 30 cm wide and sometimes even more, like in the G7 gallery (fig. 50). These concretions can be removed only with the chisel or the pick. The detachment of the waste concretionned in G8 made it possible for a series of stairs cut in the working to appear in the upper part of the inclined wall.

Thus, the inclined gallery G6 presents two lines of five stairs separated by a 1 m long stair head (fig. 47 and 51). At the right of gallery G8, along the western wall, these stairs have only a reduced size because of the part excavated by G9. Only part of these stairs could be cleared in 2002 from the iron dioxide shell. Their size is irregular but very clear (fig. 52).

The medium width of the workings is of 1 m to 1.60 m at the maximum. The galleries have sections of a quadrilateral to trapezoidal, their height varies between 1m and 1.50 m. The unevenness between the basement of the access gallery G5 and the level touched in the mud is of 7.50 m. The spiral descent in pointed angles in G6, G8 and G9 is similar to the P10 well going down to the *depilage* Dep10 of the Southern network of Cârnic 1 (reference further on). But in the Eastern network, the stairs are well masked and cut, which is not the case for P10.

The drained and summarily cleaned network showed the continuity of the inclined gallery G6 N45º on 1.50 m more. In this point, its orientation varies and becomes N19º, still keeping the same slope. At 3.55 m this work, G8, meets the rock but a bench allows it to make a half-bend in order to start going from below the inclined gallery (fig. 53). At 1.40 m from this last change of direction to the bench, the stairs occupy only part of the inclined gallery, about 0.60 m in width. There are 3 m from this bench to the actual end of the works (because nothing allows us to say that this does not go to the basement. This last work, G9, partly cleared, goes towards the north/north-east, following the direction N21º. Its structure, like that of the other works, is an ancient one.

The purpose of the study of this complete and coherent ensemble of ancient working places is to understand the dynamics and the organization of the diggings in Cârnic 1. We hope to be able to achieve the study of this part of the site next year as we are already quite ahead with it. Abandoning the archaeological research at this point would be considered a deficiency in the study of the ensemble from the Cârnic massif.

Discovered Artefacts

The diggings left in working allowed us, however, to take out of the mud:
-a series of stairs extending the inclined gallery;
-a bent bench that occupies the west and south angles of the southern end of G8;
-two stairs in the direction of the gallery G9 behind, with the diggings left unfinished in the north-east. This gallery or *depilage* could only be partially recognized, but its filling seems important.

No trace of modern research was noticed in the ensemble of the workings going from G5 to G9 that preserved their primitive cutting. No mark was noticed either for a wooden beam cutting for the setting of a winch, nor other lamp niches than those present at half-height of G6. But to be sure, a more thorough clearing of the walls is necessary for the future. From the filling that was descended from 1.30 without meeting the basement of the gallery, we extracted wood, ropes and a candle (fig. 54 and 55). The characteristics of these wooden fragments are as follows (fig. 56):
-1 frame of a winch, 82 cm long, 17 cm wide, 8 cm thick, showing a tenon arrangement, with a flat lower end and a round neck in its active end;
-1 wooden fragment, 61 cm long, 14 cm wide, 8 cm thick, carved with an axis in a slightly round shape at one end, cut with a saw in the shape of stairs at the other end;
-1 wooden fragment, 81 cm long, section 10.50 x 10 cm, pointed at one end (7 x 9 cm) to be introduced in an arrangement or to plant. This wood was sawed to make a measure of the radiocarbon;
-1 wooden fragment, 50 cm long, 7.50 cm wide, 2 cm thick. This object has a similar shape to the lath of a barrel;
-1 curved wooden fragment, 13.20 cm long ;
-1 board perfectly processed, medium length of 15 cm, 14.40 cm wide;
-1 little board, 19.50 cm long ;
-1 little board of the same shape, 16 cm long, 2.20 cm wide, 1.10 cm thick;
-1 little board of the same shape, 8 cm long, 2.50 cm wide, 1.10 cm thick;
-1 cylindrical processed wood, 26.50 cm long, 1.40 cm diameter;
-7 wooden fragments of a varying length of 4 to 17 cm, for a width of 0.60 to 0.80 cm;
-1 small branch, 8.50 cm, 0.70 cm diameter;

equally, several fragments of rope of different thickness :
-1 twisted hemp rope, made of 2 bits, 1.60 cm diameter, in three parts of 19, 29 and 49 cm long, one of them being tied;
-1 hemp rope, made of 2 threads, 0.80 cm diameter, in ten parts from 12 to 44 cm long and a simple, long thread of 12 cm in length.

These different elements put together, then doubled, form a unique rope of a 1.60 cm diameter that corresponds to the found parts. They are elements of the same rope from which a sample was taken to be measured with radiocarbon. They could come from the excavation machine, bucket water evacuation or evacuation of the waste by bucket.
-1 white candle, 7.20 cm long, 1.40 cm diameter.

The wooden fragment taken as a sample for the Radiocarbon gave the following results (fig. 10):

- Ref : RM02 Cârnic 1 - G9 - Wood, 420 +/- 45 BP, highest probability range between 1445 and 1660.

The fragment of rope gave the following Radiocarbon results:

- Ref : RM02 Cârnic 1 – G8 – Rope, 315 +/- 65 BP, highest probability range between 1440 and 1670.

These fragments of furniture are, thus, not as old as the works from where they were come. They date from the 15th-17th centuries. The fact that they were abandoned at this level of the network is to be linked to a visit of exploration of the network done by miners of the modern times equipped with a winch and ropes (surely to lower the flooded level) and using a candle! It seems that they left without doing any other workings, because the ancient walls are virgin, or, at least, the part exploited so far.

Geology of the Eastern Site

This network opens on a high level of the Cârnic 1 network, at about 1.50-2 m below the ceiling of the modern *depilage* that cuts the network in its median part, in the north/north-east side. This part of Cârnic 1 is almost inaccessible because of its difficult access to the height. The fact that the junction cut between the Eastern working place and the access passage that goes towards the upper networks of Cârnic was cleared allowed at the same time for a great part of the waste to be cleared off this pseudo-circulation gallery. The walls that had been masked were also cleared, which gave us the possibility to improve our geological knowledge of this Eastern area of Cârnic 1 (fig. 57).

It is obvious now that the ancient miners, in their subterranean diggings, directed themselves along the breccia dykes and to the areas of the vein joints. At the beginning of the gallery G15, in the pillar examined in 2000, as well as in the part that is common with the passage towards Cârnic 1-Upper, a breccia body with a *chinga* type matrix associated to an area of stockwork is outcropping (fig. 57). In this place, one can make some very interesting remarks about the breccia (fig. 58-60).

On the ascending access gallery, there is a breccia dyke with a vertical chinga that presents a well-developed network of matrix injections that go towards the exterior (fig. 58). In the breccia, there are some angular fragments of dacite (to 15 cm diameter) and some more or less round fragments of dacite of a lot smaller size, 1.50 cm diameter at the maximum (fig. 59). Apart from the dacite fragments, there are also some fragments of a medium size (centimetres to millimetres) of proto-breccia, that is, fragments of breccia that had a short existence during the evolution of the breccia.

This breccia body (fig. 58 and 59) has clear contacts with the host rock, but there still are some traces that witness the great fluidity of the matrix during its placement. Fluidisation and hydraulic brecciation are responsible for the presence of the injections around the breccia body (fig. 58). Along these structures of injection breccia, there is an obvious reduction of the transporting energy towards the exterior in comparison with the original breccia body. In the areas with injections (fig. 60), there are also fragments of the host rock. The size of these fragments is reduced towards the exterior, to slowly disappear. In the distal areas only the *chinga* type matrix is present (fig. 58). There are also some joint areas in this labyrinth of injection structures. The lack of balance in the pressure of the hydrothermal liquids, even on a small scale, is responsible for the brecciation. At the intersection of the fissures with fluidised matrix dacite fragments are detached from the host rocks (millimetric to 1-2 cm in diameter) and 'float' in this hydrothermal fluid during the genesis of the structure.

Looking at the architecture of the workings, it is obvious that the breccia dyke was preferably studied. The stockwork area is also silicified, like the breccia, and mineralised. Part of the contribution in precious metals is made by the veins that cut through this area. These veins (sample 460) show an extensional context, as there are empty spaces of 20 to 25 cm long and 2 to 3 cm thick along the veins. In the empty spaces, there are often quartz crystals (1.50 cm long) on a ribbon-like foundation of chinga and micro-crystalline quartz. On the microscope, the breccia reveals the presence of pyrite, sphalerite, galena, sulphur salts of silver and gold (sample 461).

Silicification is spread through all this Eastern part of the Cârnic 1 site and it crosses the pillar (fig. 5). The exit towards the inside of the median chamber of the Cârnic 1 network is cut in the same extremely silicified dacite and it cuts a vein underlined by an even greater silicification. This vertical vein (sample 462) was also very well scratched in the ancient gallery. The best part of the vein was explored in the median chamber of Cârnic 1. This vein always draws the attention with the magnificent quartz crystals (up to 8 cm long and 2 to 3 cm thick), preserved in geodes of 30 cm in length and depth and 5 cm in thickness).

The study of the polished sections certifies that the Ancients had well found the rich mineral. Small quantities of chalcopyrite and pyrite are associated to the gold that appears frequently near the empty spaces under the shape of paillettes and beans concentrated along the small alignments in the quartz that constitutes the major part of the vein.

The passage towards the second sector of the Cârnic 1-East network continues along the north wall, the only one preserved in its own place. Various trapezoidal galleries are cut below this passage, but the access to these mining workings is too dangerous for the time being.

A vertical vein made of massif grey quartz that can still be seen on the ceiling of the *coranda* (median chamber of Cârnic 1) is exploited in this passage area. The exploitation of this vein is partly responsible for the partial destruction of gallery G12 and of the cut in the empty space of the median chamber of Cârnic 1. Along the vein, there are often breccia pockets with empty spaces that go up to 5 cm diameter. The preserved wall is completely concretionned. On the ceiling of the median chamber of Cârnic 1 there are exploitation cupolas which mark the trace of the vein. That is, these areas were exploited before the extension of the big chamber of exploitation (median chamber of Cârnic 1).

The second part of the sector of Cârnic 1-East (G5 to G9) comes out on the empty space in the east end of the median chamber of Cârnic 1 (fig. 61). The entry of gallery G5 is cut in hard silicified dacite under the influence of a vertical vein that appears on the north wall and which goes towards the median chamber.

A breccia dyke cuts through the south wall of the gallery in all its length (fig. 62). It also crosses the ceiling but its trace is hidden by the concretions. This quite breakable breccia dyke is medium thick, about 5 cm. The fragments found in this fine sand clayey matrix have a varied composition: dacite, schists from the Cretaceous, but especially crystalline rocks (micaschists, quartz-muscovite or biotite schists, gneiss). The fragments that do not exceed 1.50 cm diameter are very round. In comparison with the shape and the composition of the fragments as well as with the matrix, this breccia is considered as a structure of the *pebble breccia* type which witnesses once more the phreato-magmatical activity responsible for the genesis of the deposit from Rosia Montana.

This breccia structure is cut and moved on a dozen of centimetres by another structure of vertical breccia (sample 467) that, on the contrary, is extremely silicified. At the angle of the galleries G5-G6 (fig. 62), this couple of dykes is, in its turn, cut by a slightly inclined vein that changes little by little its inclination in order to fall almost vertically, becoming thinner towards the bottom of the well. This vein generated a 5 cm thick local silicification on both sides of its way.

A lateral gallery opens in the eastern wall, gallery G7. It is cut by following a vertical vein also visible from the western wall and on the ceiling of G6. It is very close to the south wall of G7 which is extremely silicified compared to the north wall far from the vein which is not. This medium thick vertical vein, 2 cm, has a very simple composition: dark-grey quartz often containing geodes. It is also associated with matrix injections with mini-fragments of dacite and sedimentary rocks of the Cretacious (up to 1 mm thick). In the south of this vein, there is a breccia dyke (pebble breccia) which sticks in the basement after the deepening of G6 in a well. At the bottom of the network, the vein coming from the upper part has an almost vertical inclination. Gallery G7 followed actually the intersection area between the vertical vein (oriented to the north-west/south-east) and the vein of a variable inclination that comes from the upper part.

In the arrangement of the bottom of gallery G8, on the flooded basement (sample 472), the rock is silicified and mineralised. The study of the polished sections shows the presence of the common sulphurs (pyrite, sphalerite, calcopyrite) of a very reduced size and, of course, of the gold. Gallery G9 was completely filled with water and it could only be accessed after a month and after the placement of a pumping (fig. 63).

In order to clarify the understanding of the Cârnic 1-East network, the geological and archaeological study must be carried on, as the water drainage and the clearing of the deep parts was only partial. Taking into consideration the inclination of the mineralised area, it is possible that the ancient miners went straight to the depths in order to exploit a possibly mineralised area. Thus, we can add that there are lots of signs of the presence of an ore body, also taking into account the proportions of the mining workings situated at a few metres' distance, that is, the median and lower chambers or modern corandas of Cârnic 1. The bottom of the network can also hide nice surprises.

The South Network

This new network was discovered in 2002 in the lowest part situated between the Cârnic 1 and Cârnic 2 networks (fig. 9). At the beginning of the diggings, we thought of finding there a water evacuation gallery, because of the very low position of the workings. Before emptying the working place, the access gallery to the network, G1bis, had to be cleared in the north, cleaning the walls and installing a wooden pillar for the security in order to avoid the fall of the waste from the upper parts. The network includes a well, P10, a spiral structure following the axes in pointed angles and getting to a narrow *depilage*, Dep 10, of a rectangular shape, oriented to the north-west/south-east (fig. 64). The diggings and the survey of the *depilage* are incomplete because of the lack of time, only a longitudinal section could be raised in Dep 10 (fig. 65). Thus, it is not a water draining working.

The network presented a homogenous filling made especially of detritus of blocks. Three stratigraphical sections were done in the network, one in the access gallery G1bis, section St1-St1', another one at the entry of the well P10, section St2-St2' and the third one, section St3-St3', at the lower end of the well P10 right before the passage to the *depilage* Dep10 (fig. 66).

Stratigraphy St1-St1' (fig. 66) :

US 1 : detritus made of dacite blocks of all sizes, some being very big.
US 2 : clayey and gravel layer containing 20 % of matrix and 80 % dacite rock fragments (10 % small gravel of 1 cm in diameter and 70 % blocs from 7 to 40 cm in length).
US 3 : 95 % of very dense clayey layer, stratified in different layers coloured in beige ; 5 % small dacite gravel (1 to 2 cm diameter).
US 4 : the same type of layer as US 3 but of a more ochre colour.
US 5 : gravel layer presenting a sand clayey binder between the rock fragments, 10 % matrix and 90 % rock fragments of 7 to 30 cm in length.
US 6 : very compact level made of a very thick and concretionned clay.
The north-east wall of the gallery G1bis is concretionned in the lower part.

Stratigraphy St2-St2' (fig. 66) :

US 1 : aired heterogeneous layer, made of 40 % sand clayey matrix and 60 % dacite fragments intrusions, 5 to 30 cm in length.
US 2 : grey-blue coloured layer, made of 30 % sad clayey matrix and gravel intrusions of 0,5 to 3 cm diameter.
US 3 : very dense layer of an ochre colour, made of 20 % sand clayey matrix, 10 % gravel intrusions, 3 to 5 cm long and 70 % gravel of 2 to 8 mm diameter.

Stratigraphy St3-St3' (fig. 66) :

US 1 : detritus made of 7 to 20 cm long dacite fragments.
US 2 : layer made of 40 % sand clayey matrix with sand beans of 1 to 4 mm diameter and 60 % dacite intrusions of 4 to 10 cm in length.
US 3 : layer made of 60 % sand clayey matrix and 40 % small dacite fragments of 2 to 6 cm in length. No archaeological furniture was found in the (remplissage) filling of the different working exploited.

Workings Topography

There are vestiges of ancient ceiling workings inside the north-eastern extension of G1bis. The digging could nor be led in this direction because of the lack of time. The carving direction of the network is clearly north-east/south-west, from the upper to the lower level. P10 shaft opens on the southern wall of G1bis. After 0.75 – 1 m of length and a south western orientation, the opening of the shaft, 1.10-2 m large, directs in a right angle towards the west and starts a descent by several successive detachments, clearly marked in the ceiling and on the basement (fig. 67). This one is cut by a channel, 20 cm large and 5 cm deep, along the northern wall.

The shaft descends evenly 5.50 m deep following the east-west axis. The different detachments do not design regular stairs, but only different irregular prominences which cross the central axis of the basement or go along. The profile of the shaft is irregular, with a rounded ceiling or a quadrangular section (fig. 64 and 67). On the ceiling, different detachments in right angle are superposed in regular levels all over the depth of the work. Under 4 m in depth, the shaft takes a new direction in a right angle towards the south-east, over 1.50 of depth. At this distance, it opens to a narrow *depilage* having the shape of a quadrangular trench, on a NW/SE direction, 1 m x 5,50 m large (fig. 68). This *depilage* follows a vertical vein, but it stops on a face line where the vein is still very visible. Is it possible that it becomes barren? The geological study could not be completed because of the lack of time.

This is also the reason why the work basement could not be cleaned in 2002, stagnant gas deep down being another one. The depth of the work remains thus still unknown. Water flows incessantly along this inclined descent (shaft?), but it disappears deep down through the draining holes. The depilage deepens undoubtedly or it opens over a fault; 2.50 m of depth could however be probed under the ceiling. Only one lamp niche was found in the shaft. This ancient work was only reworked by the Moderns on the upper side of the work, near the opening, the rest of the network is intact. Its emptying must be completed in order to finish this study and to understand the function of the work.

Shaft and Depilage Geology

Inside the deepest zone of Cârnic mining sector known so far, we have opened a transition mining site between a real shaft and a descent after a long term hard-work (fig. 69). On this side of Cârnic mining network only an expeditious geological exploration could be carried out this year (fig. 70).

This mining work is hollowed downwards along a breccia structure. It is actually a breccia dyke of a very fine matrix (*chinga* type) which is visible on the basement and sometimes also on the ceiling. The host rock is silicificated near this breccia. The base of the shaft and the depilage Dep 10, only partially voided, have not been explored because of the water which has flooded the deepest zone quite immediately, a couple of weeks after the archaeological digging had ceased (fig. 71).

Cârnic 2

G1, G1bis, G2 and G3 Drifts

G1 drift is situated at the northern lower extremity of Cârnic network. It has the form of a long, curved appendix. This drift was also connected to the Cârnic 1 network, but the old junction (G1 bis) has partially been destroyed by the modern exploitation of level 932. This long drift was described geologically in the year 2000 (Cauuet *et alii*, 2000) and this year the study has been further completed on the on the section line of G2 drift which is situated at the base of G1, on the north-east side (fig. 72 and 73).

<u>Workings Topography</u>

G1 drift and its northern prolongation G1bis has 30m in length (1.30-1.50m in width and 1.70-2m in height). The drift opens on the descent towards a bend dip at the exit of a 2.5-3m high shaft, partially broken open by the modern works carried in the centre of Cârnic network (fig. 74). This shaft situated in the central area and destroyed by Cârnic 2 allows the passage to a lower level, hardly reworked by the Modern mining, partially covered and which has provided us with a stocking area for our overburdens. This poorly preserved zone of the lower part of the shaft will not be a subject for our study.

G1 incurved descent makes the connection between Cârnic 2 network in the south and Cârnic 1 in the north (fig. 75 and 76). At the beginning, at the base of the shaft, a larger G1 draws up a south-west oriented enlargement with an angle face line and a bench. This southern part of the drift has very often been reworked by the Moderns, at the basement and on the north-eastern face of the wall. After 5m of disturbed area, the drift gains its original proportions, its characteristically trapezoidal profile and flights of stairs at the basement (fig 77, 78 and 79).

G1 descends regularly towards the modern 932 level which breaks it again 19m away of the access inside the shaft (fig.80). The descent is made either through three very regular stair passages, a five stairs flight (fig 81), then, in the central part, a three stairs flight and exactly before the break-up of level 932 one last five stairs flight or by series of inclined plans, with well defined stops (fig. 82). Only one lamp niche has been noticed. It is situated on the upper part of the wall, near the last flight of stairs, before the 932 level.

Series of angle prominence are noticeable along the walls, which mark the change of the direction of the work. After following a south-east/north-west axe, the drift forks in a circle arc towards the north, obviously trying to connect to another network coming from an opposite direction from Cârnic 1. The junction with the drift pierced from the north to the south, G1 bis, is made exactly at the upper part of the modern 932 level which has broken again the G1 drift (fig 83). The opposed advancement direction of the two works is well noticeable on the walls. At the level of the junction an advancement of G1 bis draws up a drift starting point, G2 (1.70m long, 1.10m wide, 1.60m high), which starts again towards the south-east at the base of the last stairs of G1 (fig. 84).

The basement and the ceiling of G1 and G2 decline on one side and they have the appearance of a drifting work (fig. 80, 81). The southern part of G1bis has been deeply voided towards the west by modern resumption, the wall is better conserved but it has been covered in concretions. From the east wall of G1bis opens an entrance to a much higher parallel drift, G3, which descends from Cârnic 1 (fig. 83). Stairs undoubtedly hidden under heaps of concretions allowed the passage between the two levels. The southern network of Cârnic 1 and the P10 shaft open through the west wall, further north-west of G1bis.

Stratigraphy (fig. 79)

Stratigraphy St1-St1’ (cut at the entrance of G2) (fig. 79)

US 1 : dacit dry scree, modern pile (10-30cm in length).
US 2 : compact layer, coloured in beige with traces of oxidation, 70% clay-sandy and clayey matrix, 30% gravel intrusions (0.50-2cm in diameter) and dacite chips (10-15cm in length).
US 3 : a more mobile layer coloured in beige ochre, strongly oxidised. 80% sandy and clay-sandy matrix. 20% dacite clusters (15-20cm in length)
US 4 : scree layer of whitish colour, composed of thick clusters of dacite (10-50cm in diameter), wrapped in a compact clay matrix.
US 5 : aired mobile layer, coloured in beige, 90% rough sand clay-sandy matrix, 10% small grit intrusions (5-10cm in diameter).
Levels with no archaeological artefacts and wood coal.

Stratigraphy St2-St2’ (cut northern side of G1, on the upper part of the stairs) (fig. 79)

US 1 : very mobile aired layer of yellowish colour, 70% sandy matrix, 30% dacite grit intrusions (2-3cm in diameter).
US 2 : dacite block scree (up to 30cm in length), airing layer.
US 3 : clayey, sandy layer of grey-whitish colour, deformed by the clusters of US 2.

Stratigraphy St3-St3’ (cut towards the southern extremity of G1) (fig. 79)

US 1 : modern scree of thick dominant layers, light beige coloured airing layer, 10% clay-sandy matrix, 90% dacite chips intrusions (5-10cm in length), and bigger blocks. Presence of pieces of wood of modern mines (wooden ladder, trunk ladder).No old archaeological artefacts.

This waste filling made of only one layer corresponds to the excavations of the modern resumption on the south-western part of G1. The waste of this work filled only the lower third part, except for the opposite of the last stairs of G1, where the resumption of level 932 had resulted in a thick continuous waste layer inside drift (fig 75 and 76). The Moderns had not disturbed the old waste layers, they only added more material to the previously existent filling. Thus, at the very junction point with level 932 and the beginning of G1bis, a medallion of Roman canal lamp (Loeschke X type) was found in the basement of the drift (fig. 85 and 86). This vestige certifies that the activity in this area began in the 2nd century AD.

Geology of G1, G1bis and G2 Drifts

On the eastern wall of G2 levels a massif breccia structure with angular fragments rarely rounded, held within a *chinga* type matrix (fig. 87). In this breccia there is a variety of fragments: dacite, metamorphic rocks, sedimentary rocks, breccias and even pyrite fossils. The breccia is very hard because of the silicification. On the ceiling and on the basement of the drift, there are three vertical fissures which direct towards the face line. The silicification has made the fissures quite visible.

It is likely that G2 drift is a search drift. It has been carved to check up the metallic potential of the three vertical fissures which accompany the breccia pockets (fig. 87). The results have undoubtedly given no satisfaction.

The works have proved that G1, G1 bis and G2 drifts correspond to the junction area between two major parts of the ancient mine. That is, on one side, Cârnic 1 - Cârnic 8 unit which goes probably up to the surface through an area not yet worked, but partially explored, and on the other side Cârnic 2 – Cârnic 3 unit, which itself has other possible connections with the surface. These works which put under a different light the art of mining of the Ancient miners (junction in a rocky massif without using compasses) represent, in our opinion, a necessary mining work in order to ensure the ventilation of the mine bottom.

The Stairs Drift and the Adjacent Drifts

The Stairs drift also known as G36 drift is a descent, carved entirely with stairs to the basement and making the connection between a upper and an lower level of Cârnic 2. It opens initially at the upper part of the central shaft which allows the passage to the long, curved descent G1 which connects Cârnic 2 to the base of Cârnic 1. G36 drift is reconnected to a drift network which breaks up in a right angle, towards the south and then the south-west, from a north-western angle of Cârnic 2 (fig. 87bis).

<u>Workings Topography</u>

The first drift, G30, of this network is situated in the south-western upper angle of Cârnic 2. This drift (1.30x3m, 1.55m high) opens on a flank of the wall of the large chamber that occupies the northern part of Cârnic 2. Important wooden propping and cutting works were necessary, such as the propping of a plywood meant to allow a non-dangerous access to the drift and then the evacuation of the waste material. The products of the evacuation were thrown on the lower part of the central shaft of Cârnic 2, as all the waste material evacuated from Cârnic 2 and Cârnic 3.

After a 3m distance, G30 is broken up by a drift, G33, directed towards north/north-west and marked at the beginning with two series of stairs, first of all four stairs, then, at 1m distance three more stairs. This drift continues on the northern side with a prolongation called G31 which was not explored in 2002. On the eastern side and in front of G30 a modern building site has cut out the eastern wall of G33, and it has not been emptied of its waste materials. The long G33 drift (1.40mx11m, 1.80m high) ascends along a 20° steep (fig. 88 and 89). At mid-length a drift starting point of trapezoidal section marks the eastern wall (fig. 90). A lamp niche can be found in the western wall, at 3.70m off the entrance and another niche on the eastern wall at 7m off the entrance.

After the discovery, during the exploration, of a branching of the drift directed in a right angle towards the south-east in the eastern wall of G33, the exploration was oriented to that new ditch called G34 (fig. 91 and 92). Actually, the south-western extremity of G33 was leading towards a modern *depilage* descending from Cârnic 3 which had turned the area into a dangerous, unstable place. In this sector, called G39 and G40, numerous wooden proppings were installed to protect the working area in G34 (the dimentions of the drift : 1mx3.50m, 2.20m high), and to surround the obstacle represented by the modern works and evacuations.

After a 3.50m distance, G34 drift started again in a right angle, this time on the south-western part to a new ascending drift, G35 (1.30-8m, 2m high). It is at mid distance in the south-eastern wall of G35 that we can find the chute (evacuation chamber) G38 which descends from Cârnic 3 on the lower part of G9 drift of Cârnic 3 (fig.93). G35 drift also has lamp niches, carved next to the ceiling, two of them in the north-western wall, another one in the south-eastern wall, right after G38 chute. In the south-western extremity of G35 opens G36 stairs descending drift in the north-western wall (fig. 94). The south-western extremity of G35 leads towards a working called G37, unexploited yet.

G36 stairs drift actually forms a right angle with G35. This descending drift (1.40m long, 8.50m preserved length, 1.80m mid height) consists of 21 joint stairs and follows an inclination of 55° (fig. 95 and 96). It does not have an lamp niche (fig 97). It goes to the central shaft of Cârnic 2, but the ending part of the basement has been broken by the big emptied chamber of south-west Cârnic 2. So what is left of it is the ceiling part of this descending draft which succeeds the upper part of the modern chamber and goes over the shaft (fig. 95). This stairs descent should have initially measured around 20m in length.

The group of drifts which have been described reveals a network which seems to allow , in descent, the surrounding of a rock massif situated in the south-eastern angle of Cârnic 2. This drift network allowed the surrounding of Cârnic 2 from the south-east, it has maybe permitted the exploration of this deposit through different exploration drifts.

Stratigraphy (fig. 89)

Stratigraphy St1 St1’ (cut inside G35 after the chute) (fig. 89) :
US 1 : block scree with no matrix (5-50cm long) of modern filling, with recent pieces of wood ;
US2 : dry clay heterogeneous layer wrapping some dacite clusters ;
US3 : heterogeneous layer of dacite chips and clusters, wrapped in layers of clay which form pockets ;
US 4 : heterogeneous layer of brown-orange colour of sintered sands and of dacite clusters ;
US 5 : heterogeneous layer, fine, compact of bleu-grey colour.

Stratigraphy St2 St2’ (cut in the midle of G36 stairs drift) (fig. 89) :
Us 1 : dry clay wrapping scattered clusters ;
US 2 : very compact and sintered layer of oxidation solidified sands of brown-orange colour wrapping some dacite clusters. This layer was entirely revealed by sledge and chisel, a long and exhausting endeavour. The presence of a thick layer of charcoal at the base of the layer was taken and dated by a carbon 14 test.
US 3 : fine, compact, homogenous layer of grey-blue clay.

The radiocarbon dating of the charcoal layer had the following measurements (fig 10) :
Ref : *RMO2 Cârnic 2 – Stairs drift – Sample 1 ;* 1885+ /- 45 BP, probability 80-270 AD.

This dating certifies that the activity inside G36 stairs drift began between in the 2nd century, beginning of the 3rd century AD, in the Roman age.

Geology of the Stairs Drift

A wooden arrangement (bridge) has enabled the access inside the stairs drift. This drift was carved in its northern part in the breccia called Cârnic 2 (fig.8). It has enough characteristics to prove the phreatic origin of this ore structure. The dacite angular fragments, *chinga*, breccia hydrothermal quartz are surrounded by silver and quartz mineral edges.

The spatial extension of the breccia is mainly controlled by two veins of high inclination (sample 321 and 324, fig. 98) which were cut by the drift. The strong silicification is constant in the breccia. It diminishes and fades towards the exterior of the breccia structure, to the host rock. The limit of the breccified area (sample 322, fig. 99) is also revealed by the disappearance of the silicification. In the exterior part of the breccia structure, the host rock has a medium to low strength. Traces of some vertical fissures lightly silicified mark the roughest areas of the rock.

Inside the breccia there are also voids of great dimensions: 30 cm thick, more than 1 m long, and 50 cm deep. Such voids also host magnificent quartz crystals. The rock inside which the gallery was carved in its second sector becomes gradually sterile as compared to the Cârnic 2 - breccia mineral structure (breccia). Through the chute which descends from Cârnic 3 to the stairs drift which directs itself to the shaft of Cârnic 2 there are connections to other sectors of the mine. The stairs drift is itself carved inside a quasi-sterile rock and opens over the shaft to reconnect then to G1 drift of Cârnic 2.

The stairs drift has been carved around the richest ore area, that is breccia - Cârnic 2 to avoid the loss of rich ore. The access to the working area and the passage to the deepest sectors of the mine were thus possible without affecting the ore exploitation activity inside the chamber of Cârnic 2. In our opinion, the cutting of this drift was necessary out of security reasons and for the optimisation of the exploitation (access, transportation of the material and of the ore, airing of other exploitation sites) and not to exploit a particular ore structure.

Inside the breccia area cut by the stairs drift, there is still some interesting ore. In the polished sections (sample 323, 324, and 325) was noticed the presence of gold grains with pyrite, marcasite, sphalerite, covellite and silver minerals.

G4 and G5 Drifts

G4 drift, 30m long (1.20-1.80 wide, 1.60-1.70 high) opens to the grand *coranda*, at the north-western extremity of Cârnic 2 network (fig. 72 and 73).

Workings Topography

The ceiling and the northern wall were hard worked by the modern workings of the entrance (fig. 100). At the beginning of the drift, there are two high ascending stairs (fig. 100). In the first section (8m long), we notice an important modern work with traces of piercing enlarging the drift on the north/north-eastern side, then we find a small modern scraping on the southern side. The advancement has first the direction of the east-west axe, then the ancient miners directed the line towards the south. The walls present medium rock strength.

In the second section (8-14m away of the entrance), there are three small spaced lamp niches, one at 1m distance next to the other on the northern wall (fig. 104 and 105). At 14m distance, the drift opens on a face line and is displaced towards the south to take again a western direction, after a 0.60m unhooking. At the unhooking level there are two ascending stairs carved into the basement. Some traces of piercing can be noted in this area. The old tool traces (wedge) are poorly marked and visible, this is also due to the bad state of the conservation of the wall.

The filling of the drift, quite bulky at the entrance, was growing thiner up to a 0.50m thickness, on average, in the central part of the working (fig. 101 and 102). On a whole, the filling was not very thick and settled with a circulation level present all along the drift. The filling was old, except for the sections worked by the Moderns where their overburdens piled up over the old filling. The letter were not disturbed by the activities of the Moderns. Thus, 50cm after the passage of the three lamp niches, shards of a Roman lamp and an almost complete lamp were found in the filling. The two found lamp exhibits (Loeschke X type), were dated in the 2nd century AD (fig. 106). They are small and have the mark of the pot craftsman engraved on the bottom. On the lamp which is almost complete, the whole mark is FORTIS. On the bottom of the other lamp, there reads either M or N, at the beginning or ending of a word, making the reading impossible because of the badly preserved surfaces of the lamps (fig. 107 and 108).

In the third section of the drift, 14-30m long, the walls were submitted to modern works under 3m of length in the northern wall. Then, at midway, a narrow high scraping has recently been led to the ceiling and it has also equally affected the southern wall in two visible places. On the whole, the drift has maintained its original east-west axe, marking several detachments towards the south which left many prominances on the way. 22.50m off the entrance, G34 drift, which had had an ascending profile up to this point, sets in a sudden slope break towards a bend dip, maintained regularly up to the face line, 30m away. At the level of this slope change of the basement, the ceiling marks a 1.60m high face line before retaking a horizontal direction.

Two metres before this ceiling face line, we note the presence of three little lamp niches, two of them in the northern wall, the other one facing the two, in the southern wall. The well-shaped niches seem to have adapted to the small size of the two lamps which were found in the filling. All along the drift, the basement and the ceiling give a inclination impression to the whole (fig. 109).

3.60m off G4 base, a depilage G5 was opened in a right angle in the southern wall (fig. 110). Having a north-south orientation, this working, a descent completely carved with stairs, presents nine regularly arranged stairs. It is an exploitation site starting point (1.30-1.60m wide,1.70-2m high) abandoned at 3.70m because of the weakened mineralisation. A small modern scraping lightly affects the ceiling at mid distance of the work.

Stratigraphical Cut (fig.101)

Only one stratigraphical cut was done inside G4 drift in the central area.

Stratigraphy St1-St1' (fig. 101) :

US 1 and US 2 : level of the ceiling collapse formed by dacite chips of 1-30cm length and of clusters up to 50cm long;

US 3 : very compacted circulation level, of yellow-beige colour, 50% clay-sandy matrix, 50% dacite chips of 2-10cm in diameter.

US 4 : mobile, friable layer, coloured in yellow, 60% sandy matrix, 40% dacite chips intrusions of 1-15cm in diameter, equally spread inside the layer.

US 5 : filling layer marked by traces of oxidation, sintered, of brown-orange colour, heterogeneous, 70% clay and gravel matrix, 30% intrusions of small dacite clusters of 10-30cm in length.

Us 6 : old mobile, friable filling, heterogeneous, of grey-rosé colour, 50% clay-sandy to gravel matrix, 50% dacite chips intrusions of 1-3cm in diameter. The complete Roman lamp and the lamp shards were found at this level.

US 7 : clay layer of beige colour, lightly sandy, homogenous, compact.

The artefacts found inside the filling of G4 allows the dating of the activity in this area of Cârnic 2 network from the 2nd century AD.

Geology of G4 and G5 drifts

This drift (fig. 111) has followed a vertical vein (W/NW direction) which cuts breccia – Cârnic 2. This vertical vein, called 'Fortis' vein (a name given after the lamp found) has high grades of 55 g/t Au and 43 g/t Ag. The host rock is highly silicified and it is often crossed by injections of a very fine matrix (*chinga*). Fortis vein actually represents a dyke breccia structure, 10 to 15 cm thick (in the first 1/3 of the drift). This structure is a breccia of *clast supported* type, with *chinga* and hydrothermal quartz cement. Inside the voids quartz crystals of many centimetres in length have formed. The breccia fragments are angular to sub-rounded and rarely go over 3 cm in diameter. Along the breccia, areas of matrix concentration occur.

In the thin sections, the *chinga* – hydrothermal quartz temporal relationship is more than obvious (fig. 112). The study of the polished sections has revealed the abundance of gold (fig. 113 and 114). The gold deposited inside the hydrothermal quartz (fig. 115), sometimes at the quartz – *chinga* limit. It often occurs inside the filling of the cavities (fissures, geodes) under the form of small grains (fig. 114). There is also a high concentration of gold along the fissures (fig. 116). The other metal ores identified here are the pyrite, the sphalerite and the chalcopyrite. It is also likely that we can prove the presence of tellurides at Rosia Montana (sample 393, fig. 117). The microprobe or electronic microscope analysis are still necessary to validate this preliminary observation.

A very intense silicification follows the direction of this vein all along. On the western wall of G4, near the entrance, this silicification is less developed because the vein is longer (sample 389). This vein - breccia has been exploited selectively also on the ceiling. Big cavities of 1 m in depth mark the breccia dyke in its less developed part. Actually, the access to the modern 958 level and Cârnic 3 represents at the same time the exploitation area of Fortis vein in G4 (*depilage*). Out of security reasons, a wooden bridge was installed during the workings to facilitate the access to the ancient mining sector of Cârnic 3 and, at the same time, to protect the team who worked inside G4 – G5 site.

During Mission 2000 a horizontal vein had been found inside the northern chamber of Cârnic 2 sector (fig. 8). This vein also follows G4 drift direction, almost all along. The thickness of this horizontal vein is of millimetric scale. A visible difference distinguishes it of Fortis vein: apart from the inclination, also the extent of the silicification. In the case of the horizontal vein, the silicification is reduced to a few centimetres. The horizontal vein represents at its turn, at a microscopic scale, a dacite microbreccia (hydrothermal cement with adularia, quartz, chlorite and kaolinite). Adularisation has almost completely transformed the rock. In the polished sections (sample 390), we also noticed an ore resembling a telluride previously identified inside the filling of the Fortis vein breccia.

The small enlargement which can be found on the eastern side, a few metres off the entrance (fig. 111) is undoubtedly the result of the selective exploitation of the horizontal vein (with a modern work), but mainly of the junction area between this horizontal vein and the main branches (north) of Fortis vein.

Along the vertical mineralised structure exploited by G4 drift there is a transition, namely: breccia dyke → vein → stockwork. At the same time, this transition is a proof that the ancient miners had gradually changed the direction of their drift as compared to the direction changes of the vertical vein (Fortis), which divided further into several branches. Inside the chamber, there is also another transversal vertical vein (sample 397). The junction area with the longitudinal vertical system is underlined by a more intensive silicification and by the occurrence of voids (up to 5 cm in diameter) and strong impregnations.

At the beginning of G4, the Fortis breccia dyke becomes a vein. Further, the vertical vein turns into a fascicle of fissures which are included along the width of G4 drift. This fascicle crosses into a sort of stockwork prolonged, intensely silicified, of a very dark grey colour because of the sulphur impregnation, mainly of pyrite (fig. 111).

The gold grades diminish along Fortis mineralised structure, with a sudden drop to the face line of G4 (fig. 111), namely: sample 393, 55,13 g/t Au and 43g/t Ag ; sample 396, 0,65g/t Au and 3g/t Ag and sample 400, 0,34g/t Au and 8g/t Ag. In exchange, the horizontal vein divides into two important branches with growing fissures, starting from the stairs of the central part of G4 (fig. 111).

Moreover, the group of horizontal fissures which have appeared near the stairs become further a hydrothermal breccia structure of approximately 10 cm thick at a macroscopic scale as compared to the observations of sample 390. It is a highly silicified area, of varied dark grey colour because of the sulphur impregnations. The breccia consists of angular ore fragments which are maintained inside white vesicular quartz cement. On microscopic analysis, appears a dacite breccia of hydrothermal cement with adularia, quartz, calcite and pyrite. Respectively, this new breccia structure drew the attention of ancient and also recent miners.

The branching of the horizontal vein and of the phreatic breccia stand at the origin of the deviation of the carving axis of G4 drift towards the west, in its middle part. The vestiges of these axis deviation of the drift prove the interest of ancient miners in this particular area of the ore.

Another vertical fissure (sample 401) cuts the Fortis stockwerck with a high inclination, in its narrowest point. This fissure announces another vein, transversal to the drift, more developed (sample 405, fig. 111). It has been exploited selectively by the modern miners, taking into consideration the great vault carved upwards, more than 4 m (fig. 118). The vein is 2-3 cm thick and it is made of stripes of compact grey quartz. The silicification is strictly confined to a few centimetres on the two sides of the vein, which is itself very rough. The non-silicified host rock is of medium strength.

On the western wall a first niche is carved in the host rock (fig. 111 and 119). It is a phreatic breccia structure with angular to sub-rounded fragments of variable size ore (centimetric and millimetric) cemented by white, quite friable hydrothermal quartz (fig. 120). The breccia structure opened all along the height of the wall is 40 cm thick. The contacts with the highly silicified host rock are well marked. A fracturing parallel to the breccia dyke is visible on the two sides of the breccia.

Microscopic analysis (thin sections) confirm the phreatic nature of the breccia by the presence of angular fragments of mineralised dacite, cemented with adularia, calcite, pyrite and sometimes illite. The grades of this breccia are promising, namely 1,7g/t Au and 17 g/t Ag.

The horizontal vein diminishes and fades in the area where the basement of the G4 drift changes its inclination. This inclination change is due to the presence of another mineralised area of a E/W direction which prolongs towards the south. It is another stocwerk structure with quartz veins, 2 - 3 cm thick. Inside the stockwork, we often find voids filled with quartz crystals up to 3 cm long.

This new stockwork structure is also silicified. Its colour is dark grey too, because of the sulphur impregnations. The silicification wraps this ore area ending on the western wall of the drift before the face line. There are only two fissures surrounded by a peri-fissural silicification detached from the stockwork and which direct towards the face line. The presence of this new ore structure stands at the origin of the carving of the small G5 drift. It has been carved in descent to follow the inclination of this small ore structure.

On the southern wall of G5, there are also breccia pockets which indicate a weak tectonic activity. The fragments are angular, tabular, and they are black because of sulphur impregnation, contrasting with the white colour of the quartz hydrothermal cement (fig. 121). Inside G5 drift this ore area (breccia and stockwork) has been cut into 1 m deep. Inside the basement of G5, a weak mineralised structure (developed over a fissure) has been cut by the southern wall and the face line.

As for the carving system of G4 and G5 drifts, we can consider this site was first carved to exploit the Fortis vein, rich in gold and silver. Further on, the drift has been directed to the junction area of the Fortis mineralised structure (including the transition breccia dike – vein – stockwork) with the horizontal mineralised structure. The latter also transits the phreatic breccia structures. It was the miners' chance or mostly the result of their knowledge and efforts: after this area, the drift has caught a vertical breccia dyke structure, associated to a vein transversal to the drift. A final ore structure – the final stockwork – was the last exploited.

The activity was equally guided by the search for extensions of the ore structures. Thus, G5 drift has been pierced transversally up to G4 to search the extension of the last stockwork, which unfortunately was not long. The advancement inside the two drifts was stopped when signs possibly pointing to other ore structures disappeared.

Geology of G4 Connection – Big Chamber of Cârnic 2

Fortis vein directs towards the Cârnic 2 type breccia dividing into two branches (fig.122). One of them marks the northern extremity of the breccia, the other, on the contrary, cuts into the breccia (fig. 8). Then it breaks up again into two more branches. Between these two last branches, there is already a phreatic breccia, similar to the phreatic facies of the breccia – Cârnic (fig. 123). The main branch of the Fortis vein cuts into the breccia – Cârnic 2 and it becomes gradually less visible. Actually, the vein disappears inside the phreatic part of the breccia – Cârnic 2. The field evidence indicate the controlling role of the Fortis for the resuming of the phreatic activity (at least partial) of the breccia – Cârnic 2.

We can conclude that the Fortis vein partially cuts into the breccia – Cârnic 2. Along the vein, an important phreatic breccification developed. In addition to that, this vein shows a transition, namely the passage from a classic vein structure, responsible for the phreatic braccification turning into a breccia dyke and going radially to the outside, in a system of elongated stockwork profile.

It is likely a transition situation, that is the phreatic resuming of the breccia – Cârnic 2 and the genesis of the Fortis vein. We can at least suppose that the vein played a valve role in the hydrothermal pressure system which is responsible for the phreatic breccification of the breccia – Cârnic 2. The last hydrothermal outbreaks are very likely to have occurred through the vein crack which acted as a draining area. This explains, in our opinion, the cutting of the breccia equally by the vein, which reveals a temporal gap between the final implementing of the two ore structures.

The results of the grade analyses vary greatly: 10g/t Au and 225g/t Ag for the breccia - Cârnic 2 and 55g/t Au and 43g/t Ag for the Fortis vein. This too is a sign which suggests that these two ore structures are not entirely co-genetic. The high gold grades of the Fortis vein, in the sector cutting through breccia – Cârnic 2 too, at the level of the pillar of the ascending opening to Cârnic 3 (sample 414, fig. 124), represented an attraction for the ancient miners. The working of this vein subsequently gained importance by their amplitude as the present mining works show. Moreover, a recent resuming of the works by modern amateurs in search of auriferous ores is rich and visible on the vein. Near the Cârnic 2 breccia type, in the upper part of the ancient mining sector of Cârnic 2, the Fortis vein represented an important source of gold for the ancient miners.

CÂRNIC 3

The ancient mining network of Cârnic 3 is centred on a group of inclined drifts which form a general south-north axis (fig. 72 and 73). This axis goes from the surface (G2 drift of Cârnic 3) to an exploitation area (the chambers under pillars), then continues to descend lower to the depths of Cârnic massif, G20 drift which should open on a new network, called Cârnic 4. At the junction point of these two descents, a network of short exploitation drifts develops and leads to different directions and then three areas of pillar chambers. These workings, discovered in 2002 starting from Cârnic 2 and from the modern 958 level cover a surface of 540m^2 and constitutes Cârnic 3.

G2 Drift

The mining of this working which connects Cârnic 3 at the surface progressed in an opposite direction of the carving, starting from the exploitation sits of Cârnic 3 in the direction of the surface. The drift, a descent coming in an inclined plan from the surface, was worked at the basement along about 30m (fig. 125). 5-6m more were emptied. The site was stopped at this level, because of the lack of airing. The site workings cannot be carried out without an artificial airing solution or without an opening from the surface.

The architecture

At the entrance of the site section, the drift known as far as 50m of length (upper length up to the surface, but the filling prevents a larger exploration) has been worked on a 20m length only in 2002 (fig. 125). It has been emptied at the ceiling and on the walls by modern pulls. A small chamber was carved in the eastern wall. Then it quickly retakes its original section, quite low (S1-S1') with an average height of 1.75m (mid high 1-21.30m) and a length (0.90-0.95m) which allows the circulation of two people. Then up to the front part of the working, the height of the walls and the ceiling are collapsed (fig. 126).

All along the drift, the basement is well preserved, even though somewhat degraded by the leaking. Its general profile is very regular (fig. 127-130). It ascends without discontinuity. At 13m from the base of the descent, a small area is overcarved at the basement, on the ceiling and on the right wall. Interpretation difficulty: no traces of piercing, but the walls are very sintered and this scraping has the impression of an explosion work. Then the work gets more and more disintegrated, there are only a few fragments of the wall left. The basement ascents abruptly with a few stairs (5-10cm for each 1.50m, on average) and the slope has the tendency to deepen. The width is well preserved, but the height is disturbed by the collapse of the ceiling. Ascending regular slope towards the surface with no flight of stairs (fig. 131).

Three lamp niches are noticeable at 2.60m, 6.20m and 13.80m off the beginning of the sites in the eastern wall. Four lamp niches, all of them placed near the ceiling, can be found on the western wall at 2.35m, 7m, 8m and 18.80m. Thus a niche can be found every 4-5m. The general profile of the drift is trapezoidal.

Stratigraphy (fig. 126)

Stratigraphy St1-St1' (cut at the northern entrance of G2) (fig. 126)
US 1 : dry, aired layer, 20% sandy matrix of light-grey colour, 70% gravel and dacite clusters intrusions, centimetrical to decimetrical.
US 2 : indured, humid layer, of light to dark brown colour (coloration given by iron oxide), 50% sand-clayey matrix, 50% centimetrical dacite chips intrusions.
US 3 : highly indured layer of light to dark grey colour, 95% sandy matrix, 5% centimetrical grit of black colour (breccia).

Stratigraphy St2-St2' (cut lifted towards the middle of G2) (fig. 126)
US 1 : dry, aired layer of light beige colour, with ochre traces due to an oxidation layer at the surface, 70% sand-clayey matrix, highly aired, 30% centimetrical dacite chips intrusions.
US 2 : highly aired and humid layer of light beige colour, 10% sandy matrix, 90% centimetrical dacite chips.
US 3 : indured humid layer of light beige colour, 80% clay matrix, 20% dacite chips intrusions, centimetrical to decimetrical.
US 4 : more indured, dry layer of light to dark grey colour, 95% sandy matrix, 5% small breccia chips of black colour. Presence of shards of a Roman lamp.

Stratigraphy St3-St3' (cut lifted to the southern extremity of the worked area) (fig. 126) :
US 1 : dry and aired layer, of beige colour, 40% sandy matrix, 60% centimetrical dacite chips intrusions.
US 2 : dry and aired layer of light brown colour, 80% sand-clayey matrix, 20% centimetrical dacite chips intrusions.
US 3 : dry, aired layer of blue to light grey colour, 90% very dry sandy matrix, 10% centimetrical small dacite chips intrusions.
US 4 : dry, aired layer of dark brown colour, 90% sandy matrix, 10% rare and small dacite chips intrusions clayey nodules.
Us 5 : beige layer,30% clayey matrix, 70% dacite chips intrusions, centimetrical to decimetrical.
US 6 : ancient soil level, stagnation surface, layer identical to US 4.

Filling and samples

The first stratigraphy and also the working area show that the filling was fanned on the sides, surely during a modern exploitation. This filling is composed of sludge and collapse material. The stagnation level had to slip towards the base under the effect of the water (stratigraphy St1-St1' to St3-St3').

Two samples of charcoal were made. A piece of wood was taken (B1) and also two ceramic shards. One of the coal samples in the stratigraphy permitted the C14 dating as follows (fig. 10) :

- Ref. *Rm02 Cârnic 3 – G2 – St2 – US 4* ; measurements : 1860 +/- 45 BP, probability 100-290.

This dating, associated to the presence of a Roman lamp shard (lower part of the opening) certifies the activity inside G2 drift ever since the Roman age, between the 2nd and the 3rd centuries AD (fig. 132 and 133)

It all indicates that we are in the presence of the descent accessing Cârnic 3 from the surface. This drift seems to have been used by the Modern, at least in exploration and maybe also as access to the working site of the ancient area.

A research operation led with an excavator inside a space designed by a preliminary topographical study permitted to find the entrance to the surface of G2 and through that the access to Cârnic 3 network (fig. 134-137). This discovery made at the end of the mission has remained as such. It is therefore essential now to precede to the enlargement of G2 from the surface in order to end the study of this drift and to allow the ventilation of the lower networks which the study is about to finish in Cârnic 3.

Geology of the Drift G2

The drift G2 was opened from the surface as an inclined plane. It cuts a white friable dacite, which is similar to the dacite that crops out at the surface in the area where an excavator started new excavations at the end of the Mission 2002 in order to find out the connection with the underground segment of G2. The ancient sense of digging of the G2 is towards north. Our work started at the northern limit of the G2, that is, at the level of junction with drift G23 and Pillar chamber 2, and advanced towards the surface. Our approach will preserve the same sense, as we are still waiting for a direct access from the surface. All the mineralised structures opened in the lowest part of the drift were followed by the ancient miners into adjacent underground workings, so our description will be connected with the rest of observations made for Cârnic 3 network.

A first flatly dipping vein (sample 437) occurs onto the eastern wall and the ceiling of the G2 at the northern part (fig. 138). Close to the first lamp niche from the western wall this vein leaves the ceiling and it could be examined only along the walls, before disappearing into the hearth few metres after. This sub-horizontal vein induced a 10cm thick feeble silicification into the host rock on its both sides.

A first vertical vein (sample 438) passed through the drift. Its layout is underlined by an intense silicification. The vein, which may reach up to 3cm width, is composed mainly of banded quartz. Along the vein open spaces up to 10 – 15cm long and 3cm widths occurs. They are filled with quartz crystals (1cm long). This steeply dipping vein was selectively exploited, and thus formed the eastern deviation of G2 (fig. 138). The vein posses also a branch (sample 439) with similar features. Under the microscope on the polished sections we identified pyrite, chalcopyrite and of course gold.

Another vertical vein (sample 444) less developed was cut by the drift 1m after the first lamp niche, which was cut on the western wall. It is a quartz vein with long (several centimetres) but narrow (few millimeters) open spaces lined with small quartz crystals. A last steeply dipping vein (direction east-west, dip south) occurs inside the area where the horizontal vein (sample 437) vanished. This latter vein (sample 445) is also marked by a close related narrow silicification zone.

The following 15m of the drift passed through a very friable, unstable and barren rock. Only a narrow silicified zone allow us to suppose the occurrence of a silicified vertical fissure (sample 447). In this sector of the drift, few mineralised nests with common sulfides were identified along the walls (samples 446, 447, 448). Apart these minor mineralised points, the rest of the drift are barren. Thin section study revealed also an argillisation (sample, 450, fig. 139). Due to the feeble rock strength the walls and the ceiling of this part of the G2 are collapsing and the ancient trapezoidal section is not anymore preserved.

The gallery opened another vertical vein (sample 451). Traces of modern reworking into the walls, ceiling and hearth proved the interest at small scale for this vein. This better developed quartz vein is enveloped by a silicification halo of about 1.7m long on the walls. Under the microscope in thin section the real peculiarities of that vein and its host rock become more evident: dacite breccia highly silicified and adularised. Polished section study pointed out pyrite and tetrahedite as more common minerals in this vein (is it goes up to the surface?)

At the southern limit/end of the silicified area the rock change again into friable and fractured facies. The minor rock strength allowed during centuries several collapsing cupolas genesis into the ceiling. A barren fault was also cut by G2. Towards the end of the archaeological diggings of that gallery a flatly dipping vein cross another two steeply dipping veins. The horizontal vein was intensely reworked by the modern miners (with drill steel holes along it). The silicification is present only at the intersection area of horizontal with vertical veins. The first intersection was completely removed from the ceiling by the modern miners.

A last vertical vein with variable width occurs at the end of the accessible part of G2. It was also exploited by the recent miners, who also took over the silicified host rock that border the vein. This long inclined plane was certainly used as main airway and access way for Cârnic 3 and Cârnic 4 underground network (G20). It served also as transport way towards the surface for ore and waste as well as for the access of the miners from the surface towards the deep exploitation areas inside the Cârnic hill.

The Pillars Chamber Ch1

The archaeological exploration of the south-western part of Cârnic 3 was made starting from a drift of level 958. This recent work has actually reopened a wedge carved drift (G1 of Cârnic 3). It is from this point that Cârnic 3 network was found (fig. 127).

At the beginning of June, a working team started the emptying of the ancient drift reopened by level 958, to discover G1 drift of Cârnic 3, in the opposite direction of the carving (only 15cm were then open in the ceiling). Immediately after the entrance, the basement disappeared, it descents even deeper than the followed working level. We are surely in the presence of a work coming from the site of the pillars chamber, Ch 1, which constituted its upper point. We have chosen not to look for the basement, since this implied the useless carving of the base to the upper part. The initial aim was the research of the area, so we have chosen to keep a horizontal level which facilitated our working.

After 5-6m, the site divided into two simultaneous fronts :

on one side to the south, an empty area around a pillar (pillars chamber Ch1),

on the other side to the west, a second empty area placed near G2 descent which comes from the surface.

While the northern front was slowly advancing, because of its dimensions (2.50x4m in length), the volume of the fill and mainly the distances of the wheelbarrow transportation, the pillars chamber Ch1 was emptied and worked down to the base.

The administration of the overburden in this area and in the whole part of Cârnic 3 constituted the major problem of the works. Only a small network of recent drifts offered some stocking chamber. The wheelbarrow transportation and the stocking inside this network demand large spending of time and working hand, so it was decided that after the works, Ch1 pillars chamber will be filled up with the products recovered during the advancement of the eastern front.

Workings Topography

Ch1 pillars chamber was originally an old drift of only about 5m in length. Today an important modern work has transformed it into an exploitation chamber, a pillars chamber (fig. 140-142). Actually it almost seemed that the chamber was the work of the modern miners who used explosive, but from an already existent network opened to the wedge.

As the works of the base have shown, we are inside a mineralised area and it is likely that the Modern have carefully emptied this sector before restarting it (fig. 143 and 144). Because of that no artefacts have been found inside the filling. In exchange, it was obvious that a drift carved by wedge, curved and oriented towards east/north-west preceded the modern works. (fig. 145)

It is also possible that another old drift, oriented towards east-west was carved parallel to the one where the working had started. The stage of the rock in this area did not allow to differentiate it with certainty. Finally it seems that a digital exploitation network and works made by the ancient miners was then reconnected in a chamber where there is only one rock pillar. This part of Cârnic 3 has an lamp niche (fig. 146).

Stratigraphy St1-St1’ (cut in the waste drift) (fig. 142)
US 1 : layer of white to brown colour (traces of oxidation), 50% clay matrix, 50% dacite chips intrusions centimetrical to decimetrical, with iron oxide nodules.
US 2 : layer of beige to brown colour, 80% sand-clayey matrix, 20% centimetrical dacite chips intrusions with iron oxide nodules.
US 3 : mid indured layer of brown to dark brown colour, 80% clay-sandy matrix, 20% dacite chips inclusion, centimetrical to decimetrical with iron oxide nodules. Plastic clay film, highly indured to the base.
The filling of the ancient waste drift of Ch1 pillars chamber presented no artefacts and no wood or charcoal. This filling seemed to belong mainly to the modern age.

Geology

Within Pillar chamber 1 occurs a flatly dipping vein with quartz gangue; the intersection of this vein with a vertical one seems it was the main ore zone followed by the ancient miners (fig. 147). This steeply dipping two branches vein represents in fact the prolongation of the vertical vein from the drifts G23 and G24. After the branching it arrived on the other part within the recent 958 mining horizon/level. Both branches were selectively exploited during recent times as the cupolas in the roofs shown us artisan reworking.

The host rock is a white friable adularised and sericitised dacite. At microscopic scale it is also fractured and micro-brecciated. Within the rock’s cracks apart from finely comminuted rock flour matrix occurs hydrothermal cement composed of quartz, adularia, clay minerals, and pyrite.

The horizontal vein itself is a highly silicified and pervasively impregnated with common sulfides dacitic breccia. It is accompanied by a peri-fissural silicification, too. This alteration at centimetric scale change the friable dacite into a harder one, which appears distinctly on the walls

On the original western wall along the second part of the ancient drift there are two slits resulted from selectively exploitation. The host rock is adularised (adularia I and II) and sericitised up to 25 cm under the first one. The biotite is chloritised and furthermore, the adularised phenocrysts commonly exhibit a transition zone towards the rest of the rock (fundamental mass) due to the pervasively potassic alteration. The silicification does not continue further on the face line. It stops 1.25m before the actual end of the drift (sample 338). In our opinion the ancient gallery stopped at the same extension as silicification, and only the modern reworking added more the 1m to this mining working.

A stockwork with injection structures occurs on the hearth of the Pillar chamber Ch1. It covers few squared metres between two mineralised vertical structures (fig. 147). Inside these limits the white friable dacite is cut by several matrix injections. Easy to sample (sample 342), we tried to find free gold by panning this material, but the first results (panning), as well as fire assays (0.16 g/t Au, 7 g/t Ag) were negative. On the other hand, at microscopic scale (sample 339) we finally found gold (fig. 148). Along a narrow fissure filled with iron hydroxides (fig. 149) and common sulfides, gold is also abundant. Gold is associated with common sulfides like pyrite, sphalerite, chalcopyrite, galena, and silver minerals like proustite and pyrargyrite. This mineral assemblage is hosted by a porous mass of iron hydroxides (fig. 150).

The exploration – exploitation of the primary drift, which was at the origin of the actual Chamber Ch1 was motivated by searching the intersection area of a horizontal vein with a vertical one. Both veins were already intercepted in vicinity by different underground workings: G2, G26, G27, and south-western exploitation area for the vertical vein and G23 and G24 for the horizontal one.

The change of the direction of the proto-drift (fig. 147) and the later modern reworking were imposed by the presence of the stockwork body with its better-developed matrix injection edge structures. In the same direction the crosscutting zone of the horizontal vein with the stockwork zone was also of interest. This zone, which is underlined by its higher hardness and the abundance of banded quartz, was certainly quite rich. Gold is still present at macroscopic scale in this area, as proved by our samples; gold is visible at the surface of the polished sections.

The slits from the western wall delineated also the limit of the stockwork body, precisely the two western marginal injections. Along the last/latter metre of the drift, the silicification that borders the horizontal vein completely disappeared. The modern reworking destroyed the ancient face line, which certainly marked the limit of the silicification (fig. 147).

G3 and G4 drifts

They can be found in the eastern part of G2 ascending drift and they corespond to two workings or two small exploitation sits (fig. 72 and 73).

<u>Workings Topography</u>

These two drifts are placed in a right angle one to the other and they were carved starting from the opening drift of G1 network, at a quite low level, lower than the basement of the close G2 drift (fig. 151). First we enter G4 drift, opened towards west-east. Its dimensions are 1.30-4.10m for 1.80m of height. The northern wall of G4 has three lamp niches (fig. 152).

G3 drift, a little bit longer, opens at the beginning of the southern wall of G4, in a north-west/south-east direction. It measures 1.20-1.60m in width, 4.60m in length and 1.72m in height. 1m off the entrance, the basement marks ascending stairs. The north-eastern wall presents five regularly distanced lamp niches, the south-western wall two niches placed near the entrance (fig. 153). Thus there is one niche, on one of the two walls, every 50-70cm. These niches are placed near the ceiling of the workings, they mark the advancement stages of different cuttings, also visible through the prominances on the walls the base of the north-western all of G3 slowly enlarges in the northern part of the drift. The face line of G3 is marked by an entering angle on the south-eastern part (fig 154 and 155).

These two drifts of trapezoidal profile characteristic for the ancient works are found in a very humid area and they fill up quickly with infiltrated water. Only one stratigraphical cut was done in this part of the network in G3 (fig. 153).

Stratigraphy St1-St1’ (cut executed inside G3) (fig. 153)
US 1 : mobile layer of greyish colour, 90% sand-grit matrix, 10% dacite chips intrusions (5 0 20cm in diameter).
US 2 : layer of pure clay, very compacted, rosy colour.
Us 3 : layer of beige-grey colour, 70% clay-sandy matrix, 30% small dacite chips intrusions (2-5cm in diameter).
There wee no artefacts and no charcoal found in the filling of the two drifts. Because of the lack of time and the almost complete sinking of these two drifts at the end of the works, this geological study could not be carried out in 2002.

Ch 2 Pillars Chamber and G20, G21, G22, G23, G24, G25, G26 and G27 Drifts

It is a group of works articulated around four pillars, placed in the north of Cârnic 3 and crossed by the prolongation of the descent of G2 coming from the surface and which opens to the second descent G20, which is itself directed towards Cârnic 4 network and it is likely to develop to an lower level (fig. 156).

Workings Topography

Two drifts connected in a curve, G21 and G22, occupy the western part of Ch2 pillars chamber. G22 drift is a small one, 2.70m long, 1.20m wide, 1.55m high, and it is directed towards the west. G21 drift is more imposing (1.30-2.10m wide, 5.60m long, 1.40m high) and it has two lamp niches placed in the western wall, at each extremity of the drift. The northern advancement of G21 opens to G20 descent over an angle opening which corresponds to the face line of a drift starting point of trapezoidal profile, opened in the western wall of G21 (fig. 157).

The eastern part of this working area is occupied by Ch2 pillars chamber, a surface of $33m^2$ (3.30x10m). This space has an irregularly cut basement. It is marked by a curved drift axe, G23, which connects G2 to G20. In the western wall there is one long pillar and the access to the G22 drift. In the eastern wall there are three succeeding pillars on a north-south axis which limits three entrances of drifts or chambers. These ones, G24 and G25 drifts and Ch3 chamber were not worked, they have remained with this filling because of the lack of time (fig 158). In the south-eastern angle and over G24 drift, opens the branching of two other unworked drifts, G26 and G27.

This area seems extremely exploited through a network of short drifts and chamber and they ended up forming a larger chamber on four pillars. The working of this part of Cârnic 3 was led partially by the advancement from G1 access drift, and on the north-western side by the extremity of the modern 958 level which has reopened the branching area of G21, G20 and Ch2. Out of commodity and to do away with the overburden mass, this part of the chamber was then refilled with the products resulted from the following workings (fig. 159 and 160).

Stratigraphies (fig. 158)

Three stratigraphic cuts were made in the northern filling of Ch2 chamber.
Stratigraphy St1-St1' (cut made in the northern filling of Ch2 chamber) (fig. 158)
US 1 : layer constituted by the collapse of the ceiling, thick dacite clusters.
Us 2 : mobile layer, orange-grey colour, 90% clay-sandy matrix, 10% dacite chips intrusions (about 20cm in diameter).
US 3 : compact, heterogeneous layer, 90% clay-sandy matrix, 10% dacite chips intrusions (about 10cm in diameter).

Stratigraphy St2-St2' (cut made in the east of Ch2, on a north-south axe) (fig. 158)
US 1 : layer made of dacite boards collapsed from the ceiling.
US 2 : layer of white-yellowish colour, 80% clay-sandy matrix, 20% heterogeneous grits intrusions (3.30-1cm in diameter), small dacite chips (5-10cm in diameter) and more thicker clusters (15-25cm in diameter).
US 3 : layer of white-yellowish colour, 30% clay-sandy matrix, 70% thicker dacite clusters intrusions (10-40cm in length).
US 4 : layer of rusty-ochre colour (oxidation), 85% clay-sandy matrix, 15% dacite intrusions, chips of 10-20cm in length.

Stratigraphy St3-St3' (cut made along Ch2 according to an east-west axe) (fig. 158)
US 1 : dense, mobile layer, 80% clay-sandy matrix, 20% dacite chips intrusions (5-10cm in diameter).
Us 2 : layer with 20% clay-sandy matrix, 80% dacite chips intrusions (10-30cm in length).
US 3 : layer of rusty-ochre colour (oxidation), 85% clay-sandy matrix, 15% dacite chips intrusions (10-20cm in length).
There were no artefacts and no charcoal found in this filling, in its major part studied by the Modern.

Geology

The geological research of this part of Cârnic 3 mining network stopped at a preliminary stage. Further workings are necessary to complete the geological mapping and to understand the aims of the ancient miners. For a successful attempt in this direction, complementary archaeological digging must continue in Chamber 2, as well as in G24 and G25 drifts.

The drifts G23 and G24 opened two vertical branches (A and B) of a steeply dipping vein (see also the description of the Pillar chamber Ch1). A flatly dipping vein (sample 437) is still visible on the walls within the upper part of this mining sector, that means the drifts G26, G27 and the western pillar. A new opening between G23 and G27 was created by the selective exploitation of that vein within the joint wall which borders both galleries/separates these two drifts (fig. 161). The vein's branches (A and B) are passing through this window. The G26 drift also opened another two vertical veins. Within drift G23 and Chamber 2 occurs the intersection zone of the prolongation of A and B branches, which today has a bell-like shape, due to modern and recent exploitation. The hardness of the host rock was locally increased by a moderate silicification along the veins.

A new vein, which is surrounded by an intense silicification, was sampled (sample 457) within the common pillar of G25, Ch2, and Ch3. Open spaces (geodes) with nice quartz crystals are still preserved. This vein was also followed by G21. On the western wall of G21 the vein becomes a black brecciated area with a width of about 1m. There is a dacitic breccia with hydrothermal cement composed of quartz, adularia and clay minerals. Within the open spaces of the breccia there are bigger quartz and adularia crystals. The ore grades are low (sample 458, 0.2 g/t Au, 7 g/t Ag). Another vein that comes from G20 (sample 418) occurs on the ceiling of the G21 and the southern walls of G22.

It is obvious that the intersection zones between the veins were systematically searched by the ancient miners in the Cârnic 3 mining network. The following generations of miners, which reworked the area, followed the same digging strategy: the veins and especially their intersections. The frequent still preserved exploitation trenches along the veins and cupolas superposed onto vein's intersection proved this approach.

- N.E. Sites

The NE site prolongs the Cârnic 3's gallery 1. Not all the emptied galleries had been entirely filled, since a 50-cm wide opening gave access to the NE site. In part of the galleries, the basement has been superficially dug by modern miners. Finally, water was a real problem for this sector, as it proved to be an obstacle for the advance of the archaeological digging (fig. 163 and 164).

G5 Drift

It is an ancient type gallery, with a typical plate ceiling and a trapezoid profile. The basement is uneven and rough. It has been excavated by modern miners at 25 cm high, as shown by the drill traces. This sector has not been emptied completely, out of security reasons. The south wall has undergone the same works, maybe with a part of the wall being left hanging. This wall separates G5 from G6 (fig. 165 and 166).

G6 Drift

The eastern part of G6 has not been emptied (fig. 167 and 168). The presence of an lamp niche in the northern angle, close to the ceiling, may be noted. This gallery should be connected to the G9 gallery of the chute (opened at a drift intersection), a rectangular tank of approximately 50-cm deep. To the south, a modern opening (‘cat door’) allows access to a drift (G11) which is *a priori* ancient, by its very shape (fig. 169 and 170). The northern wall seems to be the starting point of a gallery. Prolonging the G6 drift, another drift has been revealed (G7) (fig. 171).

G7 Drift

It is a square chamber characterised by a difference of height at the ceiling level, as compared to the next drift, G8. To the west, another drift starting point can be noticed, taking a W-SW direction. Between G6 and G7, the ceiling descends and a tank has been dug vertically (fig. 171 and 172).

G8 Drift

The G8 drift takes a NE direction (fig. 173). The SE wall bears wedge works traces, indicating the direction taken by miners going inward the site; they might have worked along the G8-G7 direction (from NE to SW). It allows access to the G10 gallery (fig. 174), whose top has been completely destroyed by modern miners (drill traces), at the same time as the G1 one (access gallery to Cârnic 3 from the modern level 958), thus forming a chamber with a rather high ceiling (approximately 3 m from the G1 basement). G8, G7, G6 and G5 are separated by a pillar.

Chute

Before the chute, the basement of G1 has been worked. Cârnic 3 is connected to Cârnic 2 by a chute. We used it for moving our overburden to the evacuation level practiced in Cârnic 2 at the modern depilage level situated at the base of the central shaft. Different galleries meet this chute, but, for the moment, only the G10 gallery seems ancient by its shape, and also by the presence of an lamp niche close to its opening. In fact, the chute is an opening in the top of a probably modern drift. This chute would then be modern. The G9 gallery was disturbed by this chute, but it seems to be ancient (fig. 175).

Over the whole of the mined drifts, the overburden does not seem very ancient, except at the base of the stratigraphies. The base of the drifts has often been superficially worked by modern miners (border of G1, G5 and G6). We also have to stress the fact that only one illuminating notch was found between G5 and G8. The G10 drift is a priori very interesting. We have not been able to complete the study of G6 and we do not know which is the relation between G6 and G9. The study of G11 would also allow us to understand its relation to G9 or G10.

We have not been able to perform the geological study of the NE sites this year because of the lack of time. This crucial work on the area, intensively excavated by ancient miners, needs to be undertaken in the future, and so does the completion of the archaeological digging that we have interrupted in 2002.

Stratigraphies (fig. 166)

St1-St1' Stratigraphy (section raised cross-wise of G5 and G6) (fig. 166) :
US 1: hillocks of tiny modules, very compacted, of grey beige colour, 30% very clayey matrix, 70% all-sizes dacite chips inclusions. Presence of fine wood belts.
US 2: same layer as US1, with more voluminous blocks (20 to 40 cm long).
US 3: grey beige to light grey layer, of the same type as the US1 and US2, with block alignments in the centre of the layer.
US 4: pure clay layer, dark grey with touches of ochre due to oxidation. Desiccation cracks at the surface, very humid level. Presence of fine wood belts and of a piece of worked wood (tenon?)
US 5: 60% medium modules fill (5 to 10 cm in diameter) trapped in an clayey matrix (40%), slightly sandy, of light beige colour. Presence of a few wood charcoal pieces. Fill level probably more recent than the rest of the stratigraphy.

St2-St2' Stratigraphy (section raised at the the G7 gallery entrance) (fig. 166) :
US 1: layer medium populated by light beige hillocks, 50% clayey-sandy matrix, 50% all-size inclusions of tiny modules (1 to 5 cm diameter) and of great dacite blocks (10 to 30 cm long).
US 2: very clayey layer, of medium to dark grey, 60% matrix, of pure plastic clay, 40% inclusions of tiny dacite chips (5 to 10 cm long) and of greater chips (10 to 15 cm long). Presence of wood belts.
US 3: very compact layer, of light beige colour, 70% clayey-sandy matrix, 30% inclusions of grit and dacite chips (5 to 20 cm long).
US 4: same type of layer as US3, but only with dacite grit presence.

ST3-ST3' Stratigraphy (section raised at the G8 entrance) (fig. 166) :
US 1: scree level made up of centimetric chips (80%) and decimetrical blocks (20%).
US 2: yellowish layer, slightly compact, 90% clayey matrix and 10% inclusions of tiny centimetric dacite chips bearing oxidation traces.
US 3: slightly compact layer, of grey colour, 10% clayey matrix, 90% all-size dacite chips inclusions forming a coarse fill. Presence of modern wood pieces.
US 4: very compacted layer, a scree of all-size blocks, crushed into one another by oxidation.
US 5: same type of layer as US4.
US 6: scree of centimetric dacite blocks.
US 7: basement rock altered and arenized.

St4-St4' Stratigraphy (section raised at the G10 entrance) (fig. 166) :
US 1: scree without matrix made up of centimetric dacite chips.
US 2: reddish indurated clay level forming an oxidation layer.
US 3: scree of centimetric angular dacite chips, trapped in very little clayey matrix of orange colour (oxidation).
US 4: clayey layer of reddish colour, 40% grit of a few centimetres long and 60% blocks of pluri-centimetric angular dacite.
US 5: layer with strong water flow, of greyish colour, 50% clayey matrix, 50% inclusions of dacite chips ranging from a few centimetres to several decimetres long.

Pieces of wood, fragments detached from the same miner container of *troc* type (fig. 176 et 177) have been dated by means of Carbon 14. The wood charcoal found in the fill of G8 have been presented for radiocarbon dating. These items have given the following values (fig. 10):

- for the troc, ref.: *RM02 Cârnic 3 – G5 – Troc*; measurement: 85 +/- 60 BP; highest probability range 1675 to present. We deal, thus, with a modern mining item, left behind by the miners who used to work the ancient network on an occasional basis.

- for the wood charcoal, ref.: *RM02 Cârnic 3 – G8*; measurement: 1930 +/- 45 BP; highest probability range: 20 to 155 AD. This charcoal is then ancient, dating the activity in this area back to the 1st, even the beginning of the 2nd century AD. We surely deal with an activity performed at the very beginning of the Roman era.

Cârnic 4

It is a possible network along a descending drift, the G20 inclined plane, which could not be pierced because of the lack of time and the presence of stagnant gases on the bottom of G20. This drift resembles the G2 inclined plane of Cârnic 3 that comes from the surface to meet the Cârnic 3 network. We believe that this long working has been vertically driven so as to allow the exploitation of a new area of ore deposit in a sector conveniently called Cârnic 4 (fig. 72 and 73).

<u>Topography and Geology of the G20 Drift</u>

The G20 gallery is part of the central part of Cârnic 3 (Pillar chamber 2) and descends to the heart of the Cârnic massive (direction North-West). A great part of the gallery is still covered after the 2002 mission, because the problems created by the stagnant gas on the bottom of the network did not allow its discovery. Nevertheless, the geological researchers have finally succeeded despite the lack of oxygen in the drift (fig. 178).

Near the Cârnic 3 side entry, the G20 gallery digs into a friable white dacite slightly impregnated with sulphides. Two branches (samples 418 A and B) of a vertical vein slightly dipped are cut again by G20. The first branch (sample 418 A) of a injection-matrix form (meaning a mini breccia dyke) is deeper. Along this branch there are areas of parallel tubular fragments, cross-cutting the wall of the structure (breccia of the *shingle breccia type)*. This dike of miniature breccia is also associated to a system of accompanying cracks. The silicification of that accompanies this vein is weak. In the vicinity of the vein there are often pockets of sulphides obvious because of their dark gray colour.

The second branch (sample 418 B) is shallower. It is filled only with hydrothermal quartz. In comparison with the other branch, the latter shows a strong silicification at the periphery of the veins. The path of this beam of mineralised cracks and pockets has been followed by the ancient miners beyond the G20 gallery section. The left shelf close to the entrance proves it. Further away, the intersection area between these two branches that is nowadays visible on the ceiling of the modern gallery of level 958 has also been exploited by the ancient gallery G21, which digs along the East dip of the vein (sample 418).

A mineralised area has been recovered in the first 1/3 part of the G20 gallery. It is a sequence of four slightly dipped veins and four vertical veins (fig 178). The horizontal veins (lower depth of 2 mm) did not change the normal facies of the rock alteration. The dacite is strongly adularised and sericitised (illite), but not at all silicified (typical adularia- sericite alteration).

On the contrary, the highly dipped veins have an interaction margin with the host rock (silicified area) that increases the hardness of the host rock.

Along the horizontal veins, the present miners have restarted the exploitation at small scale. At the Northern limit of this narrow area of ore, namely along the last vertical vein, the grades are very weak (sample 426, 0,3g/t Au and 5g/t Ag). The microscopic examination of the polished sections has revealed the presence of pyrite, marcassite, chalcopyrite, as well as proustite, pyrargyrite and sphalerite (fig. 179).

The second 1/3 part of the drift is entirely barren and very friable (on approximately 7 metres in length). The last 1/3 part of the drift intercepts another area with ore potential. This area is crossed by a sequence of three parallel vertical veins (direction East-West), the last one itself being crossed by another coming from N/NE-S/SW (fig. 35). The veins reappear in a slightly silicified host rock. A network of better developed cracks forms a mini stockwork especially within the intersection area of the veins. The veins have been selectively exploited on the Eastern wall by the Roman and Modern miners (fig. 178).

At the lower extremity of G20, a system of two horizontal cracks is visible on the Eastern wall (the Western wall is completely hidden under the filling). These cracks are not responsible for any silicification in the phyllic altered as well as argillised host rock.

The G20 gallery has an important deviation to North-East (fig. 178). This deviation follows a vertical transversal vein exploited in a depilage half filled. On the ceiling of the depilage, the traces of the exploitation are still fresh. An area of silicification of the host rock of 15 to 20 cm in depth marks the vein. Including the two branches. The vein itself was very hard, and therefore the sampling was also tiresome.

The vein consists of quartz bands of a yellowish gray colour mixed with dark traces. The ancient miners have also exploited a branch of the vein. The modern miners, in their turn, have restarted the powdering of the walls and the ceiling strongly silicified, and therefore very hard. In the depilage, the fillinf always hides the basement. After the junction of the depilage and of the gallery, G20 is filled to the ceiling.

We can already imagine that the G20 gallery has exploited the weakly mineralised area that had been situated in the first 1/3 part of the drift. Beyond this area, a long section of drifts have dug into the barren rock, to go where? In our opinion, the G20 drift further descends to end into another ancient mining site of Cârnic, temporarily called Cârnic, 4 that is ready to be explored. The small transversal *depilage* whose lower part accessible from G20 is opened, was not the main purpose of this gallery. This drift is more likely to represent not only an access way, but also an airing way necessary for a deeper mining site.

CÂRNIC 5

Overall Description of Site 19

North-South oriented ancient works. Dip under the sub-vertical vein.
The visible works reach two levels (fig. 180 and 181):

— the lower level is composed of a exploration drift and an exploitation ‘gallery’ of at least 5 m in height.
— the upper level is entirely a level of research.
— The junction between the two levels is an ancient vertical shaft.

The digging of the filling materials within the entire ancient network has not revealed any archaeological object. Only wood remains, probably from the ancient network, have been found in a beam notch (sample N 1) as well as a board (sample N 2).

Detailed description from South to North, beginning downwards:

— The upper Southern gallery digs from South to North. It comes from an unexplored area, as it is greatly transformed and filled by the Moderns.
— The basement is regular, with an important working tang balcony on the Eastern side.
— The ceiling is regular and the gallery has a dip of 4% ascending towards the filling.
— This drift presents lamp niches. The soil does not present any facility for the water drainage.
— This drift discharges into a quadrangle vertical shaft of approximately 1.75 m x 2 m.
— Any modern work on the walls of the drift, the soil has been worked in the area of the tang balcony.
— The soil digging has not revealed any particular stratification. The refillings are modern and come also from an accumulation of the fallen rocks of the mouldy walls.

Upper Front Gallery (fig. 182)

— Exploration drift digging from South to North. Very weak modern work that did not modify the ancient work study.
— Regular basement. This gallery presents lamp niches. The basement does not present any facility for the water drainage.
— Basement digging: some centimetres of ancient sterile ballast on the soil.
— Some beautiful traces of tools, wedge type are visible at the level of the worked vein.

Shaft

— Any certitude regarding the direction of the digging. Taking into account the context, it has certainly been dug downwards. Any facility at the bank. Any wood notch in the shaft. A simple opening towards the evened rectangular walls.
— A small research al less than 1 m has been realized at the Western middle of the shaft.
— Very weak modern work that did not modify the ancient work study.

The Bottom of the Shaft

— At the bottom of the shaft, in the South, no traces of ancient work are visible.
— In the East, some remains of a exploration drift are visible on its soil and on some remains of the ceiling. The rest has been destroyed by powder exploitations.
— In the North, a drfit of at least 5 m in height develops on approximately 10 m in length.

The lower Drift (fig. 183 and 184)

— Exploitation or depilage drifts of at least 5 m in height.

— It has been dug from South to North. Its working has been achieved by more passages on three levels. The ancientest level seems to be the lower level. The upper levels have been revealed afterwards (traces of two levels of suspended ceilings. The study of the direction of the excavation reveals: the probable North-Southern lower part, the median part: indeterminable, upper South-Northern part.
— The ceiling is mostly regular and driven upwards with a 5% dip.
— Illuminating and wood notch evenly distributed. Any particularities.
— Soil not visible and without archaeological digging (fig. 185 and 186).

The Northern Lower Exploration Drift (fig. 187 to 189)

— Before the exploration drift, a tang balcony of more than 1 m has been worked by the Moderns. It seems that it has been cut in steps by the Ancients. There seem to have been three steps.
— The area before the exploration drift is very disturbed. Change of direction, change in the height of the work.
— The lower drift that goes towards North has been dug on a fault (or vein?) that has the same direction and sub-vertical dip. This gallery has been dug from South to North. It has been cut by wedge. Its soil and ceiling are regular. The mining work of the overburden gives (upwards) some centimetres (<4 cm) of probably ancient ballast without artefacts. On this ballast, the overburden of the modern works has been rejected.
— This gallery is equipped with homogenly distributed lamp niches of classical size. The soil does not present any facility for the infiltration water drainage.
— Works restarted by the Moderns (traces of powder activity). There is no ancient face line except for the traces on the Western wall that reveals the position of the ancient face line. On the basement, the starting point of the face line is still visible. Short before the abandoning of the site, the Ancients had begun to deepen the basement level by lowering two steps on the soil. The ceiling has not been affected by the beginning of the digging.

On the same axis, ancient works are accessible at an lower level through a modern drift. There is a weak development of the visible ancient works. An important modern falling or filling impedes any further study in this field. Sample of a probably ancient wood on the remains of ancient basement works (fig. 190 and 191).

According to the sketches and remains of ancient works, the Ancients are more likely to have come through the bottom of the great works. But, as the upper network is cut from South to North, they could as well realized upper works in the Southern part (fig. 192 and 193).

The two wood samples from the network have been subject to radiocarbon dating. The two measures have given very high close ancient data, especially for the pre-roman age (fig. 10):
— Ref.: *RM02 Cârnic 5 – Site 19 Sample 1* ; measure : 1940 +/- 50 BP; highest probability range: -5 to 135 ad.
— Ref.: *RM02 Cârnic 5 – Site 19 Sample. 2* ; measure : 1925 +/- 50 BP ; highest probability range: -5 to 135 ad.

These two measures placed in the same period give a dating to be situated between the beginning of the 1st and the 2nd centuries ad of the pieces of wood found conserved in the network. The network seems to have been active during the 1st century, during the independent Dacian era and also most likely at the beginning of the 2nd century ad, after the roman conquest, as indicated by the use of the roman oil lamp (numerous lamp niches in the network). Another alternative is that the network has been dug only at the beginning of the roman era, which would explain the advanced dating and the lamp niches. At the same time, the importance of the vestiges shows that the activity was successively developed in a certain period of time. Therefore, a two steps activity, the dacian era and then the roman era, is not incompatible with the present importance of the network.

Geology of the Site 19

This ancient mining site discovered during the 2000 exploration campaign impresses by its good conservation state and by its rigorous and very geometrical proportions. The exploitation of this mining site has aimed a vertical vein, more precisely an area of vein ramification heading North-South. There are more levels of overlapping drifts gathered in a same vertical depilage (fig. 194). Near the actual exploitation sector, there is also a long area of research that heads to the North in the lower levels, and a shorter area that heads to the upper levels (fig. 195).

A pillar interposes between the upper and lower parts of Site 19. The access by crawling to the upper level is possible by passing under the pillar. Taking into account the direction of the digging, it seems that the ancient miners had arrived through the upper level, and then they had headed downwards by digging a shaft. On the western wall, a starting point indicates an ancient drift, quickly abandoned.

At the upper level of Site 19, the vertical vein is entirely visible on the ceiling (fig. 196 et 194). The ancient basement of the upper level is partially preserved above the pillar and further away in the final part of the upper sector – research or exploitation section (fig. 196). On the ceiling, the vein has is a simple crack on which the miners insisted. On the other hand, several branches depart from this vein on the basement. The selective exploitation of the venal area has revealed a part of the pillar (fig. 195).

The vein is very hard. It is made of quarts bands and pockets of micro breccia. The host rock is strongly silicified and it has become very hard itself. On the contrary, the dacit in which the walls are dug is friable and lacks silicification. The unsilicified rock is strongly adularised and argillised. The orthoclase feldspars (fig. 197) and plagioclases are adularised and argillised. The hornblende and the pyroxenes are completely replaced by the argillised minerals and the iron hydroxides. The magmatic quarts itself is replaced by the adularia (adularia II) (fig. 197).

A sharply dipped transversal crack is visible on the Eastern wall. It is a mini part of a breccia of a dyke type, of approximately 2 mm in depth. At the limit between the wall and the ceiling it forms a pocket of breccia surrounded by a tight area of harder silicified rock. While passing from the lower level to the upper one there is a beautiful dyke of breccia on the ceiling of the pillar (fig. 198). This dyke is 20 cm tight and it is visible on the basement of the pillar (upper Site 19), as well as on the two walls and the ceiling. It has visible contacts with the host rock (fig. 198). The rock fragments enclosed in this breccia have very different origins, namely from the crystalline basement (muscovite micaschist, gneiss), from the Cretaceous flysch (clays and sandstones) and from the dacit. In comparison to the round schists fragments, the other fragments are angular. The matrix of the breccia is of rock flour type with unsolidificated *chinga* injections. All these characteristics prove the phreato-magmatic origin of this breccia dyke, a real '*pebble breccia'*.

The barren breccia dyke structure is older than the vein. The main branch of the vein obviously cuts the body of the breccia along approximately 10 cm in length. More approximate research are being developed so as to highlight the details of the breccia – vein relation.

At the Northern extremity of the upper Site 19, three venal branches are visible on the ceiling. The main branch (sample 333 and 334) is made of banded quartz and micro breccia. At a microscopic analysis there have been identified quartz, adularia (adularia II) and baryte filling. The hydrothermal fluids have determined the fracturing of the dacite host rock. The dacite micro breccia is impregnated by ore minerals.

The examination of the polished sections has revealed pyrite, marcassite, small quantities of chalcopyrite, covellite as well as proustite and gold (sample 333). The stibnite can also be found (sample 334). The initial opening of this ancient gallery of the Western wall has been quickly stopped because, as the silicification had disappeared, there was no reason to dig further.

When descending towards the lower level of Site 19, there is the vein area whose main branch has always been open to the pillar (fig. 194). The sampling of this area (fig. 199 and 194) has given an idea of the grades exploited by the ancient miners: 123g/t Au and 145g/t Ag, grades that do not need any comment. The initially realized panning of the unbroken material of this vein had already revealed the rich grades by the abundant presence of gold. In the obtained concentration there was a gold leaf of a bird-shaped 2 mm diameter, another long shaped leaf of 1 mm, and many smaller ones.

In the Southern part of the lower level, the section of the drift is still preserved. On the wall worked by the Moderns, the friable dacit has been cut by a unsolidificated matrix injection. At the Southern extremity, the ceiling of the modern level 932 has pierced the intermediate basement of the lower Site 19. The Northern face line of the ancient depilage is still open, allowing to follow the path of the two biggest branches of the vein.

In the ancient gallery that advances to the North, the vertical vein is always present on the ceiling. It has a complicated path with two branches that join to separate afterwards near the face line in one main branch and two secondary ones (fig. 195). The vein is hosted by into a very hard and strongly sillicified area. The intensity of the sillification diminishes towards the exterior, therefore the faces of the walls are dug into a friable dacit.

On the bottom of the face line of the exploration drift more cracks join, among which a vertical one, not very thick. Another horizontal crack appear in the terminal sector of the gallery (fig. 195). The drill recent working has aimed at the two secondary branches of the vein. The intersection area between these two vertical cracks and the horizontal vein has long been an interest area for the modern mining work.

The Geology of the Detour Drift

From the south part of the low Site 19 a modern gallery comes out in the south-west direction. This gallery, called detour drift, crosses first a low-silicified area, then it cuts across a system of five vertical fissures parallel to the large vein of Site 19. On the eastern wall a low-silicified stockwork area less than 2 m wide overlapped the fissure system. All the rest of the detour drift was dug into friable dacite. No mineralization sign is present. The southern end of the drift leads out onto two other drifts; one of them is old, the other one lying bellow is modern. They are partially filled in.

The digging operation in the old drift (wood sample nr. 2) was not accomplished and it should be pursued. Moreover, in the southern high area of Site 19, there is a good chance to find the old access entry from the surface towards that mining field. The main idea consists particularly in verifying if the known old gallery may be connected to another ancient system closer to the surface than that of the Site 19 area. At the same time, if notice is taken of the Site 19 digging direction, it is discovered that the old miners arrived from the south part of the high Site 19. Thereby, additional works are required in the said area.

The geological and metallogenetical analysis of the Site 19 revealed the efficiency of exploitation. The vertical vein exploited in this site represents in fact a connecting area similar to a stockwork, developed for more than 10 m high, at least 20 m long and about 1.5 m wide. The ceiling of the high Site 19 and the basement of the low level make the limits between which this connecting area is best developed.

The most important mineralization sign indicating a rich ore area is silicification, which was profitably spotted and followed by ancient miners. All exploitation works come to an end where silicification is no more present. It seems obvious that an accurate control of the various mineralization parameters was paralleled by the development of exploitation during antiquity. Thus, one can infer that the ancient miners possessed geological and proto-geological knowledge, which they applied in the exploitation of Carnic massif.

CÂRNIC 6

The exploration conducted in the south-eastern part of Carnic revealed two interesting areas called Carnic 6 (fig. 3). There lie two types of distinct overlapping works. In the lower part a “modern” drift is developing which is still equipped with wooden rails, an old device generally replaced by iron railways since the beginning of the 19^{th} century. In the higher part an ancient site was dug, that is the so-called “drainage” drift. Although cut through by the same recent depilage, the two researched sites are not in direct relation.

Drift with Wooden Rails

Topography

This gallery was recognised from east to west for about 21 m in length (width: 1.50 to 2 m; average height: 2 m). The eastern end is plugged up with ballast, and the western end also plugged up reveals on the ceiling a second cutting by a more recent site (fig. 200). The work follows a slightly winding line. The uneven hard-rock walls show drill holes (powder attack opening), and the ceiling is slightly rounded (fig. 201). Over the last six metres, on the eastern side of the gallery, it is remarked that the ceiling enlarges itself at a great extent and opens upwards.

In this part, recent wood reinforcements were installed along 3.50 m. They consist of ballast materials stocked or broken down against the walls (fig. 200 and 202). Along the southern facing, a small wall of cast-off large blocks forms an angle. The wall consists of ballast materials and supports a prop, which is placed against the ceiling. It is prolonged westwards by a pile of smaller blocks which covers the wall along 8 m. The same kind of large block stock is noticed against the opposite wall for 1 m in height and 3 m in length going westwards (fig. 203).

The rolling carriage-way is present for the whole recognised line. As the gallery basement was inundated, it was possible to clear the railway of mud and concretions only for 9 m long. This way is made up of two wooden parts in rectangular section (thickness: 8 cm; width: 8.5 to 11 cm; length: 2.50 to 3 m), lain flat and singled out by several sleepers at long intervals maintaining a 49 cm gauge in average. The different pieces of wood are assembled one to another by a third underlying piece (taper pin: 3 cm in diameter) (fig. 204).

In the changes of the way direction a reinforcement is set in the central and exterior parts of the bend, by means of various recovery wooden pieces wedged between rails and against the wall (branch, board, rail section etc). Traces of wood damage can be spotted in one of the bends. A rail sample has been taken for a radiocarbon dating. It provided a chronological period that lies between the beginning of the 17th century and the beginning of the 19th century[5] (fig. 10).

<u>The Geology of the Railway Drift</u>

The modern drift where a wooden rolling carriage-way is still preserved lies bellow the ancient drift construed virtually as a draining drift. Access to the modern drift has become more difficult because of the presence in this area of the ballast stock that derived from the above draining drift.

The modern drift was dug in a very friable dacite (fig. 205). Because of the low hardness of the host rock, the walls and the ceiling have failed for the most part of the drift. In the thin sections a major alteration of rock is strongly visible. The potassium metasomatosis (sample 357 and 358) has become a general fact. Orthoclase feldspars are replaced by adularia (adularia I) and illite, and so are plagioclase feldspars, by adularia and illite/montmorillonite. Also the magmatic quartz is partially replaced by adularia II. The melanocrate minerals are generally argillised.

On the southern wall, a more stable area is low silicified. This is a silicified micro-breccia pocket, which has been confirmed by the study of the thin sections. At the western end of the gallery two vertical veins cross one another. Each one of the veins has a weak thickness and the peri-fissural silicification is hardly manifest.

[5] Dating reference : *RM02 Carnic 6 – Chant. Inf. Rail*, 225 +/- 45, most probable space 1625 to 1815.

The draining drift

The digging of May 2002 made progress towards the opposite way of the digging for almost 25 metres, but only fifteen of them could be totally dug, the rest was just cleared (fig. 206). Serious water problems caused thus the desertion of the site for lack of pumping equipment indispensable for severe leaks. We were only supplied with the pumping equipment at the beginning of July, and on that date, too many sites were still in progress and due to be completed to find the time to restart work at the draining drift that had been abandoned since the end of May.

Architecture

The so-called draining gallery was dug from south to north and extends into an old depilage in the east-west direction. The continuity of these two elements is such that it does not seem to have been a junction with a preexisting site, but just an access to an unexploited sector of an otherwise already known mineralised area. (fig. 207 and 208).

The Old *Depilage*

In fact, instead of a sudden change in direction and size, the access in the exploited zone is operated by an abrupt bend of the gallery while the roof rises steeply but regularly. However this exploited zone is radically resumed by the use of explosives. There is nothing left but a fragment of facing (west) between two modern cuttings. In the ceiling only a tight tool-cut stretch of mining paths has also subsisted. It stretches smoothly (not in irregular steps) and steeply. The modern miners resumed work on the roof, but rather hesitantly, which accounts for the preservation of its previous appearance showing a rapid rise of the works.

On the western wall, the remnants of tool-cut steps undoubtedly indicate the straight-layering cutting technique. This depilage-site is then abruptly cut by an immense modern cutting zone where the traces of sharp tools work have remained here and there.

From *Depilage* to Modern Scraping

This zone was dug down to the basement (fig. 209 and 210). The work is spacious, its height (1.70 m to 1.80 m) as well as its width enable two persons to walk along upright, without lowering their head. In the well preserved stretches of mining work the ceiling, the facings and the basement are remarkably well regulated. At this point the gallery experiences a radical change of direction westwards. A detachment well shaped in the eastern wall indicates fully this reorientation of the work. On the same facing, a starting point (work NE) may be either the trace of a reorientation towards the west, or the brief exploration of mineralization, as could be shown by the lowered-down basement. On the opposite side a gallery path certifies the idea of a research zone. In fact, it shows the characteristics of an unsuccessful cutting (lowered basement, reduced dimensions).

From the Face Line to Modern Scraping

At first, the gallery has quite a straight SE-NW direction, then it seems to make its way towards north at scraping level (before heading resolutely towards west). The modern scraping followed a crack dividing the gallery from east to west. However it did not reach the old basement, and neither did it reach the first sixty to eighty cm of the facings. It seems, based on their work here, that the ancients did not test the crack. Advancing to the front of the digging the gallery is much less preserved. The ceiling and the eastern facing are totally disintegrated. A few fragments of the old wall have subsisted only to the west (fig. 211 and 212).

The stratigraphical cuts (fig. 208)

Stratigraphy St1-St1' (fig. 208)
US 1: indurated layer, from light grey to dark grey in colour, 40% clayey-sandy matrix, 60% enclosed centimetric- and decimetric-sized dacite fragments; existence of iron oxide nodules
US 2: indurated light grey-coloured layer, 80% clayey-plastic matrix, 20% inclusions of centimetric- and decimetric-sized dacite fragments. A few coals and splinters of rare wood.
US 3: layer, light grey to white in colour, 50% sandy matrix, 40% inclusions of concretioned limonite fragments and centimetric dacite fragments and 10% charcoal and samples of wood splinters.
US 4: hardened dark grey-coloured layer, 70% clayey-plastic matrix, 20% inclusions of centimetric dacite fragments, 10% samples of wood splinters

Stratigraphies St2-St2' and St3-St3' (the same stratigraphical horizons) (fig. 208):
US 1: indurated red-coloured layer, 80% sandy matrix, 20% inclusions of centimetric dacite fragments and deposits of iron oxide (limonite).
US 2: indurated white-coloured layer, 90% sandy matrix, 10% inclusions of centimetric dacite fragments.
US 3: layer from light brown-grey to dark grey in colour, 50% clayey-sandy matrix, 50% inclusions of centimetric- and decimetric-sized dacite fragments; existence of iron oxide nodules (limonite) and samples of charred wood splinters.

Only the first few metres close to the old depilage served as a stock place for modern rubble. Later on, it seems that the filling contains sludge and collapse material. A grey layer rather regular in appearance and thickness shows that the ancient stamping-out level may not have been cleaned during further works. It is very hardened and contains a great number of charcoal fragments and wood bits. Samples of plank as well as of charcoal were taken at stratigraphy St1-St1' level.

Two carbon 14 datings were obtained from coal product samples taken from the blockage of this gallery. They are the following measures (fig. 10):

- Ref: *RM02 Cârnic 6 – GE – Zone SW*; measure: 1850 +/- 50 BP; highest probability range: 55 to 260 AD
- Ref: *RM02 Cârnic 6 – GE – US3*; measure: 1720 +/- 50 BP; highest probability range: 215 to 430 AD.

The first measure corresponds perfectly to the Roman era of the 2nd and 3rd centuries; the second measure corresponds to the period between the beginning of the 3rd century and the outset of the 5th century. On the whole, one can locate the activity in this system in the 3rd century AD during the Roman era. Therefore, it is the case of an ancient work.

Hypothesis of Use

Firstly the gallery was deemed as a draining gallery by reason of its low topographical position within the massif, of the heavy waters passing across it and of its slightly low-gallery orientation descending towards the surface. All these characteristics would render a draining drift. Only the completion of the digging work will allow for a solution to the issue in question. Yet, this gallery may not be an draining drift, but rather a work enabling access to a sector of an otherwise already known mineralised area. In fact, it does not seem to lead out onto preexisting sites, but it transforms gradually in depilage, which tends to indicate the fact that the ancient cutting derived from the gallery, and not the opposite, as would be the case of a drainage gallery. There was not sufficient time to conduct a geological study of this system, this remains to be done.

CARNIC 7

This south-western zone of Carnic massif is marked by a number of fire-opened sites which constitute two units, site Ch14 and sites Ch9. Site Ch14 lies rather far from daylight, which must have caused difficulties concerning ventilation in smoky sites (fig. 213). As for sites 9, they are situated nearer the surface and thus they are more easily ventilated. In this place the works are located very high and are well developed.

After studying fire-opened sites in Gauri massif in 2001, to south-west of Cetate, and not being able to bring forth incontestable dating elements concerning the age of this kind of work, we thought it was necessary to try again and date such sites at Rosia Montana. The advancement technique by fire-cutting of the rock is a very old technique, which was used in mining since the first metal ages and subsisted until early Middle Ages with the introduction of powder. This advancement technique is generally applied for works in hard rock, too hard for hand-tool work.

Site Ch14

Site Ch14 is unique for regrouping distinct mining works intersecting one another. At first, it represents an ancient type of gallery, cut by sharp tools and trapezoid-shaped in section. It was cut in two places by fire-opened sites, which were at their turn intersected by modern powder-deepened depilages. The plan and cutting of this site were carried out. They underlie the crosschecking and thus the anteriority of the wedge cutting over the fire attack. Unfortunately no remnant of charcoal could be collected, because the Moderns resumed the basic works and considerable modern ballast covers the basement. It is the same problem as that encountered in Gauri. Site Ch14 could not be dated for the moment (fig. 214 and 215).

The Geology of Site Ch14

In this ancient wedge-cut gallery, which was pursued through fire-use, the purpose of the exploitation was a vertical vein directed towards north-south (fig. 216). The host rock is silicified and extremely hard, particularly near the vein. Observations on the thin sections confirmed the brecciation of the host rock. Deposits of adularia II, hydrothermal quartz, clay minerals and metal minerals accumulated into the cracks. The study of the polished sections confirmed the presence of pyrite, arsenopyrite, chalcopyrite, bornite and silver minerals (particularly proustite).

Sites Ch9 or Large Fire-Opened Chambers

The large fire-opened sites Ch9 reach vertiginous heights. They are domes opened in a succession, ones above the others, like the sites researched in Gauri in 2001 (Cauuet *et alii*, 2001). In default of time, it would not be possible to carry out the digging operation and an accurate survey in 2002. We have chosen to provide these high sites with climbing equipment for seeking, on the heights and small benches, charcoal rests, relics existing since the time of fire-cutting (fig. 217 and 218). The exploration was successful and a sample of the top level could be taken. It contained fire-cut rock chips, mixed with numerous charcoal bits. A radiocarbon measure was obtained on that charcoal which gave the following dating (fig. 10):

– Ref. *RM02 Cârnic 7 – Niv 960 – Chant. 9*; measure: 1785 +/- 50 BP; highest probability range: 135 to 355 AD.

Thus, the fire-cutting date corresponds perfectly to the period between the outset of the 2nd century AD and the middle of the 4th century AD, on the whole it corresponds to the Roman era. It is certified now that important works using fire had been conducted at Rosia Montana in the Roman era. In fact, it is interesting to note that a tool-opened gallery could have been continued by fire-use. Is it possible that this gallery was a mining work that dated from the Dacian era?

Geology of Sites Ch9

In the huge fire-dug exploitation sites Ch9 at level 960 (southern Carnic), the central aim was the overall exploitation of a breccia body. This breccia is a black fluidised-matrix breccia containing rather angular dacite fragments. The breccia is that of the matrix supported type.

The fire-exploitation was required by reason of high breccia hardness. The proximity of the surface and thus the possibility to provide an appropriate ventilation to the sites facilitated fire-cutting. The ore body represented by the very breccia structure is highly silicified. The dacite fragments are impregnated with adularia and pyrite. In the breccia there is also a hydrothermal cement with a quartz and adularia content. In the polished strips of the breccia body, pyrite (in a great amount) and gold were revealed.

Cârnic 8

- Object of the topography

Our purpose was to identify and to spatially place the traces of the ancient works performed in the networks upper to Cârnic 1 network (fig. 9, 219 and 219bis). These works, storied on several levels, occupy the space between Cârnic 1 and the surface. They have been exploited from the interior of the massif, starting from Cârnic 1 and going up to the surface, in partially filled, but generally accessible works. The exploration had to be stopped in several dangerous sectors, because of gas presence. The works studied in the topography are characterised by geometric detachments and trapezoid profiles. This study has been carried out in order to reconstitute, if possible, the dynamics of these ancient works, on the one hand, and to reveal the modern overlaying sites on the other hand, with a particular attention to the consequences that recent works have had on the ancient network (fig. 220 to 222).

- Exploration method

A detailed topographic plan has been drafted, as exhaustively as possible, relating to the vertical sections drawn in remarkable sectors of the network. A classic procedure was used: draft on topo notebook with numbered points between which azimuths and dips are measured by Topochaix compass, lengths by decametre and lasermetre. The results have been reported by means of a protractor and a *cutch* ruler (triangular section ruler with several grading scales) on millimetre paper, then on tracing paper, using the following graphic conventions: grey for recent works, black for ancient works and orange for ancient vestiges which are visible only on the ceiling of recent works (fig. 223 to 228).

In case of superposition, the continuous lines represent the highest works, while the dotted ones represent the lower subjacent works. The complexity of the network and the fact that several levels overlap locally has led us to define ten zones, resulting in separate planes. Illustrated on tracing paper, they indicate common points which allow us to establish overlapping and superposing areas. The altitudes have been calculated from an arbitrary 0 point that we have situated on the basement of the 958 modern level branch giving access to the mining sector of Upper NW Network of Cârnic 1 (edge of P1 shaft).

- Topography Limits

Following a detailed visit, we decided to restrain the zone to be topographied so as to have enough time left in order to cut sections of the different levels. We have limited our study upwards at approximately +46 m elevation. This corresponds to three access ways to modern depilages. Downwards, a connection has been made to the Upper and Lower Cârnic 1 network and to the Eastern network, which has also been topographied.

- Consequences of Modern Works

Modern miners deliberately filled many ancient galleries with their own excavated material. They opened chambers of about ten metres in diameter, destroying part of the ancient vestiges. Although there still are face lines and ancient detachments which are visible on the recent ceilings, it is no longer possible to follow the continuity of ancient works. Moreover, these exploitation chambers seem to have been lowered to deeper levels as compared to ancient works (fig. 229 and 230).

These recent works, as well as the ancient ones, are invaded by overburden, and locally by muddy clay, originating from upper, inaccessible levels. In modern chambers, ceilings are often fractured and partly fallen in. These are all factors that hindered the study of a coherent overall site plan of the ancient galleries. It is impossible to interconnect the different segments of ancient galleries. Modern chambers sometimes even point to communication paths between ancient vestiges which probably had not existed before modern works launch. In the 'blower' chamber, for instance, vestiges indicate three different origins of ancient works: southwards, from above, by a gallery; northwards, by a presently perched gallery; and by a shaft or a series of vertical detachments from the NE/SW gallery, whose only remains are the ceiling over this chamber (fig. 232). But did these three origins give way to intercommunicating works before the chamber's being opened?

- Origin of Modern Works

Considering the drill traces and the accumulation of overburden, the modern miners have worked downwards. It is however possible that the NW-SE drift at +28 level had been an access cross cut dug from the surface on the NW side. A piece of wood found in a medium area of this vast network has shown the following radiocarbon measurement (fig. 10):

- Ref.: *RM02 Cârnic 8 – Woods breccia area*; measurement: 340 +/- 60 BP ; highest probability range 1470 to 1680.

This dating obviously corresponds to modern works which in this case seem to go back to somewhere between the 15th and the 17th centuries, to rather distant periods.

However, in 1999, at the time of our first visit to the Cârnic massif (Cauuet *et alii*, 1999), another wood sample, taken in a NW area, very high and therefore closer to the surface, had indicated a medieval dating, namely (fig. 10):

- Ref.: *RM99 Cârnic 8*; measurement: 1090 +/- 60 BP ; highest probability range 890 to 1005.

This piece of wood would then be dated as going back between the end of the 9th and the beginning of the 11th centuries, a period known by Romanian medievalists as simultaneous to a resuming of mining works at Rosia Montana, documented by an archive item on Cârnic massif (information provided by Mr and Mrs Iosipescu, Bucharest archaeologists working in the frame of the project).

- Ancient Works

It is obvious that ancient miners opened their network from the top of the massif to its base and bottom. The descending works were performed by successive detachments of the basements, now invisible because of the overburden present all over the networks and ceilings. The northernmost sector indicates a spiral descent, with a right or sharp angle rotation. The topography of the vestiges reveals a certain exploitation technique. When a gallery touched a rich and exploitable ore zone, the miners used to open several radial or successive galleries, slightly shifting from one another. Their positions formed either a fan shape, as in the ‘Cairns’ gallery, either a star, going in all directions, as in the ‘5 metres gallery’, at +42,80 m elevation (fig. 231 and 232).

In these ancient networks, over an almost 50-m lift, we can not connect beyond doubt either of the works to a drainage activity. Nevertheless, we can advance a prudent theory according to which the gallery that ends at the 101 point (+25,80 m, section A1-A2) could have played this role (descending gallery, filled with clayey sediments).

Ancient works are all calibrated according to a trapezoidal section. Some detachments on the works’ path can only be explained by the nature of mineralisation and by the changing in the rich ore content. However, the geological study of this network could not be performed in 2002 because of the lack of time. The reason behind the numerous detachments can not be related to any topography choice.

Certain lamp niches are cut in sharp angles, leading us to think of permanent illuminating posts on an important traffic route. Most of the niches are cut in facings that are close to the ceiling; they probably hosted lamps used to illuminate the advance of the face line.

- Perspectives

Not all the accessible networks in the upper part of the Cârnic massif could be topographied in 2002. To quote an example, starting from the most elevated and the easternmost gallery (+46,80 m) and starting from the ancient, basement-less gallery of the B1-B2 section, we gain access to a sector of ancient works re-exploited by modern miners and situated more eastwards and upwards. These works are invaded by overburden and very much visited by clandestine mineral hunters. The survey work for this new area would need not less than three topography days.

Moreover, toward the NW of this sector, we can find another area which is accessible from the ‘5 metre gallery’ chamber: a vast recent depilage, sub-vertical and plugged by clayey benches. Its upward exploring would involve a fixed speleological equipment, especially in order to re-descend from this network. The presence of some hanging ancient face lines can be noticed on the ceiling of this depilage, on the SW wall. Upstream access to this area in order to try and reveal the access from the surface to these Cârnic 8 works situated between the surface and Cârnic 1 seems inevitable.

It is obvious that, along possible traces of medieval works and modern resuming, this network hosts significant vestiges of ancient works. More mining time is needed in order to prove it. Moreover, since these ancient vestiges are the closest to the surface, we have reasons to believe that they are the oldest ones in Cârnic massif. Therefore, we hope we will be able to return to this area of Cârnic in 2003 in order to perform some prospecting work which could provide us with additional dating elements.

Results and perspectives

The Digging Team

Extending over two and a half months, from the middle of May to the end of August, the 2002 mission proved to be a real success, giving very good results. It allowed us to discover an additional ancient network, Cârnic 3, perfectly preserved. Thanks to the hard work of the whole team (a dozen of French archaeologists), supported by five geologists of Cluj (among which four are students) and by an archaeologist from Deva, with the assistance of a dozen of miners of Rosia Montana, we have been able to mine and study the majority of the works that had been revealed in 2000 in the Cârnic massif and, additionally, those revealed in 2002.

The Working Conditions

We must remind that working conditions for a team performing underground are always extremely difficult. The team has to displace a lot of overburden, including clayey, heavy and humid material, passing more than 8 hours a day underground (taking lunch underground too, in order to save time and to avoid the shotfiring activity at the surface, in Cetate, and the quarry works started in Cârnic). We sometimes had to work over weekends too, so as to make things advance as planned. Our results are the outcome of this hard and demanding work. Despite our efforts, we have not had the time to really complete our work. There are still essential actions to be completed here and there, in order to reach this overall view, necessary to a satisfactory interpreting of the vestiges.

Areas Studied

Eight networks, some of which closely related: Cârnic 1, Cârnic 2, Cârnic 3, Cârnic 4 and Cârnic 8, have been studied on the southern slope of the massif. Almost 500 m of galleries have been mined, emptied and studied in Cârnic 1, Cârnic 2, Cârnic 3, Cârnic 5 and Cârnic 6. Let alone the Cârnic 1, Cârnic 2 and Cârnic 3 networks cover a surface of 8400 m², storied over a lift of almost 30 m. The Cârnic 5 network, isolated, extends over almost 1000 m², storied on top of two gallery levels.

Finally, more than 480 additional metres of ancient galleries have been classified and topographied in the new Cârnic 8 network, identified above Cârnic 1. This unit covers 2160 m², storied on at least six levels (fig. 223). It would need at least a few significant archaeological prospecting works so as to allow us to advance a dating of these vestiges. In fact, this is precisely the area, all the way up and close to the top of the massif, that hosts the most ancient vestiges, Dacian or even older. The fact is that the slat dating back to the Dacian age (3^{rd} –2^{nd} centuries BC, fig. 10, 26 and 37) was found in sites located in this very part, upstream of Cârnic 8.

Furthermore, the shaft wood dating back to the 10^{th} century found in 1999 (fig. 10 and 219, Wood Sampling 2) comes from a summit area located NW of Cârnic 8. Consequently, it is in this area that we should place medieval resuming of mining works.

Works Chronology

Vast coherent units have been mined. We have been able to date most of the vestiges considered to be ancient: they belong to the Roman age. A new dating, pointing to the Dacian age, confirmed an already active mining work during the pre-Roman age in Rosia Montana. This activity continued, being later resumed and intensified under Roman administration.

The vestiges are of very good quality and their features allowing rapid identification. The ancient Dacian or Roman networks systematically reveal trapezoidal sections. The presence of lamp niches indicates Roman age techniques. It is a fact that the *firmalampen* only reach *Alburnus Maior* at the beginning of the 2nd century, together with the Roman legions. The Dacian miners must have used different systems, such as hanging light sources onto a wood chunk, blocked across the works, a method which leaves no trace. The use of wood-laths torches is a sound possibility too, since a lot of partly carbonised laths were found in the filling of the NW sites of Cârnic 1 in 2000.

Ancient Works Features

Generally, the works are of little dimensions, always evenly calibrated and often opened by sharp tools (wedge). Traces of picks have also been noted on some walls. A few hard rock areas, close to the surface and intended for aerating were fire worked, especially in the SE part of the slope S of Cârnic, in Cârnic 7. We now know, thanks to the radiocarbon dating, that these are Roman works too.

From among the sites we have encountered, let us mention a few:

- short galleries intended for search and long ones for traffic, going to different directions, or exploitation ones, grouped close to one another and fan, star or grid-like.

- *depilages* or exploitation sites, generally obtained by extending and lowering the basement of a simple gallery (such as G2 in the NW sites of Cârnic 1 and the *depilages* of Cârnic 5).

- inclined ascending or descending galleries, called descents, often dug from the surface or between two exploitation areas. Most of the time they are equipped with stairway steps (like G2 in Cârnic 3, G20 in Cârnic 4, G4, G1 and G36 in Cârnic 2). G4 gallery in Cârnic 2 corresponds to an axis that was dug in order to open a new exploitation space, but it did not reach anything but slightly mineralised areas, the gallery being abandoned after only a 30-m advance.

- pillar chambers as a result of broken working in galleries inter-crossing over the same area (like Ch1 in Cârnic 1, Ch1 and Ch2 in Cârnic 2 and the sector NE of Cârnic 3).

- recognition and exploitation shaft on a vertical, spiral plane, turning in right angle and equipped with stairway steps (like P10 of the South network and G6-G8 of the East network in Cârnic 1). Right communication shaft between levels are short and rare. A single example has been recorded, it is located in the NE network of Cârnic 1 and allows connection of the upper and lower level. Inclined plane passages, with or without steps, and long or short descents were preferred.

The gallery is the main type of work. It is adapted to any need. Rather few drainage passages for circulation water have been noticed. However, it is obvious that circulation water is important at the base of the massif. Hence the importance of completing the archaeological digging in the so-called ‘drainage’ gallery of Cârnic 6, in order to determine its exact nature.

The Archaeological Artefacts Revealed

The archaeological artefacts are rare: only a few abandoned pieces of wood have been found (sticks, boards etc.), preserved in the humid environment of the mine, wood charcoals and fragments of Roman lamps. Tools are so far absent. Datable items are only represented by miner’s oil lamps. A single model has been encountered, the 2nd century’s channel lamp, lesser and greater versions. However, C14 dating on various wood or charcoal samples point to activities during the 3rd-2nd and 1st centuries BC and 1st and 3rd centuries AD. Pottery or other relevant items have so far been absent, failing to confirm these important dating information. If we were to limit our interest solely to the pottery discovered so far (lamp fragments of the 2nd century), we would have a very narrow and faked chronological overview on the activity in this massif.

Space Organisation

The study of the mining networks positioning in Cârnic reveals two quite distinct site areas:

- a well-organised and clearly-divided area, starting from long descents, such as G1 in Cârnic 2 and G2 in Cârnic 3 and maybe G20, which could open into a Cârnic 4 network yet to be discovered.

- a more anarchically divided networks area, as in the upstream part of Cârnic 1 and above, in Cârnic 8.

It is in this second area we encounter no unitary organisation, nor a hierarchy of the pre-Roman works. The well-divided Cârnic 2 and Cârnic 3 areas, dated back to the Roman age, indicate a quite regular and systematic cutting of the mining space. A long gallery (G2 in Cârnic 3) was dug on an inclined plane from the surface to the interior of the massif, in search of rich exploitable areas.

When an interesting area was encountered, the exploitation developed on a horizontal plane, opening galleries in all directions, along the veins and the breccia zones. In the end, this results in pillar chambers in the richer areas and in short galleries in poor areas. The exploitation may continue on inclined planes and descents equipped with stairway steps. Vertical advance passes in almost all instances by inclined galleries or spiral shaft with steps. This method of circulation is preferred for perfectly vertical passages. Vertical shaft are virtually overall absent.

Then, starting from the area under exploitation, new exploration (G4 in Cârnic 2) or liaison (G1 in Cârnic 2) ‘descents’, ascending or descending, are cut in different directions, in search of new rich zones or in order to connect two active networks (G1 connecting Cârnic 2 to Cârnic 1), most probably in order to facilitate the airing of networks and miners traffic in the massif.

The long inclined descents, between 30 and 60 metres long, are impressive, sufficiently high and wide to allow proper traffic of men and products and good ventilation of the mine. These works seem to have been pierced with a view to an extended use. They irradiate and drain the mine.

Concessioning of the Mining Area

This rational organisation of the space reminds us of another Roman system. We think of the mining concessioning mentioned in archaeological documents in relation to the Roman polymetallic mine (copper, iron, gold and silver) of *Vipasca* (Aljustrel, south of Portugal). Two bronze tablets, quoting the Roman mining code of this 2nd century AD Roman town, in force under Hadrian, were discovered in hillocks and in a mine shaft. Among other provisions, these law tablets speak of a delineation of mining concessions, leased from twin shaft, opened from the surface.

One problem though: if a plateau structure like *Vipasca* is expected to allow opening of vertical shaft, this does not apply to the very sloped massifs in Rosia Montana. In ancient *Alburnus Maior*, delineation in shape of descents cut from the surface must have been preferred to vertical shaft. Then concessions must have been cut to the heart of the massif, in the rich areas, touched by access openings. These important axes were pierced in order to facilitate the management and delineation of the mining space and to control its exploitation. We can imagine how closely these Roman miners must have supervised the piercing of such impressive works as the descents of Cârnic 2, Cârnic 3 and Cârnic 4, discovered in 2002.

Based on these initial remarks, we may advance a delineating plan of the ore deposit, cut in different leased areas, interconnected by the great access and liaison descents that enable traffic and ventilation (fig. 233). This plan is parallel to the one quoted in written sources and archaeologically confirmed at *Vipasca* (Cauuet, Domergue, Dubois 2002 and Cauuet *in print*). The mine in Portugal is organised on a vertical plane, by a succession of right shaft and high and narrow depilage chambers. These positions vary according to the ore deposit type, particularly to the iron canopy bearing vertical veins trapped in a plateau relief. On the other hand, at Rosia Montana, the space organisation follows a horizontal plane. Works do not develop on vertical panels like in *Vipasca*, but on horizontal stacked layers. These choices are dictated by the position of mineralised areas, lenticular breccia areas, horizontal veins and stockworks and by the general topography of the sloped massif. On the vertical veins, *depilages* may also be found (Cârnic 5 network, for instance).

As opposed to this clear-cut hierarchical organisation, the intergrown works system in the upstream part of the massif, Cârnic 1 and Cârnic 8, undoubtedly come from another organisation. The starting moment of mining works in this part of the site is certainly older and more complex. It might correspond to successive Dacian, Roman, or Medieval exploitation stages that affected the same exploitation area, giving birth to a huge overlapping of different types of mining works. Further study is still necessary, in order to better grasp the logic behind the prevailing exploitation in this area.

Advantage of the Complementary Geologic Approach

Thorough geologic studies on the field, supplemented and enriched by laboratory work, enable an exact overview on ancient miners' choices. Thus, when studying the diminishing of grades from the entrance to the face line of G4 (Cârnic 2), after 30 m on the path, we can understand the abandon of the work. The high grades at the entrance must have given much hope to miners, since the gallery was intensively excavated and even completed by an impressive *depilage*, G5, all steps-equipped (descent opening), before being abandoned. This example speaks beautifully about these miners' approach, as they started working before even knowing whether their work would last or not. They used to perform a close control and supervision of the mineralisation and never worked uselessly on barren rock. The only works they forced on barren rock are great communication galleries (or descents) opened in order to connect active parts of the mine such as G2, G20, G1 and G36 galleries. In exploitation areas, works stop as soon as grades drop significantly or when barren rock is reached.

The Trapezoidal Profile, a Dacian Mining Tradition

The mining technique found in Rosia Montana is of high quality. The geometrical, trapezoidal calibrating of the works is a *unicum* in the Roman world. It is most probably due to a local Dacian-origin tradition, which persisted in the Roman age. As the control over production was taken over by Roman administration at the beginning of the 2nd century, it seems that the indigenous mining population who had already worked these areas and was very familiar with local ore deposits continued to be active and to pierce the galleries as they had always done. The new administrator must have undertaken to organise the leasing system and to plan production, without any need to teach miners how to drill in galleries. It is now time for the teams of archaeologists to work on surface sites (habitats, necropolises, sanctuaries etc.) with a view to discover vestiges of this pre-Roman age that would enable a complete overview of the site.

A Field Work to Be Completed in 2003

Despite the genuine importance of 2002 works, cut at the heart of Cârnic massif, the mission has not been able to finalise the research. Because of the lack of time, essential points had to be left unsolved. We still need a few weeks so as to be able to complete ongoing works in various parts of the networks. One month and a half, maybe two months would suffice for the finalisation of the study and gathering of relevant data. In spite of all the great efforts employed by the team and by miners, we faced too vast a task to be able to duly fulfil it in two and a half months. Cârnic massif can not be surrendered to the modern quarry before unravelling the rest of its secrets. A few more weeks and the essential would undoubtedly be revealed.

We must also express our regret that the prorogation proposed by Dana Mihai did not manage to become reality, nor to attract funding, for this would have enabled us to finish Cârnic in 2002. Unfortunately, these risky initiative did nothing but momentarily distort the organisation of our mission-ending work, as it induced a period of false hope.

In order to be able to complete our work in Cârnic during 2003 spring, we should prioritise our work in the following manner:

- finalise the emptying of G2 in Cârnic 3 from the surface and of the excavation opened by excavator;
- finalise the mining work in G5-G10 of Cârnic 3;
- finalise the emptying of Dep 10 depilage in Cârnic 1;
- finalise the mining of the Eastern network of Cârnic 1;
- finalise the study of the so-called ‘draining’ gallery in Cârnic 6;
- perform archaeological prospecting in Cârnic 8;
- complete the geological study in certain networks (Cârnic 1 and Cârnic 3).

Béatrice Cauuet
Toulouse, November 2002

Bibliographie :

- Cauuet B., e*t alii* (1999) – Mines d'or antiques de Dacie. Vallée du Pianul et district de Rosia Montana (Carpates méridionales, Roumanie), *Rapport de mission archéologique,* Toulouse, 71 p.

- Cauuet B., e*t alii* (2000) – Mines d'or antiques de Dacie. District de Rosia Montana (Monts Apuseni, Roumanie), *Rapport de mission archéologique,* Toulouse, 156 p.

- Cauuet B., e*t alii* (2001) - Mines d'or antiques de Dacie. District de Rosia Montana (Monts Apuseni, Roumanie), *Rapport de mission archéologique*, Toulouse, 216 p.

- Cauuet B. (sous presse) – Mines du monde romain aux II[e] et III[e] siècles de notre ère. Etude comparée des modes d'exploitation entre le district aurifère de Rosia Montana (*Alburnus Maior*) en Roumanie et le district polymétallique d'Aljustrel (*Vipasca*) au Portugal, *V Mesa Redonda Internacional sobre Lusitania Romana , « Las Comunicaciones »*, Caceres, 7-9 nov. 2002, actes à paraître.

- Cauuet B., Domergue C., Dubois C. (2002) - Mine d'Aljustrel : fouilles archéologiques dans les anciens réseaux miniers des Algares (Portugal), *Mineração no Baixo Alentejo*, Ed. Câmara Municipal de Castro Verde, vol. 2, Castro Verde, pp. 38-87.

- Mârza I., Tamas C., Ghergari L. (1997) - Low sulfidation epithermal gold deposits from Rosia Montana, Metaliferi Mountains, Romania. St. Cerc. Geol., t. 42, pp.3-12, Ed. Acad., Bucureşti.

- Tămaş C.G. (2002) – Structuri de brecii endogene asociate unor zăcăminte hidrotermale din România. Teză de doctorat, Univ. Babeş-Bolyai, Cluj-Napoca, 337 p.

- Tamas C.G., Bailly L. (1998) – Fluid inclusion study for Roşia Montană ore deposit. Rom. Journ. Mineral Deposits, v. 78, Suppl. 1, pp. 97-98, Bucureşti.

Figures captions –Report 2002

Fig. 1: Map of the auriferous area at Rosia Montana (NW of Romania). Location of mining archaeological sites prospected and worked in 2000, 2001 and 2002.

Fig. 2: Cârnic massif: modern and ancient mining works in the massif. In orange, ancient works studied in 2002.

Fig. 3: Cârnic massif: location of networks studied in 2002, in the southern slope of the massif.

Fig. 4: North slope of Cârnic massif (photo taken by E. Kammenthaler).

Fig. 5: Southern slope of Cârnic massif (photo taken by B. Cauuet).

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Fig. 220: Cârnic 8: Detailed topographical plans of Plan 1 ‘Ascent’ and of Plan 2 ‘Skylights’.

Fig. 221: Cârnic 8: Detailed topographical plans of Plan 3 ‘the 5 m drift’ and of Plan 4 «Tumuli».

Fig. 222: Cârnic 8: Detailed topographical plans of Plan 5 ‘Ceiling’ and of Plan 6 «Detaching».

Fig. 223: Cârnic 8: Cut A1 – A2.

Fig. 224 : Cârnic 8: Cut B1 – B2.

Fig. 225 : Cârnic 8: Cut C1 – C2.

Fig. 226 : Cârnic 8: Cut D1 – D2.

Fig. 227 : Cârnic 8: Cut G1 – G2.

Fig. 228 : Cârnic 8: Cuts F1 – F2 and H1 to H4.

Fig. 229: Cârnic 8: a partly filled inclined descent (photo taken by B. Cauuet).

Fig. 230: Cârnic 8: an ancient drift of typical trapezoidal section (photo taken by B. Cauuet).

Fig. 231: Cârnic 8: three ancient drifts of trapezoidal section cut by a modern chamber, ancient lamp niche visible in the wall (photo taken by B. Cauuet).

Fig. 232: Cârnic 8: ancient drift with multiple face lines, known as ‘the blower drift’ (photo taken by B. Cauuet).

Fig. 233: Compared modelling of the mining concession in the Roman age in *Vipasca* (Aljustrel, south of Portugal) and in *Alburnus Maior* (Rosia Montana, Romania) ore deposits.