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NEOGENE COALS IN SĂRMĂŞAG – DERŞIDA AREA, PALEOENVIRONMENT RECONSTRUCTION, COAL RADIOACTIVITY AND THE IMPACT OF THE MINING ON THE ENVIRONMENT

Ph.D. Student Thesis

(Summary)

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CONTENTS

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Romania, Simleu basin, Neogene, uppermost Miocene, coal, paleontology, environmental reconstructions, coal radioactivity, radionuclides, mining impact, environment.

RESUME OF CONTENTS

INTRODUCTION

The studied perimeter includes both former underground mining, as well as a current working coal open-pit.

In 2004 I began studying the lignite deposits in the Sarmasag Mining Area, part of the National Coal Society of Ploiesti. The first three chapters relate the geology, palinology and paleontology of the studied area and were inspired by the research undertaken in the area by many generations of researchers, to which, of course I have added the results of my own research. A less studied trend of research has been the radioactivity of the coal in the region and of the ashes generated through combustion. Through this research I have attempted to examine the level of radioactivity in the area immediately adjacent to the mining operation and its effects on the local settlements. Also, a brief presentation of the Neogene paleoenvironments of the coal formation was attempted. Such a study aims to asess the impact of the mining activities upon the environment.

Coal remains an important source of pollution on the environment together with other sources of pollution which lead to the contamination of the main constituents of the environment (air, water, soil) through the degradation of the landscape especially by surface mining where the tailings and ash pits are left behind.

CHAPTER I

1. OUTLINE AND REFERRAL OF THE STUDIED AREA

The Neogene Simleu sedimentary basin (fig1.1) is located in the northwestern area of the country and is bordered to the southwest by the Plopis Mountains, the Mesesului Mountains to the southeast, the Somes river to the east and to the north-northwest is opening to the Pannonian Depression.

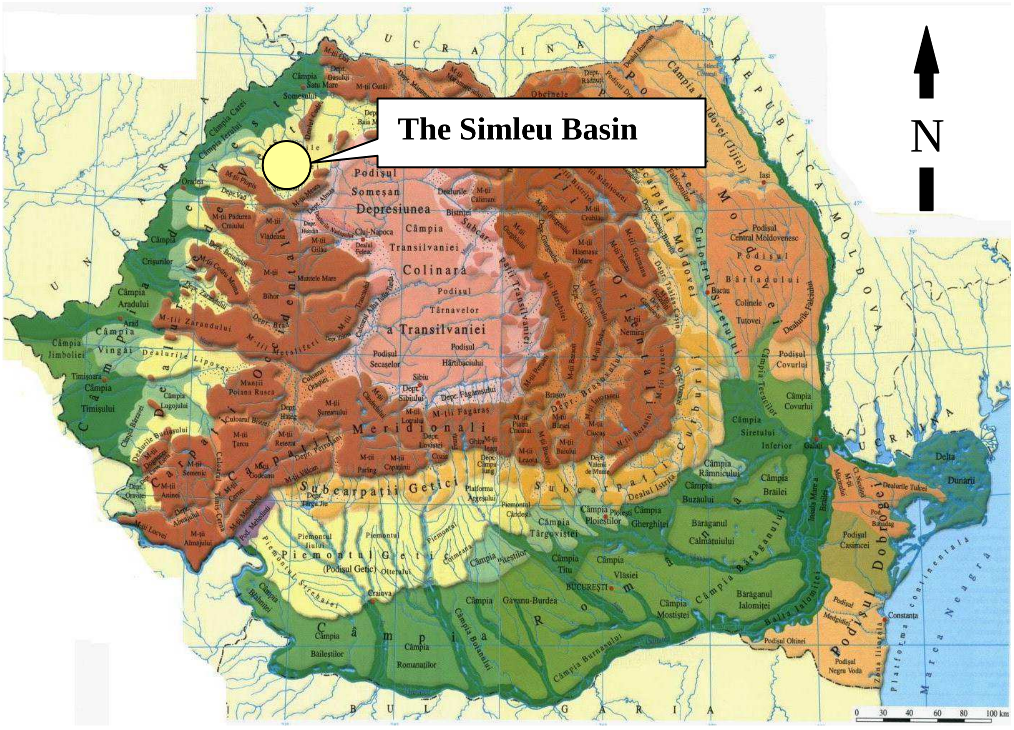

Fig. 1.1 Location of the Simleu Basin (after the geographical map of Romania 1: 500.000)

From a historical perspective, in the Simleu Basin there is evidence of ancient civilisations running back to the Neolithic and from the Dacian period. Archeological finds of silver and gold artefacts were fortuitous unearthed during agricultural works (Luca&Gudea, 2012). Most archeological sites are spread along the Crasna and Zalau valleys (Pop, 2009).

From a geomorphological perspective, the Simleu Basin has both hilly and plain aspect, with altitudes ranging from 150 to 350 meters, excepting the southern area where heights of up to 596 meters are recorded (Magura Simelului). It is drained by the Crasna Valley, a first order river offshoot of the Tisa River which has its origin to the south of the Simleu Basin and springs from a height of 577 meters at the contact between the Meses and Plopis mountains (Bocoi, 2009). The Crasna Valley is fed by tributaries, on the right side by the Zalaului and Maja springs, and on the left by the Zeniceului spring.

The Sarmasag commune is situated in the north western part of Romania, in Salaj County, 20km northwest of the Zalau municipality, along the Zalau-Satu Mare railway. It includes five settlements: Ilisiua, Lompirt, Moiad, Poiana Magura,Tarmure. The Bobota commune lies in the vecinity of the Sarmasag locality and has within its administative territory, the Bobota open pit within the Sarmasag coal deposit. To the NE, lies the Chiesd commune and its former underground coal mining (**Fig. 1.2**).

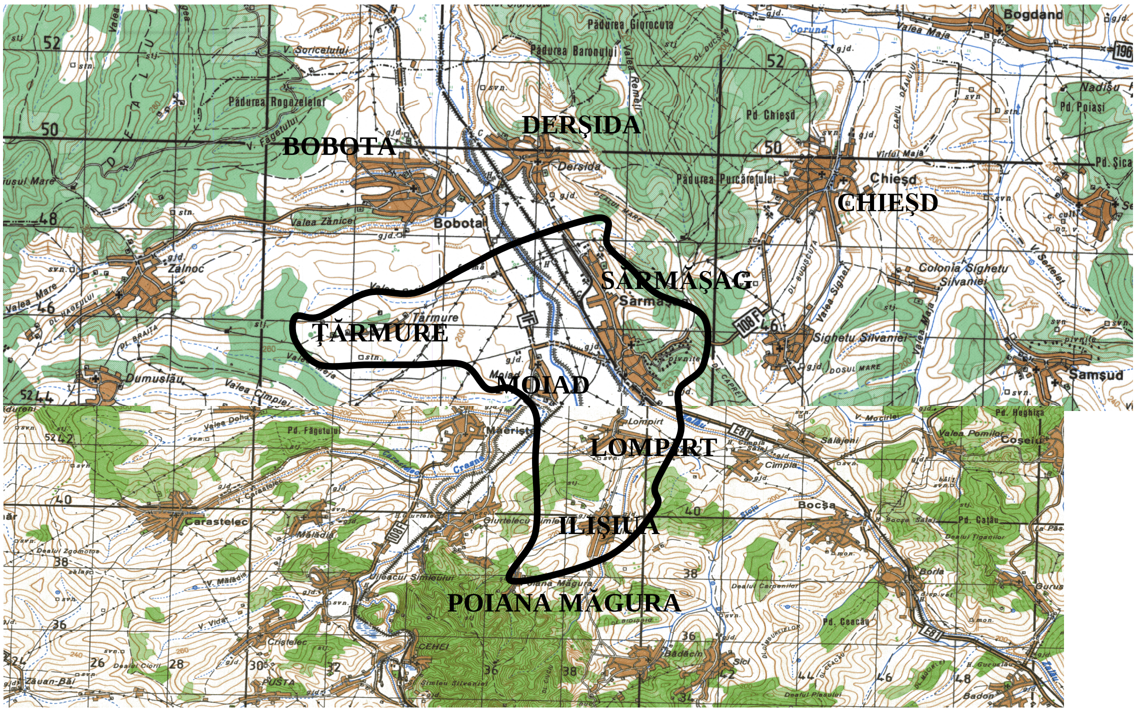

Fig. 1.2. Bobota, Chiesd and the administrative territory of the Sarmasag commune (after the topographical map 1:100.000 and plates L-34-22, L-34-34)

It is a locality based on industrial and agrarian economies, the industrial part of which is represented soly by mining works to which can be added several commercial operations of both Romanian and foreign capital.

The first records of the Simleu area date from the XIX century and belong to Beudant (1822). The following geological studies belong chronologically to the following researchers: Hauer et Stache (1863), Hoffman (1893), Telegd (1915) who studied the sedimentary exposures in the northern and southern parts of the Plopis Mountains and also describes the Sarmatian and "Pliocene" deposits, Papp (1915), Mateescu (1925, 1926, 1938), Pauca (1954, 1964), Givulescu (1961, 1964, 1980), Nicorici (1962, 1964, 1968, 1972, 1982), Clichici (1969, 1971, 1973). Also, from the XIX century, the first geological maps were drawn:

- the Austrian-Hungary geological maps (1863), which comprise the Simleul Silvaniei Basin;
- geological maps of the Tăşnad, Şimleu and Zalău areas (Hoffmann, 1893);

In the beginning of the XX century, the region witnessed the first paleontological, stratigraphical, tectonic and economic studies (Telegd, 1915). Between 1918-1944 the area was not largely studied, but new data as to its geology are published by Popescu-Voitesti (1935) and Rotarides (1931) who outlined a geological synthesis of the Simleu Basin. Other geologists who make direct reference to their works on the formations which make up the Simelu Basin are Chivu (1966), Ghiurca (1970), Mateescu (1972), Petrescu (1972, 1982), Codrea et al. (2000, 2002, 2008, 2009, 2013) etc.

Pauca (between 1947-1964) described sectors in the Pannonian Basin, as well as the adjacent neogene basins among which the Simelu Basin, synthesizing the results in the last works of the aforementioned chronology. These studies evidence in the Simleu Basin, the Badenian, Sarmatian, Pontian, Dacian, Quaternary. Among the Upper Miocene formations, the Pontian exposures are the widest ones. Between 1958-1968, the sedimentary deposits of the Simleu Basin undergo biostratigraphical research and based upon those results, the Early Badenian was outlined in the Ciucea-Vanatori area. The Sarmatian comprises trasgressive, reef and detrital facies.

In the Sarmasag and Ip-Zauan perimeters, several post-Sarmatian deposits are described, such as the Pannonian s.s and Pontian s.s.; the Pontian lower boundary is placed at the first occurrence of the coal seams (Nicorici, 1968).

Between 1960-1961, several prospecting works were carried out in the region between Derna-Tatarus and Ip-Zauan (Enache, 1961) and the Sarmasag region, Racova, Corund, and on based on the associated microfaunas, a correlation tentative was made with the Sarmatian, Pannonian and Pontian deposits of the Vienna Basin (Papp, 1951). In the Simleu Basin, all zones determined for the Vienna Basin are present, i.e. A-B-C-D-E for the Pannonian and F-G-H for the Pontian, the coal deposits comprising zone F.

The area was studied in the same period by Mateescu (1972) who survey over an area of 1500 km comprising the Giurtelec, Bobota, Supur, Solduba, Hodod, Hoata de jos, Barsau de Sus localities, in a perimeter of 50 by 30 km.

CHAPTER II

2. THE LIGNITE COAL DEPOSITS OF THE SIMLEU BASIN

2.1. General aspects of the geology of the Simleu Basin

The Neogene Simleu Basin has over the years constituted the object of study for numerous geologists. Similarly to other Neogene basins located in the western part of Romania, the Simleu Basin was formed and began to function as a unit during the Middle Miocene (Badenian), as a result of pre-existing fractures of the Internal Dacides and the rotation of the Apuseni Mountains during the Cenozoic.

Regarding the final sedimentary filling episodes of the Simelu Basin, based upon the mollusc fauna, the biozones B, C, D of the Pannonian could be outlined, and upon the peculiar lithology and coal interbeddings, zone F is the base of the Pontian. The deposits of zone F reveals episodes of advanced continentalization, when the basin was emptied by the waters of the Pannonian Lake and when this region becomes emerged, crossed by a hydrographic network.

The lignite coal deposit from the Sarmasag and Ip-Zauan perimeters was researched in detail by synthsized exploitation works (Patrut et al. 1966). Based upon this data I have drafted a geological map of the Sarmasag – Chiesd area (**Fig. 2.1.).**

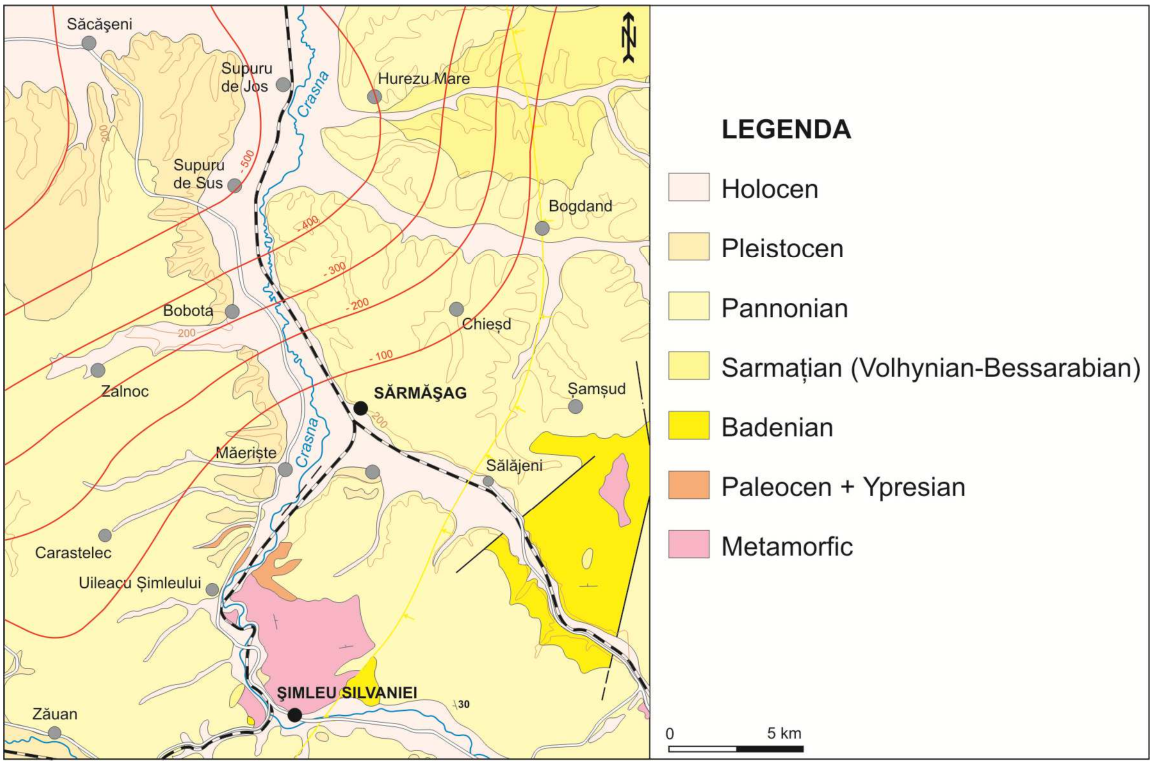

Fig 2.1. Geological map of the Simleu-Samsud-Hurezu Mare-Sacaseni area (drafted from the topographical map L-34-022-D-c, 1:25.000)

In the Simleu Basin we encounter several coal deposits, among which only the Sarmasag quarry is still active, the others being closed or preserved: Popesti-Voievozi, Ip-Zauan, Budoi-Derna-Tatarus.

In the Lower Miocene deposits (remains of an older basin, probably part of the Transilvanian Basin), gray clays, sometimes conglomerates appear, and based upon their foraminiferal faunas, were related to the Burdigalian. These clays are found east of Zalau and south of Mirsid.

CHAPTER III
SĂRMAŞAG DEPOSIT

3.1. The geology of the region

Simleu Basin belongs to the series of diving pools formed in the external area of the Apuseni Mountains, at the contact with the Pannonian Basin. It is situated between Plopiş Mountains in SW, Meseş Mountains in SSE, Gutâi and Baia Mare Basins in NE, while N and W the boundary is the Tisza basin.

The studied region belongs to the Simleu Basin, one of the five basins formed as a result of the collapse of the crystalline basement in the western area of the Apuseni Mountains, in the proximity of the Pannonian Basin. As Paucă (1964) pointed out, the Pontian/Dacian boundary is located at the level of an assemblage of planorbids, limneids, melanopsids, but he believes that the Pliocene is generally represented by gravels, deposited by receding water of the "Zalau Ditch", in piedmont environment.

The stratigraphic study highlights the presence of a part of the metamorphic Someş Series, covered by Permian, Triassic, Cretaceous and Burdigalian deposits occurring therein in the basin basement on one hand, and on the other hand, Neogene sedimentary filling rocks of the Badenian, Sarmatian, Pannonian s.s., Pontian s.s. and Quaternary deposits (Fig. 3.1).

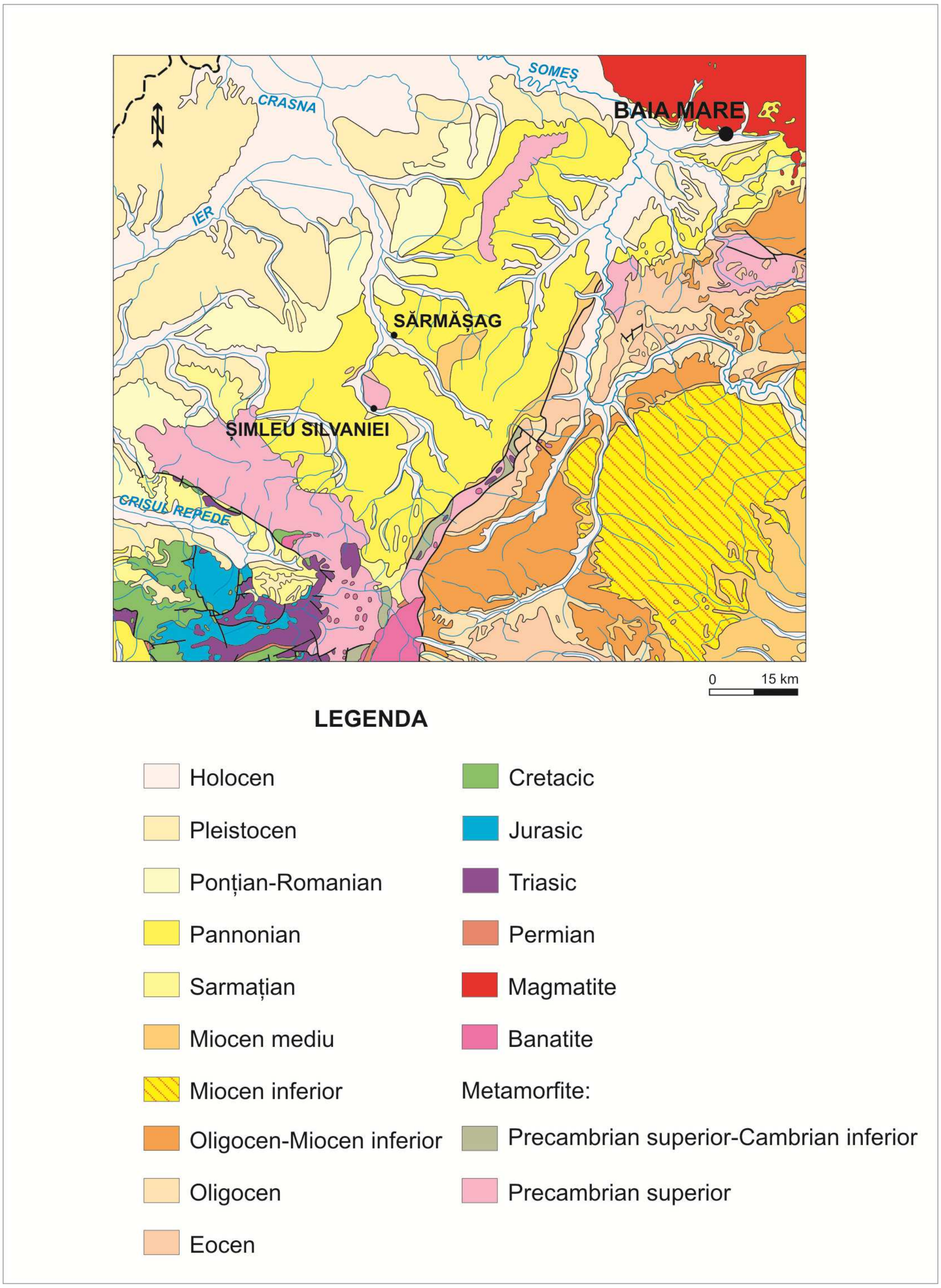

Fig. 3.1. Geological map of the Simleu Basin (retrieved and completed considering the geologic map of Romanian Geologic Institute, 1:1.000.000);

3.2. Neogene Sedimentary Deposits

Neogene is the period comprising the last 23.8 Ma and that gives us stratigraphic markers (Filipescu, 2002), the biotic and paleogeography events of the studied area. In the Neogene deposits developed in the southern area of the Simleu Basin, Badenian,Sarmatian, Panonnian and Pontian sediments can be identified, but we also encounter same Neogene deposits south to the Şimleu Basin, for example in Borod Basin (Lower Miocene), with marl, tuff, microconglomerates, sands, in the Borod Formation, their fauna consisting of molluscs, such *Pirenella - Theodoxus - Tympanotonos, Turritella - Anacada* and *Alvania - Ringicula - Pyramidella* (Popa, 2001).

3.2.1. Badenian

The Badenian largely includes a lower range of conglomerates (Nicorici, 1972), followed by sandstones, microconglomerates and then an alternation of marl, sandstone and tuff, including also two levels of gypsum, the series being completed by gray-white limestone.

There are affinities between fauna in Badenian on the southern area of Şimleu Basin and fauna known from the famous fosil *lagerstätten* in Lăpugiu, Buituri, Coştei also outside the Carpathians, in Oltenia, Moldavia and Wallachian Subcarpathians. High affinities on faunal associations offered arguments for the presence of the Late Badenian.

3.2.2. Sarmatian

The Sarmatian deposits consist of two facies, one on the coastal zone and another on the large area of the basin.

On the upper stream of Barcău River, such deposits were firstly reported in 1863 by Hauer and Stache, considering the existence of some beds with *Cerithium* and *Cardium*. The coastal facies develops directly above the metamorphic basement as a result of advancing basin water over the Badenian deposits. The deposits of this facies begin with sands and breccias with metamorphic reworkments, cemented in a clay binder with poorly preserved mollusk shells. Geological developments in this area allow to identify that the Badenian-Sarmatian-Pannonian stage is characterized by transgressions in the Badenian and Pannonian, and regressions in Upper Sarmatian and Pontian (Harzhauser & Piller, 2004).

3.3. Palinological study and Sărmăşag ore genesis

From palinological viewpoint, the Pontian coal-bearing beds from Sărmăşag was studied by Nicorici et al. (1982), showing that these deposits are nearly identical to those of Lugoj (Petrescu et al., 1989; Petrescu, 2003) and Derna – Tatarus areas.

The coal seams at Sărmăşag are well expressed both vertically and horizontally, with thicknesses of 0.10 to 3 m.

The features of these coal seams lead to understanding of the formation of coal. In the initial stage, there was a great development "*in situ*" of superior plants, specific swamps in a warm temperate climate, moist and uniformly favorable to the development of large plants.

The large number of coal seams separated by sterile beds proves that Şimleu Basin has undergone continuous and rhythmic subsidence during the Late Miocene.

Accumulated plant material has undergone a first transformation under the action of anaerobic bacteria and humic acids (humification). The second stage starts after coating and isolating the peat layers by a layer of mineral deposits and contains a number of physico-chemical changes, occurring under the catalytic influence of additives mineral acid, carbon dioxide, methane, water movement, the pressure and temperature, leading to the formation of coal in the lower end (peat) - the incarbonization.

It has also been examined carbonaceous shale found in the ramble of Chieşd, shale originating from the coating of IX layer where there were determined the following forms: *Osmunda*, *Pteridium oeningense, Salvinia* sp.

3.4. Paleoenvironment of the coal formation

Reconstructing paleoenvironment of fossil coal genesis requires the analysis of several factors that are closely related.

Of these, the most important are:

- paleogeographic and tectonic evolution of the region analyzed;
- climatic conditions;
- fossil flora.

3.5. Paleoclimate

Paleoclimatic reconstructions are dependent on flora and fauna assemblages. When referring to the region's ancient climate conditions, they can be reconstructed based on the study of land forms and continental paleoflora or the study of clay minerals.

The warmer and more humid it is the richer the flora becomes and the swamp forests grow. While in tropical-subtropical areas the swamps are completely covered by trees, in the temperate zone the trees canopy is only partial. A prerequisite for the installation of peatlands is that the average of annual rainfall to be higher than evaporation.

Regarding Sărmăşag, the paleoclimatic evidence is given from research data of flora microcontinental flora.

Numerous leaf prints of: *Carpinus*, *Alnus*, *Typha*, *Potamogeton*, *Alangium* and others lead to typical Pontian swamp association. Microflora pertaining to the current closest descendants leads us to consider the climatic conditions of Pontian, as similar to the actual existing subtropical regions of South China, eg. the temperate warm Atlantic region swamps of the North American sites (Givulescu , 1980).

The mentioned association makes us think that forest essences from which they come from belonged to some forests of the same type as the actual forest swamps of Atlantic North American sites. It is most likely that the average annual temperature to be 16^0-18^0 C, with average rainfall of 1,200-1,500 mm / year. To the upper floors (documented by pollen of *Pinuspollenites*, *Abiespollenites*, *Tsugaepollenites*), these thermal values decreased by a few units. The values significantly changed from those mentioned were registered in flood plains with Taxodiacee, Myricacee, Betulacee and others.

3.6. Fossil flora

During Neogene, as it is well-known, the fauna and flora were very divesified (Ţicleanu&Pauliuc, 2003).

Flora is the main factor acting in the development of a peat bog and thus in the genesis of coal. The evolution of flora over geological periods that are important for the formation of coal is very obvious: algae and Psilopsida during Devonian, Lepidopsida - Arthropsida - Pteridospermopsida - Cordaitopsida during Carboniferous-Permian, Cycadopsida-Coniferopsida during Jurassic, conifers and Angiosperms during Late Cretaceous-Cenozoic.

If we observe the Middle Pontian from Lugoj (Banat), which is identical to the one in Sărmăşag, it is clear that the dominant floristic elements are coniferals and Angiosperms-Dicotyledons. These elements remain specific for the entire Pontian in western Romania, the Lugoj Basin (Banat), the lignite basins in Bihor (Voivozi), Rosiori (Deva) and Salaj (Sărmăşag, Ip), etc.

CHAPTER IV

4.1. Fossil Vertebrates in the Derşida area

The Upper Miocene vertebrates in our country are extremely rare, because generally the taphonomic environments favorable for the preservation of bones or teeth are not very common. However, in some places in our country this rule is broken, as in Derşida (Bobota) Salaj County Fig. 4.1.

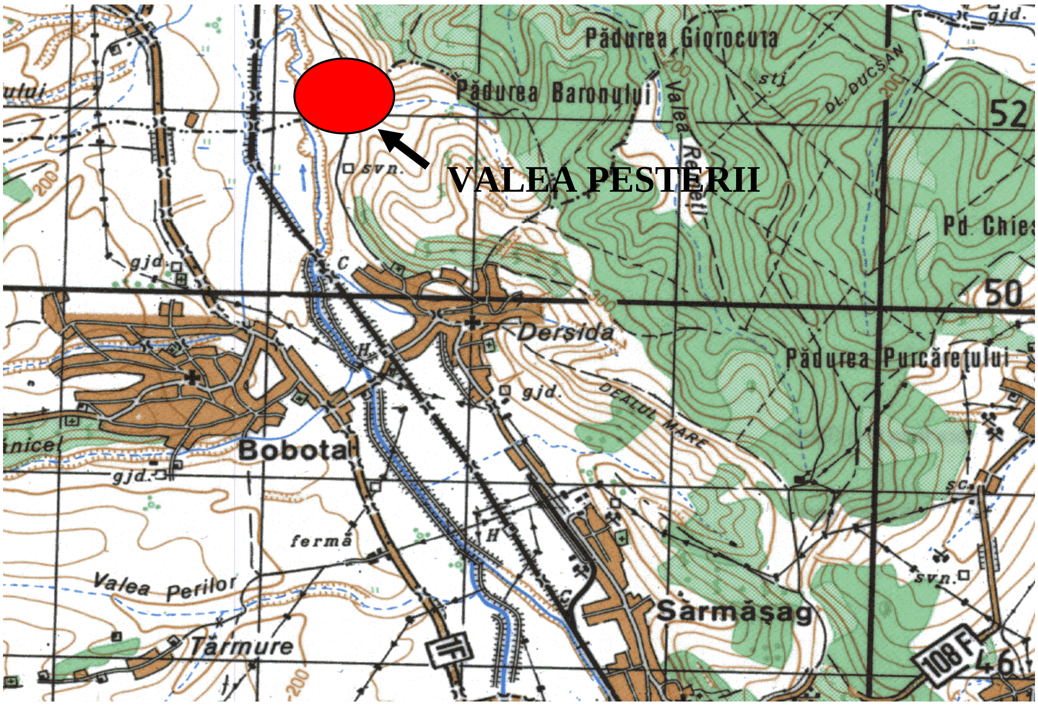

Fig.4.1. Location of Pesterei Valley, the main site bearing Pontian vertebrates at Dersida (after topographic map 1: 100,000)

This village is located near the E 81 road, that links Zalau to Satu Mare. In Derşida the deposits from the Late Miocene are exposed, the largest sections being located in Valea Pesterii, north of the village. In 1954, Paucă was the first to report these deposits and their molluscs, followed shortly after by the contributions of Maxim & Ghiurca (1960, 1963, 1964). Some vertebrate remains collected from the same levels were studied only a few years later by Macarovici & Jurcsak (1968) and Jurcsak (1973, 1983). After the 1980s, there were no further studies of the fauna in this area. Two decades later, in 2002, Codrea (Codrea et. al. 2002), extracted from the fossil sites several new vertebrate remains, adding also some sedimentological data, showing that there was a fluvial system in the uppermost Miocene, with ponds and streams in a floodplain. Its lithology is composed of fine-grained clastic deposits, interleaving with clastic levels, with thicknesses up to tens of meters, dominated by sandstone and sand.

Most fossils belong to large mammals, the small ones being relatively rare and the micromammals absent. This situation is the result of a peculiar taphonomy: most teeth and bones collected by us were accumulated in a rather small canal (lateral extension of up to 4 meters, with a thickness not exceeding half a meter), mixed with broken mollusk shells and quartz clasts (fig.4.2)

Fig. 4.2. Fossil mollusc fragments and quartz clasts from Valea Peşterii

Many of these fossils were in pieces while being transported by water streams. In these circumstances, it can be assumed that there was a hydrodynamic grading process before their definitive burial. The assemblage includes representatives originating from different terrestrial communities and environments, mixed in these deposits (Codrea & Margin, 2009).

Some remains, the majority of which belonging to large representative mammals, were unearthed by our predecessors from an upper level of the same valley, just a few meters above the mentioned channel. There can still be seen intercalations of sandstones and gray clays, the last layer containing numerous shells or mollusca shells belonging to *Unio wetzleri flabellatiformis* (fig. 4.5).

Fig. 4.5 Clays, with numerous *Unio* shells

Most fossils collected from this fossil site in Valea Pesterii belong to hipparions. Almost all the available data refer to isolated herbivore teeth, a carnivore tooth, but no cranial or postcranial bones as shown in Plates 1-4.

We can only estimate that we have medium sized hipparion probabl;y belonging to a single species, perhaps related to *Cremohipparion mediterraneum,* but a clear systematic position would require further studies based on more fossils. If the Dreşida hipparion is close to the above mentioned species, it may be related to an open habitat (Scott et al., 2005) or it may have also lived in intermediate habitats.

Despite successive excavations on this site no other vertebrate remains, particularly rhino, could be taken. Due to this fact, the presence of these herbivores in this assemblage can only be mentioned. But in the Early Pontian coal deposits, a small tapir, *Tapiriscus pannonicus* was reported (Codrea, 2000).

A small hyena lived also in open habitats, covered with grass. Obviously the carnivore diversity should be higher, but no other representatives were found in Dreşida.

The smallest number of fossils found belongs to rodents; only the *Dipoides* beaver can be documented so far. Smaller mammals are lacking, probably due to taphonomy. *Dipoides* is reported in our country only in Dacian, at Oradea – Dealul Viilor (Jurcsak, 1983), a site with a rather poor stratigraphy.

Non-mammalian vertebrates are extremely rare; we can mention only a few fragments of carapace belonging to a terrestrial turtle.

CHAPTER V

5. SĂRMĂŞAG COAL RADIOACTIVITY

5.1. Coal radioactivity

The main source of coal radioactivity is the U and Th that play an important role in the radiometry, which determines the concentrations of U, Th, K and of ^{226}Ra isotope. Their concentration varies considering the depth of the surface crust rocks and meteorites that have a composition similar to the deep areas of the earth where it is established that there is more U and Th than other chemicals. The distribution of radioactive elements (Airinei, 1977), concentrated coal deposits are determined by rock genesis phenomena (alteration, transport and sedimentation). U and Th have the same behavior in the processes of alteration, transformation and formation of coal. Th does not migrate from the site of formation and concentrates only in residual or alluvial deposits near the mountain of the origin. U gives soluble hexavalent oxidation salts, which pass into solution and migrate. These hexavalent salts turn into tetravalent salts and deposit forming U concentrations. Sometimes, U's products do not migrate with its decomposing elements, while the balance of the Th family grown back in a relatively short period, tens of years. Potassium is abundant in rocks and in granite, its concentration is relatively constant, and it varies in basic and sedimentary rocks.

Living organisms and the whole biosphere is inevitably exposed to low doses of ionizing radiation from natural sources. In different areas of the world, the population is exposed to radiation doses 3-4 times higher than the world average, as in parts of India, China, Japan and Brazil.

Radionuclides in soil are mainly K-40 isotope and radioisotopes in natural radioactive series (U-238, U-235, Th-232), their spread being uneven.

In all areas with a high concentration of these radio nuclides, we find them in uranium mines and surrounding areas, in the Apuseni Mountains (near Ştei) in Banat (near Ciudanoviţa) and Moldova (near the Crucea town).

U-238 Series consists of 14 radionuclide Th-234, protactinium Pa-234, U-234, Th-230, Ra-226 radium, radon Rn-222, Po-218, Pb-214, Bi-214, Po -214, Pb-210, Bi-210, Po-210 and Pb-206 stable. The radionuclide with the highest toxicity is Ra-226. Due to the disturbances suffered by the ground surface and the diffusion of radon in the ground, those 14 radio nuclides are not radioactively balanced in the soil.

U-235 series is found in low concentrations of 0.7% considering U-238 with 99.3%, but do not have a significant effect of irradiation over the population.

Th-232 Series consists of 11 radionuclide (Chadwick, 1966) of which the most important for the environment are the two isotopes of Ra-224 and Ra-228 and the short-lived progeny of 222Rn radon and 220Rn tendon that attaches to the dust particles in the atmosphere and get into the lungs, leading to internal irradiation.

CHAPTER VI

6. Lignite radioactivity in Sărmăşag open pit

The study on Sărmăşag open pit radioactivity was performed in the period 2005 – 2013 by measuring the absorbed dose around the quarry, on multiple tracks, and also by investigations performed in the radioactivity laboratory of Faculty of Environmental Science and Engineering in Cluj Napoca within Land Forces Academy in Sibiu. In the coal and ash samples that were analyzed, varying amounts of primary radio nuclides ^{238}U, ^{232}Th and ^{40}K were found.

Measurements in the open pit were made in 2006 and 2011, they were made using the radiometer of the miniaturized RRM 90 roentgen-meter, designed to measure the level of radiation and the beta contamination degree of the land, the various objects and even liquids, as well as Gamma Scout Geiger radiation detector that measured the absorbed dose in Bobota II quarry, which is part of Sărmăşag deposit.

These measurements were carried out on the ground, along the quarry, the way that connects the quarry to the silo; the recorded data are presented in the tables and figures below. Following the laboratory analyses conducted over the years, we have the following values of ^{238}U, ^{232}Th, ^{40}K between -109.9 5.48 Bq / kg-1 ^{238}U, 2.63 - 44.24 Bq / kg-1 ^{232}Th and 4.61 - 798 Bq / kg-1 at ^{40}K for lignite coal and the ash resulted from burning Sărmăşag lignite values between -116.6 17 Bq / kg ^{238}U-1, 15 - 46.6 Bq / kg-1 ^{232}Th and 14.65 - 914.02 Bq / kg- 1 to ^{40}K.

Measurements in the laboratory were performed using the GEM HpeGe ORTEC spectrometer (FWHM 1.85KeV to 1.33MeV) with Al (1mm) window.

6.1. Study of radioactivity around Bobota II quarry

We measured the absorbed dose in two periods, 2006 and 2011 in several attempts throughout the quarry, the quarry path to the silo and on top of the coal deposit fig. 6.1.

Fig. 6.1. Absorbed dose measurements made in Bobota II quarry/Sărmăşag deposit

The values obtained in 2006 showed a reduced radioactivity over four treks, but a higher radioactivity in the silo and on the deposit. Here the measured values (on the treks) ranged from 0.52 to 1.21 µSv / h, and the silo registered a value of 0.69 µSv / h. In the quarry, above the coal deposit, the measurement showed an absorbed dose of 3.73 µSv / h.

We have determined the measuring points along each trajectory the coordinates being chosen using the GPS.

Path 1 was monitored along the former railway around Sărmăşag station on the NE line where the radioactivity was measured in 17 points Fig. 6.2.

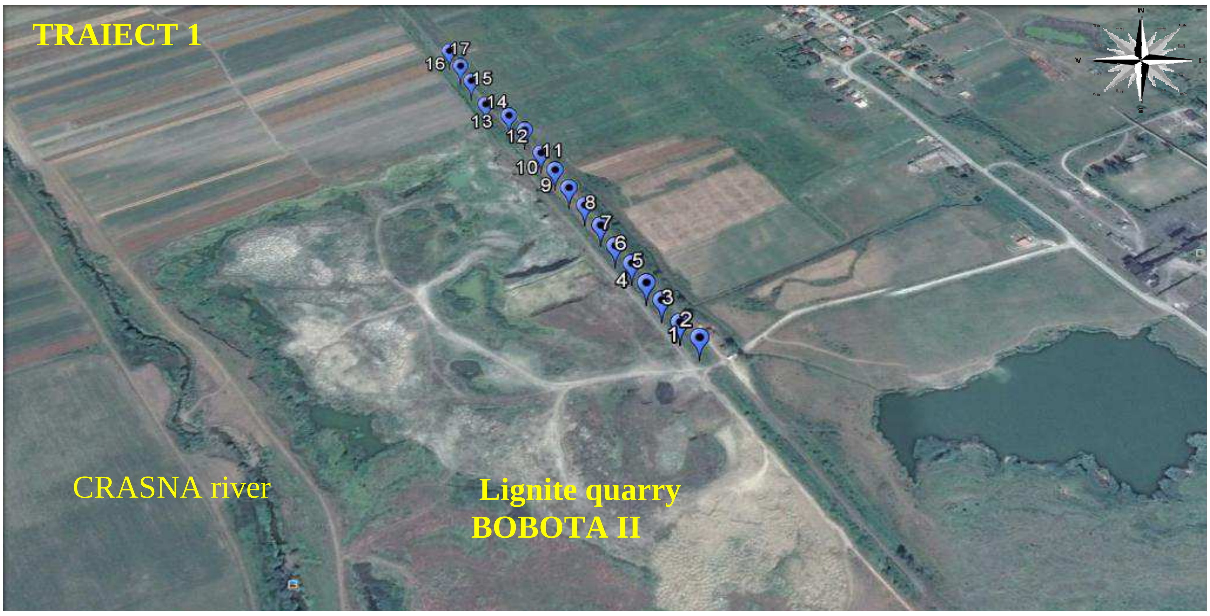

Fig. 6.2. The representation of the measurement points for the absorbed dose on trek 1

The values obtained were in the range of 0.26 to 0.78 μSv / h, the average value of these measurements was 0.34 μSv / h, fig. 6.4. The highest value was at the measuring point number 4 0.78 μSv / h and lowest at the points 1, 7, 9, 10 with an index of 0.26 9.10 μSv / h, fig. 6.3.

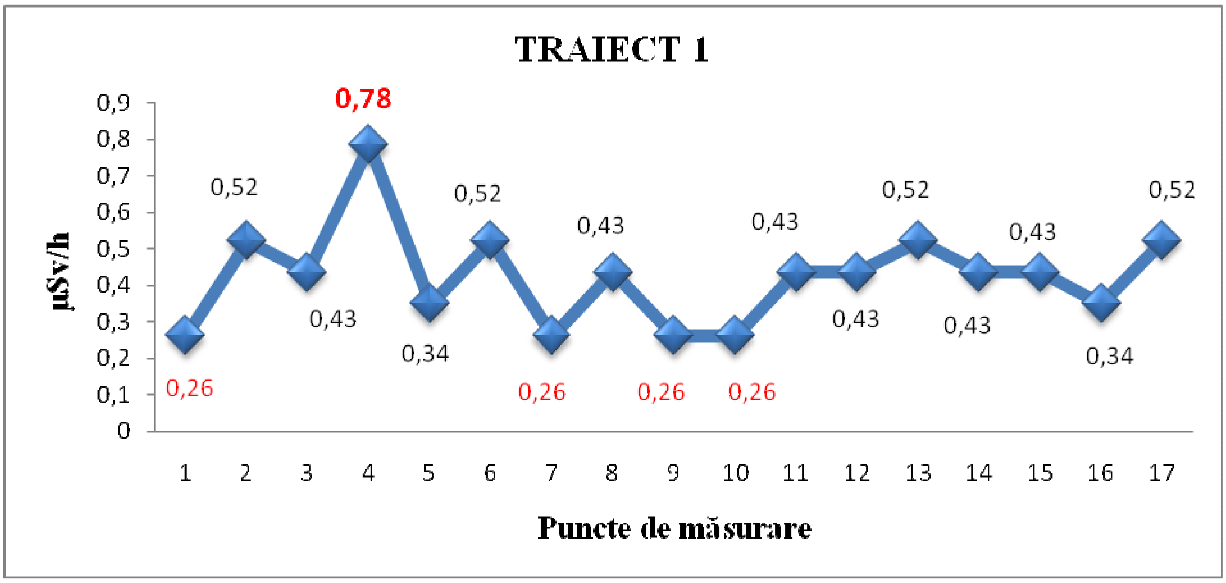

Fig.6.3. Variation of the absorbed dose on the measurement trek 1

In 2011, we continued the study on the ground along quarry using Gamma SCOUT Geiger radiation detector, Figure 6.4 presents the measurement points.

Fig.6.4. Absorbed dose measurement points - 2011

Data from the measurements that were within 0.06 to 0.20 µSv/h using Gamma SCOUT Geiger radiation detector.

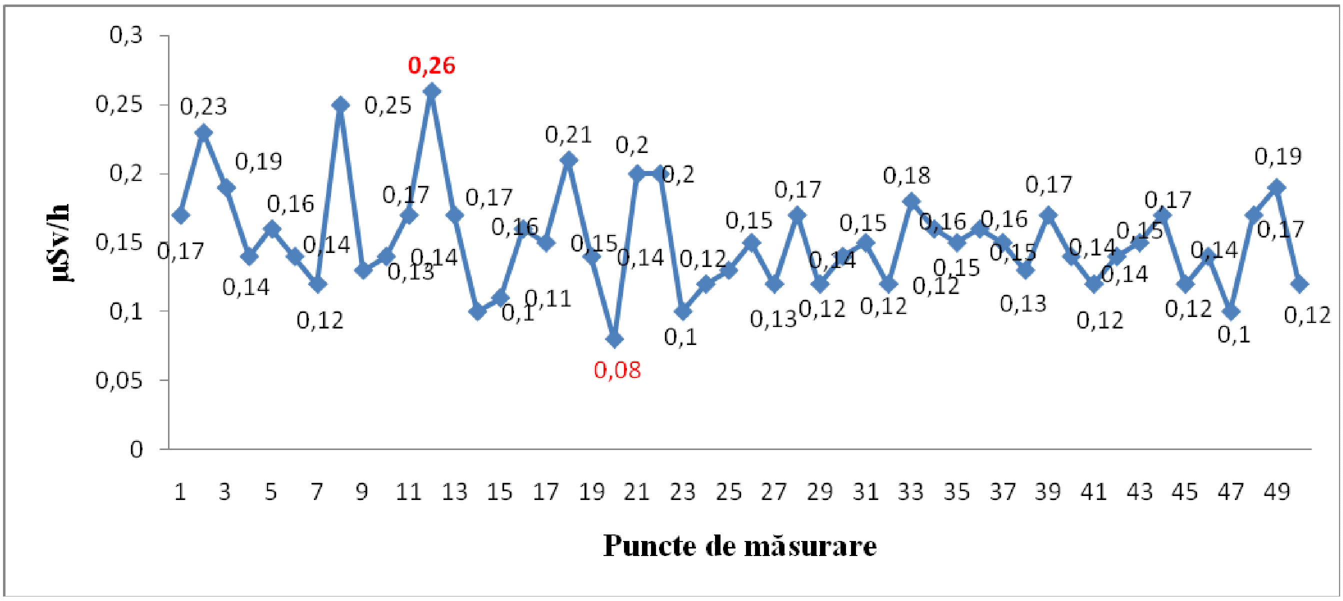

Fig. 6.5. Graph values obtained along the quarry - 2011

We performed the field measurements in 2011 in 50 measurement points along the quarry the values ranging between 0.08 and 0.26 µSv / h, as shown in Fig. 6.5. the higher value being obtained in the 12 point of measurement 0.26 µSv / h, and the lowest value being obtained in point 20 of 0.08 µSv / h.

6.2. The study of Sărmăşag lignite radioactivity

The study of Sărmăşag lignite radioactivity continued, on data obtained in the Laboratory of Radioactivity at the Faculty of Science and Environmental Engineering Cluj Napoca.

Thus, during 2005 – 2012, I collected 21 coal samples from different areas of the quarry: fig.6.7. Coordinates were taken using GPS.

An estimate of the concentration of radioactive elements in coal samples collected from Sărmăşag was made using advanced technology. The 21 samples were collected from layer sixteenth of Bobota II quarry, Sărmăşag deposit, they contain traces ^{238}U, ^{226}Ra, ^{232}Th, ^{40}K (Margin et al., 2009).

Determination of radio nuclides began with the preparation of the samples. Samples in powder form (100-150g) were placed in cylindrical cans with a diameter of 8 cm and height

3.5 cm. The boxes are sealed and stored for 30 days to reach certain equilibrium between Ra-226 and radon followers.

The measurements were performed using a multi-channel spectrometer ORTEC Digidart the HPGe detector type semiconductor such as GMX (Gamma-X) with a beryllium window fig.6.6. Field of the detector energy that works between 10 and 1,500 keV.

Fig. 6.6. ORTEC GMX detector FWHM HpeGe 1.92KeV at 1.33MeV with Be window.

The detector has a resolution of 1.92keV 1.33MeV at the energy of the Co-60 and 34.2% relative efficiency.

These, as we presented above, were dried and specific radioactivity was measured. The samples collected over the years are shown in FIG. 6.7 where one can see the sample zones from several quarry areas on the ore, considering the daily operation at that time.

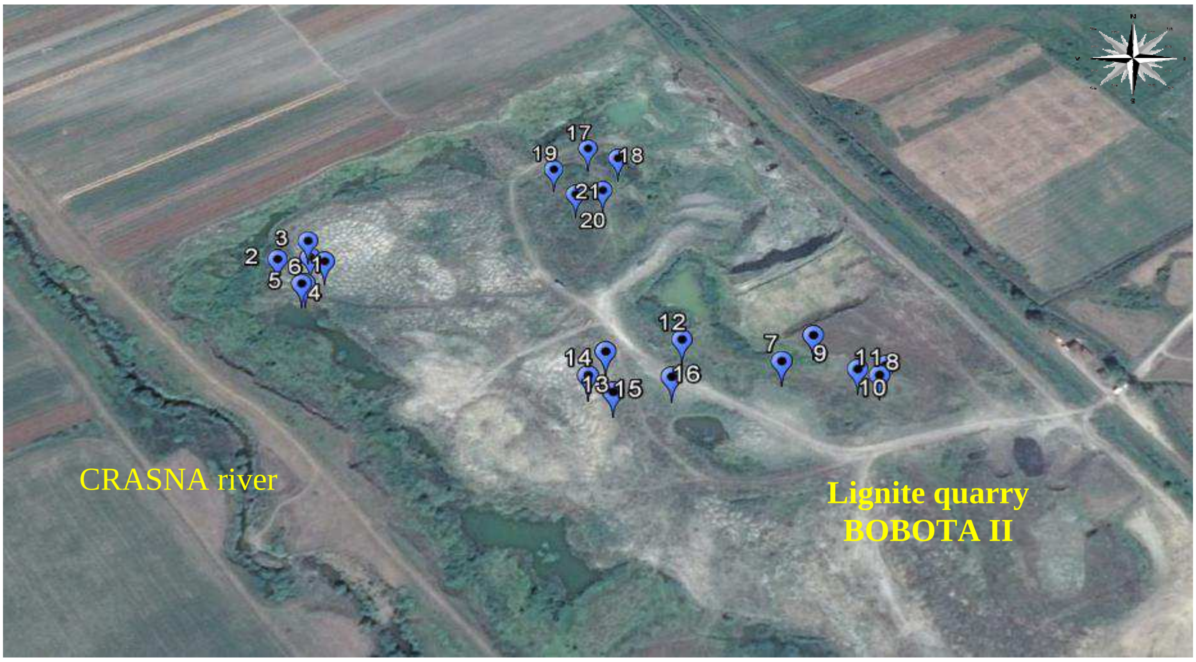

Fig. 6.7. Collection points of coal samples from BOBOTA II quarry

Below, the values of radio nuclides 238U, 232Th, 40K are presented graphically, as identified from the lignite samples studied, on each sample there are presented the minimum and maximum values obtained, which are between 2 Bq / kg-1 and 798 Bq / kg-1.

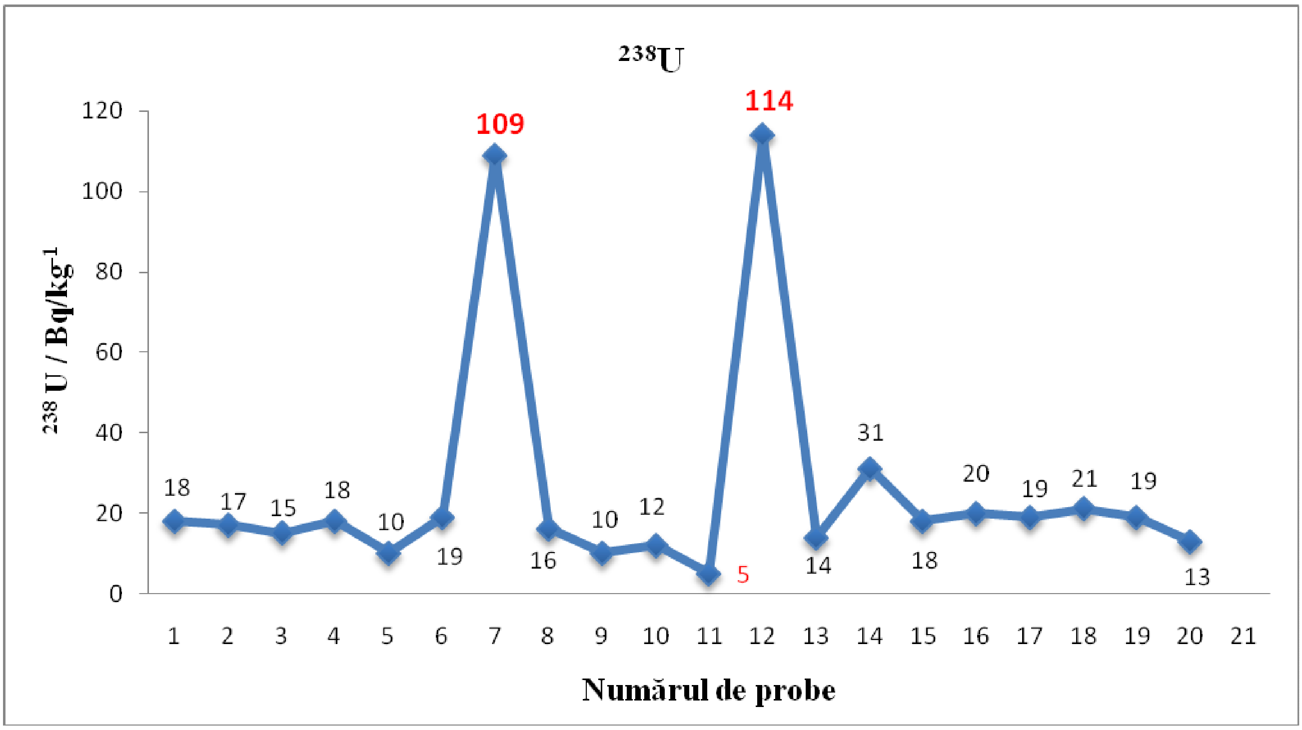

Fig. 6.8. 238U radionuclide variations samples obtained from coal

Thus, the studied samples ^{238}U registered values between 5.48 and 114.7 Bq / kg-1, the average value of ^{238}U Sărmăşag lignite being 24.66 Bq/kg-1. These concentrations maintain also regarding the global average values which are of 35 Bq / kg-1 of ^{238}U (UNSCEAR, 2000). Two high values can be observed meaning that in that part of the quarry there were higher uranium accumulations probably due to vegetation in that area.

The highest values, as shown Fig. 6.8, are in points 7, 12, 14 situated approximately in the center of the quarry where it seems that the accumulation of uranium was probably higher. The other values obtained from the west part or the north part of the quarry remained within the global average limits of coal. Accepted global limits for the concentration of ^{238}U radionuclide in coal are between 17-60 Bq / kg-1 (UNSCEAR, 2000).

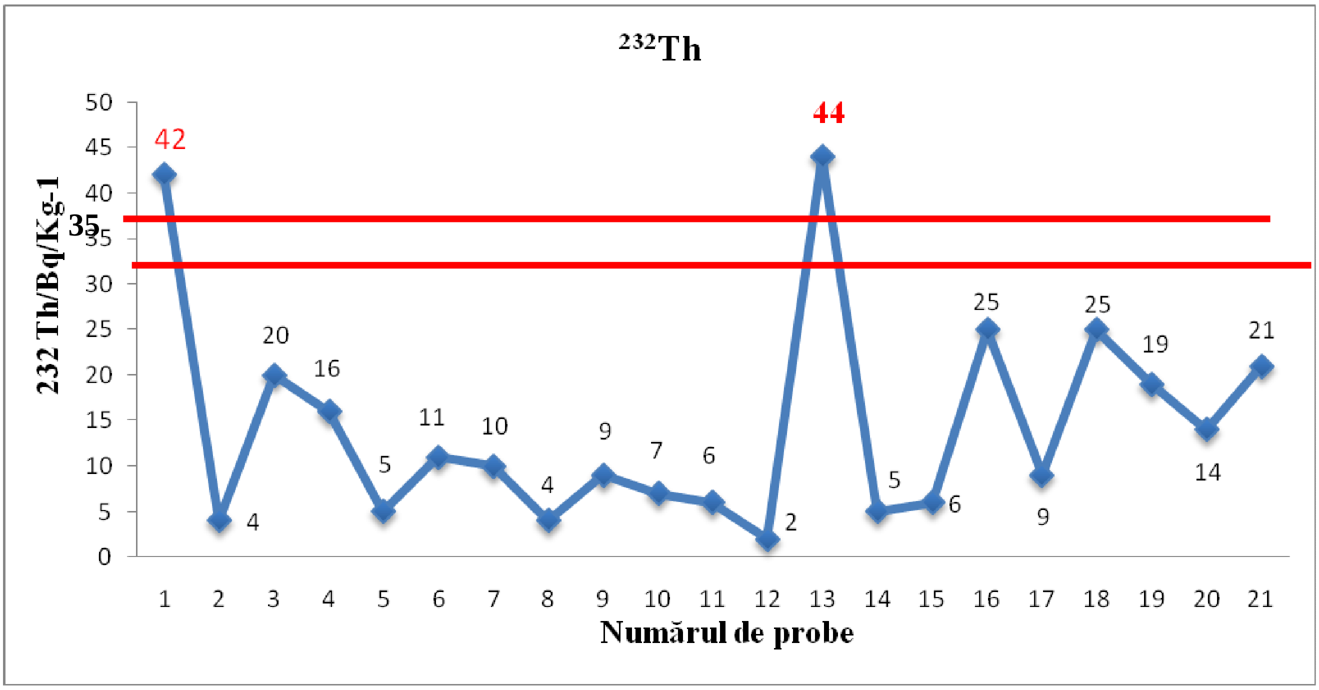

Fig. 6.9. Variations of the radionuclide 232Th samples obtained from coal

Figure 6.9 exhibits the variations of the 232Th concentration that are between 4 Bq / kg, 1:44 Bq / kg-1, the average of which being 14.47 Bq / kg-1-^{1}. We have two values over the world average in points 1 with a value of 42 Bq/kg^{-1}:13 worth 44Bq/kg^{-1}. They are above the world average of 30 Bq/kg^{-1}, but within the limit of 232Th radionuclide concentration which is between 1- 64 Bq/kg^{-1} (UNSCEAR 1993, 2000)

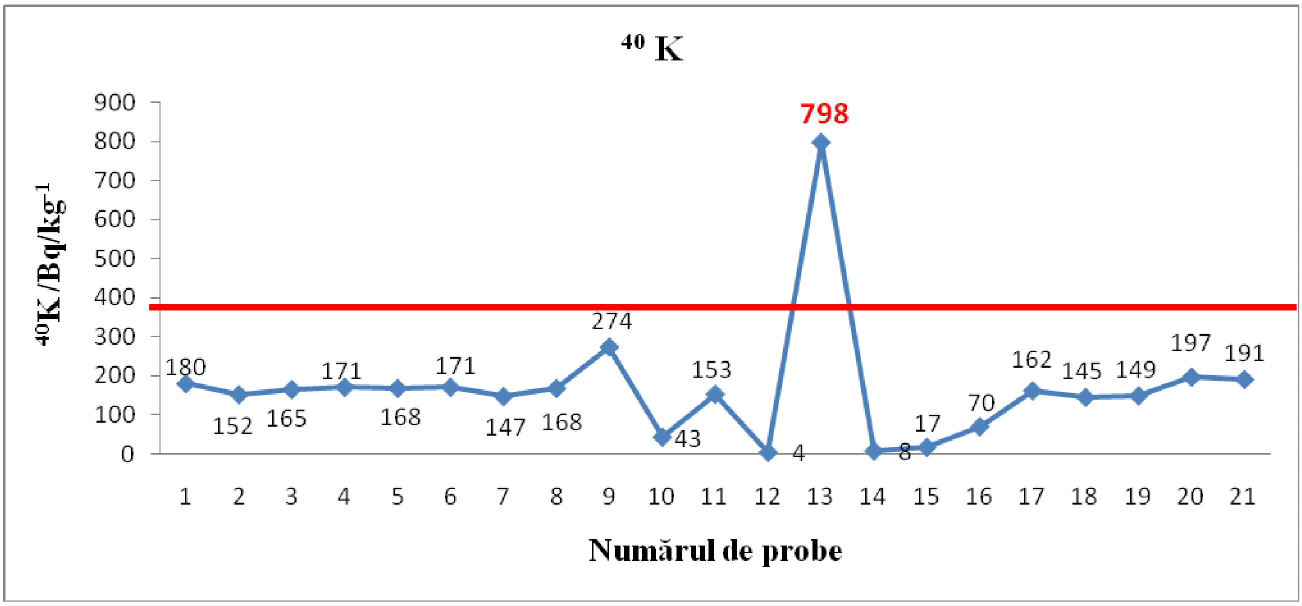

Fig. 6.10. *The v**ariations of 40K radionuclide obtained from coal samples***

In fig. 6.10., ^{40} K radionuclide concentrations are given, with values ranging from 4 to 798 Bq/kg^{-1}, their average being 168.23 Bq/kg^{-1}. Changes in ^{40} K radionuclide falls within the global average of 400 Bq/kg^{-1}.the highest value can be found in point 13 with an index of 798 Bq/kg^{-1}, a value close to the maximum permissible concentration of carbon ^{40}K the value of which is 850 Bq/kg^{-1}. The concentration limits of ^{40}K radionuclid from coal are between 140 - 850 Bq/kg^{-1} (UNSCEAR 1993, 2000).

6.3. The study of the radioactivity of Sărmăşag lignite ash

I continued the study measuring ^{238}U, ^{232}Th, ^{40}K radionuclide ashes activity resulted from burning lignite at Bobota II quarry. Coals were collected from 15 points, from Bobota II quarry, fig. 6.11. They were burned and the radioactivity of ^{238}U, ^{232}Th, ^{40}K radionuclides was measured in the Radioactivity Laboratory of the Faculty of Science and Environmental Engineering Cluj-Napoca using ORTEC GMX detector FWHM HpeGe 1.92KeV at 1.33MeV with Be window where there were displayed values between 17-122 Bq/kg^{-1} for ^{238}U, 15-122 Bq/kg^{-1} for ^{232}Th and 87-914 Bq/kg^{-1} for ^{40}K.

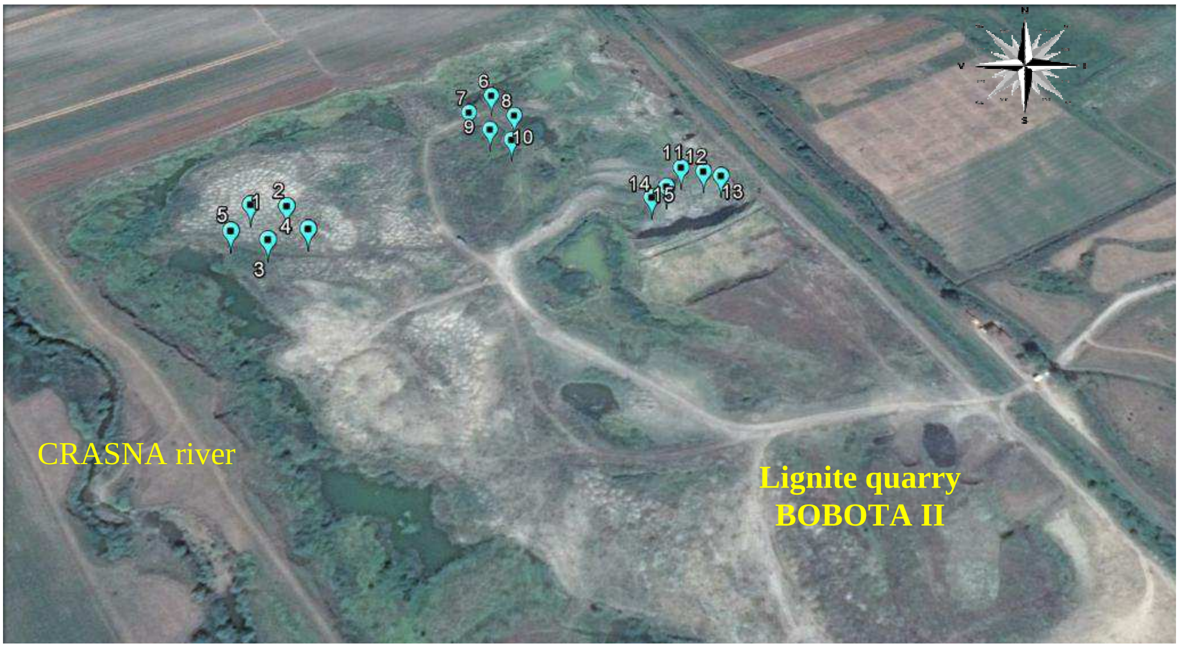

Fig. 6.11. Collecting locations of coal samples in BOBOTA II quarry (according to Google Map)

The radioactivity of the resulted ash greatly depends on the chemical and physical characteristics of the coal, in our case by the Sărmăşag lignite. These characteristics, during the burn, modify the concentration of the radionuclide which leads to values twice or three times higher for the ash than for the coal.

For uranium, thorium, potassium this higher value is due to the fact that, during the combustion, the decomposition products are distributed from the gas stage to the solid combustion products. This division is controlled by volatility and the other chemical elements, the elements ^{238}U, ^{232}Th, ^{40}K being less volatile, they remain in the solid stage meaning waste. Due to these changes, the radioactivity of the ash is ten times higher than that of the coal (Pandit et al., 2011).

For uranium, fig. 6.12, the highest value is in the collection point 5 located in the West of the quarry near Crasna river, fig.6.7, and the lowest in the point 14 located in the eastern part of the quarry, the average value being 53.33 Bq/kg^{-1}. Hence it can be concluded that the accumulation of uranium in the ash is higher in the west part of the quarry near Crasna river versus the eastern part of the quarry.

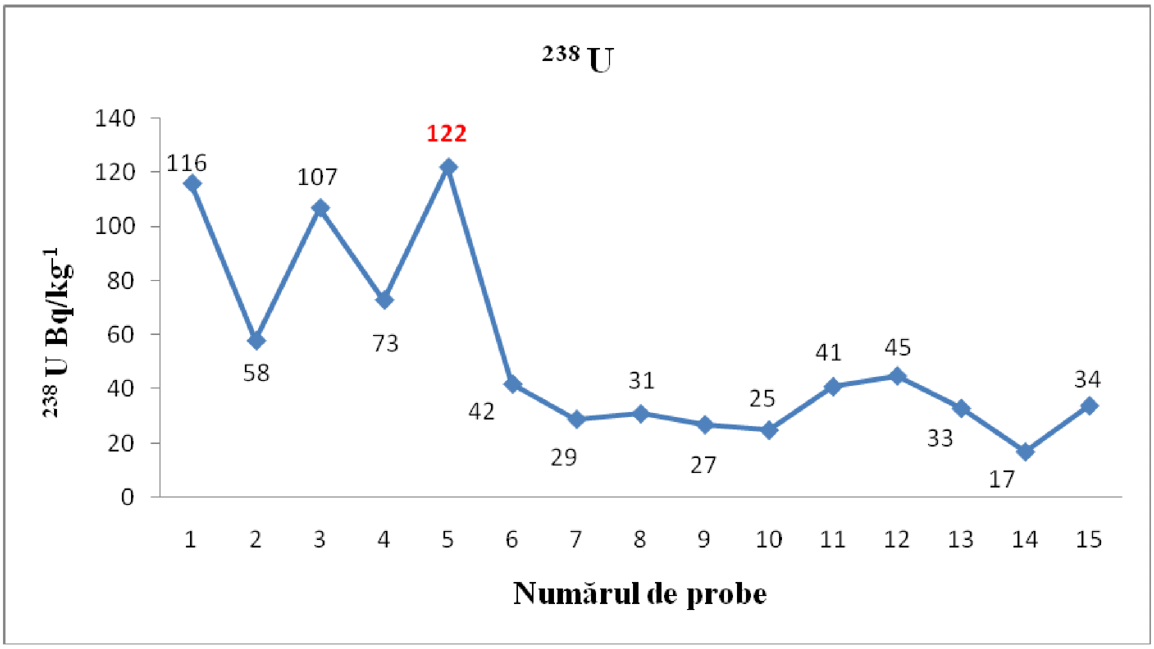

Fig. 6.12. The variations of ^{238}U radionuclide obtained from samples of ash

The highest value for ^{232}Th, fig. 6.13, was found at the point of measurement 5, of 96 Bq/kg^{-1} and the lowest at the measurement point 6 (15 Bq/kg^{-1}) in the western part of the quarry, with an average value of 38.53 Bq/kg^{-1}.

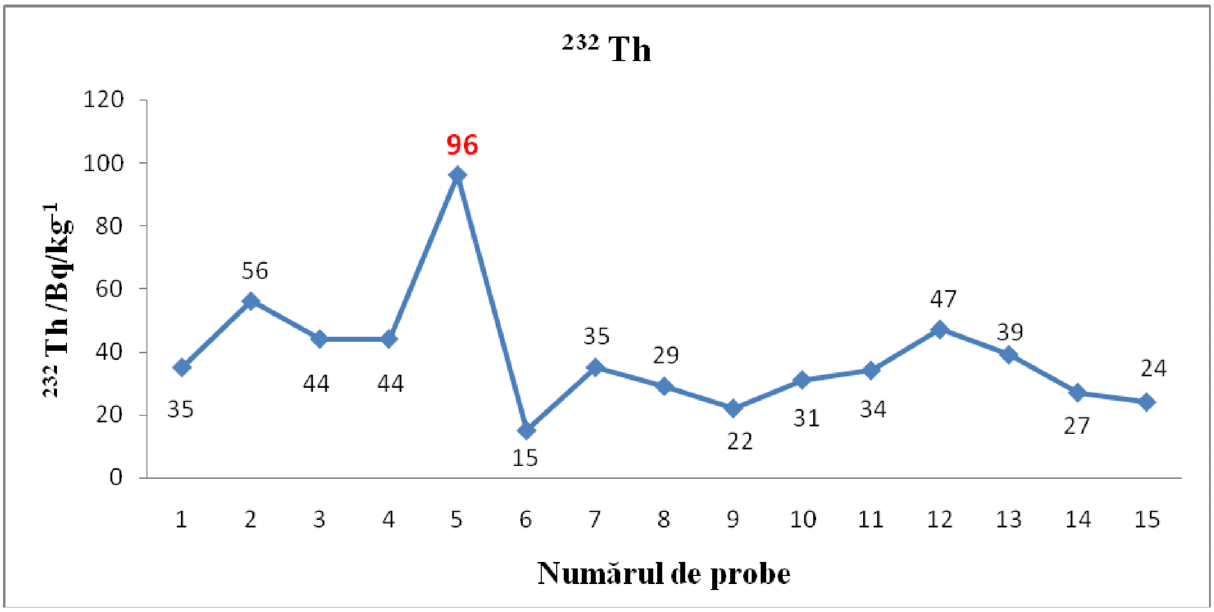

Fig. 6.13. The changes in ash obtained from samples of 232Th radionuclide

The radioactivity of ^{40}K radionuclide was measured, because it is the most common, we are exposed to it more often, and it also has the highest value. Its accumulation is higher in the Sărmăşag lignite ashes than in ^{238}U and ^{232}Th, fig. 6.14, with an average value of ^{40}K radionuclide of 213.46 Bq/kg^{-1}. This large reservoir is probably biological due to the vegetation of that period, which led to the formation of coal and assimilated more ^{40}K with longer division time (Timar, 2013)

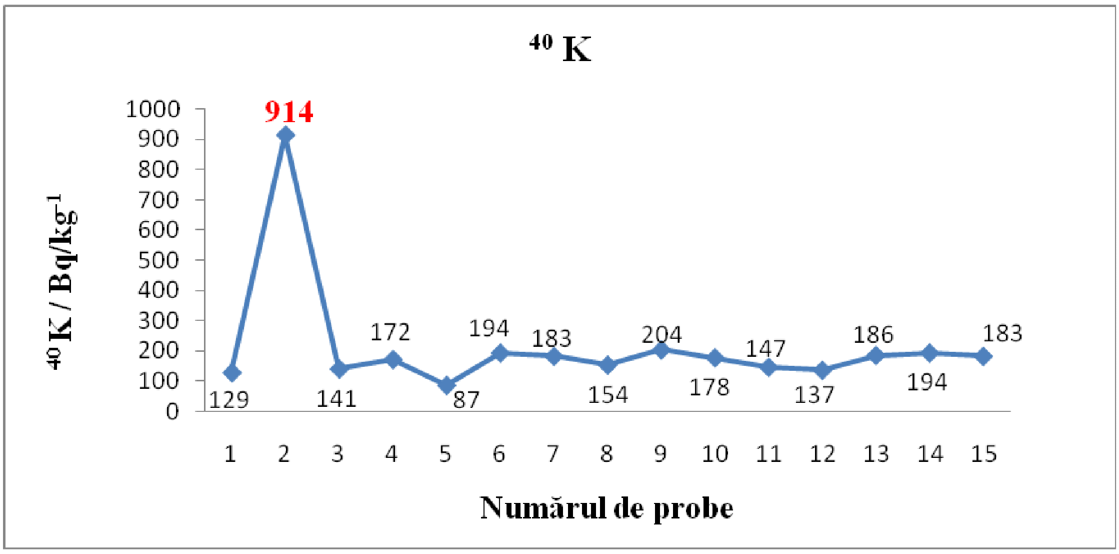

Fig. 6.14. Changes in ash obtained from samples of ^{40}K radionuclide

6.4. Risk assessment of the radioactivity of the coal and Sărmăşag lignite ash

The most important source of electricity generation remains the coal, but it is also the most polluting because the result of the combustion is ash that floats around as well as ash that is deposited in landfills. This ash contains toxic elements such as As, Cd, Cr, Ni, Co, Cu, Sb that are release into the nature, soil, groundwater, but there are also ^{238}U,^{232}Th, ^{40}K radionuclides that we studied. Most power plants that use coal to produce electricity are located near residential areas; their environmental impact is conditioned by the thermal power capacity.

Thus, in this study we used data values of ^{238}U, ^{232}Th and ^{40}K radionuclides obtained, over years of study, from the ashes of Sărmăşag coal. For accurate calculation of absorbed dose in ash, the burning was conducted in the laboratory as the coal thermal power plant in Zalau used coal from several areas and the results were not conclusive.

Using the formulas we determined the gamma dose (D) emitted in the air using the values obtained from the three elements ^{238}U,^{232}Th, ^{40}K from the ash resulted from burning lignite. We calculated the dose using Hamilton formula. Hamilton studied the gamma radiation on materials used in construction (Hamilton, 1971).

The measurement of the absorbed dose is described by the formula:

$$D = (0.462C_U + 0.604C_{Th} + 0.0417C_K)\ nGyh^{-1} \quad (6.1.)$$

where D represent the absorbed dose rate, conversion factor in sand (1 Bq kg^{-1}) which is used with radionuclides and for ^{238}U and is 0,462462, for ^{232}Th is 0.604 and for ^{40}K is 0.0417, but C_U, C_{Th}, C_K represent the values for ^{238}U,^{232}Th, ^{40}K radionuclides obtained from the Sărmăşag lignite ash. The absorbed dose rate for ash is between 31.37 and $nGyh^{-1}$118,92 $nGyh^{-1}$. The overall average of the absorbed dose is 55 $nGyh^{-1}$ (UNSCEAR, 2000).

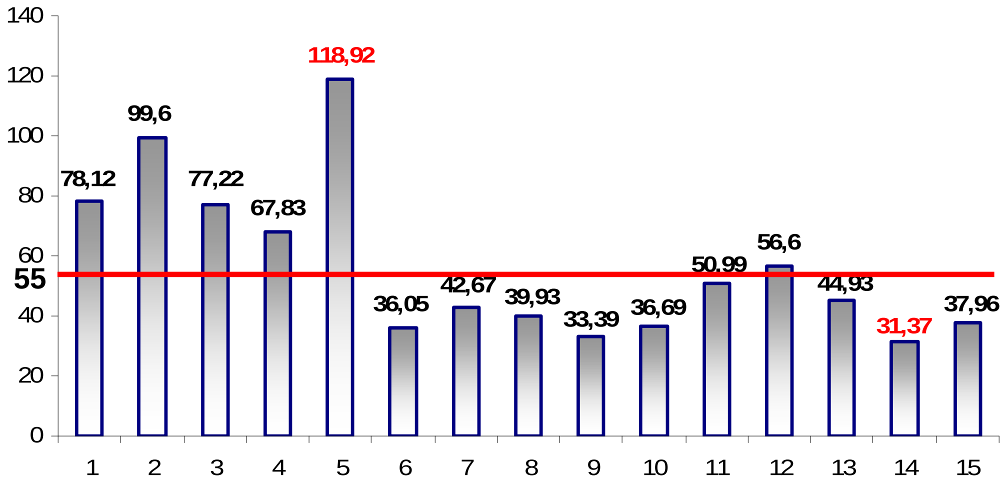

Fig. 6.15. Dose rate variation in ash samples

In fig.6.15, the values resulting from the calculation of absorbed dose in ashes, shows, at the 15 points measured, values elevated above the permissible limit of 55 $nGyh^{-1}$ in 6 measurement points 1 (78,12 $nGyh^{-1}$), 2 (99,6 $nGyh^{-1}$), 3 (77,22 $nGyh^{-1}$), 4 (67,83 $nGyh^{-1}$), 5 (118,92 $nGyh^{-1}$) and 12 (56,6 $nGyh^{-1}$).

To constitute the hazard for these three elements (^{226}Ra, ^{232}Th, ^{40}K) also called radium equivalent (Ra_{eq}), it is obtained considering the the sum of the specific activities of material radioactivity and the activity of the three radionuclides Ra, Th, K (Krisiuk et al., 1971) and it is described using the following equation, by Beretka and Mathew (Beretka & Mathew, 1985):

$$Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.077C_K \ Bq/Kg^{-1} \quad (6.2)$$

where C_{Ra}, C_{Th}, C_K represents the values of the radionuclids ^{226}Ra, ^{232}Th, ^{40}K obtained from the Sărmaşag ash, and 1,43 as well as 0,077 are the coefficients obtained from the ratio Ra/Th, Ra/K.

Radium equivalent activity in building materials is not uniform and the maximum permissible value should not exceed 370 Bq/Kg^{-1} for ^{226}Ra. For ^{232}Th the value is 260 Bq/Kg^{-1}, and for ^{40}K of 4810 Bq/Kg^{-1} (Stranden, 1976).

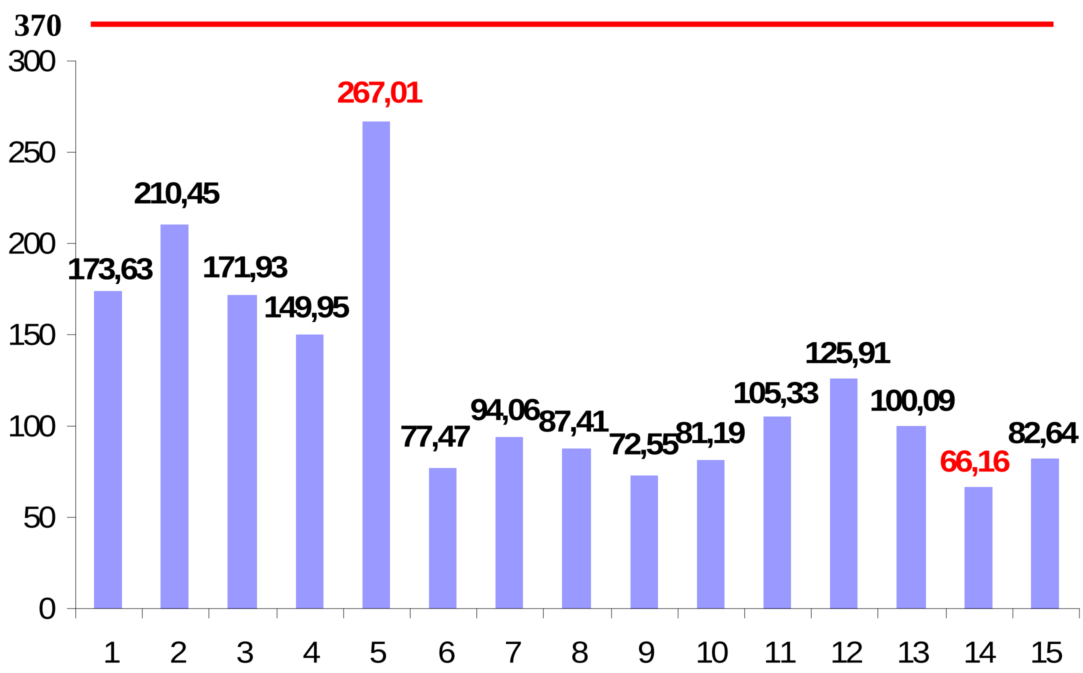

Fig. 6.16. Variation of equivalent radium activity in ash samples

The equivalent radium activity, measured in the 15 ash samples, shows values comprised between 66,16 and 267,01 Bq/Kg^{-1}6.24 fig. 6.16. These values are within the average for ^{238}U, which is 370 Bq/Kg^{-1} (UNSCEAR, 2000).

Next we calculated an estimate of the annual effective dose for ashes, where we used formulas (Cevik et al., 2007), for the occupancy factor of indoor and outdoor exposure using the formulas:

- for outdoor exposure:

$$EDR\ (mSv/y^{-1}) = D\ (nGy/h) \times 8760h \times 0.7\ Sv/Gy \times 0.2 \times 10^{-6} \quad (6.3)$$

- for indoor exposure:

$$EDR\ (mSv/y^{-1}) = D\ (nGy/h) \times 8760h \times 0.7\ Sv/Gy \times 0.8 \times 10^{-6} \quad (6.4)$$

where D is the absorbed dose, 0,7 Sv/Gy, ratio of the absorbed dose in air, respectively 0.8 is the occupancy factor for exposure inside, while 0.2 is the occupancy factor for external exposure, the data being obtained for the effective annual rate.

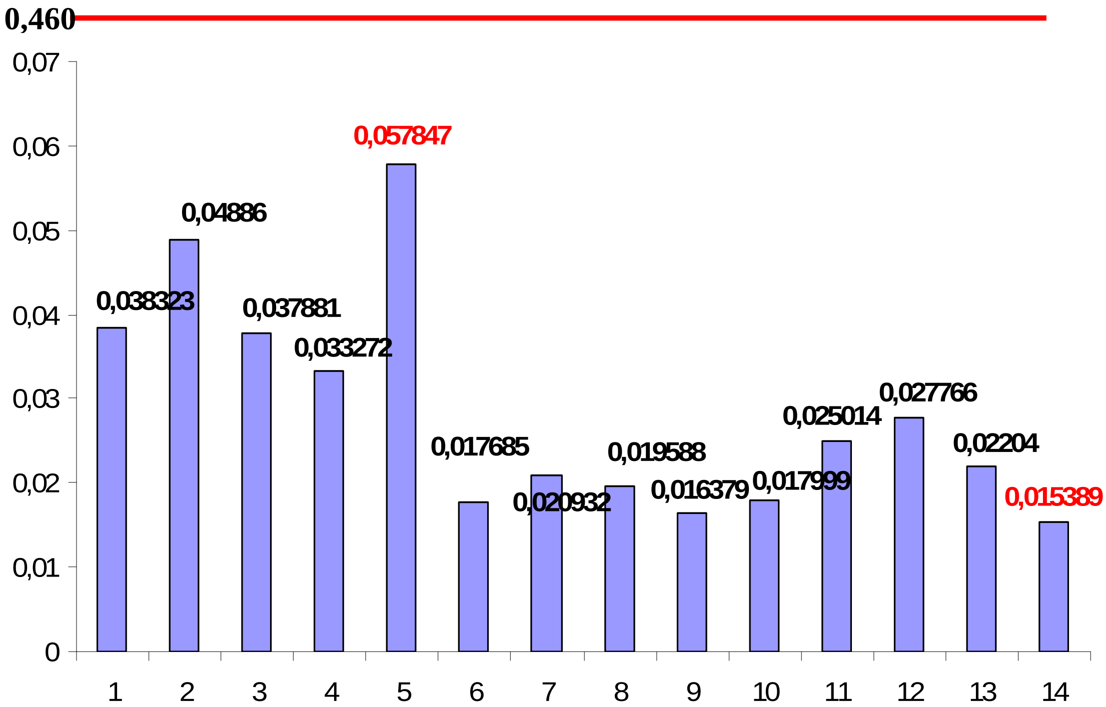

Fig. 6.17. Effective annual rate variation measured indoor for the activity of the Şărmăşag coal ash

Data for calculation of the effective annual rate of activity measured inside for the Sărmăşag coal ash fall between 0,015389 mSv/y^{-1} and 0,057847 mSv/y^{-1}, fig. 6.17.

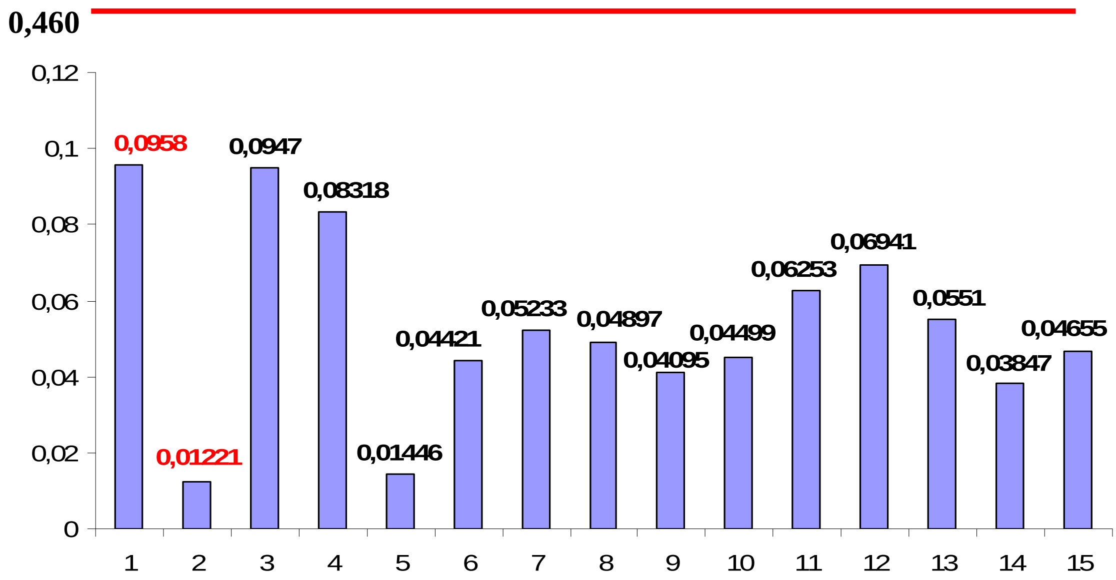

Fig.6.18. Effective annual rate variation measured outdoor for the activity of Şărmăşag coal ash

The calculations made considering the annual rate measured outdoor for the activity of Şărmăşag coal ash fig. 6.18., is in the range between 0.01221 and 0.0958 mSv/y^{-1} well below the 0,460 mSv/y^{-1} (UNSCEAR, 2000).

6.5. Study of alpha radioactivity of Sărmăşag lignite

In this section, we describe the study of coal from Sărmăşag, the alpha radiation levels present in different samples taken in 2013, this study being perfomed within the Department of the Army Technical Science Academy "Nicolae Bălcescu" Sibiu.

We collected 12 samples of coal from the quarry in Bobota II. The samples were milled and put into individual containers, then in exssicators and were weighed on analytical balance with accuracy up to 4 decimals.

6.5.1. Alpha radioactivity measurement method

The sample to be measured was introduced into the sample holder placed in the hollow disk uplifting support device. The placement of the disc on the support is necessary in order to raise the measuring tray to the smallest distance from the transducer, thus measuring the entire flow of alpha radiation; the radiation is strongly attenuated even by a few millimeters of air (Margin et al., 2013).

6.6. Comparative study of radioactivity of Sărmăşag and Husnicioara lignite

A comparison of the radioactivity of lignite from Sărmăşag and that from Husnicioara can be done. The study of the radioactivity of Husnicioara lignite was carried in the 2009 and aimed to a quantitative analysis of key ^{238}U, ^{232}Th, ^{40}K radionuclides in coal. The samples were collected from the fourth layer of the coal bed which consists of two sets of coal (Cosma et al., 2009). These samples were taken from the top and bottom area of the coal bed. Geologically, the lignite from Husnicioara is Pontian, Dacian and Romanian (Meilescu, 1994; Diaconu, 2001; Codrea & Diaconu, 2003 Diaconu, 2004) and the vegetal residues consist of *Byttneriophyllum tiliaefolium* leaf type, *Glyptostrobus europaeus*, *Salix*, with preserved wood by *Glyptostroboxylon* (Ţicleanu & Bitoianu, 1989).

The comparative study was made considering the average of ^{238}U, ^{232}Th, ^{40}K radionuclides from Sărmăşag lignite and the average of lignite radionuclides from Husnicioara quarry, from the lower layer of coal Table 6.1.

Table 6.1. The average of lignite radionuclides in Husnicioara and Sărmăşag quarries.

Quarry	Sărmăşag	Husnicioara
^{238}U (Bq/Kg^{-1})	57.33	160.33
^{232}Th (Bq/Kg^{-1})	38.53	29
^{40}K (Bq/Kg^{-1})	213.46	235.66

Average concentrations at the two careers vary from between 57.33 – 160.33 Bq/kg^{-1} to 38.53 - 29 Bq/kg^{-1} for ^{232}Th, respectively 213.46 – 235.66 Bq/kg^{-1} for ^{40}K, meaning for the samples from Husniciora. The values from Sărmăşag are between 5 -114Bq/kg for ^{238}U, between 2 - 44 Bq/kg for ^{232}Th, respectively 4 - 798 Bq/kg for ^{40}K.

6.7. Paleoenvironment studies in the mining sectors Sinersig, Visag, Derna

Changes in the Neogene period, from the paleoclimatic point of view, determined the alteration of paleoflora, which can be seen in both the micro- and macroflora. Neogene micro- and macroflora from Visag, Sinersig, Derna and Tătăruş mining sectors have been studied in many outcrops with hundreds of taxons identified. These flora elements are identical to the one studied in Chapter II of this paper so we can draw conclusions on how the three U, Th, K radioactive elements accumulate in Pontian Sărmăşag coal.

During Miocene, flora evolved much as the swampy sedimentary environment was in Sărmăşag area. At that time, the paleoclimate was warm temperate with an annual average up to 18^{o}C and precipitation regime of 1200 mm / yr. (Petrescu et al., 1980), as outlined in the mining sectors and Visag Sinersig. The studied macroflora is uniform and less differentiated in both sectors Visag and Sinersig, consisting of *Osmuda*, *Glyptostrobus*, *Alnus*, *Betula*, *Zelkova*, *Acer*, *Alangium* etc.

CHAPTER VII

7. THE IMPACT OF THE SĂRMĂŞAG MINING ON THE ENVIRONMENT

7.1. The impact of mining on the environment

As shown in previous chapters, Romania has many deposits of coal, mining activities and capitalizing on them has a great history in this part of Europe. Throughout history with the development of industry the production of mineral substances has also increased in different historical ages, the maximum being reached in the twentieth century (Fodor, 2006).

Along with the social changes, at the end of 1989, the mining industry in Romania was in full production, with a great number of operating and processing units for both coal and other minerals, of which only some were operating under the appropriate quality conditions and with economic efficiency. With the start of mining restructuring in Romania some mitigation measures were required and only the profitable units remained active. In this respect, there was a rigorous analysis of the entire extractive industry and the weak points in the mining sector were identified. Among the measures that led to the alignment of mining with the standards imposed by the European Union, both technically and economically, were the following:

- Preserving productive units;
- Closing down objectives with major losses;
- Improving the activities for the remaining operating units;
- Rendering redundant a number of employees;
- Rendering the areas affected by mining ecologically sound.

The measures mentioned above led to mining efficiency, while improving the quality of the coal and the environment.

7.2. The Sărmăşag deposit

The Sărmăşag deposit is in constant transformation, because according to the documents, by the next years, the operation could be closed, and the area integrated into the economic circuit, as it happened to the first exploitation site, Bobota I. Thus according to data obtained from the Sărmăşag exploitation site the average value of the lignite production in Bobota mine was between 80 000 tons / year and 20,000 tons / year.

7.3. The impact of ore exploitation on water

Since water is the basis of life we can conclude that water pollution is a great hazard to living organisms (Onica, 2001).

The danger is the water discharged from some uranium mines containing radionuclides of uranium, radium, vanadium. Out of these radium is the most dangerous as well as the exposure to these radionuclides harmful to living organisms and some plants, fish and animals can accumulate these radionuclides in their tissues, resulting in an accumulation of radioactive material.

Examples of water discharged from the mine in the world are Poland which operated daily 900,000 m^3 of water, while in the United States 4000 miles of rivers and streams have been affected by the water discharged from the mines (Onica, 2001).

Land deformations due to coal mine exploitation leads to a series of natural discontinuities and to the formation of channels between the ore and ground water.

American rules established since 1978 a total of 65 pollutants considered toxic in mine water, among which we mention only a few, such as arsenic, asbestos, beryllium, cadmium, chromium, copper, mercury, selenium, etc.

In the case of the Sărmăşag mine, there are a number of factors which have an impact on water, one of these factors is the disruption of groundwater resources, one qualitative and the other quantitative, hence their effect which can be temporary or long lasting.

In the case of quarries, dewatering has the effect of hydrostatic lowering of the groundwater level, which also occurred in the localities neighboring the Bobota II deposit, respectively Derşida, Bobota, Sărmăşag where wells have dried out after closing the quarry and filling it with tailings. Deep groundwater under pressure gave rise to springs, bodies of water that are captured and removed from the perimeter of the quarry using pumps and is then being discharged into the Crasna valley. There is a tendency to return to the initial hydrostatic level, but this can lead to water contamination due to mineral components from the tailings which react in water. In Sărmăşag village the locals are supplied with water from the impermeable layers of deep groundwater.

However, inside the Sărmăşag mine there was a decrease in the hydrostatic level of the groundwater through wells drying up in the area. Some of them filled up again after the cessation of underground mining, to date all underground galleries being flooded.

At present the main natural receptor is the Crasna Valley, which is situated NW from the Bobota II quarry. Waters from mining have different qualities and have a high content of chlorides, sulfates, oxides, etc.

In 2011 we collected five water samples from different areas of the quarry as presented in fig. 7.1.

Fig. 7.1. Water Sampling

The analysis of the water samples was later carried out at the LIAS laboratory in the Faculty of Environmental Sciences using the compact absorption spectrometer using the atomic absorption compact spectrometer Zeenat 700, fully automatic, single and double beam with flame atomization and transversely heated graphite furnace, the device being controlled externally through an evaluation and control unit (computer) with the possibility of moving from one technique to another through software. Fig. 7.2.

Fig. 7.2. Zeenat 700 atomic absorption spectrometer

We measured the pH, salinity, conductivity and temperature results obtained as shown in Table 7.1.

Table 7.1. The results obtained in conductivity, pH, salinity, temperature

Sample	conductivity (**μS/cm**)	**pH**	Salinity	**Eh**	**T°C**
S1	1320	8,179	0,6	-81,6	20
S2	974	8,17	0,4	-81,5	19,4
S3	2330	7,95	1,2	-68,9	19,4
S4	968	8,017	0,4	-72,5	19,7
S5	1100	8,01	0,5	-72,3	20,2
CMA / NTPA 001/2005	**-**	**6,5 – 8,5**	**-**	**-**	**35**

Out of these, according to some samples taken after the mining operations in the Bobota II from different locations in the quarry, the laboratory data showed that the pH is kept within normal limits, with values between 6,5 - 8,5, and the other values remain the same in those normal data.

For the same samples we measured the chlorides, fluorides, sulfates, nitrates, where the values of chlorine nitrate are within the limits under current regulations which are listed in Table 7.2. Higher values were observed in all five fluorine samples, nitrate sample 1 and 3 and sulfates sample 3.

Table 7.2. The values obtained in fluorine, chlorine, sulfates, nitrates

Sărmaşag	**Conc (ppm)**			
Sample	**F**	**Cl**	**NO3**	**SO4**
S1	**11,633**	46,884	**59,178**	403,627
S2	**16,722**	28,459	20,786	223,559
S3	**15,343**	72,039	**52,121**	**1201,415**
S4	**10,920**	66,597	12,226	171,724
S5	**8,315**	61,546	18,337	260,398
CMA / NTPA 001/2005	**5**	**500**	**50**	**600**

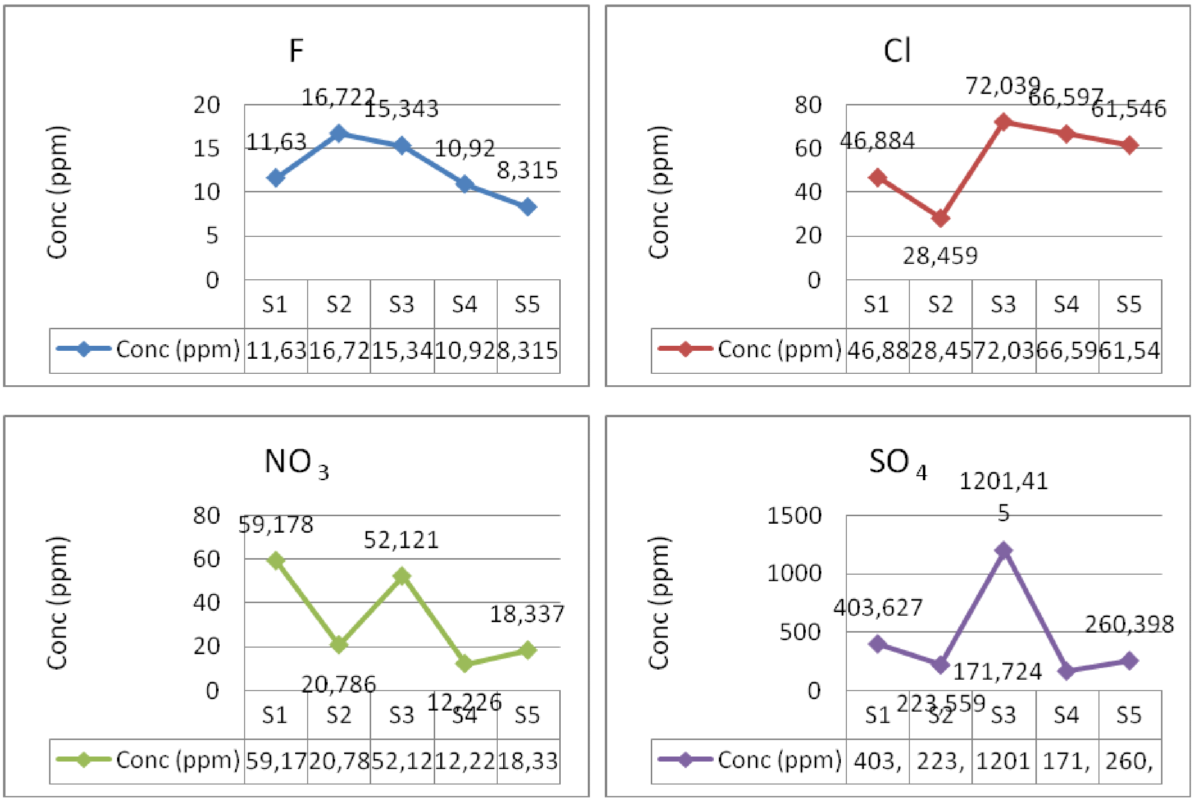

Fig.7.3. Graphic determinations in F, Cl, NO3, SO4

The values of these samples can be seen in Fig. 7.3 where we have graphically represented these determinations.

The concentration of heavy metals in the five samples we analyzed is shown in Table 7.3 and Fig. 7.4.

Table 7.3. The values obtained for heavy metals in the analyzed water

Sample	**Cr**	**Cd**	**Cu**	**Fe**	**Pb**	**Ni**
S1	0,012	0,019	0,012	0,750	0,042	**0,125**
S2	0,047	0,005	0,036	0,506	0,003	0,089
S3	0,020	0,009	0,016	0,367	**0,170**	0,096
S4	0,014	0,091	0,004	0,308	0,005	0,044
S5	0,005	0,023	0,008	0,483	0,006	0,049
CMA/NTPA 001/2005	**1**	**0,2**	**0,1**	**5**	**0,2**	**0,5**

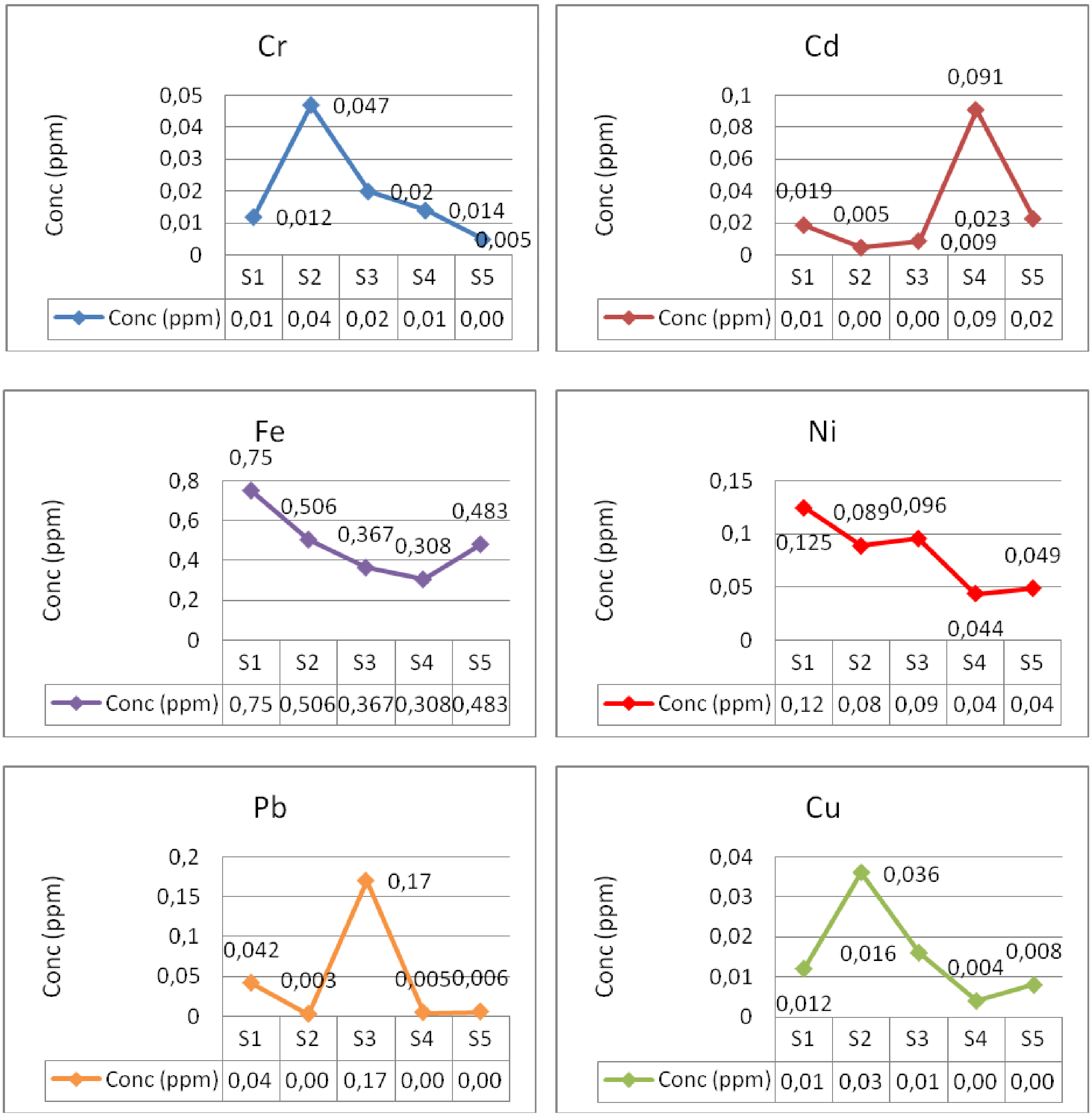

Fig. 7.4. The graphics for heavy metals Cr, Cd, Fe, Ni, Pb, Cu in the water

According to the H. G. 188/2002 regulation amended and supplemented by H.G. 352/2005, regarding the conditions of discharging wastewater used in receptors, the only elements that are above the limits imposed by current regulations are the Pb sample No. 3 with a concentration eight times higher and Ni with a concentration approximately two times higher than normal.

As a conclusion of this chapter the water analyzed from the Sărmăşag quarry is not polluted and it is maintained within normal limits, as required by law, with only a few samples that had higher values, F and NO3, SO4.

After closing the Bobota I quarry, a fishing lake was formed fig. 7.11 which led to the formation of a new form of relief replacing the one that degraded the landscape.

Studies on ash from Sărmăşag lignite combustion were made in 2000, when a technical analysis was performed on a number of 14 samples of coal. As a conclusion of these measurements it was revealed that (Aytim et al., 2000) the variation in volatile matter, fixed coal with ash presents a good linear correlation. The ash can be used in filler works, stabilizing soils or partially replacing the cement in concrete (Racoceanu & Popescu, 2007) especially in the hydrotechnical works, roads, airport runways etc.

Thus the ash from the Panic slag deposit is being used to rebuild roads in Zalau and the surrounding area as well as in the production of construction materials (Report on the state of the environment in Salaj county, 2004).

CHAPTER VIII

Conclusions

The studied region is part of the Şimleu Basin as well as part of the administrative territory of Sărmăşag commune and Bobota village,. In the last locality, there is the single still active coal open pit from the area. I added comments about the Derşida village, where on Pesterii Valley fossil bearing sites document the uppermost Pontian in Transylvania, the related vertebrate fauna being of great interest. The excavations I have done completed the materials already collected by predecessors, highlighting an evolved hipparion fauna.

Regarding the coal-bearing deposits, they belong to Pontian.

Considering the identified fauna and the established assemblages, we found that the Late Neogene from Şimleu Basin is in concordance with the Papp's units, in Vienna Basin. For a better understanding of the Pontian lignite deposit at Sărmăşag, in its complexity, but especially in order to carry out horizontal analysis, correlation and dating of the layers, palynological analysis were performed on samples taken from several former wells.

The studied Pontian is characterized by a palynology including of coniferals, angiosperms, and dicotiledons representatives.

Distribution of a quantitative-qualitative palinomophs allowed identifying accurate pollinic source areas under environmental conditions that generated the formation of coal.

Among coniferals, swamp-peat environment is supported by the Taxodiacee pollen, and at certain levels the same aspect is supported by the accumulation of leafy branches of *Glyptostrobus* (typical marsh plant). The large number of pollen grains of grasses: *Typha*, *Sparganium*, they support the swamp environment in certain boundary areas of the marsh and dicotyledonous angiosperms have a definite role in the analyzed spectrum, they provided necessary wood material for lignite genesis.

Considering the paleoclimate, Pontian vegetation from Sărmăşag evolved in a warm temperate climate.

Pontian-peat moorland vegetation in Sărmăşag swamps is similar to the current North American sites. The procedure of maintaining the foliar imprints, the pollen grains as well as the sedimentological characteristics of the deposit investigated, indicate that in Sărmăşag the accumulation of plant material was performed *in situ*, which proves the autochthony of coal in question. It is true that at certain levels, in certain areas of the deposit, the contribution of the allochthonous material can also be important.

In the Sărmăşag area, good results were obtained on petrophysical parameters of rocks and in interpretation of complex diagrams determining the layers of coal, coal clay, and carbonaceous clays.

Aquifers zones from the bed and cover layer XVI, are those that will influence the future exploitation of lignite in layer XVI. Operational work performed achieved their purpose, currently there is an amount of reserves that can provide the material for 10 years in the exploitation of Bobota II mine.

Regarding the Pontian vertebrates from Dreşida, the documents show that they belong to the uppermost Miocene. In our country, such assemblages are extremely rare, due to the restricted number of localities of this age. Two main habitats can be identified: woodland, bordering rivers (frequented by deinothers, mastodonts, deer and beavers) and grassy open areas probably located farther on (with hipparions, bovids, hyenas). The fossils of the representatives of both environments, often fragmentary, were transported by water streams, graded hydrodynamicaly, accumulating mainly in channel lags.

Regarding the numerous studies worldwide reffering to coal radioactivity, the concentrations of the three elements studied, ^{238}U, ^{232}Th, ^{40}K radionuclides, differ from values below the worldwide average to values that outweigh them by far. The radionuclides values are highly dependent on the geological period the coal formed in, the accumulation process of the three elements ^{238}U, ^{232}Th, ^{40}K, which may be, biologically, the type of vegetation that formed the coal in geologically adjacent areas, that have or not larger or smaller effect on radionuclides concentrations.

From the geological point of view, these radionuclides accumulated in Sărmăşag lignite through the microflora and the macroflora that developed in that period, also closely related to the tectonics structure and climate.

Vegetation in the Pontian from Sărmăşag is swampy-peat type, similar to the vegetation from ore fields from Visag, Sinersig, Derna where Pontian deposits contain coal seams. The accumulation of studied radioactive elements U, Th, K were observed mainly in roots and leaves, and an assessment of the distribution of the radionuclide in the soil – plant system has been quite complex, due to physico-chemical and biological processes they were subjected to. From the study, the largest accumulation of radionuclide was observed at K, closely followe by Th and U.

The wind had probably had an important role in the accumulation of the three radionuclides U, Th, K in plants and vegetation during Neogene had probably.

To conclude about the environmental impact, the mining both underground and especially on the surface affect the environment by polluting the three types of environmental factors: soil, water, air. But the most pollution is the burning of coal for electricity production, the resulting products being the ash that deposits in landfills and floating ash from the emissions funnels. The latter produces the most pollution because it contains many harmful chemicals for both humans and animals. The plants are particularly affected due to the fact that they are interlinked through microbiological processes. The floating ash is considered responsible for global warming by some experts, a very controversial topic at present.

As it can be seen from the study and analysis of the key polluting factors in Sărmăşag quarry, in the case of underground mining, the cleaning of waste dumps was done by re-cultivation of fruit trees, revegetation, and during the first current exploitation a fishing lake was built.

But the main polluting factor is still the current exploitation of Bobota II North that, although it is not a large quarry, produced and still produces the disequilibrium of the environment by polluting the air and modifying the geomorphological characteristics of the ground. Regarding the water quality in terms of pH, chlorides, nitrates, sulphates, heavy metals concentration within the quarry, the parameters are normal, only the fluoride having the highest values because the waters washed rocks that have a higher amount of fluorine and silica.

The perimeters Sărmăşag - Bobota - Derşida as well as Şimleu basin remain areas that worth to be studied in terms of geology and especially paleontology, by continuing the diggings in the fossil site of Valea Peşterii.

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