The Reflection of the Geological Factors within the Morphology of the Baraolt Depression

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Abstract: It is well known that the assessment of the geological features of a territory offers many posibilities to emphasize deterministic connections between their peculiarities and the manner in which they are reflected within the landscape. This fact is extremely useful for a better understanding of the morphology of Baraolt Depression too. In this area, the geological components hold an important role in imposing the general pattern of the the major landforms as well as in the development of some specific and actual geomorphological processes. In this respect, the tectonics and the geologic structure had the role to divide the depression in hollows, bays and basins, compartments and to impose an elongated form for these divisions. The fluvial processes that took place in these areas put finally in evidence an assimetric transversal profile of the most important valleys. In its turn, the lithology imposed the genesis of some flat, barely sloped areas, developed mainly through the volcanic plateaus. The presence of the coal pushed the human activity to a so called *anthropogenic parasitism*, which determines a present day accelerated evolution of the landscape.

Keywords: horst, graben, assimetric transversal profile, mollase, volcano-sediment, volcanic plateau, antropogenic parasitism, postvolcanic activity

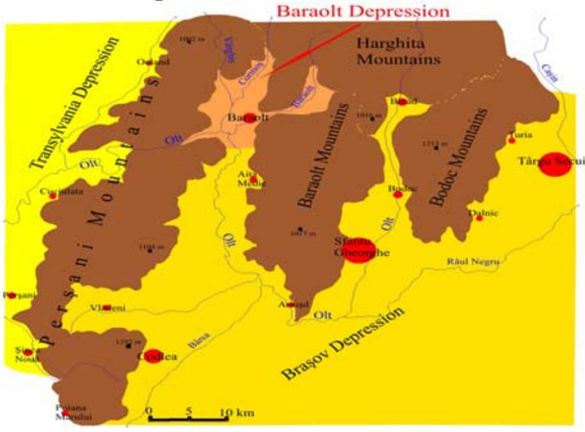
1. Introduction

The mountain depression of Baraolt is part of the internal curvature sector of the Eastern Carpathians (Map 1.) and borders with Harghita Mountains to the North and North-East, with Baraolt Mountains to the East, South-East and South and with Perşani Mountains to the West. In the South, there is a wide opening towards Braşov Depression on the valley of the Olt river.

The foundation of the depression has the same geological structure as the Baraolt Mountains, respectively the deposits of the internal flysch of the Eastern Carpathians, laid down in the Cretaceous period, which drifted into nappes, namely the Ceahlău nappe, with its characteristic layers: the Sinaia layers. From Cretaceous to Pontian, the whole structure develops in open air and becomes a peneplain with interfluves and valleys having a North-East–South-West direction. The volcanic activity of Harghita mountain range started in Pontian, which caused the reactivation of faults, the forming of new ones along which the area submerges. The main faults of the area are G8 (North-South, Cormoş fault system), g27 parallel with G8, G7 (West-East) and secondary ones, some having North-West – South-East, others North-East – South-West directions. The movements along the faults, and the volcanic activity directs each other till late Pliocene (40,000–35,000 years before) when they stopped. Throughout the period between Pontian and Pliocene, there were three intervals with intense volcanic activity having as a result three layers of volcano-sediments inserted in the mollasse stack. There were also conditions for the forming of six coal (lignite) layers, from which the first and the third, but mainly the third, have economic value, and were mined. (Map 2.)

The geological substructure, as its name indicates, sustains the other elements of the geographical landscape, but it can not be reduced just to this. The assesment of the elements of this structure gives the posibility to make correlations for showing how these elements, having also the quality of components, are reflected in the morphology of the Baraolt Depression.

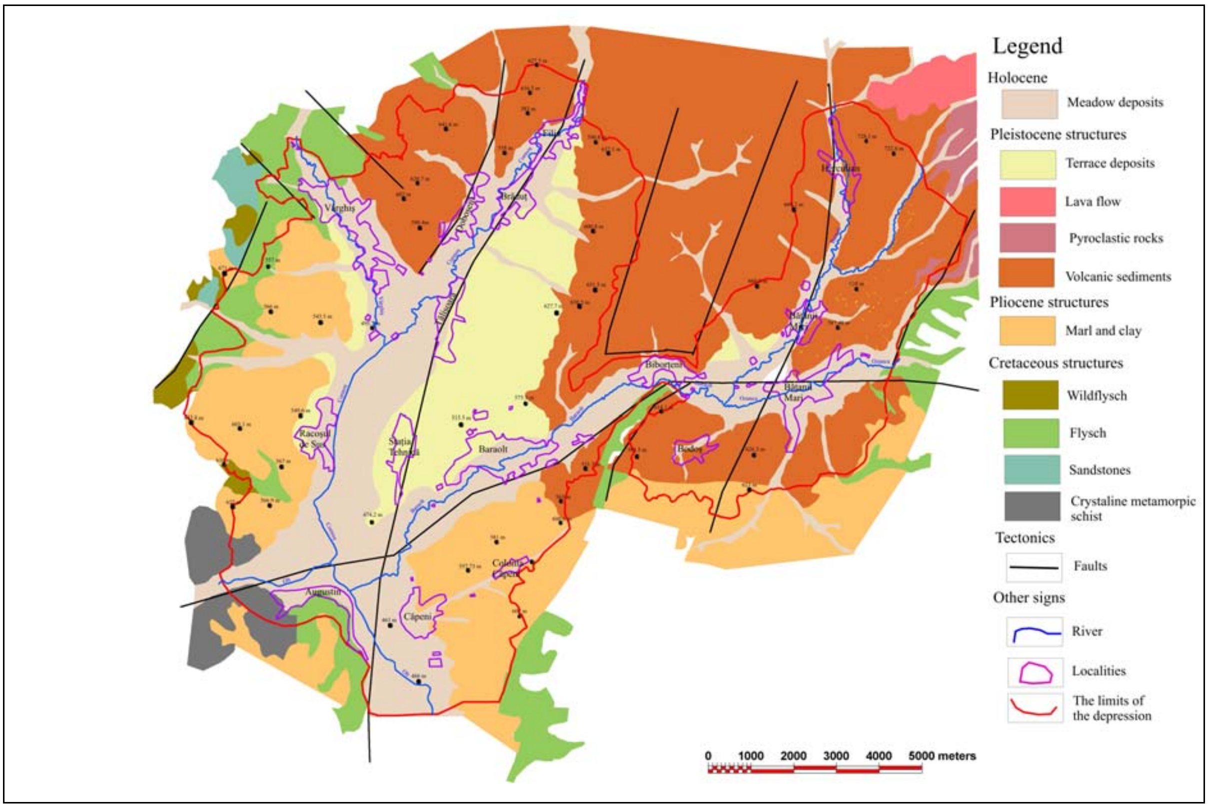
Generally speaking, the constitution and the structural peculiarities of the geology of the depression are closely related to the evolution of the Carpathian range and of the Eastern Carpahians, and particularly to the evolutional processes which marked the inner sector of the curved part of this mountain range.



Map 1. Geographical position of the Baraolt Depression

2. The reflection of the geological structure in the morphology

The horst structure aligned in the N–S direction, stands morphologicaly for a hilly alignement given by the peaks of the following hills: Dealului (892.7 m), Tirco (662.5 m), Cetății (614.1 m). This causes a strangling for the depression in the area of Biborțeni village and it materializes the separation strip between the western and eastern parts of the depression. (Figure 1 and Photo 1) These two parts are in fact two main grabens, concretized in the relief by two basins: a Western basin and an Eastern basin.



Map 2. Geologic map of the Baraolt Depression and its surroundings

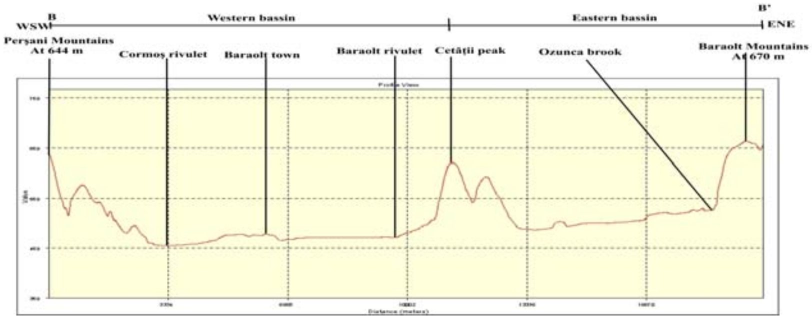
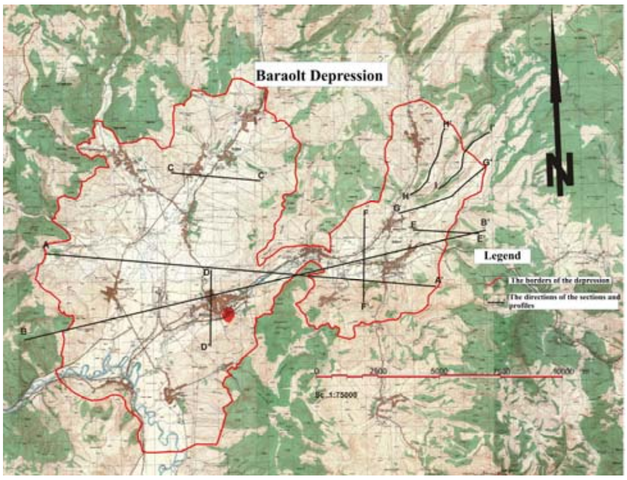


Figure 1. The cross section of the Baraolt Depression

Photo 1. The Southern part of the horst



Map 3. Positions of the cross sections and profiles

The Western basin is the expression on the surface of the Cormoş graben. Its aspect is elongated on N – S direction and it is wider in the South, at the confluence of the Baraolt and Cormoş rivulets with Olt river, and closes gradually towards North in the area of Filia village. The graben, as a geological structure, goes on towards North, under the volcanic structures of the South Harghita range, just the aspect of the relief changes from depression-like, to a mountain-like in this area. The height of the basin decreases from North, where it is around 600 m, to South, where it reaches the minimum altitude of the whole depression: 463 m. The decreasing direction is contrary to that of the graben itself, given by the surface of the Cretaceous relief, whose lowest level is in the northern part of the basin in the area of Doboşeni village, and it is placed around 50–100 m higher than the actual level of the Black Sea (László A., 1999).

On the Western side, this aspect of a N–S elongated basin, is disturbed by two bays: Vârghiş bay and Racoşul de Sus bay, given by two secondary grabens, which were formed along the NV–SE faults. The basin becomes larger in this area because of them.

The highest points of the basin in Vârghiş bay are around 550–570m, and in Racoşul de Sus bay around 530–550 m and the altitudes decrease towards SE and E till the level of the Cormoş meadow, which is around 480 and 470 m.

At a deep evaluation of the slopes inclination map, it is possible to see the asymmetry between the Western side and Eastern side of the basin. It is not possible to speak about a result of a monoclinal structure, but a result of the fault structure.

On the Western side, the border faults, which are parallel with the Cormoş fault system, imposed a discordance between the depression and the Mesozoic-crystalline structures of Perşani range. The Cretaceous base, which emerges along these faults, conditions a sharper slope angle for the Western side of the basin. (Map 3, Figure 2 and Photo 2).

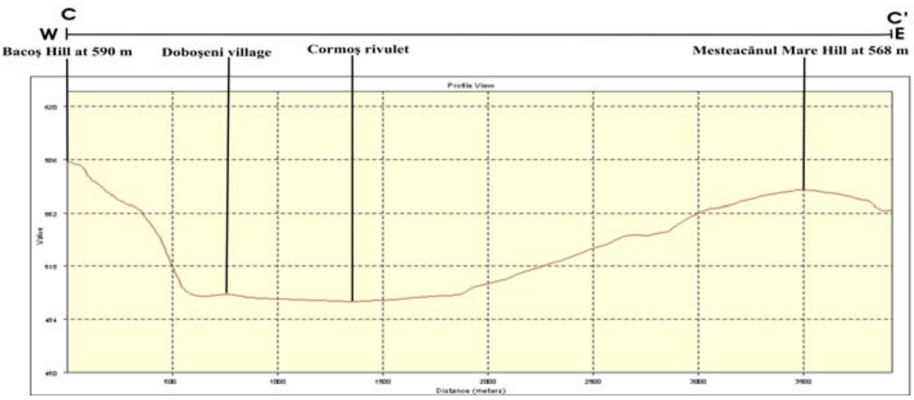


Figure 2. W-E cross section through the Western Basin nearby Doboşeni village

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Photo 2. The image of the cross section from Fig. 2

In the Southern part of the basin, the W–E crustal fault (G7) imposes a brink, a higher level of the relief, namely the compartment of Căpeni Colony, having a height of 550–560 m, which represents a level difference of about 80–90m from the bottom of this basin. On the cross section made in N–S direction, one can notice the vault caused by the fault and on the other hand the asymmetry between the slopes. (Figure 3 and Photo 3).

Performing an overlay of the tectonical alignements map of Baraolt area, and South–Western side of Harghita Mountains, made by László A. (1999), with the topographical map of the same area, it will be possible to observe that the lowest spot of the basin and of the whole depression (463 m) is situated at the crossing of the Cormoş fault system with the W–E directed custal fault. That is the spot where the Cormoş and Baraolt rivulets flow into the Olt river, so it is a confluence site.

On the Eastern side of the horst made up by Dealului, Tirco, Cetății hills, the parallel reply of the Cormoş fault system was formed, which conditioned the individualization of the Eastern basin of Baraolt depression, the area between Bățanii Mari and Herculian villages. This division of the depression into these two basins is an expression, a conditioning of the structure imposed on the relief. The general aspect of this Eastern basin is similar to the western one, in the sense of the elongated form in N – S direction, with a narrowing and closing at N of Herculian and a widening in South. The closeness of the named horst to the lifted flysch structures of Baraolt Mountains and of the volcanic structures of Harghita Mountains makes that the extension of this basin is smaller than that of the western one.

Following the same assesment method as in the case of the western basin, regarding the angles of the slopes, it is possible to mark that the Eastern (Figure 4) and the Southern side slopes (Figure 5) have a bigger inclination.

As in the case of the western basin, these are conditioned by the border faults having N–S directions, along which the Cretaceous structures of the Baraolt Mountains get to the surface. In this eastern side of the basin further to the North, this discordance can not be seen because it is covered by the upper volcano-sediment layer. In the southern part, the bigger angles of the slopes is imposed by the W–E crustal faults system.

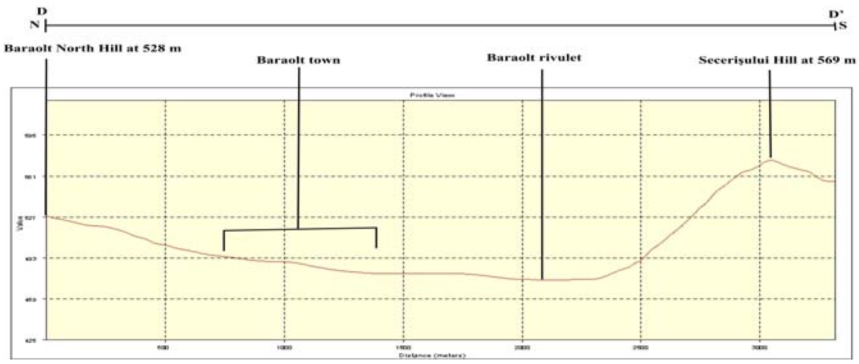


Figure 3. N – S cross section in the Western basin between Baraolt Nord Hill and Secerişului Hill

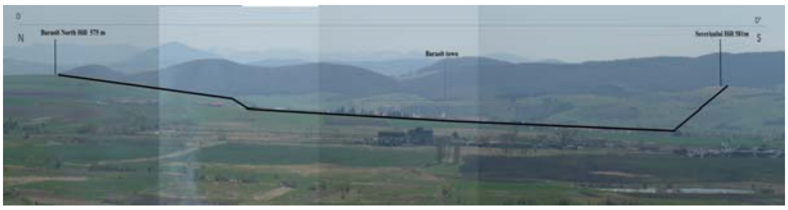


Photo 3. The image of the cross section from Fig. 3.

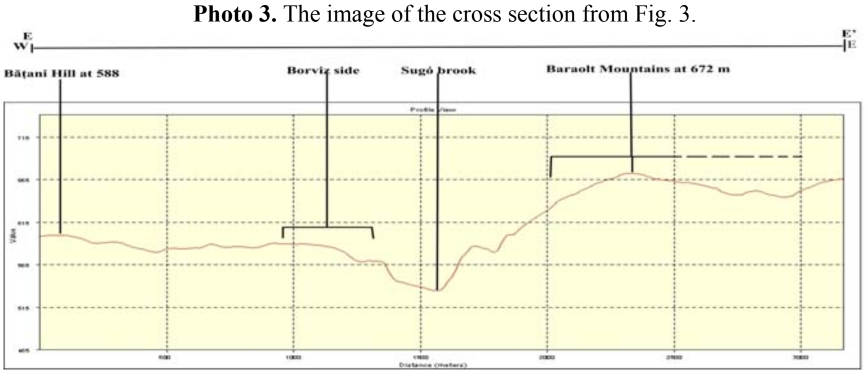


Figure 4. W – E cross section in the Eastern basin nearby Bățanii Mari

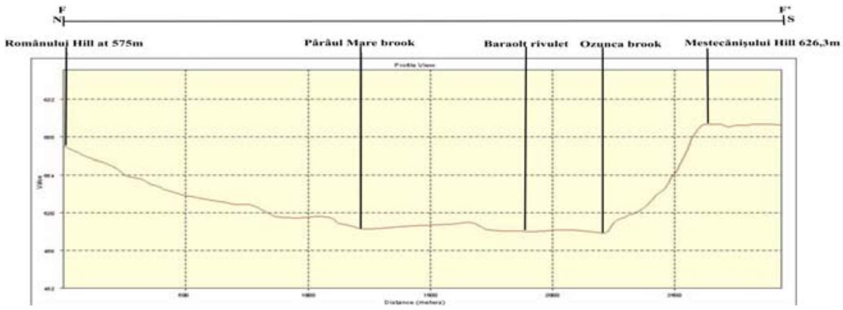


Figure 5. N – S cross section in the eastern basin in Bodoş – Bățanii Mici area

The tectonics of the Cretaceous bed, forced by these faults in the South of the basin together with the delay in the start of the descending movement along the N–S faults conditioned the individualization, in the South-Western side, of the Bodoş cuvette, bordered in South and West by the structures of Baraolt Mountains and with a certain opening towards East and North – East.

The maximum depth of the basin, from Bățani area, having its site in front of the intermediate horst, is the place where the two fault systems, N–S and W–E crosses each other. This fact also conditions a confluence area for the rivulets. Baraolt, Ozunca, Bățani, Bodoş, Pârâul Mare converge towards it, before crossing the strangling of the depression caused by the horst.

The directional lines of the draining, made by the hidrographic network, are given by the direction of the faults. In the western basin, Cormoş and Volal rivulets and partly the Olt river, flow along the Cormoş fault system, having N–S direction. Along the NW–SE faults flow the Vârghiş and Rica rivulets, and along the W–E fault flow Baraolt rivulet and Olt river. The same situation is in the Eastern basin. Along the N–S directed faults flow Baraolt, Bradul Mare, Bățani rivulets and along the W–E fault the Ozunca and Baraolt rivulets. One remarks the existence of the fault shifter rivers: Olt and Baraolt both from the N–S faults to W–E fault.

3. The reflection of the petrography in morphology

In the North and North – Eastern part of the eastern basin, the petrographic structures of the upper layer of the volcano-sediments are imposed in the relief. (Map 4.) As there are some hard rocks – andesite with pyroxene and dacite – among the components of this layer, the aspect of the relief is a volcanic plateau like. (Figure 6, Figure 7 and Figure 8) The watersheds directed N–S and NNS–SSW, are easily inclined, or curved, having altitudes that go down from 700–670 m in the North to 580–560 m in the South.

During the palaeogeographic evolution of the depression, the forming of the stack of mollasse, there were some periods with proper conditions for the formation of 6 coal layers.

The lignite, as petrographic element, having the status of subsoil resource, conditioned the development and evolution of the anthropogenic relief, due to mining. The open pit exploitation made in the coal fields of Vârghiş and Racoşul de Sus, began in 1954, created excavations having micro-cuvette forms, even 70 m deep, deches for carrying away the underground waters, artificial river beds, artificial hills of 10–15 m high and 1–3 km long serving as depot for the sterile materials, roads, buildings, coal loading facilities. The process through which it is reachable the totality of the ground forms, as a result of the modifications of the preexistent morphology, got the name of "antropogenic parazitation" (Anghel, T., Surdeanu V., 2007).

In the open pits exploitations where there is no coal mining any more – Vârghiş, Racoş bay – the active gravitational, pluvio-denudational and torrentional processes on the surface of the burrows, and of the pits themselves, compensate the excavated material. Immediately after they stopped to pump out the water, the hydrostatic level came back and this gave birth to lakes whose area, depth, form and number changes continually until a state of balance is reached.

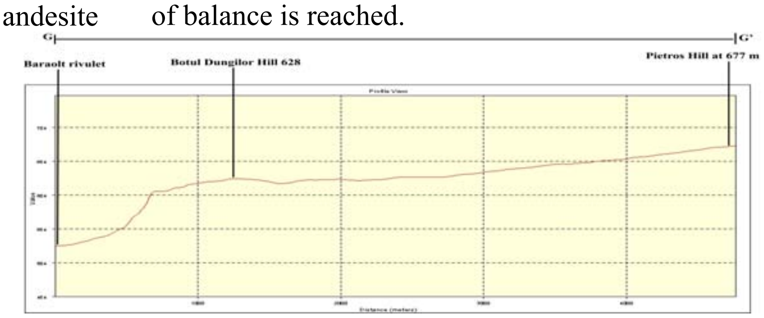


Figure 6. Longitudinal profile of the Pietros Hill – Botul Dungilor Hill

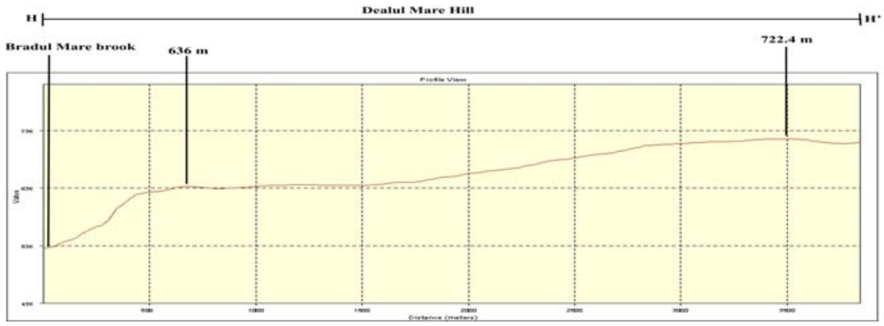


Figure 7. Longitudinal pofile of Dealul Mare Hill

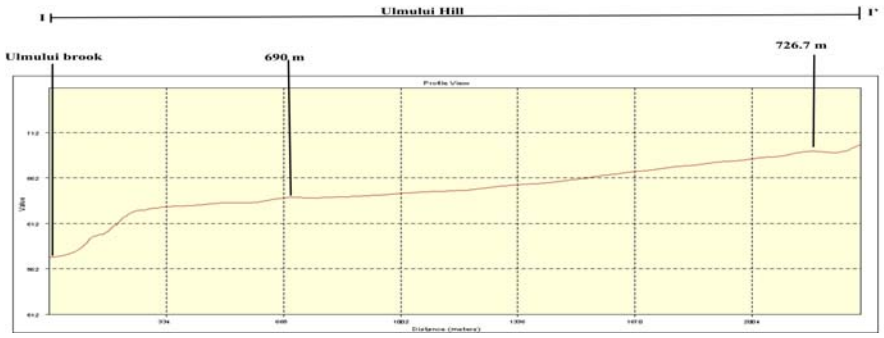
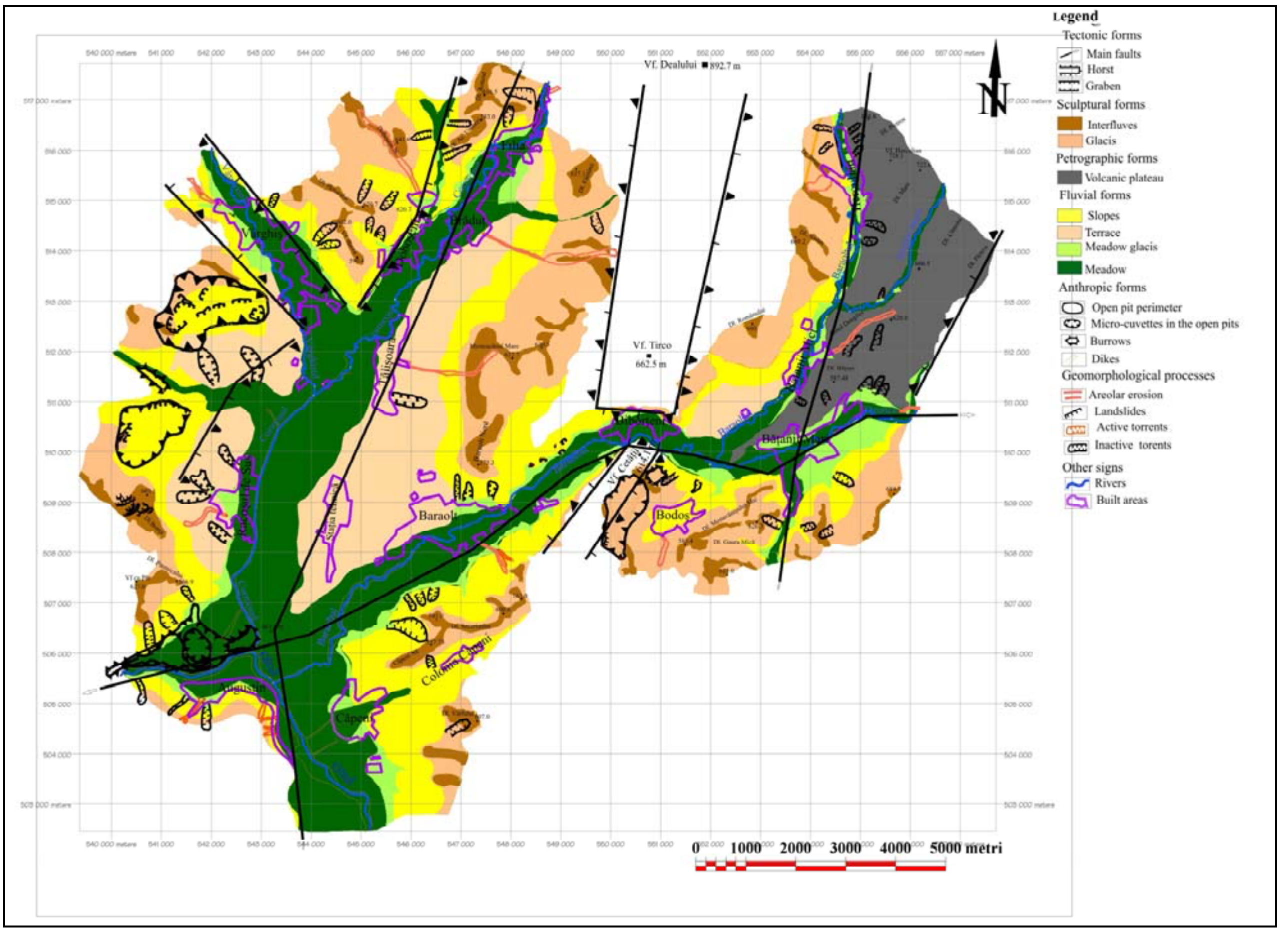


Figure 8. Longitudinal profile of Ulmului Hill



Map 4. The geomorphologic map of Baraolt Depression

At the Racoş Sud open pit, from the flood-plaine of Olt river, which is still giving coal, the radical anthropogenic transformation of the natural landscape has begun in 1996. There are stripping works still done, but without using new land, because the waste is put back on the place from where the coal was mined. There are also works for stopping the erosional processes to keep the open pit functional. On the other hand, the surface of the barrows is affected by the erosional processes listed before. The whole area occupied by the anthropogenic parasitation processes is up to 1.4 km^2, from which the negative form has 311 ha and a relative depth of 86 m (in April 2012). The flood-plain barrows, which strip along the Olt river for 2.8 km, are made up of two depots: one is oriented towards the Olt strait, being 1.9 km long and from 50 to 170 m wide, and the second placed on the East side of the micro-cuvette, having 900 m in length.

Excepting these two landforms (the micro-cuvette and the barrow), one notices the shifting of the river bed of the Cormoş rivulet in a 1.1 km long channel, the ditch digging for carrying away the water from the pit having a lenght of 2.8 km.

Assessing the geological section and the evolutional model of the depression, made by László A. in 1999, it is possible to point out that the only area in the eastern basin where the 3rd coal layer was formed is Bodoş cuvette. This process was conditioned by the earlier start of the descending movements of this cuvette then of the other parts of this basin and so, this is the only area here where the lignite could be mined. In spite of the fact that this lignite has the poorest quality, in the whole depression mining started in 1985 in underground as well as in open pits, but all the mines are closed now. In the underground mines, the closing works consisted of refilling the entrance slope to a depth of 50 m and sealing it with concrete. The other anthropogenic elements of the landscape are still there: buildings, roads, loading shafts.

At the open pits much more serious work was done. The barrows were flatted and replaced, the excavations refilled with the material of the barrows, the whole area of the pit was flatted and settled, gaining the form of a single micro-cuvette with a 0.84 ha lake in its deepest place. The ground was planted with white clover (*Trifolium repens*). The reception of the whole work was done in November 2009, but the severe winter and rainy summer of 2010 made that on the surface of the slopes of the pit to occur geomorphological processes like pluvio-denudation, gullyfication, landslides. With all the human efforts to reestablish the proper angle of the slopes, to remake the broken balance, it seems that the nature will have the final word as in the case of the pits where no work was done.

All the underground mining sites are closed and recultivated as at the Bodoş site, and the surroundings were planted with white clover (*Trifolium repens*). At some pits even the buildings were demolished. Căpeni mining site is the only one where these works have not been made. Here mining stopped in 1967 and in a short time a lake formed. Today this lake is 1.38 ha and 7 m deep.

In 2002 just a part of the closing works were made at Baraolt pit: taking out, from the underground, the reusable materials and refilling the access slopes from 50 m deep until the surface. So the terrain above the galleries, from where there had been taken out a thickness about 5 to 10 m of coal, suffered a subsidence and between 2006 and 2009 a lake of 3.6 ha and 5m deep was formed. These kind of terrain sinking, subsidence processes, with the formation of small endorheic basins in which lakes can occur are a reality and all these processes can happen in the future at the other pits. The only place where they are less possible is at Căpeni where it seems that the balance status was reached.

These small negative landforms, which take birth because of the extraction of any resourse from the underground, are not directly modelated by man. They are the result of taking out that quantity of deposit that overtakes the possibility of the surrounding rocks to fill the created hollow and to stop the phenomena of their distortion. So the movement of the rocks reaches the surface and the small endorheic basin is ready. They can be filled by metheoric water or by the natural resauration of the phreatic level, taken down during the exploitation by pumping. One of the features of these lakes is, that immediately after forming, their surface and deepth are growing and they can be a man induced natural hazard.

In the case of open pit exploitation, the man-made forms are more spectacular, beeing the case of positive or of negative ones. They are distinguished from the previous forms by the fact that they are directly created as a result of decisions and actions of carving of a surface which is already a result of the nature's self-organizing processes.

The four open pits offer four different images of this anthropogenic relief category. They catch three different evolutionary phases: 1) the phase of opening the pit, when man effectively models the surface – Racoş sud open pit –, 2) the phase that immediately follows the giving up of the mining perimeter, when the stripping processes are taking place and nature imposes its own organizatoric laws – Vârghiş west open pit –, 3) the phase of stabilisation and resettlement of natural balance – Racoş golf open pit. The fourth open pit – Bodoş – offers the image of both success and failure in closure and recultivation of an exploitation micro-cuvette.

4. The reflection of some postvolcanic activities in morphology

There is another factor of geologic origin – post-volcanic activity – which can create spectacular microforms having a very slow evolution. The presence of mineral waters indicates the final stage of volcanic activity of the Harghita range. Post-volcanic gases circulate through crustal and regional faults and at their crossings they can come towards the surface and interfering with the aquifers from the geological structures they generate carbonated mineral waters. The hydrochemistry of these waters depends on the petrographic nature of the geological structures through which they pass and in which they stay.

Taking into account the fact that Cretaceous rocks from the bottom of the depression are mainly carbonic ones, some mineral waters contain important quantities of HCO_3. At the 35 analysed mineral water springs this component is between 305 and 2562 mg/l, the Ca^{2+} between 250 and 300 mg/l and the Mg^{2+} between 90 and 110 mg/l. When they reach the surface they lose the free and dissolved CO_2 which leads to deposition, agglomeration, mineralization of the dissolved substances on the surface. So around some mineral water springs small hills, having the shape of a truncated cone, can be formed.

In the flood-plaine of Cormoş rivulet at 100 m from the Dc38 road which connects Racoşul de Sus and Doboşeni there is a small hill of 1.5 m in height and 42 m in circumference, with the shape of a truncated cone. It has a 2 m deep crater through which the mineral water had sprung out until the 1960s. This microform it is known as „The Holed Stone" (Photo 4) and was declared as monument of nature by Covasna County's Council Decission no. 39/2001.

A similar microform was formed on the bank of the Baraolt rivulet bed opposite the gas pumping station from Băţanii Mici at 100 m from road Dc45, where the waters of the "Szonda borvíz" spring flows into the rivulet. This spring comes out through a geological drilling made in 1982. The total dissolved salt (TDS) in the waters of the spring is between 928 and 947 mg/l, the HCO_3 between 1403 and 1467 mg/l. In all 30 years of flowing this spring built a half frustrum of a cone – being attached to the bank – of 1.3 m height. (Photo 5) The bottom semicircle is 3.5 m and the top one 1.3 m in diameter.

Photo. 4. The Holed Stone

Photo 5. The cone at "Szonda borvíz

4. Conclusions

The geological components of the Baraolt Depression are the conjugate results of the succession of the geological events that followed each other in this region from the formation of Ceahlău Nappe, the napping of the metamorphic structures of the Eastern Carpathians over the flysch up to the present. The tectonic movements along the crustal, regional, local faults, which influence both the Cretaceous bottom and the Pliocene-Pleistocene mollasse stack, the volcanic activity in the Harghita range, which directed each other, conditioned the finishing of the tectonic structure of grabens and horsts. The formation of the grabens along specific fault series together with the same volcanic activity created conditions for a specific sedimentation having the result of mollasse deposits which are up to 450–550 m thick. In this deposit there are layers having a very important self-organizing role: the volcano-sediment layers and the lignite layers.

Some geological factors – tectonics and structure – had the role to divide the depression into basins, bays, cuvettes and compartments, to give the elongated form to these divisions, to lead the main rivers to make themselves asymmetrical sections. The other one – petrography – imposed the development of some flat, barely inclined landforms, real volcanic plateaus. The energetic resources pushed the human activity to develop anthropogenic parasitation morphology, where it is the best place to observe the actual dynamics of the relief.

The understanding of any area of the geographic coverage is the starting point in showing out the morphology and dynamics of the relief of that area and the other processes, phenomena, manifestations of growing complexity, which are reflected in the landscape and gives it's individuality.

REFERENCES

AIRINEI, S. 1963. *Structura fundamentului hercinic al curburii Carpaţilor Orientali în lumina anomaliilor câmpurilor gravimetric şi geomagnetic*, Lucrările celui de-al V-lea Congres al Asociaţiei Geologice Carpato-Balcanice, Bucureşti, 1961, VI, Comunicări ştiinţifice (SecţiaV, Geofizică), Bucureşti.

AIRINEI, ST., PRICĂJAN, A. 1972. *Corelaţii între structura geologică profundă şiaureola mofetică din jud. Covasna cu privire la zonele de apariţie a apelor minerale carbogazoase,* Aluta p. 181 – 190, Sfântu Gheorghe.

ANDREESCU, I. 1975. *Limitele şi subdiviziunile Ponţianului*, Stud. Cercet. Geol. Geofiz. Geogr., Seria Geol., vol. 20/2, pp. 235 – 246, Bucureşti.

LÁSZLÓ, A. 1999. *Studiul geologic al structurilor vulcanice din partea de sudică a Masivului Harghita*, Teză de doctorat, Universitatea Babeş-Bolyai Cluj-Napoca.

LÁSZLÓ, A. DÉNES, I. 1997. *Elemente structural – tectonice pentru un model evolutiv în zona Bazinului Baraolt*, Acta Sicularica, Muzeul Naţional Secuiesc – Muzeul Secuiesc al Ciucului, Sfântu Gheorghe, pp. 9-16.

BARTMUS, A. 1971. *Cercetări palinologice preliminare în lignitul de la Vârghiş (Bazinul Baraolt)*, în Progrese în Palinilogia românescă, Editura Academică, pp. 143 – 152, Bucureşti.

BĂCĂINŢAN, N. 1982. *Limitele şi subunităţile Munţilor Baraolt*, Aspecte controversate, BSSGR, VI (LXXVI).

BĂCĂINŢAN, N. 1999. *Munţii Baraolt - Studiu geomorfologic*, Editura Academiei Române, Bucureşti.9. Ciupagea, D. et al.1970: *Geologia Depresiunii Transilvaniei.* – Ed. Academiei RSR, Bucureşti, 188-205.

CONŢESCU, I. 1966. *Flişul cretacic din partea de nord a Munţilor Baraoltului*, Academia RSR, Stud. Cercet. Geol. Geof. Geogr., seria Geol., 11, I, Bucureşti.

GHEORGHIU, C. 1956. *Relaţiile dintre sedimentele terţiare şi eruptivul lanţului Harghita (fenomene post-vulcanice)*, Dds.sed.CG, XL 1952 - 1953.

GIVULESCU, R., VASILESCU, AL. 1969. *Contribuţii la cunoaşterea Bazinului Baraolt*, D.S. Inst. Geol. vol. LIV/3, pp. 283 – 293, Bucureşti.

HERBICH, F. 1878. *A székelyföld földtani és őslénytani leírása*, Földt. Int. Évkönyve, V. k., II. füzet, 297, Budapest.

IANCU M. 1957. *Contribuţii la studiul unităţilor geomorfologice din depresiunea internă a curburii Carpaţilor* (Bârsa, Sf. Gheorghe, Tg. Secuiesc, Baraolt) Probl. de geografie, vol. IV, Bucureşti.

JERKELIUS, E. 1932. *Die Molluskenfauna der dazischen Stufe des Beckens von Braşov*, Men. Inst. Geol. Rom., vol. II, Bucureşti.

JEKELIUS, E. 1923, *Les dépots de Geyserite du basin dacien de Baraolt (Transylvanie)*, Bull. Sect. Sc. Ac. Roum., VIII, (1922-1923), 168-175, Bucureşti.

KRISTO, A. 1972. *Unele probleme privind delimitarea şi denumirea formelor de relief din împrejurimile depresiunilor intracarparice ale Oltului Superior*, Aluta, Sf. Gheorghe.

KUSKO, M. 1983. *Zăcământul de lignit de la Sf. Gheorghe şi poziţia lui stratigrafică în suita depozitelor pliocene ale bazinului intramontan al Ţării Bârsei*. St. Cercet. Geol. Geofiz., s. Geol., 28, Bucureşti.

LITEANU, E. et al. 1962. *Contribuţii la studiul stratigrafiei Cuaternarului din Bazinul mijlociu al Oltului (Baz. Baraolt)*. St. Cercet. Geol. Geofiz., s. Geol., 7, ¾, Bucuresti.

MUTIHAC, V., IONESI, L. 1974. *Geologia României*, Editura tehnică Bucureşti.

ORBÁN B. 1868. *A Székelyföld leírása*, Budapest.

ORGHIDAN, N. 1965. *Munţii Persani, Observaţii geomorfologice cu privire specială asupra văii Oltului*, St. Cerc. Geofiz. Geol. Geogr., seria geogr. XII, 1.

ORGHIDAN, N. 1965. *Munţii Perşani*, Natura – Geogr.- geol.XVII,4.

PELTZ, S. 1970. *Contribuţii la cunoaşterea formaţiunii vulcanogen-sedimentare pleistocene din sudul Munţilor Harghita şi nord-estul bazinului Baraol*t, D.S. Inst. Geol. Geofiz., LVII/5.

PETRESCU, I., FERENCZ, A., 1979. *Contribuţii la cunoaşterea petrografiei şi genezei lignitilor de la Racoşul de Sus (Bazinul Baraolt)*, St. Com. Muz. Brukenthal, vol. 23, Sibiu.

PETRESCU, I. colab. 1987. *Geologia zăcămintelot de cărbuni, vol. II*, Editura Tehnică, Bucureşti.

POPOVICI VIORICA, 1959. *Explorări geologice în bazinul Baraolt – Vârghiş – Căpeni – Buduş – Aita Seacă*, STE, A, 5, Inst.geol.

POSEA, GR. 1981. *Depresiunea Braşovului (caractere geomorfologice*), AUB – Geogr., XXX.
SĂNDULESCU, M. 1984. *Geotectonica României*, Editura tehnică, Bucureşti.
SAVU, M. GH. 1971. *Argumente paleontologice în favoarea susţinerii existenţei pânzei de Baraolt*, D.S. Inst. Geol., LVII/4.
SAVU, M. GH. 1984. *Studiul geologic al regiunii cuprinse între localităţile Filia – Vârghiş – Baraolt – Aita Mare – Malnaş Băi – Bicsad – Herculian cu privire specială asupra depozitelor de lignit*, Teza de doctorat, Facultatea de Geologie – Geografie, Universitatea Bucureşti.
SAVU GH. et al., 1980. *Asupra vârstei formaţiunii productive din Bazinul Baraolt*, D. S. Inst. Geol. Gf., LXV, 4, Bucureşti.
SAVU, GH. M. 1981. *Grupul lacustru-vulcanogen de Baraolt*, D. S. Inst. Geol. Geofiz., vol. LXVI., 1979, 4 (Strat.), Bucureşti.
ŞTEFĂNESCU, M. 1968. *Pânza de Baraolt*, D.S. Inst. Geol. Geof. vol. LV/5, pp. 107 – 124, Bucureşti.
SCHREIBER W. 1994. *Masivul Harghita – Studiu geomorfologic* Editura Academiei Române, Bucureşti.
VADÁSZ E. 1915. *Földtani megfigyelések a Persányban és a Nagyhagymásban*. - Földtani Közlöny, Budapest.

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