ASSESSMENT OF THE ANTHROPIC IMPACT ON THE ENVIRONMENTAL COMPONENTS OF THE FĂGĂRAS MOUNTAINS. CASE STUDY: TRANSFĂGĂRAŞAN HIGHWAY AND VIDRARU

Hydroenergetic Development

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Human activity has produced changes on Făgăraş Mountains, particularly in the beginning of the XIXth century. This took many forms such as forest's burning and cleaning in order to extend pasture areas, excessive pasture, forest's exploitation, minerals extraction, uncontrolled turism etc. New infrastructural elements such as the construction of accumulation dames (Vidraru), and the Transfagarasan highway, have also appeared since. Clearing and generally bad exploitation of these forests, represent the main anthropical action leading to the bursting of the slope's balance and to active morphodynamic effects too. This was made, first of all, for the extension of pasture surfaces both on the high peaks of Fagaras Mountains, and on the affluent/tributary stream valleys of Arges, beginning with the middle of the XVIIIth century. Then, it was also caused by the extensive extraction of the forsts' wood for sale, beginning with the second behalf of the XIXth century. The irrational exploitation of forests, to which the delay of reforestation and amelioration measures was added, generated conditions for an intense manifestation of slope processes with repercussions lasting to date. Bad exploitation has, thus, continued during the past few decades too (particularly after 1990, when a part of the forests were given back to their rightful owners). The system of tree-cutting practiced in some regions, eventually led to a complete removal of forest trees from great surfaces in the basins of the following valleys: Modrogazu, Cumpăna, Cumpeniţa, Oticul, Valea cu Peşti, Valea Lupului, Calugarita, to mention but a few affluent valleys of Arges. Frequently enough, this led to the rise of various consequential processes, among which are landslides, rain-wash, gully erosion etc. An ample pastoral process, with a transhumant character, was developed with generally moderate repercussions. Between the XIXth and XXth centuries (particularly in this period's first part), extensions of the pasture surfaces, by cuttings, clearings and arsons, took place.

1.General data and methodological aspects.

Fagaras Mountains are situated in the East-central part of Meridionali Carpathions, which is a group of the Romanian Carpathians (fig. 1). It stretches between the Olt Valley in the West and the Tamasu ravine in the East, on about 70 km of length. It is dominated by its level differences which averages between 400-800 m (with instances of over 1000 m, in the North), all along some flat contacts such as the Collinear Depression of Transilvania in the North and the sub-Carpathians hills in the South. They impose themselves by a very slim crest, guarded by abrupt slopes (the most extensive Carpathian alpine crest) corresponding to the great heights from the alpine and sub-alpine floors, among which there are 6 pyramidal peaks with heights of over 2500 m (Moldoveanu with 2544 m, Negoiu with 2535, Vistea Mare with 2547, Caltun with 2522, Vanatoarea lui Buteanu with 2507 m, Dara with 2500 m) and other 33 reaching over 2400 m.

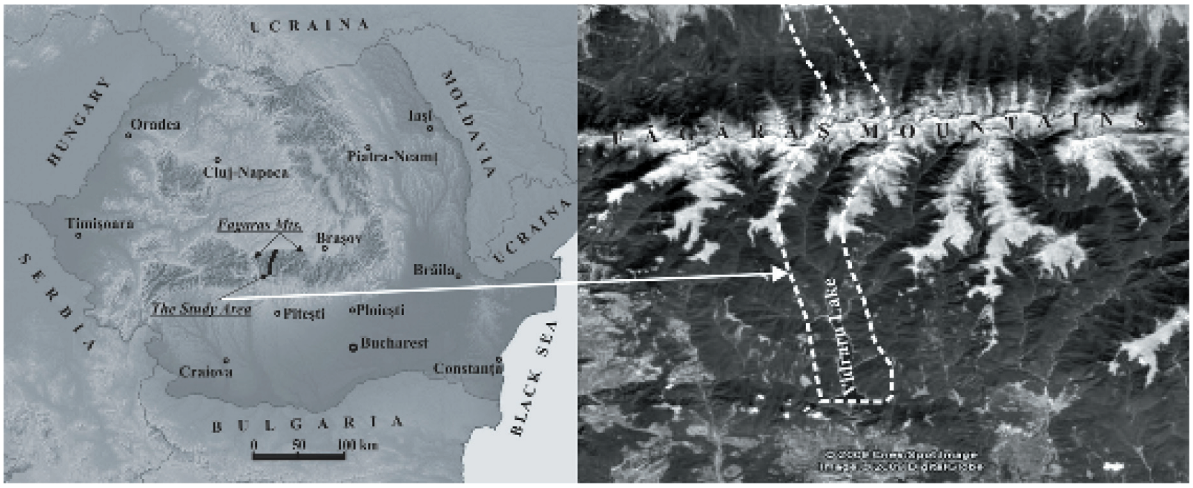

Fig.1 - The geographical position of the analyzed territory within Romania, Romanian Carpathians and Fagaras Mountains

From the main crest which is not fragmented by any transversal valley, crests and secondary peaks are detached (with erosion surfaces) and developed to the North (shorter, 6-8 km and more acclivous fast falling in many steps) as well as to the South, resulting in an asymmetric profile marked by the presence of the Fagaras North fault. The predominant rocks are the crystalline shale (gneiss, paragneiss, mica-schist, quartzite etc.) which are strongly metamorphosed gaving to the relief's aspect of massiveness. In some areas, especially in the West part, crystallized limestone patches and dolomites also appear. The techtonic movements from the end of Pliocene and Quaternaire gave rise to these mounts, situating them at superior altitudes to the limit of the permanent snows; a situation which favoured the glaciers extension. The glacial relief features:

- complex and suspended cirques,
- glacial valleys with lenghts of some kilometers, and with glacial threshold slopes and moraines,
- erratic blocks,
- peaks,
- microdepressions with lakes.

The complexity of the relief is furthered by the ruiniphorm relief, which resulted from the crionival processes (crioclastism, nivation, aeolization). There are remarkable cliffs, towers, short and deep cols (inlets), needles and crests. On the glacial cirques' slopes, there are important masses (foots and cones) of pleistocene slide rocks fixed by the soil and vegetation, but also mobile at times.

The highway reaches the massif on the North Slope, on Balea Valley, Glajarie place situated at above 800 m altitude. From there, after a great look on Culmea Smidei slope, Transfagarasan is observed on Balea Valley, till Balea Cascada hotel, at above 1200 m altitude. The highway extends in the inferior parts of the Western slope of Buteanu Ridge and till the glacier circuit where it forms a series of windings ampler on the South slope, till close Capra chalet, from where it goes down on the Capra Valley till the Vidraru lake. After its insinuation to the right bank of this lake, and its way through Arges Keys, situated close in the lake's Southern side, Transfagarasan goes out from the massif and moves towards the South Sub-Carpathians area. The transition from one slope to the other is done by a tunnel with a length of about 1 km (847 m), situated at an altitude of 2020-2040m, under the crest that binds/unites with Paltinu Peak (2372 m) to the West and with Iezerul Caprei Peak (2417m) to the East. Lengthways on Transfagarasan, there are 28 bridges and viaducts, as well as 550 footbridges.

The superior basin of Arges, where Vidraru dam is situated, extends on for about 250 km^2 between Negoiu and Moldoveanu peaks and the contact with the sub - carpathians (Arefu-Corbeni depression). Its limits are well distinguished following the water sheds: in the North – Olt basin, in the West Topolog basin; in the East Valsan basin ; in the South – the Sub-Carpathians on the localities` alignment of Aref – Capațaneni - Berindesti - Poenari –Turburea - Bradet. All these limits are clear and well pointed out, either through the agency of the interfluves alignments representing the watersheds, or by use of petrographic cliffs, as is the case with the South part, where the crystalline comes in contact with sedimentation [1].

For this study, many data were analyzed such as: topographic maps at the scales of 1: 25000 & 1: 50000, airphotogrammes at the scale of 1: 5000, geological maps of Cumpana and Negoiu at the scale of 1: 50000, as well as different (images) satellite maps that has been mapping the relief forms in high mountainous areas on the land and cabinet. Simple measurements have also been made regarding slope processes above the upper limit of the forest and the fluviatile processes in the mountainous forest area. The study has actually approached these mountainous areas that are considered less known by experts and non-experts alike. Slow accessibility and unfavorable climatic conditions for about 8-10 months a year, have been such limiting factors for any detailed research in this space. It is necessary, therefore, to redefine the difficulties associated with this study's target areas as taking primarily two directions. The first, concerns knowledge of the geomorphological features of the Argeş Valley in the mountainous sector and of the default of Făgaras' Southern slope, through existing information and especially with regards to land research performed in different periods of the year. The second also concerns knowledge, but of practical problems related to the region's relief, in conjunction with landscape-ic elements, environmental conditions, and, particularly, anthropogenic activities.

2. Transfagarasan highway– lack of balance between mountainous environment and elements of geomorphologic risk.

Transfagarasan altitude highway was developed between September 1971- and September 1974 having a total length of over 100 kms. The construction of Transfagarasan highway has produced important changes to the central part of Fagaras Massif. The generated changes were towards both the relief and its other components such as: the forest, the herbaceous vegetation, the soil, etc. Its development required a 3, 8 mil. m^3 excavations + 212 thousands m^3 of hard rock, and a further 150 thousand m^3 of terraces. Massive clearings were performed into the forests' domain, on both the North and the South slopes, and into the sinuous road sectors, as well as into the beech forests' areas, where there were a mixture of both beech and resinous trees (spruce fir forests). The phenomenon was also extended to the Carpathian superior floor, in the sub-alpine domain, where there were similar clearings of vast surfaces occupied by juniper, rhododendron and green amen trees.

Geomorphologic risk, anthropically [2] induced in this sector by the highway construction, takes varied manifestations. The clearings from the gradient floor and from the superior limit of the forest, the cuttings within the subalpine floor and the digging and excavation of the slopes (fig. 2), are, thus, incorroborated with the high morphometric values and the mountainous harsh climate, to amplify the morphodinamic potential of this sector, and implicitly, the degree of exposing the human component; the risk's potentiality. In this way, the processes signaled by us can be included, in one way or another, among the risk factors of the high sector to which the highway is also circumscribed. The areas with an increased geomorphologic risk include, first of all, the sector of the highest altitude of the highway; the one with abrupt gradients and harsh climate (cold season spanning for about 7-8 months/year), but, more significantly, the sector with Man's temporary presence by his pastoral and touristic practices.

Fig. 2 – Clearings and excavations realized for the highway construction amplified the slopes` morphodinamic potential.

Specified here, are the avalanches, the stones and boulders falls and the debris trickling. The only area from the massif where the avalanches are overseen, is situated in the superior part of Balea Valley, on its left slope, which goes down from Balea Ridge. Here, sustaining iron screens are placed successively along the length of the avalanche' couloirs, the curved level. Cemented stone walls, are also placed concurrently in order to redirect and hinder the avalanches` displacement speed. The length of these walls runs to tenth of meters, for over 100 m and their hight reaches 4-5 m. In transversal section they look like a trapeze with the great base of 5 m and the small one of 2-2, 5 m. This way, both the Transfagarasn altitude highway, in its curved sectors, situated under Balea Ridge and portions from the touristic path which climb up from Balea Cascada (fall) to Balea Lac under this crest, were protected. A collection, drainage and sewerage system of the waters resulting from snow -melting and precipitations, was also installed in the inferior half of the slope, directly under the protection screens. Another frequent phenomenon is the fall of rock blocks out of the superior limit of the forest, especially on the North Slope but also on that from the sector situated between Cota 2000 and the tunnel. Also, in the sectors where the wooden vegetation was cut, on big surfaces, the erosion, surface washings, land clogging processes, stones and slide rocks, all act strongly. Such a phenomenon, is so active that it sometimes developes right under the first protection grid at the tunnel's exit, on the South slope. Here, the erosion processes with tendency to strongly disrupt the sustaining pillars of the protection grid, destroyed the water drainage system and portions of the consolidations with stone walls and wire armour. We also have to mention the erosion rills has formed on the inclined surfaces, as those from Capra Valley slopes, in its superior part or within the surfaces around Cota 2000, on the South slope, due to the temporal character of the snow melting waters during torrential rains. Deepened by the passage of time, these waters run-offs transform into true gullies with large proportions reaching depths of 1,5-2 m. High risk areas are those near the highway on the slopes where clearings took place.

Areas with moderate geomorphologic risk are less on the surface, and are, occationally, superposed even over the highway rout, or sometimes appearing in the inferior part of the slopes that guard it. Geomorphologic processes are represented by surface washings, debris trickling, avalanches etc. Such phenomena are preponderantly met in the ruttier sector situated immediately downstream of Balea Cascade, where the boulder and stones falls are frequent. Specific to this area, along its whole lenghth, are the avalanche couloirs, to which desegregation fragments are transported and deposed, in big quantities, by snows. For e.g. on the right slope of Balea Valley, in cascade areas with the same name, some of these couloirs, appeared during construction of the highway, following the clearings done towards the superior limit of the forest. The greatest number of them is found on a route situated immediately under Transfagarasan, between the highway and the riverbed. In its inferior part, it has a large form strongly affecting the forest's boundery. It has to be remarked also, that in the same area, the active avalanche couloirs are extremely dangerous during the winter. Those are present in the superior part of the coniferous forests, on the left versant of the valley, which goes down from Balea`s peak and which intersects the touristic path which climbs up towards

Bâlea Lac. The debris deposits represent a moderate risk at present. They are situated at the border of the highway consisting of little couloirs, that have developed under the forest's floor, the springs canalized on the protection grids and wooden type vegetation (predominantly alder tree) that has covered them. These phenomenons will shortly affect the protection grids and by conjunction also the wooden infrastructures of the Transfagarasan highway. Precipitations and snow melting waters, thus, become an important geomorphologic agent, especially in the alpine and sub alpine floors or in the sectors where the forest vegetation coverage is very low, or where clearings has its effects. Water benefits by its action of modeling, generating some processes through some other preparitional factors such as: gradient slopes, substrate constitutions and the existence of some anterior networks of little ditches and channels. Such phenomena offered surprising results during the times when rain with torrential character, from the hot season happened. The materials, in this instance, were transported from the superior part of the slopes surpassing the traffic road in the gradient's sense, and getting deposed in the slopes` inferior part. In view of this process, the traffic road, at its full length, becomes very much affected by the materials sedimentations. This, consequentially, can be reactivated by future rains, as well as by the over deepening action of the slope immediately under the highway. There are also affected the rills marginal to the highway, by its filling and clogging with sensitive and brutish materials, transported from slopes. The reduced-risk areas characterize by excellence the superior part of the forest domain where the forests have an important role in hindering the geomorphologic processes and therefore, their manifestation is diffuse.

3. Hydro-energetic development from Vidraru – aspects of the influence towards the medium components.

Vidraru reservoir represents the most ample hydro power development from Fagaras Massif and even from the whole chain of Meridionali Carpathians (fig. 3). The water volume is collected from the massif's South slope, with a surface of 743 km^2, from which only 286 km^2 cover the basin reception surface of Arges, the rest being represented by the basins of 9 rivers laterally collected by headrace [3]. The most important headrace is that which collects the waters from Raul Doamnei and Valsan basins, having a surface of 349km^2, with a medium flow of 9,30m^{3}/s. It is formed by more segments that pass from a valley into the other: Raul Doamnei Cernat headrace continues with Cernat-Valea cu Pesti headrace. This main headrace is digged up on above its whole way in crystalline schists.

Fig. 3 – Hydro-energetic development from Vidraru, one of the most important within Meridionali Carpathians

Another important headrace, reaching a length of 7,7 km is situated on the righthand side of the lake. It gathers the waters of Topolog (left tributary stream of Olt), Cumpana and Cumpenita rivers, from a surface of 80,4 Km^2 ensuring an average flow of 2,26 m^3/s. Other streams piracy through headrace tunnels: Valea lui Stan, Limpedea, Dobroneagul etc. All the headrace systems, in a total lengths of 28,6 km, have a burrow shape, in which water circulates freely and gravitationally, having dimensions that can ensure the transport of overflows. In order to collect the waters of the rivers from the Arges basin, more dams and headraces were constructed. Following the dam's construction, the slopes were increased in gradient level, due to strong erosion by the change of the base level [4]. Average gradient increase are from 15^0 to 25^0 degrees. Relief energy, as a result, also increased by over 50 m. The relief fragmentation density increased from 1, 7-2 km/km^2 (on the topographic maps since 1950) to 3, 9-4 km/km^2 (on the present topographic map). Forests' clearings, in the reservoir area, created conditions for the reactivation of the surface and linear erosion processes, especially on the abrupt slopes which limited the volume of dam's lake, resulting in a series of rills, ravines and torrential organisms [5]. The water of the lake is generated by infiltration and damping from the materials and riverbed, new detachments, crumbling or landslides, also favored by the abrupt gradient (bigger than 25^0 of the slopes). These processes produced degradations of the forest highway from the lake's left handside. As a result of construction works (the highway situated on the lake's left) modeling processes were reactivated (crumbling, landslides), and a series of anthropic forms appeared.

Vidraru dam development has imposed major tranformations on the region's geomorphologic aspects. The dam can function as a threshold slope with a temporary character leading to changes of Arges longitudinal profile as well as of other rivers such as Valsan, Topolog, Limpedea etc. The dam interrupted the evolution continuity of Arges river in longitudinal and transversal profile; - the dam has the role of a flows' regulator, with changes in the downstream run-off frame of the dam. But, it can function also as water reservoir (water used in case of exception). After the dam's development, some important changes in the dynamics of the riverbeds and the slopes took place, producing modifications in the reports between solid and liquid phases, meaning the increasing of the solid flow [6]. The size of the transported fragments with diameter >200 mm is of 15% from the solid flow. The dam can be considered as threshold slope type, a threshold slope induced by man [7], leading to the creation of a new base level upstream, and implicitly to some changes of the erosion and accumulation processes, at present being distinguished as "the regressive accumulation". Vidraru hydro- technical development variously influenced the vegetation, in function of the geographical position of the works, as well as of the ecological valence of the plants species from the afferent vegetation floors. A series of clearings imposed by the dam construction were done, access roads and power lines crossings. Especially on the lefthand side of the Vidraru Lake, the appearance of various plant species in the herbaceous crust has been observed. On top of all such direct changes, vegetation also suffered indirect modifications. Because of the great number of excavations and use of large vehicles leaving their tyre imprints on the soil profile, some major modifications appeared. A growth slow- down in vegetation and a gradual regardation of the forest species is also observed. Another lack of balance due to the hydro-technical construction is the disappearance of some species of scientific value, some endemics, following to the access roads and lakes development.

4. Conclusions. Referring to the Transfagarasan highway we can retain the following aspects. The frost-thaw process generates frost-shattered blocks of different dimensions, as well as rock's friability and high degree of humidity on the one hand, and route traffic vibrations ,especially in the summer season, on the other hand. At the slopes' base from the highway border, there are accumulated important quantities of debris or of rock blocks, which burden or even sometimes block the route circulation. These being the most frequent risk forms; - in the sectors where the forest was cleared and in the same relief conditions but with an antropically modified profile of the gradient, the erosion processes were strongly intensified. Some bridges, viaducts, protection grids and support walls present a high degree of instability and, therefore, of insecurity for traffic circulation, due to the regressive and vertical erosion process. Some permanent measures of highway supervision and maintenance have been imposed, especially on its sub alpine route, where

the dynamics of the present modeling processes is varied and extremely active at specif.c spots and time intervals.

The hydro-technical developments [8] within the superior course of Arges, besides the electric energy generation, has lead to flood reductions and subsequent catastrophic debts attenuation having a measure equal to those recordered in the summer of the 1941, when a part of Corbeni village situated at the exit of Arges Keys, had been destroyed. About 10 000 ha of Arges basin were given back to the agricultural circuit. Development possibilities of new industrial branches in the region of the Curtea de Arges city and especially Pitesti were also subsequently created. Landscape has changed due to the construction of the hydroelectric power station, the development of Vidraru Lake and Transfagarasan highway that goes up on the dam's cornice. This also has lead to the fact that this sector is now visited by lots of tourists. However, the development of Vidraru reservoir, besides its obvious economic advantages, has had such a negative impact on the biodiversity of our country. Water of Valsan River where the aspret (Romanichthys valsanicola- relict and tertiary fish) has lived for millions of years,, is now being collected in before Vidraru dam. The systematic reduction of Valsan river, negatively influenced the aspret`s ecosystem, which at present is close to extention. The needed complex observations in which many specialists should participate from different branches of science (hydrologists, botanists, forestry people etc.), would bring important contributions to the existent changes' explanation, accounting for previous work depicting the massive changes that man has brought to his surrounding environment.

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