WATER INTERFERENCES IN THE APUSENI MOUNTAINS

R. BĂTINAŞ[1], *V. SOROCOVSCHI*[1]

ABSTRACT. – Water interferences in the area of the Apuseni Mountains. In the first part of the paper are presented the general attributes of water interferences and the location of studied area that has been analyzed. Then were identified, analyzed and detailed localized, depending on their nature (physical, chemical and mechanical) phenomena and processes underlying this category of water hazards. Regionalization of interference phenomena and processes can be based on several criteria (duration, intensity, frequency and number of water interferences determined in the researched area). Based on the latter criterion we have stated several areas, defined by the number of water interferences. Finally, we have identified four different regions, defined by the number of water interferences, (high, medium and minimum), which will determine the character of water hazard: complex, intermediate and low.

Key words: water interferences, turbidity, water quality, regional distribution, Apuseni Mountains.

1. Introduction

Water interference are included in the water hazards, being defined by a number of similar features like the complexity of phenomena and processes that maintain them, dynamism and their great spatial-temporal variety, duality of the effects etc. Differentiated by their nature (physical, chemical, mechanical) water interferences induce a number of effects on the environment components in which they appear.

Location of study area corresponds to a mountain area situated in northern part of Western Carpathians, between the Mureş valley in the south and Barcăului valley in the north, known as Apuseni Mountains (fig. 1). Outlined in the east by Transylvanian Depression and in the west by the Crişurilor Hills, Apuseni Mountains are characterized by a great diversity of morphometric and morphologic

[1] Babeş-Bolyai University, Faculty of Geography, 400006, Cluj-Napoca, Romania, e-mail: svictor@geografie.ubbcluj.ro
[1] Babeş-Bolyai University, Faculty of Geography, 400006, Cluj-Napoca, Romania, e-mail: rbatinas@geografie.ubbcluj.ro

features of the landscape, a complex geology (structure, petrography etc.) but also other environmental components (such as bio-pedo-geographical cover) and the diversity of economic activities conducted from ancient times in this mountain area. Also we can notice a high degree of population variety, distributed in relation with soil and subsoil resources (presence of several metallogenetic areas).

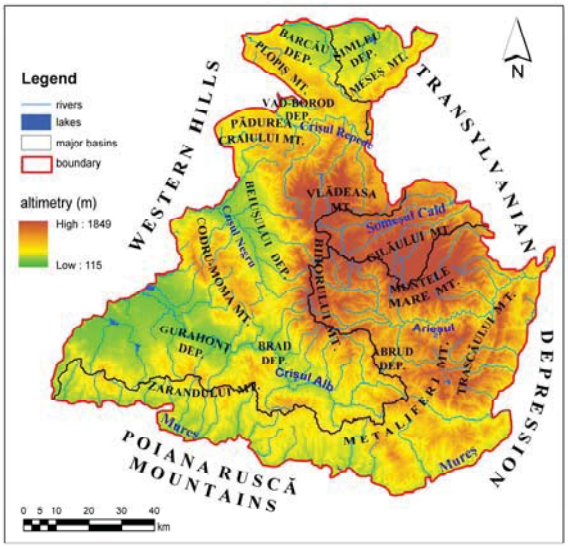

Fig. 1. Hypsometric map and relief units of Apuseni Mountains

The most important mealogeetic areas are asscoiated with the Metaliferi, Piatra Craiului, Bihorului and Trascăului Mountains (Ianovici, 1976).

The mentioned features and developments have led to numerous phenomena and processes of water interferences, which have been identified, analyzed and localized after their nature. The old population degree combined with the early mining activity in this area has an important role in the emergence and evolution of water interferences phenomena and processes.

2. The nature and location of processes induced by water interferences

Processes that occur during the interference phenomena can be of physical, chemical or mechanical nature. Each process has numerous attributes that influenced the development of a large number of water interferences (Sorocovschi, 2010).

2.1. Physical processes

From the physical processes we can mention those relating to temperature, transparency, color and water radioactivity.

a. River's water temperature, depends greatly by the climatic zone in which the catchment area is developed and by the water temperature of the tributarries. The water temperature of rivers draing the carstic areas (Bihorului, Trascăului and Pădurea Craiului Mountains) are defined by a different thermic regime. Thus, at an altitude of 1300-1400 m the passing of the monthly mean temperature over +1°C is producing with one or even two month later (March or even April), than those from the lower fields. The highest monthly mean

temperature is observed in July, reaching 22 °C, in the lower regions, while in the upper areas is around 16 to 18 °C. The maximum water temperature values in the plains, are reaching 33-34 °C, while in the nearby high mountains is about 25-27 °C.

The rivers with a high water feeding from karstic areas (Upper Barcău, Someşul Cald, Gârdişoara and Arieşul Mare from the Arieşului basin, Crişul Repede in the Vad-Aştileu sector, Crişul Pietros with Galbena and Bulz tributarries, Roşia and Holod from the Crişul Negru basin, Râbița, Izbucului Creek and Moneasa from Crişul Alb basin). At their emerging points at the surface, waters have a relatively constant temperature. For example the spring cave near Vadu Crişului, had in 1961, almost all year round, a temperature of 10 °C (Ujvari, 1972). The waters from karst regions induced multiple effects on the thermal regime of rivers. Thus, in case of big rivers, feed by the waters from karstic springs, can let to a lower frequency occurrence of winter frost (Crişul Repede between Stâna de Vale - 60% and Vadu Crişului - 53% Crişul Pietros - 47%, Holod - 67%, Roşia at Pocola station - 40%).

Instead, these waters intake are determined a decreased of summer overheating processes. The instability of frost phenomena in river basins in the mountain area is influenced by the high water speed, the frequent heating and by the intake of warm karst water.

Frequent thermal changes occur in winter in the rivers downstream of dams and reservoirs in the Someşul Mic and Crişul Repede catchments, because of the thermal inertia of the water discharged from the reservoirs. These changes leave their mark on the winter phenomena's across the lower basin of Someşul Mic River. A great contribution to the appearance of this phenomenon has the chemical load that is imprinted on Someşul Mic waters, after crossing Cluj-Napoca city (Şerban, 2007).

b. ***The trancparency and color of river's water*** are other marks that can detemine a different type of water interferences, of physical nature ones. Thus, the trancparency and color of water is largely modified by the amount of waters from the exploitation regions of ferous, non-ferous and precious ores, of mineral fuels and construction materials. Thus, the Arieş waters, downstream of its tributaries mouth's that are draining the Abrud area, are gaining a yellowish color (fig. 2).

Similar examples of water interferences, caused by the nature of the substrate on which drainage is formed, are reported on other rivers. Thus, they received chromatic hydronyms associated with petrographic nature of catchment area (Roşia River – Pădurea Craiului - reddish clays developed in its basin while Galbena Creek name is related with yellow clays). Another example is related with the type of transported materials (the Crişul Negru River's name is connected with the abundant vegetation represented by fallen leaves from trees in the upper basin). Rivers that are draining mining or preparation areas of ferrous and precious ores also can receive a color name (Crişul Alb, Roşia – Foieşul - Metaliferi).

a b

Fig. 2. Changes of river's water color: a) confluence between Valea Şesei and Arieş; b) Valea Seliştei Creek downstream of the homonymous tailing pond (Bătinaş, 2010).

2.2. Chemical processes

From the large variety of water interference we can noticed the frequently appearance of chemical processes, caused by natural factors, but mostly anthropogenic ones.

Outside of water interferences with a negative repercussions resulting from water pollution, we can speak (although the term known in the literature is a misnomer), about the "natural pollution", where the risk of interference is induced due to contamination mobility determined by natural processes. Negative water interference due to natural processes can be produced in different conditions: *the water passage through areas with soluble rocks* (sulphates, radioactive rocks etc.) which can lead to the contamination of surface water or groundwater; *surface water passing through areas affected by soil erosion*, causing contamination through the solid particles entrained, especially if the nearby soils are contaminated with various chemical fertilizers, or due to fine particles (marlstone and clay) that remain for a long time in suspension; *aquatic vegetation*, fixed or floating, in particularly slow drainage waters and lakes lead to contamination phenomena variable over time, depending on the vegetation periods; *vegetation on the banks* can produce also a contamination, both by falling leaves and by whole plant's decomposition. River water chemistry is determined by substrate characteristics and influenced by fluid, climatic and morphological peculiarities of the territories which collect its waters.

Thus, river waters running through the limestone regions, mostly of carbonated nature (Arieşul Mare at Scărişoara and Arieş River at Câmpeni, Gârda Seacă or Valea Morilor - Huda lui Păpară Cave – from the Arieşului basin, Roşia Creek at Pocola, Holodul Creek at Holod and Peştera Creek at Vadu Crişului from the Crişurilor catchment (Table 1).

Table nr.1. Hydrochemical type of river's water influenced by karst

River	Hydrometric station	Cations (mg/l)			Anions (mg/l)		
		Ca	Mg	Na+K	SO_4	Cl	HCO_3
Arieş	Scărişoara	24,6	6,54	4,43	17,82	7,02	85,47
Arieş	Mihoieşti	22,3	5,42	3,1	10,47	5,02	88,65
Gârda Seacă	up. cnf. Arieş	51,8	5,2	1,15	5,3	1,0	173,2
Huda lui Păpară	down. of cave	51,2	5,76	4,88	11,47	4,5	172,6
Crişul Negru	Şuştiu	35,6	9.7	18,1	25,2	9,2	154,2
Holod	Holod	68,9	8,49	26,4	49,6	11,6	222,73

The significant karst areas, the metallogenetic ones and those associated with swamps (oligotrophic bogs) are marked on the map in Figure 3.

The river's water that are crossing or are feeding the marshes areas are defined by an increase acidity. The swamps from the Apuseni Mountains, known also as "molhaşuri" are mainly located in the upper basin of Someşul Cald, Someşul Rece, in the Muntele Mare-Dobrinu area, whre they are „climbing" up to 1400-1700 m (Chinan, 2010).

Natural processes can temporarily and spatial change parameters of rivers water, but most of the negative water interferences are induced by human activities. These sources of pollution often cause significant changes in water quality characteristics, negatively influencing their usability. The most common sources of pollution include industrial waste, agricultural waste, municipal water that are getting in the natural network through leakage, seepage, direct injection, etc.

On the territory of Apuseni Mountains are a wide variety of pollution sources represented by: water discharged from mining centers of nonferrous ores and gold-silver exploitations, located in the three big metallogenetic areas; waters from ore flotation or those who are washing the waste dumps; wastewater from ore processing, sewage from towns situated along major river collectors. The most significant changes are reported in the middle basin of Arieş River, in the vicinity of following mining areas: Roşia Montană – Roşia Poieni, where the extension of degraded areas is very large (quarries, waste dumps, tailing ponds.)

The hydrographical network has been suffered important changes during mining exploitation, expressed by the following types of transformations:

- ***Structural*** – over the catchment areas by the alteration of morphometric features (surface, slope), changes in the draining density (due to a large development mining operation), changes in land use;
- ***Quantitative*** – by modification of runoff indicators (allochthonous water intake), of solid flow parameters (increase of turbidity);

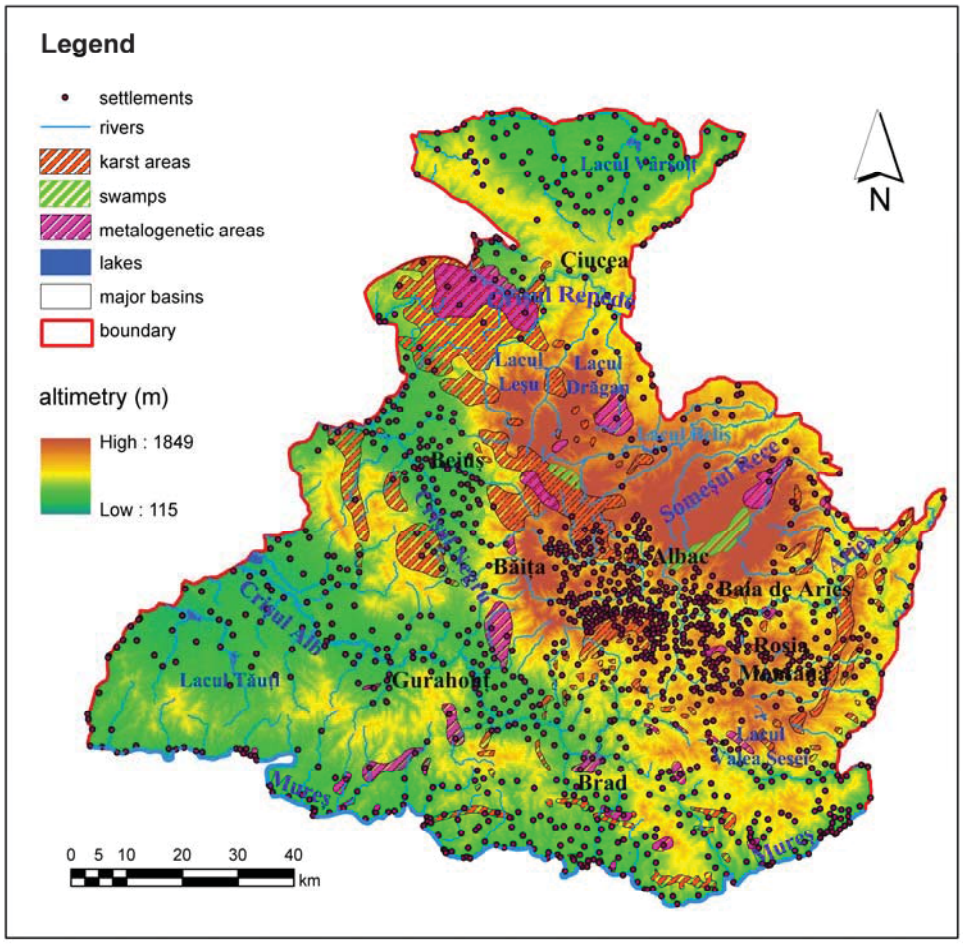

Fig. 3. Map of karstic, metalogenetic and oligotrophic bogs areas from the Apuseni Mountains (adapted after Pop, 1960, Iacob, 1971, Popescu, 1986).

- ***Qualitative*** – by an alteration of physic-chemical of surface and underground waters, expressed by a high concentrations of heavy metals ions, correlated with an accelerated process of acidification;
- ***Morphological*** – through changes in the longitudinal profile of streams, due to an increment of river beds as a result of successive accumulation of sediment, especially in the vicinity of mining galleries (Bătinaş, Sorocovschi, 2012).

The rivers waters affected by the products resulted from the mentioned activities (flotation reactives, cynides, phenols) have been included in the fourth class

of water quality, according to the classification criteria used in the Water Framework Directive EU 60/2000, emitted by European Commission on Environment (fig. 4).

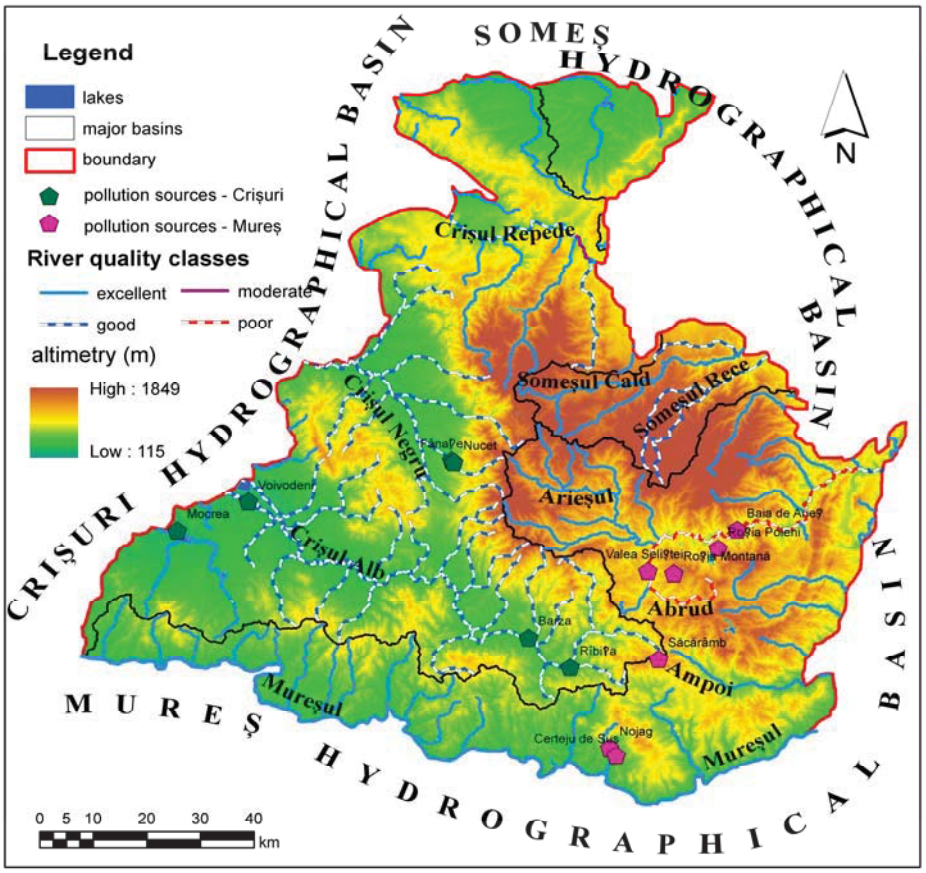

Fig. 4. Map of rivers water quality and major pollution sources from Apuseni Mountains (adapted after the River Basin Management Plans)

Most of the rivers situated in the Abrud catchment, but also along Ampoi River, downstream of Zlatna city, lower sector of Geoagiu Creek, Cri;ul Alb River, downstream of Gura Barza, are included in these category.

The second class water quality values are associated for the streams situated mostly in Crişul Alb catchment basin, but also to those from Someşul Rece River.

2.3. Mechanical processes

The mechanical processes occur frequently in running waters, but does not lack from reservoirs and lakes. Degradation and aggradation processes are included

in the water hazards category of mechanical nature. Hydro-morphological changes are a consequence of erosion and accumulation processes that are more intense during floods. Negative effects consist in banks degradation, damage and even destruction of hydraulic structures (dams, embankments, levees). A very interesting pattern is related to the tracks changes in water courses. The phenomenon is specific to the main courses on the western slope of the Apuseni Mountains. Most courses are loose in their own sediments. Thus the strong alluvial process developed on the Crişul Alb has imposed successive rising of the nearby levees.

Erosion carried out by rivers can cause property damage and restrictions for lands suitable for crops. Lateral erosion does not affect by a large proportion riverbeds where there are stabilization works. The average rate of erosion in temperate climate for rivers with non-cohesive banks can reach 10 m / year. Coastal areas of lakes situated on Someşul Cald, but also in the Crişul Repede become dynamic environments where degradation and aggradation processes are intense, driven by wave energy, currents and by the materials transported into the lake by its tributaries.

Clogging is a process that consists of solid particles deposition in both surface and underground waters. The degree of lakes's clogging depends on many factors: the intensity and extent of erosion and sediment transportation, physical and geographical characteristics of the receiving basin, the use of land in the catchment basin, the abrasion process of the banks, the size of lacustrine basin, the volume of water stored, the position of the reservoir in the basin, the longitudinal profile posed between two reservoirs etc.

Clogging lakes entails a series of negative effects such as: their invading with vegetation in portions where silt deposits are near the surface, leading to a restriction of slick with all known consequences. The most significant negative effect of clogging is the reducing of water quality accumulated in the lake. The changes that occur after clogging may diminish or even cancel some functions of the accumulation reservoir. Depending on the listed factors there are quite significant differences between the values of the rate of clogging in the lakes from the upper basin of Someşul Mic. Thus, in Fântânele and Tarnița lakes, the accumulation rate valuesare reduced due to rocks resistance to erosion, on which lies the related basin (granite and crystalline schists) with a thin layer of soil developed upon it. The reduced rate of silting in Tarnița Lake is due largely to its position within the cascade system of reservoirs on Someşul Cald.

The degree and rate of accumulation exhibits significant differences between specific volumes. The rate of clogging calculated for time intervals between 11 and 14 years has higher ratios values for *dead-volume* amount (Someşul Cald - 3.23, Fântânele - 0.73). The lowest rate of clogging in percentage are registered for *useful volumes* (Fântînele - 0,10, Tarnița - 0,20, Gilău - 0,12) and for *reserve volumes* (Someşul Cald - 0,04) (Şerban, 2007).

The loaded degree with suspensions, as alluvial matter is expressed by average turbidity, whose values increase gradually towards the periphery of the Apuseni Mountains, reaching values of 500 gr/m^3, at altitudes of 500-600m, close to the transition towards Transylvanian Plain and Somes Plateau. Rivers on the eastern slope of the Apuseni Mountains have favorable conditions for high sediment flow due to the alternating depressions with gorge like areas (Arieş, Someşul Cald). Thus, the small depressions carved in sedimentary deposits favors the erosion. Gorge sectors, carved in solid rocks are defined by a low turbidity. Abrud Valley, right tributary of Arieş has a high turbidity due to mining works deployed at Roşia Montana and Bucium. The elevated values recorded here are influencing even the turbidity of Arieş River, downstream of Câmpeni hydrometric station.

In the western part of the Apuseni Mountains, the existence of tertiary small bays that penetrate deep into the mountain area modified the hydrodynamic features of rivers, which is reflected in high turbidity values. The low hydraulic gradients cause intense sedimentation of transported silt, such as rivers are changing tracks in their own silt. The high fragmentation of relief in Brad-Hălmagiu Depression, low level of afforestation and the washing waters that drain the decommissioned tailings from mines from Brad, Gura Barza, Râbi□a, Baia de Criş and Ţebea, explains the high values of turbidity in the Crişul Alb basin (682 g/m^3 at Gurahonţ hydrometric station) compared to the Crişul Negru basin (132 g/m^3 Beiuş hydrometric station).

Degree of erosion carried by the rivers is more intense on the western slope of the Apuseni Mountains, where average values of specific runoff of suspended silt remains between 1 and 20 t/ha.an. In the middle basin of the Crişul Alb are recorded the highest average values of specific runoff of suspended sediment of more than 20 t / ha.an. Instead on the eastern slope of the Apuseni Mountains average values of specific runoff silt in suspension are much lower, between 0.1 and 1 t/ha.an (Buta, Iacob, 1967).

3. Regionalization ow water interferences

Territorial analysis of water interferences and the effects they induce, allows delineation of some areas that are affected similarly by the phenomena and processes that are accompanying the water interferences. Similar affected areas can be identified based on several criteria: duration, intensity, frequency and by the number of types of interferences that affect the researched region.

In the Apuseni Mountains have been identified several types of regions differentiated in terms of number of phenomena and processes of water interferences (fig. 5).

- *Regions with a large number of water interferences.* These regions are dominated by phenomena and processes of physical, chemical and mechanical nature, with a

wide variety of forms. Territories included in this type are belonging to the Bihor Mountains (central and northern part), Vlădeasa, Mountains and Pădurea Craiului Mountain. Important disturbances are marked on environmental components due to high erosion and by surface and underground water carbonation. To these, we can add pollution of surface waters by discharges of mine waters and those resulting from the preparation of ferrous and rare minerals.

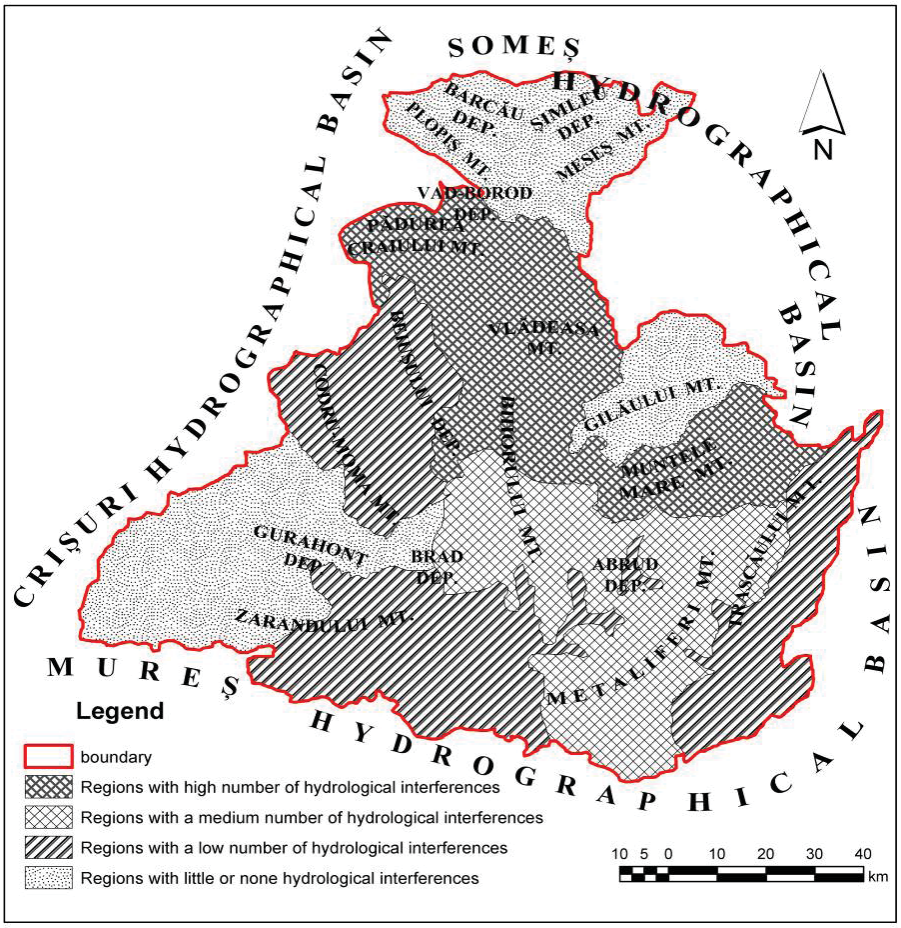

Fig. 5. Regionalization of water interferences in Apuseni Mountains

- *Regions affected by an average number of water interferences*. These areas include the southern extremity of Bihor Mountains and the Metaliferi Mountains, where special effects are induced by interferences of natural or anthropogenic chemical nature.

- *Regions with a few water interferences*. In these regions associated with Trascău Mountains and eastern part of Zarand Mountains are prevailing the phenomena and chemical processes.
  Interference-free regions occupy small areas corresponding to Plopiş Mountains, Meseş and western part of Zarand Mountains.

Conclusions

Water interferences are a category of water hazards less analyzed in the scientific literature. Processes that occur after the water interferences can be of physical, chemical, mechanical nature. Identify the location and nature of water interferences are essential conditions for developing plans needed for preventing and combating waterborne hazards.

The choice of study area was imposed by the complexity and peculiarities of environmental components, characterized by a great diversity reflected also in the specific processes and phenomena of water interferences, found in Apuseni Mountains. Water interferences are a special category of hazards characterized by complex features with multiple environmental implications for surface water.

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