

## THE IMPORTANCE OF THE ASYMMETRY OF SMALL HYDROGRAPHIC BASINS IN THE OCCURRENCE OF MAJOR FLOODS IN THE RARĂU MASSIF

Cristian-Dan LESENCIUC<sup>1</sup>

**Abstract:** The present study approaches a series of geomorphological aspects specific to hydrographic basins of small sizes which, in certain circumstances, favor the occurrence of floods having major effects upon the human settlements. We focused our attention on three neighboring hydrographical basins, located in a mountainous area in the north of the Romanian Carpathians, where on the 24<sup>th</sup> of July 2008, following some heavy rains, there occurred major floods. Although the three rivulets the Valea Seacă, the Izvorul Alb and the Valea Caselor are tributaries on the right side of the Moldova river, they behaved differently during the above mentioned flood. The particularity is that within the Izvorul Alb hydrographic basin the maximum flow during the flood was two times lower than in the case of the other two basins between which it is located. Given the fact that the quantity of precipitations received by all three basins did not differ and the physical-geographical features are similar, there was performed the morphometric analysis of all three hydrographical basins in order to outline the morphometric variables with a role in the concentration of the runoff: the surface, the slope, the roundness, the shape coefficient, etc. The conclusion drawn from this case study is that the asymmetry of the basin is an essential parameter in making the difference in respect to the behavior of small hydrographical basins during the formation of exceptional floods.

**Key words:** flood, hydrographic basin, asymmetry, Rarău

**Rezumat:** Importanța asimetriei bazinelor hidrografice mici pentru producerea viiturilor majore din Masivul Rarău.

Studiul de față abordează o serie de aspecte geomorfologice specifice bazinelor hidrografice de dimensiuni reduse care favorizează, în anumite condiții, producerea unor viituri cu efecte majore asupra așezărilor umane. Atenția noastră a fost direcționată spre trei bazine hidrografice învecinate, situate într-o zonă montană din nordul Carpaților României, unde în ziua de 24 iulie 2008, în urma unor ploi torențiale, s-au produs viituri majore. Deși cele trei pâraie Valea Seacă, Izvorul Alb și Valea Caselor sunt afluenți de dreapta ai râului Moldova, acestea s-au comportat diferit în timpul viiturii amintite. Situația particulară constând în faptul că în bazinul hidrografic Izvorul Alb debitul maxim din timpul viiturii a fost de două ori mai mic decât în cazul celorlalte două bazine între care se află poziționat. În condițiile în care cantitățile de precipitații primite de cele trei bazine nu au fost diferite iar caracteristicile fizico-geografice sunt asemănătoare s-a efectuat analiza morfometrică a celor trei bazine hidrografice cu scopul evidențierii variabilelor morfometrice cu rol în concentrarea scurgerii: suprafața, panta, circularitatea, coeficientul de formă etc. Concluzia ce se desprinde din acest studiu de caz este aceea că asimetria bazinului este un parametru esențial în diferențierea comportamentului bazinelor mici la formarea viiturilor excepționale.

**Cuvinte cheie:** viitură, bazin hidrografic, asimetrie, Rarău.

At the level of small hydrographic basins there are a series of geomorphologic characteristics which, in certain circumstances, cause floods with major negative effects upon the human settlements. Among these extremely important characteristics there are the morphometric variables having a role in the concentration and propagation of surface runoff. The asymmetry of the hydrological basin is one of the variables which influence the runoff within the three hydrographical basins afferent to the Valea Seacă, the Izvorul Alb and the Valea Caselor rivulets, tributaries on the right side of the Moldova river, which drain the north-east sector of the Rarău Massif (Figure no. 1).

This massif is located in the north-central sector of the Orientali Carpathians being grafted on a sublayer which, from the structural-lithological

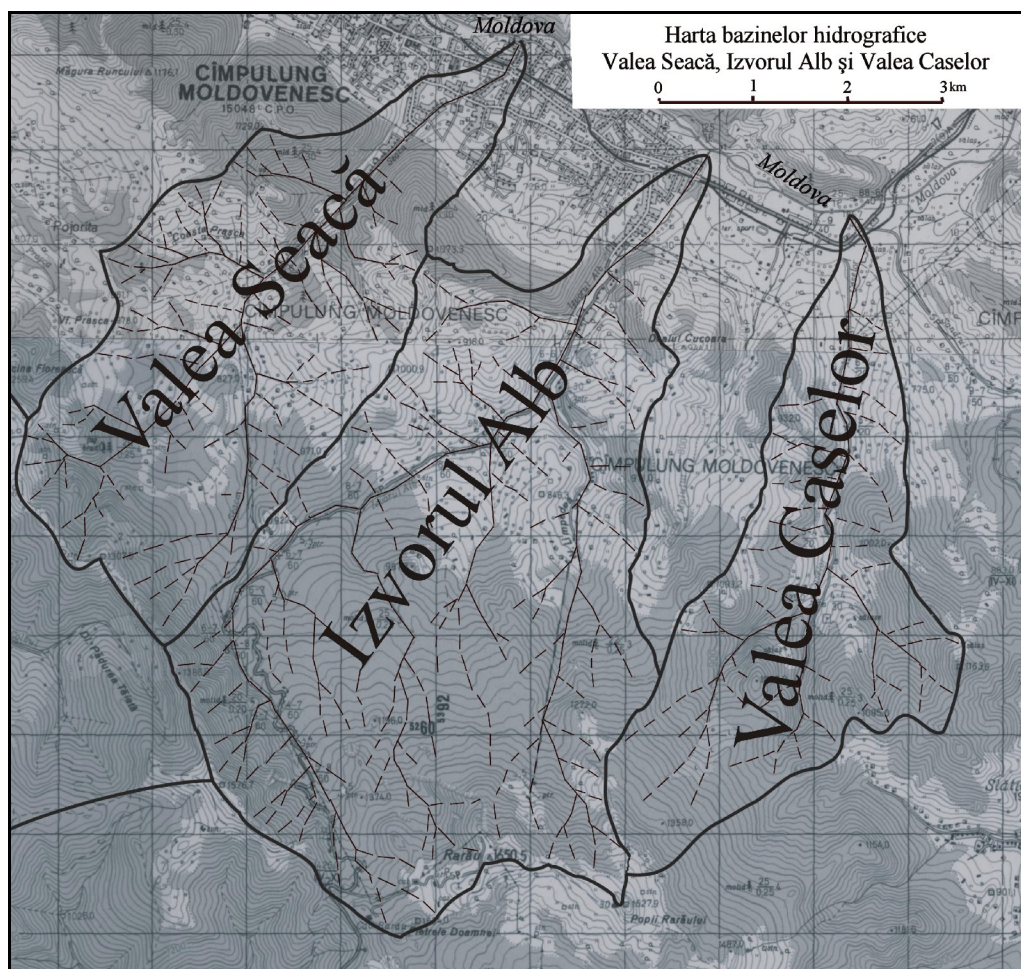
point of view, belongs to the crystalline-intermediate area.

The hydrographic basins represent geomorphologic fluvial systems which can be described by a high number of variables. Part of the variables and the existent relations between them had been identified for the first time by Horton (1945), who pursued an entire group of experts interested in this domain. In Romanian, Zăvoianu (1978) was among the first people who focused on the research of the relations between the morphometric variables of the hydrographic basins. Subsequently, there was quite an explosion of the studies based on the morphometry of hydrographical basins, approaches which, in a certain measure, remain timely due to the variety

<sup>1</sup> Department of Geography, „Al. I. Cuza” University of Iași, Romania, dlesenci@yahoo.com

of geomorphologic aspects analyzed. Of great practical importance remain the geomorphologic studies based on issues concerning the risk to floods existent in certain inhabited areas.

The present study had been initiated after the occurrence of some major floods, on the 24<sup>th</sup> of July 2008, which affected differently the human objectives located on the above mentioned valleys.



**Fig.1 The map of the hydrographic basins analyzed**

The working methods consisted in: 1. applying the method of crosscut section to determine the maximum flows occurred; 2. applying the morphometric method of analysis for hydrographic basins; 3. mapping the fluvial geomorphologic processes along the valleys analyzed; 4. making the inventory of the losses caused by the flood (houses, appendixes, lands, roads etc).

It is remarkable that, pursuant heavy rains superincumbent on a three days period with important precipitations, the Valea Seacă, a rivulet with a hydrographical basin of about 15 km<sup>2</sup> and with an average flow estimated to 0,15 m<sup>3</sup>/s, registered an increase of the flow which at high amplitude (2<sup>15</sup> hrs from the 24<sup>th</sup> of July 2008), reached the estimated value of approximate 20 m<sup>3</sup>/s. During the maximum flow of the flood, the rivulet raised with approximate 3,5 – 4 m affecting directly a number of

approximate 30 dwellings located along the valley on the riverside terrace of 1-2 m (Fig. 2 and 8).

In the same time an important flow increase was also registered on the Valea Caselor rivulet, whose hydrographical basin has about 11 km<sup>2</sup>, with an average flow estimated to approximate 0,14m<sup>3</sup>/s. In this valley the water level raised during the maximum flood with approximate 3-3,5 m, reaching a maximum flow estimated to approximate 10-15 m<sup>3</sup>/s. Though, also in this place, the water level raised a lot, there were directly affected only 12 dwellings located on the riverside terrace of 0,5-1,5m, because the house density here is smaller here than in the Valea Seacă, nearby the center of the Cîmpulung Moldovenesc city.

Between the two hydrographic basins considered for the analysis there is the Izvorul Alb rivulet, whose hydrographic basin is larger

(about 25km<sup>2</sup>) with a total surface approximate equal to the surface summed up from the other two hydrographic basins Valea Seacă and Valea Caselor. The average annual flow, estimated for this rivulet, is approximate 0,35m

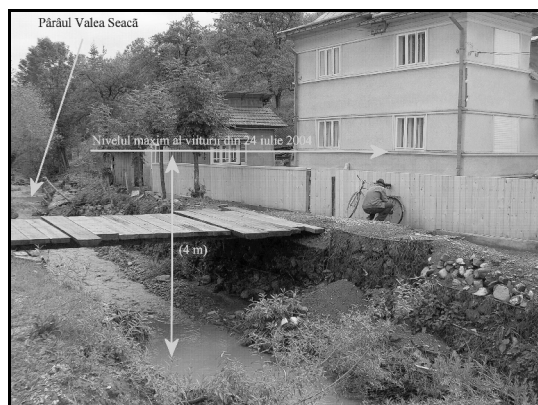


Fig. 2 The maximum level of the flood on Valea Seacă

During the flood occurred on the 24<sup>th</sup> of July 2008, it reached a maximum flow of approximate 15-20 m<sup>3</sup>/s raising its level with approximate 2 – 2,5 m. Unlike the Valea Seacă and the Valea Caselor, during the flood on the Izvorului Alb valley, only a touristic complex build nearby the river bed was damaged. The fact that on this valley

there were not any cases of flooded houses during the flood is because the houses are located on the riverside terrace of, terrace which was not affected on this occasion. Consequently, in this valley the most important material losses were registered due to the damage caused to the access road on certain sectors and by the damage of a crossing bridge over the rivulet.

From the analysis of this events there result the fact that at the level of the Izvorul Alb rivulet hydrographic basin there are a series of particularities which differentiate it from the other two basins from the point of view of its behavior during the flood.

We mention the fact that all three hydrographic basins received similar quantities of precipitations (66 mm/24 hours at the Rarău station – 1572 m altitude and 68 mm/24 hours at the Pojorâta hydrometric station – 700 m altitude). Also their distribution during the 24 hours, as well as the torrentiality are similar, given the fact that during the time interval 1<sup>45</sup> – 2<sup>30</sup> on the 24<sup>th</sup> of July 2008 there were registered maximum flows on all three rivulets analyzed to which we add the Izvorul Giumalăului rivulet where there is a hydrometric station (Fig.3).

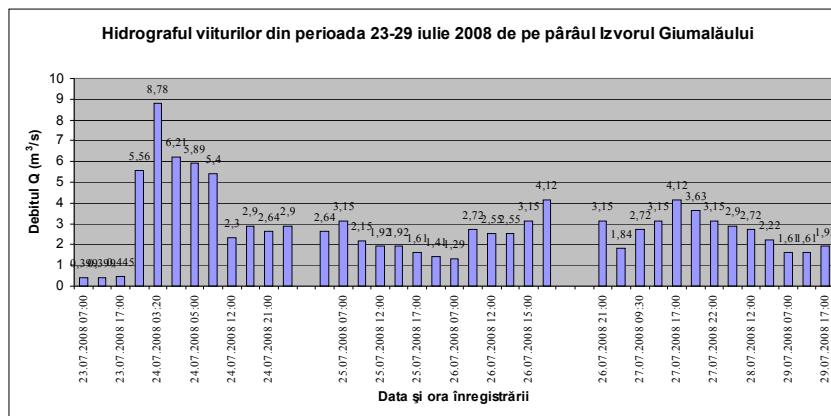
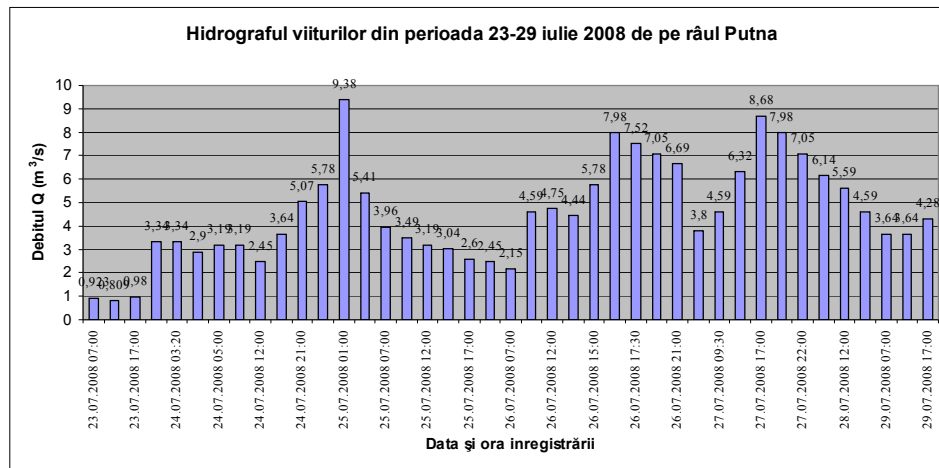


Fig. 3 The flow hydrograph from the Izvorul Giumalăului rivulet

It is important to mention the fact that the Izvorul Giumalăului hydrographic basin is located at the border between the Rarău and the Giumalău massifs. This hydrographic basin (hydrological monitored) had the same type of response to the heavy precipitations (Figure no. 3). The maximum flood had been registered in the same time as for the basins analyzed, but its flow did not increased too much, taking into consideration the surface of 30 km<sup>2</sup>, because the air masses direction was performed from the east to the west and among the three analyzed basins and the Izvorul Giumalăului was interposed the Munciei Însirași of Rarău ridge

which covered the basin taken into consideration, a great quantity of precipitations being discharged on the eastern side of this ridge. The same time of orographic barrier was also felt at the level of the Putna hydrographic basin, tributary of the Moldova river, a basin located west of the Giumalău main ridge. This ridge determined an outpashing in the registration of the maximum flow with a delay of almost 24 hours, and the amplitude of the flood was not as high as for the other three hydrographical basins analyzed, if we take into consideration the big surface of the hydrographic basin – 120 km<sup>2</sup> (Fig. 4).

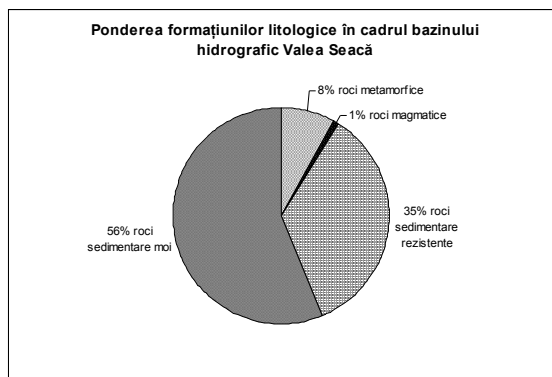




**Fig. 4 The flow hydrograph from the Putna river**

If, at the level of the quantity of precipitations there were not differences, then the research must take into consideration other physical-geographic factors from the level of the three basins. The geological sublayer is similar to a bigger correlation between the Valea Seacă and the Izvorul Alb basins (Figures no. 5, 6, and 7).

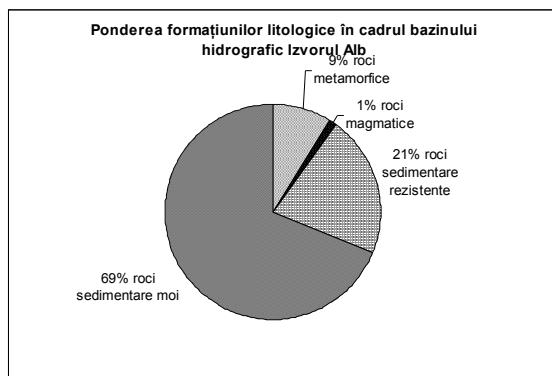
Izvorul Alb hydrographic basin. In the same time, the percentage of different categories of vegetation, as well as its condition is similar for all three hydrographic basins, the human impact, concerning the deforestations, affecting all three perimeters in the same percentages.



**Fig. 5 The Valea Seacă hydrographic basin – the percentage of petrographical formations**



**Fig. 7 The effects of the flood from 24 of July 2008 on the Valea Seacă brook**



**Fig. 6 The Izvorul Alb hydrographic basin – the percentage of petrographical formations**

The reflection of the geological sublayer within the geomorphology of the area does not differentiate substantially the two basins from the

The only significant differences between the Valea Seacă and the Valea Caselor hydrographic basins, on one hand, and the Izvorul Alb, on the other hand, are noticed at the level of morphometric parameters. The surface of the Izvorul Alb hydrographic basin, almost two times bigger, should be reflected within a higher flow compared to the other two hydrographic basins, registered during the maximum flood. In practice, this supposition was not verified and the explanation could be given by a higher capacity of the runoff to concentrate in smaller hydrographic basins (with a surface ranging between 10 – 15 km<sup>2</sup>).

In order to evidence this aspect it was performed the analysis of the Izvorul Alb hydrographic basin of 4<sup>th</sup> degree (Strahler system) having a surface of about 12 km<sup>2</sup>. The field

researches did not confirmed the occurrence of a flood similar to the other two (the level of the rivulet raised with maximum 2 m), therefore the differentiation is not given by the surface.

Even the rest of the morphometric parameters are not different for the Izvorul Alb hydrographic basin (if we keep the percentages), please refer to the table attached. Therefore, the shape coefficient is higher (0,49) than the one for the Valea Seacă (0,40) or for the Valea Caselor (0,32) and the roundness of the basin is 1,39, being placed between the value for the Valea Seacă (1,32) and the one for Valea Caselor (1,49), (Table no.1) .

**Table no. 1**  
**Morphometric features of the hydrographical basins**

	Valea Caselor	Izvorul Alb	Valea Seacă
Strahler order	4	5	5
Surface of the basin, Sb, (km <sup>2</sup> )	10,9	24,6	15,3
Average altitude (m)	1050	1130	990
Maximum altitude (m)	1501	1651	1351
Minimum altitude (m)	603	611	628
Maximum energy, E max, (m)	898	1040	723
The diameter of the inscribed circle, d, (km)	2,2	4,2	2,9
The diameter of the circumscribed circle, D, (km)	6,88	8,64	7,4
Shape coefficient d/D	0,32	0,49	0,4
Relief ratio RR=E <sub>max</sub> /D	130,5	120,1	97,5
Circumference of the basin (km)	17,2	24,5	18,3
Circularity of the basin P/2(II*Sb)	1,49	1,39	1,32
Length of hydrographic network, Lt, (km)	54,4	144,4	80,4
Number of segments of I order, N1	125	277	162
Network density Dt=Lt/Sb (km/km <sup>2</sup> )	5	5,8	5,2
Asymmetry index (Sst-Sdr)/Sb	0,21	-0,45	-0,16

As a consequence, the only morphometric parameter which contributed to the reduction of the flood on the Izvorul Alb rivulet is the asymmetry coefficient. In case of the Izvorul Alb hydrographic basin, the coefficient of asymmetry is very high (-0,45), fact which determines a flow in stages with an important advance for the left sector with steep and short slopes. This geomorphological feature prevents the formation of catastrophic flows similar to the ones registered on the Seacă and Caselor valleys.

A conclusion drawn from this case study performed on small hydrographic basins, with similar physical-geographic features, is that the asymmetry of the basin is an essential indicator in differentiating the behavior in cases of exceptional floods.

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