GEOMORPHOLOGICAL HAZARDS AND RISKS IN JIU DEFILE

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ABSTRACT: Jiu Defile has a length of 33 km and is located in the Southern Carpathians, between Parâng Mountains (east) and Vâlcan Mountains (west). This paper stars from the analysis of field mapping and measurements (based on topographic maps, scale of 1:25 000), and data from local institutions and other sources (web, press). In Jiu Defile, geomorphological hazards results from the combined action of meteorological conditions and other factors such as geology, geomorphology and socio-economic development. They may affect transport infrastructure, which is at risk especially in spring and summer.

Keywords: Jiu Defile, geomorphological hazards, risks

Introduction

Jiu Defile is located in the Southern Carpathians, between Parâng Mountains (east) and Vâlcan Mountains (west). It has a length of 33 km on 246 m of elevation (between Livezeni – 556 m and Bumbeşti-Jiu/ Gura Sadu – 310 m) (fig. 1).

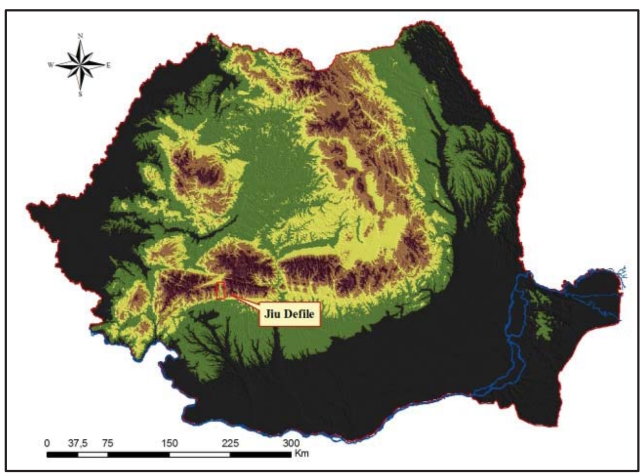

Figure 1 Jiu Defile's location in Romania

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Defile's origins were intensely analysed – firstly, the hypothesis of capture came up (Lehmann, 1884, Inkey, 1892, quoted by Niculescu, Roată, 1994), then the one of capture and antecedence (De Martonne, 1899,1907) and of antecedence (Burileanu, 1943, Mihăilescu, 1965, Orghidan, 1969, Niculescu, Roată, 1994). Actually, Jiu pass is considered to be the most impressive example of antecedence from all the crossing valleys of Lower Danube watershed (Orghidan, 1969). Apparently, the incision continues in the time being. Natural processes of erosion and transport take place only on the bottom of the valley; despite the lithology, the hillsides are protected by compact forests against massive natural processes (Niculescu,Roată,1994).

The aim of this paper is to identify geomorphological hazards, which may damage transport infrastructure (rail and road) and interrupt the traffic.

Methodology and data

Our work methodology followed four main steps. 1) We analysed geological maps and the DEM (Digital Elevation Model) in order to understand the particularities of Jiu Defile. 2) We measured geomorphological processed and landforms and we mapped them on existent topographic maps (scale 1:25000); our work was accomplished on the field and, then, in laboratory using ArcMap-GIS and Corel Draw software. We captured some observations on photos in order to show them in our paper. 3) We gathered information on geomorphological events, which affected the traffic, from National Administration of Roads (A.N.D.) – of Gorj and Inspectorate for Emergency Situations (I.S.U.) – of Gorj. 3) We compared these events with climatic and hydrological data from National Administration of Meteorology and National Institute of Hydrology and Water Management; the graphs resulted from Microsoft Office Excel software.

The factors conditioning geomorphological hazards and risks in Jiu Defile

- **Geological factors.** Jiu Valley is steeped in several lithological complexes: 1) Mesozoic sedimentary series of Tulisa (north); 2) native crystalline, consisting in Dragşan series (amphibolites and clorite-sericites) and Lainici series of gneiss (sericite-chlorite schists, quartzites, crystalline limestone) (north and centre); 3) granitic intrusions of Şuşiţa (south); 4) quaternary deposits (debris and silts) (Pavelescu et al., 1964) (fig. 2).

- **Geomorphological factors.** Jiu River forms a defile – narrow pass, with steep slopes and confined meanders. It is considered the wildest valley of our country (Orghidan, 1969). Local relief reaches 300-400 m/km^2 and even exceeds 400 m/km^2 in some sectors. Hillsides' slope (fig. 3) averages 20-30°, outreaching locally 30°. Road's embankment has a slope of 80-90°. Active geomorphological processes, induced by road and rail's construction, affect the hillsides on the bottom of the valley – 50-150 m above the thalweg (Niculescu, Roată, 1994).

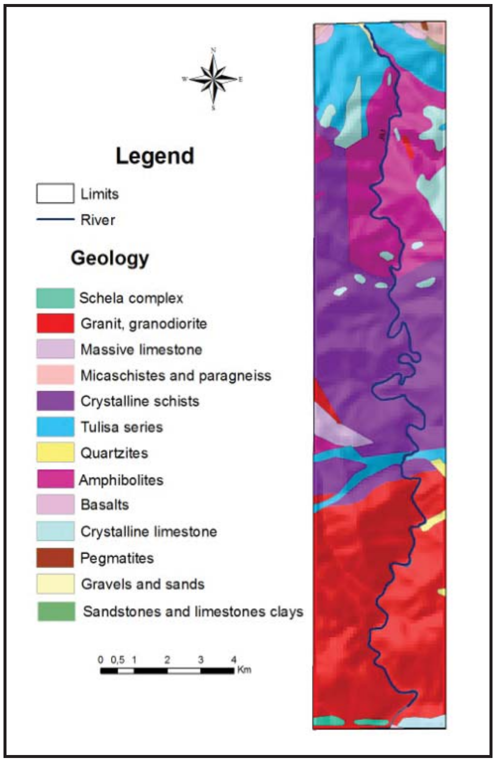


Figure 2 Geological map of Jiu Defile (After geological map at 1:200.000 scale, Geological Institute of Romania, 1968)

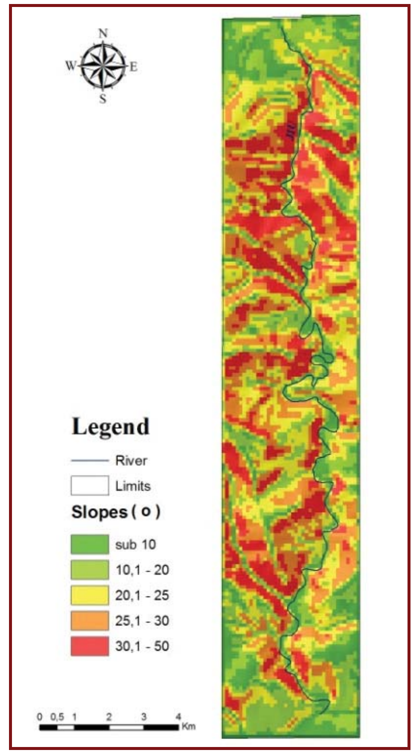


Figura 3 Jiu defile – slopes map

- Climatic factors. Geomorphological hazards follow large amplitudes of temperature and humidity, and intense rainfalls. For example, significant landslides succeeded the rainfalls from July 2005 (Fig. 4 a), and June 2006 (Fig. 4 b) (Săndulache, Cheval, 2009).

- Hydrological factors. Jiu River determines the lateral erosion and incision of its channel in relation to its water levels and discharges. Its mean annual discharge is about 20.8 m^3/s, but it can exceed 500 m^3/s: 564 m^3 /s on June 11th 1970 and 541 m^3/s on July 14th 1972 (Barbălată, 2005).

- **Biogeographical factors.** Defile's hillsides are covered by compact deciduous and mixed forests, which prevent geomorphological processes; as we have already sad, they occur only on the lower part of the hillsides, above the thalweg. Jiu Defile is a National Park (Stoiculescu, 1999).

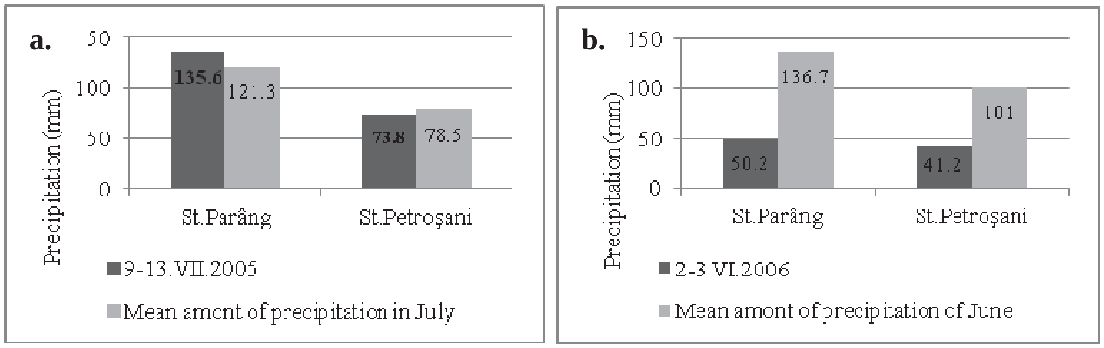


Figure 4 The amount of precipitation recorded during several periods, compared to the annual average, responsible of landslides

- **Anthropic factors.** The infrastructure elements provoked hillsides' base instability and they aggravate it by traffic's vibrations. 3749 cars roll every day on road D.N. 66 (according to A.N.D. – of Gorj). This road dates from 1894 and it was cobbled in 1968. The railway's construction started in 1924 and it became functional (and electrified) in 1948; it has 38 tunnels and protection shelters against rockfalls, several bridges and viaducts (Pop, 2000).

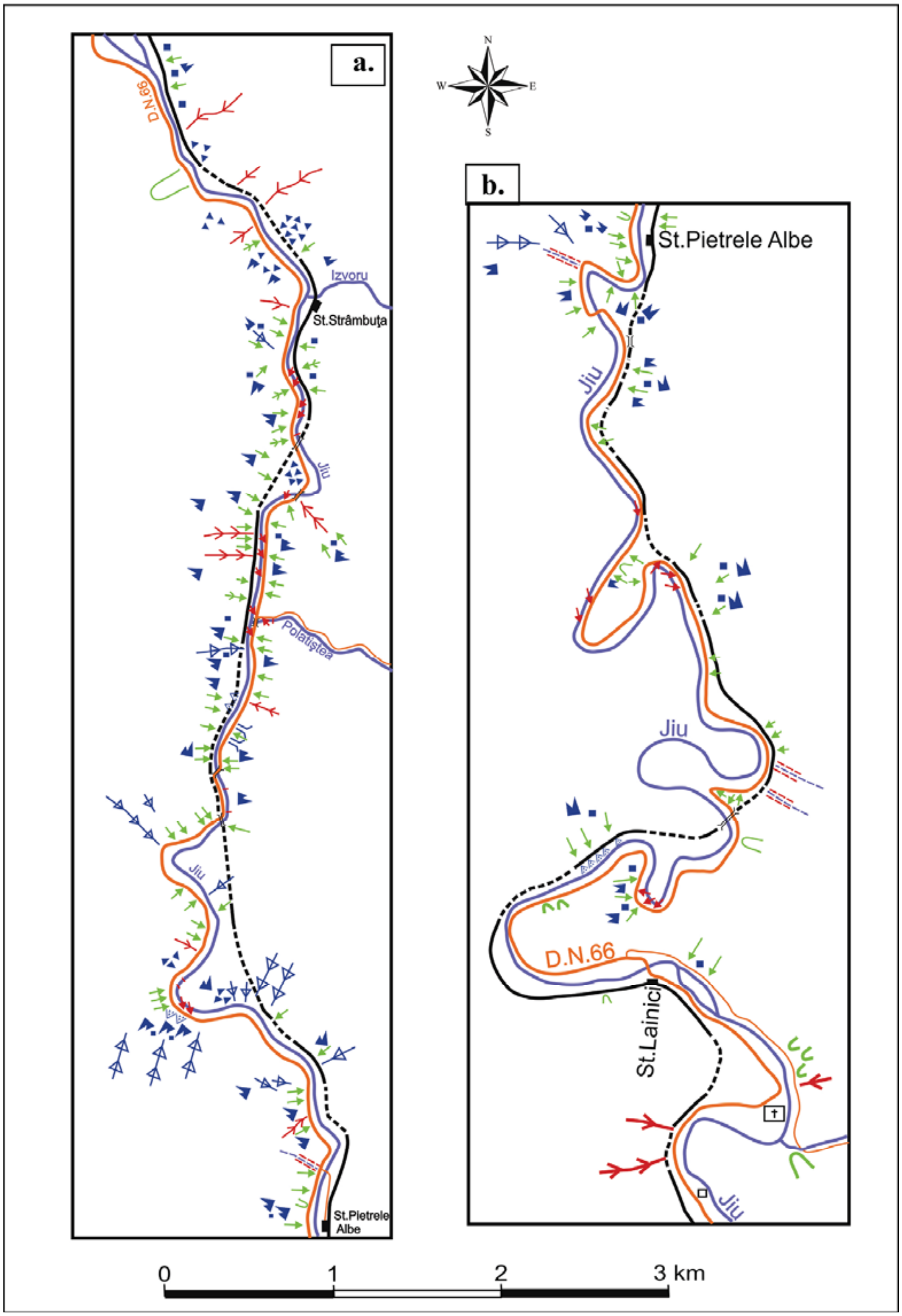
Results and discussions

Based on this methodology, we obtained a typology of geomorphological hazards and risks in Jiu Defile: fluvial and torrential erosion, rockfalls, block slides, landslides (fig. 5 a, b, c) (Săndulache, 2010).

Fluvial erosion (sidewise and incision) is continuous and increases with water level and discharge. The sidewise erosion creates overhangs on the banks, breaking down portions of road's asphalt. For example, one event took place on April 11th 2005 at km 121 + 272 (Polatiştea) (Fig. 6). At present, such events could happen in meanders' concavities (Murga Mare, Cotor, Cârligul Închis, Cârligul Mare, Dragu, Leurzoaia and upstream from the confluence Polatiştei – Jiu).

Figure 6. Bank's collapse and asphalt's damage (www.editie.ro), near the confluence Polatiştea-Jiu, at km 121+ 272

Rockfalls are common, especially on the hillsides located next to the road. There is a permanent risk between km 117 + 900 ... 118 +500, km 120 + 200 ... 120 + 400. The most exposed areas are in the proximity of Polatiştea, Cârligul


a.
b.
D.N.66
Izvoru
St.Strâmbuța
Jiu
Polatiștea
Jiul
St.Pietrele Albe
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W
0
1
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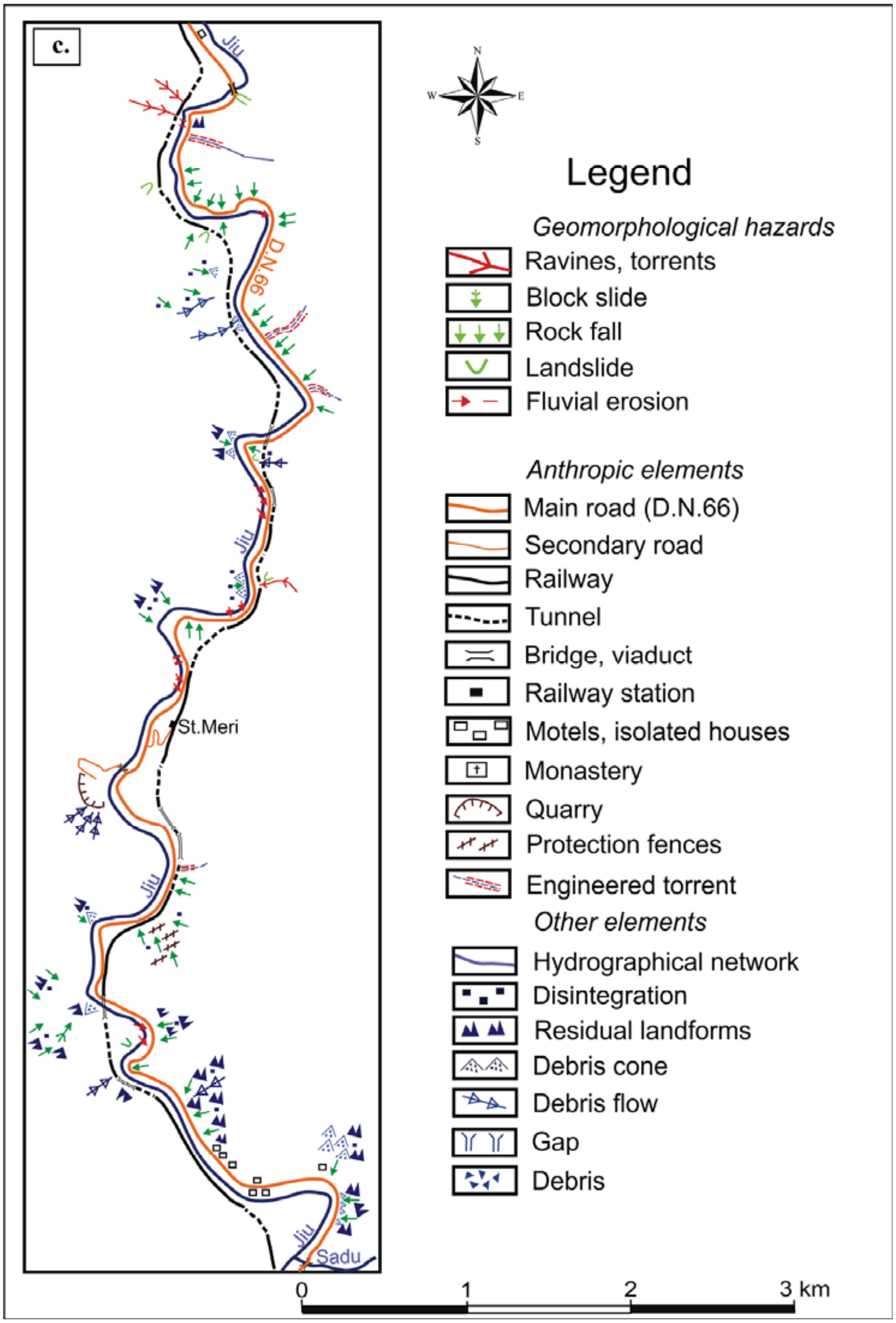

Figure 5 Geomorphological hazards in Jiu Defile:
a. Livezeni – Pietrele Albe reach
b. Pietrele Albe – Lainici reach
c. Lainici – Bumbeşti reach (Sadu Valley)

Caprei, Sfinxul Lainici, Murga Mică – Murga Mare. All along the defile, there are 26 traffic indicators for these processes and they cover 16 km – half of defile's length.

Block slides affect the debris formed of amphibolites or sericite-chlorite schists. Large volumes of materials were brought in the proximity of km 122+ 500, 123+100 and 123+600.

Landslides occur in thicker altered deposits, especially on crystalline schists. They may affect them partially or totally, creating scarps of 1-3 m of height; these landslides have 30-60 m of elevation and 50-150 m of length. The largest landslides, based on the amount of material transported and deposited, are presented in Fig. 7, 8.

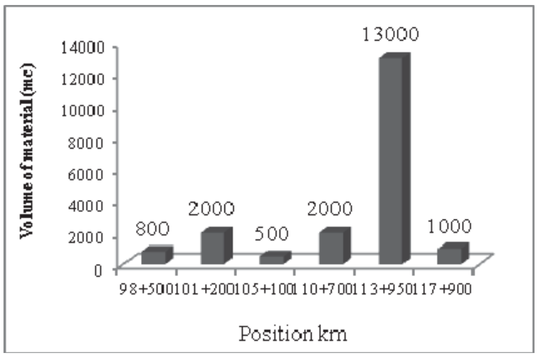

Figure 7 The largest landslides in Jiu Defile (according to A.N.D. – of Gorj)

Figure 8 Landslide at km 113+900 (on 07/13/2005)

Figure 9 The landslide from km 110+700 (Cârligul Întors)

Some of the analysed landslides are stabilised by engineering measures and are inactive (km 113+950), while others, despite human interventions, still raise problems (km 110+700) (Fig. 9). Besides the rainfall, this processes' activity is due also to a spring that continuously moisture the deposit. In order to solve this problem, this spring will be capture and redirect towards Jiu River (according to A.N.D. - of Gorj).

We noticed that, in some sectors, the debris has a potential to slip despite the forest cover. It is the case of the debris fixed by alder forests at km 123+450... 123+600, on sericite-chlorite schists and on a slope of 35-40°. The debris is located on a side of the road, on 150 m of length.

At km 124+100, the altered deposits of crystalline schists (cca. 2 m of thick, 15-40° of slope, forest cover) has a potential to slip especially because its base is unstable (Fig. 10 a, b).

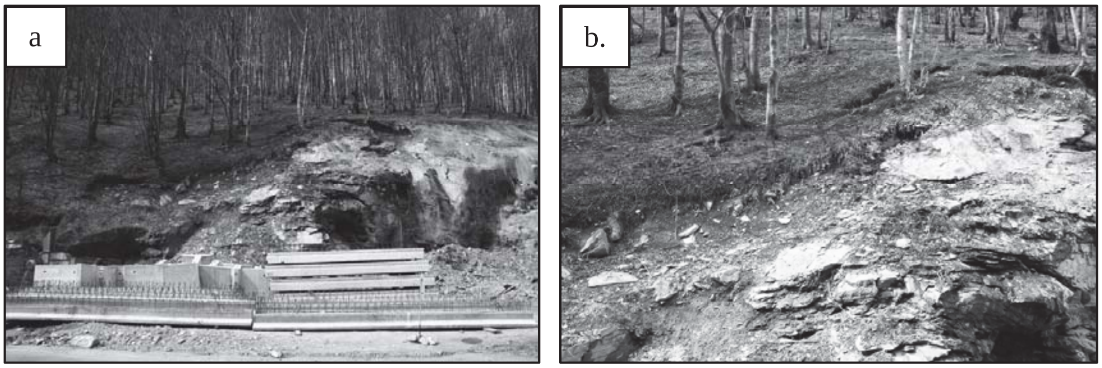

Figure 10 a, b Altered deposits with slip potential at km 124 +100

Torrential erosion becomes active after heavy rainfalls (expressed by maximum amounts of rainfall in 24 hours at PH Strâmbuța – fig. 11), especially in summer and early autumn.

It creates ravines, which are generally small, and torrents. Most torrents, especially the big ones, are stabilised due to engineering works. The torrential erosion manifests itself also by earthflows (fig. 12).

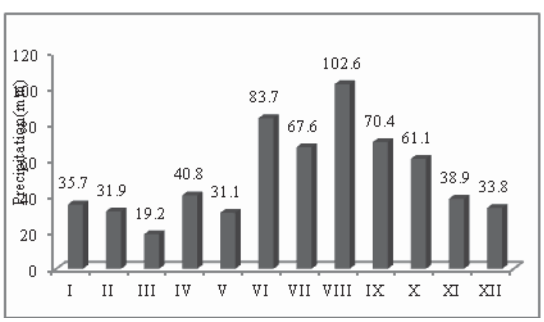

Figure 11. Variation of maximum amount of rainfall in 24 hours at PH Stâmbuța

Figure 12. Earthflow from July 2005 Upstream from Lainici Station, which caused the interruption of railway's traffic

As we have sad, the geomorphological hazards and risks (rockfalls, block slides, landslides) impact on road and / or rail's traffic in Jiu Defile, which is repeatedly interrupted (Table 1). This requires the intervention of a team from the National Administration of Roads and Inspectorate for Emergency Situations, or Salvamont rescue teams

Table 1. Events interrupting road's and / or rail's traffic in Jiu Defile

N^o	Date	Place	Type/Effects
1.	1987	-	Block of ice on 5 m
2.	02/27/2005	Several places	Avalanches and rockfalls
3.	03/06/2005	Km 110+910/110+950	Protection works' slide
4.	07/01/2005	Km 105 (Pod Lainici)	Landslide 500 m^3
5.	07/13/2005	Km 113+950 (Meandru Cotor)	Landslide 13 000 m^3
6.	07/14/2005	Railway station Lainici	Block slides, 5 trains and the Trans-Balkan Express blocked in different railway stations, electricity cut-off
7.	12/27/2005	Km 110 + 600	Rockfall
8	12/30/2005	Km 110+700	Landslide 200 t
9.	01/10/2006	Cârligul Întors, Km 110+700	Block slide 2000 t of debris and 20 t of rock
10.	03/16/2006	Km 110+700	Land and wood slide
11.	06/122006	Cârligul Întors, Km 110 +700	Landslide 2000 m^3
12.	06/03/2006	Cârligul Întors, Km 110 +700	Block slide: over 150 m^3
13.	07/15/2006	98+450 dr.	Landslide 800 m^3
14.	02/09/2007	Cârligul Întors, Km 110 +700	Landslide
15.	03/28/2007	Cârligul Întors, km 110+700	Rockfall
16.	05/21/2007	Cârligul Întors, km 110+700	Huge rock and alluvium
17.	06/20/2007	101+200 dr	Landslide 2000 m^3
18.	07/15/2007	117+900 st	Landslide 1000 m^3
19.	04/15/2008	Lainici	Rockfalls
20.	03/18/2009	Cârligul Întors	A felled tree damages the back of a car, without victims

* data from the archive of the National Road Administration – of Gorj, Inspectorate for Emergency Situations – of Gorj and other sources (web, press).

Although we investigated only a few events, we conclude that they occur mostly in spring and summer, due to temperature variations and high amounts of precipitation. Their frequency and return period are shown in Fig. 13 a and b.

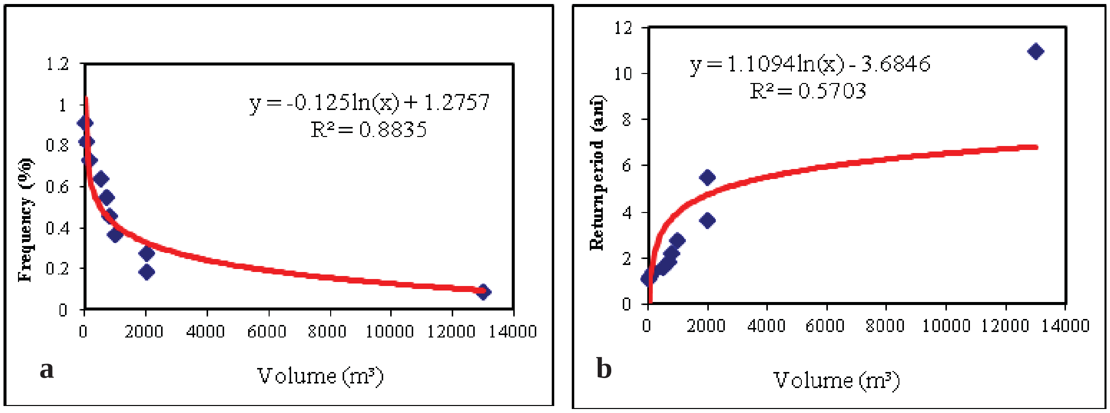

Figure 13 Frequency (a) and return period of landslides (b)

Conclusions

Geomorphological hazards and risks in Jiu Defile are the result of climatic factors' interaction with local geology and socio-economic development. They may damage the infrastructure and affect the population especially in spring and summer. They are a risk for road and rail traffic.

Local public authorities operate to manage geomorphological hazards by various measures: A.N.D. – of Gorg engineer landslides and torrents; they remove debris from the road and railroad to reopen the traffic; they reinforce hillsides by protection walls; they place traffic indicators to announce rockfalls.

Our analysis represents an example of approch of geomorphological hazards and risks problematics in Jiu Defile. It remains open to future studies for improvement and extension of the present results.

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