Published in : Floods and landslides : integrated risk assessment / Riccardo Casale, Claudio Margottini, (eds.) (1999), Berlin : Springer, pp. 125-132
DOI: 10.1007/978-3-642-58609-5_9
Status : Postprint (Author's version)

The Importance and the Problems of Cartography - An Example: The Cartography of Natural Constraints on a Territory of 74 km² in Belgium (the Sprimont Territory)

A. Pissart, D. Closson

9.1. The Authors of the Research

A team of scientists from the Department of Physical Geography at the University of Liège have worked with A. Pissart on the present research; Damien Closson carried out the Arc-Info cartography and the studies on the protection of water catchments, on the sewage possibilities and on the fertility of soils; Camille Ek studied the karstic dangers; Michel Erpicum and Georges Mabille the climatological issues, while François Petit was concerned with the flood hazards.

9.2 Presentation of the Studied Area

The district of Sprimont located south of Liège in Belgium covers 74.28 km² and is a part of a natural region called "Condroz", The substratum is formed by Palaeozoic hard rocks folded and giving a typical Appalachian morphology. The ridges, levelled by an Oligocene peneplain, correspond with Devonian sandstones. The depressions are on Carboniferous limestones. The ridges are elongated along a south-west/north-east direction which corresponds to the orientation of the geological structure. Two important rivers (Ourthe and Amblève) are surimposed in the Palaeozoic structure and flow through the morphology without any connection with the geology. The bottoms of the valleys of these rivers are around 100 m a.s.l; the highest summit is close to 315 m. The gentle slopes feature a discontinuous cover of eolian loesses which are usually reworked by slope processes.

This district is situated approximately at a 20 km distance from the centre of Liege and is part of the suburban belt which exists around this city. The landscape shows deciduous forests and grasslands in which there are villages in expansion due to the opening, a few years ago, of a new highway crossing the whole district.

9.3 The Cartography

For the administration in charge of planning in Wallonia, we carried out a cartographic research under the title of "Research of a methodology to identify which physical constraints are important for planning good land use". The aim was to recognize the physical elements which may play a role in land use, and to present maps collecting all these elements.

During this research we considered all the physical factors which may be interesting for a planner. They are first the hazards connected with floods, landslides, falls of rocks, and karstic

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dangers; secondly the protection of water catchments, the problems of sewage; third the exposure to the sun, the fertility of the soils and the locations where buildings may spoil the landscape.

This research is a typical physical study which considers not only floods and landslides hazards, but also all the physical parameters which concern the land use problems. It is an extension of the problem considered here from the sole point of view of floods and landslides hazards.

Because we do not know any landslide in the Sprimont district, we will not speak about this hazard. We will consider mainly the cartography of the flood hazards and later, very briefly, the other questions. About the flood cartography, we will explain the regulations which are in force in other countries (mainly in France) where the problem of cartography is officially the first priority and for which rules were enacted by the government.

9.4 The Flood Hazards and the Cartography of Prone Areas

We will consider two different questions. First the cartography of hazards in the alluvial plains of the largest rivers of our district, and secondly the cartography of the storm hazards in small basins (catchments of a few square kilometres or less), hazards which exist when heavy rains occur, a risk which is called "ruissellement pluvial urbain" by the French Ministry for Environmental Problems.

9.4.1 THE CARTOGRAPHY OF THE FLOOD EXTENSION OF LARGE RIVERS

In France, the cartography of the areas which experience floods has been imposed by the administration since 1982. The realization is very slow, as at the end of 1994, the maps of only 500 amongst the 2 000 districts of first priority had been drawn. The aim of this cartography is to have a tool to decide where 1) to prohibit the erection of any new building because the level of water may be high, 2) to limit, by adequate regulations for construction, the vulnerability of new buildings which are located under a lower water level, 3) to preserve the zones in which the water may have accumulated during the floods.

This cartography is difficult: the administration requests that a centennial flood be taken into consideration. Also for this flood, the zones where the level of the water will be higher than 1 m, between 0 and 1 m, and out of the flood, should be defined on the map. The problems of such a cartography are addressed in a booklet published by the French administration under the title of "La cartographie des plans d'exposition aux risques" (Garry 1988). These problems are numerous:

a. The first one is to have a very good cartographic base not only in planimetry but also in altimetry. Three quarters of the work is done if good maps are available. In France, on the IGN map, the accuracy is very often 1 m for the points with a marked elevation value and 2-3 m for the contour lines. The French administration writes that such accuracy is not high enough for mapping the floods.

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b. The second difficulty consists in collecting information on the preceding floods. If a flood occurs in the period studied, it is possible to take aerial pictures and to level the high water marks in the field.

c. Another problem lies in the estimation of a centennial flood; it is necessary to have discharge observations during many years to calculate the discharge which may occur every too years. With this value it is possible to estimate the level of the centennial flood everywhere, if very accurate maps exist. Such highly accurate altimetric maps are very expensive. In France, one "departement" (administrative subdivision) which has a budget of 1.4 million franc for the whole cartography received proposals just to prepare the base topographic map for 0.75-1.5 million franc!

We have prepared the cartography of this hazard in the Sprimont district. Two rivers, the Ourthe and the Amblève River, are flowing and join on the district of Sprimont. They have basins of 2 666 km^2 for the Ourthe River and 1052 km^2 for the Amblève River at their confluent. The mean discharge of the Ourthe 20 km down this confluence, is 61 m^3/s but with peaks which reach of 500 m^3/s for a decennial flood, and 750 m^3/s for a centennial maximum. As for many rivers, the floods are more and more costly mainly because there are more buildings on the alluvial plain. Two kinds of projects are under study to limit the hazards: a) the construction of dams in the upper part of the basin to control the highest discharges, b) local works to protect inhabited areas.

During our study, we were lucky enough to have high floods of these main rivers. We collected many observations during the floods: a) aerial pictures taken from a small plane for a level of the river with a recurrence of eight years and half for the Ourthe River and for six years for the Amblève River (a flight was impossible when the flood was at its peak), b) information about the high-water marks collected in the field and about the maximum water levels in the houses (this information gives the level of water for a recurrence of 70 years which was the maximum for this flood), c) because we had the best topographic and altimetric maps of the alluvial plain, it was possible to calculate the level of the rivers for the centennial discharge (750 m^3/s) and to map the depth of the water everywhere on the alluvial plain.

9.4.2 THE CARTOGRAPHY OF STORM FLOW HAZARDS

Let us consider now another flood hazard: the hazard related to short but very heavy rains. An example from France is the catastrophic event which resulted from a precipitation of 300 mm in 7 h which fell on Nîmes in October 1988 (Desbordes and Noyelle 1994). The occurrence of such heavy rainfall is rare in Belgium (it sometimes happens during summer thunderstorms) where they have a much lower frequency than in other climatic environments and especially under the Mediterranean climate. The comparison of the curves of the rain characteristics (intensity/length/frequency) in Uccle (near Brusells) (Laurant 1976) with the curve of the decennial rain in the Mediterranean parts of France (Desbordes and Noyelle 1994), clearly shows that Belgium is under an another climatic environment where the hazards are not so great. However, catastrophic events may occur in Belgium, like in Dison in 1957 where we experienced a fall of 146 mm of water in 45 min. The curves of the recurrence of rains clearly show that the greatest differences in the occurrence of heavy rains in Belgium and in Mediterranean countries correspond to events longer than 1 hour.

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A catastrophic flood occurs when the runoff coefficient is high and this factor is mainly controlled by the intensity of the rain. A graph given by the French administration for this kind of hazard (Desbordes and Noyelle 1994) shows that the runoff coefficient is high when the intensity is over 100 mm/h. On the intensity/length/frequency graph of Spa (which is the closest meteorological station to Sprimont) a rain with an intensity of 100 mm during 30 min occurs every 100 years (Laurant 1973). In France, the protection against floods has been calculated since around 1940 for events with 10-year recurrence. However, because storm flows may be really catastrophic events when they occur in cities, the proposal has been made to calculate the hazard for longer recurrence periods: 50 or 100 years. This is the reason why we consider here for Sprimont a recurrence of 100 years which, as noted above, is 100 mm per hour during 30 min.

For such a rain, the maximum discharge will occur from a basin with a concentration time of 30 min. It is not easy to calculate the surface from where the water is collected in 30 min; it depends on the values of the slopes, on the cover of the vegetation and on the length of the channels. The equations which are proposed in the "Handbook of hydrology" (Maidment 1992) give concentration times which range from 16- 48 min for a basin which we took as a sample in the Sprimont district. This basin was three kilometres long. Subsequently, we will take the value of 3 km as a crude estimate in the district of Sprimont as the length of basins with a concentration time of 30 min.

It is almost impossible to have a rough estimate of the discharge which is likely to result from a rain of 100 mm/h during 30 min on a natural basin because the runoff coefficient depends not only on the permeability of the soil, but also on the previous rains and degree of humidity of the soils. However, the primary objective of the cartography we are discussing is to locate the basins in which problems of storm flows may occur. For this purpose, it is not necessary to have values of discharges but to appreciate where the most dangerous places are located. In our study we have suggested calculating an index of danger for different basins. This index is based on the measurement of the areas with different values of slope and different land uses. It is easy to make the calculations of the different surfaces with a geographical information system, On the other hand it is not necessary to calculate such an index for a large number of places because on a slope map showing the limits of the basins, the few places where a danger is possible immediately become visible.

9.5 Map of the Slopes and Derived Maps

If you want to use a GIS to answer some questions related to storm floods, we need a map of the slopes. It is possible to have a very useful document for this use by digitalizing all the information of the topographical map and exploiting it with a geographical information system like Arc-Info. For this purpose, we do not need the same accuracy as for the cartography of the alluvial plains. With the map the GIS will calculate not only the mean, but also the percentages of slopes of different inclinations. We need these values to calculate the index representative of the storm flow hazards (see Table 9.1).

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The map of the slopes gives us, on the other hand, the places where the slopes are steeper than 58%. This slope value corresponds approximately to the equilibrium angle for natural materials and therefore, it is the limit for the fail of rocks. Such a hazard needs to be considered by planners.

Since it is possible to superimpose the map of slopes on the map of the thickness of loose materials and on the map of degree of humidity of the ground, the GIS may help to recognise the places where landslides may occur. However, in the district of Sprimont, we do not know of any great thickness of loose material on slopes and the risk is very limited. No present day or fossil landslide were recognised in the district.

The map of the slopes can be of other interest to the planner: it allows the calculation of the amount of solar energy received during the different seasons (Fig. 9.1), an indication which is of great interest to save the heating energy and for the comfort of the people.

Table 9.1. *Proposed table for the calculation of a storm flow likelihood index (% of surface with different values of slope * value for land use)*

Values for slopes[a]		**Values for land uses**[b]	
0- 1%	1	Woodland	0.3
1 - 2%	2	Pasture	0.35
2-5%	5	Cultivated	0.4
5-10%	10	Residential	0.75
10-20%	20		
> 10%	50		

[a]From Desbordes and Noyelle 1994;
[b]From Dunne and Leopold 1978.

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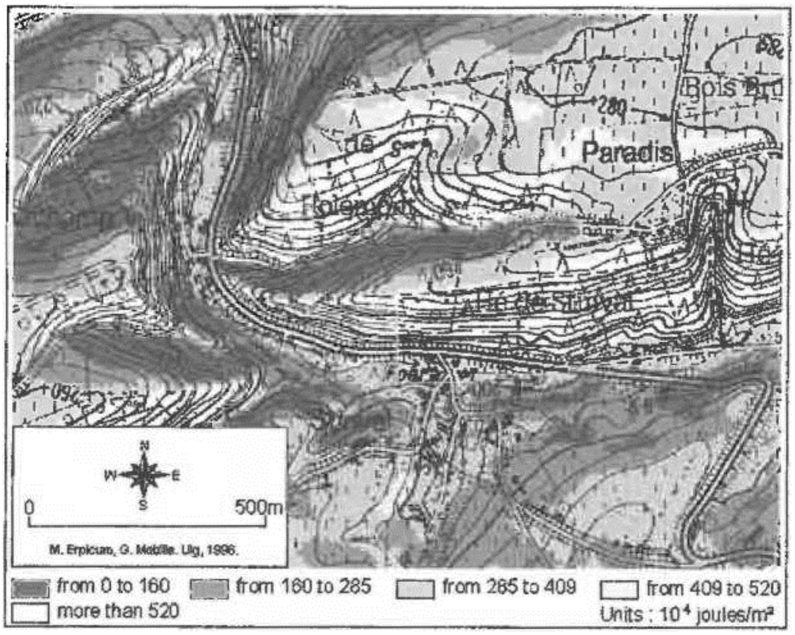
Figure 9.1. *Part of the map giving the amount of heat received on the ground during the day of the winter solstice*



9.6 Map with Protection Zones of Water Catchments

Easy to draw, this map only presents the limits of the application of administrative regulations which are imposed to protect the water catchments. This map is very important, as it is forbidden to let the water from sewages sink into the soil of these protected areas, even if the water is rehabilitated by a purification system.

9.7 Map of the Karstic Dangers

The cartography of the karstic phenomena indicates the dangerous spots for the occurrence of caving-in of the ground. It is mainly the proximity of previous karstic holes which are considered as dangerous (Fig. 9.2). With the dangers of floods and of rock falls, they are the most important hazards in the district of Sprimont.

9.8 Map of the Sewage Possibilities

This map gives a picture of the most constraining problem for the country today. In a few years, all the sewage waters will have to be purified in accordance with the regulations of the European Union. The cost will probably be higher than 100 milliard Belgian francs (3 milliard US dollars), a sum which is very important for Wallonia. To pay for the purification of liquid waste, the price of the water will increase tenfold in the next few years.

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The location of houses in the topography is the main constraint to connect the sewers together and with the purification stations. It is necessary for the planners to have a general view of this problem to limit, as much as possible, the individual purification systems on which people do not usually keep a close eye and which do not work correctly most of the time. We drew a map showing where it is possible to flow by gravity the sewers to the purification stations and where it is impossible to do so in accordance with the locations of the stations (Fig. 9.3).

Figure 9.2. *Part of the map showing the karstic dangers*

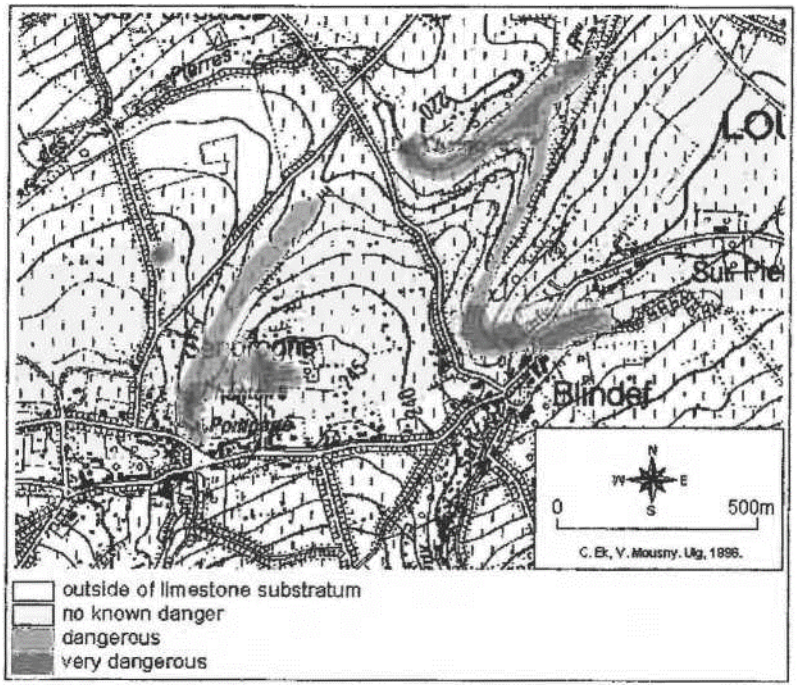

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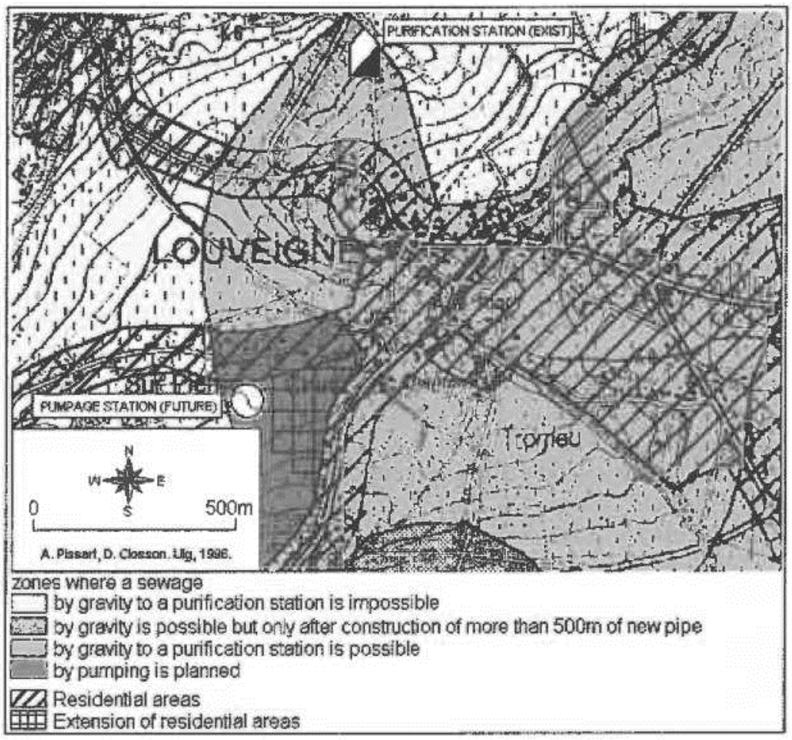
Figure 9.3. *Part of a map of Sprimont showing the sewage possibilities related to the locations of planned purification stations*



9.9 Maps of the Fertility of Soils

On the basis of the pedological maps of Belgium, a map of the fertility of the soils was presented. Crossed with the slope map (mechanical agriculture is difficult on slopes steeper than 8%), these maps indicate the best soils for different uses.

9.10 Map of the Summits

Buildings on the highest parts of the landscape may destroy the sights of the landscape. For the planners, it is necessary to know the places where they are concerned with this problem.

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9.11 A Synthetic Map with All the Physical Constraints

The final map shows all the different constraints put together. It is a useful tool on which it is possible to see immediately where the physical constraints are and to recognize the kind of constraint which is at stake. The caption of this map is presented below:

1. *Areas with natural risks.*
   a. Floods with a probability of 10-year intervals; floods with a probability of 25-years intervals;
   b. Dangers of caving-in related to karstic processes; axes where the solution processes are the most effective; karstic depressions where floods may occur;
   c. Slopes where rock falls may occur.
2. *Areas with constraints related to planning.*
   d. Zones of protection of water catchments;
   e. Sensitive crests for landscape preservation.
3. *Areas where buildings should not be located.*
   f. Soils of great fertility;
   g. Slopes steeper than 15%;
   h. Slopes receiving low solar energy.
4. *Areas with geotechnical constraints related to sewage.*
   i. Areas where the sewage by gravity to a purification station is not possible.

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