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A METHODOLOGY FOR GEOMORPHOLOGICAL ASSET EVALUATION IN A STUDY AREA NEAR GERARDMER, VOSGES (FRANCE)*

B. Haaf[1] - G. Tosatti[2]
[1] Centre Européen sur les Risques Géomorphologiques, Université Louis Pasteur, Strasbourg (France)
[2] Dipartimento di Scienze della Terra, Università di Modena (Italy)

RIASSUNTO - *Un metodo per la valutazione dei beni geomorfologici in un'area di studio nelle vicinanze di Gerardmer (Vosgi, Francia)* - Il Quaternario *Italian Journal of Quaternary Sciences,* 9(1), 1996, 155-166 - Dopo aver presentato le principali caratteristiche geologiche e geomorfologiche del massiccio dei Vosgi, il lavoro descrive un metodo di validità generale per la valutazione dei beni geomorfologici in valli glaciali. La prima parte dello studio è incentrata sull'inventario e la valutazione dei beni morfologici in una valle glaciale sulla base di un'analisi dettagliata della bibliografia e dei dati aerofotogrammetrici. La seconda parte del lavoro consiste nella presentazione di una carta ottenuta per mezzo di tecniche informatiche (Sistema geografico d'informazione).

RÉSUMÉ - *Méthodologie générale d'évaluation des biens géomorphologiques appliquée à une vallée glaciaire près de Gerardmer, Vosges (France)* - Il Quaternario *Italian Journal of Quaternary Sciences,* 9(1), 1996, 155-166 - Après une introduction générale présentant les principales caractéristiques géologiques et géomorphologiques du massif vosgien, cet article décrit la méthodologie générale d'évaluation des biens géomorphologiques appliquée à une vallée glaciaire. La première étape de l'étude consiste à réaliser un inventaire et une évaluation des sites géomorphologiques en utilisant les résultats combinés d'une analyse bibliographique détaillée et de la photo-interprétation. Dans un second temps, est présentée la cartographie réalisée au moyen de techniques informatisées (Système d'Information Géographique).

ABSTRACT - *A methodology for geomorphological asset evaluation in a study area near Gerardmer, Vosges (France)* - Il Quaternario *Italian Journal of Quaternary Sciences,* 9(1), 1996, 155-166 - After a short introduction on the main geological and geomorphological features of the massif of the Vosges, this paper describes a general methodology for evaluating geomorphological assets in a glacial valley. The first step of the research consisted in carrying out an inventory and assessment of the geomorphological sites, by using the combined results of a detailed bibliographical analysis and aerial photography interpretation. The second step of the study resulted in a cartographical elaboration by means of computer techniques (Geographical Information System).

Key words: Geomorphological assets, G.I.S., Vosges, France
Mots-clés: Biens géomorphologiques, S.I.G., Vosges, France
Parole chiave: Beni geomorfologici, S.G.I., Vosgi, Francia

1. INTRODUCTION

1.1 The area of investigation

The area investigated corresponds to the region of Gérardmer which is situated at the confluence between two main glaciers: the first one is localised in the Vologne valley and the other in the Cleurie valley. In this area, rising at only 5 km from the main watershed (Fig. 1), the glacial heritage has a great importance from a geological and geomorphological standpoint.

This research was carried out by making an inventory of all the geomorphological sites and ranking the geomorphological assets, following their order of importance. In the first part of the research some data had already been collected by means of bibliographical investigations and accurate analyses of geological maps (Haaf, 1995). The second part consisted in an application of remote sensing interpretation methodologies which, through a detailed investigation of successive stereo pairs of aerial photographs, allowed the completion of the data base by putting together other better-defined geomorphological indicators.

Finally, the outcome of this assessment methodology was elaborated and represented by means of computer techniques using the G.I.S. *ILWIS* software.

1.2 Geological and geomorphological features of the Vosges

The Vosgian massif is a medium-sized mountain chain in north-eastern France rising at the average latitude of 48°30' (Fig. 1), stretching from SSW to NNE for a maximum length just exceeding 100 km and an altitude always below 1500 m (max. height: Le Grand Ballon, 1424 m a.s.l.). Its geological origin goes back to the Paleozoic and all its basement is made up of magmatic rocks. During the Mesozoic, following sea level variations, Triassic sandstone formations were deposited. During the Cenozoic, the central and southern part of the massif underwent a tilting to the north caused by the Alpine surrection and the Triassic cover was cleared away by intense erosional processes. The present structural characteristics of the Vosges are mainly the result of the Cenozoic orogenesis of the Rhein rift bordure. During the Quaternary the most elevated parts were

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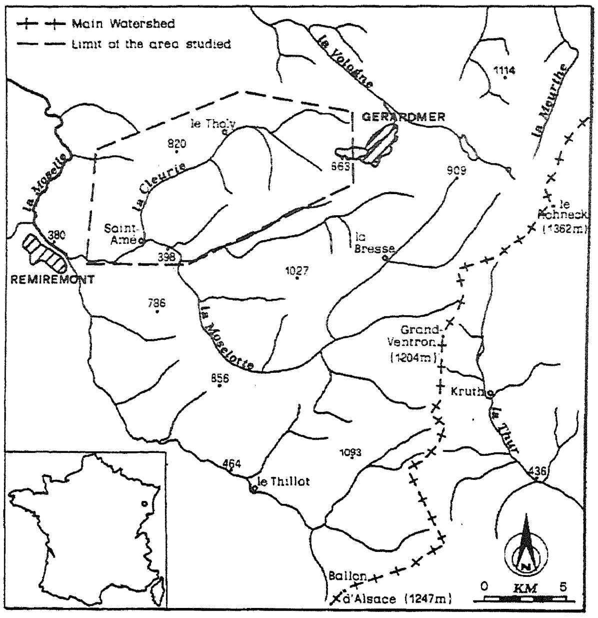

Fig. 1. Location of the study area.
Localisation de la zone d'étude.
Ubicazione dell'area esaminata.

subjected to glacial processes (Fig. 2), which left several relict landforms to witness these intense activities.

The Vosges topographical characteristics are only slightly influenced by the Hercynian structures of the basement, except for some faulted basins of subsidence resulting from a later Hercyninan tectonic phase, during which the products of the relief, demolished toward the end of the Paleozoic, were collected. In the Cenozoic the former structures and deposits were rejuvenated by Alpine tectonic activity. During this last mountain-building period a typical horst-graben structure was formed, with the Rhein tectonic rift bordered by two elevated blocks: the Vosges to the west and the Black Forest (Schwarzwald) to the east. The tectonic movements were accompanied by several displacements along fault surfaces that dismembered the Vosgian massif into monoclinal blocks characterising the chain's marked dissymmetry: gentle slopes to the north and west and steep ones to the east, toward the Rhenan rift. The blunt outstanding reliefs called *ballons* or *chaumes* are the witnesses of post-Hercyninan peneplain lifting, cleared of its Triassic cover and cut by erosional processes. The faults' orientation has noticeably influenced the hydrographic network pattern.

During the Quaternary glacial periods, the altitude of the chain has facilitated the glacial and periglacial processes, of which many characteristic and well preserved features remain. Their testimonies are given both by the nature of the sediments (moraines, glacio-fluvial deposits, dispersion of erratic boulders) and by the erosional forms (cirques and glacial valley steps, U-shaped valleys, umbilical basins, drumlins). It is possible to distinguish several stages of glacial drift by referring to the pollen analysis of some peat bogs (Flageollet, 1988). Although their precise dating is still submitted to uncertainties, the manifestations of the last cold period (Würm) are the most easily recognisable (Fig. 2)

The main characteristic of the glacial forms in the Vosges is given by their relevant difference in distribution and extension on the two sides of the crest line. Low-gradient slopes prevail on the western side and the relief is dominated by summit plateaux where a glacier with several digitations was established thus causing the present scattering of erratic boulders.

On this side of the chain the cirques are relatively poorly developed and not particularly typical. To the east, on the Alsatian side, which is short and steep, several independent Alpine-type glacial forms developed, especially along the slopes of the deepest valleys. Their cirques are definitely better developed and preserved than those of the opposite side owing also to their downwind position, in the snow accumulation areas. Their moraines too belong rather to the Alpine type: lateral and ground moraines, push moraines and glacio-fluvial deposits are here very frequent (Debelmas, 1974; Eller, 1976).

The purpose of this research is to identify and classify these glacial forms by means of aerial photographs, evaluating geomorphological assets and impacts following a well established methodology recently applied by Rivas *et al.* (1995) according to which all geomorphological sites are numbered both in the text and on the maps, in order to provide a precise localisation of each of them (Fig. 5).

2. INVENTORY AND ASSESSMENT OF GEOMORPHOLOGICAL SITES

2.1 The outcome of the bibliographical analysis

Among the great structural units of France, the Vosges are the only Hercynian massif widely affected by Quaternary glaciations, in spite of its moderate altitudes in comparison with the Alps. Owing to this peculiarity, many scientists have considered this region as an interesting site for fieldwork during the past 150 years. The first document is ascribable to the research by Hogard (1840), and since then some hundreds of books, articles and geological guides have been published up to the present.

A detailed perusal of each document allowed an extensive inventory of the geomorphological sites quoted by the authors to be established as well as gathering both qualitative and quantitative scientific information. However, the aim of the study is not to reinterpret the scientific considerations or conclusions already expressed by previous researchers, but to rank all the data collected so far.

Before the Second World War, scientific considerations were essentially descriptive and geomorphologists were divided on the rational interpretation of the glacial power in this region. The four moraines of the Cleurie valley, for example, have a relative height of 100 m, their shape is well preserved and they went through a small interglacial period at the end of the Würm glaciation without undergoing any significant degradation. A lot of different explanations were given to justify this particular aspect of the Vosges glacial relief. According to Delebecque (1901), these natural dams correspond to four granite barriers simply covered by a morainic facing. According to Meyer (1913), the moraines are not frontal but median and lateral produced by several very thick

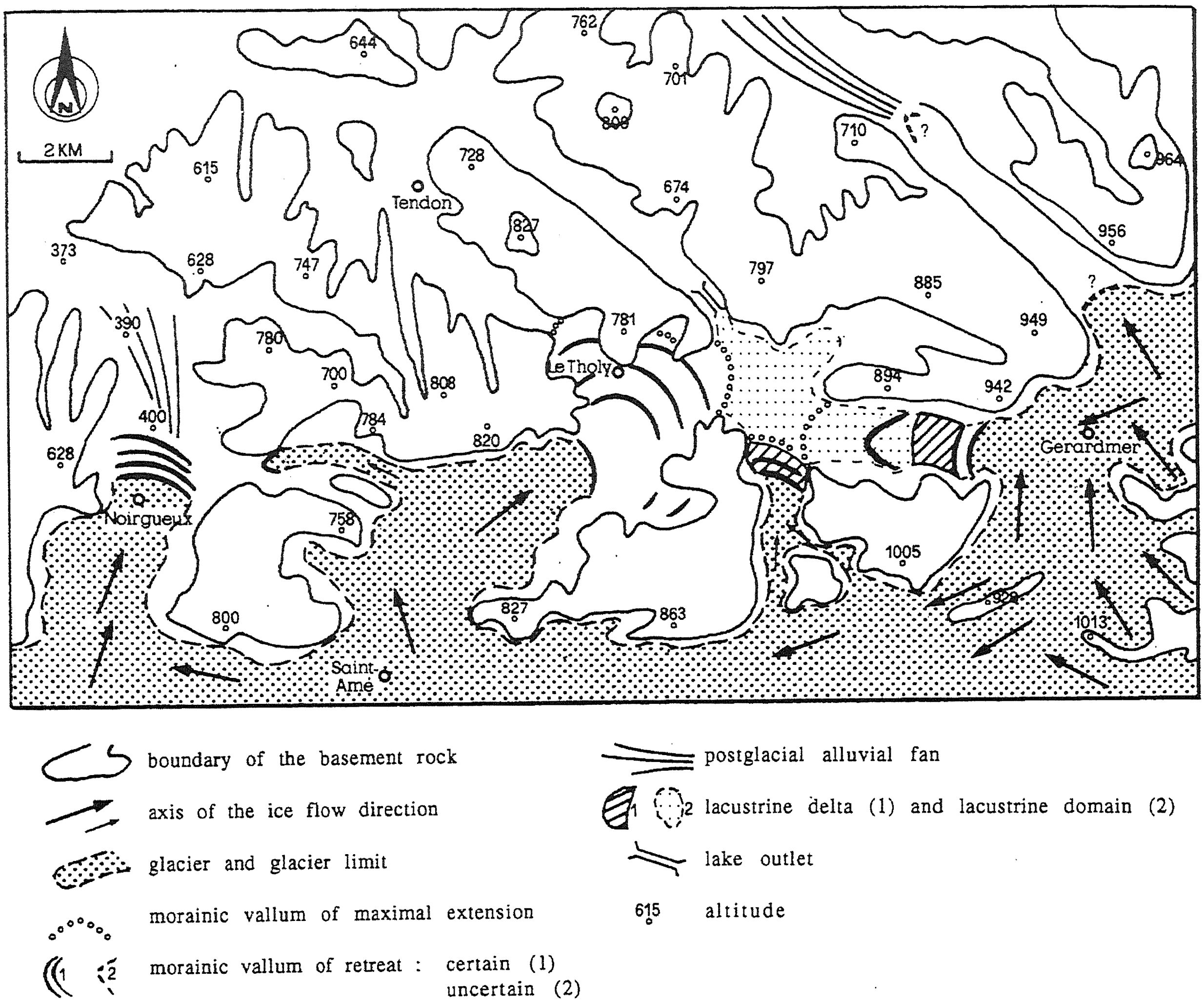

Fig. 2 - Extension of the valley glaciers and repartition of the glacial deposits during the glaciation of "Noirgueux", late Würm [modified from the Bruyères sheet (Vincent *et al.*, 1985)].

Extension des glaciers de vallées et répartition des dépôts glaciaires lors de la glaciation dite de "Noirgueux", fini Würm [modifiée d'après la feuille Bruyères (Vincent et al., 1985)].

Estensione dei ghiacciai e ripartizione dei depositi glaciali durante la glaciazione di "Noirgueux", tardo Würm [dal Foglio Bruyères (Vincent et al., 1985), modificato].

glaciers coming from the main watershed and flowing out perpendicularly to the secondary watersheds, and then the post-glacial runoff has accentuated the ravine isolating the lobes and cutting the larger deposits.

In the second half of our century, with the further development of Geomorphology as a new science, a new wave of scientists have brought about new views compared with the opinions of their predecessors, by using sedimentological notions and aerial photographs. One of them, Seret (1967), carried out a complete analysis of all the glacial formations of the massif and by means of correlations between the deposits he elaborated a temporal scale. However, some contradictions may appear regarding the dating of certain formations, so more recent analyses, developed in the past twenty years, are taken into account since they use more reliable modern techniques (^{14}C dating and pollen analysis).

After the examination of relevant publications, all the data bearing a precise reference number were stored in a database and afterwards quantitatively evaluated with a calculation system and histogram representation (Haaf, 1995) and, qualitatively, with parameters following six independent attributes as objectively as possible:

- degree of conservation of the element;
- level of accessibility to the element;
- scientific notoriety;
- educational exemplarity;
- natural rarity;
- paleomorphological interest.

Then, a global evaluation was carried out by synthesizing the results of each partial evaluation and by shading the respective weight of each attribute, in order to obtain an order ranking the levels of interest of the sites defined as geomorphological assets (very strong, strong, average, weak and no importance).

2.2 Hazards and risks

The area investigated does not show a particular tendency towards mass movements or other disarrangement phenomena. Indeed, a particular characteristic of the central part of the Vosgian massif, is given by the extreme stability of the slopes, made up essentially of magmatic rocks of the Mesozoic and metamorphic rocks.

The few natural hazards observed can nevertheless be ascribed to two types of processes:

- rock falls and topples: localised in well preserved glacial cirques in the eastern portion of the crest line and in sandstone formations of the Bundsandstein, situated essentially in forest-covered areas;

- solifluxion and gelifluxion: associated with glacial deposits (morainic lobes and embankments of fluvio-glacial terraces), residual knolls of sandstone and weathered granite formations. In general, gelifluxion is more widely represented than solifluxion. Slow and progressive movements are in some places detected by modest displacements of the terrain lacking rupture surfaces and more similar to creep rather than properly developed landslides. By aerial photography interpretation it was possible to identify cases of solifluxion along some streams that are not included within the study area.

2.3 The role of aerial photography interpretation

In spite of the numerous and detailed data derived from scientific inferences, some sites cannot always be identified and certain attributes such as the degree of conservation of the element or its educational exemplarity cannot be well estimated. Aerial photography interpretation compensates for this lack of information by discovering new morphological elements with a global view of the area and bringing about new information on each site from a three-dimensional standpoint.

The 3-dimensional stereoscopic view permits to identify and inventory some glacial forms which, although not showing paramount scientific importance, can nevertheless offer other interesting aspects such as those concerning a natural environment preserved from man-induced alterations (for example, some glacial cirques).

In other respects, a global view of the region of Le Tholy allowed the modalities of glaciation of this complex sector to be better understood. For example, aerial photograph investigations showed an eastward curvature of the arched moraines, suggesting a western origin of the material, coming from the Moselotte valley. On the opposite side, the moraine of Le Cresson is arched to the west, and also its origin is different. This sector presents a double origin of the glacial drift that came from two different glaciers, as mentioned and discussed by several authors. The two glaciers converged without joining and between them created a vast lake, subsequently filled by an important postglacial delta deposit, which can be ascribed to the same glacial episode, that is the last stage of the Würmian glaciation (Fig. 2).

Moreover, the moraine of Le Cresson, the delta of Costet Beillard, developed along its external face, and the four moraines of Le Tholy (Fig. 3) are characterised by a high level of conservation, quite evident from aerial photographs. Furthermore, the Cleurie stream has eroded the moraines of le Tholy through a deep gorge which developed some cuts, thus showing their inner texture.

An accurate examination and description, in the form of a short text, has been made for each site already considered in the bibliographical study and for the sites identified by aerial photography interpretation. This parallel approach allows the level of conservation to be properly evaluated in an area which is deeply characterised by man's activities and developments. To a certain extent, aerial photo interpretation allows the educational exemplarity of the general shape to be properly assessed by reducing subjectivity.

Finally, the results of the two means (bibliographical study and aerial photography interpretation) provided both the parameters for evaluating geomorphological assets and, moreover, precious elements of information for the decision makers and for a correct management of the territory and its resources.

3. MAPPING OF GEOMORPHOLOGICAL ASSETS

3.1 Description of the methodology applied

The aim of this presentation is not to describe the technical instructions for the use of specific kinds of software (Cavallin *et al.*, 1995), but to show the main steps of elabo-

Fig. 3. Morainic barrier of Berlingoutte (retreat moraine).

Barrage morainique de Berlingoutte (moraine de retrait).

Lo sbarramento morenico di Berlingoutte (morena di ritiro).

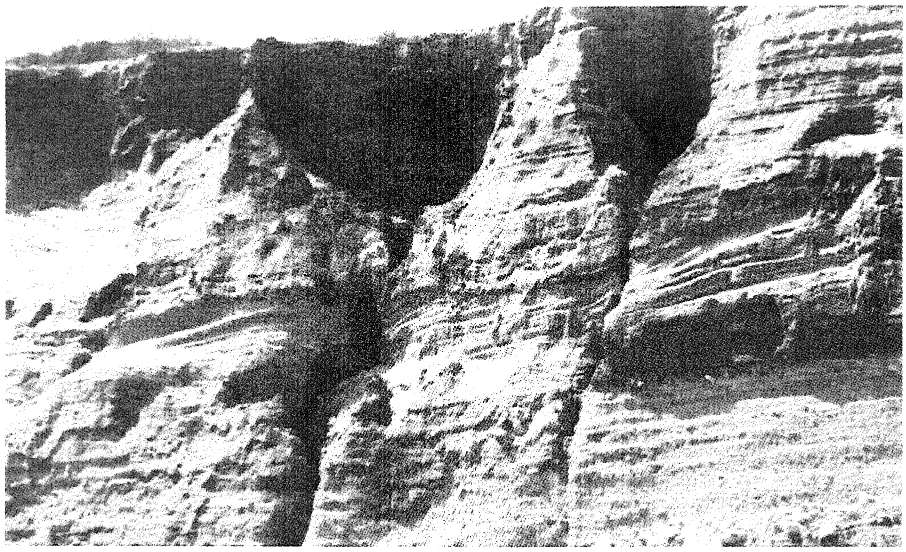

Fig. 4. Cut in a fluvio-glacial terrace near Le Passage (the structure is very representrative).

Coupe dans une terrace fluvio-glaciaire près de Le Passage (la structure est très représentative).

Sezione di un terrazzo fluvio-glaciale nelle vicinanze di Le Passage (notare la rappresentatività della struttura).

ration followed in order to produce geomorphological asset maps.

The first step consisted in the scanning of the two basic maps with a programme called *Intergraph®*. On the one hand, the basic document was the topographical map with single contour lines and, on the other hand, the geomorphological site map. Every single deposit bear-ing witness to the glacial processes and resulting land-forms was mapped in detail and defined with a polygon representation.

After the scanning, the raster maps were exported in the *ILWIS* software in order to vectorise the raster data. Some corrections were afterwards carried out followed by a smoothing of the vectors, thus obtaining a more realistic representation.

Then, each contour line was identified by its respective altitude and, by means of the software programme, the altitudes between two adjacent lines were calculated following the respective distance so that an altitude for each pixel was obtained and, finally, the model was built. The polygons are automatically numbered to easily indentify them (Fig. 5).

After this stage, each polygon received the attributes derived from the assessment in a listing board and was divided in attribute columns (degree of conservation of the element, level of accessibility to the element, scientific notoriety, educational exemplarity, natural rarity and paleomorphological interest) and evaluated at three levels (1 = weak; 2 = average; 3 = strong; see Figs. 6 to 11).

Finally, the last step consisted in superimposing the three dimensional models and the partial evaluation maps. A global assessment map was eventually elaborated with the evaluation issue of the database in five classes (no importance = 1; weak = 2; average = 3; strong = 4; very strong = 5; Fig. 12).

3.2 Discussion and criticism

With regard to cartographical elaboration, several interesting interpretations can be achieved by comparison between the maps. By taking the first two attributes (degree of conservation and level of accessibility) some correlations can be brought to light. To a certain extent, the results of the assessment are in opposition especially those concerning the sites at the bottom of the valley. These sites are represented by shades corresponding to weak and average patterns on the map showing the degree of conservation, that is, where man's interventions have modified the natural aspects of the assets. On the contrary, the map of the level of accessibility shows the same sites with a strong evaluation linked to the density of the means of transport travelling along the valley floor. The outcome of the confrontation between the two maps appears evident: the more a site presents a natural aspect, the less man's interventions have degraded it.

When considering the map of scientific notoriety, some geomorphological sites are immediately emphasized on the map. The glacial deposits which are essentially moraines and postglacial deltas, belong to and depend on the same glacial system. Moreover, a particular basin was formed by the combined action of the two glaciers coming down from the Vologne valley and the Moselotte valley. At the place of their maximum advancement, the glaciers built two big moraine barriers and the ice held an important lake during the post-Würm period. The waters resulting from ice-melting fed the lake and constructed glacio-lacustrine deltas. For a long time scientists have studied this complex area and several publications concerning this basin have been issued.

The last three maps (educational exemplarity, natural rarity and paleomorphological interest) show different results. Nevertheless, the two deltas of the Le Tholy basin seem to constitute very interesting assets from the scientific point of view. On the contrary, the glacial cirques on the whole, easily recognisable by the particular shape of their polygons, do not appear to be very interesting assets, at least from the geomorphological standpoint.

By examining the global evaluation map elaborated following five levels in order to obtain a more explicit assessment, several geomorphological assets prevail on one another. At the extreme west of the map, two assets obtained the greatest evaluation (very strong): they make up the complex of Le Cresson at the end of the lake of Gérardmer. This end complex, composed of a terminal moraine

1- Les Pinasses (k)	21- Les Granges Bas (h)	40- Les Petites Royes (c)	59- Julienrupt (l)
2- La Petite Neuvelotte (h)	22- Berlingoutte (h)	41- La Grande Goutte (b)	60- Chargoutte (n)
3- Bois de Botte Côte (k)	23- Feignes de la Morte Femme (n)	42- Haut de Bouvacôte (j)	61- Haut des Courts (j)
4- Le Petit Tholy (h)	24- Blongoutte (k)	43- Les Founelles (b)	62- Le Hêtre de la Vierge (j)
5- Le Pré Chaussotte (g)	25- Le Passage (e)	44- La Peute Goutte (e)	63- Plainchifaing (j)
6- Le Planot (h)	26- Le Costet Beillard (g)	45- Le Pré des Ormes (h)	64- La Charme (j)
7- Le Pré Gérard (n)	27- Le Lait (p)	46- Bouvaufaing (l)	65- Chévrimont (i)
8- Le Petit Paradis (h)	28- les Granges Bas (n)	47- Malpoirier (k)	66- bémont (e)
10- Le Rain Brice (h)	29- Lac de Gérardmer (m)	48- Fontaine St-Augustin (k)	67- La Goutte (k)
11- Le Tholy collège (h)	30- Le Pont Mansuy (b)	49- Col du Singe (j)	68- Les Brûleux (j)
12- Le Beillard (n)	31- Le Passage (p)	50- Le Corsaire (j)	69- Bois de Blanche Roche(k)
13- le Tholy centre (h)	32- Le Pré J'Espère (g)	51- Ferme de Noir Rupt (k)	70- Chèvre Roche (j)
14- Le Bannerot (h)	33- Le Cresson (h)	52- Les Grandes Roches (j)	71- La Sotière (j)
15- Le Bas-Beillard (h)	34- Les Granges Bas (h)	53- Les Brûleux (i)	72- Le Haut des Charmes (k)
16- Le Tholy village (e)	35- La Cotiange (j)	54- Chévrimont (p)	73- Haut des Charmes (k)
17- La Goutte Villemin (h)	36- Gazon du cerisier (k)	55- Bouvacôte (h)	74- Bémont (p)
18- Fontaine des Poilus (p)	37- Le Costet Beillard (n)	56- Le Faing des Meules (j)	75- Faing la Beurre (j)
19- Tête Luc (j)	38- Bout du Lac (f)	57- Pré Chaussotte (j)	76- Haut du Tôt (j)
20- Le Bas-Beillard (h)	39- Pétainfaing (j)	58- Poissonfaing (k)	77- Bois de Bémont (k)
78- Le Palton (e)	81- Les Xatis (e)	84- Saut de la cuve (l)	87- Les Closieures (l)
79- Le Sapé (j)	82- Ruisseau des Voués (k)	85- Les Journaux (b)	88- Bréhavilliers (d)
80- L'Omet (p)	83- Les Géméaux (l)	86- Bois des Corbelières (a)	89- village (d)
			90- Pont des Fées (a)

Codification :

a : scree	b : morainic deposit
c : fluvio-glacial terrace	d :fluvio-lacustrine terrace
e : kame terrace	f : fluvio-glacial delta
g : glacio-lacustrine delta	h : morainic lobe
i : kame ridge	j : glacial cirque
k : nivation hollow	l : glacial valley step
m :glacial lake	n : peat bog
p : quarry	

Fig. 5 - Designation and morphogenetic character of the geomorphological sites.
Dénomination et caractère morphogénétique des sites géomorphologiques.
Nome delle località e carattere morfogenetico dei siti geomorfologici.

Fig. 6 - Degree of conservation of the geomorphological assets (weak = 1, average = 2, strong = 3).
Degré de conservation des biens géomorphologiques (faible = 1, moyen = 2, fort = 3).
Grado di conservazione dei beni geomorfologici (basso = 1, medio = 2, alto = 3)

and a glacio-lacustrine delta (Fig. 4), owes its origin to two of the main glaciers of the Vosges (the other is the complex of Noirgueux in the Moselle valley). The assets which obtain a strong evaluation are the other morainic barriers, the kame terraces and ridges at the outlet of the Cleurie valley and the large glacial cirque evident on the left bank. These sites present a weak degree of conservation (man's activities are intensive at the bottom of the valley) but

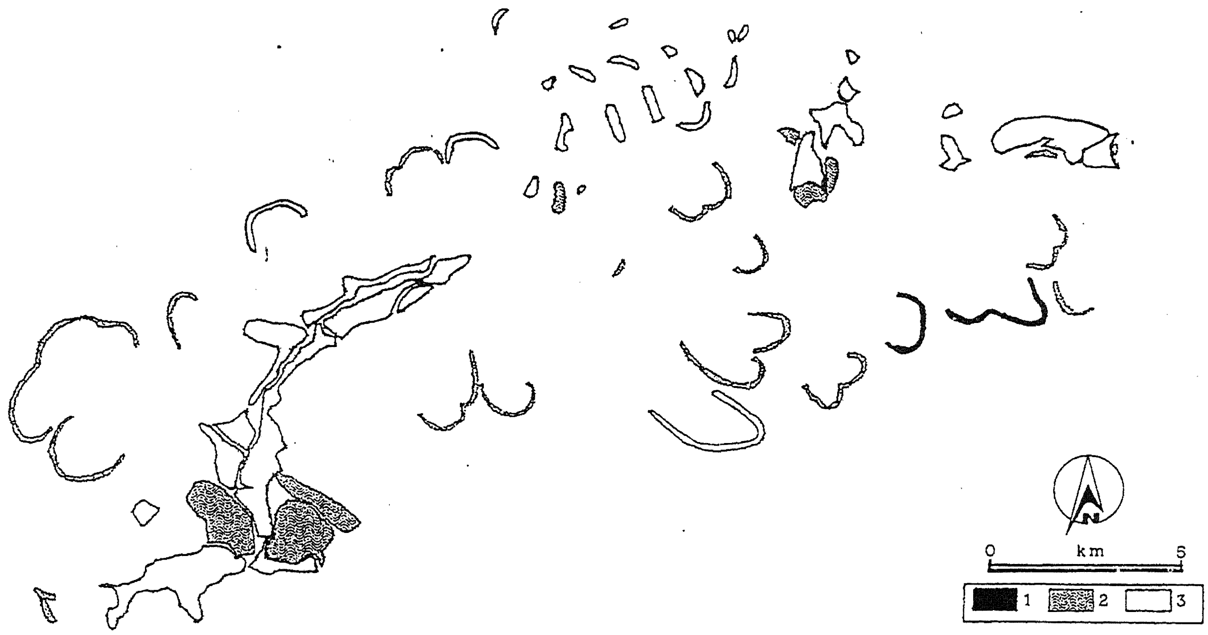

Fig. 7 - Level of accessibility to the geomorphological assets (weak = 1, average = 2, strong = 3).
Niveau d'accessibilité aux biens géomorphologiques (faible = 1, moyen = 2, fort = 3).
Livello di accessibilità ai beni geomorfologici (basso = 1, medio = 2, alto = 3).

Fig. 8 - Scientific notoriety of the geomorphological assets (weak = 1, average = 2, strong = 3).
Notoriété scientifique des biens géomorphologiques (faible = 1, moyen = 2, fort = 3).
Livello di notorietà scientifica dei beni geomorfologici (basso = 1, medio = 2, alto = 3).

occupy an important place in the relative weight of the attributes owing to their scientific importance.

The main glacial cirques obtained the weakest evaluations in relation with the less important development of the glacial modelling of the summit on this side of the main watershed (see introduction).

From a more methodological viewpoint, some criticisms may be made. About the maps representing the partial evaluations in black, grey and white, it is not always easy to distinguish the three levels of assessment (Figs. 6 to 11). The global asset map is elaborated in colours with Digital Terrain Modelling (D.T.M.) in the background. Never-

Fig. 9 - Educational exemplarity of the geomorphological assets (weak = 1, average = 2, strong = 3).
Exemplarité didactique des biens géomorphologiques (faible = 1, moyen = 2 , fort = 3).
Esemplarità didattica dei beni geomorfologici (scarsa = 1, media = 2, buona = 3).

Fig. 10 - Natural rarity of the geomorphological assets (weak = 1, average = 2, strong = 3).
Rareté naturalistique des biens géomorphologiques (faible = 1, moyen = 2 et fort = 3).
Frequenza naturale dei beni geomorfologici (bassa = 1, media = 2, alta = 3).

theless, the choice of the colours does not respect any progression either but this procedure allows a clearer distinction of the polygons on the dark topographical map. The D.T.M. is represented by the view of the top in order to have all the results of the asset evaluation. The other views, giving a better picture of the detailed shapes of the glacial valley, hide some information concerning the polygons.

4. CONCLUSIONS

Among remote sensing means of interpretation, large-scale aerial photography analysis remains an important instrument for identifying geomorphological landforms and evaluating geomorphological assets, hazards and man's impact on the environment.

Fig. 11 - Paleomorphological interest of the geomorphological assets (weak =1, average =2; strong =3).
Intérêt paléomorphologique des biens géomorphologiques (faible = 1, moyen = 2 et fort = 3).
Interesse paleomorfologico dei beni geomorfologici (scarso = 1, medio = 2, alto = 3).

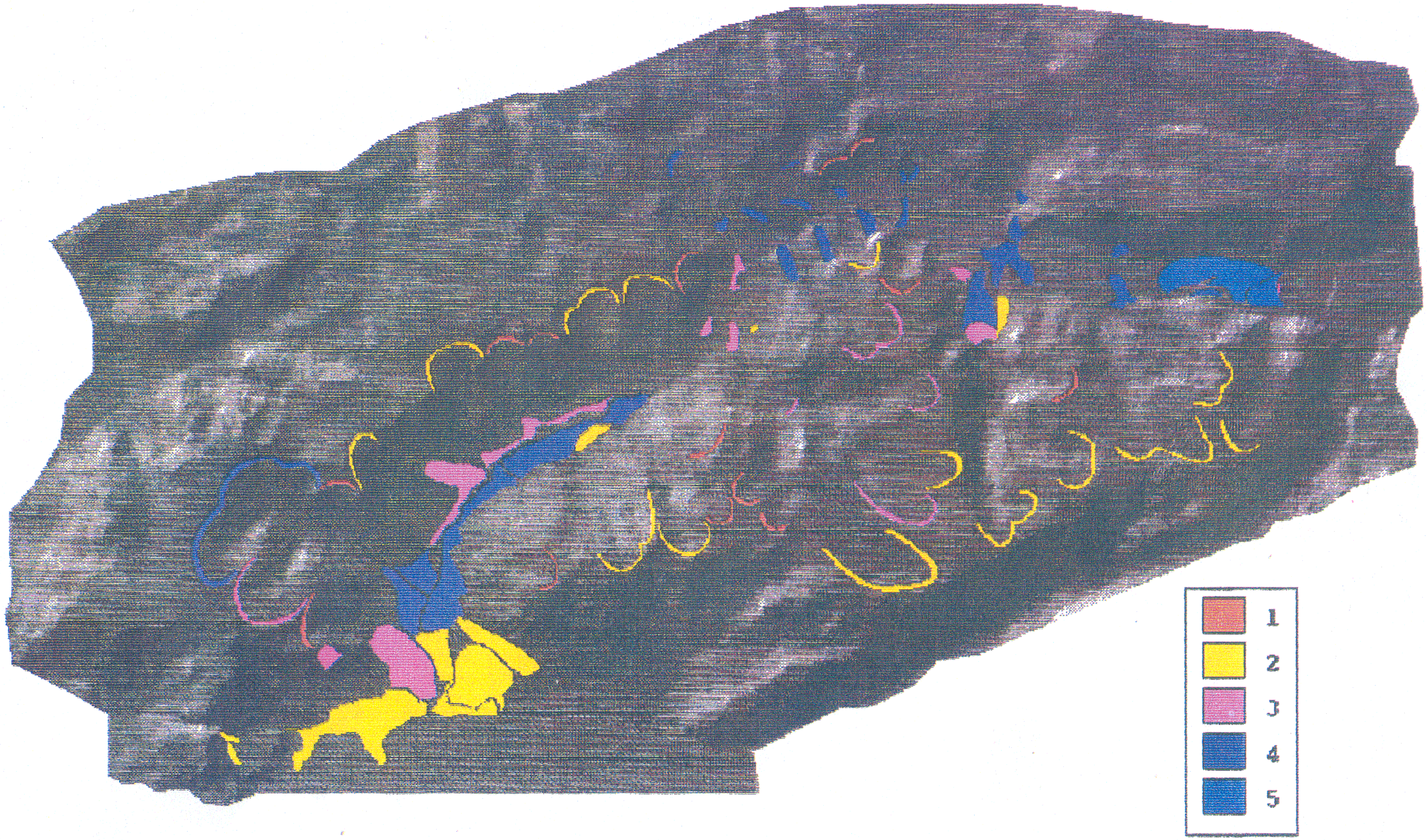

Fig. 12 - Global assessment of the geomorphological assets (no importance = 1, weak = 2, average = 3, strong = 4, very strong = 5).

Evaluation globale des biens géomorphologiques (sans importance = 1, faible = 2, moyen = 3, fort = 4 et très fort = 5).

Valutazione globale dei beni geomorfologici (di nessuna importanza = 1, poca importanza = 2, media importanza = 3, grande importanza = 4, grandissima importanza = 5).

Moreover, analytical investigations from another angle permitted certain glacial elements to be properly interpreted and new sites to be discovered, which were not described in literature nor represented in geological maps, such as glacial cirques and glacial valley steps. Aerial photo-interpretation also allowed the educational interest to be evaluated from a scientific viewpoint (cuts, exemplarity landforms, etc.) as well as the paleomorphological interest of the glacial forms so far identified.

Owing to certain problems arising at the time of the mapping elaboration and representation, the final outcome of the research inevitably implies a certain degree of subjectivity. The asset evaluation will in fact change from one geomorphologist to another, even if the same general methodology is applied. For this reason, the levels of interest (worldwide, national, regional, local and not significant) following the methodology of Carton *et al.* (1995), were not respected. The final assessment is objective as far as regards the Vosges region because the asset evaluation was carried out not only in the Cleurie valley but also in all the southern Vosges glaciated during the Quaternary.

This approach could also be completed by integrating it with other geomorphological assets (waterfalls, river gorges, natural bridges, *ballons,* etc.) which have not been taken into account so far.

Finally, this asset evaluation methodology marks the first main step of Environmental Impact Assessment (E.I.A.). The work will continue following the general methodology accepted in the Human Capital and Mobility Programme (Panizza, 1995) by assessing the environmental impact of the construction of a new road (Rivas *et al.,* 1994), with a straighter course and an enlargement of the carriageway in the Cleurie valley.

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