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## A method for assessing «scientific» and «additional values» of geomorphosites

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### 1 Introduction

During the last two decades, several attempts have been made to evaluate the quality of geomorphological heritage in various contexts, for example in environmental impact assessment (RIVAS et al. 1997; CORATZA & GIUSTI 2005), inventories of natural heritage sites (SERRANO & GONZÁLEZ-TRUEBA 2005), tourist promotion (PRALONG 2005) or management of nature parks (PEREIRA et al. 2007). In order to reduce subjectivity (BRUSCHI & CENDRERO 2005), numerous more or less quantitative assessment methods have been developed (e.g. GRANDGIRARD 1997; CORATZA & GIUSTI 2005; SERRANO & GONZÁLEZ-TRUEBA 2005; PEREIRA et al. 2007). The various methods are based on several assessment criteria – three of them are recurrent, that is rarity, representativeness and integrity (GRANDGIRARD 1999), and others, for example «ecological value», palaeogeographic importance, «educative value», etc., are dependent on the context of the assessment and on the aims of the research. They also depend on the actual definition of geomorphological heritage.

Geomorphological heritage can refer to a collection of sites of interest called geomorphological sites or geomorphosites (PANIZZA 2001). Different terms have been used in literature to refer to the individual components that make up geomorphological heritage (REYNARD 2004), such as geomorphological assets (PANIZZA & PIACENTE 1993), geomorphological goods (CARTON et al. 1994), geomorphological sites (HOOKE 1994), geomorphological geotopes (GRANDGIRARD 1997), sites of geomorphological interest (RIVAS et al. 1997), and finally geomorphosites (PANIZZA 2001). In this paper, we use the term «geomorphosites» to refer to sites of particular interest in terms of geomorphological heritage. Study of the literature shows that the various terms cover a relatively broad spectrum of definitions (REYNARD 2005a): for some scholars (e.g. GRANDGIRARD 1997), geomorphosites are sites of particular importance for the knowledge of Earth history and for the reconstruction of history of life, climate and Earth; for others (e.g. PANIZZA & PIACENTE 1993; PANIZZA 2001), the importance of geomorphosites is not only related to their «scientific value» – that is their importance for knowledge of Earth history –, but also to other possible «ecological», «economic» or «cultural values» (PANIZZA & PIACENTE 2003). The two definitions are

not exclusive and their use depends on the objectives of the research (REYNARD 2005a): for inventories of sites to be protected, the more restrictive definition of the term should be used because the sites and areas to be selected would need to be of particular importance for the knowledge of Earth history; on the other hand, within the context of geotourism or integrated cultural landscape management, the broader definition may be used in order to facilitate the analysis of possible links to other areas of culture or science.

The coexistence of different types of definitions and various terms for more or less the same concept does not facilitate the development of assessment methods. Further, as GRANDGIRARD (1999) points out, the choice of the assessment method and criteria depends on the objectives of the research. It depends also on whether a broad or narrow definition of geomorphosites has been chosen. To contribute towards clarification of the debate on value of sites, we propose here the use of two value sets (REYNARD 2005a): a central set dealing with «scientific value», and an additional set taking possible other aspects into consideration («cultural», «economic», «aesthetic» and «ecological value»). Following the description of the proposed assessment method, the paper presents the results of its implementation in two different areas in Switzerland.

### 2 The assessment method

#### 2.1 Evaluation card

Following the approach proposed for geomorphological mapping (SCHOENEICH 1993) fifteen years ago, the Institute of Geography of the University of Lausanne again aimed to develop an assessment method that could easily be applied by students. Consequently, length and complexity of procedure were factors that played more of a role here than perhaps was the case for other existing methods (PRALONG 2005; PEREIRA et al. 2007).

The evaluation makes use of a card (REYNARD 2006) divided into six parts, each with a number of sub-criteria (Tab. 1). The actual assessment is dealt with in the third and fourth parts («central» and «additional values»), making use of both quantitative and qualitative measures. «Quantitative values» are expressed in parts of 1, with 0 reflecting no value and 1 a very high value.

#### 2.2 General data

Part One on the card deals with the collection of general data, the nature of which is described in more

Parts and criteria	Sub-criteria
1 General data	E.g. code, location, type, property
2 Descriptive data	2a Description 2b Morphogenesis
3 Scientific value	
4 Additional values	4a Ecological value 4b Aesthetic value 4c Cultural value 4d Economic value
5 Synthesis	5a Global value 5b Educational value 5c Threats 5d Management measures
6 References	

Tab. 1: Parts of the evaluation and criteria used for the assessment

*Abschnitte und Kriterien der Bewertung  
Différentes parties de l'évaluation et critères utilisés*

detail in Tab. 2. The data is expressed in a numerical form (e.g. coordinates, altitudes, size) or by using a code (e.g. identification, type, property). The identification code is divided into three parts (region, process and number), each of which has three elements: e.g. VALgla001 for a moraine (glacial form) assessed within the inventory of geomorphosites of the Canton of Valais. The characteristics concerning the property rights (private, association, public and common-property) are particularly important for the management of sites (REYNARD 2005b): sites located on privately owned terrains are generally more difficult to protect (or promote) than objects owned by the State or by corporations. The property data may be difficult to obtain. In fact, the geomorphosite's owner is not always identical with the terrain owner, as is, for example, the case with erratic boulders, many of which were acquired by scientific associations in the 19th century. For large geomorphosites, referred to here as «geomorphological landscapes» (REYNARD 2005a), the owners may be numerous and of different kinds. The use of numerical data and codes is particularly interesting if the database is created in a Geographic Information System (GIS), because use can be made of spatial analysis (e.g. selection, classification).

**2.3 Descriptive data**

Part Two on the card looks at descriptive data with data collection concentrating on both description and morphogenesis. The description is based on observations made by the assessor during fieldwork, as well

as on document analyses (maps, air photographs) and bibliographical information (previous studies). The description deals not only with geomorphological features, but also with features such as archaeological findings, human infrastructures, biotopes, etc. For the morphogenesis analysis, the emphasis is on the processes responsible for the landform genesis and development, and can include temporal information (dating) and landform activity. In a second phase, human transformations – if existing – are also analysed.

**2.4 «Scientific value»**

Part Three of the evaluation aims at assessing the «scientific value» of the site, based on the restrictive definition of geomorphosites proposed by GRANDGIRARD (1995, 1997, 1999). The criteria used also reflect those suggested by GRANDGIRARD (1999): rareness, representativeness, integrity and «palaeogeographic value». The terms are defined closer in Tab. 3. The last criterion, «palaeogeographic value», is included to encourage greater context-sensitivity in analysis in terms of Earth and climate history.

**2.5 «Additional values»**

Part Four focuses on «additional values» to be assessed and can include one or more of the following categories: ecological impact, «aesthetic», «cultural» and «economic value». The characteristics of each category are described in more detail in Tab. 4. As a geomorphologist can not be expected to evaluate technical components covering a large spectrum of disciplines (biology, history, economy), this part of the evaluation builds on bibliographical data and simple criteria. The aim is not to give an exhaustive analysis of the site in terms of economy, ecology, arts or history, but to highlight possible links that may exist between geomorphology and other aspects of nature or culture.

The «ecological impact criterion» (EcI) takes into account the importance of the geomorphosite for the development of a particular ecosystem or the presence of a particular fauna and vegetation. A moraine that allows the presence of a marsh with orchids will, for example, be given a high score. Assessment decisions are made based on discussions in the existing literature or directly with specialists. Concerning the «protected site» criterion (PS), consideration is taken of sites that are already protected in a national inventory, or at cantonal or local level for ecological reasons (e.g. marshes, alluvial zones). Several Swiss inventories of «natural values», e.g. marsh landscapes, proglacial margins, are moreover based on biological and geomorphological selection criteria. The «ecological value» corresponds to the arithmetical mean of the «ecological impact» and «protected site» criteria:  $ECOL = (EcI + PS)/2$ .

<b>Identification code</b> CAPITAL LETTERS FOR THE REGION; letters for the process*), numerical code for the site. Each code has three characters (see text).	<b>Name</b> Name of the landform or very simplified description of the geomorphosite (e.g. moraine, group of sinkholes, glacier forefield, meander)	<b>Place</b> As precise as possible (e.g. Le They, Finhaut, VS)
<b>Coordinates</b> Swiss national system or other national systems	<b>Minimum altitude</b>	<b>Maximum altitude</b>
<b>Type</b> PCT: punctiform (e.g. sinkhole) LIN: linear (e.g. river) AER: areal (e.g. glacier forefield)	<b>Size</b> Punctiform: no indication or width [m] (e.g. sinkhole) or volume [m <sup>3</sup> ] (e.g. erratic boulder) Linear: length [m] Areal: surface [m <sup>2</sup> ]	<b>Property</b> Property of the terrain or the object: PRI: private ASS: association PUB: public COM: common
<b>Map</b> Scale: 1:25'000 or 1:10'000, with precise localisation or perimeter	<b>Pictures</b> Good quality, 300 dpi	<b>Schemes</b> e.g. diagram, simplified map, paleogeographic sketch

Tab. 2: General data. \*) Codes used for the processes are the following: STR=structural landforms, FLU=fluvial, KAR=karstic, GLA=glacial, PER=periglacial, ORG=organic, EOL=aeolian, LIT=coastal, ANT=anthropic.

*Allgemeine Informationen.* \*) Die verschiedenen Codes stehen für folgende Prozesse: STR=Strukturformen, FLU=fluvial, KAR=karstmorphologisch, GLA=glazial, PER=periglazial, ORG=organisch, EOL=äolisch, LIT=litoral, ANT=anthropogen.

*Données générales.* \*) Les codes concernant les processus sont les suivants: STR=formes structurales, FLU=fluvial, KAR=karstique, GLA=glaciaire, PER=périglaciaire, ORG=organique, EOL=éolien, LIT=littoral, ANT=anthropique.

The assessment of the «aesthetic value» is very subjective. Use is made here of two simple criteria: VP (view points) and STR (structure). The first one takes into account the visibility of a site. A site covered by a forest or very difficult to access would, in this case, have a lower score than a site visible from several viewpoints. The second criterion takes into account research into landscape perception (see for example GRANDGIRARD (1997) or DROZ & MIÉVILLE-OTT (2005) for a review), which indicates that contrasting landscapes, landscapes with a vertical development or landscapes with individual elements that give that space structure are generally considered the nicest. Consequently, sites with colour contrasts (e.g. contrasts due to lithological changes), with high vertical development (e.g. peaks) or with spatial structures (e.g. morainic arcuate ridge that closes a valley, braided rivers) will receive a higher score than monotone reliefs (e.g. alluvial plain, large plateau). The «aesthetic value» corresponds to the arithmetical mean of the two criteria:  $AEST = (VP + STR)/2$ .

The «cultural value» criterion is more heterogeneous in character. It is made up of four independent

sub-criteria: religious importance, historical importance, artistic or literary importance and geohistorical importance. The sub-criterion «religious importance» concerns sites that have a «religious», «mythological» or «mystic value». Numerous erratic boulders have, for example, been used as religious or mystic sites in the past (LUGON et al.). «Historical importance» covers history in a broad sense, thereby including archaeology, prehistory and history, and takes into account the presence of vestiges. Further, the criterion does not only note the role of an object in political history (e.g. the presence of castles on glacial locks), but also takes into consideration possible roles in tourism (e.g. waterfalls in Switzerland that were tourist attractions in the 18th century) or science history (e.g. the Pierre Bergère erratic boulder in Salvan, Valais, was used by GUGLIELMO MARCONI for the first wireless experiments in the world – see REYNARD et al.). The «artistic and literary importance» concerns the presence of the site in artistic realisations (e.g. paintings, sculptures) and in books and poems. Finally, «geohistorical importance» is related to the role of particular sites in the development of geosciences (LUGON & REYNARD 2003). Expe-



Criterion	Evaluation
Integrity	State of conservation of the site. Bad conservation may be due to natural factors (e.g. erosion) or human factors.
Representativeness	Concerns the site's exemplarity. Used with respect to a reference space (e.g. region, commune, country). All the selected sites should cover the main processes, active or relict, in the study area.
Rareness	Concerns the rarity of the site with respect to a reference space (e.g. region, commune, country). The criterion serves to identify exceptional landforms in an area.
Paleogeographical value	Importance of the site for Earth or climate history (e.g. reference site for a glacial stage).

Tab. 3: Criteria used for the assessment of «scientific value»

*Kriterien zur Ermittlung des Wissenschaftlichen Wertes*

*Critères utilisés dans l'évaluation de la valeur scientifique*

rience has shown that geomorphosites generally have only one or two of these «cultural sub-values». For this reason, the quantification process is different here with the highest score obtained in one of the four sub-criteria rather than the average being taken into account.

The «economic value» is obtained by a qualitative – and, if possible, quantitative – assessment (e.g. number of visitors, benefits) of the products generated by the geomorphosite. Only the income actually produced by the presence of the geomorphosite is evaluated (e.g. number of entrances in a tourist site), and not potential income or indirect income (e.g. the presence of a hotel in the surroundings of a tourist cave).

**2.6 Synthesis**

Part Five of the card is divided into four sections (Tab. 5). The first section deals with «global value» and is essentially a quantitative and qualitative summary of the two previous parts («central» and «additional

values»). Thus, for the quantitative summary, the results from the scientific assessment and the mean of the results from the «additional values» are presented. The results are not combined in order to underline the different qualities of the two value sets. Further, as the number of «additional values» assessed may vary depending on the context (see the Trient case study below), greater transparency of results is ensured by keeping the scores separate. For the qualitative summary, the «global value» of the site is also described in words. The description is restricted to one sentence.

In the second section, the importance of the site for educational purposes is also formulated in a sentence. Thus, for example, a geomorphosite with a high «educational value» may be a place where the landforms are particularly visible in the landscape or where the processes are particularly active.

The endangerment level of a particular site is accounted for in section three. As far as possible, all human and natural threats, both existing and potential, are listed. It is possible, for example, that a geomorphosite may be disturbed, and even destroyed, by both human impacts and natural processes (REYNARD 2004). Human impacts may involve infrastructure, buildings, urbanisation, territorial planning, agriculture, forestry, tourism and vandalism. Natural impacts could include processes linked to climate change (destruction of a cryospheric geomorphosite), biological processes (weathering), geomorphological and geological processes or hydrological phenomena.

Value	Criteria
Ecological value (ECOL)	a. ecological impact (EcI) b. protected site (PS)
Aesthetic value (AEST)	a. view points (VP) b. contrasts, vertical development and space structuration (STR)
Cultural value (CULT)	a. religious importance (REL) b. historical importance (HIS) c. artistic and literature importance (ART) d. geohistorical importance (GEO)
Economic value (ECON)	economic products (ECO)

Tab. 4: «Additional values»

*Zusatzwerte*  
*Valeurs additionnelles*

Parts	Content
Global value	The global value is expressed by a sentence that summarizes the central and four additional values.
Educational value	Importance of the site for education (schools, universities)
Threats/Endangerment level	Natural and human, existing and potential threats
Management measures	Proposed measures in order to protect and/or promote the site

Tab. 5: Synthesis of the assessment  
*Zusammenfassung der Bewertung*  
*Synthèse de l'évaluation*

Drawing on the assessment of «global value» and endangerment level, management measures are then proposed. They are divided into two groups covering the geoheritage issues of protection and promotion. Protective measures may be both active (e.g. building of protection infrastructures, fencing) and passive (territorial planning measures and institutional measures such as public policies, property rights) (REYNARD 2005b). Promotional measures, on the other hand, would refer to the development of tourism or educative goods and services (geotourism, geodidactics).

### 3 Case studies

#### 3.1 The inventory of geomorphosites in the Blenio valley and Lucomagno area

As means of illustration of the basic approach to assessment of geomorphosites proposed here, two case studies are presented. The first example is taken from research carried out in the Blenio valley and Lucomagno area in Northern Ticino, Switzerland. The objective was to contribute towards the National Park of Adula project with an inventory of the geomorphological heritage of the area. The geomorphosites were assessed with the method presented above (Tab. 6 and 7) and presented in map form (Fig. 1).

For both the Blenio valley and Lucomagno area, two maps were created. The first one (Fig. 1, above) represents the sites in relation to their morphogeny (process). In the second map (Fig. 1, below), the «central» and «additional values» are presented. For the «scientific value», use is made of proportional circles and for the dominant «additional value», appropriate graphics are used.

#### 3.2 The inventory of cultural geomorphosites in the Trient area

Incorporated within a project aimed at promotion of cultural geomorphosites of the Trient area (Mont Blanc Massif, Valais, Switzerland) (REYNARD et al.), an inventory of geomorphosites focusing on specific «scientific» and «cultural values» was carried out (Fig. 2). The objective was to find evidence of sites that could integrate natural and cultural aspects of landscapes (see PANIZZA & PIACENTE 2003). The inventory was carried out in two phases. A first selection of potential sites was made using document analysis on the geomorphology and history of the valley. A complete assessment of each site (KOZLIK 2006) was then carried out using the method described above. Because the focus was on the «cultural value», the other «additional values» were not assessed.

The synthesis map of the cultural geomorphosites is presented in Fig. 2. The importance of the «geocultural value» is expressed by the size of the circle and the differentiation of each circle in two parts (above and below) allows insight into the proportional contribution of each element – geomorphology and culture – to the «global value». This inventory is now contributing to the tourist promotion of the geocultural heritage of the area within several projects (see REYNARD et al.).

### 4 Conclusion

The methods developed in previous years for assessment of the geomorphosites focused essentially on their scientific quality (e.g. RIVAS et al. 1997; GRANDGIRARD 1999; BRUSCHI & CENDRERO 2005; CORATZA & GIUSTI 2005; SERRANO & GONZÁLEZ-TRUEBA 2005). They were used mainly for inventories of natural goods and environmental impact assessment (EIA) studies. During the last decade, the promotion of geoheritage has developed rapidly due to the creation of geoparks and the development of geotourism. In this context, the assessment of geomorphosites is in need of the inclusion of other values in the evaluation process (e.g. cultural, ecological). The aim of the proposed method is therefore to combine the assessment of central «scientific values» with additional, context-specific values.

The method was developed with two main objectives in mind: simplicity, in order to be used by students and by research departments, and comprehensiveness. Because the method aims at evaluating more than the «scientific value» of sites, it opens up new perspectives in the area of geoheritage conservation and management. The two case studies themselves were carried out in quite a large context. The first one (Blenio-Lucomagno area) was related to the creation of a National Park. The project is led by non-geomorphologists and

Geomorphosite			Scientific value				
Nr	Code	Name	Integrity	Representation	Rarity	Palaeogeographical value	Total
1	BLEkar003	Karstic area	1.00	1.00	1.00	0.75	<b>0.94</b>
2	BLEkar004	Fluvial/karstic area	1.00	1.00	1.00	0.75	<b>0.94</b>
3	BLEper003	Relict rock glacier	1.00	1.00	1.00	0.75	<b>0.94</b>
4	BLEgla002	Erratic boulder	1.00	1.00	0.75	1.00	<b>0.94</b>
5	BLEgla004	Ice cave	1.00	1.00	1.00	0.75	<b>0.94</b>
6	BLEkar001	Karstic area	1.00	1.00	1.00	0.50	<b>0.88</b>
7	BLEgla003	Granite/diorite glacial lock	1.00	1.00	0.75	0.75	<b>0.88</b>
8	BLEper001	Active rock glacier	1.00	1.00	0.75	0.75	<b>0.88</b>
9	BLEper002	Inactive rock glacier	1.00	1.00	0.75	0.75	<b>0.88</b>
10	BLEkar005	Residual landform	1.00	1.00	1.00	0.25	<b>0.81</b>
11	BLEorg001	Marsh area	1.00	1.00	0.50	0.75	<b>0.81</b>
12	BLEgla006	Postglacial gorge	1.00	1.00	0.75	0.50	<b>0.81</b>
13	BLEgla005	Roches moutonnées	1.00	1.00	0.75	0.50	<b>0.81</b>
14	BLEflu001	Alluvial zone	1.00	1.00	0.75	0.25	<b>0.75</b>
15	BLEgra001	Postglacial rockfall	1.00	1.00	0.50	0.50	<b>0.75</b>
16	BLEgla001	Glacial lake	1.00	1.00	0.75	0.00	<b>0.69</b>
17	BLEkar002	Sinkhole alignment	1.00	1.00	0.50	0.25	<b>0.69</b>
18	BLEant001	Gold mine	1.00	1.00	0.75	0.00	<b>0.69</b>
19	BLEant002	Soapstone quarry	1.00	1.00	0.50	0.00	<b>0.63</b>
20	BLEant003	Marble quarry	0.75	1.00	0.50	0.00	<b>0.56</b>

Geomorphosite		Ecological value	Aesthetic value	Cultural value				Economic value
Nr	Code			Religious	Historical	Artistic literature	Geohistorical	
1	BLEkar003	0.75	1.00	0.00	0.25	0.25	0.00	0.75
2	BLEkar004	0.88	0.88	0.00	0.00	0.00	0.00	0.75
3	BLEper003	0.00	0.75	0.00	0.50	0.00	0.00	0.50
4	BLEgla002	0.25	0.75	0.00	0.00	0.00	0.00	0.50
5	BLEgla004	0.25	0.25	0.00	0.50	0.00	0.00	0.50
6	BLEkar001	1.00	1.00	0.00	0.75	1.00	0.00	0.25
7	BLEgla003	1.00	0.88	0.00	0.00	0.00	0.00	0.50
8	BLEper001	0.00	0.63	0.00	0.00	0.00	0.00	0.00
9	BLEper002	0.00	0.63	0.00	0.00	0.00	0.00	0.00
10	BLEkar005	0.38	1.00	0.00	0.00	0.50	0.00	0.75
11	BLEorg001	1.00	0.75	0.00	0.00	0.00	0.00	0.50
12	BLEgla006	0.25	0.88	1.00	1.00	0.00	0.00	0.75
13	BLEgla005	0.50	0.63	0.25	0.75	0.00	0.00	0.25
14	BLEflu001	1.00	0.63	0.00	0.25	0.25	0.00	0.25
15	BLEgra001	0.25	0.75	0.00	1.00	0.00	0.00	0.50
16	BLEgla001	0.25	1.00	0.00	0.50	1.00	0.00	0.50
17	BLEkar002	0.88	0.75	0.00	0.00	0.00	0.00	0.50
18	BLEant001	0.63	0.13	0.00	0.75	0.25	0.00	0.00
19	BLEant002	0.13	0.50	0.00	0.75	0.25	0.25	0.50
20	BLEant003	0.63	0.25	0.00	0.75	0.00	0.00	0.25

Tab. 6: Geomorphosite assessment in the Blenio valley. Above: «scientific value»; below: «additional values». *Bewertung der geomorphologischen Geotope im Val Blenio. Oben: Wissenschaftlicher Wert; unten: Zusatzwerte.*

*Evaluation des géomorphosites du Val Blenio. En haut: valeur scientifique; en bas: valeurs additionnelles.*

Geomorphosite			Scientific value				
Nr	Code	Name	Integrity	Representation	Rarity	Palaeogeographical value	Total
1	LUCkar003	Karstic area	1.00	1.00	1.00	0.75	<b>0.94</b>
2	LUCkar005	Fluvial/karstic area	1.00	1.00	1.00	0.75	<b>0.94</b>
3	LUCgla001	Erratic boulder	1.00	1.00	0.75	1.00	<b>0.94</b>
4	LUCgla004	Ice cave	1.00	1.00	1.00	0.75	<b>0.94</b>
5	LUCgla002	Granite/diorite glacial lock	1.00	1.00	0.75	0.75	<b>0.88</b>
6	LUCflu002	Alluvial zone	1.00	1.00	0.75	0.75	<b>0.88</b>
7	LUCper001	Rock glacier	1.00	1.00	1.00	0.50	<b>0.88</b>
8	LUCkar006	Residual landform	1.00	1.00	1.00	0.25	<b>0.81</b>
9	LUCgla003	Marsh area	1.00	1.00	0.50	0.75	<b>0.81</b>
10	LUCkar004	Cave	1.00	1.00	0.50	0.50	<b>0.75</b>
11	LUCkar001	Sinkhole alignment	1.00	1.00	0.50	0.25	<b>0.69</b>
12	LUCkar002	Gypsum badlands	0.25	1.00	1.00	0.25	<b>0.63</b>
13	LUCflu001	Torrential system	0.50	1.00	0.75	0.25	<b>0.63</b>

Geomorphosite		Ecological value	Aesthetic value	Cultural value				Economic value
Nr	Code			Religious	Historical	Artistic literature	Geo-historical	
1	LUCkar003	0.75	1.00	0.00	0.25	0.25	0.00	0.75
2	LUCkar005	0.88	0.88	0.00	0.00	0.00	0.00	0.75
3	LUCgla001	0.25	0.75	0.00	0.00	0.00	0.00	0.50
4	LUCgla004	0.25	0.25	0.00	0.50	0.00	0.00	0.50
5	LUCgla002	1.00	0.88	0.00	0.00	0.00	0.00	0.50
6	LUCflu002	0.88	0.75	0.00	0.25	0.00	0.00	0.75
7	LUCper001	0.25	0.50	0.00	0.00	0.00	0.00	0.25
8	LUCkar006	0.38	1.00	0.00	0.00	0.50	0.00	0.75
9	LUCgla003	1.00	0.75	0.00	0.00	0.00	0.00	0.50
10	LUCkar004	0.25	0.50	0.00	0.00	0.00	0.00	0.50
11	LUCkar001	0.88	0.75	0.00	0.00	0.00	0.00	0.50
12	LUCkar002	0.38	1.00	0.00	0.50	0.25	0.00	0.50
13	LUCflu001	0.50	1.00	0.00	0.25	0.00	0.00	0.25

Tab. 7: Geomorphosite assessment in the Lucomagno area. Above: «scientific value»; below: «additional values». *Bewertung der geomorphologischen Geotope in der Region des Lukmanier. Oben: Wissenschaftlicher Wert; unten: Zusatzwerte.*

*Evaluation des géomorphosites de la région du Lukmanier. En haut: valeur scientifique; en bas: valeurs additionnelles.*

the original project did not take geomorphology into account at all. The goal was, therefore, to show through the realisation of the inventory, the importance of geomorphology for the biodiversity of the area. It was important to bring to light which sites have an important «ecological value». As was seen in Tab. 6 and 7, several sites score maximum points in this criterion. The map in Fig. 1 shows, moreover, that several sites with a particularly important «scientific value» (large circles) and a dominant ecological «additional value» are situated in the northern part of the Blenio valley, in

the area proposed for the National Park. This concentration allowed emphasis to be placed on the relationship between geodiversity and biodiversity in this part of the park, an aspect of particular «didactic value» for the project.

The second example shows that the method can be adapted to the objective of the evaluation. In this case, the assessment was carried out as one of several projects related to heritage and tourist promotion of the Trient area. The aim was, therefore, to highlight

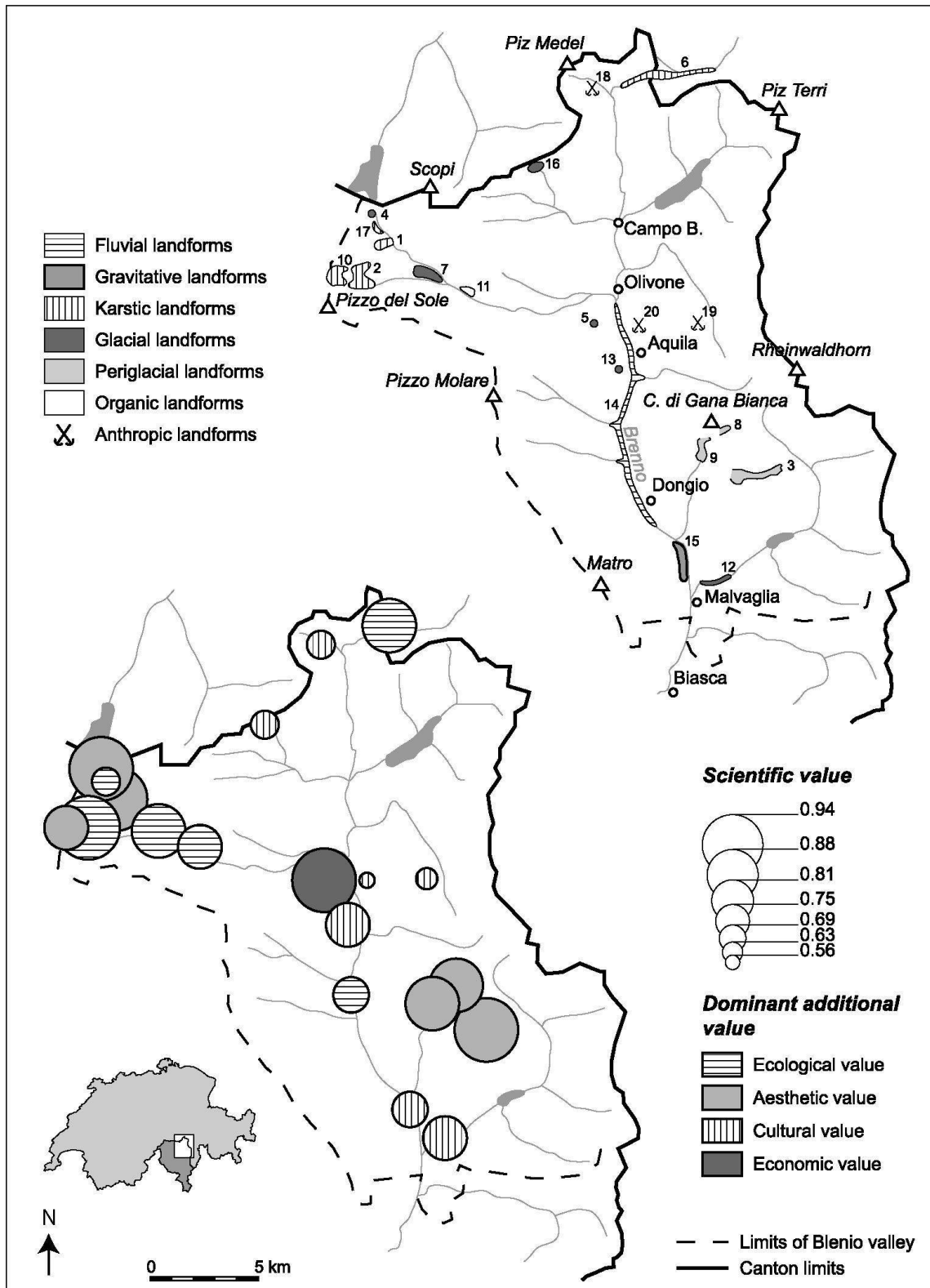


Fig. 1: Geomorphosites of the Blenio valley. Numbers refer to data in Table 6.  
*Geomorphologische Geotope im Val Blenio. Die Nummern entsprechen denjenigen in Tabelle 6.*  
*Géomorphosites du Val Blenio. Les nombres se rapportent au tableau 6.*  
 Source: data collected by G. FONTANA; cartography: C. SCAPOZZA

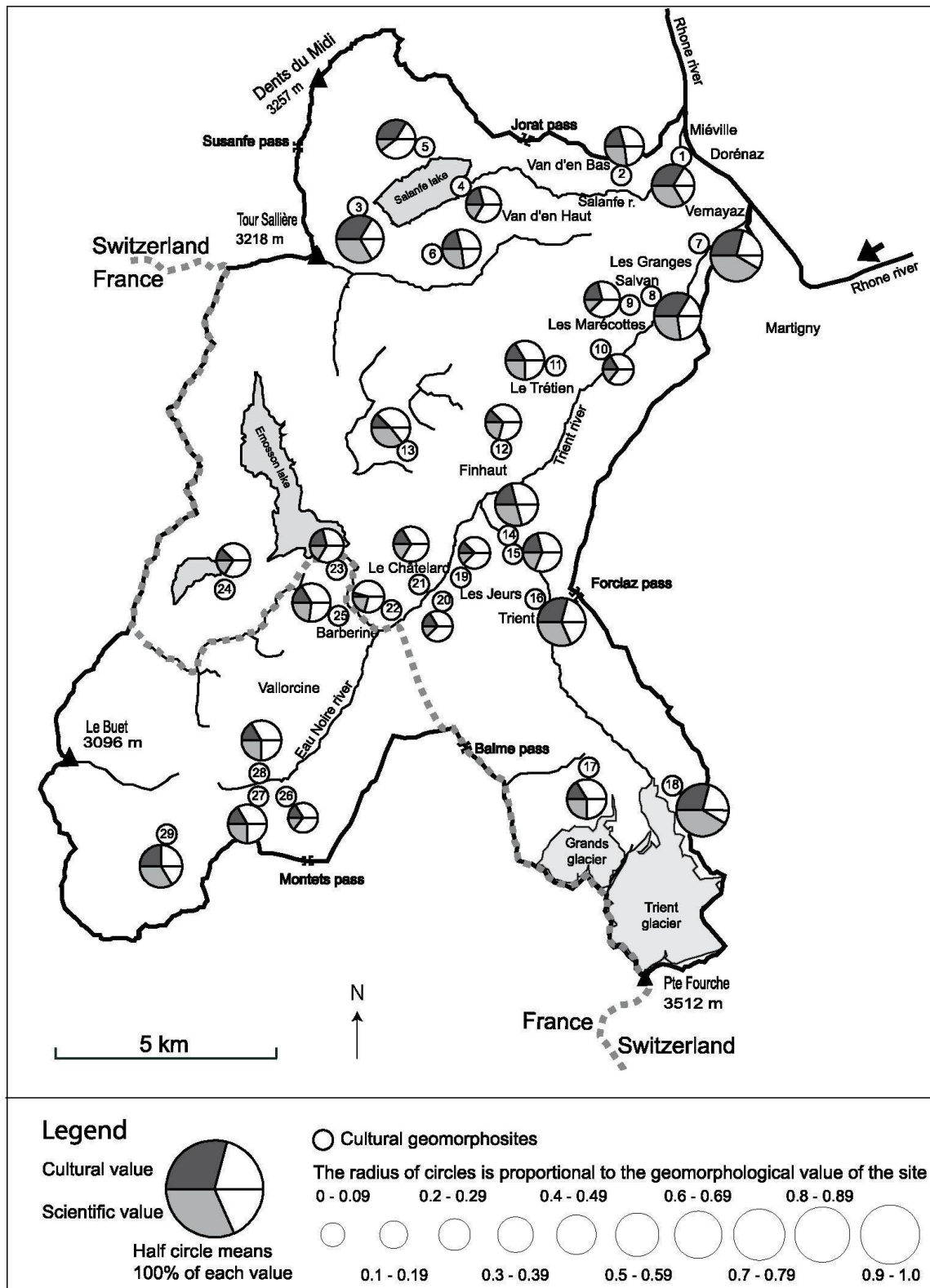


Fig. 2: Cultural geomorphosites of the Trient area. Numbers relate to the 29 geomorphosites included in the inventory. *Kulturelle geomorphologische Geotope in der Region Trient. Die Nummern entsprechen den 29 Objekten des Inventars. Géomorphosites culturels de la région du Trient. Les nombres concernent les 29 géomorphosites inclus dans l'inventaire.* Source: KOZLIK 2006; cartography: L. KOZLIK



relationships that possibly existed between the geomorphology and the social and cultural development of the valley, especially from the view point of tourism history. The inclusion of the criteria of cultural importance allowed this link to be made. The inventory of cultural geomorphosites is currently used as the basis for the realisation of several tourist and didactic products created for the promotion of eco-tourism and geo-tourism in the area.

The assessment method has, in the meantime, been developed further. It is now available as a GIS software product. This new step is expected to facilitate the realisation of spatial analyses (e.g. queries, classifications) and simplify updating of data.

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### Abstract: A method for assessing «scientific» and «additional values» of geomorphosites

Over the last two decades, several methods have been developed to reduce subjectivity of geomorphosite selection through use of transparent assessment cri-

teria. Most of these methods propose criteria such as integrity, rarity, representativeness and palaeogeographical importance for the evaluation of the «scientific value» of sites. For the assessment of their global quality, «additional values» of ecological, cultural, aesthetic and economic nature have, at times, been taken into consideration. This paper proposes a new assessment method that integrates both sets of values into the evaluation of geomorphosites. The method is described and its implementation in two different cases presented: compilation of an inventory of geomorphosites in the National Park of Adula (Ticino, Switzerland) and evaluation of the geocultural heritage of the Trient area (Valais, Switzerland).

**Zusammenfassung: Eine Bewertungsmethode für den Wissenschaftlichen Wert und die Zusatzwerte geomorphologischer Geotope**

In den letzten zwei Jahrzehnten wurden auf dem Gebiet der Bewertung von geomorphologischen Geotopen verschiedene Methoden entwickelt, welche die Subjektivität durch die Einführung von objektiven Kriterien reduzieren. Der Grossteil dieser Methoden basiert auf der Bewertung von Kriterien (Erhaltungszustand, Seltenheit, beispielhafter Charakter, von Interesse für die Paleogeographie), die den Wissenschaftlichen Wert der Objekte betrifft. Der Gesamtwert eines Objekts hängt jedoch auch von verschiedenen so genannten Zusatzwerten ab. Diese sind ökologischer, kultureller, ästhetischer oder ökonomischer Natur. Im Artikel wird eine neue Bewertungsmethode vorgestellt, welche diese Zusatzwerte in den Bewertungsprozess mit einbezieht. Die Methode wird beschrieben und anhand von zwei Beispielen verdeutlicht – ein Inventar von geomorphologischen Geotopen, das im Zusammenhang mit dem Projekt Nationalpark Adula (Tessin, Schweiz) erstellt wurde, und die Erfassung des geokulturellen Erbes des Vallée du Trient (Wallis, Schweiz).

**Résumé: Une méthode d'évaluation des valeurs scientifique et additionnelles des géomorphosites**

Différentes méthodes utilisant des critères objectifs ont été développées durant les deux dernières décennies en vue de réduire la subjectivité relative aux processus d'évaluation des géomorphosites. La plupart de ces méthodes sont basées sur l'utilisation de critères tels que l'intégrité, la rareté, la représentativité et la valeur paléogéographique, qui concernent la valeur scientifique des sites. La qualité globale des sites dépend toutefois aussi de différentes valeurs dites additionnelles, comme les valeurs écologiques, culturelles, esthétiques et économiques. Cet article propose une nouvelle méthode d'évaluation qui intègre les valeurs additionnelles dans le processus d'évaluation. La méthode est décrite et deux exemples sont présentés: un inventaire réalisé dans le cadre du projet de Parc national de l'Adula (Tessin, Suisse) et une évaluation du patrimoine géoculturel de la vallée du Trient (Valais, Suisse).

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