Procedure for evaluation of the attractiveness of the quarries' landscape

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ABSTRACT
Post-mining workings, especially after the exploitation of the rocks, become attractive mainly because of their landscape forms. These new forms of landscape can be an important element of tourist interest, and can cause the regional tourist revival. Quarries, as a quite specific forms, may, however, be received by individuals, as more or less attractive. The existing methods of landscape attractiveness evaluation cannot be directly applied to assess the attractiveness of abandoned quarries without the introduction of some partial criteria. The article attempts to present the methodological basis of the procedure for evaluating the attractiveness of the landscape of the quarries by setting new criteria for such an assessment. To do this, the method of semantic differential, called the Osgood's Method, was used, as well as principles of entropy and point bonitation. The evaluation of the attractiveness of the quarries' landscape consists of the results of these methods. On such basis, four classes of the attractiveness of the landscape of abandoned quarries have been defined.

Keywords: mining, quarry, landscape, attractiveness, evaluation, rocks exploitation.

INTRODUCTION

During the mining activity, quarries are mainly associated with a negative influence on the environment. The situation changes after the mine has closed when interesting and sometimes even extraordinary geological structures are revealed. Much later, one can notice precious species of fauna or flora settling in a place of that kind. The quarries also happen to be attractive with regard to morphologically differentiated landscape (Chwastek et al., 1998). Therefore, one can consider them in terms of the combination of natural and cultural (industrial) values and post-industrial tourism. One can also assume that rock mining gives one a possibility of creating, shaping and perceiving the landscape. Therefore, the landscape of a quarry should be discussed since it forms a separate unit characterised by separate natural conditions and features. However, former quarries may be perceived by individuals as more or less attractive, therefore, there is a need of analysing the attractiveness these specific places after the mining has ceased.

The literature gives numerous examples of attempts of analysing land attractiveness after mining has been completed (Kruczek, 2011; Nowacki, 2007; Shoval & Raveh, 2003; Lew, 1987); still, sometimes they are lacking a clear distinction between post-mining areas and quarries which are characterised by different features and may perform different functions, locally significant from the human and natural perspective. What is more, quarries constitute a more durable environmental component than places after mining for sand and gravel, and thanks to harmonising with the surrounding landscape through interesting morphological forms, they become a specific flagship of a place. The studies on landscape quality or selection of the way of utilising post mining area with the use of different methods and analyses are different with regard to assessment, approach or education of experts conducting the research. Each landscape is an individual component and it should be approached as such; therefore, the previous methods have not been bearing the expected fruit. A lack of unified methods and treating other ones as experiments are the main reasons for the situation and this results from the difficulties with using measures of quantitative changes of qualitative assessments and, consequently, attributing numeric values to aesthetic sensations related to attractiveness (Eben Saleh, 2001). The aim of this article is to offer the method of assessing the attractiveness of areas after rock mining has been completed with the use of the procedure for evaluation of the attractiveness of quarries landscape.

ATTRACTIVENESS EVALUATION OF QUARRIES' LANDSCAPE

The existing methods of landscape evaluation cannot be directly applied to the quarries' attractiveness evaluation. Multi-step method to distinguish the types of tourist attractions, then the study a preference of tourists, evaluating the uniqueness of the given attraction and the analysis of its availability and location was proposed by Piperoglou (1966). Ferrario (1976) has applied a similar method by designating 22 types of tourist attractions. Geo-botanic methods of assessment used by Kostrowicki (1970) and Mazurski (1981) based on bonitation of natural attractions for the purposes of sightseeing tourism. In contrast, Lew (1987) had proposed the division of tourist attractions into following research perspectives: ideographic (description of a given attraction), organizational (in terms of location, size, tourist capacity, period of operation), and cognitive (the study of perception). To assess the natural attraction Saaty (1987) used a method of Hierarchical Analysis Process, based on a comparison of different groups of factors and giving the appropriate grade of importance to the analysed elements. Shoval and Raveh (2003) have applied a similar method but using variables such as the number and duration of visits or the analysis of tourists in terms of the number of stranger visitors in relation to the number of locals. All mentioned above methods study the tourist and natural attractions or they analyze the preferences of tourists. None of these methods at the same time does not take into account factors such as: the preference of society with respect to the assessment of attractiveness of the post-mining sites, their social acceptance, geomorphology, the state of preservation of the workings or the current progress of natural succession. Moreover, research using these methods were not organized on a large scale but only locally, and therefore they did not have so far nationwide application. Therefore, determining additional partial criteria and confronting them with the criteria of the existing methods seem to be essential as it will constitute the foundations for the procedure of attractiveness assessment of quarries' landscape. In order to achieve the assumed goal, the three following methods were used: (1) semantic differential, (2) assessment of a number of signals coming from the landscape through assessment of landscape entropy and (3) point evaluation. Modification of these three mentioned above methods by their respective complementation will be presented in details in the following chapters below.

SURVEY WITH THE USE OF SEMANTIC DIFFERENTIAL

This method is based on the assumption that the more surveyed people there are, the more similar mean value of independent evaluations to the objective assessment will be. The survey combined with a statistical analysis of the results constitute an important component of design works, and, especially, those connected with reclamation and development of a particular area; and using semantic differential for analysis and then evaluation of landscape attractiveness of the closed quarries will enable one to show preferences of the surveyed in relation to these areas and constitute one of the factors of the method used to evaluate quarries' attractiveness. What is more, an important aspect is the fact that this method enables one to consider a human factor in attractiveness evaluation and feelings towards a particular area.

The semantic differential is a type of a measuring scale used to assess connotations and means linking contents with a word by means of words established in social consiousness. This process was presented by Osgood (op. cit.) by means of a simplified model composed of three stages: I – stimulus which enters human consciousness and is recognised as a sign meaning a certain feeling to a particular individual; II – positive or negative word expression and comparing it to the current event; III – staying in or leaving a particular place, depending on positive or negative stress (Kowalczyk, 2004). The distinguishing feature of this method is a scale which outermost points are two antonyms: bad – good, inexpensive – expensive, useless – useful, etc. (Kruczek, 2011; Babbie, 2010; Osgood et al., 1957). Between them, there are several "in-between" categories marked with natural numbers by default. The analysis consists in drawing up a graphic profile which is formed by connecting numerical values obtained by an analysed structure with a line on each scale of evaluation (Steinberg and Jakobovits 1971, Kruczek 2011). In order to achieve that, one calculates the mean value for each pair of contrasting features and a synthetic index of the evaluation of a structure in a form of a mean value calculated for total evaluative features. Advantages of the scale are, most of all, easiness of communicating conclusions and a reliable measurement of intensity of attitude towards the analysed structure.

The results of the survey showed the mean evaluation of respondents for a particular quarry which can be assigned to six groups and then given points (Tab. 1).

EVALUATION OF A NUMBER OF SIGNALS COMING FROM THE LANDSCAPE THROUGH LAND-SCAPE ENTROPY EVALUATION

Within this method, the landscape is perceived as a multisensory unit received by a human being with many senses which have various impacts on him/her. The notion of multisensory landscape was coined by Bartkowski in 1986 who in this way determined a psychological and geographical reality perceived with senses providing a set of signals becoming stimuli for receptors (Bartkowski, 1992; Bernat 2004). The occurrence of signals is determined by the structure and functioning of a landscape (Kowalczyk, 2004). Possible sources of signals coming from a quarry's landscape are received with the senses of sight, hearing, smell and touch. The most (80-90%) information is received by a human being with the sense of sight, and the rest (10-20%) with other senses

Tab. 1 Indicator of the mean evaluation of the surveyed

Mean of the surveyed	Points
from 2,00 to 1,30	5
from 1,29 to 0,60	4
from 0,59 to 0,10	3
from -0,09 to -0,60	2
from -0,61 to -1,30	1
from -1,31 to -2,00	0

(Młodowski, 1998). Therefore, the received signals can be divided into two groups: perceived with sight, and the one perceived with other senses.

This discussion assumed (Baczyńska, 2014) that a source may send 19 different (positive or negative) messages, hereinafter marked as 1,2……19 for the reasons of simplicity. It was assumed that messages are divided into two groups: I: 1-9 and II: 10-19. The occurrence of signals from group I is equally probable as in the case of group II. Messages 1-9 are equally probable while messages from II group form three equally probable subgroups: IIA (10-13), IIB (14-17), IIC (18,19). The probability of the occurrence of messages in groups IIA, IIB, IIC is assumed to be equal (Turski, 1989). The signals sent by a landscape are hereinafter referred to as notices. If the sent signal is received with a sight then one of 9 notices will take place, while when the signal form the second group appears, one of 10 notices will take place. This division is shown in Fig. 1.

Therefore, if there is notice P(1|2|3|4|5|6|7|8|9) then one of nine notices must take place, that is ¼, while when one of the notices from group II P(10|11|12|13|14|15|16|17|18|19) takes place it will be $^{1}/_{8}$. Additionally, one should assume that the landscape does not provide all the assumed signals, but some of them, which causes that this method can be used to evaluate a certain landscape. The probability of signals' occurrence is determined by the features of landscape components, that is, the assumed sources of signals. One may assume that a signal coming from certain components of landscape, with p probability, includes $k = \log_2(\frac{1}{2})$ co = $-\log_2 p$ of units of information. The applied assumptions show that when the discussed source sends only one message, which probability is 1, then it is $\log_2(\frac{1}{1}) = 0$. Therefore, if a landscape may send n signals - according to the provided example there are 19 with the probability of occurrence p_i, a $i = 1,2, \dots n$ - then the weighted mean amount of information in messages coming from the landscape, that is, information entropy of the information source can be calculated from the following formula (Turski, 1989):

$$H = \sum_{i=1}^{n} p_i \log_2 \left(\frac{1}{p_i} \right)$$

On the basis of entropy analysis one can distinguish three types of landscapes and decide whether the potential landscape will turn out attractive to the tourists and encourage them to come again with regard to a number of stimuli occurring there. The closer to 0 the entropy rate is, the less emotions it elicits so one can assume it is less attractive. The suggested distribution of points could be as follows: Strongly stimulus landscapes over 6.00 – 2, moderately stimulus landscapes from 6.00 to 3.00 – 1, little stimulus landscapes below 3.00 – 0.

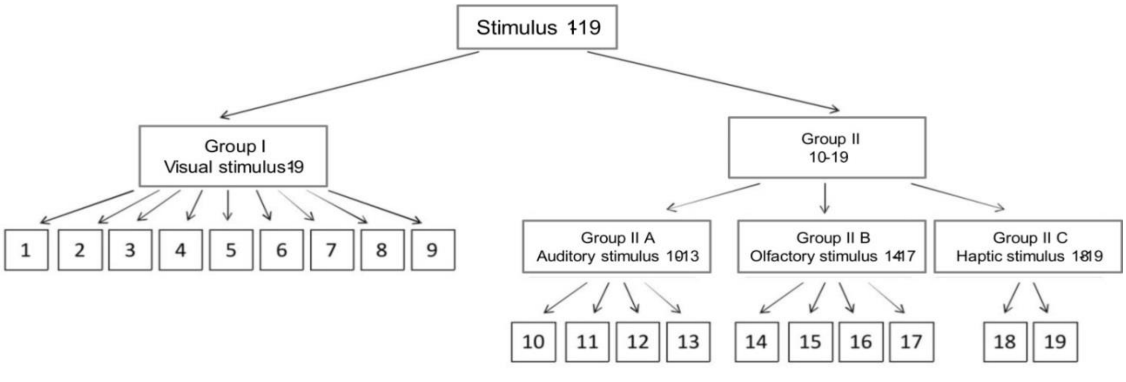

Fig. 1 Division of notices (after Kowalczyk, 2004)

Point evaluation method

The aim of this analysis is to distinguish components of natural and anthropogenic environments, which are carriers of possible values, from the area of a quarry's landscape, and determine their attractiveness. In order to achieve that we offer to conduct analysis by means of point evaluation method based on the works of Bartkowski (1986), Śleszyński (1999), Dubel (2000), Bezkowska (2005). This uses an evaluation scale which shows a relation between the assumed natural or landscape variable and a number of points (Kożuchowski, 2005). Usually, the points are given to some conventional areas which are interiors of quarries. However, with regard to different sizes of quarries, this method has been modified, otherwise there was a possibility that a bigger quarry would receive more points and a very attractive quarry (with regard to its structure, profile exposures, etc.) would receive few points due to its small area. Therefore, there was an additional assumption concerning a narrowed-down understanding of area attractiveness excluding tourist infrastructure and negative environmental impact resulting from tourist use.

What is more, this method assumed the following criteria forming the basis for classificaton and evaluation of physio-geographical phenomena. These are:

- **vertical differentiation of the area** – indicator influencing values of a particular area, determining a flexible value and utility in relation to different activities. On the basis of height differences calculated from the centre of a quarry, the particular heights are assigned to pre-determined factor values: over 25 m – 5 points, 21-25 m – 4 points, 16-20 m – 3 points, 10-15 m – 2, 5-10 m – 1 point, below 5 m – 0 points.
  If there are considerable height differences occurring in a quarry (different height at every wall), we offer to calculate a point value from the following formula:

$$W_p \frac{(P_1\ x\ T_1\ x\ P_2\ x\ T_2\ x\ P_n\ x\ T_n)}{100}$$

where:

W_p – indicator of vertical differentiation of the quarry
P_n – percentage of quarry slope area of certain n height
T_n – point predictor of vertical differentiation of the area of n type

- **percentage of natural succession** – it was assumed that the quarries with strong natural succession should obtain a small number of points since the vegetation covers interesting morphological forms developed as the result of mineral mining: below 10% – 5, 10-29% – 4, 30-49% – 3, 50-69 % – 2, 70-89% – 1, 90-100% – 0 point.
- **state of quarry preservation** – well-preserved quarries of low natural succession and with interesting geological exposures will be components of particular tourist interest: good – 2 points, average – 1 point, bad – 0 point.
- **boundary contrasts for particular types of land cover** – quarries with strong natural succession demonstrate little contrast in relation to adjacent areas (forests, fields, pasturelands, meadows), and the tourist will find a more contrasting area more attractive (Tab. 2).

If one quarry borders with many types of adjacent areas, the points were awarded according to the formula:

$$W_k = \frac{(L_1\ x\ K_1 + L_2\ x\ K_2 + L_n\ x\ K_n)}{100}$$

where:

W_k – indicator of boundary contrasts
L_n – percentage of the area bordering with n-type area
K_n – point-indicator of contrasts for the border with n-type area

Tab. 2 Indicator of boundary contrasts for particular types of land cover

Dominating type of adjacent lands cover	Dominating type of quarry land cover			
	trees	**shrub-like vegetation**	**grasslands**	**slight traces of natural succession**
trees	0	1	2	3
shrub-like vegetation	1	0	1	3
grasslands	2	1	0	3
other contrast land cover	3	3	3	3

- **number of adjacent area types** – depending on a number of area types adjacent to the quarry, the points are as follows: 3 and more – 3 points, 2 – 2 points, 1 – 1 point, lack of differences between the quarry and adjacent area – 0 points.
- **presence of surface waters** – the tourist will be more attracted to areas with surface water thanks to a wider range of possibilities making the place more attractive with regard to tourism (Tab. 3).
- **Road and tourist routes accessibility** – the better accessibility to the quarry the more points are given: good – 2, average – 1, Very aggravated – 0.

Tab. 3 Indicator of presence of surface waters

Presence of surface waters	Points
entire quarry interior	4
close vicinity of a huge reservoir	3
huge reservoir making 40-60% of quarry area	2
small reservoir making 10-30% of quarry area	1
lack of surface waters	0

Additionally, this method offers giving 1 point if the quarry has a form of nature conservation established since this can have a considerable influence on tourists' willingness to visit the quarry and frequency of the visits. What is more, the research study should take a negative anthropological factor into account which can have a considerable influence on the perception and evaluation of a particular quarry. Each analysed structure within which one notices the presence of disfiguring anthropogenic structures should be given a negative point (-1 point). A similar situation should take place in the case of structures located at busy streets or operating processing plants.

Procedure for evaluation of the attractiveness of quarries' landscape

The procedure for evaluation of the attractiveness of quarries' landscape consists in the results of the above-mentioned evaluation criteria:

- Indicator of the mean evaluation of the surveyed;
- The entropy rate;
- evaluation criteria selected and assessed with the use of point evaluation.

Total evaluation of the particular criteria can be expressed the following way:

$$AKK = (W_p + W_{sn} + W_{sz} + W_k + W_g + W_w + W_d + W_a + W_e + W_o) - W_n$$

where:

AKK – attractiveness of quarry's landscape
W_p – indicator of vertical differentiation
W_{sn} – indicator of percentage of natural succession
W_{sz} – indicator of state of quarry preservation
W_k – indicator of boundary contrasts
W_g – indicator of a number of adjacent area types
W_w – indicator of presence of surface waters
W_d – indicator of road and tourist routes accessibility
W_a – indicator of the evaluation of the surveyed
W_e – indicator of entropy evaluation
W_o – indicator of legally protected areas
W_n – indicator of unfavourable human impact

As the result of using the offered procedure, four qualification groups are offered concerning attractiveness of the abandoned quarries' landscape (Tab. 4). The point scale was determined on the basis of the research on the abandoned quarries carried out in Poland, Austria and Great Britain (Baczyńska, 2014; Baczyńska et al., in press).

EXAMPLES OF APPLYING THE PROCEDURE FOR EVALUATION OF THE ATTRACTIVENESS OF THE ABANDONED QUARRIES' LANDSCAPE

In order to show the procedure for evaluation of the quarries' landscape attractiveness, two extremely different quarries were selected. Białe Krowy gabbro quarry with area of 3000 m^2 is located on the slope of Sadno natural elevation which is 230 m high and situated within Ślęża Landscape Park in the South West Poland. The abundance of trees and shrubs as well as road infrastructure are considerably impeding access to the quarry (Fig. 2). Winspit limestone quarry is located at Jurassic Coast in Dorset, Great Britain. It covers the area of approximately 10000 m^2; road accessibility is good and the structure itself in protected by the National Trust (Fig 3).

The first stage of the research was conducting a survey which comprised seven questions concerning associations with the "quarry" word, frequency of visits, distance to be travelled by the surveyed to use the area of the abandoned quarry and determination of the values through evaluating the attractiveness on the basis of choosing negative or positive features. On the basis of the answers of the surveyed concerning evaluative features, the polarised graphic profiles were drawn up (Figs. 4, 5). Next research stages consisted in evaluation of entropy of information sources concerning the particular quarries and application of the point evaluation which results were shown in Table 5.

The analysis of the results showed that

Tab. 4 Qualification groups for the attractiveness of abandoned quarries' landscape

Group	Qualification categories	Total points
I	Very attractive quarry landscape	over 24
II	Attractive quarry landscape	from 24.00 to 16.00
III	Little attractive quarry landscape	from 15.99 to 8.00
IV	Unattractive quarry landscape	below 8

Fig. 2 Białe Krowy quarry

Fig. 3 Winspit quarry

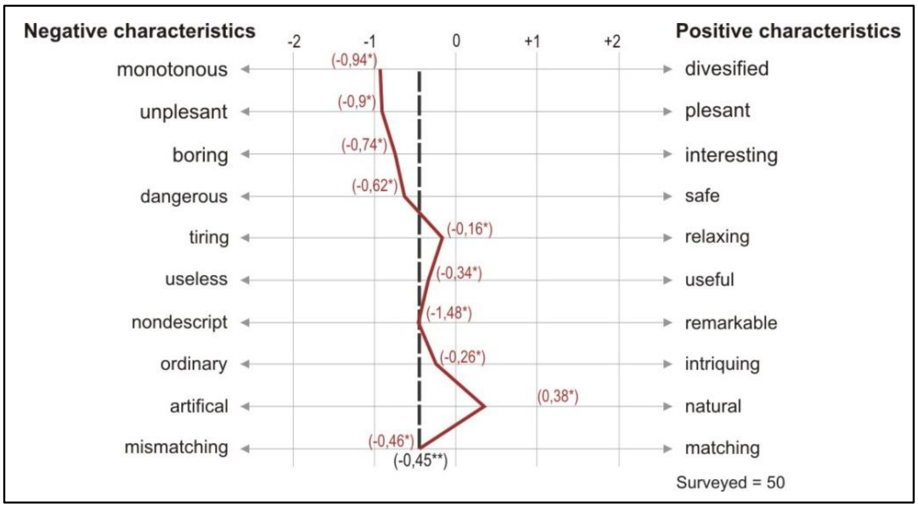

Fig. 4 Polarised profile of the evaluative characteristics of the Białe Krowy quarry

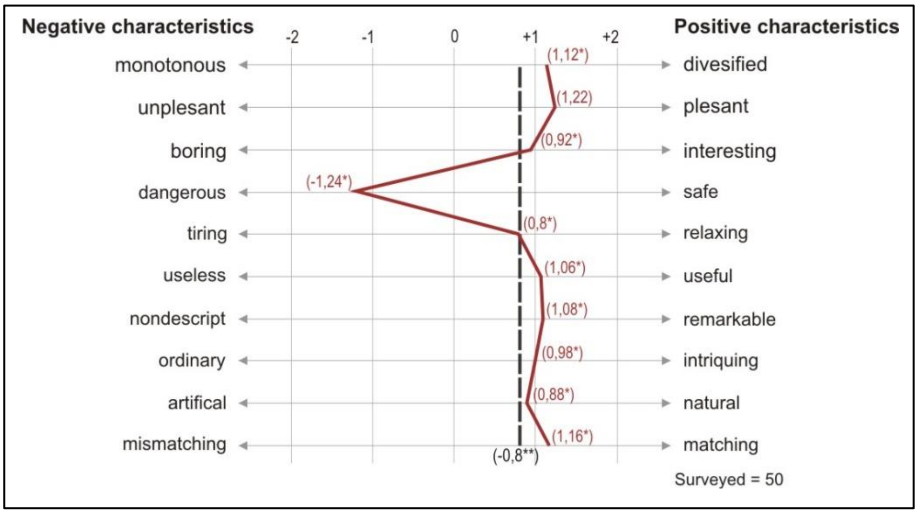

Fig. 5 Polarised profile of the evaluative characteristics of the Winspit quarry

Tab. 5 Detailed results of the evaluation of the landscape attractiveness of the abandoned quarries

Evaluation criteria	**Białe Krowy quarry**	**Winspit quarry**
Vertical differentiation	0	4
Natural succession	0	5
Preservation state	0	2
Contrast	0	2,25
Neighbouring lands	0	2
Surface waters	0	3
Accessibility	0	2
Evaluation by the surveyed	2	4
Entropy evaluation	0	2
Protected areas	+1	+1
Unfavourable impact	-1	-
Total	2,0	27,25

the exemplary gabbro quarry, Białe Krowy, was qualified to IV group of landscape attractiveness (below 8 points) and is little attractive with regard to considerable natural succession and impeded accessibility. On the other hand, great landscape attractiveness of Winspit limestone quarry (I group of landscape attractiveness qualification of the abandoned quarries – over 24 points) results from great vertical differentiation, good preservation state, low natural succession, high contrast, good accessibility and the fact of legal protection.

CONCLUSIONS

The offered procedure for evaluation of the abandoned quarries' landscape attractiveness was established through confronting it with the criteria of the existing methods and determining additional partial criteria. The result of the total evaluation of the particular criteria is qualification of the particular structure to one of the four qualification groups (I-IV). The quarries from I group are characterised with great landscape attractiveness thanks to: great vertical differentiation, high contrasts in relation to the adjacent areas and the location within the areas legally protected. They are also described with the highest entropy rate which makes the be perceived as highly stimulating structures. On the other hand, unattractive quarries are qualified as group IV and characterised by the lowest parameters. They have small vertical differences, preservation state is very bad, natural succession is considerable, they do not have road access and are not characterised with contrasts so they are hardly noticed. The quarries characterised by landscape attractiveness (group II) usually show lower vertical differentiation than in group I, natural succession slightly covers some valuable and interesting geological profiles, and road accessibility is good. In case of little attractive quarries (group III), there are structures incorporating elements influencing the evaluation as: small height differences, impeded access due to natural succession, no surface waters, and no contrasts in relation to adjacent areas.

As a result, the application of the offered procedure enables one to determine the level of attractiveness of the abandoned quarries and show whether they create new values which could constitute e.g. an important element of tourist, recreational or educational interest. To show the potential of the quarries can encourage the use of such sites by arranging there special events, concerts, art-exhibitions, etc. Moreover, these very special areas can be used for popular social education, being a good didactic place, that could be a part of programme of various kinds of trips, including those focused on education. Such a way of development will be associated with the large-scale promotion of the quarries' landscape values, release of the popular guide-book, information booklet and proper signposting of these sites as both tourist- and/or geo-sites. Another option is to create a trail of old quarries along with explanation of the rock exploitation process, extracting techniques and tools, etc., as it was successfully done and fully accepted by tourists in Adnet region (Austria). It is worth noting that such objects are testimony to the rich mining history of the area, becoming at the same time, historical heritage of the region.

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