Cerro do Jarau and the Importance of Its Preservation as Records of the History of the Land and Its Current Scenic Beauty

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Abstract The Cerro do Jarau, which is located the southwest of Rio Grande do Sul, in the Pampa region, is the sixth impact crater (astrobleme) identified in Brazil, being considered a set of extreme quality, from the landscape point of view, with its uniqueness and its local and regional representativeness. In this sense, the main objective of the research is to identify the basic elements of landscape qualification of the space, from the point of view of perception, as a spatial and social element of reference for residents and passersby, especially for its tourist interest. As procedures, the methods that identify the landscapes, considered of great aesthetic value, as a consequence of the junction of significant visual properties, such as differentiated forms, exuberant colors, and elements of great proportions, among others, are adopted. These combinations form spectacle landscapes, the case of Cerro do Jarau, a privileged landscape, by tourism activities and interest, as geopatrimonial and regional references, because it has elements with outstanding geological and geomorphological particularities, which are of easy attribution to tourism and identity interests.

1 Introduction

For common sense, the term landscape suggests two distinct understandings: the objective and the representation. The idea that landscape is based on what the vision can reach—spatial scale—makes us build the notion of a more or less ordered mosaic of shapes and colors. In terms of temporal scale, we notice that the spatial cut, given by the vision, changes, that is, the landscape is endowed with a dynamic. All landscapes, which are transformed over time, can be objects of study, both from the isolated elements that compose it and their totality. However, this temporal dynamic suggests that each landscape contains an essentially unique structure and functioning, characteristics that lend a specific character to each landscape. Thus, studying the

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G. Barbosa dos Santos et al. (eds.), *Geomorphology of Brazil: Complexity, Interscale and Landscape*, Springer Proceedings in Earth and Environmental Sciences,
https://doi.org/10.1007/978-3-031-05178-4_11

relationship between nature and society, having the landscape as a category of analysis, is extremely important because, through it, it is possible to understand, in part, the complexity of geographic space at a given moment, or over time, and its importance as a geo-historical reference of a human group in a given space.

By the studies carried out, Grehs (1969) and Lisboa and Schuck (1988), researchers at the Federal University of Rio Grande do Sul (UFRGS), based on the analysis of aerial photographs, satellite images and geomorphology of the region, proposed that the Cerro do Jarau, located in the municipality of Quaraí, in the southwest of Rio Grande do Sul, would have been formed by the impact of a meteorite (Fig. 1). Later, research conducted by the geologists Crósta et al. (2010), from the Institute of Geosciences of the State University of Campinas (Unicamp), found evidence that these elevations were formed as a result of the impact of a meteorite, which fell in the region millions of years ago, opening a large crater. Microscopic analysis of the rocks confirmed that they could only have been formed at extremely high temperatures and pressures, such as those generated by the fall of a celestial body. Over millions of years, wind, rain, and the movement of the planet's surface eroded the edges of the Cerro do Jarau, raising the geomorphological feature to altitudes of around 200 m at its vertical end, whose constituent rocks form a ring 3.5 km in diameter, marking the most central region of the crater, where the crash possibly occurred.

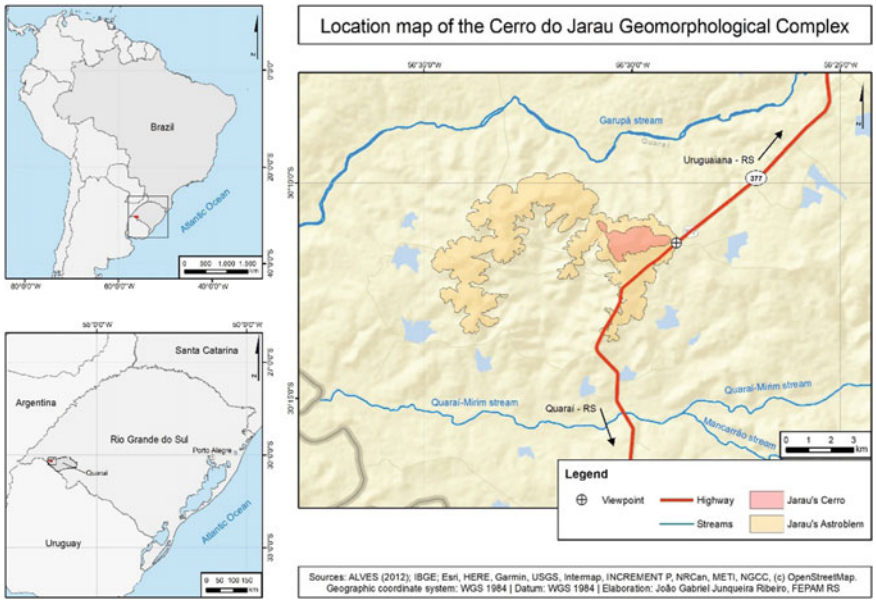

Fig. 1 Location of Cerro do Jarau, in the municipality of Quaraí, Rio Grande do Sul, Brazil. *Source* prepared by João Gabriel Junqueira Ribeiro, based on Alves (2012)

2 Presentation and Relevance of the Study Area

According to Sánchez et al. (2014), the evaluation of the structure of the rocks of Cerro do Jarau indicates two pieces of evidence of the fall of a celestial body in the area in question (Fig. 2). The first is the location of so-called impact breccias, rocks

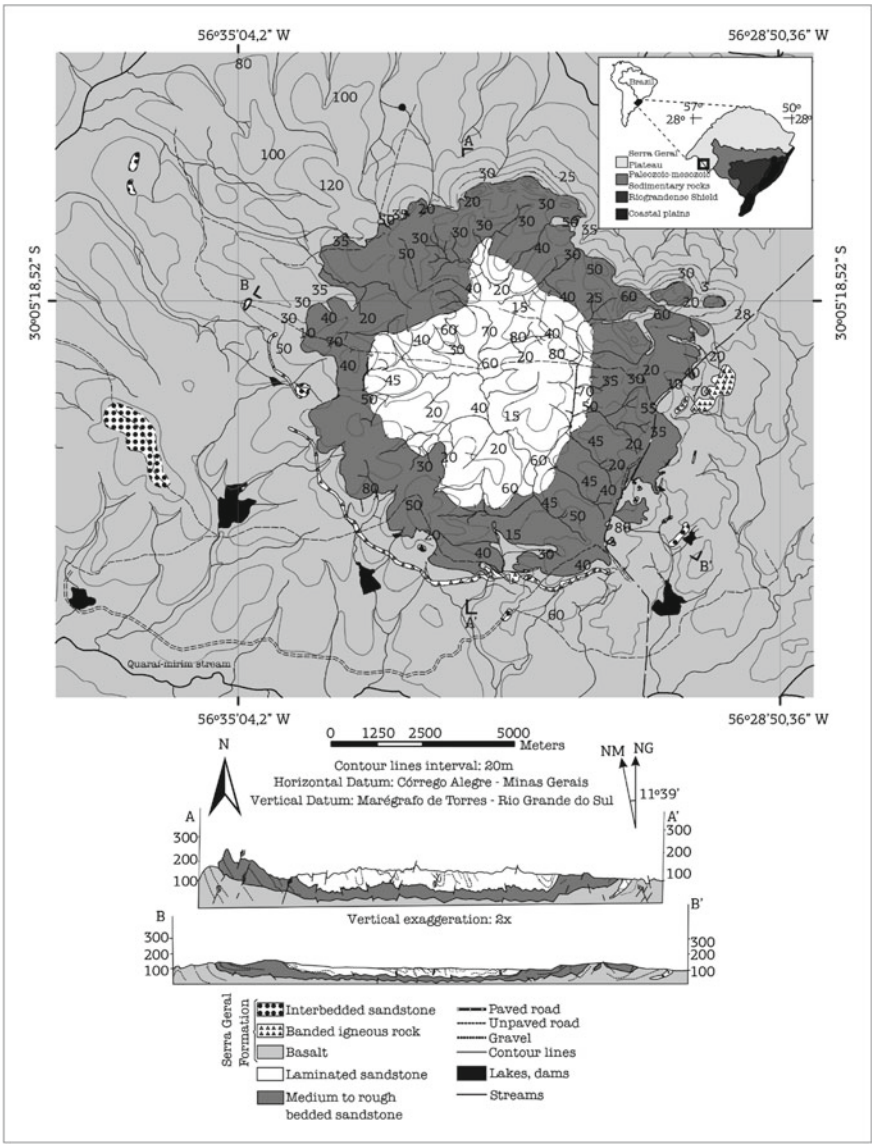

Fig. 2 Geological map of Cerro do Jarau. *Source* Adapted from Sánchez et al. 2014

formed by fragments of other rocks. The second and more conclusive evidence is that the quartz grains of the rocks suffered a phenomenon known as planar fracturing, as the samples analyzed present parallel traces of vitrified material, different from the natural structure of the quartz crystals. These grains are only formed in deeper regions of the planet, such as the mantle, located between 30 km and 2.9 thousand kilometers below the surface, where the temperature is thousands of degrees Celsius and the pressure is hundreds of thousands of atmospheres, enabling the formation of structures equivalent to those found in impact craters.

However, the rocks of Cerro do Jarau have characteristics of surface rocks, not mantle rocks. Only the energy released by the shock of a body such as a meteorite would produce the pressure and temperature necessary to cause this kind of deformation in the quartz of the planet's surface.

As mentioned, the Cerro do Jarau is the sixth impact crater—or astrobleme, Greek expression for "scar left by a star"—identified in Brazil (Crósta et al. 2010). The number is small but tends to rise, with time, as knowledge about the space bodies that hit Brazil in the distant past should increase. Geologists believe that the number of known astroblemes in the southern hemisphere is small because comprehensive geological surveys are lacking.

It is estimated that the original crater was approximately 13 km in diameter, but the difficulty in determining its size with some precision comes from the fact that the edge is quite eroded (Fig. 3). This would be a piece of fundamental information to accurately calculate the size of the meteorite that fell in the region, which is supposed to be between 600 and 700 m in diameter.

Another priority question is to find out when the impact occurred, which is no simple question to answer. To determine the crater's age, it will be necessary to find rock samples that had melted at the exact moment of impact, to measure their isotope ratio of the chemical element argon. The problem is that the rocks melted at

Fig. 3 Current morphology of Cerro do Jarau and its crater rim structure, eroded over time. *Source* Roberto Verdum's collection on November 27, 2019

the moment of impact may be very similar to those that make up most of the terrain of Cerro do Jarau, basically, basalt, igneous rock, formed at high temperatures, like those inside volcanoes. Moreover, considering the correction of the diameter of about 13 km of the crater opened by the impact and the action of weathering, the surface of occurrence of such rock fragments can be millimeters long.

According to Crósta et al. (2010), the maximum age of the youngest rocks affected by the impact (basalts) is around 135 million years, but as the crater edges are quite eroded, they are thought to be tens to a hundred million years old. This dating is important because it may reveal another story hidden in the geological record, given that an impact of this scale may have strongly affected life in the southern part of the South American continent, causing considerable local extinctions.

In addition, Jarau may also reveal more about Earth's past, since the collision of meteorites with basaltic rocks possibly causes specific transformations, which would allow us to differentiate their evolution from those of other types of rock—and reveal details of how other rocky planets were formed, such as Mars and Venus, where there is a lot of basalts.

2.1 Methodological and Operational Procedures

For the definition of the geographic space of reference of the study, using the landscape as a category of analysis, two levels of information were chosen:

(a) The landscape units, defined by FEPAM, for the environmental licensing of wind turbines;
(b) The municipal territory is defined as a reference for the request for licensing of wind farms, with FEPAM, by the entrepreneurs.

The proposed steps for the study of landscape perception indicators are as follows:

(a) A bibliographic survey of the methods, related to the study of the landscape, through the perceptual landscape approach;
(b) Bibliographic and visual surveys of studies on the deployment of wind turbines in the world, and adoption of methods for evaluating the indicators of perception given their installation;
(c) Elaboration of the research instrument, for the definition of landscape perception indicators;
(d) Search for iconscapes (identities) on the *websites* of municipalities potentially favorable to the installation of wind turbines, in this case, Quaraí;
(e) Research on *Google Maps* images, related to photographic records of landscapes of aesthetic and heritage interest, made by tourists, in municipalities potentially favorable to the installation of wind turbines.

Thus, to achieve the proposed objectives, the landscape perception methodology was developed, based on geographical, historical, and ecological recognition of the landscape. In this sense, levels of analysis were established, which refer to:

(a) The protection of the landscape as regards its natural and heritage features;
(b) Human perceptions, valuing individual and collective identities, related to the landscape, as elements or sets that people identify as references, through observation, characterization, and differentiation of landscapes (identity landscapes or icons);
(c) The publicization of municipal territories, by understanding the relations of social groups with their living spaces, i.e., the local landscape commons, which typify or function as an identity, brand, or attraction of a (municipal) territory;
(d) Differentiation of landscapes according to the temporal scale.

3 Presentation and Discussion of the Results

For Vieira (2014, p. 15), as "[…] object of contemplation, the landscape is usually linked to the memory of a place of great scenic beauty, concerning which one has, in memory, the record of some pleasant experience", while the scenic beauty is "[….] is characterized by being the central place of the observer's gaze when reading a landscape, that is, it is the scenario with formal and structural aesthetic properties marked by harmony, proportion, brightness and balance" (Vieira and Verdum 2017, p. 155).

The dichotomous classification of beautiful/weak is the simplest way to assess a landscape. However, there are other aspects to evaluate the quality of a landscape, such as integrity, diversity, uniqueness, and representativeness. The basic aspects of landscape perception consist of the spatial element (the landscape), the social element (the observer), and the subjective element (perception).

The landscape can be divided into three planes (Fig. 4), according to the elements captured by the viewer's vision and the distance of the elements arranged in space,

Fig. 4 Landscape plans. *Source* Roberto Verdum's collection on November 27, 2019

concerning the observer: the foreground, which is the zone of details, is located a few meters away from the observer; the landscape itself, in which the details are not distinguished, but the shapes of the elements of the landscape, observed at a distance of up to one kilometer; and the background, in which the eye no longer accurately distinguishes the characteristics of the elements, capturing only volumes, located more than one kilometer away (Brandão 2018).

Landscape plans are important and should be considered in the evaluation of a landscape and its constituent elements, especially if the evaluation is intended to identify its tourism potential, because the landscape is the product of tourism and there must be harmony between the three plans, forming a balanced and pleasant to the eye. This look, which is given, is from certain points of observation, which are as important as the landscape itself.

Therefore, landscape plans influence the intrinsic visual quality intrinsic to the landscape, as well as the visual quality of the immediate surroundings and the scenic background. The most important elements motivating the observer's perception of the landscape and consequently determining its visual quality are geomorphology, vegetation, the presence of water or rocky outcrops, and the altitude of the horizon.

In addition to landscape planes, shape, line, color, texture and scale and spatial configuration are important in determining the visual quality of the landscape (Kroeff and Verdum 2011; Vieira 2014), as well as the following properties:

- Diversity: expresses the landscape variety of a given territorial space. It is assumed, then, that a varied landscape contains more value than a homogeneous landscape, for having differentiated parts, with distinct visual elements and absence of monotony;
- Naturalness: degree of approximation of current conditions, verified in the landscape, to its natural form, free of human actions. The closer to this condition, the greater the naturalness;
- Singularity: natural or man-made occurrences in the landscape become points of visual attraction because of their uniqueness, scarcity, strength, traditional value, or historical interest;
- Topographic complexity: degree of movement or irregularity of the relief. The more irregular, with greater differences in level and with more distinct cardinal orientations of the slopes, the greater visual value the landscape has;
- Surface and water's edge: these are the natural forms of surface water, such as the sea, lagoons, and rivers. In turn, the water's edge is the boundary between the water surfaces and the other components, such as land, vegetation, and sky;
- Human actions: are responsible for the introduction of structures and artificial elements of superficial character (urban settlements, industrial complexes, crops), of linear character (roads, transmission lines), and punctual character (buildings, bridges, towers). Human actions modify the natural characteristics of the landscape (PIRES, 1996 apud Kroeff and Verdum 2011, p. 25).

Based on the forms and characteristics cited, the landscapes of great aesthetic value are a consequence of the junction of significant visual properties, such as differentiated forms, exuberant colors, and elements of great proportions, among others. These

combinations form the landscapes privileged by tourist activity. Concerning the Cerro do Jarau, this has specific elements, which stand out and are easily visualized and appreciated.

It is also noteworthy that the perception of the visual quality of tourist areas is related to the natural potentialities, especially those that are prominent in the landscape, as is the case of this hill.

The *Atlas of the Scenic Beauties of the Pampa Landscapes: look, read, reflect and understand to value the landscape—Cuesta do Haedo region* (Vieira et al. 2018) presents some speeches, collected in interviews:

> "[…] by the contrast in the landscape, when seeing it." "[…] it is a form of relief that differs from the flatness of the fields. It brings to the residents a different dimension of nature. It has a cultural expression, a place of stories, legends, and films". "[…] by the presence of ornamental species, the view of the surrounding landscape and the traditional management of herds by the gaucho". "[…] for its imposing morphology, its ecological composition, and its historical references that have even made it a regional cultural icon". "[…] for its rare beauty, pristine environments, endemic/rare species, among others".

Concerning the concept of landscape, expressed by people, who register this morphology of landscape exceptionality, through photography, and by the municipality, which defines it as an outstanding set on its *website*,[1] it is emphasized that this is associated with the elements of nature, which are considered beautiful and pleasant: the green (field and bush), the coxilhas, and the animals in the field.

Additionally, this landscape is said to be notable for its natural beauty and its historical value, as this element is highlighted as a municipality symbol, through poems, and represents a monument of interest to be preserved as geopatrimonial (Borba 2014). The Cerro is also depicted in one of the oldest legends of the literature of the state of Rio Grande *do* Sul: *A Salamanca do Jarau*, by João Simões Lopes Neto, written in 1913 (Vieira et al. 2018). In this sense, the sensory evaluation of the Cerro do Jarau landscape, from the publicization of this landscape, by the municipal government, and the individual records, found on the satellite images of *Google Earth*, can be considered a rating of 5, on a scale between 1 and 5.

Among the main economic activities developed in the municipality, agriculture and livestock are recognized as activities that do not alter the landscape, both in the past and in the present, being part of the "natural context". However, the new projects, located near the hill, linked to the production of wind energy, have tensioned local actors, tourists, researchers from various fields of knowledge and the environmental licensing body of Rio Grande do Sul, the Henrique Luiz Roessler State Foundation for Environmental Protection (FEPAM), since such elements will be able to alter the landscape and interfere with its recognition as heritage.

[1] http://www.quarai.rs.gov.br/CONHECENDO_fotos_de_quarai.htm.

4 Conclusions

Through the studies carried out in the late 1980s, when the interest and need to know the geological-geomorphological genesis of the Cerro do Jarau, the recognition of this space as an icon of the local and regional landscapes was further increased, already recorded in the literature and the landscape matrix of the surrounding residents and passersby. The thesis that the morphology of this hill results from the impact of a meteorite reaffirms its originality and the interest in dating more precisely the episode is still considered an unknown in the field of science.

Today, this geomorphological feature, whose highest altitudes, which are around 200 m, mark a landscape referenced by the elements of nature that surround it. In this sense, the visual quality of this landscape can be specifically related to its naturalistic value (landscape unit, whose ecosystem conservation status has remarkable animal species or even natural singularities, related to geological-paleontological-geomorphological factors). From this, regarding the points of view of perception and human expressions, which refer to it and revere it, the Cerro do Jarau is undoubtedly an identity icon for its visual, ecological, and cultural qualities.

Therefore, if wind farm installation projects advance in the area surrounding this hill, it will be essential to consider this landscape as of aesthetic interest, as well as cultural heritage and geopatrimonial. In this case, it is essential and mandatory to propose scenarios that establish in detail the landscape of the future, inserting the wind turbines in the landscape, so that the population can have the ability to build a reference of the new landscape to be produced. In doing so, one can obtain a notion of the scalar dimension of the new elements that will be inserted into the landscape (wind turbines) and that are not necessarily (re)known by most of the people around the hill or even by passersby. There will certainly be changes in the shape of the landscape and its functionality, as well as restrictions and precautions regarding access to the hill and its surroundings from the time the wind farms are in operation.

Acknowledgements This article is part of the research on institutional relations between the PAGUS Landscape Laboratory, Department of Geography, the PPG in Geography (POSGEA) – from the Institute of Geosciences of the UFRGS –, and the State Foundation of Environmental Protection Henrique Luiz Roessler (FEPAM-RS), in the contexts of university research and extension.

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