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IMPACT CRATER OF COLÔNIA-SP: A GEOLOGICAL HERITAGE WITH RELEVANCE FOR ASTROBIOLOGY

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RESUMEN

El cráter Colônia está situado en la región de São Paulo, Brasil, y tiene gran relevancia para varias áreas, entre ellas la Astrobiología. A pesar de su importancia y de contar con leyes de protección, aún le faltan medidas más severas para su conservación e inventario para ser considerado un sitio geoturístico. En este trabajo se presentará la importancia de esta estructura y las razones por las que se considera relevante.

ABSTRACT

The Colônia crater is located in the region of São Paulo, Brazil and has high relevance for several areas, including Astrobiology. Despite its importance and protection laws, it still lacks more severe measures for its preservation and inventorying in order to be considered a geotourism site. In this work we will present the importance of this structure and the reasons why it is considered relevant.

Key Words: astrobilogy — impact crater

1. INTRODUCTION

The main goal of this work is to present the Colônia Crater as a geological heritage and its relevance to astrobiology. Craters are common throughout the Solar System and are produced by the impact of an asteroid or comet on the surface of a body with solid crust. In general, the geology of the area directly influences the preservation and formation of craters, as well as the lack of atmosphere. However, on Earth, due to the effects of physical and chemical weathering, impact crater structures are rare. Among the reasons, it is possible to list plate tectonics, volcanism, orogeny, climate, water, and the action of life itself on the planet that cause these structures to wear out over time. Of the several impact craters existing on our planet Earth only two are populated, the Ries located in Germany and Colônia in Brazil. Unfortunately, the Brazilian one doesn't receive as much visibility as it should, and despite several protection measures it still lacks specific studies for the region to be treated as a geoconservation and geotourism site. In this work we will detail the location and the values in the scientific and educational environment (Velázquez et al. 2013).

2. LOCATION

The Colônia impact crater is located 40 km from São Paulo ground zero, in the southern part of the Metropolitan Region, centered at 23° 52' 27" S, 46° 42' 36" W, in Parelheiros. It is located inside the conservation unit of the Capivari Monos Environmental Protection Area and the Billings watershed. It has a ring-shaped depression easily visible on satellite image as a circular structure of 3.6 km in diameter, occupies an area of approximately 10.2 km^2, is formed by several flattened hills that configure a smooth basin shape, with a gentle slope of the inner walls, and a difference of 12 m of relief between the rim and the crater floor (Velázquez et al. 2013). Currently Cologne has approximately 45,000 inhabitants.

3. GEOLOGY

It is part of a complex Neoproterozoic orogenic zone named by Hasui et al. (1975), the Ribeira Fold Belt, and according to Tassinari et al. (2004) three major geological domains are distinguished for the Ribeira Fold Belt in São Paulo State: Costeiro, Embu and São Roque. The most dominant part of the study area corresponds to the Embu Domain, which is largely composed of metamorphic and igneous rocks of the crystalline basement. According to Coutinho (1972), the Colônia impact crater region is within the Embu Domain and consists mainly of mica schist, gneiss, quartzite, migmatite, diorite, and quartz diorite. Tertiary sediment deposits of the São Paulo Basin also outcrop within the crater as narrow bands in the southern part.

Tertiary sediment deposits of the São Paulo Basin, correlated with the Resende Formation (Riccomini & Coimbra 1992), are discontinuously exposed in the southwestern portion of the Billings catchment. These deposits also occur inside the

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crater as narrow bands, circumscribing the southern edge (Riccomini et al. 2005). We also have a significant thickness of the crater-fill deposits, estimated by Riccomini et al. (2011) at about 275 m, which according to Velázquez et al. (2013), has four different lithological associations that can be recognized in these deposits: (a) unshocked rocks, formed mainly of mica schist, gneiss, quartzite and granite, (b) fractured/brecciated rocks with remarkable deformation: brittle and ductile structures are much more intense and penetrating than those exposed along the outer crater margin, (c) allochthonous crater-fill deposits, including a complex mixture of lithic fragments and mineral clasts derived from crystalline basement rocks and, more rarely, older sedimentary rocks, and (d) post-impact deposits consisting of very poorly separated siliciclastic sediments, including some intercrystalline lations of organopelitic materials.

In order of abundance, the terrigenous sediments include disaggregated clasts of quartz, K-feldspar, mica, tourmaline and clay minerals. Other minor constituents are zircon, epidote, biotite, corundum, plagioclase, apatite, anatase, and rutile, as well as lithic fragments of igneous and metamorphic rocks. On deformation, they include a wide range of faults and fractures that exhibit an unusual orientation pattern, significant paleostress field variation, and fluid percolation along the planes. Minerals derived from subsurface rocks exhibit a number of shock metamorphism effects, which document extreme pressure and temperature conditions.

4. GEOHERITAGE

According to Gray (2004), the geoconservation aims the conservation and management of the Geological Heritage and natural processes associated with it. Geological heritage is defined by the set of geosites inventoried and characterized in a given area or region.

Colônia was confirmed to be a impact crater from the studies of Velázquez et al. (2013, and references therein), and in 2005 it was named as a "Geological Site" by the Brazilian Committee of Geological and Paleontological Sites (SIGEP) and four years later, it was named "Geological Monument" by the Council of Geological Monuments of the State of São Paulo (CoMGeo- SP). It is protected by two Laws: (1) the state law of the CapivariMonos Environmental Protection Area, which was enacted in 2001 and (2) the São Paulo State Council for the Defense of Historical, Archaeological, Artistic and Tourist Heritage (CONDEPHAAT) in 2003, which enacted the legal protection of the region that is occupied by the crater. Recently, a small part of the southern sector of the crater was declared "Municipal Natural Park of the Colônia Crater" (SMVMA 2012). However, despite these incentives and other efforts by various social and institutional conservation sectors, no specific studies have been carried out to consolidate the crater region as a geoconservation and geotourism site; moreover, deforestation and burning practices; illegal hunting, capture and sale of wild animals and predatory extraction of palmetto, bromeliads and orchids are still common in the region. For these reasons, the adoption of a conservation strategy for the crater should be a priority, not only for its direct impact on the quality of life of the local community, but for the intrinsic value of its natural diversity.

Terms such as geoconservation, geotourism, geological heritage, among others, are not as well known by the general population, and this occurs in part to the lack of a comprehensive database on the various benefits that these natural resources can provide, the lack of interest of the population and also the lack of disclosure may be one of the causes.

4.1. *Scientific relevance to Astrobiology and Geology*

The scientific part is based on the access and study of representative samples of geodiversity, which help to know, interpret and reconstruct the long history of the Earth. It is important to conserve these features in order to understand the mechanics of their formation, periodicity (if any) and potential danger to society as well as the potential of impact craters to explain mass extinction cycles.

Colônia has the outer elevated ring underlain by metamorphic and igneous rocks, while internally the crater is slightly undulating and partly covered by swamp vegetation. The flooded area gradually increases towards the center, where the marsh landscape is dominant. Doubts about its age still remain. With the geophysical methods it is known that the maximum depth of the crater floor is about 275 m and the elevation of the outer rim has a maximum height of 120 m. With petrographic examinations it was verified the effects of impact metamorphism on the minerals, which exposed them to high temperatures and pressures. The set of geological features of the Colônia impact crater region has a high scientific interest for academic works such as: (a) structural and metamorphic geology, (b) geomorphology, (c) Quaternary geology, and (d) ecological and environmental sciences.

Finally, the crater is of paramount importance to astrobiology and astrogeology for providing information about the evolutionary history of planet Earth.

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4.2. *Educational potential*

The educational value is related to formal educational activities, of school scope, or non-formal educational activities, aimed at the general public, that the field trips allow to confer to the geodiversity an extraordinary educational value.

The lithological units that outcrop in the region include metamorphic and igneous rocks, and represent a sequence of crustal growth episodes in western Gondwana in the Neoproterozoic Brasiliano Orogenic Cycle of southeastern Brazil (Brito Neves & Cordani 1991; Cordani et al. 2002). Outcrops provide an opportunity to learn the basic concepts and connection between structural and metamorphic geology. Field observations can aid in understanding the transformation of minerals and rocks by metamorphic processes caused by physical and chemical changes in response to the dynamics of a large-scale geologic event. In addition, students can observe regional deformation caused by the hypervelocity impact of an asteroid.

The Colônia Crater has an extensive Quaternary deposit, whose geology present in the sedimentary deposits of the crater can provide valuable information to compare with global climate change data and establish more accurate inferences about possible extreme climate variations in the future.

Although the crater has suffered problems resulting from anthropic actions (such as land use for agricultural, livestock and urban purposes), it still preserves an impressive variety of fauna, including birds, mammals and reptiles (Marçon 2009), and flora, marsh vegetation and other types of herbaceous plant species and already having records of 211 vascular species, some of which are threatened with extinction. The vegetation fragments that occur in the crater are some of the best examples that illustrate the influence of geological conditions on the natural environment. The crater exhibits a continuous change in vegetation cover from the areas of erosion, through the rim, to the areas of deposition in the center. The difference is markedly noticeable by the predominance of tall, dense trees along the crater slopes, where animals, insects, mammals, birds, amphibians, and reptiles are abundant. A gradual change occurs towards the center of the crater, where a mosaic of peatland and flooded forest is observed. A better understanding of the multiple factors controlling the complex dynamic behavior of this ecosystem is a common goal for paleontologists, biologists and geoscientists.

5. FINAL CONSIDERATIONS

Geoconservation, even though it still does not have a unanimous definition, can be, according to Sharples (2002), summarized as: "Geoconservation aims to preserve the natural diversity (or geodiversity) of significant geological (substrate), geomorphological (landscape forms) and soil aspects and processes, maintaining the natural evolution (speed and intensity) of these aspects and processes". In a broad sense, it aims at the sustainable use and management of all geodiversity, encompassing all types of geological resources. Thus, the Colônia Crater fits an area that deserves to be conserved and has potential for geotourism, which is an option to improve the use of geological sites and encourage the practice of environmental preservation (Hose 1995). When this activity is well planned, it contributes to increase public interest on these themes, together with preserving and generating knowledge about geology, biology, ecology and astrobiology, in this case. As previously mentioned, it is still necessary to adopt a better conservation strategy for the crater, prioritizing not only its direct impact on the quality of life of the local community, but for the intrinsic value of its natural diversity.

REFERENCES

Brito Neves, B. B. & Cordani, U. G. 1991, PreR, 53, 23
Coutinho, J. M. V. 1972, Boletim IG-USP, 3, 5
Cordani, U. G., Coutinho, M. V. & Nutman, A. P. 2002, JSAES, 14, 903
Gray, M. 2004, Geodiversity: valuing and conserving abiotic nature. 1. ed. Londres: John Wiley e Sons Ltd
Hasui, Y., Carneiro, C. D. R., & COIMBRA A. M. 1975, Revista Brasileira de Geociências, 5, 257
Hose, T. A. 1995, Environmental Interpretation, 10, 16
Marçon, S. L. 2009, MSc dissertation, University of São Paulo, São Paulo
Riccomini, C. & Coimbra, A. M. 1992, Geologia da bacia sedimentar de São Paulo. In Solos da Cidade de São Paulo, edited by Negro A. Jr., Ferreira A. A. A., Alonso U. R., and Luz P. A. C. São Paulo: ABMS and ABEF, pp. 37–94
Riccomini, C., Turcq, B., Ledru, M. P., Sant'Anna, L. G., Ferrari, J. A. 2005, In Sítios Geológicos e Paleontológicos do Brasil, Winge, M., Schobbenhaus, C., Berbert-Born, M., Queiroz, E. T., Campos, D. A., Souza, C. R. G. (eds). Available at `http://www.unb.br/ig/sigep/sitio116/sitio116.pdf`
Riccomini, C. et al. 2011, M&PS, 46, 1630
Sharples, C. 2002, Concepts and Principles of Geoconservation, Tasmanian Parks & Wildlife Service, Hobart, `http://dpipwe.tas.gov.au/Documents/geoconservation.pdf`
Tassinari, C. C. G., Babinski, M. & Nutman, A. P. 2004, Rev. Inst. Geoc. 4, 91
Velázquez, V. F., et al. 2013, IJG, 4, 274
Velázquez, V. F., et al. 2014, Geoheritage, 6, 283
Velázquez, V. F., et al. 2021, Solid Earth Sciences, 6, 27