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(RESEARCH ARTICLE)

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Bathymetry study of the Rio Grande submarine mineral province using data from the Topex 19.1 Model

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Abstract

Bathymetric studies enable the identification of seabed depths and elevations. This is achieved through maps created using satellite data and software that use depth information within a defined geographic region. Bathymetry provides valuable insights into regions that are difficult to access using existing technologies, without requiring significant investment. Bathymetric studies can contribute to the economic assessment and operationalization of mineral exploration in the region. It is important to consider the right to obtain advantages considering the belonging of geological origin associated with the American Continent. Additionally, possible environmental impacts that may occur as a consequence of mineral extraction in the region.

Keywords: Bathymetry; Rio Grande Submarine Mineral Province; Subsea Mining; Topex 19.1 model

1. Introduction

The Rio Grande Submarine Mineral Province is a mountain range that covers approximately 3,000 square kilometres at the bottom of the Atlantic Ocean. It is located 1,500 kilometres off the Brazilian coast and contains a wealth of rare minerals and chemical elements [1].

Baima (2018) [2] states that the province is not under national jurisdiction, but is of significant interest to Brazil. In 2009, the Brazilian Geological Service, in partnership with the Brazilian Navy, mapped the ocean floor of this region, revealing the dimensions and complexity of this great elevation.

The area contains several polymetallic nodules, averaging 10 centimeters, as well as numerous areas full of these nodules. The constitution of the material is primarily composed of iron and manganese, with other chemical elements such as tellurium, cobalt, and selenium also present and relatively easy to extract. These ores, however, are typically found at depths ranging from 1 km to 5 km [1].

Baima (2018) [2] analysed collected rocks and found that they share characteristics with rocks from the continent. Therefore, it is currently interpreted that this province was once part of a portion of the ancient supercontinent of Gondwana that became submerged during the separation of South America and Africa around 130 million years ago.

For many years, mining these deposits has been considered unfeasible due to the engineering challenges and high costs associated with it. However, with the increase in offshore oil operations, such as in the case of Pre-Salt, there has been significant technological development that allows for exploration at great depths [3].

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According to Freire (2015) [1], mining, in general, has a major environmental impact. Additionally, the marine ecosystem is very fragile and does not recover quickly. To make the exploitation of the Rio Grande Submarine Mineral Province viable, numerous studies are required.

Bathymetry is a branch of hydrography that determines the water depth for specific geographical coordinates. The term Bathmeter means the measurement (metron) of depth (bathus) [4].

Like this, the objective of this project is to create an ocean depth map of the Rio Grande Submarine Mineral Province using bathymetry data from the Topex 19.1 model. The resulting map will enhance our understanding of the region's sea depth and may contribute to other studies such as environmental and logistical ones.

2. Material and Methods

The origin of the Rio Grande Submarine Mineral Province was due to excessive volcanic activity between 100 and 80 Ma in a segment of the southern Meso-Atlantic Dorsal. In 2019, German researchers conducted an expedition to the Rio Grande Submarine Mineral Province. Preliminary results support the volcanic origin hypothesis. The P-wave velocity patterns of the Rio Grande Submarine Mineral Province crust resemble those of ocean shelves and dorsal seabeds more than continental crust and plates. The Rio Grande Submarine Mineral Province model was compared with other Earth features, and the results show similarities between the Rio Grande Submarine Mineral Province and the Walvis Chain [5]. Currently, the most widely accepted theory for the origin of the Rio Grande Submarine Mineral Province is associated with continental break-up and magmatic events, which occurred in large igneous provinces conjugated in the South Atlantic. The Rio Grande Submarine Mineral Province and the Walvis Chain are the two parts that correlate with the open axis of the ocean. The initial phases are believed to have been the massive eruption of basaltic rocks into the continental lithosphere during the Mesozoic era. The subsequent phase resulted in the formation of the Rio Grande Submarine Mineral Province and the Walvis Chain as the South Atlantic opened up [6] [7].

The Rio Grande Submarine Mineral Province is situated in the South Atlantic Ocean, approximately 1,500 km from the southeastern Brazilian coast, and is demarcated by Rio Grande and 35.3°S oceanic fracture zones. Together with the Walvis Chain on the African oceanic plate, it is one of the most prominent bathymetric features in the South Atlantic Ocean basins [8]. Fig. 1 displays the location of the Rio Grande and the Walvis Chain on the map.

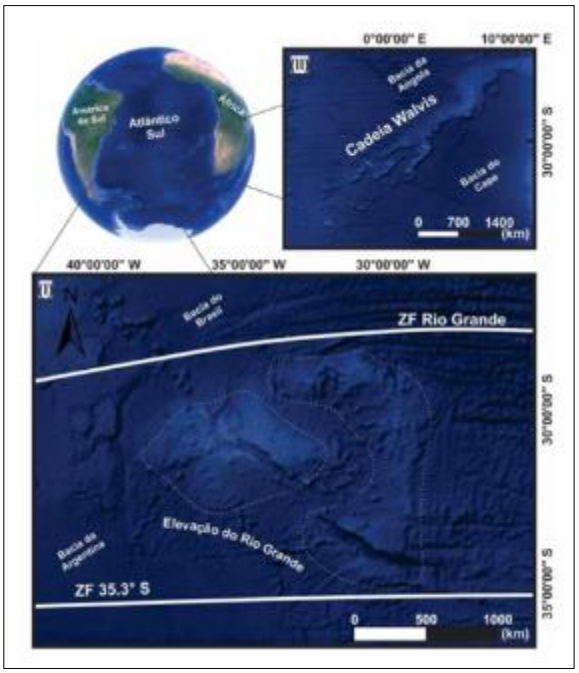

Figure 1 South Atlantic map with the location of Rio Grande and the Walvis Chain [8]

The Rio Grande Submarine Mineral Province is situated between latitudes 28° and 34°S and longitudes 28° and 40°W. It is defined by the Rio Grande and 35.3°S oceanic fracture zones and is located near the Brazilian sedimentary basins of Santos and Pelotas on the south and southeast Brazilian margins, via the ocean basins of Argentina and Brazil. Fig. 2

shows more prominently the location of the Rio Grande Rise and features on the margin of the Brazilian sedimentary basins [9].

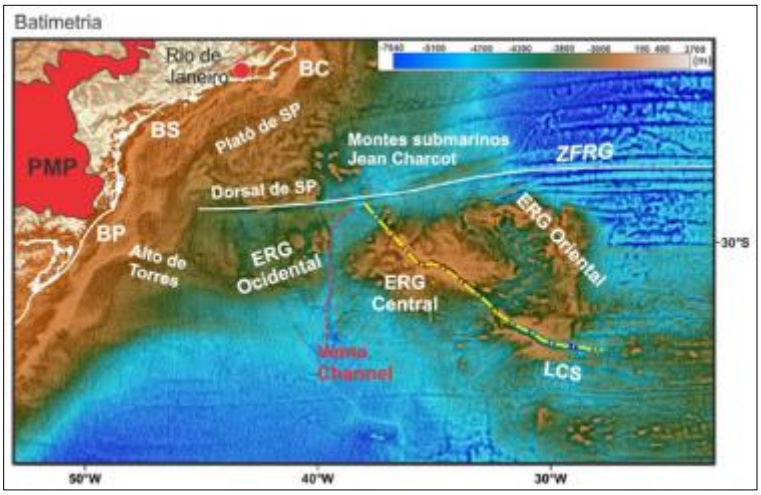

Figure 2 Map indicating the location of the Rio Grande Submarine Mineral Province and the most important features of the adjacent Brazilian margin, including the Pelotas Basin (BP), Santos Basin (BS), Campos Basin (BC), and Cruzeiro do Sul Lineament (CSL) [9]

In 2015, the International Seabed Authority (ISA) granted Companhia de Pesquisa de Recursos Minerais (CPRM), a company linked to the Ministry of Mines and Energy, the right to investigate the economic potential of iron and manganese crusts on rocks in the uplift for 15 years. CPRM conducted a preliminary study and identified 9,729 km^2 with reflection of electromagnetic radiation [10].

The continental shelves identified are primarily covered by carbonate, siliciclastic, and mixed sediments. These sediments originate from various sources, including terrigenous materials transported by rivers, biogenic compounds from marine organisms, and antigenic minerals resulting from salt precipitation from seawater [8].

Researchers from the Oceanographic Institute of the University of São Paulo (USP) have discovered bacteria responsible for a biomineralisation process that forms underwater reserves of cobalt, nickel, molybdenum, niobium, platinum, titanium, and tellurium [11].

The distribution and preservation of iron crusts and manganese mineral deposits, which are rich in metals critical to the electronics industry and the production of new technologies, were also observed. Research indicates abundance of two elements, cobalt and tellurium, which are crucial in the production of rechargeable batteries for electric vehicles and high-efficiency solar energy respectively [8].

We use satellite data to conduct bathymetric studies, which involve creating of 2D and 3D maps of the region. The first step in this process is to determine the geographical coordinates of the area of interest, as bathymetry is a measure of the depth of the sea at a given point defined by these coordinates.

This area was chosen to encompass the entire relief in the Rio Grande Submarine Mineral Province and surrounding geological formations, providing a clear reference for the location of the study. The study area was defined by selecting longitudinal coordinates ranging from 40°W to 25°W and latitudinal coordinates ranging from 35°S to 25°S which allowed you to view details of the region.

3. Results and Discussion

After defining the study region, satellite data from the topex 19.1 model was used specifying the depth of the points within the chosen range. The estimated depth values for the intermediate points were calculated through interpolation by minimum curvature in the Oasis Montaj software, then the maps below were constructed.

The first map was constructed has a two-dimensional structure, as can be seen in Fig. 3.

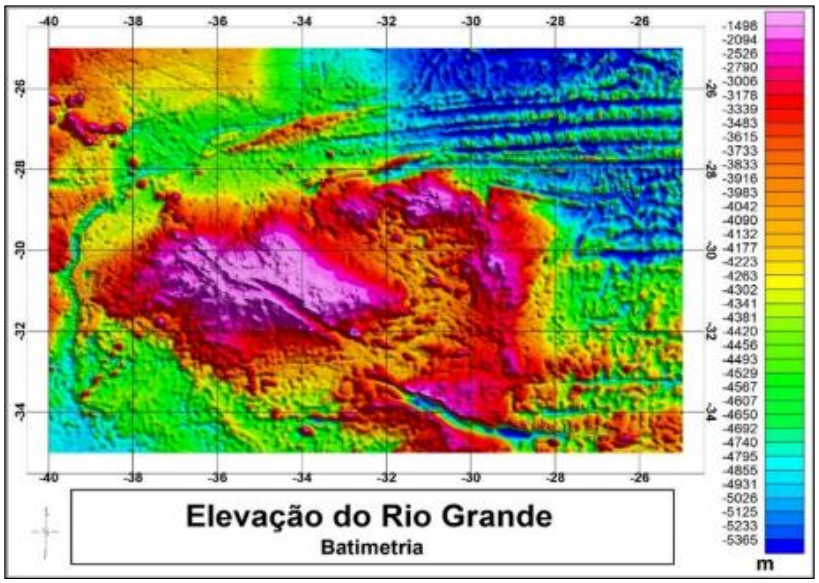

Figure 3 Map of the Rio Grande Submarine Mineral Province in two dimensions

The second map required a series of adjustments so that it could be viewed in three dimensions in a way that was better understood, as can be seen in Fig. 4.

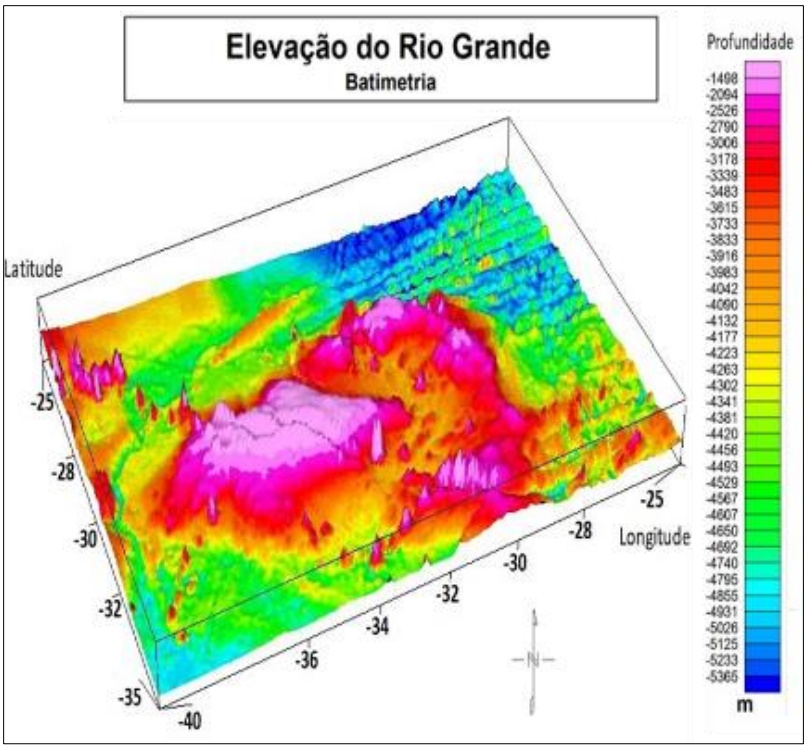

Figure 4 Three-dimensional map of the Rio Grande Submarine Mineral Province

The mapped region provides a reference to the south-east of the Brazilian coast in the top and middle corner of the map. The region with the lowest depth, reaching only around 1,500 meters, is represented in light magenta, indicating the highest elevation. The central and most prominent area of the two-dimensional map of the Rio Grande Rise Region is depicted in Figure 3.

Formations with a depth of around 3,500 meters, represented in red, predominate around the region with the highest elevation shown in Figure 1. These formations are bordered by deeper areas whose colours gradually vary from orange to yellow, light green, light blue and dark blue, indicating depths of up to 5,365 meters around the Rio Grande Submarine

Mineral Province. Figure 4 displays the same characteristics identified on the two-dimensional map, providing a clearer understanding of the elevations and spatial location on a three-dimensional map.

4. Conclusion

The Rio Grande Submarine Mineral Province is located in the South Atlantic Ocean, approximately 1,200 km off the Brazilian coast. The region has an area of more than 900,000 km^2, with depths ranging between 600 and 4,000 meters, as identified on maps.

The Rio Grande Submarine Mineral Province has great potential for exploring mineral resources, such as cobalt, nickel and rare earths. It is worth highlighting that the region was recently incorporated into the Brazilian Continental Platform, expanding Brazil's maritime territory and its rights to explore the region's natural resources.

Two bathymetry maps were produced using the Topex 19.1 model to cover the area of interest located between longitudinal coordinates ranging from 40°W to 25°W and latitudinal coordinates ranging from 35°S to 25°S, showing details of the region.

At long last, the Rio Grande Submarine Mineral Province presents considerable technical and environmental challenges. It is necessary to ensure that exploration is carried out in a sustainable way, minimizing impacts on the marine environment.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflict of interest.

Authors diclaration

All authors have read and approved the final version of this manuscript.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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