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Seismic Characterization of the Brazilian Equatorial Margin: Historical Assessment and Monitoring Network Expansion

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The Brazilian Equatorial Margin is a geologically complex and resource-rich region, characterized by its sedimentary basins and significant hydrocarbon potential. Its importance spans multiple sectors, serving as a critical area for scientific research, energy exploration, and socioeconomic development. The region's offshore basins contain vast oil and gas reserves, positioning Brazil as a key in the global energy market. However, the margin's geological complexity requires continuous seismological monitoring to ensure safe exploration. Expanding the seismic monitoring network across the region would not only improve risk assessment and warning systems but also optimize resource exploration by providing real-time data on subsurface dynamics. This enhanced monitoring infrastructure would mitigate risks in offshore operations, protect marine ecosystems, and support long-term socioeconomic growth.

For this study, we compiled and analyzed historical seismic data from public platforms: the U.S. Geological Survey (USGS), EarthScope Consortium (SAGE), International Seismological Centre (ISC), the University of Brasília Seismological Observatory (Sis/UnB) and the Brazilian Seismographic Network (RSBR). Additionally, we employed PyWEED, an open-source tool integrated with the ObsPy ecosystem, specifically designed for seismic data search, visualization, and analysis. Our search criteria included events with magnitudes between 0 and 8 mb (ranging from microseisms to major earthquakes) from 01/01/1930 to 01/05/2025, covering the region's known seismic history. The results revealed 236 recorded seismic events in the region, with magnitudes ranging from 1.0 mb to 5.7 mb. On the continental shelf, we observed concentrated seismic activity along basin edges, while in the oceanic portion, we identified a clear association between seismic events and slope regions with submarine canyon systems. Three states stood out in terms of event frequency: Ceará, with 82 earthquakes (34.74%), Rio Grande do Norte, with 67 earthquakes (28.38%) and Maranhão, with 49 earthquakes (20.76%). The remaining events (16.12%) were distributed among Amapá, Piauí and Pará. Regarding sedimentary basins, the Ceará Basin recorded the highest number of earthquakes (41), followed by the Potiguar Basin (36) and the Amazon River Mouth Basin (24).

These findings suggest that the Brazilian Equatorial Margin exhibits more intense seismic activity than traditionally assumed. The occurrence of events such as the 5.7 mb earthquake indicates the region's potential for generating significant seismic activity. Spatial comparison between event distribution and RSBR station locations reveals critical gaps in monitoring coverage. These deficiencies prevent accurate characterization of regional seismicity and a proper understanding of the underlying mechanisms, leaving us unable to establish a true seismic identity for the region. The results highlight the urgent need to expand the seismographic network, emphasizing the installation of ocean-bottom stations and increased equipment density in critical coastal zones. These measures would not only advance scientific understanding of regional seismicity but also enhance safety for resource exploration operations and coastal communities, ensuring social, economic, and environmental security. Thus, this study aims to advance this research field by raising awareness about the need to expand monitoring efforts in the area.