2024 International Nuclear Atlantic Conference – INAC 2024
Escola de Guerra Naval, Rio de Janeiro, RJ, May 6 - 10, 2024

ISBN: 978-65-594-1256-3

Geological study of sediments from the Negro and Solimões rivers

P. R. Carvalho[1], C. S. Munita[1], R. B. Ribeiro[1], E. A. A. Soares[2], R. R. P. Tarabossi[2]

[1]*patricia.ramos.carvalho@gmail.com,*
Instituto de Pesquisas Energéticas e Nucleares – IPEN/CNEN
Rua do Matão, Travessa R, 400 – Butantã, São Paulo – SP
[2] *easoares@ufam.edu.br,*
Universidade Federal do Amazonas – Departamento de Geociências. Avenida General Rodrigo Octavio Jordão Ramos, 6200 – Coroado I, Manaus - AM

1. Introduction

The Amazon is the largest and most complex ecosystem on the planet, and its entire evolutionary history was influenced by the dynamics of the Amazon River System. The geomorphological features of sections of the Solimões-Amazonas River have been studied using images from remote sensors, combined with multitemporal analysis data [1, 2, 3, 4]. Part of the sedimentary deposits is confined in four tectonic depressions that occurred during the Neomiocene-Pliocene, called hemigrábens of Paraná do Ariaú (GPA), Cacau do Pereira (GCP), Cachoeira do Castanho (GCC) and Lago do Miriti (GLM) [2, 5].
The objective of this work was to characterize 59 sediment samples from the confluence region of the Negro and Solimões Rivers, Central Amazon using the instrumental neutron activation analysis (INAA). The experimental results obtained had the purpose of obtaining a preliminary database with the physical and chemical characteristics of sediments.

2. Methodology

The samples from seven outcrops located in the region, were collected vertically by removing material at intervals of approximately 20 cm from the base to the top and were analyzed by INAA [6]. Two series of measurements were carried out using a Canberra hyperpure Ge detector, with a resolution of 1.90 keV at the 1332 keV peak of ^{60}Co, an S - 100 multichannel analyzer with 8192 channels and associated electronics. After 6-7 days of decay, the following were determined: K, La, Lu, Na, Nd, Sm, U and Yb, and after 25-30 days of decay: Ce, Co, Cr, Cs, Eu, Fe, Hf, Rb, Sc, Ta, Tb, Th and Zn. The gamma radiation spectra were analyzed using the Genie - 2000 NAA Processing Procedure program, developed by Canberra [7].

3. Results and Discussion

The analytical procedure used was carried out through quality control with the study of six samples of the reference material IAEA - Soil 7. The values found were compared with the recommended values. The precision of the elements Lu, Sc, Ce, Co, Cr, Cs, Eu, Fe, La, Na and Th the was ≤ 10%.

Geochemical studies of trace elements in sedimentary samples are useful, in particular, rare earths, because are considered immobile during weathering, transport, and sedimentation [8]. With the purpose to study the similarities/dissimilarities between the samples, the results were transformed to $\log_{10}$ [9] and submitted for cluster analysis using Ward's method and Squared Euclidean distance [10]. The discriminant analysis was applied and the results showed the separation in three groups very well defined, confirming the cluster analysis. To minimize the effect of variation in the elemental concentrations of Sc, Co, Cr, Cs, Fe, Na, Ce, Th, La, Eu, Yb and Lu due to their natural abundance in sedimentary samples, the results were compared and normalized with the North American Shale Composite (NASC) [11].

The normalized elemental standards for NASC considering the minimum and maximum concentration for all samples shows the average. These data revealed elemental distribution with similar patterns between the groups analyzed. The graphs also show differences in behavior when individual elements are compared between the three groups. This variation is related to deposition in environments that have lower salinity in relation to the concentration of marine sediment used as a standard. In general, elements are removed due to changes in the physicochemical conditions within the estuary, which is mainly due to coagulation and colloid formation under the influence of saline waters [12, 13, 14, 15].

Cesium is one of the least mobile elements in natural environments. Its occurrence in the continental crust is 1.9 mg/kg, and in seawater it is 0.5 mg/kg. This element adheres very well to soil and sediments, being 280 times better than interstitial water. Thus, a certain amount of Cs occurs in sediments, and its distribution is expected to decrease with a seaward shift in depositional environments. The higher concentration of Cs in the deposits indicates a lower marine influence in the study area, which agrees with this general statement.

The highest concentration of Cr in the groups was expected, as the occurrence of this element is favored in environments influenced by freshwater due to its preferential association with organic and colloidal material. Under low salinity in central fluvial to estuarine areas, dissolved trivalent and hexavalent Cr is flocculated or adsorbed on these particulate materials [15].

Based on the geochemical interpretation of the results the three depressions can be associated with the continuous tilting of the floors towards E-NE, which enabled the deposition of river terraces from the migration of secondary channels, it is in accordance with geochronological data in previous studies [2].

4. Conclusions

In this work, 59 sediment samples were analyzed from the region of the confluence area of the Negro and Solimões Rivers. The samples were analyzed by INAA, and the results were subjected to cluster and discriminate analysis, revealing the formation of three groups with similar chemical composition.

For the samples studied, the concentration patterns of some elements relative to the NASC vary significantly. The differences are related to the geochemical conditions inherent in the individual depositional environments. This is observed by the clustering of samples in the dendrogram, as well as in the discriminant plot, where the deposits indicate that the groups are not geochemically related.

The graph of the minimum and maximum mass fractions of the elements in relation to the NASC follows a general pattern like that of the variation of the upper continental crust. The increased concentration of La, Ce and Eu relative to NASC is the evidence of deposition in a coastal to fluvial environment.

References

[1] M. S. Passos; E. A. A. Soares, "Análise multitemporal do sistema fluvial Solimões-Amazonas entre os tributários Purus e Negro, Amazônia Ocidental, Brasil" *Geologia USP. Série Científica*, vol. 17, pp. 61-74 (2017).

[2] E. A. A. Soares, S. H. Tatumi, C. Riccomini, "OSL age determinations of Pleistocene fluvial deposits in Central Amazonia", *Academia Brasileira de Ciências*, v. 82(3), pp. 691-699 (2010).

[3] E. S. Gonçalves Júnior, E. A. A. Soares, S. H. Tatumi, M. Yee, J. C. R. Mittani, "Pleistocene-Holocene sedimentation of Solimões Amazon fluvial system between the tributaries Negro and Madeira, Central Amazon", *Brazilian Journal of Geology*, vol. 46 (2), pp. 167-180 (2017).

[4] Carta Geológica do Brasil ao Milionésimo, *Geologia e Recursos Minerais do Estado do Amazonas, Programa Geologia do Brasil*, Ministério de Minas e Energia/CPRM/Serviço Geológico do Brasil, Brasília & Brasil (2006).

[5] J. L. Guyot, J. M. Jouanneau, L. Soares, G. R. Boaventura, N. Maillet, C. Lagane, "Clay mineral composition of river sediments in the Amazon Basin", *Catena*, vol. 71(2), pp. 340-356 (2007).

[6] J. P. Ybert, M. L. Salgado-Labouriau, O. M. Barth, M. L. Lorscheitter, M. A. Barros, S. A. M. Chaves, C. F. P. Luz, M. Ribeiro, R. Scheel, K. R. F. Vicentini, "Sugestão para padronização da metodologia empregada para estudos palinológicos do Quaternário", *Revista do Instituto de Geologia*, vol. 13, pp. 47–49 (1992).

[7] R. J. Speakman, M. Glascock. "Acknowledging fifty years of neutron activation analysis in Archaeology", *Archaeometry*, vol. 49, pp. 179-183 (2007).

[8] S. M. McLennnan, "REE in sedimentary rocks: influence of provenance and sedimentary processes", *Rev. Min.*, vol. 21, pp. 170-199, (1989).

[9] M. J. Baxter, I. C. "Freestone. Log-ratio Compositional Data Analysis in Archaeometry", *Archaeometry*, vol. 48(3), pp. 511-531 (2006).

[10] R. Hazenfratz, C. S. Munita, M. Glascock, E. G. Neves, "Study of exchange networks between two Amazon archaeological sites by INAA", *Journal of Radionalytical and Nuclear Chemistry*, vol. 309, pp. 195-205 (2016).

[11] S. R. Taylor, S. M. McLennan, *The Continental Crust: its Composition and Evolution*, Blackwell Scientific Publications, Oxford & United Kingdom (1985).

[12] E. J. Hoyle, H. Elderfeld, A. Gledhill, M. Greaves, "The behavior of the rare earth elements during

mixing of river and sea waters", *Geochim. Cosmochim. Acta,* vol. 48, pp. 143-149 (1984).

[13] S. L. Goldstein, S. B. Jacobsen, "Rare earth elements in river waters", *Earth Planet. Sci. Lett.,* vol. 89, pp. 35-47 (1988).

[14] E. R. Sholkovitz, "The geochemistry of rare earth elements in the Amazon River estuary", *Geochim. Cosmochim. Acta,* vol. 57, pp. 2181-2190 (1993).

[15] L. M. Mayer, L. L. Schick, C. A. Chang, "Incorporation of trivalent chromium into riverine and estuarine colloidal material", *Geochim. Cosmochim. Acta,* vol. 48, pp. 1717–1722 (1984).