CPRM
Geological Survey of Brazil

TECHNICAL REPORT

N. 4
Brasília, Brazil, March 2016
ISSN: 2448-2242
DOI:

New sedimentary phosphate occurrences in the Parecis Basin, State of Rondônia, Brazil: results, perspectives and preliminary interpretations

Rodrigo Rodrigues Adorno[1] (*rodrigo.adorno@cprm.gov.br*)
Leandro Guimarães da Silva[1] (*leandro.guimaraes@cprm.gov.br*)
Tiago Buch[1] (*tiago.buch@cprm.gov.br*)
Ruy Benedito Calliari Bahia[1] (*ruy.bahia@cprm.gov.br*)
Marcelo Esteves Almeida[2] (*marcelo.esteves@cprm.gov.br*)

[1]CPRM – Geological Survey of Brazil, REPO - Porto Velho (RO) Office
[2]CPRM – Geological Survey of Brazil, Special Projects and Strategic Minerals Division - Manaus (AM)

Reference: CPRM – Geological Survey of Brazil website: www.cprm.gov.br / Geologia em Evidência/RECURSOS MINERAIS/Informe Técnico – CPRM/Edições Anteriores /Informe 4 (03/2016): Ocorrências inéditas de fosfato sedimentar na Bacia dos Parecis em Rondônia: resultados, perspectivas e interpretações preliminares.

Abstract

We present preliminary results of a survey conducted in the westernmost portion of the Parecis Basin, which shows new occurrences of sedimentary phosphate limited to specific stratigraphic intervals. Outcrop and core descriptions from drill hole PB-01-RO coupled with Portable X-ray Fluorescence analyses allowed the identification of important phosphate bearing calciferous rhythmite strata with grades in excess of 20% P_2O_5. We have also achieved considerable improvement in the understanding of the stratigraphic stacking of this part of the basin, as well as in the understanding of environmentally favorable settings for primary (sedimentary) and secondary (hypogenic) phosphate accumulation. Stacking pattern of the lithofacies and their associations is related to a typical marine unit deposited in platform influenced by storm waves and turbidity currents, with close relation to phosphate accumulation.

Keywords: Sedimentary phosphate, Parecis Basin, Stratigraphy.

INTRODUCTION

New sedimentary phosphate occurrences were identified during execution of the project Evaluation of phosphate potential in Brazil: Western Parecis Basin/Rondônia, developed by CPRM–Geological Survey of Brazil/Porto Velho Office. These occurrences, identified in outcrops and drill cores, are located in the southeastern region of the State of Rondônia, ~450 km from the state capital Porto Velho (Figure 1).

This report presents the record and preliminary interpretation of these new occurrences in the Parecis Basin. The scarcity of basic stratigraphic works on this basin limits the understanding of its sedimentary stacking, which is far from consensual. It is known that sedimentary phosphate deposits are generally controlled by paleo-environmental conditions during deposition, and that they can be submitted to secondary processes of reconcentration (e.g., Hiatt et al., 2015 and references therein).

METHODOLOGY

This work involved bibliographic data integration, fieldwork in the Parecis Basin and description of the drill hole PB-01-RO, available at the Porto Velho Office of CPRM – Geological Survey of Brazil.

Tests of rock reaction to the ammonium molybdate + nitric acid were undertaken in outcrops. The samples that showed positive results (yellow color after reaction; Fig. 2) were analysed by portable x-ray fluorescence (pXRF), Olympus Delta X 6000C model, with detection limit of 0.1% P_2O_5. Reference samples were analysed to control the equipment accuracy, including blank and certified standard samples.

The outcrops considered strategic for the lithofacies definition were sampled for analyses by lithogeochemistry, X-Ray diffraction and petrography. The samples showing whole rock phosphorus content higher than 3% were defined as of interest.

The following step of the project included research on new targets favourable to phosphate occurrence in the Pimenta Bueno and Colorado grabens. In this step, only outcrops with topographic key features (scarps, wide openings, canyons, etc.) were studied, in order to observe the stacking of identified sedimentary facies. We built lithologic profiles with identification of sedimentary structures, systematic rock sampling and in situ whole rock pXRF analyses.

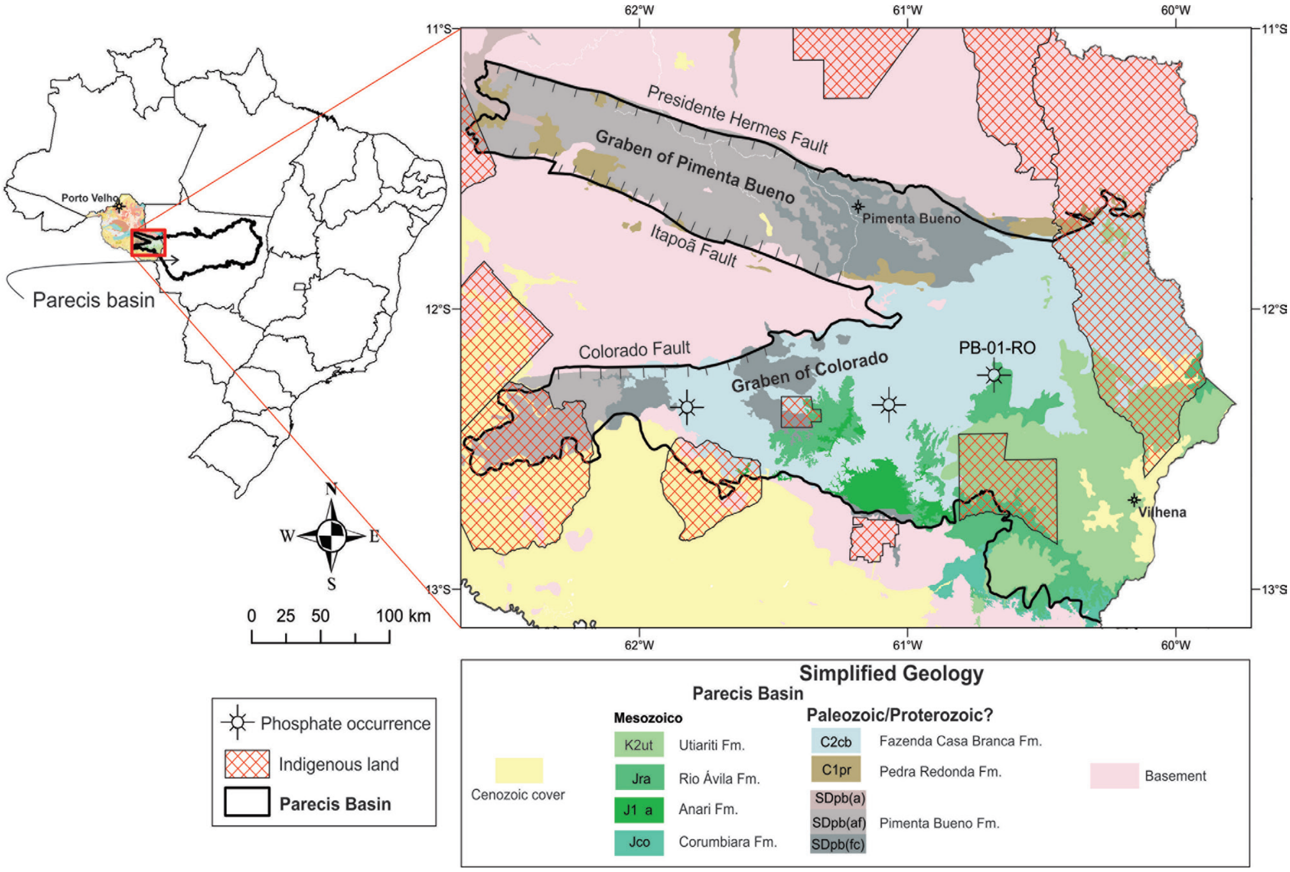

Figure 1: *Geological map of the Rondônia Sub-Basin with location of the P_2O_5 occurrences and drill hole PB-01-RO.*

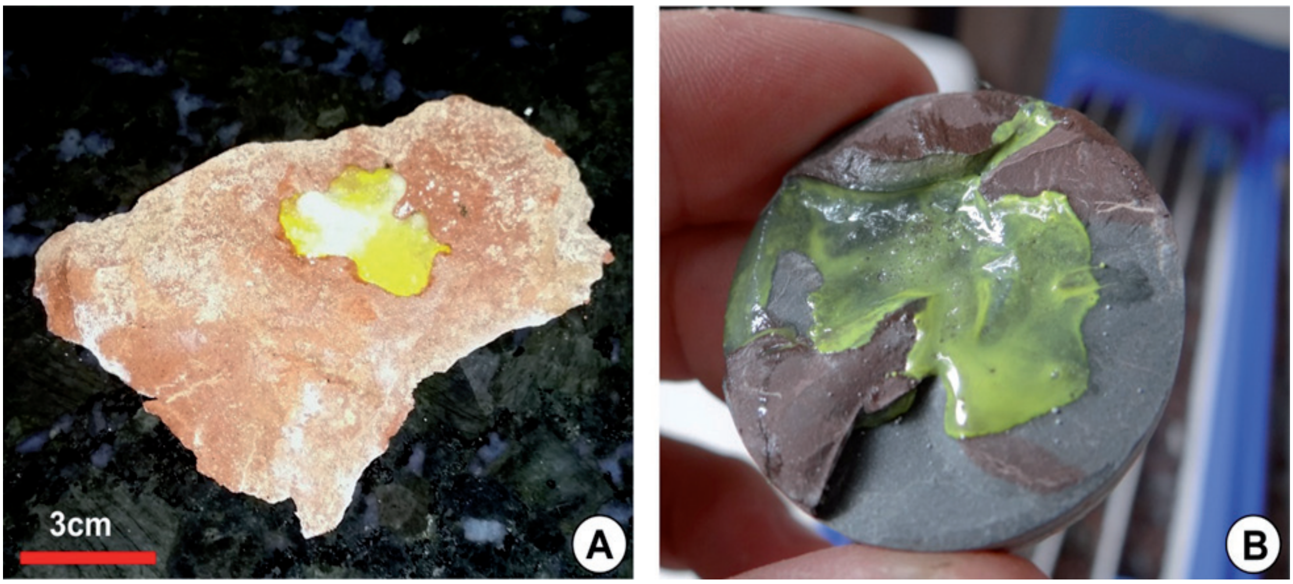

Figure 2: *Results of in situ reactions to ammonium molybdate. A) Cachoeira do Samuel sample, Line 26. B) Drill hole PB-01-RO core at 825 m. Both samples contain ~3% P_2O_5.*

GEOLOGICAL SETTING

The Parecis Basin has a surface area of ~500,000 km^2, which set it among the major Brazilian intracratonic basins. It is located at Middle West and North regions of Brazil, in the states of Rondônia and Mato Grosso, between the Solimões, Alto Tapajós and Paraná sedimentary basins. The maximum thickness of the Parecis Basin is estimated into 7,000 m (Siqueira, 1989).

Airborne geophysical data allow the subdivision of the Parecis Basin into three sub-basins (Figure 3): 1) Xingu Sub-Basin; 2) Parecis low gravimetric or Juruena Sub-Basin; and 3) Rondônia Tectonic Trough or Rondônia Sub-Basin (Bahia, 2007).

The Parecis Basin tectonosedimentary evolution was initiated with filling of an intracontinental rift, followed by deposition on sag-type basin (Siqueira, 1989; Teixeira, 2005; Bahia et al., 2006). Seven depositional sequences are described: 1) Cacoal Formation; 2) Paraná Group; 3) Pimenta Bueno Formation; 4) Fazenda da Casa Branca Formation; 5) Rio Ávila Formation; 6) Parecis Group; and 7) Tertiary sedimentary covers (Bahia et al., 2006).

The Pimenta Bueno Formation (Silurian-Devonian) is constituted by thick package of siliciclastic and carbonate rocks that crop out at the Pimenta Bueno and Colorado grabens. The Formation is unconformably (discordant and erosional contact) covered by 80 to 100 m of ocher yellow brittle sandstone of the Fazenda da Casa Branca Formation, of probable Carboniferous-Permian age (Leal et al., 1978). This sandstone shows channelled cross-bedding, locally conglomeratic layers, and is interpreted to be formed in braided fluvial system.

During the Mesozoic there was deposition of eolian sandstones of the Rio Ávila Formation and the Parecis Group, which cover unconformably all sequences above cited.

PRELIMINARY RESULTS AND DISCUSSION

The data showed in this report are from outcrops and drill hole PB-01-RO cores, all located at Rondônia Sub-Basin (Table 1). The hole PB-01-RO was drilled by CPRM in 1981, during the development of the Energetic Coal Prospection in Rondônia Project, down to 941 m without reaching the basement (Soeiro et al., 1981). The first 105 m are constituted by brittle sandstones attributed to the Fazenda da Casa Grande Formation, which covers siliciclastic and carbonate sedimentary rocks attributed to the Pimenta Bueno Formation.

The Pimenta Bueno Formation sedimentary facies containing phosphate, identified up to now, comprise: 1) brown siltstone with plane-parallel lamination; 2) red siltstone with convolute folds (gutter casts) and syneresis cracks; 3) red intraclastic sandstone (intraformational breccia); and 4) red calciferous rhythmite with turbogliphs (flute marks) and hummocky cross bedding. This facies association is compatible with shallow sea environment in neritic zone above the base level of storm waves, with locally associated turbidity current.

Contents of ~1-5% P_2O_5 were measured on samples of calciferous rhythmite cropping out at the margin of the Kapa 56 road, Chupinguaia municipality (State of Rondônia), outcrop CM-74. Similar contents were measured on calciferous rhythmite at Cachoeira do Samuel, located at the P26 line road, Alto Alegre dos Parecis municipality (State of Rondônia), outcrop RO-133 (Table 1).

In addition to the phosphate occurrences at the cited outcrops, spaced peaks with contents between 2% and 5% P_2O_5 were observed in the drill hole PB-01-RO (Table 1), with measurements made on 1 m interval (Figure 5). In depths between 270-320 m, punctual grades of 8-20% P_2O_5 have been identified by pXRF, whereas whole-rock geoche-

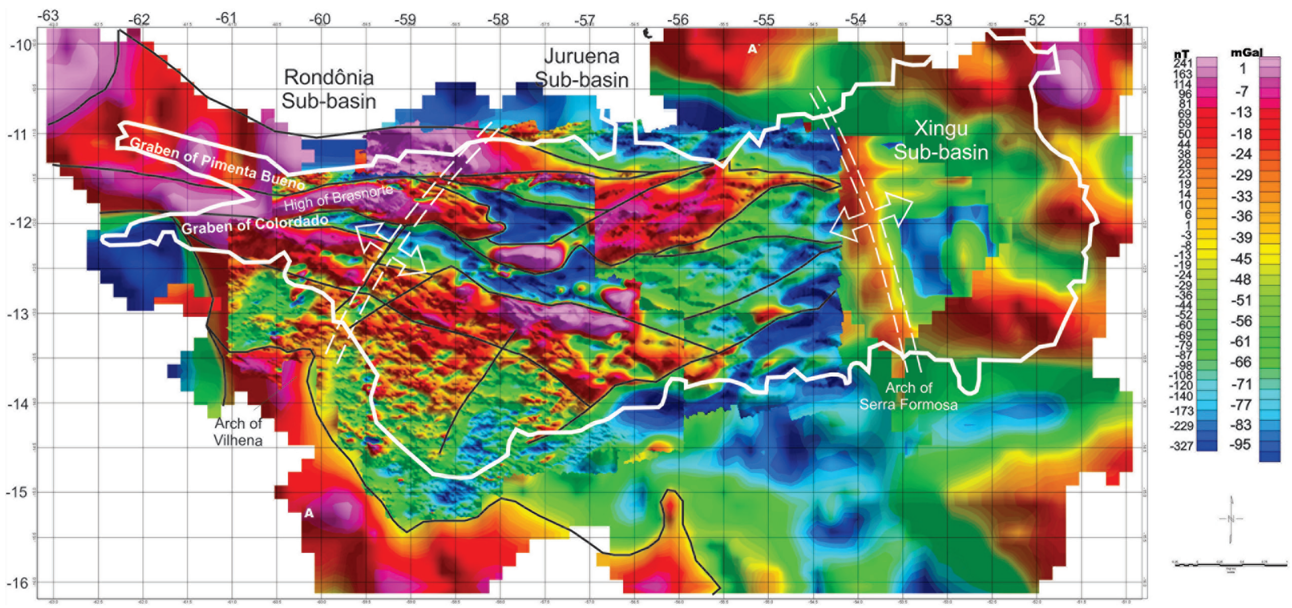

Figure 3: *Aeromagnetometric map showing integration of magnetic and gravity linements of the Parecis Basin (adapted from Bahia, 2007). The white line marks the basin limit; white stars represent phosphate occurrence.*

mistry identified 5% P_2O_5 in the same samples. This interval is characterized by reddish calciferous siltstones with moderate to intense rock cementation, brecciating and veining (Figure 4).

The geochemical behavior of the 270-320 m interval of drill hole PB-01-RO is characterized by low silica contents relative to adjacent intervals, and high Mg contents. Phosphorus peaks in this interval are coincident with high Ca and S peaks, and with low Al peaks (Figure 5).

The textural features described as brecciation and veining, occurring in the interval with high phosphate contents, associated to high S, Ca and Mg contents, may indicate hypogenic remobilization and secondary reconcentration of phosphate (Figures 4 and 5).

FINAL REMARKS AND NEXT STEPS

The data obtained up to now are insufficient to draw in depth considerations regarding to economic aspects of the phosphate occurrences. We intend to develop additional studies aiming the detailed characterization of the mineral phases containing phosphorus, the determination of stratigraphic and spatial distribution of metallogenic processes that produced the high P_2O_5 contents found on the 270-320 m interval of drill hole PB-01-RO, and the moderate phosphate contents in rock samples from rhythmite outcrops.

As an expected activity for the next steps of the phosphate project, it is important to carry out detailed mapping of the mineralized horizons, giving priority to localities in which these horizons can be identified at surface.

We hope that the presented results can serve as initial reference for more detailed studies to be carried out by the scientific community and private sector, sponsoring investments for the mineral sector linked to the productive chain of raw materials for agriculture in the State of Rondônia.

Table 1: *Phosphate occurrence locations.*

Outcrop/drill hole	Latitude	Longitude
PB-01-RO	-12.227°	-60.662°
CM-74	-12.385°	-61.030°
RO-133	-12.320°	-61.792°

REFERENCES

BAHIA, R. B. C. **Evolução tectonossedimentar da Bacia dos Parecis - Amazônia**. 2007. 163 p. Tese (Doutorado em Geologia Estrutural e Geotectônica) - Escola de Minas, Universidade Federal de Ouro Preto, Ouro Preto, 2007.

BAHIA, R. B. C. et al. Revisão estratigráfica da Bacia dos Parecis - Amazônia. **Revista Brasileira de Geociências**, v. 36, n. 4, p. 692-703, 2006.

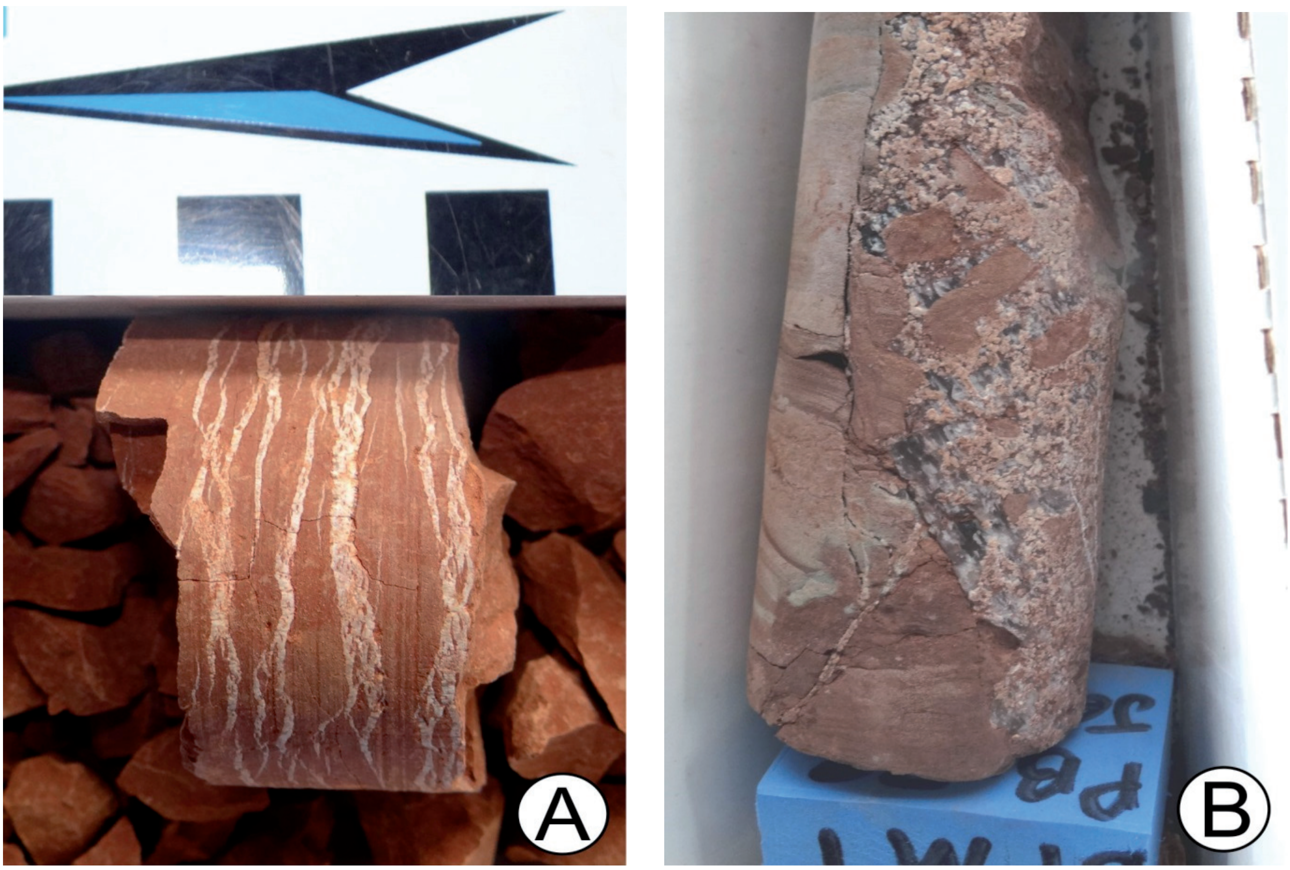

Figure 4: *Drill hole PB-01-RO cores: phosphate-bearing calciferous rhythmite evidencing diagenetic alteration: A) veining (cm-scale); B) brecciation (core width = 5 cm).*

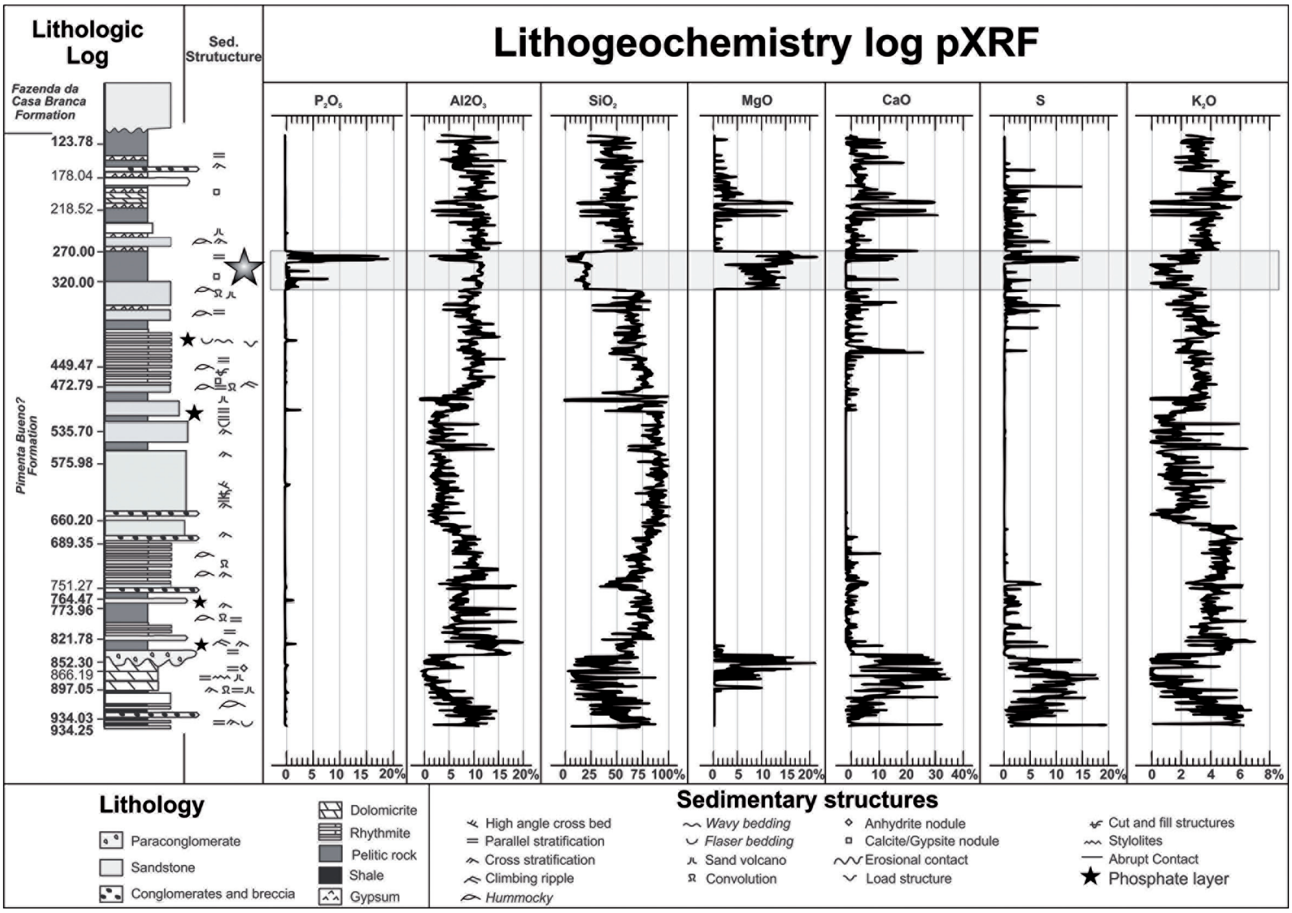

Figure 5*: Drill hole PB-01-RO lithologic profile and pXRF lithogeochemical profiling data (depth in metres).*

BATURIN, G. N. Formation and evolution of phosphorite grains and nodules on the Namibian shelf, from recent to Pleistocene. In: GLENN, C. R.; PRÉVÔT, L.; LUCAS, J. (Eds.). **Marine authigenesis**: from global to microbial. Tulsa: Society for Sedimentary Geology, 2000. p. 185-199. (Special Publications, 66).

GLENN, C. R. et al. Phosphorus and phosphorites: sedimentology and environments of formation. **Eclogae Geologicae Helvetiae**, v. 87, n. 3, p. 747-788, 1994.

GOLDBERG, K. et al. Diagenesis of Paleozoic playa-lake and ephemeral-stream deposits from the Pimenta Bueno Formation, Siluro-Devonian (?) of the Parecis Basin, central Brazil. **Journal of South American Earth Sciences**, v. 32, n. 1, p. 58-74, 2011.

HIATT, E. E.; PUFAHL, P. K.; EDWARDS, C. T. Sedimentary phosphate and associated fossil bacteria in a Paleoproterozoic tidal flat in the 1.85 Ga Michigamme Formation, Michigan, USA. **Sedimentary Geology**, v. 319, p. 24-39, 2015. 7

LEAL, J. W. L. et al. Geologia. In: BRASIL. Departamento Nacional da Produção Mineral. Projeto RADAMBRASIL. **Folha SC.20 Porto Velho**: geologia, geomorfologia, pedologia, vegetação e uso potencial da terra. Rio de Janeiro, 1978. p. 17-184. (Levantamento de Recursos Naturais, 16).

PUFAHL, P. K. Bioelemental sediments. In: JAMES, N. P.; DALRYMPLE, R. W. (Eds.). **Facies models**. 4 ed. Canada: Geological Association of Canada, 2010. p. 477-504. (Geotext, 6).

PUFAHL, P. K.; GRIMM, K. A. Coated phosphate grains: proxy for physical, chemical, and ecological changes in seawater. **Geology**, v. 31, n. 9, p. 801-804, 2003.

SIQUEIRA, L. P. de. Bacia dos Parecis. **Boletim de Geociências da PETROBRAS**, Rio de Janeiro, v. 3, n. 1-2, p. 3-16, jan./jun. 1989.

SOEIRO, R. S. et al. Projeto **Prospecção de Carvão Energético em Rondônia**: relatório final. Porto Velho: CPRM, 1981. 1v.

TEIXEIRA, L. Bacia dos Parecis. **Phoenix**, Aracajú, v. 7, n. 84, dez. 2005.

TECHNICAL REPORT N. 4 (2016)
Brasília, Brazil, March 2016

Serial online publication by CPRM – Geological Survey of Brazil

Available at www.cprm.gov.br

CPRM - Geological Survey of Brazil
SBN – Quadra 02 – Bloco H, Ed. Central Brasília, 1st floor
Brasília - DF - Brazil
CEP: 70040-904
Phone: +55 (61) 2108-8400
Contacts: bibliotecarj@cprm.gov.br
evandro.klein@cprm.gov.br

Bibliographic normalization
Terezinha de Jesus Fôro

Translation
Paulo Henrique M. Varão and Evandro Luiz Klein

Desktop Publishing
Marcelo Henrique Borges Leão
Nelma Fabrícia da P. Ribeiro Botelho