GEOCHEMISTRY AND MINERALOGY OF SEDIMENTS FROM AMAZON WETLANDS

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ABSTRACT
The sedimentary facies, mineralogical and chemical analysis suggest alternation of flooding frequency on wetland sediments with contribution of rocks near the study sites, development of autochthonous and newly formed minerals. In the hinterland wetlands, the morphology followed the natural filling process of an abandoned channel and increase of autochthonous influence with peat and pyrite formation. The coastal wetlands present a typical tidal flat setting with pyrite and iron oxyhydroxides formation during extended flooding and prolonged exposure, respectively, and may be due to the contribution of K^{+} *and* Mg^{2+} *from marine water and their concentration by evaporation or ionic diffusion in the sediment surface, and amorphous* SiO_2 *from diatoms.*

1. INTRODUCTION

Wetlands are environments subject to permanent or periodic inundation long enough to the establishment of hydrophytes and/or the development of hydric substrates. Vegetation development, extended flooding and prolonged waterlogging all influence the diagenetic processes in wetland environment. As a result, some clay minerals swell (e.g. smectite group) thus reducing the permeability of the substrate and consequently the supply of oxygen is depleted, carbon dioxide levels rise and the sediment pH decreases (Henderson & Patrick, 1982). However, studies about geochemical and mineralogical behavior of wetland sediments from Amazon region are still incipient. Therefore, this study aimed to evaluate the mineralogical/chemical composition and possible sources of wetlands sediments from alluvial and tidal flat settings in the Amazon region.

2. MATERIALS AND METHODS

The sediment cores of 1 meter depth were collected from wetlands colonized by herbaceous vegetation (Calçoene - AP; N 2º36’52”, W 50º50’41”), mangrove (Marajó - MJ; S 0º40’26”, W 48º29’37”) and alluvial forests (Marabá - MB; S 5º20’16”; W 49º5’11”) using a Russian Sampler. The MJ and AP site are situated on tidal flats influenced by the Atlantic Ocean. The

AP site is located on an interbank area of a cheniers ridge, the MJ site is found on a supratidal zone and the MB site is a floodplain lake adjacent to the Tocantins River. Facies analysis included descriptions of lithology, color and structures. The identification of minerals was achieved using X-ray powder diffraction by a PANalytical diffractometer model PW 3040. The results were interpreted using X'Pert HighScore 2.1 software with ICDD. The chemical composition was analyzed from a 0.2g sample by ICP-OES following a Lithium metaborate/tetrabortate fusion and dilute nitric digestion on an Acme Analytical Laboratory. Total sulphur (TS) and total organic carbon (TOC) were obtained from a LECO CS-300 combustion analyzer. Using all chemical analysis and stoichiometric calculations, minerals were quantified. The data similarity analysis was performed by Single Linkage and Pearson product-moment correlation coefficient.

3. RESULTS AND DISCUSSION

3.1 Facies Association HF (Herbaceous flat)

Association HF only occurs in the AP core (Figure 1), and presents mud with many herbaceous roots in growth position (facies Mb). SiO_2 and Al_2O_3 are also the most abundant (Figure 1), comprising quartz, diatoms shells and clay minerals (kaolinite). The contents of Al_2O_3, K_2O and MgO, together with the coefficient between Al_2O_3/K_2O (0.98) may be indicative of muscovite and newly formed K-feldspars, despite the relatively weak coefficient between MgO/K_2O (0.35) and Al_2O_3/MgO (0.32). The high contents of Na_2O may be correlated to albite. The slight upward depletion of Na_2O, MgO, CaO, Ba and Sr likely indicates a decrease in sea water influence (Figure 1). The high contents of Fe_2O_3 and weak coefficient between Fe_2O_3/Cr (0.44) and Fe_2O_3/S (-0.04) correspond to iron oxyhydroxides formed during prolonged subaerial exposure. The presence of albite and muscovite also indicate some contribution of Precambrian crystalline rocks from the Guianas Shield found near the coastal plain of the Sate of Amapá State (CPRM, 2010).

3.2 Facies Association MMF (Mangrove/Mixed flat)

This association occurs throughout the MJ core. It consists mud with lenses of rippled sand (facies Hl) that indicate low energy flow with mud deposition from suspension and periodic sand inflows, mud (facies Mb) and sand (facies Sb) with many bioturbation features (Figure 1). The relatively high contents of Al_2O_3 and correlation coefficient between SiO_2/Al_2O_3 (-0.85) corresponds to the contribution of the sand fraction. SiO_2 and Al_2O_3 are the most abundant, and constitute quartz, clay minerals and other siliceous materials. The contents of MgO and K_2O, and the coefficient between Al_2O_3/MgO (0.96), Al_2O_3/K_2O (0.95), MgO/K_2O (0.88), Al_2O_3/Ba (0.88) and Al_2O_3/Sr (0.73) may be correlated to K-feldspar and muscovite. As observed by Costa et al. (2004), the presence of K-feldspar in tidal mud flats is likely related to mineral neoformation. The neoformation of K-feldspar may be due to the contribution of K^+ and Mg^{2+} from marine water and their concentration by evaporation or ionic diffusion in the sediment surface, and amorphous SiO_2 from diatoms.

The contents of Na_2O and coefficient between Al_2O_3/Na_2O (0.64) possibly reveal a partial contribution of albite. In facies Hl, the samples contain higher levels of TOC and TS (Figure

1), and coefficient between Fe_2O_3/S (0.99) and Fe_2O_3/Cr (0.57) suggest a sulphate reduction zone that allowed pyrite formation. Moving upward towards facies Sb, the lower TOC and TS content, coefficients between Fe_2O_3/S (-0.55) and Fe_2O_3/Cr (0.62) may correspond to iron oxyhydroxides derived from the oxidation of pyrite and other clay minerals during prolonged subaerial exposure. The presence of quartz, kaolinite and anatase, and the contents of Fe_2O_3 and TiO_2 suggest weathered products of Barreiras and Post-Barreiras sediments as a partial source to the deposit (e.g. Lima et al., 2008). However, the presence of albite and muscovite indicate the contribution of Precambrian crystalline rocks from the Central Brazil Shield.

3.3. Facies Association COL (Cut-off Lake - upper deposit)

Association COL only occurs in the MB core (Figure 1). The deposit presents massive and cross-laminated sands (facies Sm and Sc), related to relatively low energy flow with current action shaping the bedform. The upper segments consist of laminated mud (facies Ml) and peat material (facies Pt). The contents of SiO_2 decrease from facies Sm to facies Pt and is inversely proportional to Al_2O_3 and TOC (Figure 1), reflecting a higher influence of clay minerals (e.g. kaolinite and illite) and organic matter than quartz/sand fraction. The correlation coefficient between SiO_2/Al_2O_3 (-0.95) reiterates the quartz/clay antagonism. The TiO_2 contents and the coefficient between TiO_2/Nb (0.97) are well correlated with anatase which likely derived from the Itapecuru Group (e.g. Nascimento & Góes 2007), found near the MB site, while Zr/Sc (0.98) may be related to a source of igneous rocks that extends throughout the city of Marabá (CPRM, 2010). High contents of Fe_2O_3, P_2O_5 and TS in the facies Ml and Pt (Figure 1), and the coefficient between Fe_2O_3/S (0.78) and Fe_2O_3/Cr (0.93) may indicate an organic and sulfide zone that promoted the formation of autochthonous authigenics minerals represented by pyrite. Futhermore, P_2O_5, CaO and MgO also increase toward the top of the core and the coefficients between P_2O_5/TOC (0.88), CaO/TOC (0.93), MgO/TOC (0.75) and K_2O/TOC (0.63) indicate a partial correspondence with organic matter, while Al_2O_3/MgO (0.96), Al_2O_3/K_2O (0.85) and P_2O_5/Al_2O_3 (0.90) may suggest the presence of illite and adsorption of phosphorous on clay minerals, respectively.

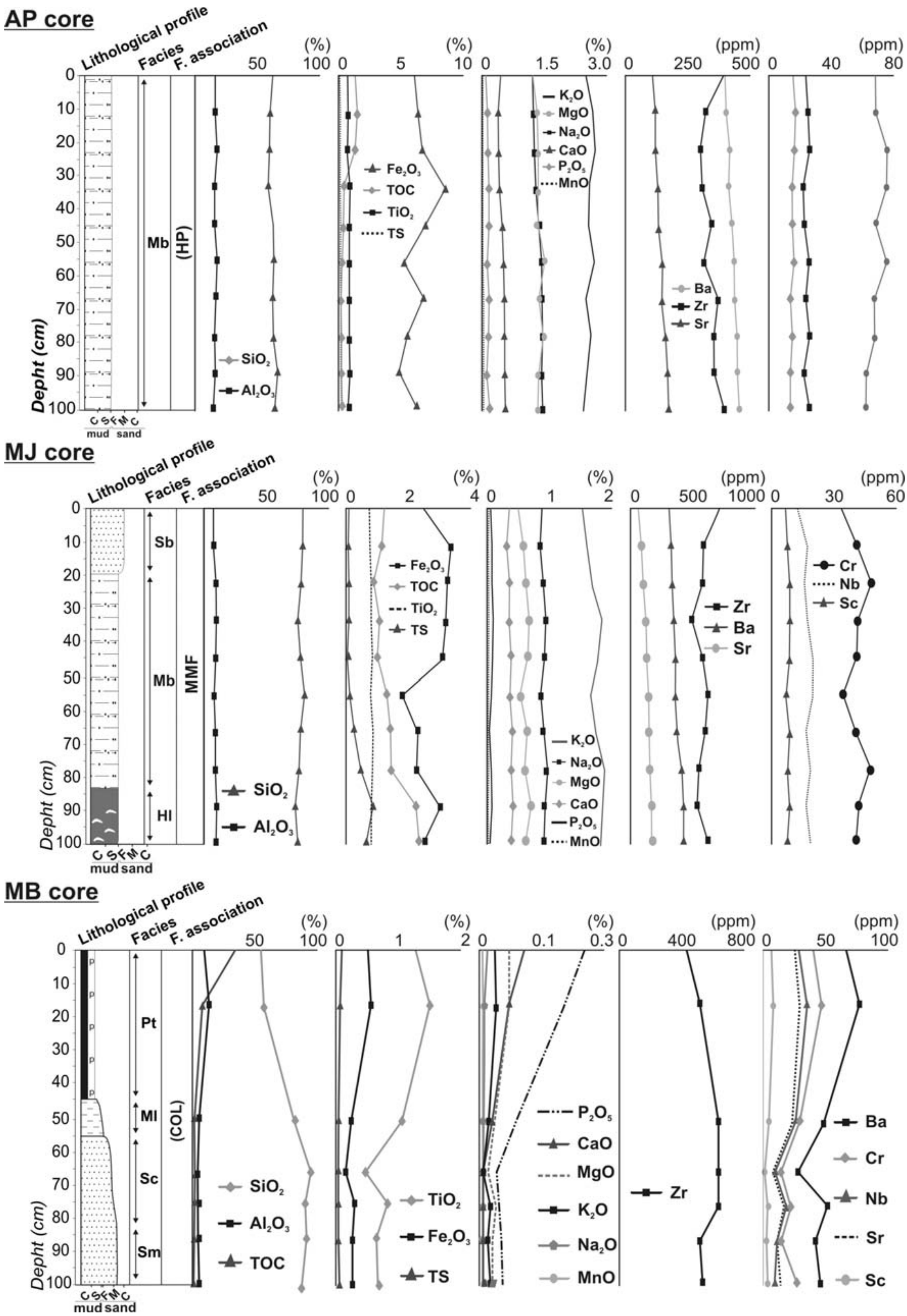

Figure 1: Integrated graphics of sedimentary facies and chemical data of the cores.

4. Conclusion

The sedimentary facies, mineralogical and chemical analysis suggest alternation of flooding and waterlogging frequency on wetland sediments with some contribution of rocks near the study sites, development of autochthonous and newly formed minerals. In the MB site, the morphology followed the natural filling process of an abandoned channel and increase of autochthonous influence with peat and pyrite formation. Considering the coastal wetlands, the MJ and AP sites represent the development of a typical tidal flat setting with pyrite and iron oxyhydroxides formation during extended flooding and prolonged exposure, respectively, and K-feldspar may be due to the contribution of K^+ and Mg^{2+} from marine water and their concentration by evaporation or ionic diffusion in the sediment surface, and amorphous SiO_2 from diatoms.

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