AN ATTEMPT TO USE CIE LAB DIGITAL COLOUR TO STUDY SEDIMENT PROFILES FROM THE ALVOR ESTUARY, SOUTH PORTUGAL

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RESUMO

O estudo dos registos sedimentares estuarinos é de grande relevância para as reconstruções paleo-ambientais e paleo-climáticas uma vez que representam ambientes sensíveis às variações climáticas e do nível do mar, e apresentam também uma elevada taxa de sedimentação. No entanto, devido aos custos e ao tempo necessário para analisar os sedimentos do ponto vista da sua composição geoquímica é muito difícil obter perfis com uma resolução elevada adequada para responder aos problemas científicos actuais. O presente trabalho apresenta os resultados da aplicação da espectrofotometria do estado sólido a testemunhos sedimentares provenientes do estuário da Ribeira do Alvor (Algarve) afim de obter perfis digitais de alta resolução. Os dados de cor CIE Lab, obtidos com o espectrofotómetro Colortron nos três testemunhos estudados, foram comparados com os dados das análises geoquímicas (elementos maiores e traços, carbono orgânico e inorgânico, enxofre e azoto total) através de análises estatísticas multivariadas. Assim, o método utilizado permitiu definir duas unidades sedimentares nos testemunhos do alvor, e caracterizá-las em relação à composição geoquímica do sedimento.

ABSTRACT

The study of estuarine sedimentary records is of great interest for paleo-environmental and paleo-climatologic reconstructions, because they represent environments that are sensitive to sea level and climatic variations, and also because they are characterized high sedimentary rates. However, due to the price and time needed to analyze the geochemical composition of sediments, it is very difficult to obtain profiles with a high resolution needed to answer present scientific problems. In the present work, we report results obtained by applying solid-state spectrophotometry on cores from the Alvor's estuary (Algarve), which allows acquiring almost continuous, high resolution, digital colour profiles. CIE Lab colour data, obtained with a Colortron spectrophotometer in three cores, were to geochemical sediment characteristics using multivariate statistical analyses. This methodology allowed to define two sedimentary units in Alvor's cores and, to characterize them in relation to the sediment geochemical composition.

Introduction

Studying sediments from environmental settings such as estuaries is of great importance for paleoclimatic reconstructions because these environments are very sensitive to sea level and climate changes (Dalrymple 1992). Unfortunately, there are very few proxies that can be used as continuous indicators along sedimentary profiles, mostly because their use is time consuming and expensive. Accordingly, it is important to develop and validate new methodologies that allow acquiring quick and cheap continuous profiles on sedimentary cores raised in estuaries. Solid-state spectrofotometry has been used for some years in deep-sea sediment studies, allowing to obtain high resolution down core profiles of CIE Lab colour parameters and to quickly determine glacial/interglacial intervals based on the reflectance parameter (CIE L), which varies, in deep sea sediments, with the Si and/or Ca content representative of primary production (e.g. Merrill and Beck 1996). The present results are integrated in a project whose main objective was to apply and validate the use of solid-state spectrophotometry to estuarine sediments.

Material and methods

Three ~3 m long sedimentary cores have been recovered in the Alvor estuary (Fig.1), perpendicularly to the main channel and distant of 50 m from each other, using a hand corer. CIE Lab digital colour parameters have been acquired every 5 cm down core using a Colortron II spectrophotometer. Sediment has been analyzed every 20 cm down core for its major and minor elements' composition (ICP-MS), its organic and inorganic content (Carlo-Erba) and its granulometry (Malvern). Some AMS ^{14}C analyses have also been done on shell fragments. Statistical analyses,

including correlations, principal component analyses and factor analyses, have then been used to compare and correlate CIE Lab and geochemical data.

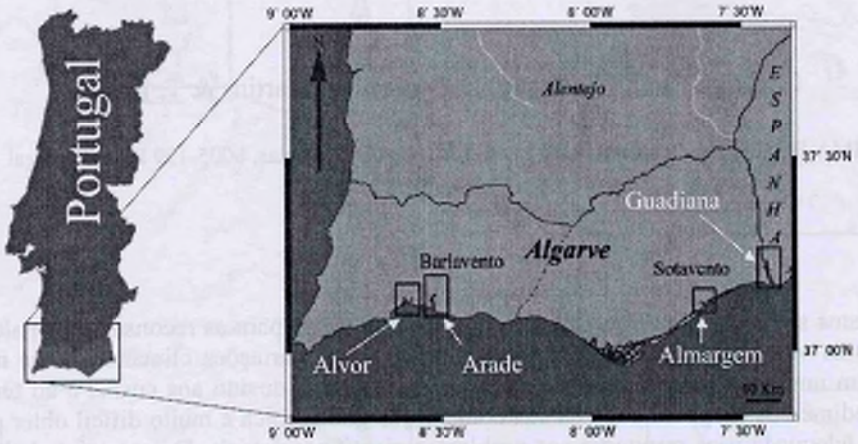

Figure 1- Sampling Location. Results presented here are from the western most estuary of southern Algarve studied during the LOCOTO national research project (POCTI/CTA/39733/2001).

Results

The 142 colour measurements done on the three sedimentary cores gave mean values of ~34.9, for CIE L parameter, ~2.6, for CIE a, and ~8.6 for CIE b. Major and minor element distribution in the analysed sediments show that sediment composition varies down core (Fig. 2a). This variation in the mineralogical composition seems to be reflected in colour changes in the three cores, namely, AL1, AL2 and AL3 (Fig. 2 b, c and d).

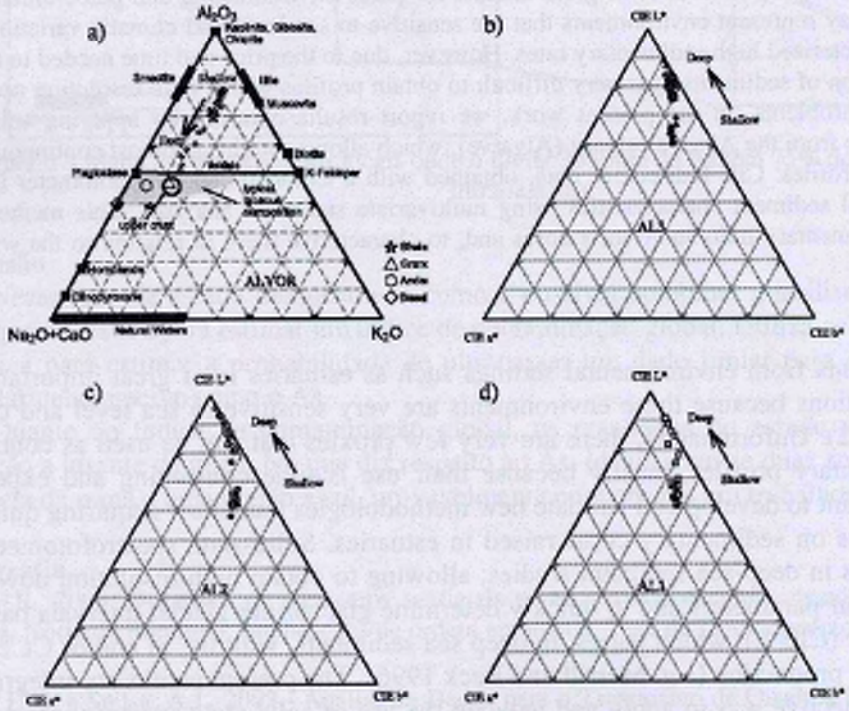

Figure 2 - Ternary diagrams for Alvor estuary's sediments showing the part of mineralogical composition for all the samples (n = 34) (a) and CIE Lab colour composition for each of the three cores, namely, AL3 (n=52) (b), the closest core to the main channel, AL2 (n=52) (c) and AL1 (n=38) (d).

Based on the two correlation matrixes shown in table 1, the three colour parameters CIE Lab seem to be positively correlated with most of the major elements, namely Al, Fe, Mn and K, as well as with most on the trace elements and the mean diameter. Si and total sulphur are in general negatively correlated with CIE Lab parameters.

Table 1- Correlation matrixes of CIE Lab colour parameters in relation to chemical and granulometrical parameters, referring to the three sedimentary cores from Alvor's estuary, for positive correlations greater than 0.5 (a) and negative correlations greater than 0.5 (b).

a) Positive corelation > 0,5

Alvor	*CIE L*	*CIE a*	*CIE b*
Si			
Al	AL1, AL2, AL3	AL1, AL2, AL3	AL1, AL2, AL3
Fe	AL1, AL2, AL3	AL1, AL2, AL3	AL1, AL2, AL3
Mn	AL1, AL2, AL3	AL1, AL2, AL3	AL1, AL2, AL3
Mg	AL1, AL2	AL1, AL2	AL1, AL2
Ca			
Na	AL3	AL3	AL3
K	AL1, AL2, AL3	AL1, AL2, AL3	AL1, AL2, AL3
Ti	AL1, AL2, AL3	AL1, AL2, AL3	AL1, AL2, AL3
P	AL1, AL2, AL3	AL1, AL2	AL1, AL2
Ba	AL1, AL2	AL1, AL2, AL3	AL1, AL2
Sr	AL1, AL3	AL1	AL1
Y	AL1, AL2, AL3	AL1, AL2, AL3	AL1, AL2, AL3
Sc	AL1, AL2, AL3	AL1, AL2, AL3	AL1, AL2, AL3
Zr			
Be	AL1, AL2, AL3	AL1, AL2, AL3	AL1, AL2, AL3
V	AL1, AL2, AL3	AL1, AL2, AL3	AL1, AL2, AL3
TS			
TN	AL3	AL3	AL3
TC	AL3		
TOC			
TIC	AL3	AL3	AL3
Mean grainsize	AL1, AL2, AL3	AL1, AL2, AL3	AL1, AL2, AL3

b) Negative corelation > 0,5

Alvor	*CIE L*	*CIE a*	*CIE b*
Si	AL1, AL2, AL3	AL1, AL2, AL3	AL1, AL2, AL3
Al			
Fe			
Mn			
Mg			
Ca	AL2	AL3	AL3
Na			
K			
Ti			
P			
Ba			
Sr			
Y			
Sc			
Zr			
Be			
V			
TS	AL1, AL2	AL1, AL2	AL1, AL2
TN			
TC	AL1	AL1	AL1
TOC			AL1
TIC	AL1	AL1	AL1
Mean grainsize			

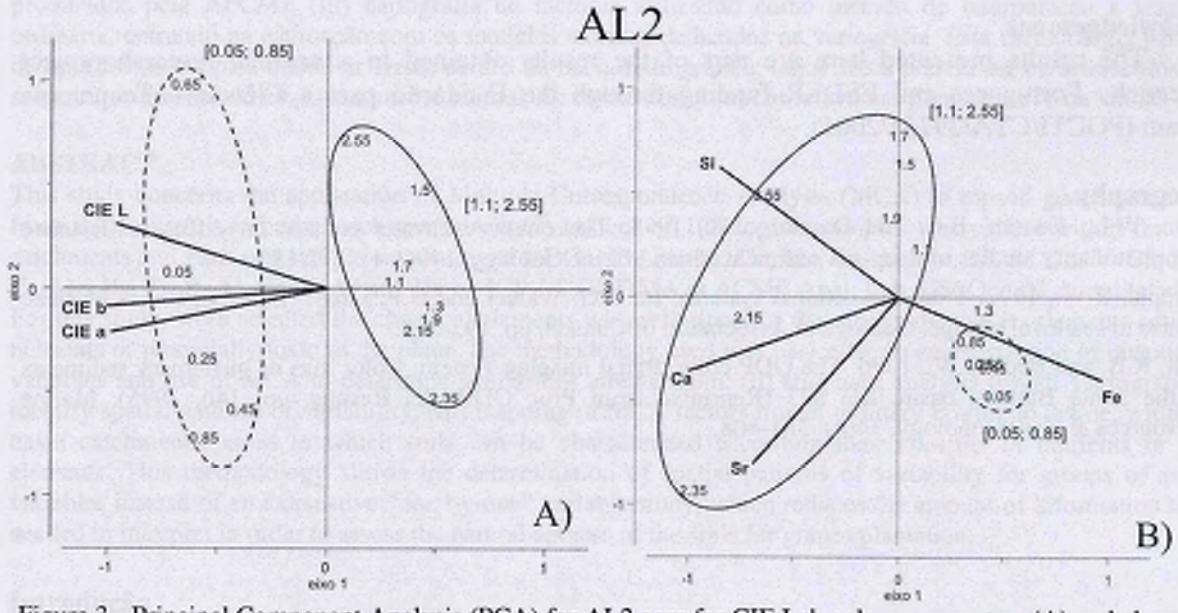

Figure 3 - Principal Component Analysis (PCA) for AL2 core for CIE Lab colour parameters (A) and chemical parameters (B). Ellipses group sample depth of two different sedimentary units: the upper one from 0.05 to 0.85 m and, the lower one, from 1.10 to 2.55 m. Axis 1 represents 94.8% (A) and 68.5% (B) of the total variance, whereas Axis 2 represents 4.9% (A) and 28.9% (B) of the total variance.

Principal Component Analyses (PCA), done based either on CIE Lab colour data or on geochemical data for each core, allowed to define two sedimentary units. As an example, figure 3 represents both PCAs for core AL2 and clearly shows two distinct assemblages with different colour and geochemical characteristics. There is the upper unit, from the top to 0.85 m, characterized by a reddish colour and associated to the Fe content, and the lower unit, from 1.1 m to the bottom, characterized by a grey-brown colour associated with Si, Ca and Sr contents.

Discussion and conclusions

From the above results, and as expected, CIE Lab colour parameters are influenced by the physical and chemical characteristics of the sediments. Although, even when looking at sediment

cores that are only distant of 50 m, as it is the case here, it seems that CIE Lab do not respond the same way to the sediment characteristics, see table 1 for instance. None of the three colour parameters responds exactly the same way for each of the three cores. Accordingly, no constant linear correlation has been defined, as it has been done for CIE L parameter in deep-sea sediment cores and primary productivity (Merrill and Beck 1996). The water content could be responsible for CIE L variations in the studied cores as already observed by other authors (e.g. Balsam et al. 1998). Unfortunately, we have no data on water content, although when looking to the position of the cores in relation to the main channel of the estuary, it doesn't seem that there is any influence on the colour profiles. Therefore, the colour parameters that seem to answer more effectively to geochemical characteristics of the sediments are CIE a and b, which vary from green to red and from blue to yellow, respectively. This is in agreement with the results obtained with the PCAs where the two observed sedimentary units seem to respond to the influence of iron concentration, which is one of the main contributor to the red and yellow colour end members. This observation suggests that the observed two sedimentary units are in fact linked to the redox conditions of the sediment and not necessarily to its composition. Nevertheless, these two colour units exist in the three analyzed cores from the Alvor's estuary but with depth limits between the two varying from 1.6 m for AL3 core to 1 m for Al2 core. Even if representing redox conditions, those units must be linked to sediment characteristics such as grain size.

In conclusion, solid-state spectrophotometry presents promising applications in estuarine sediment studies although much more work needs to be done is order to find more accurate relations between colour parameters and sediment characteristics.

Acknowledgement

The results presented here are part of the results obtained in a national research project financed by Portuguese and FEDER funding through the Fundação para a Ciência e Tecnologia program (POCTI/CTA/39733/2001).

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