MINE-RELATED POLLUTION IN THE GUADIANA ESTUARY (SW IBERIA)

J. Delgado[1*], J.M. Nieto[1] & T.Boski[2]

[2] Centre for Marine and Environmental Research, University of Algarve, 8005-139 Faro, Portugal

[1] Department of Geology, University of Huelva. Avda. Fuerzas Armadas s/n, 21071 Huelva, Spain. E-mail: joaquin.delgado@dgeo.uhu.es

INTRODUCTION AND REGIONAL SETTING

The Guadiana River drains the western part of the Iberian Pyrite Belt (IPB), one of the most important metallogenetic massive sulphide provinces of the world *(Fig.1)*, where the exploitation of sulphide deposits dates back to the Third Millennium B.C.[1]. Associated with the exploitation of these sulphide deposits, highly polluted acidic leachates with high concentrations of metals, metalloids and sulphates are been originated. These leachates are responsible of the pollution and water quality degradation of part of the river basin and, consequently, of the estuarine marshes which act as the ultimate continental filters before the discharge to the Gulf of Cadiz.

The main aims of this work are: a) to evaluate the environmental quality of the most recent sediments through comparison with the local background of Holocene sediments, and b) to assess of the influence of upstream human activities on the estuarine system.

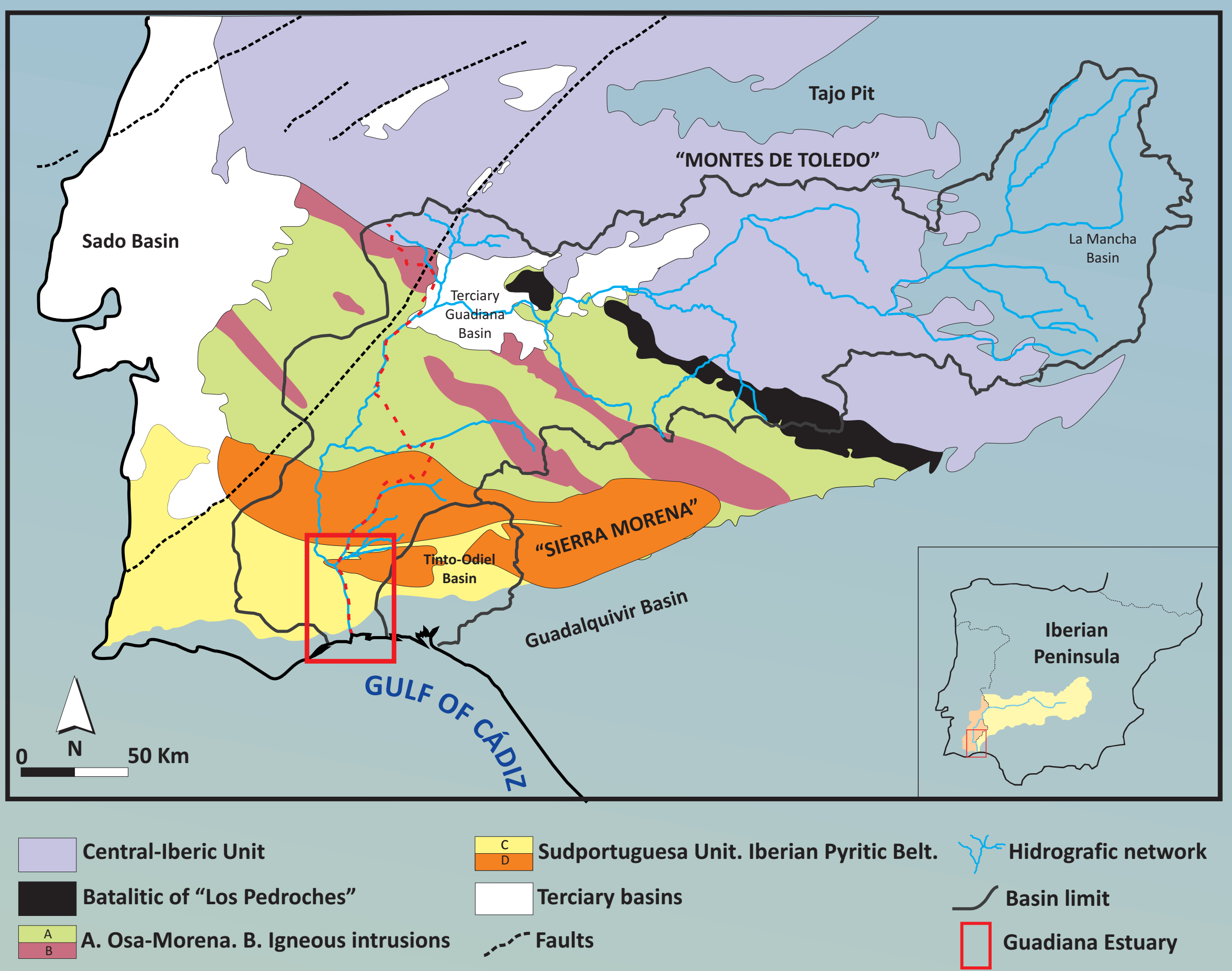


Figure 1.-
Regional setting of the Guadiana River Basin.

METODOLOGY

Sedimentological and geochemical characterization of the sediment samples recovered from two boreholes *(Fig. 2)* has been done. Al-normalized concentrations have been calculated for the most important metals and metalloids to obtain the local background levels, as the environmental quality studies requires previous grain size compensation or normalization on the metal content in different textural samples [2] . By using these background levels, enrichment factors *(Eq. 1)* have been calculated for the superficial sediments *(Fig. 4)* of the Guadiana estuary.

Eq 1.- $EF = ([M] / [N])_{sample} / ([M] / [N])_{background}$

$[M]_{sample}$ = metal concentration for the studied sample
$[M]_{background}$ = regional or local Background
$[N]_{sample}$ = concentration of the normalising element for each sample
$[N]_{background}$ = value of the normalising element in the background

Finally, EF distribution maps were generated by krigeage geostatistical method using Arcview 9.X software, to identify sites of environmental vulnerability in the Guadiana river estuary.

RESULTS AND DISCUSSION

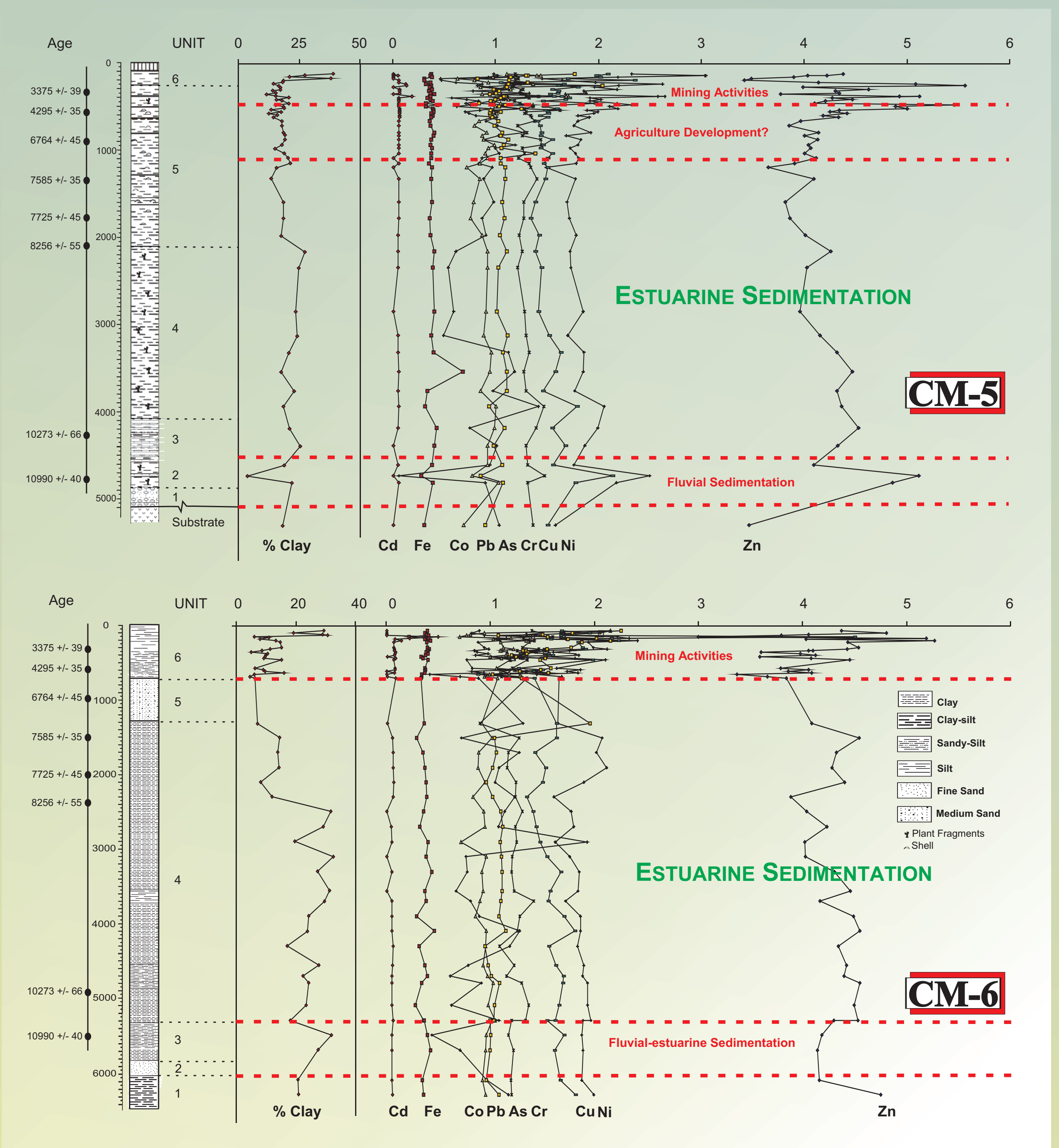
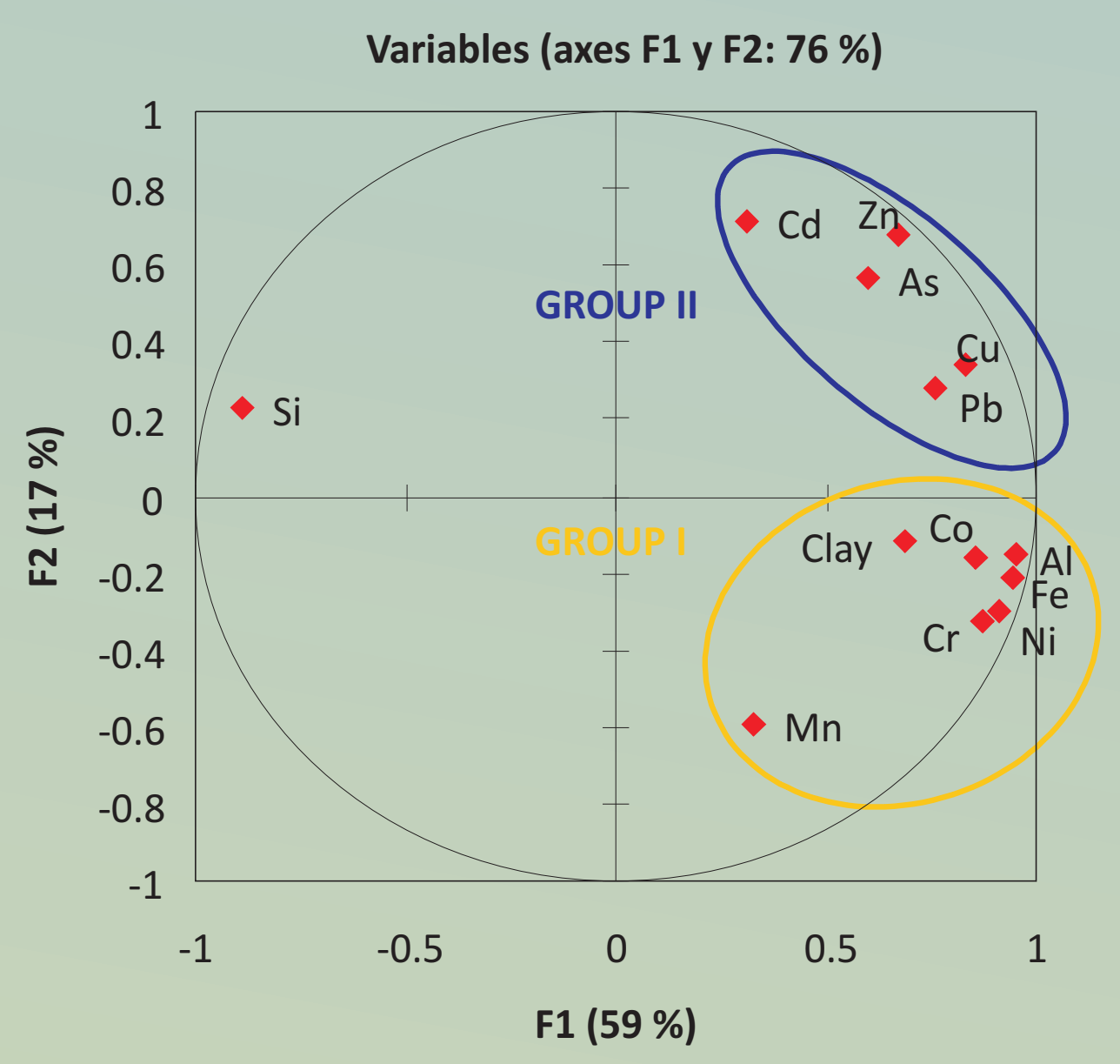


Figure 2.-
Vertical evolution of EF of the main elements asociated with AMD pollution and sedimentary environments of the infillig in the Guadiana estuary infered in this study.

Figure 3.-
PCA for the total samples analysed in the Guadiana river estuary. Alpha significance level 0.05.



Analysis of the vertical evolution of the elements related to sulphide oxidation and borehole litologies *(Fig. 2)*, has allowed the stablishment of the units used for the local background (Table 1) determination of Guadiana river (estuarine sedimentation without anthropic influence). This selection is also based on the chronoestratigraphic model by Boski [3].

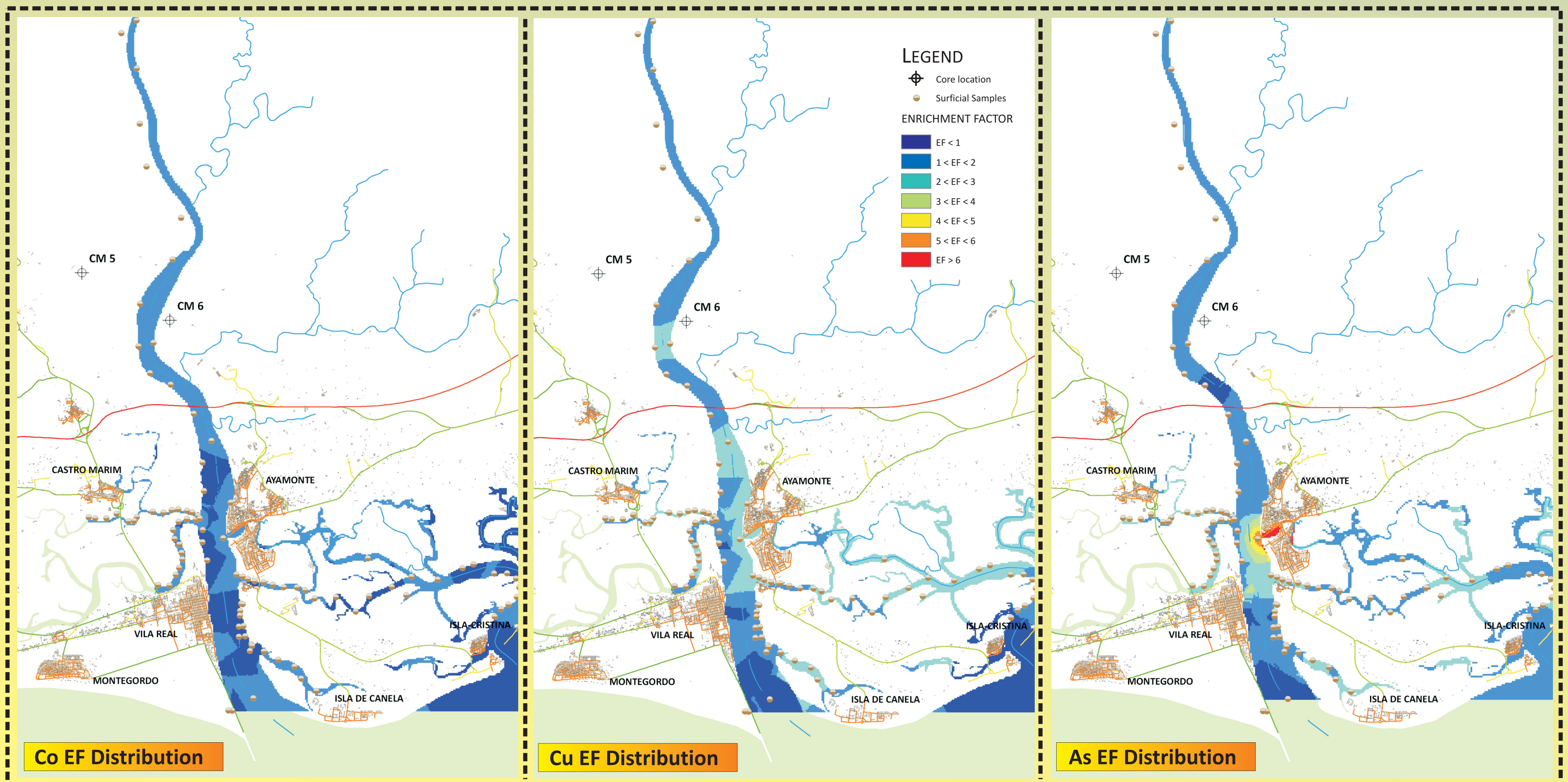
	CM-5 Core			CM-6 Core			LOCAL
	Máx	Min	Media	Máx	Min	Media	Background
Al_2O_3	19,9	7,09	17,0	19,0	16,2	17,8	17,4
Fe_2O_3	8,22	2,57	6,27	11,1	5,54	6,98	6,63
TiO_2	1,01	0,32	0,86	0,96	0,79	0,86	0,86
As	36,9	7,70	16,3	24,7	9,20	15,8	16,0
Cd	0,10	0,01	0,08	0,10	0,01	0,08	0,08
Co	19,1	6,50	15,9	18,1	12,0	15,8	15,8
Cr	27,2	6,40	21,1	25,6	20,8	23,2	22,2
Cu	32,3	11,6	27,1	31,2	23,6	26,8	26,9
Ni	36,2	11,7	31,6	36,6	24,9	31,8	31,7
Pb	22,0	13,5	18,3	22,5	16,3	19,1	18,7
Zn	87,0	29,0	73,3	83,0	61,0	73,2	73,3
Ba	537	244	453	477	373	425	439
Rb	154	49,6	131	145	123	133	132
Sr	216	102	128	136	102	115	122
V	147	36,0	123	137	113	124	124
Zr	339	96,5	214	217	167	193	204
Y	36,9	11,4	32,7	34,4	27,8	30,9	31,8
Cs	9,90	2,00	7,55	9,50	7,40	8,29	7,92

Table 1.-
Statistical analysis of the metal contents of the cores, and LOCAL BACKGROUND values obtained from the selected sedimentary units. Main in %, Trace in ppm.

Results show a conspicuous covariance of the studied elements in two groups *(Fig. 3)*; Group I of natural origin (Al, Fe, Mn, Co, Cr and Ni), and Group II of anthropic origin (As, Cd, Cu, Pb and Zn).

The distribution of the EF for the elements of Group II within the estuary suggests the existence of a diffuse mining pollution (i.e. Cu in *figure 4*) associated with the AMD forming processes in the Guadiana watershed [4]. Other local sources of metallic pollution have been found near the villages of Ayamonte (Spain) and Villa Real de Sto. Antonio (Portugal) showing high EF values for As *(Fig. 4)*, Cd and Zn.

Figure 4.-
Examples of the surficial EF distribution, Co (natural distribution), Cu ("difuse" contamination asociated with AMD) and As ("difuse" contamination and local source of contamination).



Co EF Distribution

Cu EF Distribution

As EF Distribution

CONCLUSIONS

- ***A local background of the main pollutant elements of holocene sediments in the Guadiana estuary has been determinated, from which is posible to evaluate the environmental quality of the most recent sediments.***
- ***This study has allowed us to show the existence of "diffuse" contamination in the sediments of the Guadiana estuary related with AMD generated in inner zones of the basin, and to prove that EF calculation along with spatial analysis by GIS is a great tool to assess the environmental quality of estuarine systems.***
- ***The GIS tecnique evidences the high values of most important metals and metalloids probably responsible of contamination and the relation between these elements and human activities. As, Cd, Cu, Pb and Zn were found in relatively high concentrations near the coastal localities, as confirmed by the GIS mapping.***

REFERENCES:

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