

## REGIONAL AND FOREGS GEOCHEMICAL BASELINE SURVEYS OF PORTUGAL – A COMPARISON

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### RESUMO

Foram realizados em Portugal dois levantamentos geoquímicos usando sedimentos de corrente (“stream sediments”) tendo sido analisada, em laboratórios diferentes e para cerca de 30 elementos, a fracção < 80 mesh por espectrometria ICP, após ataque com água régia. Um dos levantamentos, de baixa densidade de amostragem (653 locais em 88 740 km<sup>2</sup>) foi efectuado entre 1992 e 1997 e destinou-se ao mapeamento geoquímico do país; o outro, de densidade ultra-baixa (17 locais de amostragem na mesma área, distribuídos por 4 células geográficas de 160 x 160 km) foi efectuado entre 1998 e 2000 e destina-se ao mapeamento geoquímico da Europa. Foram utilizados parâmetros estatísticos usuais para comparação simples dos resultados relativos a 10 elementos seleccionados com base na sua importância composicional, ambiental e económica (Al, Ca, Fe and As, Cr, Cu, Mn, Ni, Pb, Zn). Em geral os valores para ambos os levantamentos são semelhantes, com excepção de Al e As e possivelmente Mn e Ca. Os resultados são tentativamente interpretados em termos de factores geogénicos e antrópicos.

### ABSTRACT

An attempt is made to compare some results of a low density stream sediment geochemical survey of Portugal ("Regional survey") with the results of a very low density survey ("FOREGS survey"). In both cases active stream sediment samples (<80 mesh fraction) were analysed for some 30 elements by ICP spectrometry after aqua regia digestion. In the case of the regional survey the sampling sites (653 in 88 740 km<sup>2</sup>) are evenly distributed all over the country; in the other survey the sites (17) are located in 4 geographic cells (160 x 160 km) covering most of the country. Simple statistical parameters were used for to compare the results for 10 selected elements (Al, Ca, Fe and As, Cr, Cu, Mn, Ni, Pb, Zn). In general the computed average values for both surveys are similar for each cell, Al and As excepted and possibly for Ca and Mn. The results are tentatively interpreted in terms of geogenic and anthropogenic factors.

Palavras-Chave: mapeamento geoquímico, Portugal

Key words: Geochemical mapping, Portugal

### 1. INTRODUCTION

Between 1992 and 1997 a low density geochemical survey of the whole continental territory of Portugal was carried out based on active stream sediments (Ferreira 2000). It followed technical recommendations - on sampling, sample preparation, analysis, statistical processing and map production - of Project 259 “International Geochemical Mapping” (Darnley et al. 1995) of the International Geological Correlation Programme (IGCP) and of previous reports related to the launching in 1988 of that project. Being a survey for national coverage of Portugal it was, of course, a regional survey within Europe and so it is named here the “Regional survey” or “Regional mapping”.

Another project - the European Baseline Geochemical Mapping - was carried out all over Europe, from 1998 to 2000, as part of the activities of the Forum of European Geological Surveys (FOREGS) under the supervision of the Geological Survey of Finland. It was a very low density survey based on sampling of several media, including active stream sediments, in sites within cells 160x160 km of a geographic grid covering all the continents - the Global Terrestrial Network or GTN - established by the IGCP Project 259. In Portugal four of the cells corresponding to the continental territory were selected in order to cover most of it and in each one five sites were subject to sampling. This survey is named here the “FOREGS survey” or “FOREGS mapping”.

The Regional survey and the FOREGS survey have different purposes, the former having been used for geochemical mapping of the country (Ferreira 2000) and the later being intended for geochemical mapping of Europe. They use some different experimental procedures and so different end results are to be expected. Nevertheless it was considered that a comparison between the two sets of data relative to selected elements should be attempted in order to see which general differences could be observed.

### 2. EXPERIMENTAL WORK

The regional survey was based on active stream sediment samples collected in a consistent way at 653 sites evenly distributed all over the country (roughly 88,740 km<sup>2</sup>) with a sampling density close to 1 site/ 135 km<sup>2</sup>. The sampling sites correspond to small catchment areas (sub-basins) between 40 and 60 km<sup>2</sup> in size. The < 80 mesh fraction (dry sieved) of each composite sample (from superficial material grabbed in points along a line up to 200 m on the stream bed) was analyzed in a commercial laboratory for 31 elements by ICP-AES (Al, Ca, Fe, K, Mg, Mn, Na, P, Ti and trace Ag, As, Au, B, Ba, Bi, Cd, Co, Cr, Cu, Fe, La, Ni, Pb, Sb, Sr, Th, Tl, U, V, W, Zn) after digestion with aqua regia. .

For the FOREGS project active stream sediments were collected at a total of 19 sampling sites (17 in Portuguese territory) distributed by four GTN cells, after a random selection of sites in each cell. The analysis of the < 80 mesh fraction (wet sieved) of each composite sample (from superficial material grabbed in points along a 500 m line) was performed not in the same laboratory by ICP-MS preceded by *aqua regia* digestion and XRF. The 30 analyzed elements were: Al, Ca, Fe, K, Mg, Mn, Na, P, Ti and Ag, As, Ba, Be, Cd, Co, Cr, Cu, Li, Mo, Ni, Pb, S, Sb, Sc, Sn, Sr, V, Y, Zr, Zn.

Sampling points, basins and cells of the FOREGS survey and sampling points of the Regional survey are shown in Figure 1. Sub-basins of the regional survey, not shown, are systematically smaller than the basins.

Simple statistical parameters were used for the purpose of comparison of results for 10 selected elements (Al, Ca, Fe and As, Cr, Cu, Mn, Ni, Pb, Zn).

### 3. RESULTS AND DISCUSSION

The ten elements were selected on the grounds of their importance in compositional, environmental and economic terms and also because their distribution could eventually be related to geogenic (namely lithology) and anthropogenic (namely pollution) factors.

In Table I arithmetic mean (A), median (Mdn), geometric mean (GM), minimum (min), maximum (max), standard deviation (stdev) and coefficient of variation (C%) of element contents were shown for each GTN cell and for each data set (FOREGS and Regional).

Only a simple comparison between the two sets in each cell was made because of their expected differences due to differences in the number of samples (see N on Table I) and also to differences in experimental procedures used, as explained. The main conclusions of such simple comparison are: a) except for Al and As, and possibly for Mn and Ca, the average values are similar for both data sets in each cell; b) Al and As average values, particularly the median values, are always higher (1.5 to 2 and 2 to 4 times respectively) in the FOREGS data set; Ca and Mn values show similar trends in both sets.

The higher aluminum average contents seen in both data sets of the N28W05 cell is most probably due to the abundance of granite intrusions in that area.

As for arsenic, the higher average values that can be found in the data sets of the N28W04 and N28W05 cells may be due to the fact that the corresponding areas belong to the Central Iberian Zone that has rocks enriched in As (Ferreira 2000, Ferreira et al. 2001).

The higher Cr and Ni median values seen in both data sets of cells N28W04 and N26W05 are in accordance with the occurrence of mafic-ultramafic rocks in both areas. This is also true for Mn and Fe, and it should be taken into account the occurrence of a pyrite belt in the area of the N26W05 cell.

Anthropogenic influences are not clearly visible, perhaps with the exception of Pb and Zn that show tendency to have higher median values in the northern areas of N28W04 and N28W05 cell for both data sets.

This may be due to a bigger number of industrial units in the north. But the signals are weak and it should be remembered that that industrial units and areas occupy very small as compared to the size of the GTN cells.

In conclusion: in a relatively small area like Portugal the FOREGS survey reflected the general geochemical differences detected by the Regional survey, at least for some elements. This is important in terms of the usefulness of very low density surveys in big areas, like the Iberian Peninsula or Europe.

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Table I - Some statistics for each GTN cell and dataset (FOREGS and Regional)

	REGIONAL MAPPING							FOREGS MAPPING						
	A	Mdn	GM	min	max	stdev	C%	A	Mdn	GM	min	max	stdev	C%
<b>N28W05 (N=141)</b>							<b>N28W05 (N=4)</b>							
Al %	2.13	<b>1.98</b>	1.99	0.51	4.40	0.79	37	3.81	<b>3.71</b>	3.68	2.71	5.12	1.16	30
As mg/kg	32	<b>14</b>	15	2	944	106	327	33	<b>30</b>	25	12	61	25	76
Ca %	0.18	<b>0.17</b>	0.15	0.02	0.75	0.11	60	0.14	<b>0.14</b>	0.11	0.05	0.21	0.08	61
Cr mg/kg	26	<b>19</b>	19	4	305	32	124	19	<b>21</b>	17	8	27	9	47
Cu mg/kg	37	<b>22</b>	23	5	762	75	201	29	<b>31</b>	23	6	47	17	61
Fe %	2.26	<b>2.11</b>	2.08	0.72	4.99	0.91	40	2.38	<b>2.49</b>	2.28	1.37	3.17	0.76	32
Mn mg/kg	413	<b>316</b>	321	49	10251	850	206	315	<b>326</b>	310	232	376	63	20
Ni mg/kg	15	<b>11</b>	10	1	74	12	85	12	<b>10</b>	9	4	23	8	73
Pb mg/kg	38	<b>24</b>	26	7	1378	115	301	29	<b>28</b>	27	16	45	12	42
Zn mg/kg	125	<b>94</b>	98	9	1339	146	117	86	<b>71</b>	79	52	148	43	51
<b>N28W04 (N=80)</b>							<b>N28W04 (N=3)</b>							
Al %	1.72	<b>1.66</b>	1.68	1.01	2.78	0.38	22	2.48	<b>2.43</b>	2.48	2.40	2.62	0.12	5
As mg/kg	31	<b>14.0</b>	16	2	699	81	262	47	<b>57</b>	40	17	67	26	56
Ca %	0.29	<b>0.20</b>	0.22	0.07	1.78	0.28	99	0.28	<b>0.27</b>	0.27	0.17	0.41	0.12	43
Cr mg/kg	31	<b>26</b>	24	7	232	29	93	32	<b>26</b>	30	22	48	14	44
Cu mg/kg	28	<b>24</b>	22	6	240	28	102	35	<b>24</b>	28	14	66	28	80
Fe %	2.85	<b>2.75</b>	2.64	1.05	7.15	1.14	40	2.74	<b>2.86</b>	2.70	2.10	3.27	0.59	22
Mn mg/kg	665	<b>492</b>	534	190	3420	559	84	605	<b>481</b>	575	443	891	248	41
Ni mg/kg	32	<b>27</b>	21	1	371	43	134	23	<b>22</b>	21	12	34	11	49
Pb mg/kg	24	<b>20</b>	20	5	118	18	76	22	<b>22</b>	22	21	24	2	7
Zn mg/kg	93	<b>80</b>	84	13	358	49	53	94	<b>88</b>	93	78	117	20	21
<b>N27W05 (N=172)</b>							<b>N27W05 (N=5)</b>							
Al %	1.27	<b>1.26</b>	1.10	0.31	3.09	0.63	50	2.35	<b>2.59</b>	2.18	1.19	3.29	0.92	39
As mg/kg	16	<b>8</b>	8	1	873	67	411	17	<b>22</b>	14	7	24	9	53
Ca %	1.71	<b>0.19</b>	0.32	0.01	23.55	4.22	247	2.22	<b>0.25</b>	0.42	0.09	10.15	4.43	199
Cr mg/kg	21	<b>17</b>	16	3	148	18	87	22	<b>20</b>	17	6	41	15	70
Cu mg/kg	23	<b>19</b>	17	2	270	29	123	24	<b>23</b>	20	6	49	16	66
Fe %	2.13	<b>1.90</b>	1.83	0.45	5.63	1.13	53	2.47	<b>1.84</b>	2.26	1.32	4.07	1.17	47
Mn mg/kg	397	<b>306</b>	293	32	7185	578	146	612	<b>473</b>	503	205	1062	399	65
Ni mg/kg	18	<b>13</b>	11	1	136	16	93	15	<b>14</b>	11	3	30	12	77
Pb mg/kg	21	<b>17</b>	18	7	85	13	63	18	<b>17</b>	18	12	26	5	28
Zn mg/kg	79	<b>64</b>	56	7	801	84	107	62	<b>71</b>	54	20	90	30	48
<b>N26W05 (N=169)</b>							<b>N26W05 (N=5)</b>							
Al %	1.43	<b>1.50</b>	1.26	0.22	3.37	0.60	42	2.77	<b>2.86</b>	2.75	2.33	3.28	0.37	13
As mg/kg	21	<b>5</b>	4	1	2234	172	802	13	<b>15</b>	11	3	23	8	59
Ca %	0.86	<b>0.30</b>	0.39	0.03	9.77	1.40	163	0.48	<b>0.44</b>	0.44	0.19	0.73	0.20	42
Cr mg/kg	29	<b>30</b>	23	3	74	17	57	35	<b>32</b>	32	16	59	16	45
Cu mg/kg	29	<b>22</b>	19	1	817	64	222	26	<b>27</b>	23	10	40	12	46
Fe %	2.76	<b>2.82</b>	2.27	0.39	7.64	1.47	53	3.44	<b>3.46</b>	3.32	1.97	4.25	0.90	26
Mn mg/kg	1201	<b>724</b>	709	54	19878	2023	168	2370	<b>2299</b>	1584	431	5613	2098	89
Ni mg/kg	24	<b>21</b>	16	1	138	20	84	25	<b>24</b>	20	5	48	16	62
Pb mg/kg	27	<b>17</b>	17	3	924	71	268	24	<b>14</b>	20	12	57	19	79
Zn mg/kg	77	<b>50</b>	46	7	2365	196	256	69	<b>51</b>	61	37	146	44	64

A, arithmetic mean; Mdn, median; GM, geometric mean; min, minimum; max, maximum; stdev, standard deviation and C%, coefficient of variation.

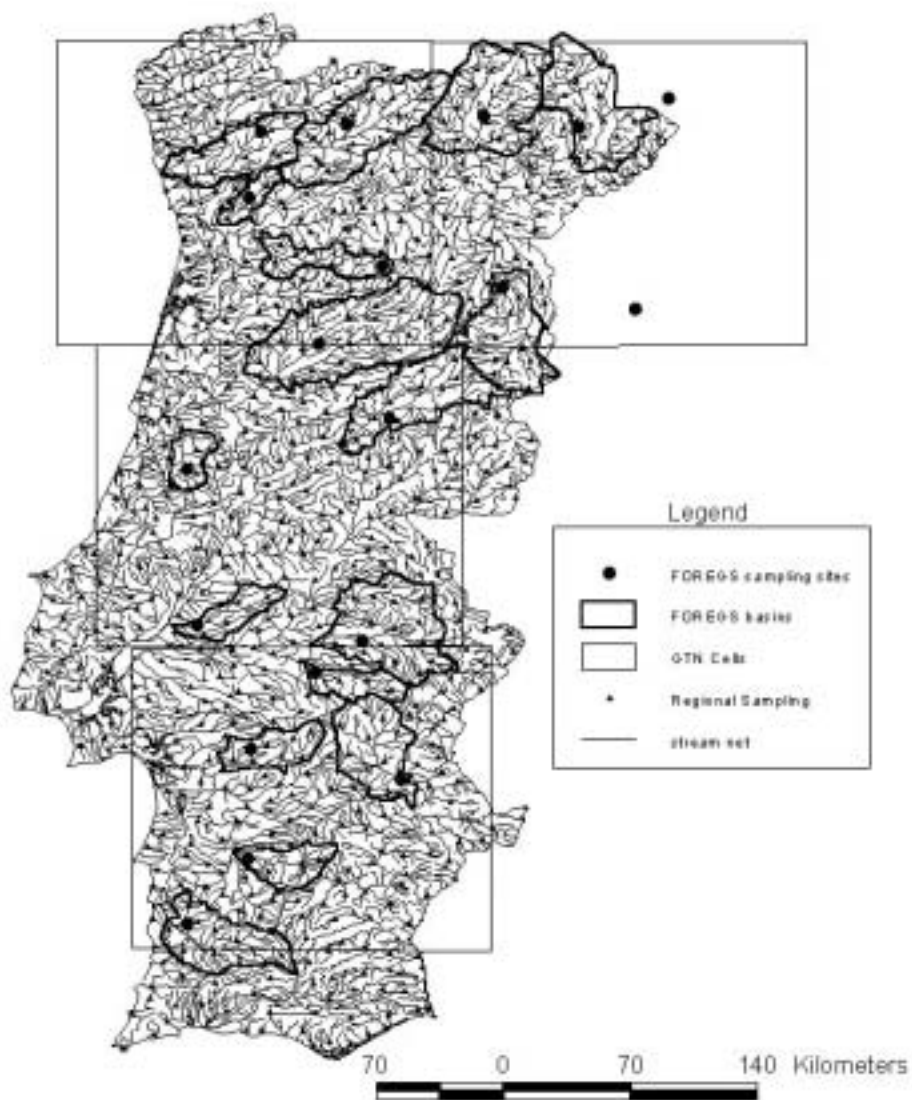


Fig. 1 – FOREGS and regional surveys in Portugal