

Trace element contents of the Lava xylite/lignite and Ptolemais lignite deposits, Macedonia County, Greece

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ABSTRACT

The concentrations of 47 trace elements in the Lava xylite/lignite and Ptolemais lignite deposits, as well as in their intermediate sterile bands, were determined by ICP-MS. The majority of the trace elements are depleted, as compared to Clarke's earth. Three elements (As, Se and Ag) are enriched in all samples. The stock pile samples of Lava are enriched in Ge, As, Se, Ag, Cd, Hg and U, while the stock pile samples of Ptolemais are enriched in B, As, Se, Ag and U. The majority of the elements are more or less, positively correlated with the ash content of the coal samples, while Mo and Hg are possibly negatively correlated. The elemental composition of the investigated samples is related to the nature of plant communities and to the geological conditions and processes of the basin and surrounding areas.

1. INTRODUCTION

Trace elements occur in coal in wide concentration ranges and are expected to occur, at least in part, in the mineral matter of coal. In this study the concentrations of 47 trace elements in Lava and Ptolemais coal deposits were determined by ICP-MS. Samples from the intermediate steriles were also investigated for their trace element contents(ICP-MS) and for their mineralogical composition by powder XRD. Geochemical data of this type are important in designing environmentally acceptable technologies for utilizing coal as a fuel and for better understanding the interaction between the biological and inorganic geochemical cycles of elements.

2. GEOLOGICAL SETTING AND SAMPLE LOCATION

The Quaternary-Neogene sediments of the Lava and Ptolemais basins unconformably overlay the Paleozoic-Mesozoic rocks[1] of the Pelagonian geotectonic zone(Fig. 1). The Miocene lacustrine deposits of Lava basin contain three xylite/lignite horizons[2]. The deepest first horizon(118-130 m depth) consists of xylite, xylitic lignite and lignite intercalations(average total thickness 9 m). The second horizon(110-113 m depth) consists of a unified lignite bed(Fig. 2). The third horizon(95-100 m depth) consisting of xylite, appears only in the peripheral parts of

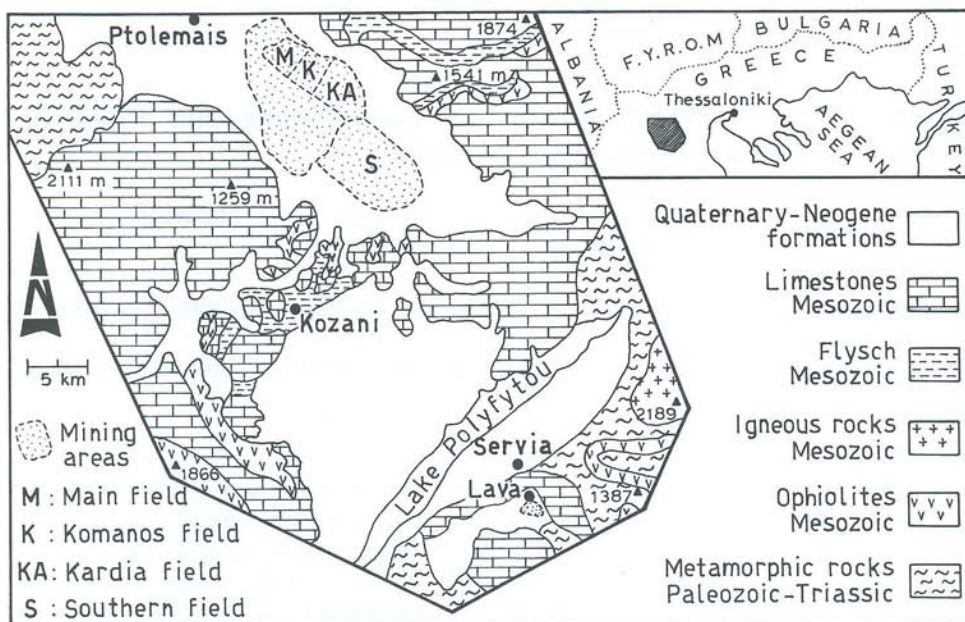


Figure 1. Simplified geological map of Ptolemais-Lava area[1].

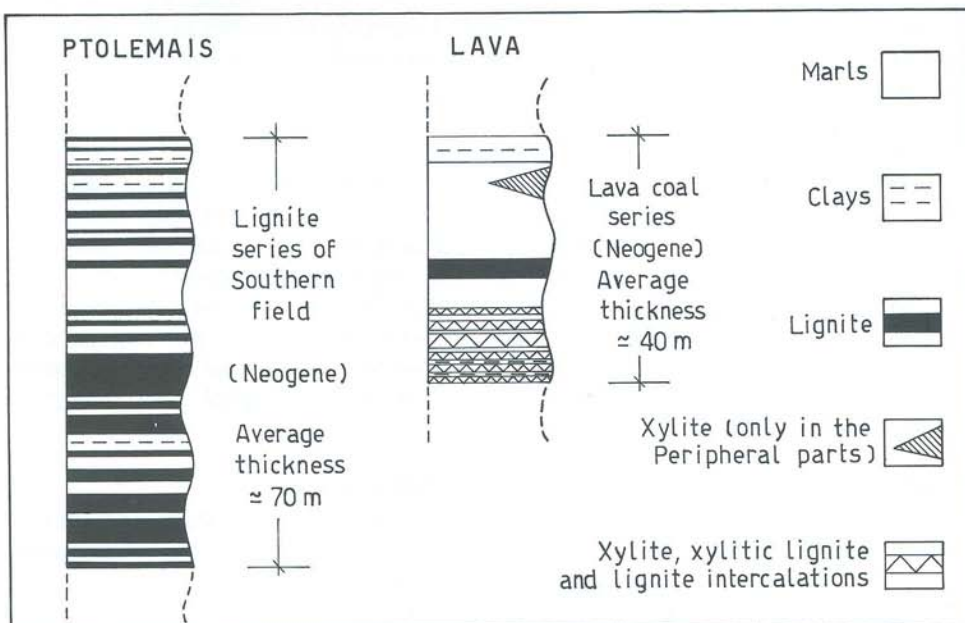


Figure 2. Generalized sections of the Ptolemais and Lava Coal deposits.

Table 1. Average content (ppm) of intermediate sterile (IS), xylite (X), lignite (L), xylitic lignite (XL) and stock pile (SP) samples.

No of samples	L A V A					P T O L E M A I S			Earth's crust
	IS (3)	X (2)	L (3)	XL (3)	SP (2)	IS (3)	L (7)	SP (4)	
Li	67	3.5	38	25	20	10	14	4.1	20
Be	2.2	0.3	1.2	0.8	0.9	0.3	0.6	0.2	2.8
B	15	14	19	20	15	21	36	21	10
Sc	9	1.4	6	3.9	4.5	3.1	4.1	1.8	22
V	53	27	57	32	44	30	40	27	135
Cr	157	17	69	31	30	85	86	32	100
Co	18	1.9	4.6	3.7	3.2	8	5	2.1	25
Ni	206	11	35	19	20	89	77	34	75
Cu	32	10	26	19	16	17	17	9	55
Zn	136	40	60	52	78	208	47	70	70
Ga	34	3.0	16	13	13	4.9	6	3.4	15
Ge	8.9	2.1	5.4	4.4	3.9	5.2	1.6	2.2	1.5
As	15.8	8.3	9.8	4.8	7.9	19.9	5.7	5.5	1.8
Se	6.00	3.37	3.59	3.19	1.09	6.01	1.18	2.17	0.05
Rb	110	2.3	41	24	16	12	15	5	90
Sr	127	23	44	36	42	221	73	57	375
Y	14	2.7	10	7	8	4.1	6	2.7	33
Zr	20	7	25	15	14	5	20	9	165
Nb	3.5	1.8	4.5	4.7	4.2	1.7	4.8	2.3	20
Mo	0.7	1.3	0.4	0.9	1.9	0.9	1.4	2.0	1.5
Ag	1.16	0.23	0.27	0.28	1.10	1.03	0.40	0.29	0.07
Cd	0.6	0.5	1.0	0.5	0.5	0.3	0.3	0.3	0.2
Sn	1.7	0.6	2.2	1.5	0.9	4.8	3.9	1.3	2
Sb	0.2	0.1	0.2	0.6	0.2	0.6	0.7	0.4	0.2
Cs	4.7	0.2	3.2	2.1	1.3	0.8	1.5	0.5	3
Ba	429	40	186	172	189	62	76	39	425
La	32	2.7	16	12	11	3.6	9	4.0	30
Ce	73	6	38	29	18	8	17	6	60
Pr	7.2	0.8	4.0	3.1	2.4	0.9	2.2	0.8	8.2
Nd	28	3.0	16	12	9	3.4	8	3.1	28
Sm	5	0.6	2.9	2.2	1.7	0.7	1.6	0.6	6
Eu	1.2	0.2	0.7	0.5	0.4	0.3	0.4	0.1	1.2
Gd	4.9	0.7	2.8	2.1	1.7	0.9	1.6	0.6	5.4
Tb	0.7	0.1	0.4	0.3	0.3	0.2	0.2	0.1	0.9
Dy	3.7	0.6	2.2	1.5	1.4	0.8	1.2	0.4	3
Ho	0.6	0.1	0.4	0.3	0.3	0.2	0.2	0.1	1.2
Er	1.9	0.7	1.4	1.1	0.8	0.5	0.7	0.3	2.8
Yb	1.5	0.3	1.0	0.8	0.7	0.5	0.6	0.3	3.4
Hf	0.8	0.3	0.8	0.9	0.6	0.7	1.0	0.4	3
Ta	1.4	0.5	0.4	3.4	2.3	0.4	2.1	3.0	2
W	0.3	0.7	0.5	0.7	1.0	0.5	1.1	1.1	1.5
Hg	0.21	0.17	0.09	0.05	0.20	0.71	0.09	0.11	0.08
Tl	<0.1	0.1	0.5	0.3	0.2	<0.1	0.2	0.1	0.5
Pb	19	3.2	13	9	5	4.9	8	1.4	13
Bi	0.4	0.1	0.3	0.2	0.3	0.2	0.2	0.1	0.2
Th	13.5	1.5	8.2	7.5	4.8	1.3	3.1	1.2	7.2
U	4.0	3.2	3.8	4.5	4.7	1.1	7.0	8.4	1.8
750°C Ash (%)	-	10.7	49.2	40.7	27.3	-	27.1	14.3	-

the Lava basin. The Ptolemais lignite beds (mean thickness of mineable lignite 35 m) located within the middle (Pliocene) formation, alternate mainly with marls and clays (Fig. 2). The analyzed coal samples were taken from the stock piles and open cast mines of Ptolemais (Main, Komano, Kardias and Southern fields) and Lava.

3. RESULTS AND DISCUSSION

The investigated intermediate marl samples consist of calcite and minor amounts of mica + clay minerals, while the intermediate clay samples contain mainly mica + clay minerals and minor amounts of chlorite and feldspars.

Compared to the elements crustal abundances the majority of the trace elements (Be, V, Cr, Co, Cu, Rb, Sr, Zr, Nb, Mo, Cs, Ba, Hf, Ta, W, Tl, Pb, Bi, Th and REE) are depleted or show similar average values in all analyzed samples (Table 1). When the ratio of an element concentration to that of Earth's crust is >2.0 , the element is considered to be enriched, and when it is <0.5 , depleted. Three elements (As, Se and Ag) are enriched in all samples (Table 1). Boron (B) is enriched only in the samples from Ptolemais basin, while cadmium (Cd) only in the samples from Lava deposit. Li, Ni and Ga are enriched only in the intermediate sterile samples of Lava, while Zn and Sn only in the intermediate sterile samples of Ptolemais. Ge is enriched in the intermediate sterile samples of both deposits and in the lignite, xylitic lignite and stock pile samples of Lava deposit. Sb is found to be enriched in the xylitic lignite sample of Lava and in the intermediate sterile and lignite samples from Ptolemais. Mercury (Hg) is enriched in the intermediate sterile samples of both deposits and in the xylite and stock pile samples of Lava. Uranium (U) is enriched in all samples except the xylite sample from Lava and the intermediate sterile samples from Ptolemais.

Among the eleven inorganic elements, cited as potentially hazardous air pollutants [3], four elements (As, Se, Cd, Hg) are enriched in the stock pile samples from Lava, while two (As, Se) are enriched in the stock pile samples from Ptolemais. In the Ptolemais fly ash, which consists mainly of anhydrite, lime and calcite [4] only W, Ni and Cr are enriched [5]. It is commonly supposed that the elements positively correlated with the ash content are imported elements, while negatively correlated elements are authigenic and mainly associated with organic substances of the coal. The majority of the elements (Li, Be, V, Cr, Co, Ni, Cu, Ga, Rb, Zr, Nb, Cs, Ba, Hf, Tl, Pb, Th and REE) are, more or less, positively correlated with the ash content of the analysed coal samples, while Mo and Hg are possibly negatively correlated with the ash content. The differences as well as the concentration and enrichment degree of the analysed trace elements indicate that the elemental composition of the investigated samples is related to the nature of plant communities and to the geological conditions and processes.

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