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ABSTRACT

The distribution of the trace-elements Al, Si, P, S, Cl, K, Ca, Ti, Fe and V in the atmospheric aerosol of the Amazon Basin was determined by means of samples collected between August 23 and September 2 of 1980, at a remote place located in the Amazon Forest, about 30 km NE of the city of Manaus. In all, 10 complete cascade impactors of 6-stage, Battelle model, were exposed but only 8 with success, generating, therefore, 48 samples that discriminate the collected particulate matter in the following size ranges of their aerodynamic diameters: stage-1, between 0.25 μm and 0.5 μm; stage-2, 0.5 - 1 μm; stage-3, 1-2 μm; stage-4, 2-4μm; stage-5, >4 μm; the so called stage-0 had a nuclepore 0.4 μm filter which retained the $\leq$ 0.25 particulates.

33 samples were succesfully analyzed by the PIXE method (Particle Induced X-Ray Emission) by using α-particle beam of the Pelletron Accelerator of the University of São Paulo, and the results revealed that the trace-elements S and K have a large predominance, mainly as fine particle size relative to the others; this fact is consistent with the statement that the natural cycles of these two elements are critically involved in

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in the biophysical processes responsible for the life of the tropical rain forest of the Amazon.

INTRODUCTION

Despite the increasing number of experiments which have been recently performed in many remote regions of the world[1,2,3,4], the general knowledge on the distribution of natural trace-components on the atmosphere is still insufficient to support precise evaluations of background concentrations, either for the trace-gases of the atmosphere or for the trace-elements of the natural aerosols.

A particularly important point on this matter is to accumulate data on the trace-elements constituent of the natural atmospheric aerosol of the Amazon Basin. It is generally supposed that the natural cycles of some of these elements are critically involved in the biophysical process responsible for the life of the tropical rain forests of the Amazon[5].

In this experiment, although we look practically for all elements with Z>13, only the trace-elements Al, Si, P, S, Cl, K, Ca, Ti, Fe and V were significantly detected in the different size ranges selected by the operated 6-stage cascade impactor samples. Some trace-elements which are ordinarily constituents of all urban aerosols, as, for instance Cu, Zn, Br and Pb, were not detected, in spite of the uncommonly low detection limit of the PIXE method adopted for the analysis of the samples.

SAMPLING AND ANALYTICAL PROCEDURE

Sampling was performed in August-September, 1980, by using 6-stage home-made cascade impactor of Battelle model operating

at a flow rate of about 0.7 l/min, at the remote location of "Estação Duque", an experimental meteorological station inside the jungle, 30 km northeast of the city of Manaus (Amazonas, Brazil), belonging to the "Instituto Nacional de Pesquisas da Amazônia" (INPA), as shown in fig. 1. Table 1 presents the general data relative to this field sampling.

In all, 10 complete cascade impactors were collected but 2 were lost by failure in air flux measurements. 48 samples (6 for each impactor) were, therefore, succesfully generated.

33 samples were analyzed by the PIXE (Particle Induced X-Ray Emission) method: each sample has been irradiated by an α-particle beam of 8 MeV, performing an electric charge accumulated of about 2 μC, from the Pelletron Tamden Accelerator of the University of São Paulo[6]. The X-Ray spectrum produced by each sample was first stored in a magnetic tape and then analyzed by special semi-authomatic computational program in a PDP-11/60 computer.

The estimated accuracy of the resulting concentrations so obtained is of about 30% for the medium Z-elements (K, Ca, Ti, F and V), falling down to about 50% for the low Z-elements (Al, Si, P and S).

RESULTS AND CONCLUSIONS

Tables 2 to 4 present the elemental concentrations for the elements Al, Si, P, S, Cl, K, Ca, Ti, Fe and V as determined for the atmospheric aerosol of Amazon Basin, classified by their size range according to the stage of detection of the cascade impactor samplers used.

The 6-stages cascade impactors have the 50% collection efficiency cut-points at, respectively : 0.25μm for stage 1; 0.5μm

for stage 2; 1 μm for stage 3; 2 μm for stage 4; 4 μm for stage 5. The 0.4 nuclepore filter placed in stage 0 has a minimum collection efficiency (>85%) between 0.05 μm and 0.2 μm of particle aerodynamic diameter, being 100% efficient outside of this range[7].

On each of the Tables 2, 3 and 4 we present the results of pairs of cascade impactors that ran together and simultaneously in the sampling field, that is: Table 2 is for the pair labeled 2A-2C; Table 3 for 3A-3C; Table 4 for 4A-4C. The very good consistency generally obtained for the results generated by the two impactors of each pair is an important indication of the quality of the final data.

Also, it should be noticed that the field sampling was carried out at the end of the dry season of the Amazon Region, and in general, with quite good weather, and an almost constant light wind blowing from NE; this circunstance gives a high representativeness for the obtained mass distributions of the trace-elements detected in the aerosol of that region during that season.

A better visualization of the trace-elemental mass distribution among the different sizes of the amazon aerosol can be obtained by the examination of the average size distribution curves shown in figures 2 to 4. In fact, in these curves it is quite noticeable, for instance, the dominant behaviour of the S and K-curves relative to the other trace-elements: the S-curve, actually a fine-mode (particles with aerodynamic diameter <2.5 μm) distribution of the mass (once its coarse mode area was estimated as of about 12% of the fine one), while those of K with a bi-modal feature but with a clear predominance of the fine mode compared to the coarse one. The other two average-distribution curves shown (for Ca and Fe) have, approximately, feature of coarse mode distributions.

Generally speaking, it seems that the concentration distributions revelead by this experiment fit quite well the picture of the biophysical processes involved in the life of the tropical rain forest of the Amazon Basin; particularly significant, under this point of view, is the close correlation observed between the fine modes of the distribution curves of S and K (see figs. 2 to 4).

ACKNOWLEDGMENTS

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REFERENCES

1) D.R.Lawson and J.W.Winchester - A Standard Crustal Aerosol as a Reference for Elemental Enrichment Factors. Atmos. Environ. 13 (1977) 925-930.

2) F.C.Adams, M.J.Van Craen and P.J.Van Espen - Enrichment of Trace Elements in Remote Aerosols. Environ.Sci. & Techn. 14 (8) (1980) 1002-1005.

3) F.Adams, M.Van Craen, P.Van Espen - The Elemental Composition of Atmospheric Aerosol Particles at Chacaltaya, Bolivia. Atmos.Environ. 14 (1980) 879-893.

4) P.J.Crutzen et al - Biomass Burning as a Source of Atmospheric Gases CO,H_2,N_2O,NO,CH_3Cl and COS. Nature 282 (1979) 253-256.

5) D.Lawson - Chemistry of the Natural Aerosol: A case study in South America. Ph.D.Thesis, Fla. State Univ., Tallahassee, U.S.A., 1978.

6) C.Q.Orsini and L.C.Bouéres - A PIXE set up for South America Air Pollution Studies. Nucl.Instr. & Meth., 142 (1977) 27-32.

7) C.M.Q.Orsini and L.C.Bouéres - Atmospheric Aerosol Characterization by means of Impactor Samples Analyzed by PIXE. Rev.Bras.Fis. 9 (3) (1979) 747-757.

TABLE 1 - GENERAL DATA FROM FIELD SAMPLING AT DUQUE-STATION IN THE AMAZON FOREST (1980).

SAMPLING #	DATE OF SAMPLING		DURATION OF SAMPLING (HOURS)	AVERAGE FLOW RATE (P/MIN.)	TOTAL SAMPLED VOL. (M^3)
	STARTED ON DAY/MONTH/TIME	FINISHED ON DAY/MONTH/TIME			
AM6A AM6C	23 AUG 10:33	25 AUG 15:42	53,2	0,63	2.009
AM5A AM5C	25 AUG 16:10	26 AUG 08:30	~ 11*	—	—
AM4A AM4C	26 AUG 16:20	28 AUG 16:50	48,5	0,55	1.595
AM3A AM3C	28 AUG 17:25	02 SEPT 15:20	89,5*	0,60	3.209
AM2A AM2C	02 SEPT 15:55	04 SEPT 11:55	44	0,56	1.486

* There was power interruption during about 4hs.

TABLE 2: TRACE-ELEMENTS CONCENTRATIONS DETERMINED BY THE PAIR OF IMPACTOR 4A AND 4C (IN NG/M^3); VOLUME OF AIR SAMPLED: 1.595 M^3

	IC - AM4A							IC - AM4C						
IC STAGE / ELEMENT	0	1	2	3	4	5	Σ (0to5)	0	1	2	3	4	5	Σ (0 to 5)
Al			12.34	21.51	63.05		96.90			4.82		41.43	136.2	182.5
Si	25.40		13.27		60.77		99.44	40.41		7.38		56.11	131.0	234.9
P				4.21			4.21							
S	27.20	159.6	91.80	22.61	13.79	25.95	34.09	19.02	156.9	132.1	23.10	24.02	20.43	374.9
Cl			3.98	12.75	48.00	41.65	106.4					63.61	47.91	111.5
K	9.88	62.89	39.60	15.49	45.29	22.10	195.3	5.32	59.46	73.64	19.31	50.08	17.87	225.7
Ca		3.21	3.26	4.07	12.27	83.23	106.0			7.67	6.86	11.90	52.70	79.13
Ti				1.09	4.51	27.79	33.39				1.33	3.56	10.59	15.48
Fe			2.79	7.04	20.18	35.84	65.85			2.86	8.15	19.26	32.56	62.83
V		3.34	2.39				5.73		3.37	1.50				4.87

TABLE 3: TRACE-ELEMENTS CONCENTRATIONS DETERMINED BY THE PAIR OF IMPACTORS 3A AND 3C (IN NG/M^3);

VOLUME OF AIR SAMPLED: 3.210M^3.

	IC - AM3A							IC - AM3C						
IC STAGE / ELEMENT	0 (*)	1	2	3	4	5	Σ (1 to 5)	0	1	2	3 (*)	4	5	Σ (0 to 5,-3)
Al	-		3.11		2.26		5.37		39.20		-	1.26		40.46
Si	-		5.96		6.88	8.20	21.04	20.53	6.08		-	8.40	21.85	56.86
P	-				4.19		4.19				-	5.02		5.02
S	-	136.2	57.38	11.79	7.76	1.97	215.1	5.79	95.7	105.5	-	8.47	3.02	218.5
Cl	-			2.79	12.88	6.81	22.48				-	12.69	8.96	24.44
K	-	57.54	17.47	12.48	31.54	13.88	139.9	6.93	32.42	39.58	-	36.92	17.13	132,9
Ca	-	0.77	1.32	1.94	4.49	5.60	14.12		1.52	3.30	-	5.11	8.91	20.78
Ti	-			0.52	0.44	0.31	1.27				-	0.81	1.04	2.37
Fe	-	0.79	1.74	4.44	5.05	3.54	15.56		1.97	2.40	-	6.23	5.55	16.15
V	-								0.36					0.36

* - Samples correspondent to stage 0, IC-AM3A, and stage 3, IC-AM3C, were not analyzed by PIXE.

TABLE 4: TRACE-ELEMENTS CONCENTRATIONS DETERMINED BY THE PAIR OF IMPACTOR 2A AND 2C (IN NG/M^3);

VOLUME OF AIR SAMPLED: 1,486M^2

	IC - AM2A							IC - AM2C						
IC STAGE / ELEMENT	0	1	2	3	4	5	Σ (0 to 5)	0(*)	1	2	3	4	5	Σ (1 to 5)
Al		13.2	—			5.45	18.66	—				0.91	9.33	10.24
Si	36.71	16.6	6.03		27.36		86.10	—		7.71		26.87	43.76	78.34
P				4.31			4.31	—			7.37			7.37
S	30.92	137.9	47.9	5.71	12.18		234.6	—	127.3	74.4	9.29	12.14	2.97	226.1
Cl				4.98	23.53	7.17	35.68	—			6.89	25.37	14.21	46.47
K	9.37	68.5	21.1	12.13	29.45	7.80	148.4	—	58.32	32.70	10.83	31.99	15.33	149.2
Ca		3.65	2.26	4.33	7.09	8.64	25.97	—	2.36	2.00	3.62	7.90	6.90	22.78
Ti				0.21	0.68	1.58	2.47	—				1.07	3.69	4.76
Fe			2.92	5.09	15.24	9.54	32.79	—		2.02	10.33	14.46	15.68	42.49
V		0.79					0.79	—						

* - Samples correspondent to stage 0, IC-AM2C, weren't analyzed by PIXE.

FIGURE CAPTIONS

FIG.1 - The geographic location of "Estação Duque" of the "Instituto Nacional de Pesquisas da Amazônia".

FIG.2 - The average size distribution curves of S, K, Ca and Fe from the impactors 4A ad 4C.

FIG.3 - The average size distribution curves of S, K, Ca and Fe from the impactors 3A and 3C.

FIG.4 - The average size distribution curves of S, K, Ca and Fe from the impactors 2A and 2C.

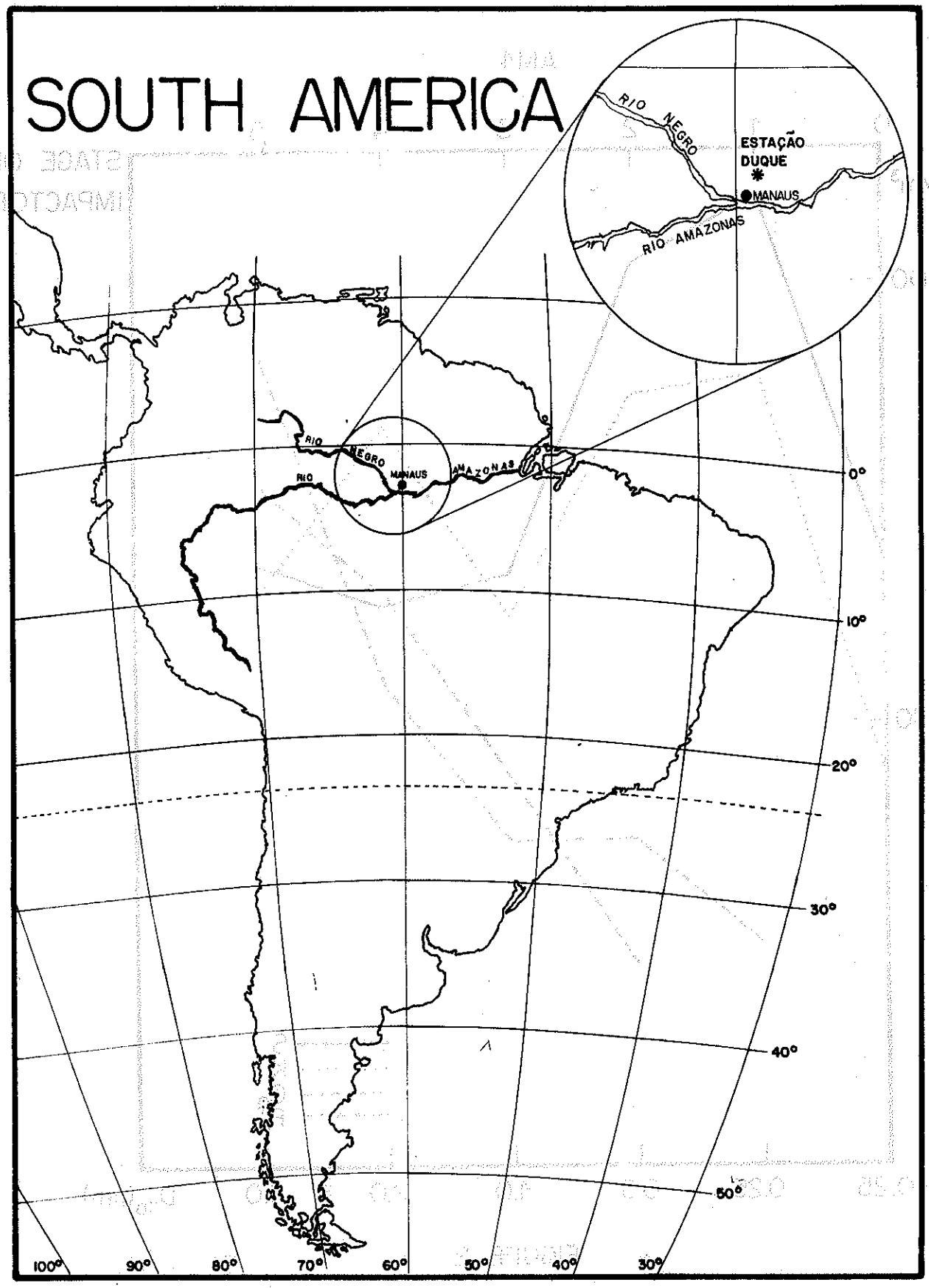
SOUTH AMERICA
RIO NEGRO
ESTAÇÃO DUQUE
MANAUS
RIO AMAZONAS
RIO NEGRO
MANAUS
AMAZONAS
RIO
0°
10°
20°
30°
40°
50°
100°
90°
80°
70°
60°
50°
40°
30°

FIGURE 1

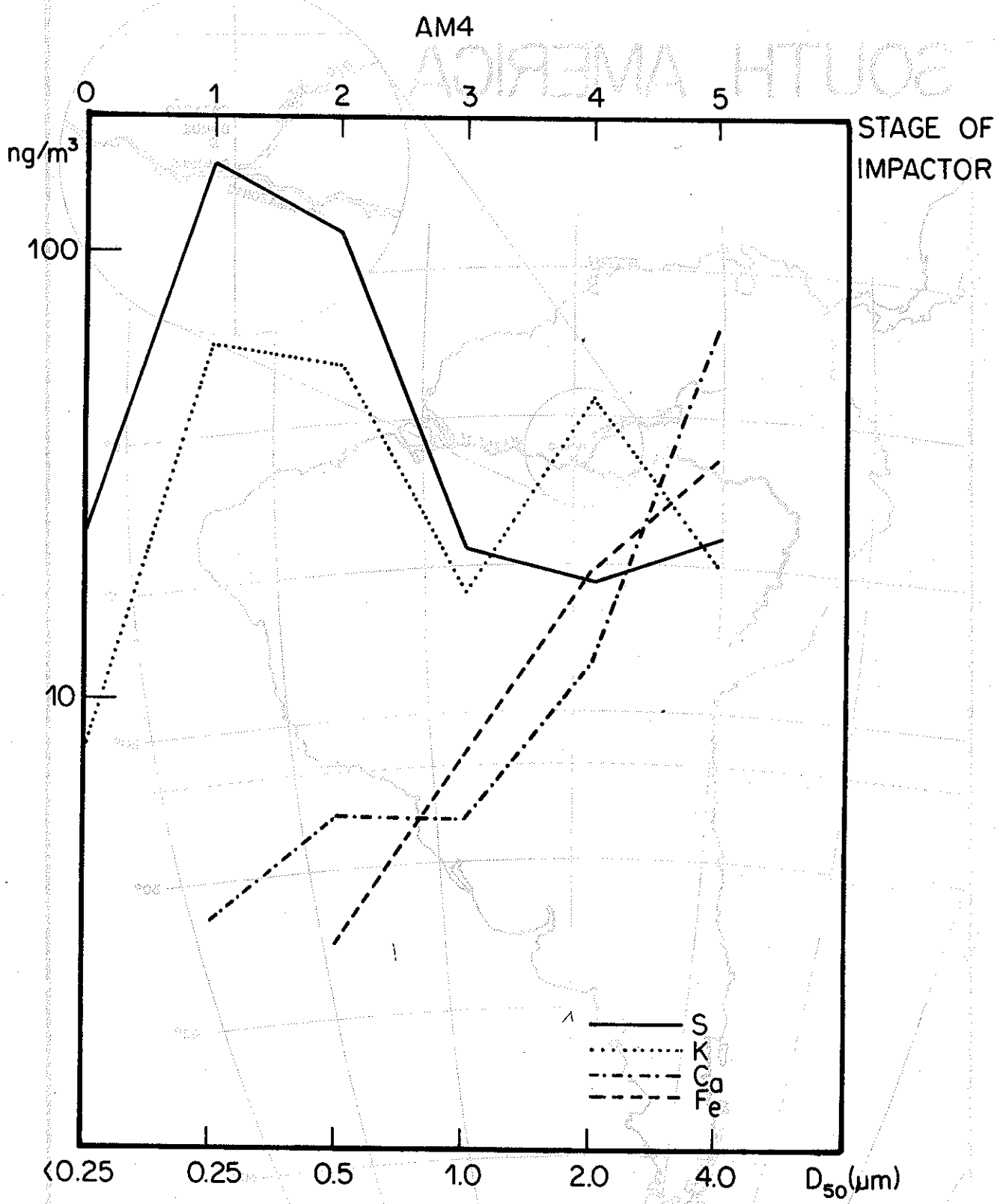
AM4
0
1
2
3
4
5
STAGE OF IMPACTOR
ng/m³
100
10
S
K
Ca
Fe
<0.25
0.25
0.5
1.0
2.0
4.0
D50(μm)

FIGURE 2

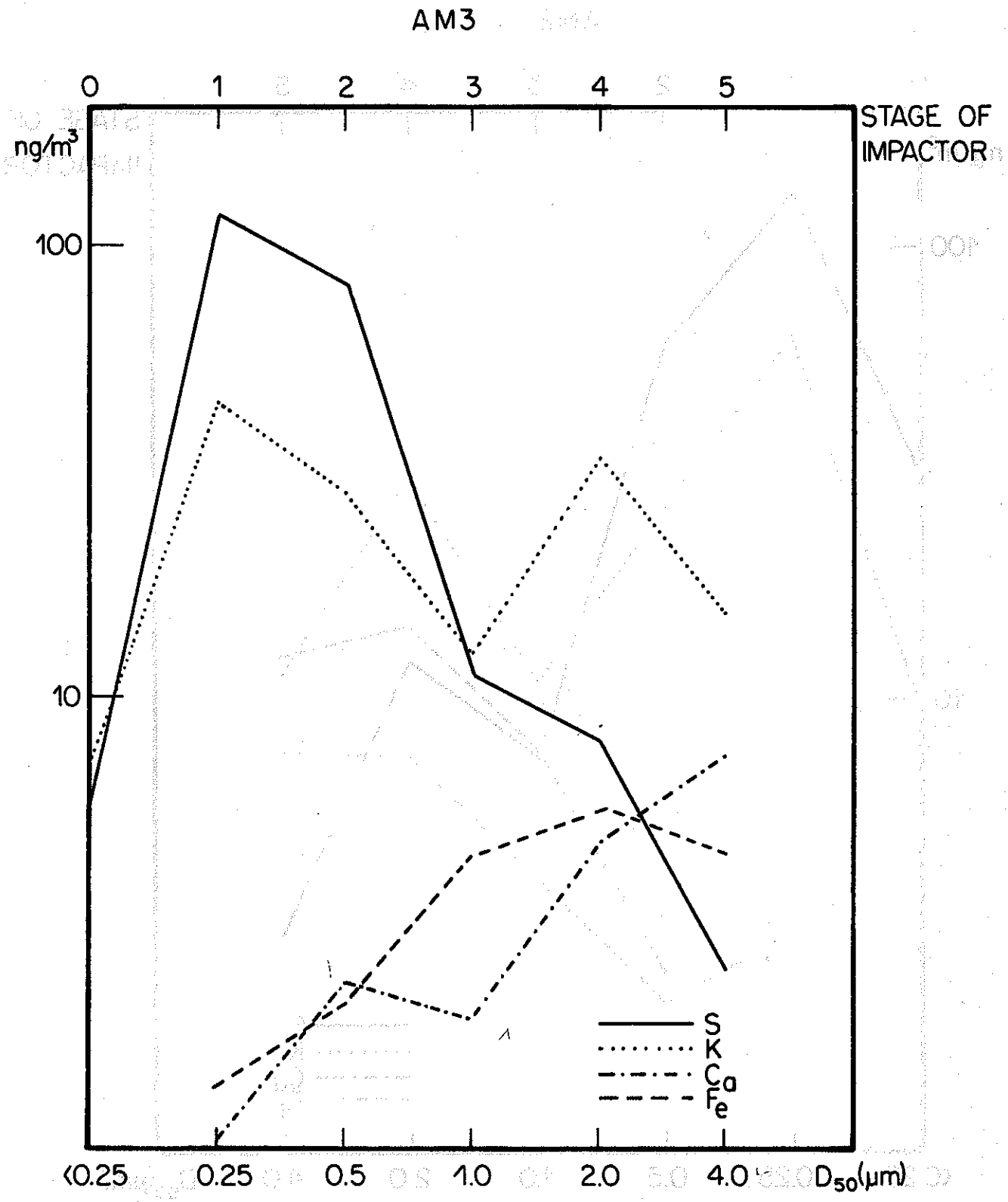
AM3
0
1
2
3
4
5
STAGE OF IMPACTOR
ng/m³
100
10
S
K
Ca
Fe
<0.25
0.25
0.5
1.0
2.0
4.0
D50(μm)

FIGURE 3

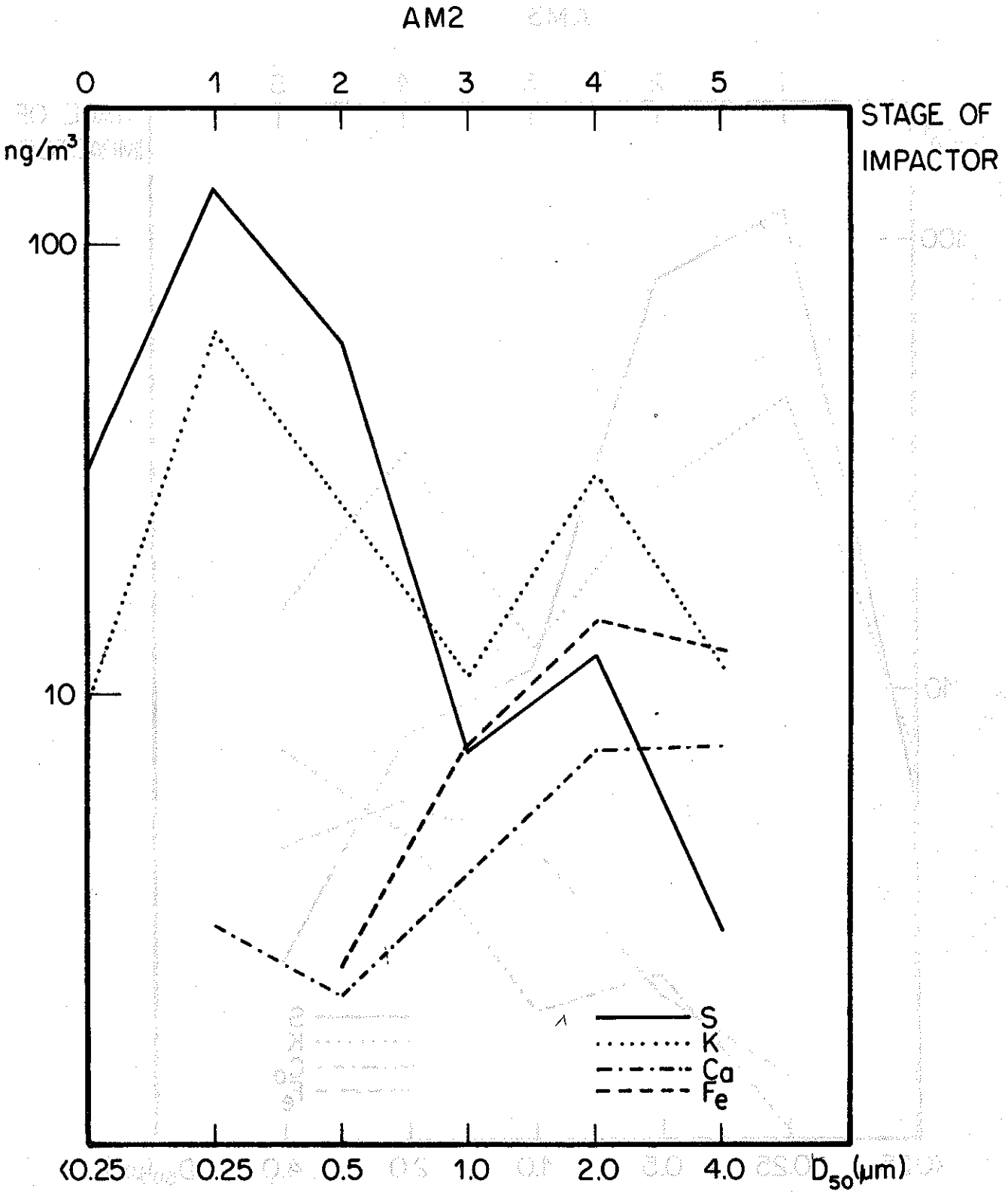
AM2
0
1
2
3
4
5
STAGE OF IMPACTOR
ng/m³
100
10
S
K
Ca
Fe
<0.25
0.25
0.5
1.0
2.0
4.0
D50(μm)

FIGURE 4