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DESERT

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A brief summary of the motivation for and the results so far achieved in a project on determination of trace elements in the remote background aerosols of the Namib desert is presented. The project is an international collaborative effort between the universities listed, and carried out with the cooperation and assistance of the S.W.A. Department of Nature Conservation and Tourism and the Desert Ecological Research Unit.

Motivation

The sulphur content of atmospheric particulate matter in non-urban areas is apparently rising above natural levels in the Northern Hemisphere. Sulphur emissions to the atmosphere are also increasing with increasing combustion of fossil fuels. Current research attention is being focussed not only on gaseous sulphur dioxide, but also on particulate forms, including sulphates and sulphuric acid which may have more severe biological effects than SO_2 . Atmospheric residence time and transport distance from the point of origin may depend on particle size as well as on the rate of conversion of gaseous to aerosol form. The understanding of the transformation and transport of sulphur compounds in the atmosphere requires the measurement of aerosol characteristics in locations far from, as well as near to, pollution sources. Also required are simultaneous measurements of trace metals and other constituents which may be associated with gas-to-particle conversion processes of sulphur or which may serve as tracers of atmospheric pollution transport. A task of fundamental importance, as yet not completed, is the determination of natural atmospheric levels of aerosol sulphur compounds.

Proton induced x-ray emission, PIXE, is a method suitable for determining sulphur in atmospheric particulates, together with other heavier trace elements, when suitable

sampling equipment is used. A global network of non-urban studies using PIXE, of which the sampling site at Gobabeb in the Namib desert is one, are now developing a data base on which questions on natural levels of sulphur can be answered.

Sampling and Analysis

A site for sampling background aerosols must satisfy conflicting requirements: It should be remote from all possible sources of anthropogenic aerosols, specifically industrial centres and major highways, yet it should be reasonably accessible to qualified servicing personnel, have a mains electricity supply and laboratory facilities if long term sampling is envisaged. Preferably the site should not be in a region of heavy vegetative cover since burning and various organic processes can add significant local concentrations of heavier elements to the aerosol. The Desert Ecological Research Unit, situated at Gobabeb (23° 45' S, 15° 03' E) in the Namib desert, was selected since it satisfies most of these requirements. Gobabeb is 100 km from Walvis Bay, the nearest town and vehicle movements in the vicinity are less than ten per day.

Samples were collected using a Batelle type cascade impaction which divides the aerosol into six size fractions in the range $> 0.2 \mu\text{m}$ and $< 4.0 \mu\text{m}$ aerodynamic diameter. Sampling began in November 1976 and continued until May 1977. Sampling time was generally 126 hours at 1.2 l/min, yielding a volume of 9 m³. A first order weather station is maintained at Gobabeb (by the S.W.A. administration) so continuous wind and thermohydrographic data are available.

Samples for the first fourteen weeks have been analysed at Florida State University, using PIXE and the spectra have been reduced using the computer code REX.

Results and Discussion

An example of an aerosol spectrum is given in Fig. 1. The size distributions of the elemental concentrations for each of the twelve runs analysed were very similar; a summary of the data, in the form of geometric means of the concentrations over all samples, is plotted in Fig. 2 for Ca, K, Fe, Mn, Ti and Sr, and in Fig. 3 for Cl, S and Br. The time variations of the concentrations for various elements are presented in Fig. 3. For Ca, K, Cl, Fe and Ti the total concentrations, summed over all six stages, are plotted. Inspection of Fig. 3 shows that S and possibly Br have bimodal size distributions. Accordingly the concentrations for each mode have been plotted, by combining the first three and last three impactor stages for these two elements.

In terms of aerosol chemistry, the concentration variations with time are remarkably small. Variations for all elements follow the same approximate pattern; there are no coherent variations between different groups of associated elements. There was no obvious correlation with wind direction. The size distribution patterns for each element are remarkably similar from sample to sample. These observations point to an aged, well mixed aerosol typical of a large region and free from strong local sources, either natural or man made. (The large concentration on the last stage, a Nuclepore backup filter, is due to bounce-off of particles from the previous stages, due either to overloading or electrostatic effects.)

Various deductions can be made from the size distributions of the different elements. The group of elements Fe, Mn, Ti and Sr have closely similar distributions; these elements are all soil derived. Cl, which has a much larger fraction of its mass in the largest (stages 1 and 2) fraction than the soil derived elements, is of marine origin. Ca and K differ from the soil derived elements, as shown by the broken and dotted lines superimposed on the Fe

distribution curve in Fig. 2. Part of the Ca may be of marine origin, or may be derived from soil dust from calcium rich minerals.

The distribution of Br is a typical and appears to show a bimodal distribution. Br is volatile and this may account for its relatively low concentration in the larger sizes. The small particle phase, generally originating from a gaseous phase, is not derived from automobile exhaust gases; such Br is always associated with Pb in the ratio $Pb/Br \approx 5$ and here Pb was observed only intermittently, with $Pb/Br \approx 0.2$.

Sulphur shows a bimodal distribution, indicating two sources, one condensation from a gaseous phase and the other from a liquid or solid phase. The larger fraction is probably of marine origin. The condensed fraction may be due to natural volcanic or anthropogenic (industrial) origin. The S concentrations measured in the present work are consistently low and are among the lowest levels recorded on a continuous basis, indicating a genuine background determination.

Certain elements were only observed sporadically at levels close to detection limits. These were Va, Cr, Cu and Zn.

Conclusions

Interesting and valuable data concerning the true metal composition of background aerosols has been obtained from the Namib aerosol project. A further fourteen samples are being analysed at the N.P.R.U. and further sampling using directionally controlled sampling has been planned. A full report on the data so far obtained is being prepared for submission to the journal Madoqua II, and the results of the S measurements will be combined with the results of other remote sites in a detailed interpretation of sulphur particulate measurements in the Southern Hemisphere.

Figure Captions

Fig 1. Typical PIXE spectrum for an aerosol sample on a Mylar backing.

Fig. 2 The particle size distributions of the geometrical mean elemental concentrations from twelve sets of impactor data, for Ca, K, Mn, Fe, Ti and Sr. Equivalent aerodynamic diameters of the stages sampled by the cascade impactor are:

Stage 1	> 4 μm ;
Stage 2	2 - 4 μm ;
Stage 3	1 - 2 μm ;
Stage 4	0.5 - 1 μm ;
Stage 5	0.25 - 0.5 μm ;
Stage 6	0.4 μm Nuclepore filter.

Fig. 3 The particle size distributions for Cl, S and Br. Refer to caption to Fig. 2.

Fig. 4 Time variation of the total concentration of elements in the atmospheric aerosol. Total concentrations obtained by summing over all impactor stages, except for S and Br, which have stages 1 - 3 (large) and 4 - 6 (small) summed and plotted separately.

FIGURE 1

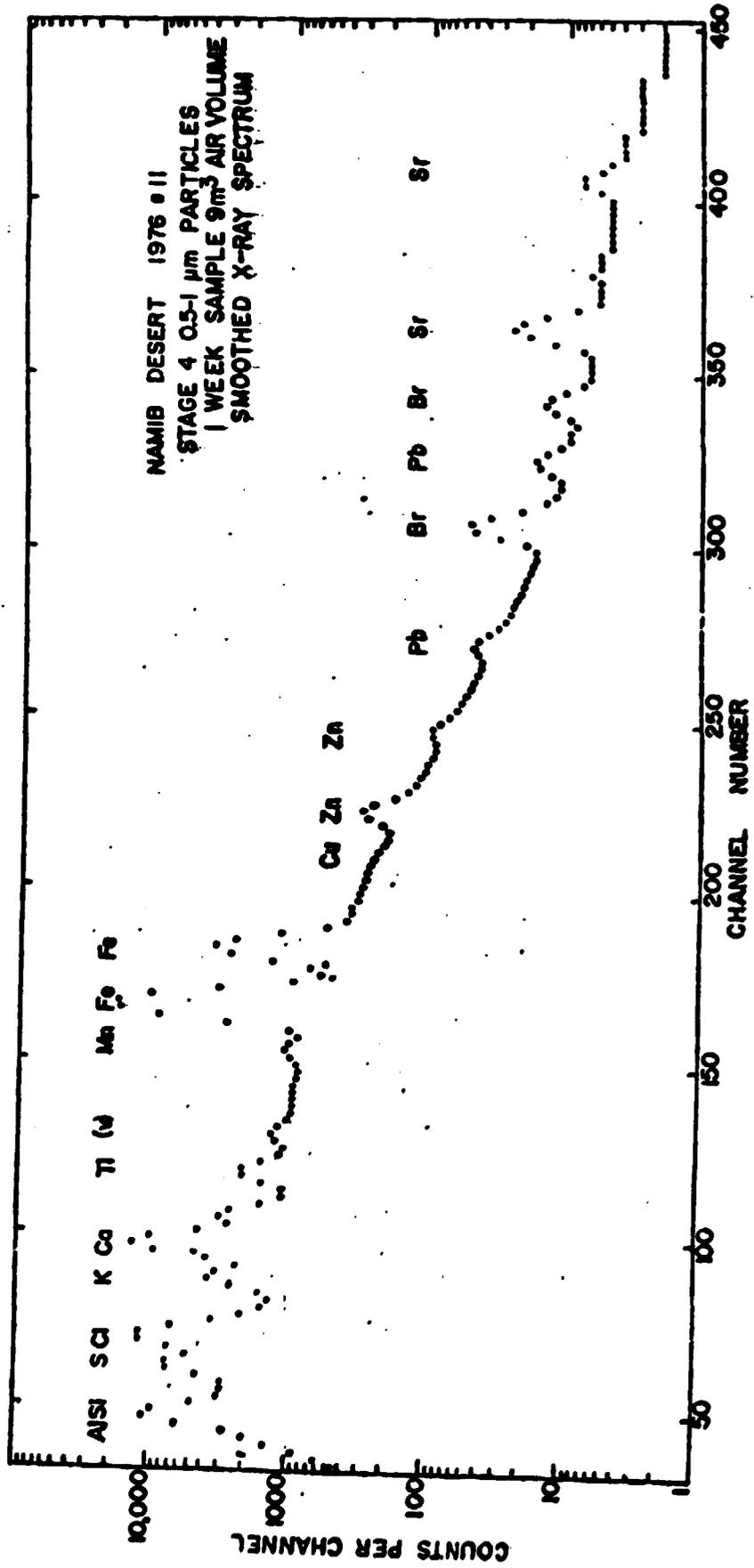


FIGURE 2

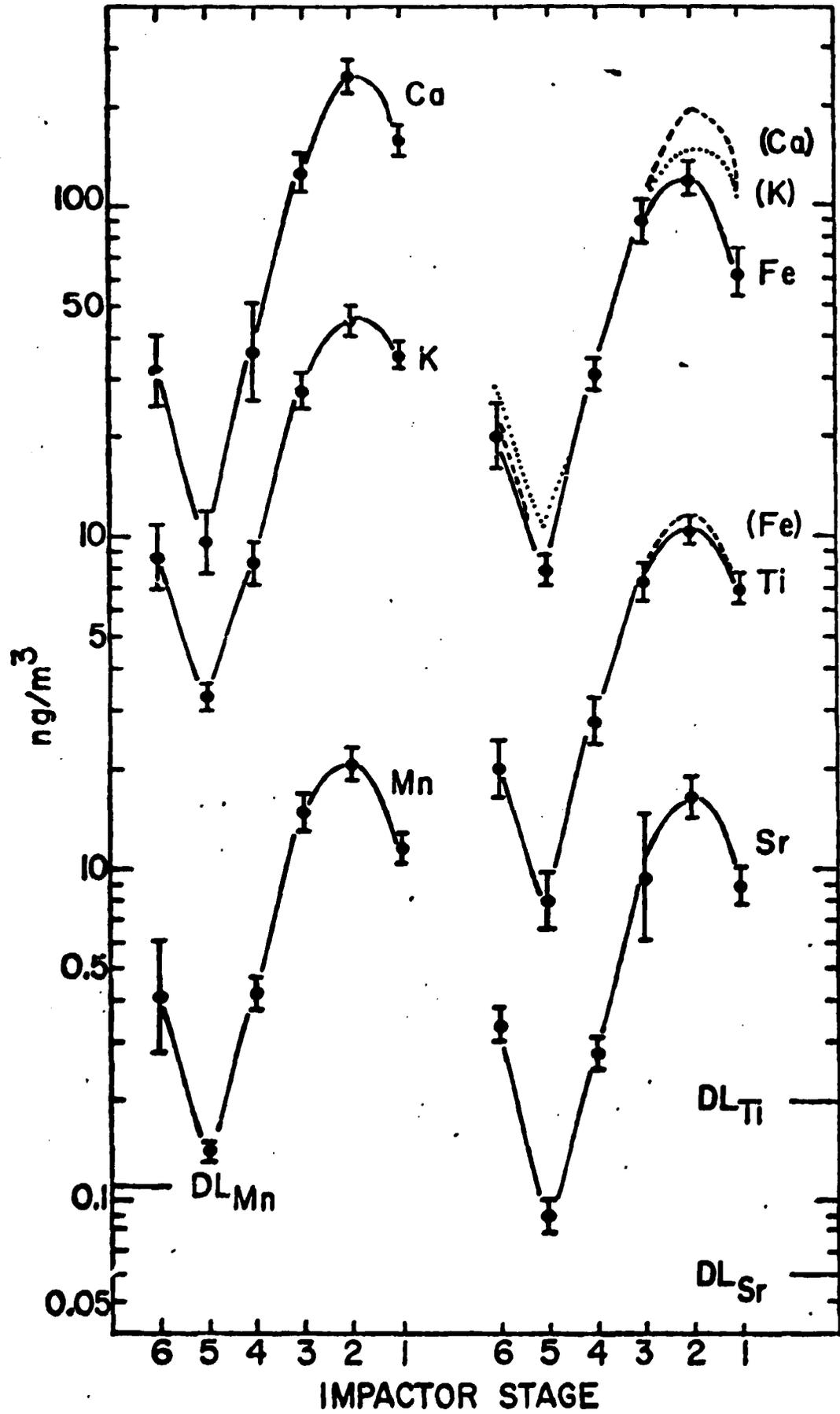


FIGURE 3

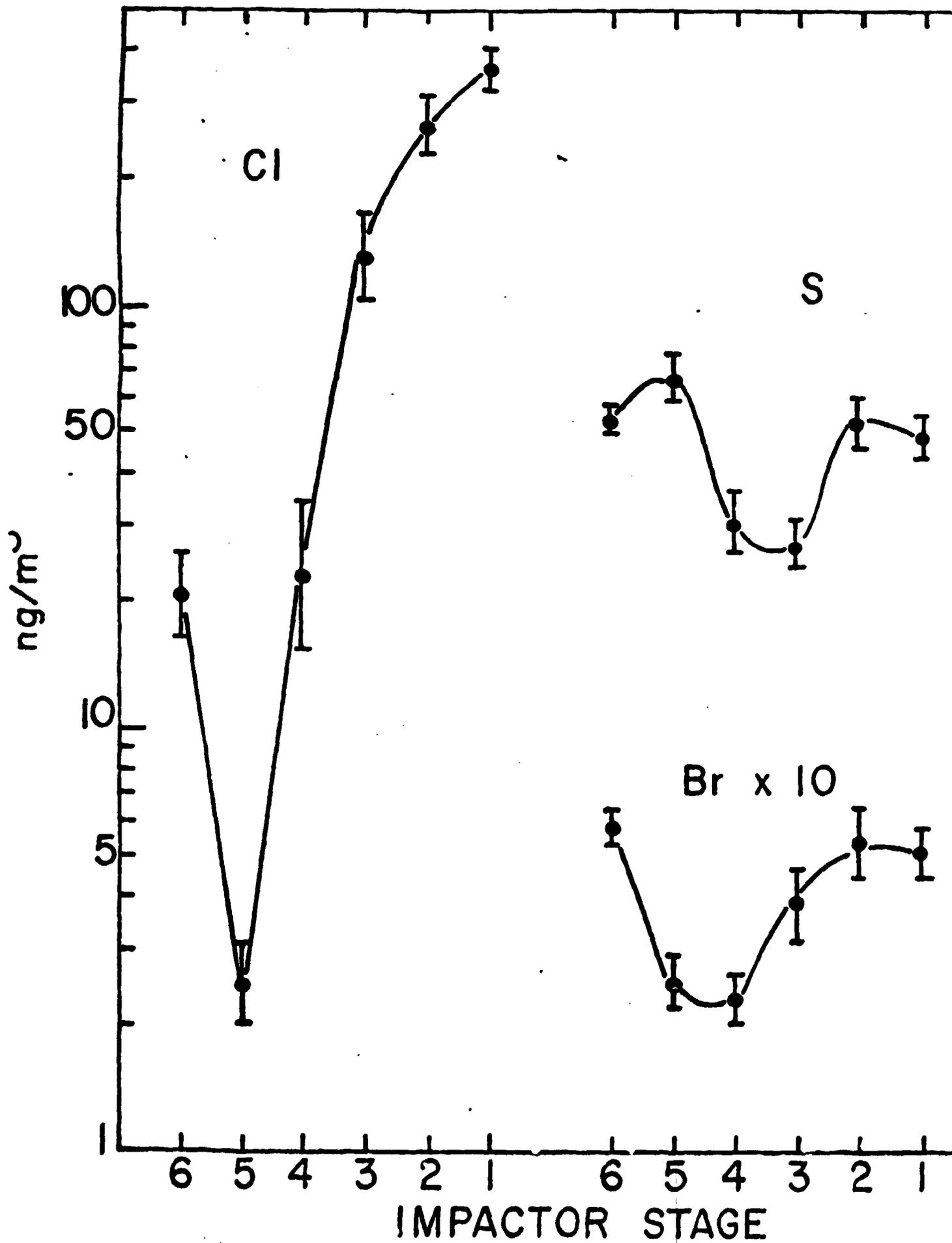


FIGURE 4

