

tion rate is $0.49 \mu\text{g P mg}^{-1} \text{ hr}^{-1}$. A value of 54% for the assimilation efficiency, as suggested by Peters and Rigler, yields a release rate of $0.27 \mu\text{g P mg}^{-1} \text{ hr}^{-1}$.

The estimates of release rates based on radiotracers and illustrated here differ from each other by about twofold. They differ from the average estimate based on molybdate reactive phosphorus measurements in our earlier studies by threefold to fivefold. We believe that, although experiments with radiotracers may yield somewhat higher estimates, there is insufficient evidence that these estimates are more reliable than those obtained using the reactive molybdate analysis. We also believe that the limited variability of the estimates of zooplankton P release compared with the great variability of other parameters in the P cycle of lakes does not warrant despair with the reactive molybdate phosphorus technique of determining zooplankton P release

or the general problems of estimating these rates.

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References

- BARLOW, J. P., AND J. W. BISHOP. 1965. Phosphate regeneration by zooplankton in Cayuga Lake. *Limnol. Oceanogr.* **10**(suppl.): R15-R24.
- PETERS, R. H., AND F. H. RIGLER. 1973. Phosphorus release by *Daphnia*. *Limnol. Oceanogr.* **18**: 821-839.

Fluoride: Global circulation

Kilham and Hecky (1973) convincingly demonstrated that the high levels of fluoride in East African surface waters are due to rock weathering. However, they have extended the interpretation of their data to the global circulation of fluoride in a way that is unjustified.

Kilham and Hecky propose, contrary to the views of Carpenter (1969), that the majority of fluoride entering the World Ocean is derived from weathering and not from atmospheric recycling of oceanic fluoride. To support this thesis they suggest that the F:Cl ratios in atmospheric precipitation quoted by Carpenter (0.03-0.12 kg kg⁻¹) are due primarily to fluoride from volcanic emanations, anthropogenic activity, and atmospheric dust of continental origin. Bewers (1972) has shown that the average F:Cl ratio in atmospheric precipitation required to account for all the fluoride in rivers is only 0.013 kg kg⁻¹. While we admit that even this figure requires considerably more efficient transport of

marine fluoride than chloride through the atmosphere, one cannot conclude, as Kilham and Hecky have done, that this must infer the existence of elevated (relative to seawater) F:Cl ratios in marine aerosols. It is indeed pertinent to this discussion that Wilkness and Bressan (1971, 1972) have established that the F:Cl ratio in marine aerosols is close to that of seawater, but to assume that aerosols are the only agents of fluoride transport from the oceans to the atmosphere is premature. Calculation of the hydrogen fluoride flux across the sea-air interface, based on the model of Liss and Slater (1974), suggests that sufficient fluoride to account for the concentrations of this element found within the hydrologic cycle can enter the atmosphere in gaseous form.

In their work on the MacKenzie River basin, whose waters and sediments have fluoride concentrations close to that of the world average river, Reeder et al. (1972) concluded that precipitation is a primary

contributor to river fluoride. This agrees with Carpenter's (1969) conclusion that the rate of fluoride removal by oceanic sedimentation processes is insufficient to account for the majority of this element discharged to the World Ocean by rivers.

The importance of nonmarine sources to the fluoride content of atmospheric precipitation may be gauged by comparing estimates of the maximum rates of fluoride availability from anthropogenic activity (4×10^8 kg yr⁻¹), volcanism (1×10^9 kg yr⁻¹), and airborne terrigenous dust (5×10^8 kg yr⁻¹) with the estimated rate of global precipitation of fluoride in rain and snow (1.2×10^{10} kg yr⁻¹) (Bewers and Haysom 1974). Not only is fluoride from nonmarine sources inadequate to greatly influence the composition of atmospheric precipitation on a global scale, but anthropogenic fluoride superpositions on natural levels are unlikely to be detectable in polar ice or lake sediments, even if the latter were unmodified by postdepositional changes.

In conclusion, Kilham and Hecky's paper provides valuable and well interpreted geochemical data from the African continent. Considerably more evidence is required, however, to support their contention that weathering dominates atmo-

spheric recycling of oceanic fluoride on a global scale.

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References

- BEWERS, J. M. 1972. The global circulation of the halogens. *Int. Geol. Congr.*, 24th, Montreal. *Geochemistry* **10**: 273-281.
- , AND H. H. HAYSON. 1974. The terrigenous dust contribution to fluoride and iodide in atmospheric precipitation. *J. Rech. Atmos.* (in press).
- CARPENTER, R. 1969. Factors controlling the marine geochemistry of fluorine. *Geochim. Cosmochim. Acta* **33**: 1153-1167.
- KILHAM, P., AND R. E. HECKY. 1973. Fluoride: Geochemical and ecological significance in East African waters and sediments. *Limnol. Oceanogr.* **18**: 932-945.
- LISS, P. S., AND P. G. SLATER. 1974. Flux of gases across the air-sea interface. *Nature (Lond.)* **247**: 181-184.
- REEDER, S. W., B. HITCHON, AND A. A. LEVINSON. 1972. Hydrogeochemistry of the surface waters of the MacKenzie River drainage basin, Canada—I. Factors controlling inorganic composition. *Geochim. Cosmochim. Acta* **36**: 825-865.
- WILKNISS, P. E., AND D. J. BRESSAN. 1971. Chemical processes at the air-sea interface: The behavior of fluorine. *J. Geophys. Res.* **76**: 736-741.
- , AND ———. 1972. Fractionation of the elements F, Cl, Na and K at the sea-air interface. *J. Geophys. Res.* **77**: 5307-5315.

Transparency-chlorophyll relations

Recent papers by Bannister (1974a, b) in this journal have developed equations for phytoplankton production which are more satisfying theoretically than previous ones in the literature and which I regard as a major contribution to the subject. However, as the author points out, there are problems in applying the equations to a natural situation. One difficulty is that total light absorption must be partitioned into k_c , the extinction coefficient for phytoplankton pigments, and k_w , the extinction due to the water itself and to dissolved and particulate substances. This presupposed

that k_c is relatively constant, and one must then measure total absorption and determine k_w by difference.

Bannister (1974b) postulated a value of 0.016 for k_c ; the extinction coefficient for phytoplankton is then $0.016C$, where C is the concentration of chlorophyll a . In deriving this value he quoted various literature sources, and among them was a paper that I wrote some years ago (Riley 1956) in which a statistical analysis of the relations between the extinction coefficient K and chlorophyll C yielded the equation

$$K = 0.04 + 0.054C^{0.75} + 0.0088C.$$