

References and Notes

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Pyrene and Fluoranthene in Manganese Nodules

Abstract. *The polynuclear aromatic hydrocarbons pyrene and fluoranthene have been isolated from manganese nodules of the western North Atlantic.*

Polynuclear aromatic hydrocarbons occur in many geological materials, including recent marine, inshore sediments (1). The hydrocarbon content of a marine mineral deposit of high redox potential has now been investi-

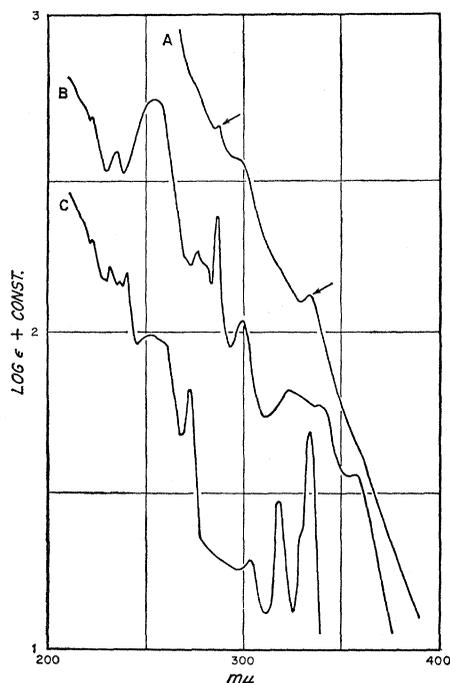


Fig. 1. A, Total isooctane-benzene fraction; B, fluoranthene from GLC; C, Pyrene from GLC.

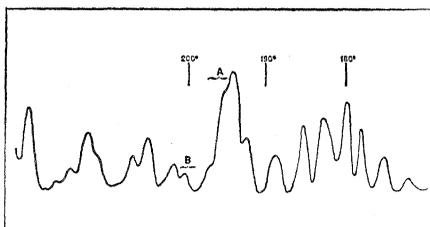


Fig. 2. Gas chromatogram of total isooctane-benzene fraction.

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gated and the four-ring aromatics pyrene and fluoranthene have been isolated.

The manganese nodules used in this investigation were collected from the Blake Plateau (2). Two nodules were examined separately, giving similar results (Table 1).

After grinding to less than 200 mesh, samples were extracted with chloroform and the extracts were chromatographed on activated alumina with graded eluents composed of isooctane, benzene, and diethylether. An ultraviolet spectrum (3) (Fig. 1) of the fraction eluted with a mixture of isooctane-benzene (4:1) showed principal maxima for pyrene and fluoranthene at 334 and 287 m μ .

A gas chromatogram (4) (Fig. 2) indicated many compounds in this fraction. Shoulder A had the retention time of synthetic fluoranthene, and peak B corresponded to pyrene. Each of these components was collected by condensation in glass capillary tubes inserted into the gas chromatograph outlet. The capillaries were then rinsed with isooctane. Ultraviolet absorption spectra (Fig. 1) of the resulting solutions confirmed the presence of pyrene and fluoranthene. Incomplete chromatographic separation accounts for additional peaks in the spectra.

All concentrations given in the table are based on ultraviolet spectra of the total chromatographic fraction containing both hydrocarbons. The absorption maxima mentioned above were used for the calculations, after a correction for high background absorption.

Spectra of all fractions in the alumina chromatogram were examined for the presence of other hydrocarbons; however, none were detected. The other compounds indicated in the gas chromatogram, some in significant concentrations, were not further investigated. They lacked characteristic ultraviolet spectra, which made possible the identification of the hydrocarbons on a microgram scale.

Pyrene and fluoranthene are the two most abundant polynuclear hydrocarbons in sea water, with the latter in larger concentration (5). These compounds may have been adsorbed from the sea water during the formation of the manganese nodules. However, the possibility that they were formed *in situ* by organisms living on the nodules, such as bacteria, cannot be excluded. This finding extends the known range

Table 1. Hydrocarbon concentrations.

Manganese nodules (g)	Hydrocarbons (10 ⁻³ ppm)	
	Pyrene	Fluoranthene
283	2	4
338	6	8

of natural occurrence of polynuclear hydrocarbons and suggests that compounds of this type can be well preserved in strongly oxidized sediments deposited under high redox potentials.

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References and Notes

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2. 30°53'N, 78°47'W, 445 fathoms, *Atlantis* cruise No. 266.
3. Cary recording spectrophotometer, Model 14.
4. Aerograph HyFI, model 600, with hydrogen flame detector and linear temperature programmer. Column: 0.3 cm by 1.8 m of 5 percent Dow Corning RTV 502 on 80/100 mesh acid-washed, silanized Chromosorb W.
5. M. Blumer, unpublished data.
6. Supported by research contracts with the U.S. Navy Bureau of Ships and the U.S. Office of Naval Research [Nonr 2196 (00)] and by the grant of a Woods Hole Oceanographic Institution summer student fellowship to one of us (D.W.T.). The manganese nodules were collected by T. R. Stetson. This report is contribution No. 1430 of the Woods Hole Oceanographic Institute.

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Hydrogen in a Tektite Vesicle

A philippinite, No. PO-301, found by E. C. T. Chao at the Rafael Ortega site, Mandalayong, Philippine Islands, was shown by P. D. Lowman, Jr., to have a specific gravity of 2.04, which, taken in conjunction with a mass of 11.10 grams and a presumed specific gravity of the stony material of 2.45 indicates an internal bubble with a volume of 0.89 cm³. When the contained gases were excited by an electrodeless discharge at the Goddard Space Flight Center by the technique of O'Keefe, Dunning, and Lowman (1), the spectrum consisted almost exclusively of the so-called second spectrum of hydrogen, that is H₂, between 6225 and 5949Å every line with an intensity 10 in Gale *et al.* (2) was found; in addition, only one other line, of intensity 8, was measured. Shortward of 5949Å the correspondence was poorer; nevertheless, all lines could be explained as due to H₂, with the possible ex-