

Growth Rate and Chemical Composition of a Manganese Nodule from the EEZ of Seychelles

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Abstract

A ferro-manganese nodule collected in EEZ of Seychelles yields a growth rate of 1.5 mm/10 ⁶Y by ²³⁰Th(ex) and ²³⁰Th(ex)/²³²Th activity ratio methods indicating very slow growth of ferro-manganese nodules. The Mn/Fe and U/Th ratios suggest that the genesis of the studied nodule is of hydrogenetic origin.

INTRODUCTION

One of the important parameters concerning the ferro-manganese nodules is their growth rates. The data on growth rates supplemented by chemical and mineralogical studies is useful in deciphering age and nature of their origin. U-Th series radionuclides are commonly used as a chronometer for ferro-manganese nodules (Ku, 1977; Broecker and Peng, 1982). ²³⁰Th has a half life of 75,200 years which permits age determination for the past 0.4 m.y. in the ferro-manganese nodule. Though the ²³⁰Th(ex) dating is confined to 1 mm depth in the nodule, these estimated rates are found to be in good agreement with those based on ¹⁰Be techniques (Sharma and Somayajulu, 1982; comprehensive review article by Broecker and Peng, 1982). Although extensive studies have been carried out on the mineralogy and geochemistry of the Indian Ocean Nodules (Cronan and Tooms, 1967; Coolley *et al.* 1979; Cronan and Moorby, 1981; Rao, 1985; Karisiddaiah, 1985; Ahmed and Hussain, 1987), very little data exists on the Indian ocean nodules growth rates, barring a few (Sharma and Somayajulu, 1983). Here we report ²³⁰Th(ex) and chemical composition results on a nodule from the EEZ of Seychelles.

The nodule under study is collected from a depth of around 4500 m. It is highly compact with smooth surface texture and spherical in shape. The depositional environment in the area is a calcareous sediment.

SAMPLING PROCEDURE

The sampling procedure employed for the radiochemical and chemical studies is essentially the same as the one earlier reported (Ku and Broecker, 1969; Bhat *et al.* 1970). In brief, the successive layer-by-layer scraping of the topmost 1 mm thick layer of the nodule was done using surgical blade and dental drill. The thickness of each layer was determined by weight density relation and as well as directly by vernier calliper. The thickness calculated and directly measured are in agreement within $\pm 20\%$.

The nodule layer samples were finely powdered and dried at 110°C for about 12 hours. For U-Th isotope analyses, known weight of the dried sample was dissolved in 6N HCl + 2 drops H₂O₂ and 400 μ l ²³²U/²³⁸Th equilibrium tracer (Ku and Broecker, 1967) was added. U-Th isotopes were separated and purified by ion exchange techniques (Krishnaswami and Sarin, 1976; Sharma, 1982). These isotopes were finally electroplated on platinum planchets and used as alpha sources and assayed for alpha activity by pulse height analyses by using a solid state detector of 300 mm² active area coupled to a multichannel analyser of EG and G ORTEC.

For elemental concentration, 100 mg of dried powder sample was leached twice with 6N HCl + 2 drops H₂O₂ and made to known volume in 0.5 N HCl medium. The concentration of Mn, Fe, Co, Ni, Cu were measured in Varion Techtron AA-6 AAS using the standard conditions and reagent blanks and ferro-manganese standards (USGS-A₁ and NIO Std. 2388). The reproducibility of the results was checked analysing the samples in triplicate and the coefficients of variation found within 6, 8, 5, 7 and 5% for Mn, Fe, Co, Ni and Cu respectively.

RESULTS AND DISCUSSION

The U-Th isotope data is given in Table I and the radionuclide profiles are given in Figure 1. The errors quoted are due to counting statistics only.

The distribution of uranium and thorium (U/Th wt. ratio) indicates the nature of origin of ferro-manganese nodule (Bonatti *et al.* 1972; Bostrom and Rydell, 1979). In the present case, the uranium content along the depth within the nodule remains nearly constant, while the thorium content shows an increase with depth from 19 to 81 ppm. U/Th ratios range from 0.1 to 0.4 indicating the hydrogenous origin of the nodule studied.

The ²³⁰Th(ex) and ²³⁰Th(ex)/²³²Th profiles give an av. accumulation rate of 1.5 mm/10⁶y. The ²³⁰Th(ex) extrapolated to surface activity is 540 dpm/g and using this value and above deduced growth rate the integrated activity in the nodule is estimated to be 94 dpm/cm². From this data an exposure age of this nodule is 7400 y and the cumulative deposition of ²³⁰Th(ex) is only 10% of its production rate in the overlying water column which is 950 dpm/cm². This observation is similar to the reported values by earlier workers (Ku and Broecker, 1967; 1969; Bhat *et al.* 1970; Krishnaswami *et al.* 1979; Sharma, 1982) and the possible explanations put forth, namely, the nodules grow only 10% of their life time on the sediment surface and/or there is a continuous growth and erosion of their surface such that their net effective overall growth is only 10% and that the radionuclide flux is incorporated in the adjoining sediments (Ku, 1966) are applicable to the presently studied nodules also.

The surface section ²³⁴U/²³⁸U activity ratio is 1.14 \pm 0.02 which equals the present day sea water value indicating the uranium isotopes are incorporated directly from the seawater (Ku, 1966; Ku and Broecker 1967). Assuming the decrease in the ²³⁴U(ex) with depth is due to radioactive decay (Ku 1966) a growth rate for the nodule studied can be estimated to be 1.5 mm/10⁶y, which is consistent with that of ²³⁰Th(ex).

This growth rate estimate for the nodule is for the topmost 1 mm thick layer and hence represents the contemporary growth process. This rate falls in the

TABLE I. Radiochemical and chemical analyses of RVG (S)-134 D ferromanganese nodule.

Layer No.	Depth within nodule (mm)	Uranium (ppm)	Thorium (ppm)	^{234}U		^{230}Th (ex) dpm/g	^{230}Th (ex) ----- (AR)	Elemental concentration (%)				
				----- (AR)				^{238}U	Mn	Fe	Co	Ni
I	0.00-0.09	8.00 ± 0.22	19.0 ± 0.7	1.13 ± 0.03		407 ± 11	22.9 ± 0.9	16.7	14.9	0.28	0.45	0.14
II	0.09-0.21	7.9 ± 0.3	53.0 ± 0.8	1.13 ± 0.03		110 ± 1	7.6 ± 0.2	15.6	15.3	0.25	0.43	0.13
III	0.21-0.57	7.7 ± 0.2	80.5 ± 40	1.05 ± 0.02		53 ± 3	2.4 ± 0.2	16.3	14.9	0.25	0.58	0.15
IV	0.57-1.09	7.8 ± 0.1	10.7 ± 0.2	1.03 ± 0.02		Zero		16.0	15.0	0.28	0.47	0.13
BODO-127 D. UN Data on Indian Ocean								13.5	15.6	0.88	0.34	0.05
a) Ferromanganese encrustation								24.7	16.6	0.66	0.56	0.07
b) Ferromanganese nodule								16.8	14.9	0.15	0.56	0.24
Somali basin nodules (Cronan and Moorby, 1981) av. of 2 nodules												

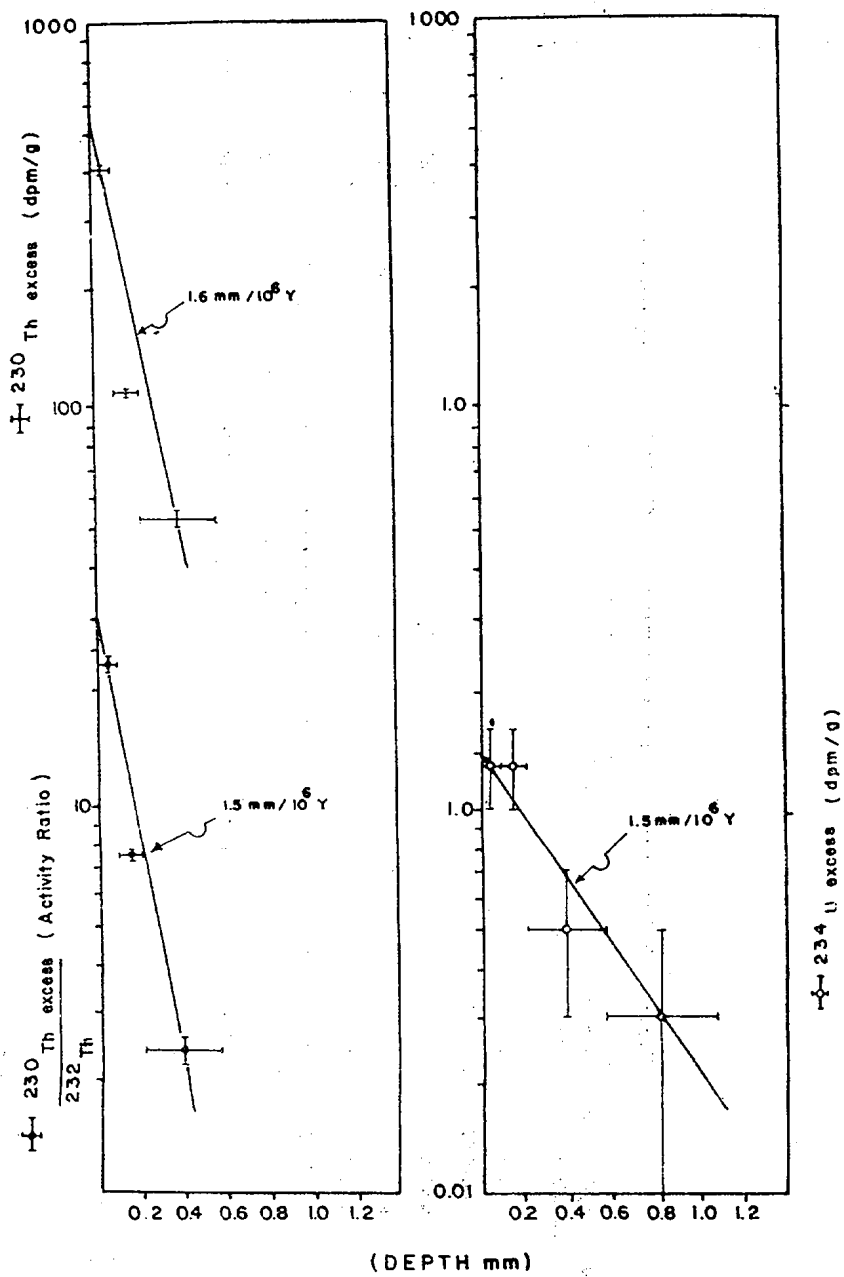


Figure 1. Depth-Decay profiles of Thorium and Uranium in RVG(S)-134D Nodule.

range of 1–6 mm/10⁶ y as reported earlier (Ku and Broecker, 1967 ; 1969 ; Krishnaswami and Cochran 1976 ; Krishnaswami *et al.* 1979 ; Sharma and Somayajulu, 1983) for Pacific and Atlantic. For Indian Ocean nodules, the range is 1–3 mm/10⁶ y (Ku and Broecker, 1969 ; Sharma and Somayajulu, 1983).

The concentrations of Mn, Fe, Co, Ni and Cu are given in Table I. The Mn/Fe ratio for the nodule analysed varies between 0.8 and 1.13 indicating the hydrogenetic growth of nodules (Halbach *et al.* 1981). Comparison of our results with published data for nodules from calcareous sediments of Indian Ocean (Cronan and Moorby, 1981) and nearby location to the present nodule (DODO-127, UN Data) is given in the same Table. The remarkable feature is the vast disagreement between our data and the published data ; such a phenomenon of compositional heterogeneity from nodules for the same area has already been reported (Sharma and Somayajulu, 1983 ; Siddiquie *et al.* 1979). However, our results agree with the nodules from calcareous sediments of Indian Ocean Somali Basin.

CONCLUSIONS

1. The radiochemical studies yielded a slow growth rate of 1.5 mm/10⁶ y for the nodule from calcareous environment of Somali basin.
2. The U/Th wt. ratios and the Mn/Fe ratios suggest that the nodule under study is of hydrogenetic origin.
3. This nodule has grown only up to 10% of its life time or the effective overall growth is only 10%.

ACKNOWLEDGEMENTS

The authors wish to thank late Dr. H. N. Siddiquie, Mr. R. R. Nair for their interest in the present work, Dr. Selvin Gendron for cooperation during our study in Seychelles EEZ and Dr. B. L. K. Somayajulu for suggesting improvements in the MS. Thanks are also due to Miss Alison for typing.

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(Received: Dec. 8, 1987)