THICK SOURCE ALPHA ACTIVITY OF SOME NORTH ATLANTIC CORES[1]

By

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ABSTRACT

Six representative deep sea cores have been analyzed for their thick source alpha emission at about every 20 cm. Some correlation can be made with a calcium carbonate content but not with absolute surface area. The range of relative alpha activity is 2–3 counts/cm^2/hr for sand, 2–4 for globigerina ooze, 4–6 for foraminiferal green clay, and 5–10 for fine white to red clay with low foram content. It appears that total alpha activity cannot be correlated simply with age as might be suggested from the Urry ionium vs. depth curves.

INTRODUCTION

Reconnaissance measurements of the radioactivity of deep core material have been carried out by several workers (Piggot and Urry, 1941, 1942a, b; Urry, 1949; Urry and Piggot, 1942; Evans, Kip and Moberg, 1938; Sanderman and Utterback, 1941; Utterback and Sanderman, 1948). Piggot and Urry determined the radium content of several North and South Atlantic cores; from their data they interpreted the radium vs. depth curve in terms of ionium decay and suggested some tentative dates for various depths. Since radon measurements (from which the radium content is calculated) are more difficult and time-consuming to use than direct alpha-counting, it was thought worthwhile to apply the latter technique to several representative cores. Provided the excess ionium and its decay products contribute a significant fraction of the total activity and provided the uranium and thorium series concentration in the bulk sediment is reasonably constant, a curve of total alpha activity vs. depth would show a maximum due to radium accumulation and ionium decay. Such a curve would permit age estimates to be made. As the following

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results show, this simple picture is not observed in any of the cores measured. In spite of the negative result with regard to age determination, it is considered worthwhile to make these quantitative data available for other purposes such as stratigraphic correlation and sedimentation studies.

EXPERIMENTAL

The alpha activity was measured on thick sources by the scintillation method. The scintillation counting technique, developed in this laboratory for low level alpha activity measurement, is described elsewhere (Kulp, Holland and Volchok, 1952). By this method the reproducibility for the counting intervals used is about 2%. Duplicate analyses were made on a large portion of the samples included in this report, and in several cases three or four repeat measurements were made. The results are reported in counts/cm^2/hr. Conversion of this value to α/mg/hr involves a number of uncertainties, including the nature of the distribution of the radioelements, the uranium-thorium ratio, and the mineral densities. On this particular type of sediment, it is not considered likely that the surface contamination around grain boundaries, observed by Hurley (1950) for granites, is a major problem. However, there are other equally difficult things to consider, especially particle size and mineral distribution. Thin source and radon studies are in progress which will make it possible to determine the exact uranium-thorium ratio and the activity per unit mass.

The core samples were dried at 110° C, powdered to less than 200 mesh and placed in a circular tray within 0.5 mm of the silver activated zinc sulfide phosphor which is coated on the window of an RCA 5819 photomultiplier tube. Absolute calibration is obtained with thick sources containing known amounts of the uranium and thorium series in a silicate matrix obtained from the National Bureau of Standards (B. S. No. 11, No. 12).

Calcium carbonate determinations by standard gravimetric procedure were carried out on certain samples. Surface area determinations on some of the samples were made as described by Kulp and Carr (1952). Estimates of surface water temperature changes at the various core stations were made by Ericson. These are based on variation in the planktonic or floating species of foraminifera and therefore apply only to the uppermost few hundred meters of water.

RESULTS

Fig. 1 shows the location of the six cores investigated in this work and of one Kelvin core measured by Urry. Table I summarizes the geographical and depth data of each core. All of the cores except

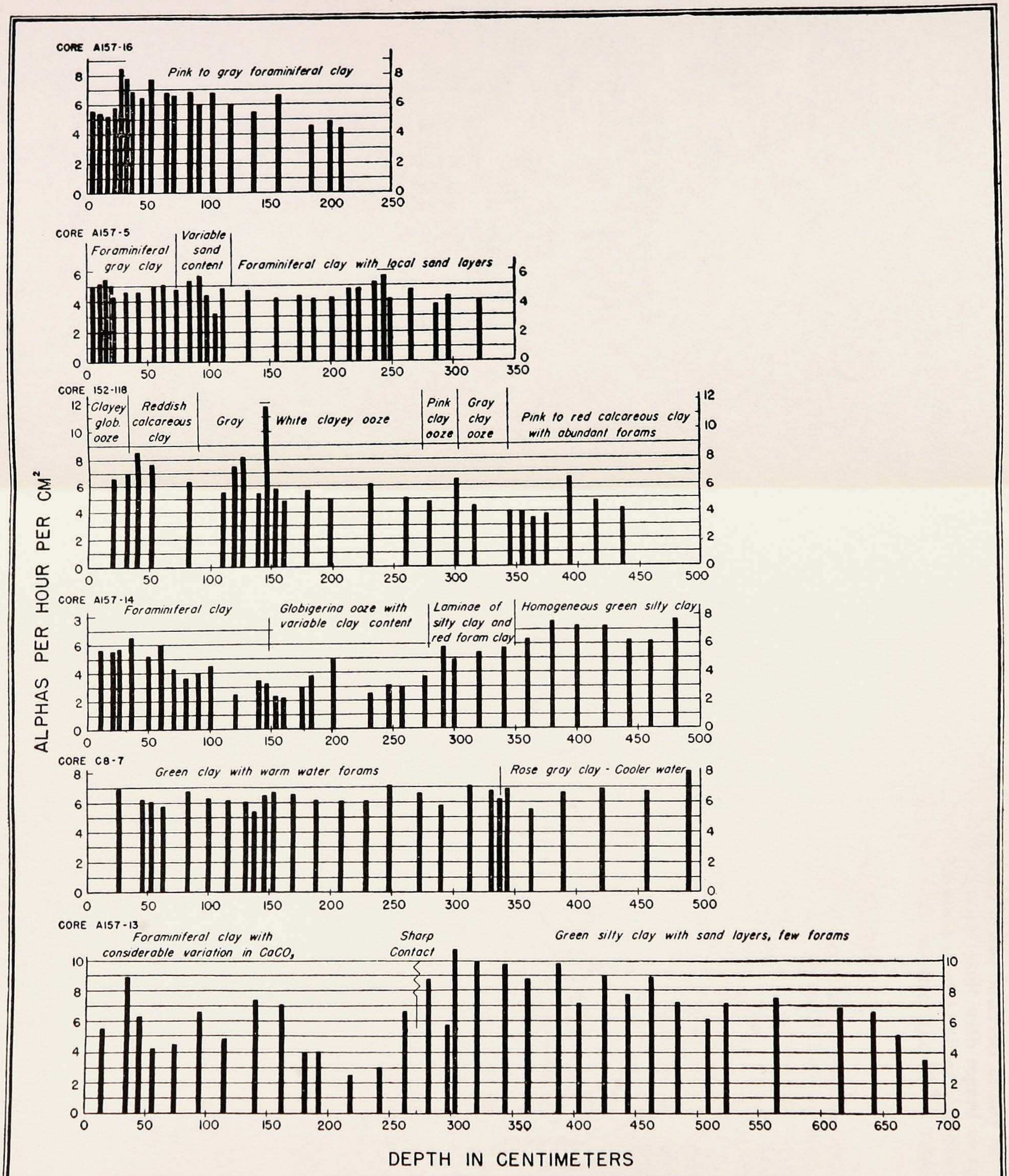

Figure 2. Bar graph of the thick source alpha activity.

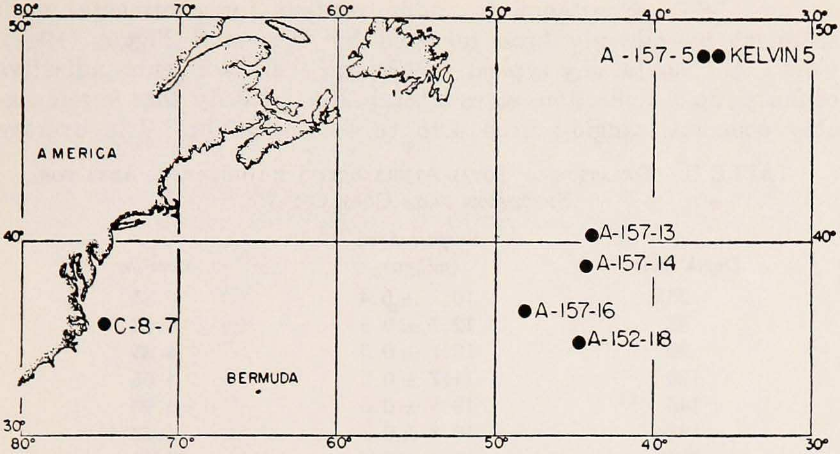

Figure 1. Location of cores.

TABLE I. GEOGRAPHICAL AND DEPTH DATA OF THE CORES.

Core No.	*Lat.* (*N*)	*Long.* (*W*)	*Water Depth* (*m*)	*Core Length* (*cm*)	*Remarks*
C-8-7	35° 56′	74° 41′	1370	495	NE of Hatteras; 100 mi. off shore; shelf
A-157-5	48° 35′	36° 51′	4500	320	43.5 km W of Urry's core Kelvin 5
A-157-13	40° 30′	43° 50′	4680	720	167 km N of A-157-14; SW Grand Banks
A-157-14	39° 0′	44° 15′	4775	490	SW Grand Banks
A-157-16	36° 45′	48° 5′	5230	317	S of Grand Banks; 480 km S of Gulf Stream; SE of A-157-14
A-152-118	35° 07′	44° 40′	4340	645	Due S of A-157-14; NW Flank of Mid-Atlantic Ridge

C-8-7, which is a continental shelf core, are from the broad and relatively flat expanse of the central North Atlantic. Core A-157-5 was taken from a locality that is close geographically and similar topographically to the location of the Kelvin No. 5 core to which the Ionium Age Method has been applied by Piggot and Urry (1942b). If long-range stratigraphic correlation is possible, it should show up in these cores.

Fig. 2 shows bar graphs of the thick source alpha activity and a generalized lithologic description. This representation was chosen because the nature of sediment deposition does not necessarily follow smooth changes in composition.

Core C-8-7. Constancy in radon content for continental shelf sediment has already been reported by Urry and Piggot (1942). Core C-8-7, containing typical continental shelf sediments indicative of fairly rapid deposition, gives a total alpha activity that is remarkably constant, ranging from 4.15 to 6.23 $\alpha/cm^2/hr$. The average

TABLE II. Relation of Total Alpha Activity to Surface Area for Specimens from Core C–8–7.

Depth (cm)	*Surface Area (m²/gm)*	*α/cm²/hr*
26	10. ± 0.4	5.35
53	12.7 ± 0.5	4.68
99	12.1 ± 0.5	4.85
130	11.7 ± 0.5	4.65
145	12.5 ± 0.5	4.96
188	10.3 ± 0.7	4.73
227	11.1 ± 0.4	4.68
330	14.0 ± 0.5	5.20
340	15.5 ± 0.5	5.33
343	10.7 ± 0.4	5.33
361	17.3 ± 0.5	4.20
487	12.6 ± 0.5	6.21

alpha activity is 5.00 $\alpha/cm^2/hr$. The top two-thirds of the core consists of rather homogeneus green mud with warm water forams. At a depth of 335 cm there is a sharp change from green mud to rose-gray clay that corresponds to a warm-to-cold surface water temperature transition. However, this abrupt change is not reflected in the alpha activity. Such a situation may be expected if the detrital material is from a constant source and if the major fraction of the activity is from the interior of the mineral grains. The color change was superficial, therefore, so far as the major mineral composition is concerned. Table II shows the relation of total alpha activity to surface area for selected specimens of this core.

It is clear from the data in Table II that there is no correlation of surface area of the sediment with alpha activity, which suggests that the major fraction of the activity lies within the particles rather than on the surface. This in turn indicates that any adsorption process makes a second order contribution to the total activity of this type of sediment unless some minor constituent adsorbs most of the radioelements, which is considered unlikely. Such an adsorption process is probably occurring (Holland and Kulp, 1952) but is masked by the bulk activity.

Core A-157-5. This is the northernmost of the remaining five cores from the North Atlantic basin, and it was chosen for study due to its proximity to a core studied by Piggot and Urry (1941). The first 75 cm consist of a reasonably homogeneous foraminiferal gray clay in which the total alpha activity appears to be related to the surface water temperature during deposition (see Table III). Around 100 cm the rapid variations in alpha activity appear related to the sand

TABLE III. Alpha Activity in Samples of Core A-157-5, Arranged in the Order of Increasing Temperature as Estimated from the Faunal Array

Depth (cm)	$\alpha/cm^2/hr$
15	5.42
65	5.09
55	4.92
10	4.92
30	4.60
40	4.51
45	4.51

concentration. At this depth the washed sediment consists of about 95% heterogeneous sand, with granules up to 4 mm in diameter, whereas mechanical analyses of washed samples showed 50% sand at 90 cm and 40% at 110 cm. While these mechanical analyses were not obtained for samples from exactly the same depths as the alpha counts, the general trend is considered significant. From 120 cm to the bottom of the core the sediment consists of a reasonably uniform foraminiferal clay with minor variations. It seems that this core is relatively homogeneous in broad aspect and should therefore be usable for age determination by the ionium method. Radon measurements are now being carried out on this core to study this possibility.

Some surface area data are also available for this core, and in Table

TABLE IV. Relation of Total Alpha Activity to Surface Area for Specimens from Core A-157-5

Depth (cm)	*Surface Area* (m^2/gm)	$\alpha/cm^2/hr$
10	18.8	5.16
23	27.8	4.35
43	22.5	4.60
63	24.5	5.06
84	28.8	5.28
112	32.7	4.85
155	18.3	4.16
186	14.2	4.13
222	31.1	4.80
248	17.8	4.06

IV they are compared with the alpha activity. Again the correlation of surface area with alpha activity is negative, although the surface areas are considerably higher on the average than those in core C-8-7.

Core A-157-13. This sample was taken 1520 km SW of A-157-5, and in general the alpha activity is double that in core A-157-5. Core A-157-13 is relatively nonhomogeneous down to 270 cm. From

TABLE V. SAND CONCENTRATION AND ALPHA ACTIVITY IN CORE A-157-13

Depth (cm)	*Sand concentration (%) in washed samples*	*$\alpha/cm^2/hr$*
180	95	3.91
60	85	4.18
160	20	6.25
40	15	7.10
140	1–2	7.37

200 cm down the sediment is a foraminiferal clay with varying sand concentration, and it appears that the alpha activity in this zone may be correlated with sand content, as is shown by the data in Table V. In this section also there are two thin layers of globigerina ooze, but these were not alpha counted. The sample at 215 cm lies in a globigerina ooze layer and thus might be expected to show a low activity. The sample at 240 cm consists largely of foram shells and sand grains. From 273 cm down the core consists primarily of a green silty clay with a few sandy layers such as those at 295, 400, 505, 660, and 680 cm. Again it appears that the total thick source alpha activity is reasonably constant for a constant sediment type but that it is directly affected by the concentration of carbonate shells and sand. The extent of the effect can be predicted qualitatively.

The contact between the two sediment types at 273 cm is so sharp that it could represent an unconformity. This break is also distinct in the alpha activity (see Fig. 2). There is no apparent correlation in alpha activity or lithologic type between cores A-157-5 and A-157-13.

Core A-157-14. This core was taken 201 km directly south of A-157-13. The top 10 cm consists of globigerina ooze with an alpha activity below 5 $\alpha/cm^2/hr$. The 10-150 cm section consists of a fairly homogeneous foraminiferal clay which shows a suggestion of an Urry-type curve. At 150 cm the sediment becomes a globigerina ooze with considerable variation in clay content until the green silty clay begins to appear at 275 cm alternating with thin layers of red foraminiferal clay. At 340 cm an impure sand occurs with an activity of 5.23 $\alpha/cm^2/hr$; this compares closely with the activity of similar sand layers (295 and 660 cm) in the green silty clay section of core A-157-13. Below 350 cm the core consists of a homogeneous green silty clay that is similar to the lower part of A-157-13 and is probably correlative with it; this part of A-157-14 contains more forams than the similar sediment in A-157-13, which suggests why the alpha activity ranges from 6.5–7.3 $\alpha/cm^2/hr$ instead of 6.5–9.5 $\alpha/cm^2/hr$, as in A-157-13.

Core A-157-16. This core appears to have been taken south of the glacial zone, since it is long enough to be Wisconsin but contains no glacial marine layers. It consists of a pink to gray foraminiferal clay.

TABLE VI. Carbonate Data for Core A-157-16

Depth (cm)	*% $CaCO_3$*	*$\alpha/cm^2/hr$*
5–6	15	5.56
11–12	26	5.40
16–17	28	5.18
23–24	26	5.75
27–28	19	8.47
31–32	26	7.75
36–37	29	6.85
44–45	28	6.46
52–53	6	7.66
64–65	8	6.78
71–72	22	6.55
84–85	10	6.80
91–92	9	5.95
103–104	13	6.78

Some inhomogeneity is observed in the first 30 cm, but at 30 cm there is a lithologic break which is reflected in the alpha activity. Another such break, which is not as evident in the alpha activity, occurs at about 53 cm. The alpha activity ranges from 5–8 $\alpha/cm^2/hr$, and there is a downward trend from 30 cm to the bottom of the core which suggests an ionium decay curve. Compared to A-157-13 and A-157-14, this core is quite homogeneous.

In this core it is evident that other factors are more important in determining the total alpha activity than the fluctuation of calcium carbonate content from 6–29%. See Table VI for carbonate data obtained for this core.

Core A-152-118. This was located 501 km south of A-157-14. The top 30 cm consist of a clayey globigerina ooze, and from 30–80 cm the sediment is a reddish calcareous clay which changes to a gray-white clayey ooze to 270 cm. A similar clay with a faint pink color occurs from 270–300 cm and then turns gray from 300–340 cm. From

TABLE VII. $CaCO_3$ CONTENT AND ALPHA ACTIVITY OF CORE A-152-118

Depth (cm)	*% $CaCO_3$*	*$\alpha/cm^2/hr$*
	Red Calcareous Clay (few forams) (30–80 cm)	
30	48	4.00
80	30	4.41
40	25	4.93
	Gray-white clay ooze (80–270 cm)	
263	45	2.89
162	45	2.77
180	35	3.25
200	32	3.40
	Pink Calcareous Clay (abundant forams) (350–442 cm)	
370	52	2.00
360	45	2.23
350	45	2.39
442	40	2.42
420	35	2.78
400	25	3.59

TABLE VIII. SURFACE AREA AND ALPHA ACTIVITY FOR CORE A-152-118

Depth (cm)	*Sample Area (m^2/gm)*	*$\alpha/cm^2/hr$*
30	34.1	4.00
40	29.7	4.95
52	27.1	4.3
75	32.5	3.8
147	23.3	7.0
162	——	2.7
181	21.7	3.1
200	23.7	2.9
263	25.3	3.0
283	22.1	2.8
305	18.0	3.8
321	——	2.4
350	——	2.2
360	15.8	2.2
380	18.8	2.0
400	30.1	3.7
410	24.2	2.8
442	——	2.4

340–490 cm the core is a pink to red calcareous clay with an abundance of forams. In these sections a correlation can be shown between the calcium carbonate content and the alpha activity (Table VII), providing samples of identical lithology are compared. Again it appears that the total alpha activity is determined by the radioactive elements within mineral grains, not on the surface. Table VIII shows some surface area data for this core.

CONCLUSIONS

The alpha activity of samples from six representative deep sea cores has been determined. The thick source alpha count ranges from 1.6–3.2 $\alpha/cm^2/hr$ for sand and globigerina ooze, from 4.0–5.6 $\alpha/cm^2/hr$ for foraminiferal green clay, and 6.5–9.7 $\alpha/cm^2/hr$ for fine red clay with low foram content.

Although certain sediment types have distinct total thick source alpha activity ranges, there is considerable overlap. The actual alpha activity measured is determined to a large extent by such variables as the per cent of foraminiferal shells, the concentration and radioactivity of the sand grains, and the composition of a particular clay type. It appears that the greatest determinant of activity is the mineral composition of the particles. However, it is possible that coprecipitation brings in considerable alpha activity to the sediment. Limited qualitative correlation is possible between the total alpha activity and $CaCO_3$ content or sand content, both, however, being limited to zones of similar lithology. In the cases of A-157-13, A-157-14 and of A-152-118, A-157-16, comparison of the sediment type and the alpha activity at certain depths does not appear to yield stratigraphic correlation except for the distinctive green silty clay which appears at 339 cm in A-157-14 and at 273 cm in A-157-13. This may be due to the fact that the cores were taken at too great a distance from each other. It should be noted, however, that since the alpha activity varies considerably outside of the experimental error it would seem that stratigraphic correlation by such a method might be possible if cores sufficiently close in geographic location were studied.

It may be concluded from this study that total thick source alpha counting is inadequate for age determination of the sediment layers by the ionium method.

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