RADIUM CONTENT OF OCEAN BOTTOM SEDIMENTS FROM THE ARCTIC OCEAN, BERING SEA, ALASKA PENINSULA, AND THE COASTS OF SOUTHERN ALASKA AND WESTERN CANADA

By

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The radium content of several surface bottom samples in the region of the San Juan Archipelago and Vancouver Island have been reported previously (*15*). The present paper deals with the radium content of both surface bottom and core samples taken along the Pacific coast of Canada and the coast of Alaska, in the Pacific Ocean, Bering Sea and the Arctic Ocean.

The surface bottom samples were collected by means of a telegraph snapper or clam shell which sampled the bottom to a depth of several centimeters. The samples were prepared as previously reported (*15*). The experimental procedure and apparatus used for the determination of the radium content of the samples was essentially the same as that developed by Evans (*2*).

The location of the stations as well as the radium content of the samples, in grams of radium per gram of dry material, is tabulated in Table I. The results are indicated in Figure 31, in which the diameter of each circle is proportional to the radium concentration of the sample taken at the indicated station. Figure 32, which is a more detailed map of the Southern Alaska coast and Queen Charlotte Islands, shows the location of the stations and the radium content of the samples in this region. The average of 74 determinations is 0.74×10^{-12} grams of radium per gram. The radium concentration of deep sea samples as reported by various investigators (*3*, *4*, *7*, *8*, *9*, *10*) varied from 5 to 10 times this value. The low concentrations were much more pronounced in the vicinity of Vancouver Island, where the average was 0.34×10^{-12} grams of radium per gram of dry material (*15*). It will be noticed that the highest average is from the region of the southern Alaska coast where the inland passages are more or less protected by islands from the open ocean and where most of the rivers rise from the glacial slopes of the nearby granitic Rocky Mountains. The lowest averages are from the volcanic Alaska Peninsula and the Queen Charlotte Island regions which are open to the ocean and are devoid of rivers of any size.

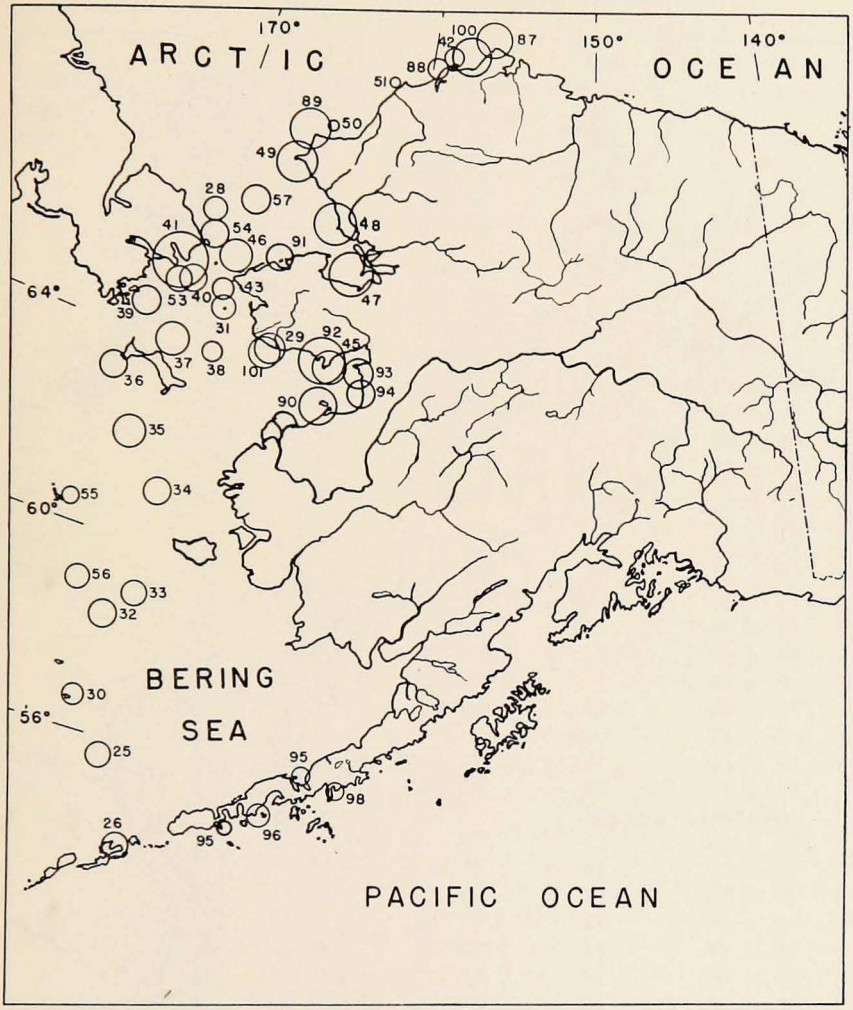

Figure 31. Chart of the Pacific coast, Bering Sea, and Arctic Ocean regions. The diameter of the circles is proportional to the radium content.

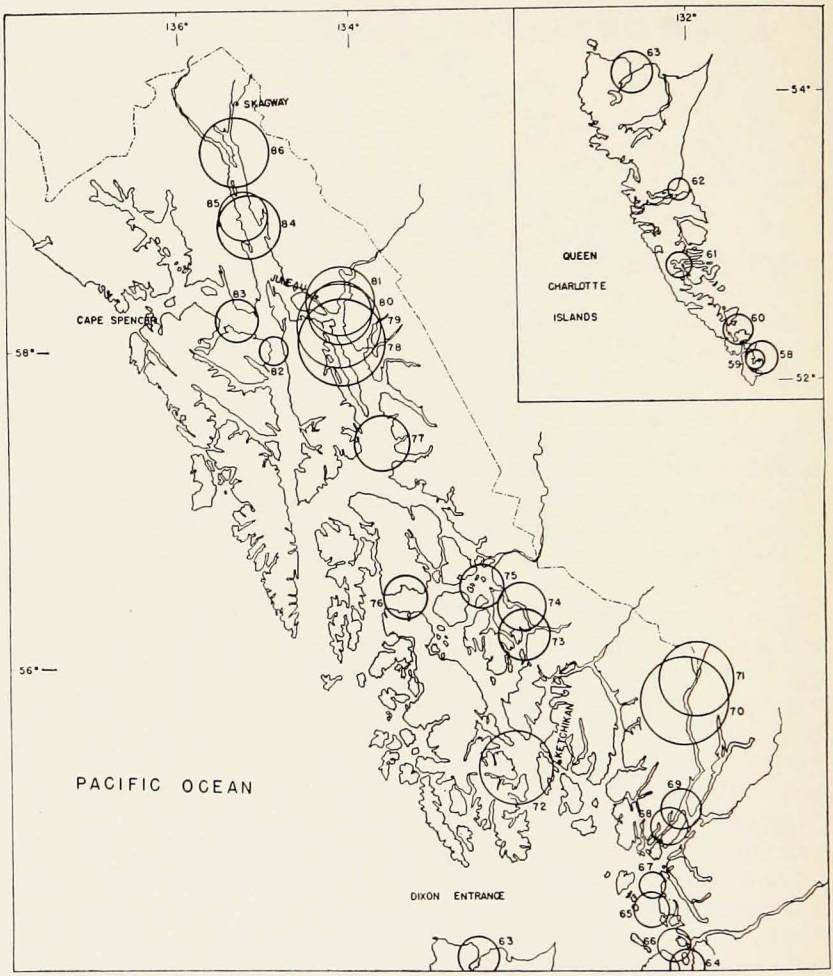

Figure 32. Chart of the southern Alaska coast and Queen Charlotte Islands regions. The diameter of the circles is proportional to the radium concentration.

TABLE I

LOCATION OF STATIONS AND RADIUM CONCENTRATION OF SAMPLES

Location	*Station*	*Latitude*	*Longitude*	*Depth (meters)*	*Radium concentration in 10^{-12} g. Ra per g.*
Arctic	28	66° 46′ N.	170° 01′ W.	47	.53 ± .01
Ocean	42	70° 55′	158° 67′	25	.42 ± .01
	46	66° 03′	168° 14′	53	.74 ± .01
	47	66° 12′	162° 40′	14	.96 ± .01
	48	67° 06′	164° 00′	21	.92 ± .01
	49	68° 19′	166° 41′	20	.90 ± .01
	50	69° 24′	165° 03′	33	.41 ± .01
	51	70° 14′	162° 47′	30	.24 ± .01
	54	66° 23′	169° 40′	49	.60 ± .01
	57	67° 21′	167° 35′	40	.64 ± .02
	87	71° 30′	156° 40′	16	.79 ± .02
	88	70° 42′	159° 58′	14	.45 ± .01
	89	68° 54′	166° 54′	43	.90 ± .03
	91	66° 12′	166° 12′	9	.58 ± .01
	100	71° 09′	158° 00′	40	.84 ± .01
				Average:	0.66×10^{-12}
Norton	29	64° 10′ N.	165° 37′ W.	22	.70 ± .01
Sound	45	64° 18′	162° 42′	15	.76 ± .01
	90	63° 39.5′	162° 23′	14	.83 ± .01
	92	64° 27′	162° 56′	9	1.01 ± .01
	93	64° 18.5′	161° 84′	10	.63 ± .01
	94	63° 52′	160° 57′	1	.84 ± .01
	101	64° 18′	165° 33′	21	.78 ± .01
				Average:	0.79×10^{-12}
Bering	25	55° 36′ N.	168° 11′ W.	131	.58 ± .01
Sea	27	65° 37′	170° 58′	33	1.21 ± .02
	30	56° 36′	169° 37′	20	.48 ± .01
	31	64° 57′	168° 06′	42	.52 ± .01
	32	58° 26′	169° 06′	64	.61 ± .01
	33	58° 46′	168° 08′	46	.57 ± .01
	34	61° 08′	168° 22′	37	.60 ± .01
	35	62° 16′	170° 32′	55	.73 ± .02
	36	63° 09′	172° 17′	51	.59 ± .02
	37	64° 03′	169° 57′	31	.75 ± .02
	38	64° 06′	168° 20′	35	.45 ± .02
	39	64° 35′	171° 21′	37	.65 ± .01
	40	65° 21′	170° 02′	44	.59 ± .01
	43	55° 18′	168° 25′	52	.51 ± .01
	44	65° 48′	168° 30′	45	.91 ± .02
	53	65° 25′	170° 31′	37	.55 ± .01

TABLE I (*Cont.*)

Location	*Station*	*Latitude*	*Longitude*	*Depth (meters)*	*Radium concentration in 10^{-12} g. Ra per g.*
Bering	55	60° 22′	172° 10′	31	.38 ± .01
Sea	56	58° 57′	171° 03′	75	.55 ± .01
				Average:	0.65×10^{-12}
Alaska	26	53° 57′ N.	166° 31′ W.	123	.59 ± .01
Peninsula	95	55° 56′	160° 40′	16	.39 ± .01
	96	55° 14′	161° 59′	100	.50 ± .01
	97	54° 48′	163° 16′	70	.33 ± .01
	98	55° 52′	159° 30′	34	.40 ± .01
				Average:	0.44×10^{-12}
Southern	64	53° 55′ N.	130° 08′ W.	36	.63 ± .01
Alaska	65	54° 16′	130° 32′	80	.65 ± .02
and	66	54° 05′	130° 15′	72	.60 ± .01
Canadian	67	54° 30′	130° 25′	48	.47 ± .02
Coasts	68	54° 58′	130° 22′	170	.68 ± .01
	69	55° 03′	130° 12′	200	.72 ± .01
	70	55° 44′	130° 09′	80	1.57 ± .02
	71	55° 51′	130° 03′	240	1.32 ± .01
	72	55° 18′	132° 09′	55	1.38 ± .02
	73	56° 11′	132° 00′	370	.93 ± .03
	74	56° 21′	131° 59′	165	.86 ± .02
	75	56° 29′	132° 29′	135	.79 ± .01
	76	56° 26′	133° 27′	22	.81 ± .01
	77	57° 22′	133° 40′	130	1.00 ± .02
	78	58° 04′	134° 05′	100	1.55 ± .02
	79	58° 07′	134° 07′	214	1.50 ± .02
	80	58° 12′	134° 07′	190	1.13 ± .02
	81	58° 17′	134° 06′	100	1.24 ± .02
	82	57° 56′	134° 50′	460	.53 ± .02
	83	58° 09′	135° 16′	146	.77 ± .01
	84	58° 43′	135° 10′	310	1.14 ± .02
	85	58° 49′	135° 13′	248	.86 ± .01
	86	59° 14′	135° 20′	91	1.25 ± .01
				Average:	0.97×10^{-12}
Queen	58	52° 05′ N.	130° 50′ W.	225	.60 ± .02
Charlotte	59	52° 06′	130° 55′	20	.41 ± .01
Islands	60	52° 14′	131° 10′	113	.55 ± .02
	61	52° 48′	131° 56′	100	.48 ± .01
	62	53° 15′	131° 56′	35	.40 ± .01
	63	54° 03′	132° 36′	13	.75 ± .01
				Average:	0.53×10^{-12}

Through the kind cooperation of Dr. G. A. Young, Chief Geologist of the Department of Mines and Resources of Canada, it was possible to obtain representative rocks from the underlying drainage basin of the Skeena River. The average radium content of these samples was 0.64×10^{-12} grams of radium per gram, while the average of the samples taken in the region of the mouth of the Skeena River was 0.63×10^{-12} grams of radium per gram. While the data seems to indicate that the radium content of inshore samples tends to approach that of the adjacent land areas, the number of samples analyzed do not permit of a general conclusion.

During the course of the experiments, it was observed that the radium content of the samples obtained from the region of glacier-fed inlets was approximately twice that of the other off-shore samples. These are tabulated in Table II. The exact reason for this greater concentration is not quite clear. It has been observed that the highest radium concentration seems to exist in the fine grained portions of a bottom sediment (*3*, *6*). This was found to be true in the case of a single sample of very fine sediment which was secured at a depth of 1730 meters approximately a hundred miles off the coast of northern Washington. This sample was accidently brought up in a water bottle and no doubt represents the very top surface of the ocean bottom. The sediment was very fine and required several days to settle out. The radium concentration was $(2.32 \pm 0.02) \times 10^{-12}$ grams of radium per gram.

Trask (*14*) has pointed out that the sediments of enclosed bodies of water that have narrow connections to the ocean are in general fine

TABLE II

RADIUM CONCENTRATION IN GLACIER-FED INLETS

Location	*Station*	*Latitude*	*Longitude*	*Depth (meters)*	*Radium concentration in 10^{-12} g. Ra per g.*
St. Lawrence Bay (Sibera)	27	65° 37′ N.	170° 58′ W.	33	1.21 ± .02
Golovin Bay (Norton Sound)	92	64° 27′	162° 56′	9	1.01 ± .01
Lynn Canal	86	59° 14′	135° 20′	91	1.25 ± .01
Taku Inlet	81	58° 17′	134° 06′	100	1.24 ± .02
Taku Inlet	80	58° 12′	134° 07′	190	1.13 ± .02
Taku Inlet	79	58° 07′	134° 07′	214	1.50 ± .02
Taku Inlet	78	58° 04′	134° 05′	100	1.55 ± .02
Portland Canal	71	55° 51′	130° 03′	240	1.32 ± .01
Portland Canal	70	55° 44′	130° 09′	80	1.57 ± .02
				Average:	1.31×10^{-12}

grained and comparable to deep ocean deposits. While the mechanical analysis of the sediments is incomplete. sufficient data is available for some comparison of sample No. 81 which has a radium content of 1.24 x 10^{-12} grams of radium per gram with sample No. 42 which contains 0.42 x 10^{-12} grams of radium per gram. Sample No. 81 was taken at the foot of Taku Glacier. It is composed in part of particles of glass or ash, which have a maximum diameter of 0.2 mm. and an average diameter of 0.05 mm. These particles comprise about one-half the bulk of this sample. The other constituents of this sample vary in diameter from 0.01 mm. to 0.001 mm. Approximately 80% of these small particles are volcanic glass and the remainder are clear minerals such as quartz, mica, zircon, and augite. Sample No. 42, which was taken in shallow water near the coast of Alaska in the Arctic Ocean, contained several large particles of water-washed sand which varied from 0.35 mm. to 0.40 mm. in diameter. Most of the particles in this sample averaged about 0.2 mm. in diameter. The smallest particles

TABLE III

VARIATION OF RADIUM CONCENTRATION ALONG CORE SAMPLES

Location	*Sample Number*	*Latitude*	*Longitude*	*Depth (meters)*	*Depth from Surface*	*Radium concentration in 10^{-12} g. Ra per g.*
St. Lawrence	152	65° 35′ N.	107° 51′ W.	27	1 cm.	1.15 ± .01
Bay	155				7	1.04 ± .02
	154				15	0.95 ± .02
Bering Sea	173	67° 21′	167° 35′	40	1	0.59 ± .01
	165				8	0.57 ± .01
	168				16	0.59 ± .01
Norton Sound	174	64° 20′	166° 15′	24	1	0.66 ± .01
	167				14	0.71 ± .01
East Sound	151	48° 36′	122° 52′	42	1	0.43 ± .02
Olga	142				14	0.47 ± .01
Rosario	146	48° 40′	122° 54′	28	1	0.52 ± .02
	141				14	0.51 ± .01
Tacoma	185	47° 16′	122° 33′	− 1.5	3 m.	0.44 ± .02
(Washington)	186				6	0.61 ± .01
Narrows	187				12	0.54 ± .02
Bridge	188				15	0.52 ± .02
	189				21	0.52 ± .01
	190				28	0.48 ± .01
	191				31	0.63 ± .02
	192				37	0.58 ± .03

averaged 0.01 mm. diameter and consisted mostly of a glassy ash. The sample contained garnet, mica, feldspar and zircon.

Several short cores, approximately 15 cm. in length, were secured from the Arctic Ocean and the Bering Sea by driving a pipe into the ocean bottom by means of a weight attached to the cable. The location of the stations and radium content of the cores is given in Table III. That no consistent variation of radium concentration with depth was observed is in agreement with the results reported by other investigators (*9*, *12*). Since these short cores were collected, a Piggot Core Sampler (*11*) has been provided and put into use. Analyses of several cores, varying from 7 to 10 feet in length, are now in progress, the results of which will be tabulated and presented when they are completed.

Two cores, 14 cm. in length, were obtained in East Sound in the San Juan Archipelago. This sound is very rich in plankton during the spring and summer months. While plankton has been reported (*2*, *5*) as containing from 100 to 1000 times as much radium per gram as the sea water in which they live, their role as a carrier of radium to the ocean bottom has been shown to be insignificant (*5*, *13*). This is substantiated by the analyses of the cores taken from East Sound, since the radium concentration is not greater than those from the surrounding area (*15*) and shows no variation with depth.

Through the kindness of Mr. L. V. Murrow of the Washington Toll Bridge Authority samples, to a depth of 120 feet, were obtained from the survey made for the purpose of locating the piers of the Tacoma Narrows Bridge. This region was once covered by Pacific Ocean waters. This core, which was the only one of appreciable length, does not fall in either of the two classes of deep sea cores as designated by Piggot and Urry (*13*).

TABLE IV

Radium and Selenium Concentration

Station	*Latitude*	*Longitude*	*Depth (meters)*	*Radium concentration in 10^{-12} g. Ra per g.*	*Selenium concentration in parts per million**
25	55° 36′ N.	168° 11′ W.	131	0.58 ± .01	0.30
26	53° 57′	166° 31′	123	0.59 ± .01	0.30
27	65° 37′	170° 58′	33	1.21 ± .02	0.40
28	66° 46′	170° 01′	47.5	0.53 ± .01	0.25
29	64° 10′	165° 37′	22	0.70 ± .01	0.20
30	56° 36′	169° 37′	20	0.48 ± .01	0.03
101	64° 18′	165° 33′	21	0.78 ± .01	0.25

* Determined by Williams and Byers.

Selenium determinations have been made by Williams and Byers (*16*) on seven of the samples from which radium determinations were made. The radium and selenium content of these seven samples are given in Table IV. It will be noted that there is no apparent correlation between the radium and selenium content. Both radium and selenium are found in soil and river waters as well as ocean sediment. However, no selenium was found by Byers and others (*1*) in ocean water while the radium concentration in ocean water is found to be of the order of 1.0×10^{-16} grams of radium per cc. of water (*3*, *5*).

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