Strontium-90 in Alaska

Alaskan Eskimos for whom the caribou is a dietary staple have a high strontium-90 concentration.

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Abstract. Strontium-90 concentrations have been determined in a variety of foods used by the native population. Caribou from the tundra carry 10 to 20 times the level of domestic cattle. Eskimos for whom caribou is a staple in the diet are found to have four times the strontium-90 content of the average for the world population of the North Temperate Zone.

The strontium-90 distribution in the ecology of the Arctic tundra has been given relatively little attention. The closeness to the U.S.S.R. test site, the permafrost surface, and the initial high concentrations in caribou bone from Alaska suggested that a survey of critical samples from this area should be performed (*1*). It was decided to examine caribou which live on the mosses and low vegetation overlying the permafrost zone, foodstuffs grown on farms along the coastal belt, native fish, and human bone and particularly urine from isolated Eskimo groups (*2*). The localities of interest are shown in Fig. 1.

Most of the samples were obtained in cooperation with the Arctic Health Research Center of the Public Health Service. The farm crops were obtained through the University of Alaska. Some caribou samples were obtained by personnel at the Ladd Air Force Base in Fairbanks. About 75 percent of the human bone samples were analyzed by commercial laboratories. The remainder of the human bones, and all other samples, were analyzed at the Lamont Laboratory by use of previously reported methods (*3*).

Table 1 gives the results of pooled samples of deer antlers obtained in California in 1945, 1952, 1955, and 1958, and shows the gradual increase in concentration. In contrast, the pooled sample of caribou antlers from Alaska showed over ten times the concentrations of the California deer. Since the fallout appears roughly proportional to precipitation, which is very low in the tundra region, this great difference would appear to point toward an ecological mechanism. For example, in late 1959 the strontium-90 cumulative deposition in Columbus, Ohio, and New York, N.Y., was about 67 mc per square mile in the 40-inches per year rainfall belt, while at Point Barrow, Alaska, deposition was 11 mc per square mile for 10 to 20 inches of rainfall (*4*). The tundra region averages less than 10 inches per year of rainfall.

The strontium-90 content of a variety of Alaskan foods is given in Table 2. The farm crops are compared with the average values for three eastern United States locations previously reported, namely, Atlanta, Georgia; Baltimore, Maryland; and Cincinnati, Ohio (*5*). The cabbage and potatoes show much lower concentrations of strontium-90 in Fairbanks than in the eastern United States, but the wheat carries similar concentration. The milk produced in the vicinity of Anchorage, Alaska, has a similar strontium-90 concentration to that in the Midwest (*4*). Thus it might be expected that the level of strontium-90 in human bone for the non-Eskimo population in the cities and towns along the southern coast of Alaska would be similar to that in the continental United States.

Among the native foodstuffs sampled, marine fish as well as polar bears, who feed largely upon them, show generally low concentrations with the exception of one sample of Beluga meat. The fresh-water fish and one sample of plant roots are in the range of vegetables and grain grown in the United States. One walrus sample showed a high concentration of strontium-90 in the meat. Overall it would be expected that Alaskan natives who live predominantly on fresh-water fish would have body burdens of strontium-90 similar to the rest of the United States, whereas those who live predominantly on marine life would have values somewhat lower, particularly those that eat the bony parts of small fish.

In contrast to the above, samples associated with caribou of the Arctic tundra show much higher concentrations (Table 3).

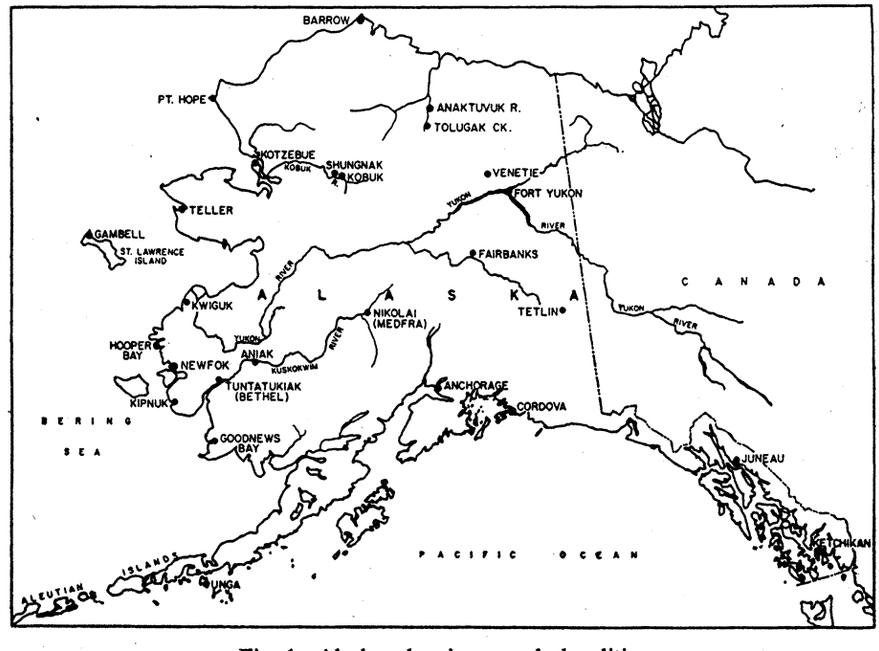

Fig. 1. Alaska, showing sample localities.

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The stomach contents of the caribou show extremely high concentrations, indicating that the strontium-90 from fallout must be concentrated on the surface and soaked up by the lichens, mosses and other plant life which exists on top of the permafrost and constitutes the caribou diet. Since there was no significant reduction in the concentration between 1959 and 1961, the concentration of strontium-90 in the atmosphere and rainfall must not be an important factor for this ecological situation.

The lower strontium-90 concentration in bone and meat compared to stomach contents is in the direction of the discrimination against strontium relative to calcium which exists in almost all biological processes. The discrimination from diet to bone in the caribou, however, as indicated by these data, is 10 to 20, as compared to 4 for man. The strontium-90 concentrations in soft tissue and newly depositing bone are similar but are 10 to 20 times higher than animals' bones in Germany or Nevada at about the same time (*6*). The antlers which are replaced yearly show values similar to those of the bone.

In view of the high strontium-90 concentration in caribou, an attempt was made to obtain bone samples from outlying districts, since it is understood that a few of the inland Eskimos live largely on caribou. This, of course, is very difficult in the sparsely settled areas where autopsies are almost nonexistent, but some samples were obtained from natives in these areas, who were treated at the Public Health hospitals. Most samples were obtained during thoracic resection; some were obtained at autopsy.

Bone samples, shown in Table 4, were obtained from native people, but most of them lived near towns or villages or along the seacoast. A few probably lived inland. No precise dietary information was obtained on these subjects.

The average of these adult samples (0.5 $\mu\mu$c Sr^{90}/g Ca) lies somewhat above that for the rest of North America (0.3 $\mu\mu$c Sr^{90}/g Ca for adults) (*7*). The individual adult samples which gave 1.9, 1.4, and 1.0 $\mu\mu$c Sr^{90}/g Ca are unusually high. Since young children have eight times the concentration of adults, a child on the diet which gave an adult level of 1.9 $\mu\mu$c Sr^{90}/g Ca would reach 15 $\mu\mu$c Sr^{90}/g Ca, and newly formed bone would have a concentration slightly greater than this,

Table 1. Strontium-90 concentration in deer and caribou antlers.

Antlers	Dpm/g ash	$\mu\mu$c Sr^{90}/g Ca
1945 California deer antlers	<0.10	<0.12
1952 California deer antlers	0.71	0.85
1955 California deer antlers	4.19	5.04
1958 California deer antlers	6.81	8.05
1958 Alaska caribou antlers	98.4	106.1

Table 2. Strontium-90 concentrations in foodstuffs and animal products.

Sample	Location	Collection date	Strontium-90 content		
			Dpm/kg wet	Dpm/g ash	$\mu\mu$c/g Ca
		Farm crops			
Wheat	Fairbanks	1957	22.0	1.42	22.6
	Fairbanks	1958	98.0	6.38	104
	Fairbanks	1959	106	6.20	125
	Fairbanks	1960	50.5	3.03	60.5
	Eastern U.S.	1959	143	6.09	147
	Eastern U.S.	1960	100	5.89	114
Cabbage	Fairbanks	1959	5.9	1.11	7.8
	Fairbanks	1960	4.1	0.52	4.4
	Eastern U.S.	1959	76.2	7.78	45.4
	Eastern U.S.	1960	44.8	5.92	36.5
Potatoes	Fairbanks	1959	1.6	0.17	7.8
	Fairbanks	1960	1.5	0.26	7.6
	Eastern U.S.	1959	15.0	1.85	54.1
	Eastern U.S.	1960	13.1	1.25	52.2
		Milk			
	Av. U.S. Mid-west (*3*)	1960			8
	Anchorage, Alaska, milkshed (*3*)	1960			7
		Native foods			
Marine fish					
Tom cods	Pt. Hope	Dec. '59	3.45	0.05	0.1
Needlefish	Hooper Bay	Oct. '59	605	7.24	7.6
Beluga meat	Kotzebue	Oct. '59	0.39	0.12	8.8
Beluga meat	Kotzebue	Fall '59	26.3	0.81	142.3
Beluga Muktuk	Kotzebue	Oct. '59		0.67	11.5
Dried flounder and herring	Newfok	Oct. '59	110	1.46	2.7
Cod	Kotzebue	Oct. '59	362	6.63	7.9
Fresh-water fish					
Whitefish	Kobuk River	Oct. '59	156	2.25	15.7
Whitefish	Kobuk River	Spring '60	(2390)*	42.4	62.4
Whitefish	Kobuk River	Spring '60	(115)*	2.03	3.5
Whitefish	Kobuk River	Spring '60	(1410)*	25.0	32.8
Marine mammals					
Whale meat	Pt. Hope	Oct. '59	<0.04	<0.07	<2.4
Whale rib (bowhead)	St. Lawrence	May '59	<64	<0.12	<0.1
Seal backbone	Pt. Hope	Fall '59	8.40	0.07	0.1
Walrus backbone	St. Lawrence	Spring '59	324	0.65	0.8
Walrus meat	St. Lawrence	Spring '59	180	9.38	360
Walrus meat	Gambell	Dec. '60		0.66	25.2
Land animals					
Polar bear meat	Pt. Hope	Fall '59	<0.6	<0.06	<2.8
Plants					
Plant roots	Shungnak	Oct. '59	106	4.30	16.7

* These values are approximate, since accurate wet weights were not obtained on these samples.

Table 3. Strontium-90 in samples of Alaskan caribou.

Sample	Location	Collection date	Strontium-90 content			
			Dpm/kg wet	Dpm/g ash	$\mu\mu$c/g Ca	
Antlers	Arctic Tundra	1958		98	106	
Antlers	Anaktuvuk River	Oct. '59	9450	238	281	Av. 207
Antlers	Anaktuvuk River	Oct. '59	6480	146	170	
Antlers	Tolugak Creek	Oct. '59	6400	143	170	
Meat	Anaktuvuk Pass	Nov. '59	16.0		160	
Stomach contents	Anaktuvuk River	Nov. '59	7880	245	1264	
Caribou–A	Shungnak	Mar. '61				
Backbone				136	177	
Leg bone				179	180	Av. 179
Meat				3.3	162	
Stomach contents				300	3444	
Caribou–B	Shungnak	Feb. '61				
Backbone				121	140	
Leg bone				150	175	Av. 158
Meat				1.3	146	
Stomach contents				231	2968	

corresponding to an average diet of about 50 $\mu\mu$c Sr^{90}/g Ca, which is about four times the U.S. average for the same period. Thus, while the average in this series in which high values were sought is about 25 percent greater than the U.S. average, a few samples are quite high, which may reflect an appreciable quantity of caribou in the diet.

A few tribes that consume caribou almost exclusively are known in Alaska, but bone samples did not become available from this small group. Therefore, in order to get an adequate index of their exposure to strontium-90 and thus what the level would be in newly deposited bone, urine samples were obtained on six such individuals in February 1961 with the results shown in Table 5. Their tribe is located near Shungnak in northwest Alaska about 50 miles north of the Arctic Circle and 150 miles from the coast along the Kobuk River. Thus, in addition to caribou, they had access to fresh-water fish, but probably not marine life. It is noted that the strontium-90 concentration averaged 25 $\mu\mu$c (range 20 to 32) in the individuals of this predominately caribou-eating tribe.

Table 4. Strontium-90 content of bones from native Alaskan children and adults.

Age	$\mu\mu$c Sr^{90}/g Ca
Single bones, Nov. 1959–Dec. 1960	
4 mo	2.4 ± 0.3
7 yr	3.4 ± 0.3
16	2.4 ± 0.1
20	1.0 ± 0.2
20	0.8 ± 0.2
20	0.6 ± 0.1
24	0.4 ± 0.1
24	0.7 ± 0.2
25	0.2 ± 0.1
26	0.4 ± 0.2
26	< 0.3
26	< 0.1 ± 0.0
26	1.9 ± 0.2
29	0.4 ± 0.1
30	0.5 ± 0.1
30	< 0.2
32	0.2 ± 0.1
33	0.7 ± 0.1
35	1.4 ± 0.1
36	< 0.2
38	0.3 ± 0.1
38	0.3 ± 0.1
39	0.8 ± 0.1
40	< 0.4
42	< 0.4
44	0.4 ± 0.1
46	< 0.4
46	< 0.2
48	0.5 ± 0.1
53	0.4 ± 0.1
54	0.7 ± 0.2
54	0.3 ± 0.2
58	0.2 ± 0.1
60	0.8 ± 0.2
60	0.4 ± 0.1
60	0.4 ± 0.1
61	0.4 ± 0.1
62	0.5 ± 0.1
Composite samples, Jan.–Feb. 1961	
38	0.58 ± 0.06
38	0.38 ± 0.04

Table 5. Strontium-90 content in human urine specimens from Alaska, February 1961.

Sample	Dpm/liter	$\mu\mu$c Sr^{90}/g Ca
1	10.4	23.4
2	22.6	32.1
3	11.4	19.9
4	8.9	21.1
5	12.3	31.6
6	7.5	22.1
Av.	12.2	25.0

In earlier work comparing the diet and urine concentrations of strontium-90 in three diverse population groups, it was shown that the diet level is about twice that found in the urine (*8*). Therefore, these individuals had diet levels of about 50 $\mu\mu$c Sr^{90}/g Ca. The diet/bone discrimination against strontium-90 is four, and thus these individuals are forming bone at concentrations of 12 $\mu\mu$c Sr^{90}/g Ca. This is more than four times the U.S. average in 1961 and corresponds with the highest value obtained in bone among the 36 samples received and individually analyzed from native residents of Alaska.

The following conclusions are reached:

1) The foodstuffs consumed by the bulk of the population in Alaska probably have strontium-90 concentrations similar to those in the North Temperate Zone.

2) The concentration of strontium-90 in Alaskan caribou exceeds that of other foods by a factor of ten or more.

3) Urine concentration of strontium-90 in a caribou-eating tribe indicates that new bone is being laid down with about 12 $\mu\mu$c Sr^{90}/g Ca, which is more than four times the average U.S. concentration.

4) Three human bones of 35 that were analyzed also indicated new bone deposition of about this concentration.

References and Notes

1. Most of the sample procurement was accomplished by Dr. Christine Heller of the Arctic Health Research Institute of the Public Health Service at Anchorage, Alaska. This followed arrangements made in cooperation with Dr. A. B. Colyar and Dr. E. M. Scott in October 1959. Some caribou samples were obtained by Col. J. D. Fulton of the Ladd Air Force Base in Fairbanks. The wheat, cabbage, and potatoes were obtained by Dr. Arvo Kallio of the Department of Horticulture, University of Alaska. The California antlers were submitted by Dr. Harry Foreman of the Los Alamos Scientific Laboratory, Los Alamos, New Mexico. Professor J. L. Kulp critically read the manuscript and offered helpful suggestions. The Lamont analyses were conducted by Rieta Slakter Hirshman and Karin Bartelsen. This research was supported by the U.S. Atomic Energy Commission on contract AT(30-1)-1656. This report is Lamont Geological Observatory contribution No. 537.
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Electroesophagogram of Individual Hookworm (Ancylostoma caninum)

Abstract. A device for recording regular rhythmic electrical phenomena that are synchronous with esophageal contractions in *Ancylostoma caninum* is described.

A method for studying the hookworm in vitro under conditions simulating to some extent those obtaining in nature (*1*) has been previously published. Essentially, the method is as follows: by means of a steel needle a live hookworm is threaded through a thin rubber membrane so that the head is on one side of the membrane and the tail on the other. The membrane with the hookworm is then mounted between two chambers. The "head chamber" is filled with a nutrient solution (usually dog's blood or plasma), and the "tail chamber" with a saline solution.

In this report, a description of a device for detecting electrical phenomena originating from the worm is presented, and a preliminary study of the nature of the recordings thus obtained is given.

After the live worm is placed in the apparatus, silver electrodes (diameter, 0.5 to 0.8 mm) are introduced into the head and tail chambers (Fig. 1, left) and connected, by means of an a-c coupled amplifier, to an oscilloscope or an ink recorder. The chambers are kept in a water bath at 37°C. The pulses observed on the oscilloscope are at first somewhat irregular (especially if the worms have been recently removed from the dog), but within 1 or 2 hours they become steady. If the worms are first kept at least 4 hours in a 50-percent mixture of dog's plasma