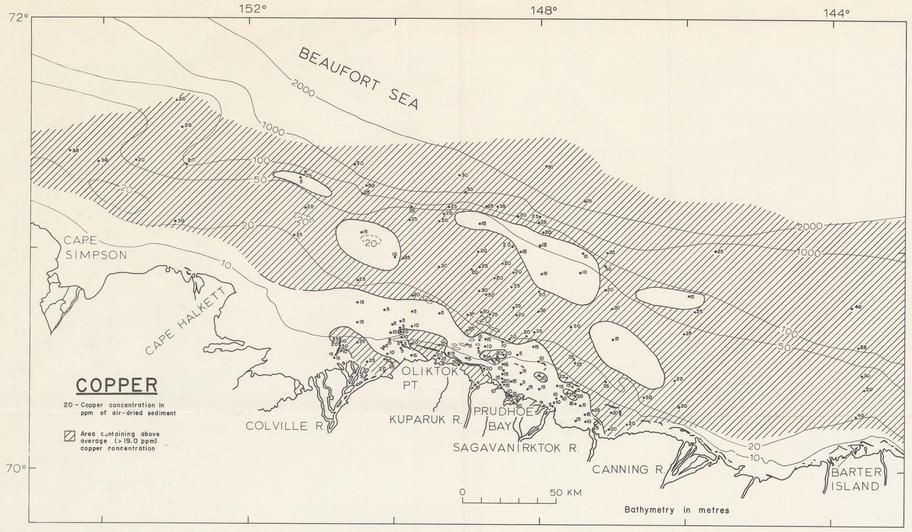
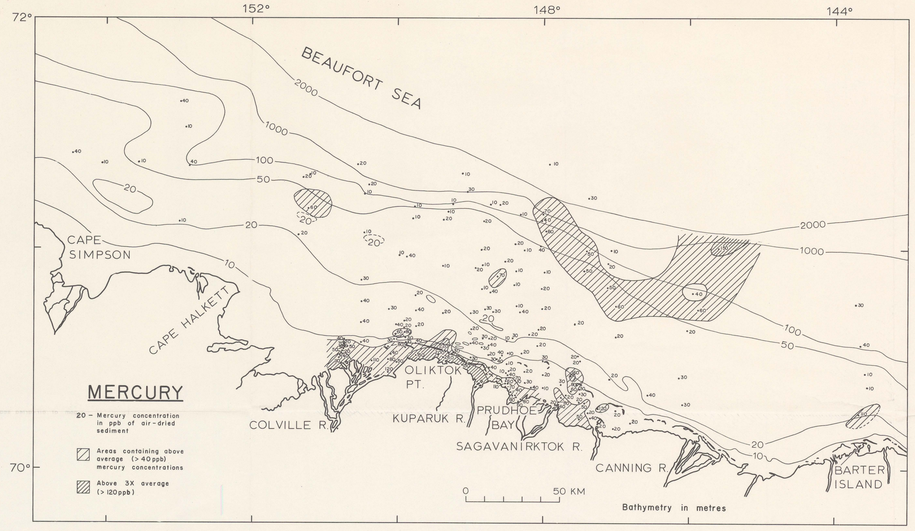
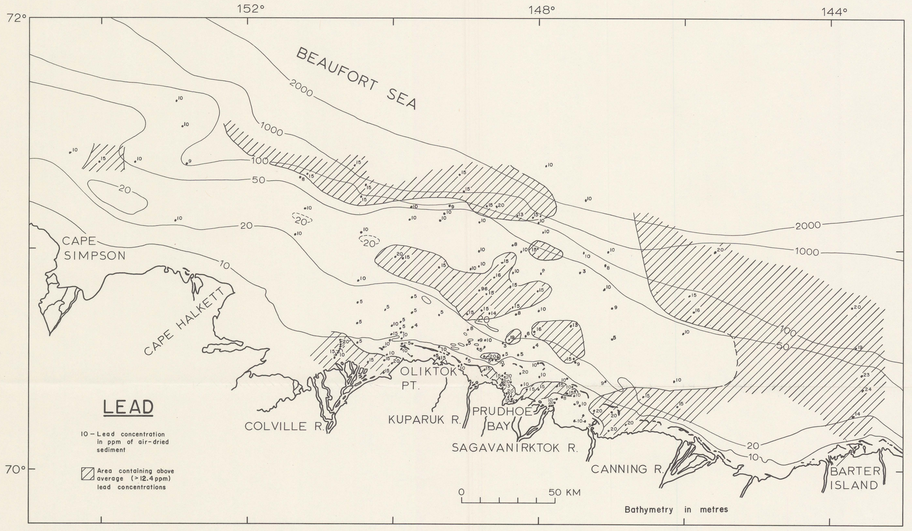
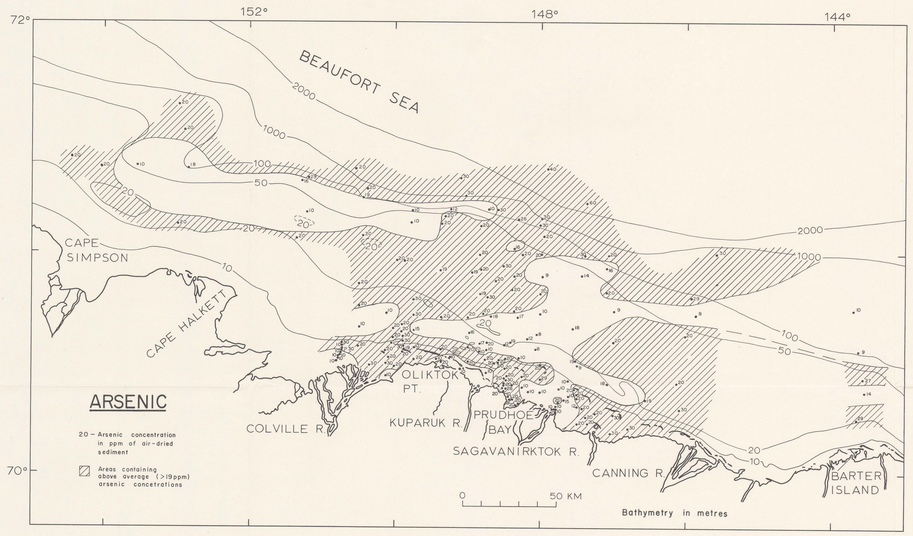
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

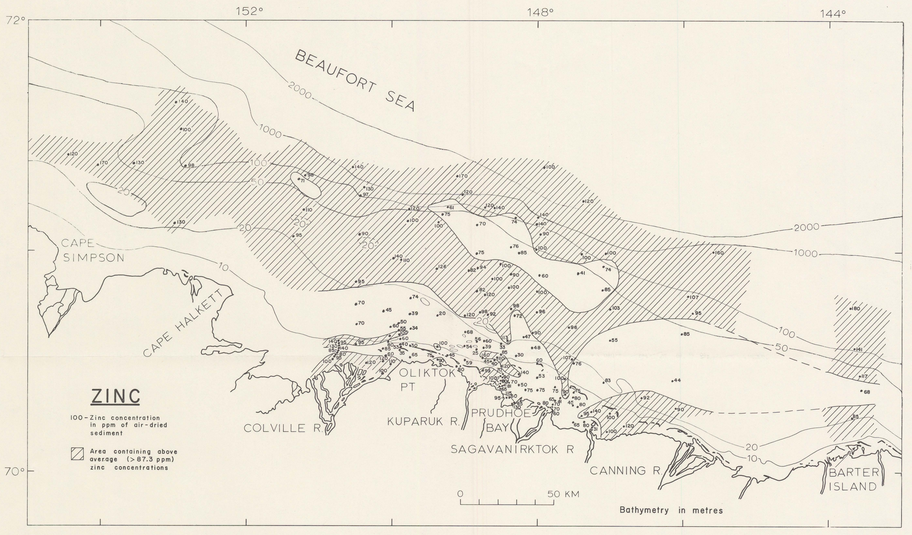
MISCELLANEOUS FIELD STUDIES
MAP MF-614

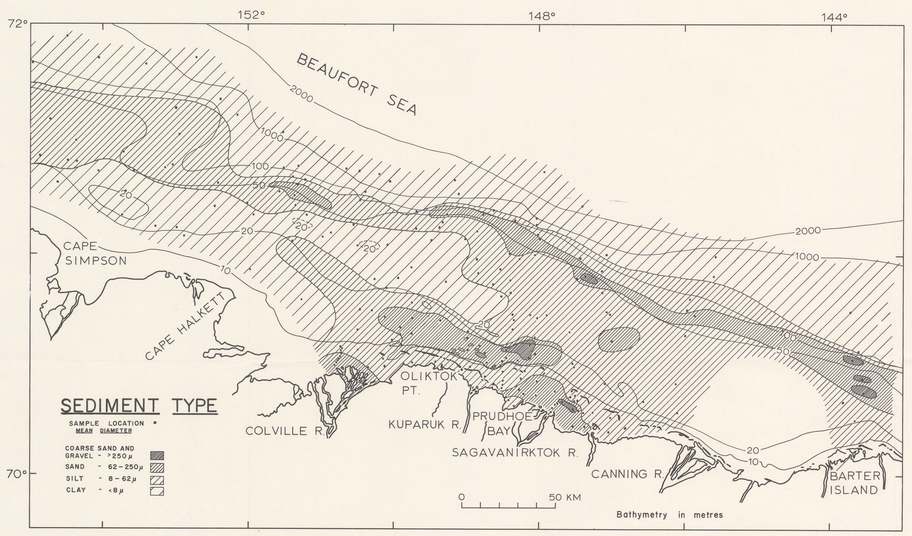












MAP SHOWING DISRIBUTION OF COPPER, LEAD, ZINC, MERCURY, AND ARSENIC IN THE SEDIMENTS OFF THE COAST OF NORTHERN ALASKA

by

Peter Barnes, Kam Leong, and Charles Gustafson

1974

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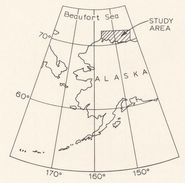

Alaska (Coasts, north). Bottom deposits. 1:1,400,000. 1974.
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Maps showing distribution of copper, lead, zinc, mercury, and arsenic in the sediments off the coast of northern Alaska

by

Peter Barnes, Kam Leong, and Charles Gustafson

INTRODUCTION

A developing interest in the normal distributions of potentially harmful substances in the natural environment has prompted a baseline study of a virtually pristine region along the northern coast of Alaska. The information reported here outlines the background values of copper, lead, zinc, cadmium, mercury, and arsenic in the nearshore sediments and is a companion to a similar report covering the sediments off the northwestern coast of Alaska (Barnes and Leong, 1971). This study forms a part of a larger investigation in which many other aspects of the physical, chemical, biological and geological aspects of the continental shelf are considered (Hufford, in press).

SAMPLING PROCEDURES

During August and September 1971, sediments were collected with a Van Veen grab, which samples an area of .15 m^2 to a depth of about .2 m. Additional samples were collected from coring and diving operations. All the samples that contained surficial sediments (upper 2 cm) were readily segregated on the basis of their markedly lighter color and the surficial orientation and concentration of the fauna in the samples. All samples were stored at room temperature for about 1 month and then held in a cooler at about 5°C for 3 to 6 months in sealed plastic containers until prepared for analysis.

ANALYTICAL PROCEDURES

Samples with gravel-size materials were wet sieved through 2-mm screen, and the remainder of the sample air dried and disaggregated gently in a mortar and pestle to minimize mercury evaporation. Samples without gravel were not sieved. On a series of eight replicate samples, drying at 105°C was found to decrease the mercury content an average of 24 percent over splits of the same samples air dried at room temperatures (20-25°C). The samples whose analyses are given here were dried at room temperature. The powdered samples were analyzed using the atomic absorption technique of Vaughn and McCarthy (1964) for mercury. Arsenic was determined using a wet chemical method developed by Ward and others (1963). Copper, lead, cadmium, and zinc were analyzed by an atomic absorption method described by Ward and others (1969). It should be noted that the method of digestion used is not designed to determine more than a fraction of the Cu, Pb, Cd, and Zn in the silicate lattice.

PATTERNS OF ELEMENT DISTRIBUTION

Elemental concentrations near or below the limit of detection and with a minimal range, as is true for many of our samples (table I), often show particle sparsity effects (Clifton and others, 1969). This effect results when the elemental abundance in the analyzed part of the sample depends more on the random occurrence of concentrations of that element owing to its low concentration than on the actual abundance in the sample. In addition, the errors found in obtaining a split of the sediment suggest that individual values for elemental abundance may not be representative of the samples; however, averaging, grouping and contouring of similar values, as is done in this report, increases confidence in the general trend of values and their interpretation.

The distribution of these elements is considered in terms of their areal distribution (figs. 1-5) and of the affinity of elements for certain sediment size fractions (table I and fig. 6). Cadmium was at or below the limit of detection (0.2 ppm) in more than 90 percent of the samples analyzed. Therefore, averages and trends were not computed or plotted for cadmium. All of the other elements show greatest concentrations in finer grained sediments and the lowest concentration in the coarse sand and gravel (table I). The preferential concentration of trace elements in fine-grained sediment is known from other studies (Hirst, 1962; Peterson and others, 1972) and has been ascribed to organic enrichment and absorption on clays.

Patterns of elemental aerial distribution (figs. 1-5) do not relate as simply to the sediment distribution pattern (fig. 6) as the size-concentration relation stated above might indicate. Copper, lead, zinc, and arsenic show an association with the finer grained sediments on the central and outer shelf (figs. 1, 2, 3, and 5); however, higher concentrations of these elements also occur along the coast particularly in the vicinity of the rivers, where the sediments are generally coarser (fig. 6). High mercury concentrations are found in the fine lagoonal sediments behind the barrier islands east of Oliktok Point (figs. 4 and 6) and off the Colville, Kuparuk and Sagavanirktok Rivers. Other above-average mercury values are along the shelf break. These areas of high mercury values correspond to regions where the fauna are more abundant than on the central shelf where ice gouging disrupts the sediment and fauna (Barnes and Reimnitz, 1974; Carey and others, 1974) and mercury values are lower. This correspondence suggests that the higher mercury values may reflect concentrations of organic matter as was demonstrated by DeGroot, DeGoeij, and Zegers (1971).

A linear regression analysis of sediment size and elemental abundance (table II) shows a strong negative correlation for all of the elements measured. Inter-element and element-depth correlations, however, are weak to very weak, and virtually all are positively correlated. This statistical analysis suggests that the abundance of each element is dependent on sediment texture but not dependent on water depth or the relative abundance of the other elements.

Uncertainties regarding the many aspects of source, transport mechanism, and depositional regime of the sediments (Barnes and Reimnitz, 1974) make an explanation of these aspects with regard to elemental mobility difficult at this time. However, comparison with several other baseline studies in the marine environment (summarized in Wedepohl, 1969; Barnes, 1972; Nelson and others, 1972, and Peterson and others, 1972), coupled with the fact that man's influence to date has been minimal, suggests that the values reported here are background concentration for these elements in the study region.

ACKNOWLEDGMENT

Ship time for the collection of samples was provided by the U.S. Coast Guard aboard the icebreaker GLACIER, by the Naval Arctic Research Laboratory aboard the R/V NATCHIK, and by our own agency aboard the R/V LOOK. We gratefully acknowledge the help and cooperation of our fellow scientists, in particular James V. A. Trumbull and Erk Reimnitz for their assistance in the field and for their discussion of our results.

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Table I.--Concentration of elements in different sediment types

Size fraction	Number of samples	Average (ppm)	Range of 70% of values (ppm)	Range (ppm)
Copper				
Clay	21	28.6		25-40
Silt	94	21.1		10-40
Sand	43	12.0		5-25
Coarse sand and gravel	12	11.7		5-25
Total	170	19.1	5-30	5-40
Lead				
Clay	21	14.0		10-20
Silt	94	14.4		5-20
Sand	43	9.8		4-20
Coarse sand and gravel	12	7.0		3-24
Total	170	12.4	10-70	3-24
Zinc				
Clay	21	133.4		100-180
Silt	94	95.2		44-140
Sand	43	59.2		20-95
Coarse sand and gravel	12	43.4		25-68
Total	170	87.3	40-140	20-180
Mercury				
Clay	21	0.035		0.010-0.15
Silt	94	0.046		0.010-0.25
Sand	43	0.035		0.010-0.12
Coarse sand and gravel	12	0.020		0.010-0.05
Total	170	0.040	0.010-0.110	0.010-0.250
Arsenic				
Clay	21	22.8		9-60
Silt	94	20.0		6-30
Sand	43	16.2		9-30
Coarse sand and gravel	12	14.3		6-20
Total	170	19.0	10-30	6-60

Table II.--Correlation coefficients of chemical elemental abundances

	Hg	As	Cu	Pb	Zn	Depth	Size
Hg	1.00						
As	0.02	1.00					
Cu	0.07	0.29	1.00				
Pb	0.14	0.21	0.43	1.00			
Zn	0.14	0.31	0.45	0.47	1.00		
Depth	-0.11	0.44	0.29	0.06	0.29	1.00	
Size	-0.89	-0.84	-0.72	-0.92	-0.80	-	1.00