CANADA BRITISH COLUMBIA – OKANAGAN BASIN AGREEMENT

PRELIMINARY REPORT NO.18

(SUBJECT TO REVISION)

The Limnogeology of the Okanagan Mainstem Lakes

PREPARED FOR THE
OKANAGAN STUDY COMMITTEE

CANADA - BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT

TASK 121

The Limnogeology of the Okanagan Mainstem Lakes

by
Brian E. St. John

NOTICE

This report was prepared for the Okanagan Study Committee under the terms of the Canada-British Columbia Okanagan Basin Agreement. The Information contained in this report is preliminary and subject to revision. The Study Committee does not necessarily concur with opinions exed in the report

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SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The foregoing discussion has presented a large amount of data on the Okanagan mainstem lakes that can be related significantly to many aspects of water management in the Okanagan Valley. A detailed re-listing of these data in this chapter would not aid in its understanding. Hence the writer will present brief discussion of those aspects of the limnogeology of these lakes of primary interest to the Okanagan Basin Study.

Discussion

<u>Wood Lake:</u>

Wood Lake, the smallest of the Okanagan mainstem lakes, shows indications of man's influence in sediments deposited over the past 100 years. The significant increase in organic carbon and calcium carbonate content in the cores near the surface probably reflects the accelerated eutrophication that resulted from human settlement of the surrounding watershed. More recent acute mercury pollution appears to have occurred over that past few decades, however, and the source of this pollution remains uninvestigated at the present time. The extended period of anoxic conditions in the Wood Lake hypolimnion, reflecting the high degree of eutrophication of that lake and the high concentrations of mercury in the surface sediments, suggest that sophisticated water management of the Wood Lake watershed is a necessity. It is possible that the anoxic conditions common at the bottom of this lake has resulted in the mineralization of the bulk of the mercury to a sulphide, rendering it essentially unavailable for methylation, and hence essentially harmless. If this is true, attempts to improve Wood Lake water quality should not result in an increased mercury problem in the Valley.

<u>Kalamalka Lake:</u>

The extraordinary carbonate cycle of Kalamalka Lake has probably been the prime "protector" of that lake's excellent water quality. The $CaC0_3$ coprecipitates large abundances of the trace metals of the lake and must be accompanied by hydroxyapatite in its precipitation. It seems probable that the annual removal of reactive species in association with this $CaC0_3$ cycle has contributed materially to the preservation of Kalamalka's Oligotrophic state. The high surface concentrations of mercury in the surface sediments of this lake are presumably derived from Wood Lake, however, and indicate that Kalamalka Lake is not insulated from input through Vernon Creek.

It is not clear from the available evidence how the carbonate cycle of Kalamalka Lake would be altered through further deterioration of and/or increased input from Wood Lake. Further analyses and calculations on this problem will be undertaken by the writer in the future to attempt to assess this problem.

<u>Okanagan Lake:</u>

Readily apparent water quality degradation in Okanagan Lake appears to be restricted to the Armstrong and Vernon Arms. The anomalous organic carbon and mercury results of these arms of the lake are probably a result of man's activity in the Vernon Creek and Deep Creek watersheds.

The enrichment in organic carbon accumulation apparent rate in the upper 10 cm. of a core from Okanagan Lake suggests that a man-induced acceleration of eutrophication may have occurred in this lake as a result of predominantly rural activities over the past century.

Skaha Lake:

The alterations in water quality that resulted in blooms on Skaha Lake in 1966 led to the initiation of the Okanagan Basin Study. Of prime interest from the Task 121 project is the hypothesis that these alterations are probably reversible through the rapid mineralization of phosphorus in this lake to hydroxyapatite and related phases. The time span for this reversal of eutrophication cannot at present be accurately estimated, but further research in progress at CCIW may allow such an estimate.

The sharp increase in accumulation rate for organic carbon in the uppermost 5 cm. of the core from Skaha Lake indicates that net carbon detritus production increased sharply over the past 25 years. It seems probable that this increase has been caused by the sudden acceleration of eutrophication occasioned by the input of sewage waste to Skaha Lake over the past 25 years. No longterm increase in organic carbon accumulation rate is apparent in the data from Skaha Lake other than this aforementioned change.

Osoyoos Lake:

The enrichment in organic carbon concentrations in sediment deposited over the past century in Osoyoos Lake probably reflects the man-induced eutrophication of that lake by rural activity. Statistical analysis of the data suggests that mercury is strongly associated with organic carbon in the sediment of this lake, and hence the mercury must be considered to be available for methylation. The source of the mercury in Osoyoos Lake has not be identified.

It is of interest to note that agricultural development in the Osoyoos Lake area has only been significant in the present century. Hence, changes in Osoyoos Lake sediments that reflect water quality alterations in the nineteenth century could not have been from active agricultural programs, but may have resulted from accelerated erosion caused by cattle grazing.

Conclusions and Recommendations

The sedimentary evidence for long-term (one century) water quality degradation in Wood, Okanagan, and Osoyoos Lakes, the lakes of the chain draining the watersheds most affected by rural activity, suggest that a considerable study of the effect of various rural practices on water quality is warranted. This study should encompass the effects of early land use methods as well as a detailed look at present agricultural methods in the Valley.

In addition to the carbon evidence, the surface distributions of anomalous concentrations of mercury in the Vernon Creek drainage, the Armstrong Arm of Okanagan Lake, and in Osoyoos Lake provide strong circumstantial evidence that rural practices may have resulted in the release of this toxic element to the lake environment. The trend of higher mercury content in sediments from Wood Lake, Kalamalka Lake, and the Vernon Arm of Okanagan Lake suggests that the source of this mercury is in the Wood Lake drainage, an area of extensive rural activity. The presence of mercury upstream from Vernon and the lack of any anomalous mercury abundances in association with Kelowna and Penticton suggests strongly that urban development has not contributed significantly to the release of this element.

Skaha Lake appears to have undergone a rather sudden change in water quality at a time (25 years ago) essentially contemporaneous with the initiation of sewage input from Penticton. This resulted in an increased accumulation rate for organic carbon in the sediments as biomass production increased in the lake because of accelerated eutrophication. However, as a tertiary sewage treatment plant has been built for Penticton, and as the mineralization of phosphorus to unreactive material appears to be very rapid in this lake, the probability of significant short-term water quality improvements in Skaha Lake is very high. As longer term (one century) processes do not appear to have been significant in the deterioration of water quality in this lake, the prognosis for Skaha Lake in the future is excellent.

The carbonate cycle in Kalamalka Lake has "protected" that lake from significant water quality degradation since man settled in the Okanagan Valley. However, the increased flow into this lake caused by the opening of the Hiram Walker distillery near Winfield will have unpredicted effects on this cycle. If these effects are adverse and significant in magnitude, it is possible that Kalamalka Lake could undergo an undesirable acceleration of eutrophication. The author will be doing further calculations and analyses to attempt to formulate an accurate assessment of this problem.

CHAPTER I – INTRODUCTION

Introduction

Task 121 of the Okanagan Basin Study has been designed to provide basic information on the limnogeology of the five mainstem lakes in the Okanagan Valley, for use in the overall evaluation of the limnology of these lakes. To accomplish this end, studies have been made on Wood's, Kalamalka, Okanagan, Skaha, and Osoyoos Lakes investigating sedimentological, stratigraphic, and geochemical parameters. The analysis of the data gained from these studies is the subject of this report.

Scope of the Present Study

The primary aims of the Task 121 studies can be summarized as follows:

1. To gain new information about the post-Pleistocene history of the lakes.
2. To describe sediment structure, distribution, mineralogy, and major element composition in the lakes and to measure gross sedimentation rates.
3. To investigate sediment reactions involving biologically significant elements, both nutrient and toxic in nature.

During the accomplishment of these primary aims, a number of incidental information was gained including the production of an improved set of bathymetric charts for the lakes and new information about the Pleistocene history of the valley. In addition, certain basic research problems in sedimentary geochemistry that are presently under investigation were elucidated.

Previous work in the Okanagan Valley

Geology of the Okanagan Valley

The earliest publications concerned with the geology of the Okanagan Valley are those of Dawson (1878 and 1879) and Daly (1912). More recent work on bedrock geology has been reported in Cairnes (1932), (1937), (1939), Jones (1959), Hyndman (1968), and on the maps (annotated) GSC (1940), (1960, and 1961).

Surficial geology and Pleistocene history has been discussed in Flint (1935a and b), Meyer and Yenne (1940), Mathews (1944), Nasmith (1962), Wright and Frey, (1965), Armstrong et al (1965), and Fulton (1965, 1969, and 1971). The works of Nasmith (op. cit.) and Fulton (op. cit.) provide the most complete discussions of the Pleistocene history of the area.

Soil types of the Okanagan Valley have been discussed by Woodridge (1940), and Kelly and Spilsbury (1949). Hansen (1955) has published valuable work on pollen geochronologies in peat deposits from southern B.C. and his work provides a background for Okanagan Valley pollen studies.

Volcanic explosion ash bands have been used with success in geologic studies in the B.C.-Washington border area. Information on these ash bands has been published in Rigg and Gould (1957), Wilcox (1965), and Westgate et al (1970). Publications on ash band chronology have been reviewed by Fulton (1971).

Geomorphological aspects of the Okanagan area have been discussed in Reinecke (1915), Holland (1964), and Tipper (1971).

Limnogeology of the Okanagan Lakes;

Studies on the limnogeology of the modern Okanagan Lakes have been almost non-existent. Logs were made of the cores drilled near Kelowna during the construction of the floating bridge at that city. These cores penetrated up to 300 feet of silts, sands, and clays near the centre of the lake at that point. Saether (1970) presented a primitive sediment classification for the samples that he collected for benthic fauna analysis. In their reports on water quality in Skaha and Osoyoos Lakes, Coulthard and Stein (1969) and Booth et al (1969) presented a small quantity of data on sediment chemistry from those lakes. Values for calcium, phosphate, and nitrate in sediment samples are presented in these reports.

Field Activities of the Present Study

Field work for the Task 121 study was accomplished during the summer and fall of 1971. An acoustic sounding program was run using a Kelvin-Hughes 26b echo sounder and over 715 km. of lines were covered (fig. 1). In addition, a transit sounder survey of the nearshore areas of Skaha and southern Okanagan Lakes was performed using a Kelvin-Hughes 39b sounder over 100 km. of lines. Over 150 surface samples of sediment were collected (0 cm. to 3 cm.) (fig. 2) with a Shipek grab sampler and a total of about 50 cores were taken by the writer and by Drs. A.L.W. Kemp and J.D.H. Williams. A benthos corer with 100 lb of lead weights was used and most cores recovered were about one meter in length. Shipek samples and subsamples taken from cores were freeze-dried in the field and were returned to CCIW in Burlington, Ontario for analysis. Field observations of colour, texture, and general sample characteristics were noted, and a photograph (colour slide) was taken

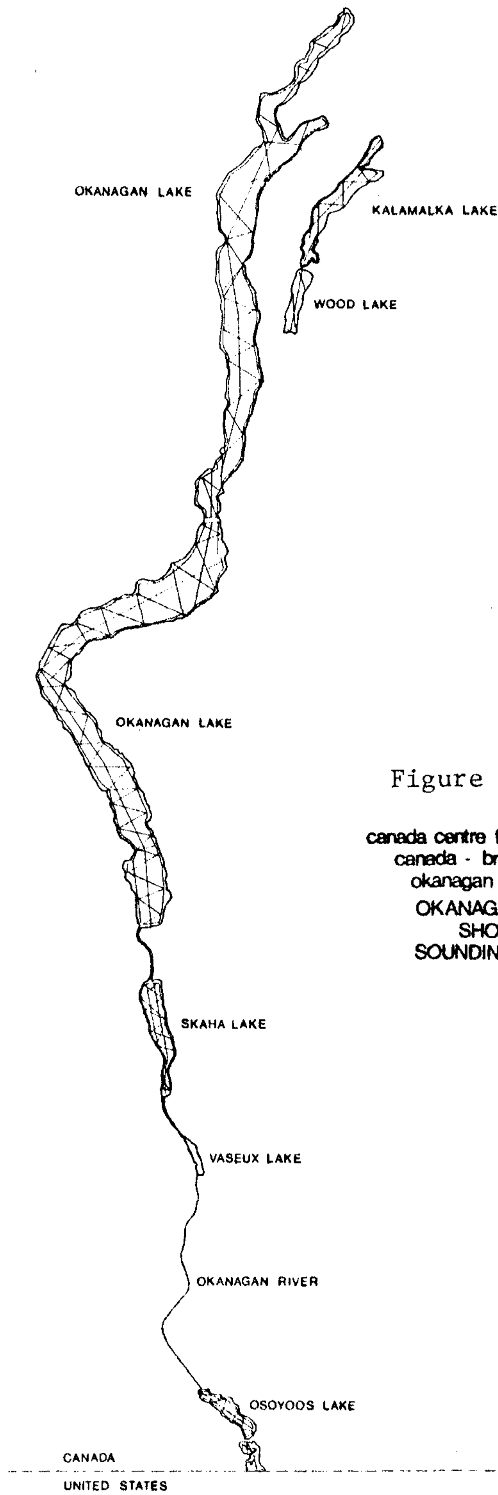

Figure 1.

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OKANAGAN BASIN
SHOWING
SOUNDING LINES

BATHYMETRY BY B E ST JOHN 1971 TASK 121

of each sample. The depth of each sample location was recorded from the meter block of the winch, and positioning was accomplished with sextants and compasses.

Measurements of pH, Eh, and water content were taken from cores from each of the mainstem lakes by Dr. A.L.W. Kemp in August of 1971.

Laboratory Methods of the Present Study

The samples collected for the Task 121 program have been subjected to a large number of laboratory investigations, and the methods employed are detailed below.

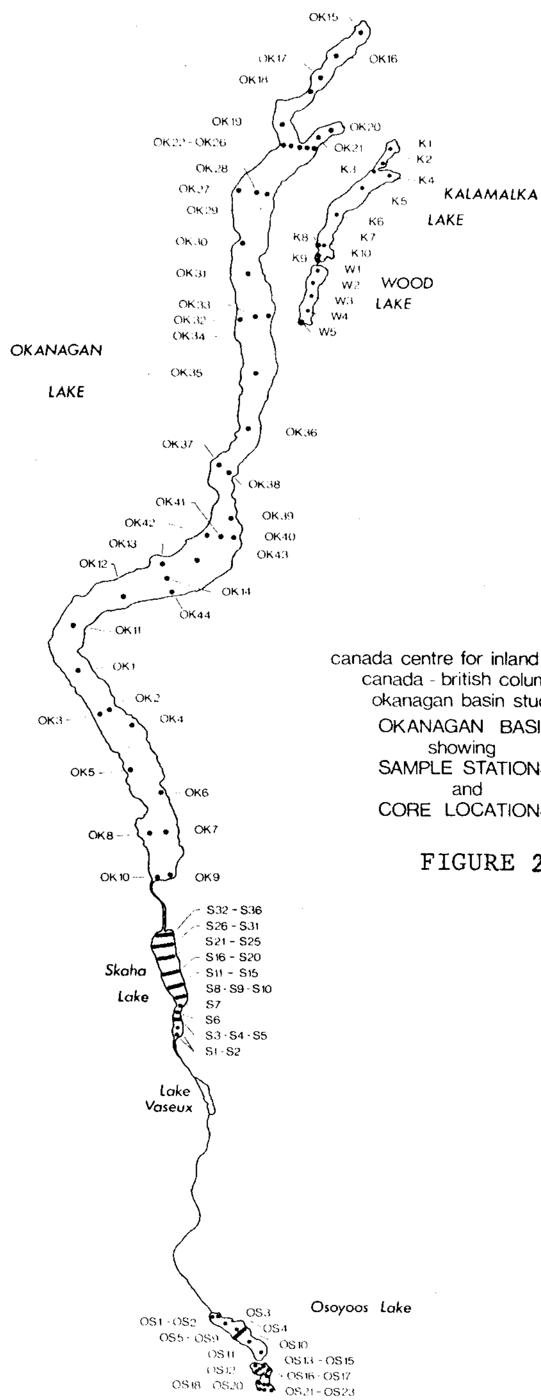
Total major element analysis of the samples was done by X-ray fluorescence using a Phillips PW1220C semi-automatic X-ray fluorescence spectrometer on pelletized samples. Ca, Na, Fe, Mg, P, Mn, Si, K, S, Al, and Ti were determined with this system. HCl extractable Pb, Fe, Mn, Cu, Zn, Ni, Co, Cr, Cd, Be, V, K, Mg, and Ca were measured by a Techtron AA-5 Atomic absorption spectrophotometer. The freeze dried sediment samples were subjected to attack by hot concentrated HCl for 30 minutes and the leachate was analysed.

Additional trace element results were obtained under contract to the Commercial Products Laboratory of the Atomic Energy Commission, Ottawa. This laboratory analysed perchloric acid leaches from the sediments for Cu, Mn, As, Sc, Eu, and Sm using instrumental neutron activation analysis.

Mercury analyses of the sediment was performed under contract by Barringer Research of Toronto, using their patented mercury spectrometer. Additional differential thermal mercury analysis of selected samples have also been done at Barringer Research to assist in characterizing the forms of mercury in the sediments.

core locations

STATION NUMBER	CORE NUMBER
W3	WC-1
K6	KC-1
K9	KC-2
OK 1	OKC-1
OK 12	OKC-2
OK 31	OKC-3
S4	SC-1
S18	SC-2
OS8	OSC-1
OS14	OSC-2
OS22	OSC-3



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OKANAGAN BASIN
showing
SAMPLE STATIONS
and
CORE LOCATIONS

FIGURE 2

B.E. St John 1971 Task 121

Organic carbon and carbonate carbon contents of the sediment have been measured using a Leco induction furnace according to the method described in Kemp (1971).

Acid extractable phosphorus was determined by a modification of the method of Shah et al (1968). The modification consisted of the use of HCl in place of H_2S0_4. Further attempts to characterize the forms in which phosphorus are present in sediments are being undertaken using the methods described in Williams et al (1967). The results of these investigations will be presented upon their completion.

The grain size fractionation present in the sediments has been measured by standard long pipette analysis at CCIW. X-ray diffraction studies have been undertaken on the mineralogical composition of each size fraction, and this work has been assisted by microscopic investigation.

Finally, assistance has been sought from a number of investigators for volcanic ash band refractive index measurement, palynological studies, and carbon-14 dating. The data gained from all of these investigations is contained in Appendices I to V.

CHAPTER II - GEOLOGY OF THE OKANAGAN VALLEY

Pre-Pleistocene Geology

The Okanagan Valley is a structural trench overlying a system of subparallel, linked faults that separate the late Paleozoic or early Mesozoic Monashee Group of the Shuswap Metamorphic Complex from the rocks of differing lithology but similar age west of the Valley (fig. 3). Near Vernon in the Monashee Mountains, unfossiliferous rocks correlated with the Cache Creek Group appear to lie with angular unconformity on the Monashee Group (Jones 1959). The Cache Creek Group bounds the Armstrong and Vernon Arms of Okanagan Lake, and the northernmost arm of Kalamalka Lake, and is characterized by a profusion of small, sub-economic gold, silver, and base metal deposits.

The greater part of the shoreline of Okanagan Lake, however, is formed by the granite, granodiorite, and allied rocks of the Jurassic or Cretaceous Coast Instrusions, and the gneisses, schists, marbles, and quartzites of the Monashee Group. The main exception to this rule is the area of early Cenozoic volcanic and sedimentary rocks straddling the lake in the Kelowna Area.

Wood and Kalamalka Lakes are similarly bounded by Monashee metamorphic rocks on the east and granites and granodiorites on the west. A relatively localized band of limestone in the Monashee Group forms the north shore of Cosens Bay in Kalamalka Lake.

Skaha Lake is bounded by Monashee metamorphic rocks and by later acid intrusives on the east side, but by Eocene or Oligocene andesite and trachyte flows and agglomerates on the west. The fault line trace between these two dominant lithologies coincides with the course of MacLean Creek, which enters Skaha Lake opposite Kaledan.

The east shoreline of Osoyoos Lake is comprised of Monashee metamorphic rocks and later acid plutonic intrusions, and the west shore of that lake includes the Paleozoic metamorphic rocks of the Kobau Group.

In co-operation with officers of the Geological Survey of Canada, a seismic reflection survey was run on Skaha, Okanagan, Wood, and Kalamalka Lakes during the fall of 1971. In the interests of efficiency, it was agreed that the GSC would take responsibility for reduction and publication of the data from this survey, and hence it will not be presented in detail in this report. Evidence collected by this survey indicates that the structural trench of the Okanagan Valley is partially filled by several hundred feet of unconsolidated material that rests on a floor of moderate and rounded relief. It seems probable that this floor, along with the topography of most of the Okanagan Highlands, is a remnant of the uplifted and dissected gently rolling early Tertiary erosion surface referred to by Tipper (1971).

The thickness of unconsolidated material underlying these lakes differs from place to place, but typical minimum thicknesses under the centres of these lakes are:

Skaha Lake - north of Kaleden	1200 ft.
Okanagan Lake - Penticton to Squally Pt.	1500 ft.
Okanagan Lake - Squally Pt. to Westbank	1600 ft.
Okanagan Lake - Kelowna area	1200 ft.
Okanagan Lake - Wilson's Landing - Okanagan Centre	1200 ft.
Okanagan Lake - OK Centre to Vernon	1200-2000 ft.
Okanagan Lake - Armstrong Arm	1300 ft. +
Wood Lake	400 ft. +
Kalamalka Lake	300-400 ft.

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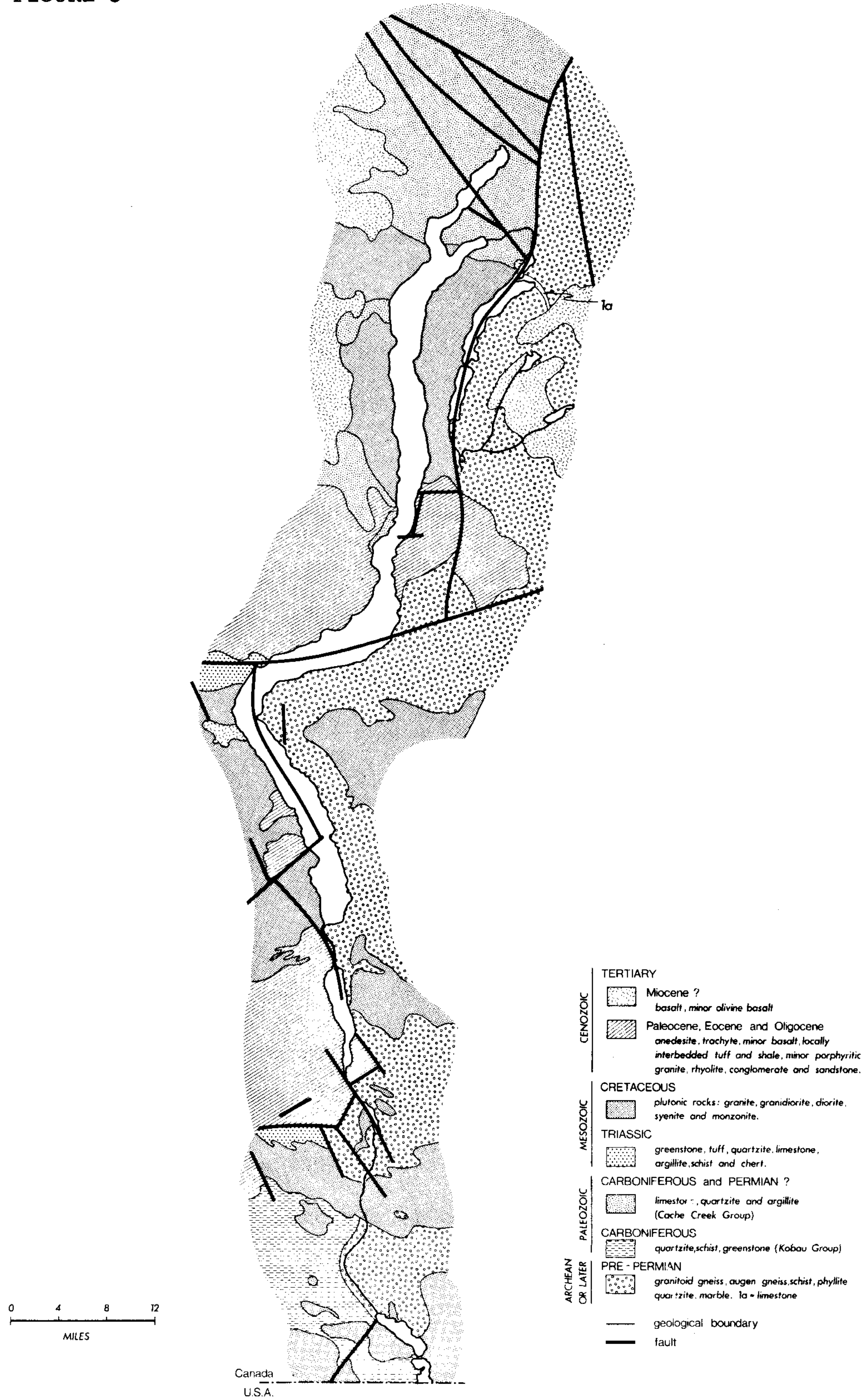
BEDROCK GEOLOGY AROUND THE OKANAGAN MAINSTEM LAKES

FIGURE 3



B.E. St John, Task 121 after G.S.C. maps 1059a & 15-1961

The structural trench is apparently continuous under the Okanagan River between Skaha and Okanagan Lakes and under the Vernon Creek between Wood and Kalamalka Lakes. Its continuity is apparently interrupted at the narrows of Skaha Lake at Kaleden, at which point bedrock is less than 100 feet below the surface of the lake.

Economic Geology

A detailed discussion on the mineral resources of the Okanagan Valley area is presented in the report of Task 201, Okanagan Basin Study. For the purposes of this report, however, only a few points about the economic geology of the area are pertinent.

The only major economic ore body in the Okanagan Valley at the present time is the copper-molybdenum deposit of Brenda Mine, near Peachland. This mine was opened in March, 1970, and has proven reserves of 177 million tons of 0.18% copper and 0.049% molybdenum. The Brenda Mine is a large one, with a milling rate in excess of 24,000 tons daily.

Mining activities in the Okanagan Valley not associated with the Brenda deposit have been very limited by comparison. Two areas within the Okanagan Valley typically contain numerous small sub-economic mineral deposits: The Fairview Camp in the Oliver area, and the rocks of the Cache Creek Group near Vernon.

The Fairview Camp contains a large number of small deposits of gold in white quartz, with minor sulphide mineralization. Mining activity in this area has occurred periodically from prior to 1900.

The Cache Creek Group is the host for a number of small deposits containing gold, copper and silver, with associated minor antimony, lead, arsenic, and zinc. This Group forms the shoreline of the Armstrong and Vernon arms of Okanagan Lake, and of the west shore of the north arm of Kalamalka Lake.

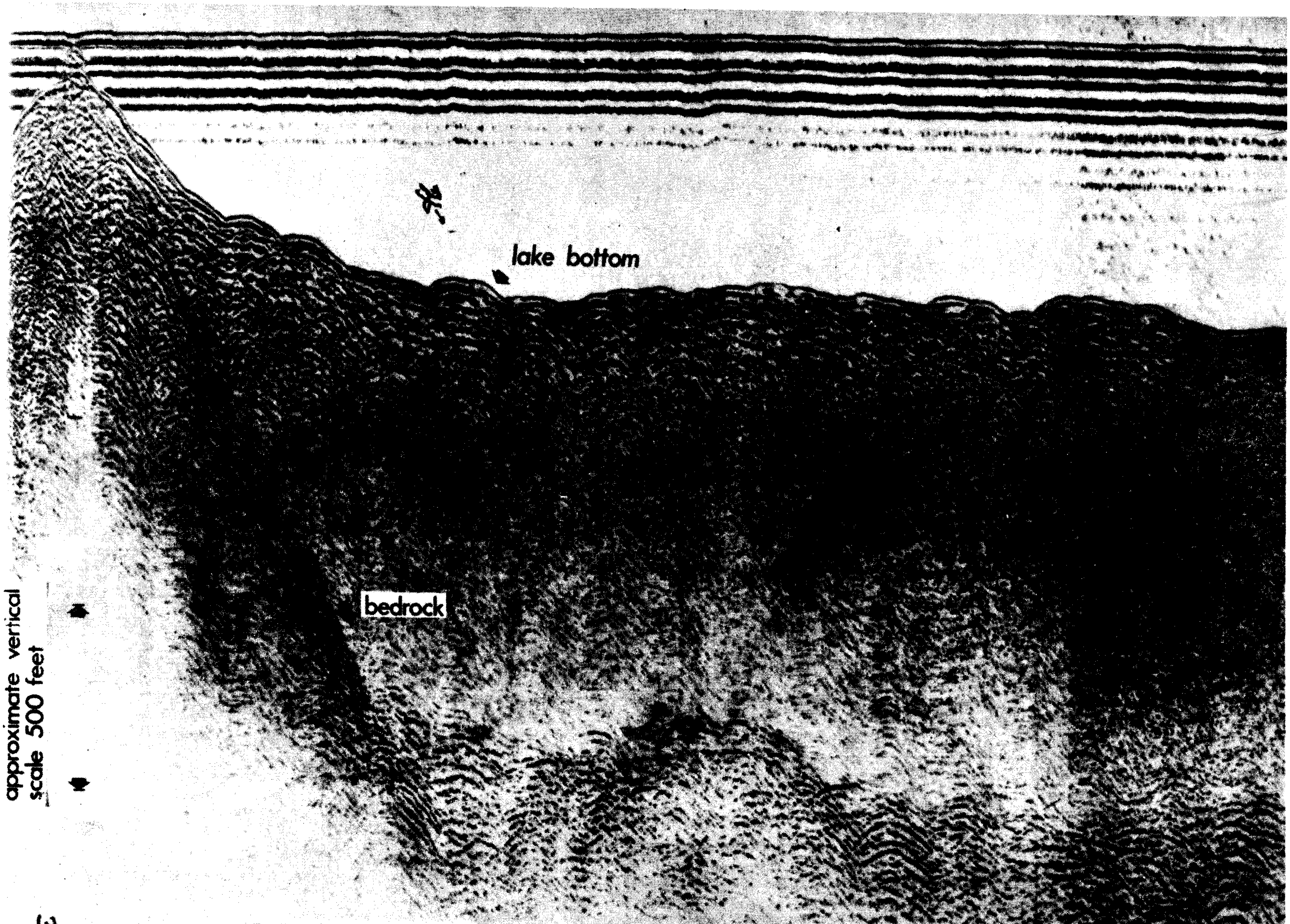


Fig 4: SEISMIC RECORD TAKEN ON OKANAGAN LAKE SOUTH OF FINTRY LANDING

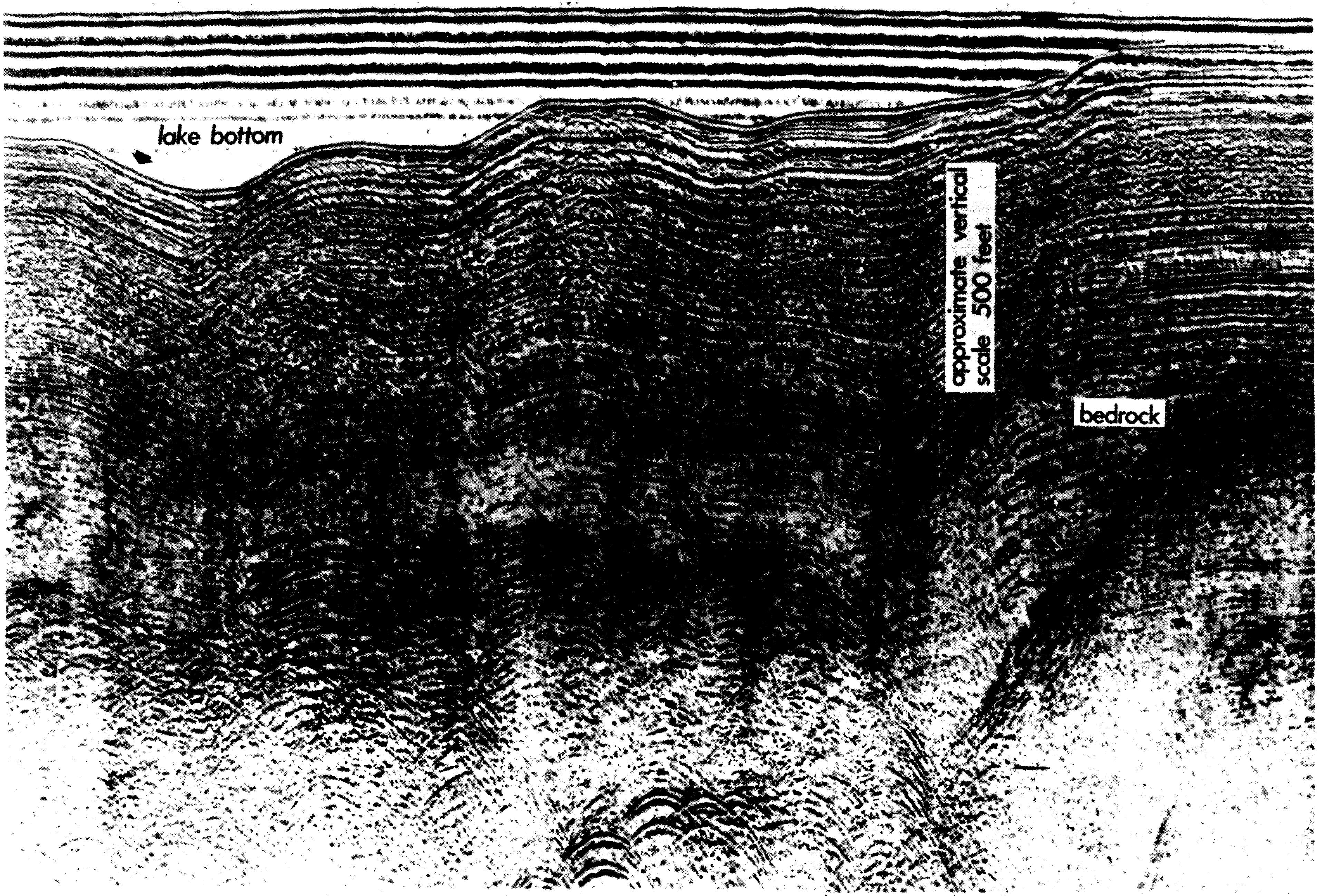


Fig 5: SEISMIC RECORD TAKEN ON OKANAGAN LAKE NORTH OF FINTRY LANDING

Hence it can be seen that the only known points of contact of anomalously mineralized rocks with lake waters in the Okanagan occurs where the Cache Creek Group forms a shoreline near Vernon.

Pleistocene Geology and History

The Pleistocene geology and history of the Okanagan Valley has been extensively reviewed in Nasmith (1962) and Fulton (1965 and 1969). The present discussion will be limited to new material discovered as a result of the task 121 surveys.

It is most probable that the unconsolidated material in the Okanagan Valley Trench was deposited in association with the earlier glaciations of the Pleistocene Epoch. The presence of a large drumlinoid structure on the floor of Okanagan Lake near Squally point (outlined by the Task 121 acoustic survey), and the known late glacial history of the Valley (Fulton 1969) suggest that the ice sheets of the last Pleistocene glaciation may have overridden this thick deposit. The nature of these unconsolidated deposits in the Okanagan structural trench is not certain from the seismic records alone, but it seems probable that during the Pleistocene Epoch the valley was the site of deposition resulting from glacial outwash, direct glaciation and lacustrine and fluvial sedimentation.

A significant difference characterizes the seismic record of Okanagan Lake south of Fintry (fig. 4) from that taken north of Fintry (fig. 5).The record south of Fintry is characterized by apparently structureless material that records as a mass of point reflectors. North of Fintry, however, bedding structure is well defined to the northern tip of the Armstrong Arm. The records from Kalamalka and Wood

6. Prograding beach deposits;
7. Longshore drift deposits;

Lakes are also characterized by well bedded structures. It seems probable that these structured sediments were deposited through a different agency from the unstructured material to the south. Possibly an ancient lake occupied the northern part of the Valley prior to the last glaciations while the southern part of the Valley was filled with glacial drift. More work is required to solve this problem.

Certain other facts that influence interpretations of the Pleistocene history of the Okanagan Valley were discovered during the Task 121 survey. The most important of these was the detection of a terrace existing on the bottoms of Okanagan Lake (south of Squally point) and of Skaha Lake. It seems probable that this terrace is a record

8. Post-terrace rapid sedimentation:
   a) Weed beds,
   b) Stream deltas.

The integrated result of all of these processes has been the production of a very complex physiography in the benthic littoral zone of Skaha Lake and the southern part of Okanagan Lake.

Recent Geology and History

Deglaciation of the southern part of the Cordilleran Glacier Complex was accomplished largely by downmelting and stagnation of the ice mass as a whole, with no clearly defined halts or re-advances (Nasmith 1962). The prominent glaciolacustrine silt and clay cliffs that border Skaha and southern Okanagan Lakes were formed during this period of glacial downwasting and degradation (Flint 1935). Fulton (1969) has estimated that the deglaciation of the Interior Plateau of B.C. was well advanced by 9750 B.P., and by 8900 B.P. all ice was melted and the glacial lakes had been drained. From this time until the present day, the mainstem lakes of the Okanagan Valley have been in existence. It is not known when the low stand of Okanagan and Skaha Lakes noted above occurred, but it seems probable that it occurred early in the evolution of the modern mainstem lakes.

The total accumulation of sediments in the Okanagan Valley structhral trench that can be ascribed directly to sedimentation from the modern mainstem lakes cannot be estimated accurately from the data available to the present writer, but it must typically have been in the order of tens of metres. A sedimentation rate of one mm. of compacted sediment per year would yield a net accumulation of 8.9 m. of sediment in 8900 years (29.2 feet). Although stability of the sedimentation rates in the mainstem rates of the Okanagan Valley over post-Pleistocene time cannot be assumed, it seems probable that only a very small part of the unconsolidated material in the Okanagan Valley structure is derived from the recent lakes.

Accurate estimates of present day rates of sedimentation in these lakes have been made during the Task 121 study. These estimates will be discussed below in Chapter III.

CHAPTER III - THE OKANAGAN MAINSTEM LAKES

Physiography

Bathymetric charts have been constructed from the data gained during the Task 121 survey (figs.6 to 10). The discussion presented below will be restricted to a consideration of the new knowledge gained during the Task 121 studies.

Wood Lake;

Wood Lake is the smallest of the mainstem lakes with an area of 2300 acres, and consists of a single shallow basin of maximum depth 110 feet. The bathymetry of Wood Lake is presented in fig. 6.

Kalamalka Lake:

The most unusual feature of Kalamalka Lake is the presence of the essentially flat terraces of calcium carbonate that are found at the southern end of the lake and at a few other points on the shoreline. Kalamalka Lake actively precipitates calcium carbonate each summer from the waters of its epilimnion, and the break in the bathymetry at the edge of the terraces approximate the mean depth of the thermocline during the recent evolution of the lake. The lake contains two distinct basins that are separated by a ridge in the unconsolidated material filling the structural trench (fig. 7).

Okanagan Lake:

The complex physiography that exists in southern Okanagan and Skaha Lakes above the 50 foot contour has been discussed. In addition, the bottom of Okanagan Lake is characterized by irregular undulations

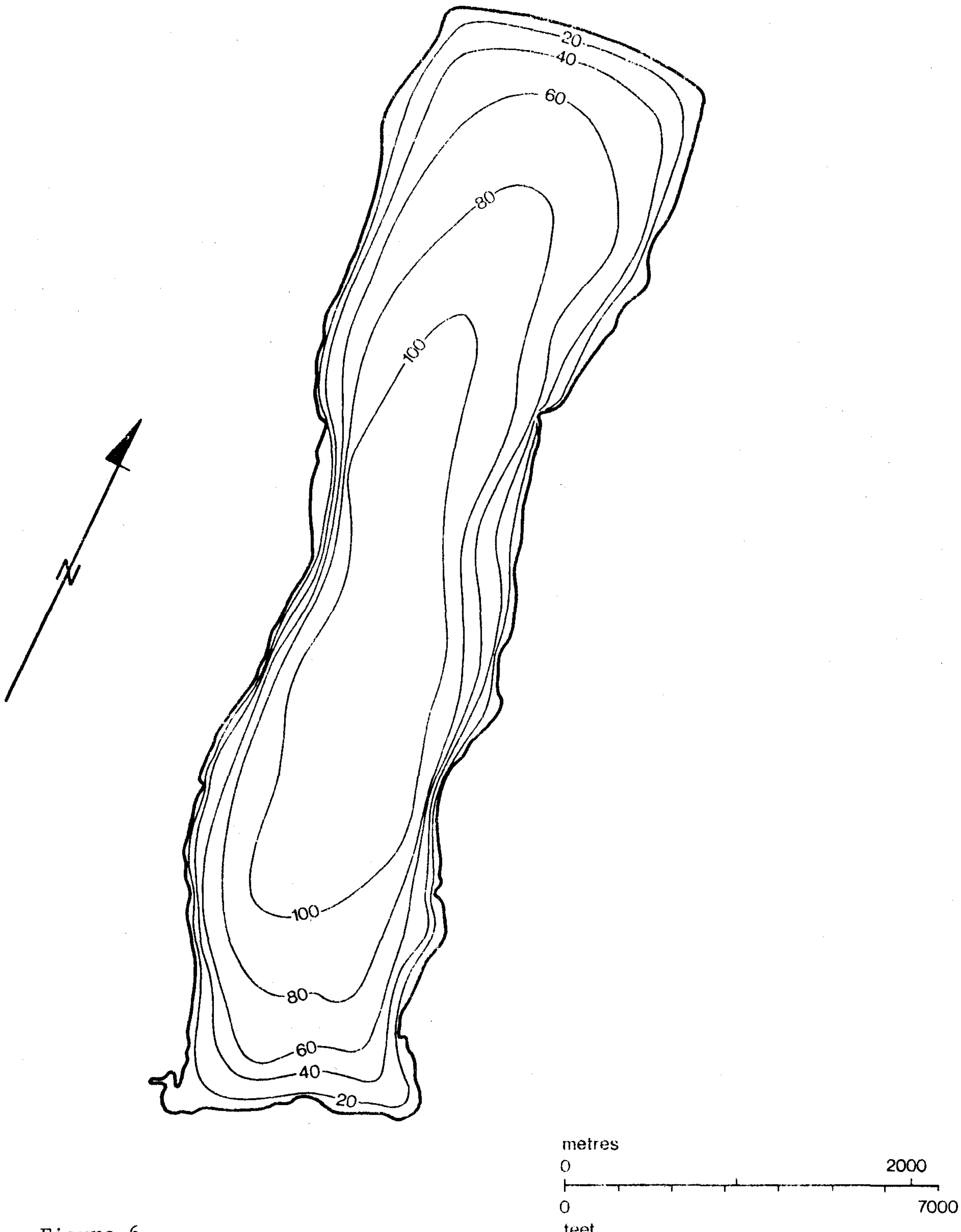


Figure 6.

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WOOD LAKE
bathymetry

CONTOURS AT 20ft INTERVALS

BATHYMETRY BY B.E ST. JOHN 1971 TASK 121

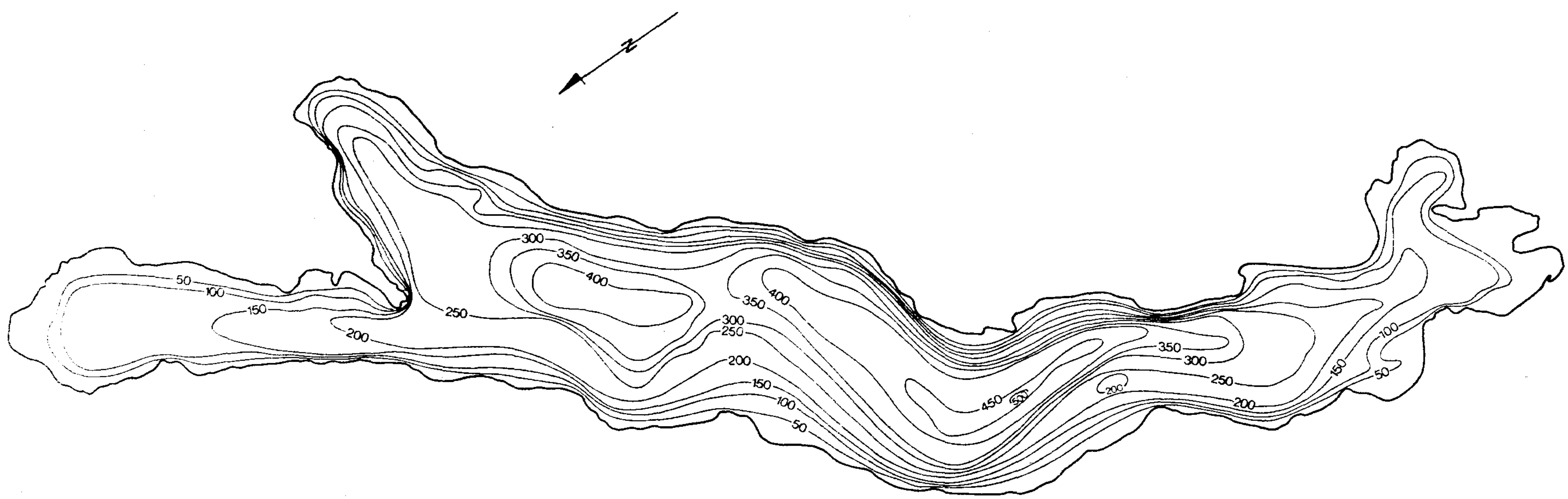

Figure 7.

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LAKE KALAMALKA
bathymetry

CONTOURS AT [illegible] INTERVALS

metres
0 3000
0 9000
feet

BATHYMETRY BY G.E. ST JOHN 1971 TASK 121 that presumably reflect the glacial modifications in the Valley from the last ice age. A large drumlinoid structure exists under 200 ft. of water off Squally Point, and a point 700 ft. deep was discovered south of Trepanier (fig. 8).

Skaha Lake:

Skaha Lake is comprised of two distinct basins that are separated by a bedrock sill at a depth of about 80 ft (fig. 9). The complex physiography above the 50 ft. contour that exists in Skaha Lake has been discussed. A well defined bench at a depth of 50 ft. exists off McLean Creek. It seems probable that this bench is a further remnant of the low stand postulated above. The dual basin morphology of this lake provides a terrigenous sediment trap situation, with the north basin accumulating terrigenous material and the small south basin manifesting greater organic carbon concentrations.

Osoyoos Lake:

Osoyoos Lake is, in fact, three lakes, with sand deposits dividing them (Fig. 10). The northenmost of these "lakes" has three distinct basins and attains a maximum depth in excess of 200 feet. The central basin (about 100 ft. maximum depth) and the southern basin (about 75 ft. maximum depth in Canada) are hence partially shielded from significant terrigenous sedimentation by the northernmost basins. This physiographic condition has resulted in greater accumulations of organic carbon and mercury in the sediments taken from south of the town of Osoyoos. No seismic survey was run in Osoyoos Lake under Task 121.

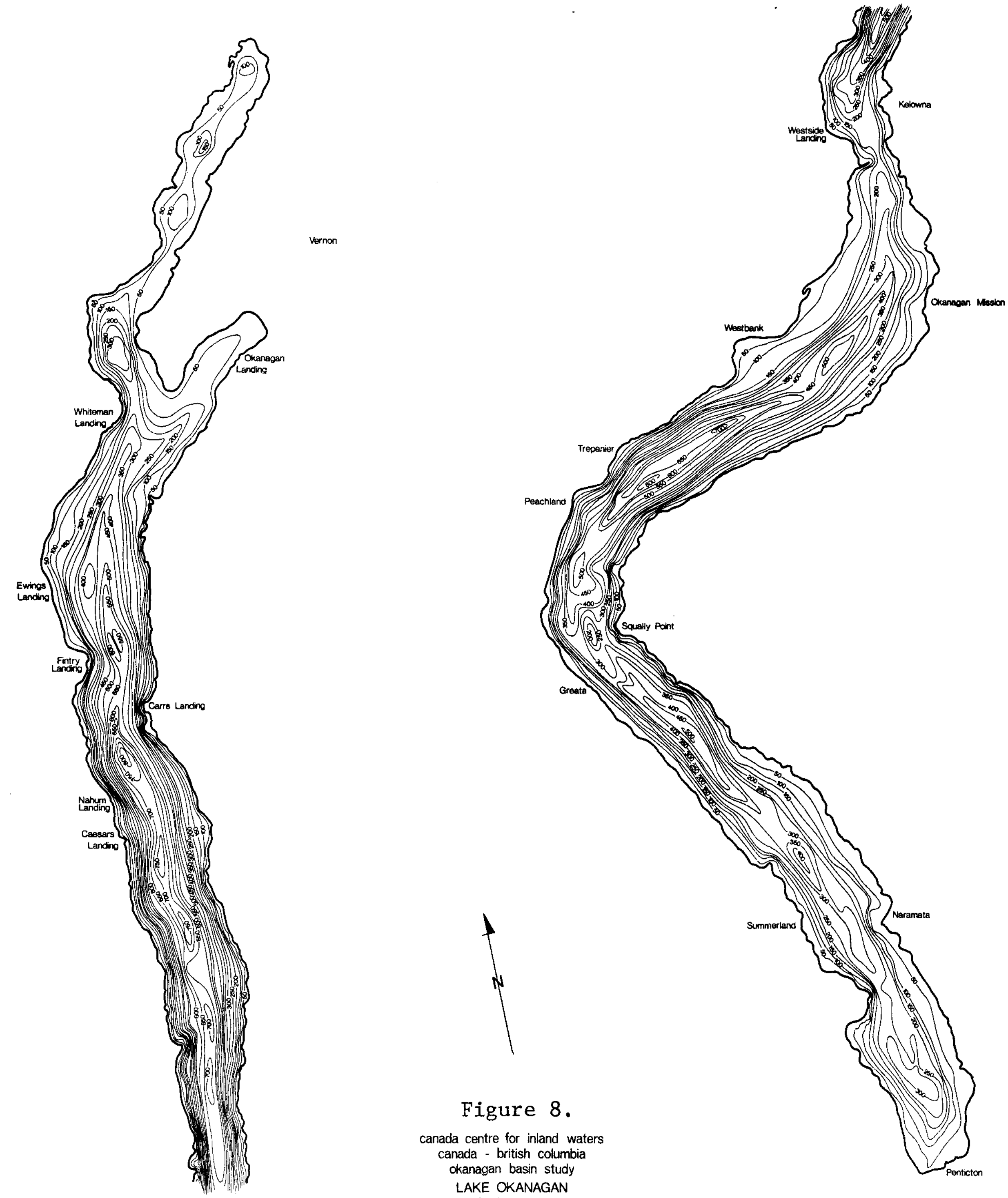

Figure 8.

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LAKE OKANAGAN
bathymetry

kilometres
0 1 2 3 4 5 6 7 8 9 10
0 1 2 3 4 5 6
miles

CONTOURS AT 50ft INTERVALS

BATHYMETRY BY B.E. ST. JOHN 1971 TASK 121

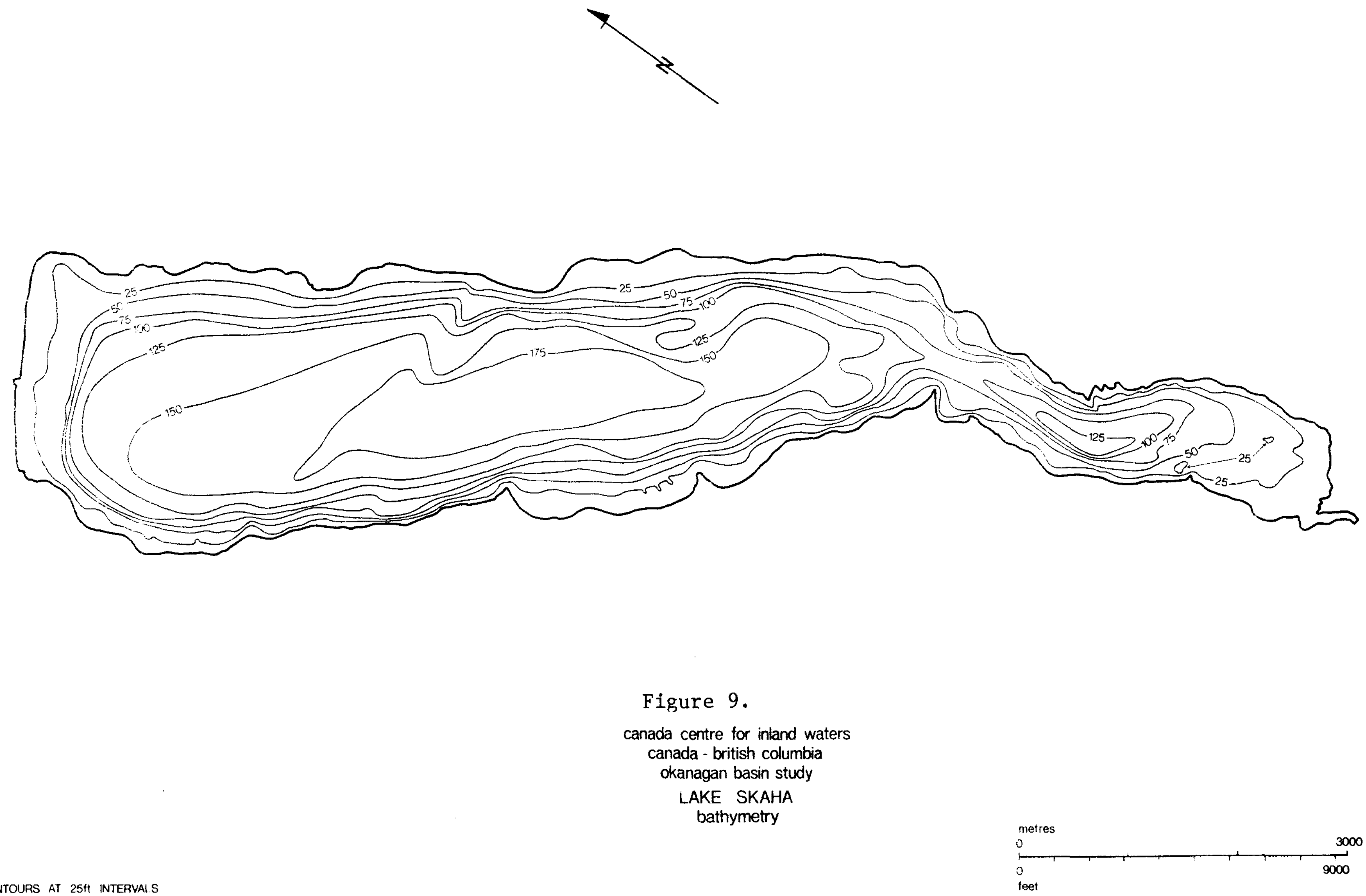

Figure 9.

canada centre for inland waters
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okanagan basin study
LAKE SKAHA
bathymetry

CONTOURS AT 25ft INTERVALS

BATHYMETRY BY B.E. ST. JOHN 1971 TASK 121

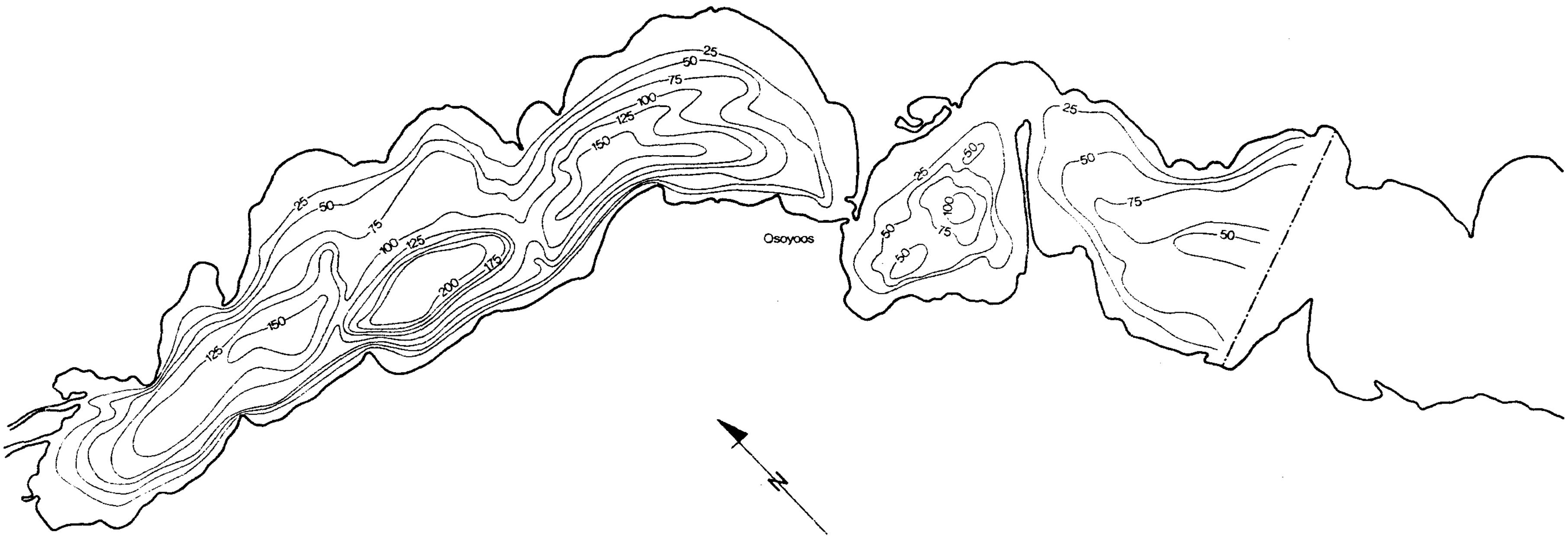


Figure 10.

canada centre for inland waters
canada - british columbia
okanagan basin study
LAKE OSOYOOS
bathymetry

metres
1000 0 2000
1000 0 6000
feet

CONTOURS AT 25ft INTERVALS

BATHYMETRY BY B.E. ST. JOHN 1971 TASK 121

Sediment Distribution and Mineralogy

Approximately 150 surface and core samples from the Okanagan mainstem lakes were analysed by pipette analysis. Measurements made from the particle size fractionation so produced include per cent sand (greater than 63 micron), per cent silt (between 63 microns and 4 microns), percent clay (less than four microns) and most common size (mode).

Mineralogical studies were undertaken on size fractionated subsamples of representative samples from each lake. These studies were accomplished with X-ray diffraction and microscopic examination.

Wood Lake:

Five sediment sampling stations were occupied in Wood Lake (fig. 2) and a number of cores were obtained from the deepest part. Pipette analysis of the samples indicates that the surface sediments of the bottom of Wood Lake are 3.31% sand, 61.73% silt, and 34.96% clay, with the most common size averaging 12 microns. Dilution of this mean composition by coarser terrigenous material in the nearshore parts of the lake reflects normal sedimentary processes of sorting and dispersal.

Mineralogical analysis by X-ray diffraction indicates that the sediments from the deep parts of Wood Lake consist of quartz, calcite chlorite, kaolinite, illite, and orthoclase, microcline, and plagioclase feldspars.

Kalamalka Lake:

Ten sampling sites were occupied in Kalamalka Lake and cores were taken from the deepest part and from the carbonate terraces at the south end (fig. 2). Pipette analysis indicates that the deep sediments from Kalamalka Lake. are 2.46% sand, 43.65% silt and 53.89% clay, with

4 microns being the most common size (mode). The shallow terraces of Kalamalka Lake, however are bimodal, with size fractionation peaks at 12 microns and at 50 microns. The sediments of these terraces consist of 15.96% sand, 57.14% silt, and 26.90% clay. Mineralogical and chemical analysis of samples taken from these terraces indicate that terrigenous components are minor, with the bulk of the sediment being composed of calcite derived from precipitation from the water. Mineral phases identified from the deeper sediments include calcite, microcline and orthoclase feldspars, quartz, kaolinite, illite, and chlorite.

Okanagan Lake:

A total of 43 sampling stations were occupied in Okanagan Lake and cores were taken from the deep areas of Greata, Trepanier, and Carr's Landing (fig. 2). Pipette analysis of these samples indicates that deep muds from Okanagan Lake consist typically of 50% silt and 50% clay, with occasional sand contamination, presumably from density current deposition. The detailed sedimentology of Okanagan Lake is exceedingly complicated, and cannot be adequately described or mapped on the basis of only 43 stations. Certain of the most significant features of this complex sedimentary pattern are discussed below.

Accumulations of coarser terrigenous material are present at the mouths of almost all definable creeks entering the lake, with exceptional accumulations occurring adjacent to Whiteman Landing, Fintry Landing, Kelowna, Westbank, Naramata, and Poplar Grove north of Penticton. In addition, normal processes of dispersal and segregation have resulted in coarser fractions being more common in shallow nearshore environments of the lake.

One sample is of sufficient interest to merit special note. Sample OK-32 was collected from a depth of 19.0 m. adjacent to Caesar's Landing. This sample consisted of a stiff grey clay unlike any other collected during the initial Task 121 survey. (A similar sample was collected from a depth of 25 m. of Ewings Landing in Sept. 1971.) Pipette analysis of this sample gave a composition of 3.81% silt and 96.19% clay. Chemical analysis of this sample indicates that it is anomalously low in S, P, Hg, and organic carbon and anomalously high in Fe, Mg, K, Al, Cu, Zn, Ni, and Co. It seems probable that this sample was from a clay deposited in an environment unrelated to the modern lacustrine environment. The writer postulates that this clay is a newly exposed remnant of ancient post-glacial sediment, that has been recently brought into contact with the modern lake waters by the mass transport of overlying modern lake sediments to the adjacent depths of the lake. The discovery of a second patch of this material during the September follow-up sampling program suggests that an unknown, but possibly significant area of the Okanagan Lake bottom consists of this ancient material. It is probable that this material differs significantly in its exchange kinetics from "normal" modern sediment, but the significance of this phenomenon cannot be assessed within the limitations of Task 121.

Skaha Lake:

Skaha Lake has been the subject of the most intensive study in the Task 121 project. A total of 36 surface samples and a number of cores have been collected from this lake, and the resulting sample coverage has permitted more detailed investigations than have been possible for the other lakes. Pipette analysis indicates that the typical deep muds of this lake consist of .52% sand, 58.49% silt, and 40.99% clay, with the most common size averaging 8 microns. The sediment distribution patterns of Skaha Lake are complicated by a number of unique processes not evident in the other mainstem lakes.

The complex bathymetry of Skaha Lake above the 50 foot contour has been discussed above. This has resulted in an analogous complex sediment distribution pattern in the nearshore zone of this lake that reflects the variety of mechanisms that influenced the evolution of this area. Transit sonar records of this zone have helped to elucidate these mechanisms, but no attempt has been made during the Task 121 study to accurately map this zone.

Nasmith (1962) has noted that the accretion of sand onto the beach at the north end of Skaha Lake has been sufficient to extent the beach more than a mile into the lake since its formation in early postglacial times. This process has presumably been partially arrested by the erection of the control dam on the Okanagan River at Penticton, but it is responsible for the fact that sediments from a depth of 11 m collected on a line parallel to the beach contained 31.5% sand (average of four samples).

The presence and mode of formation of the white silt cliffs bordering Skaha and southern Okanagan Lakes has been noted in a previous chapter. Symptoms of mass wastage from these cliffs are readily visible in the field as landslide scars, and deposits on the lake bottom adjacent to such landslide scars have been detected by transit sonar in Okanagan Lake north of Naramata. A subsample of station S-18 (labelled S-18a) taken at a depth of 3 - 5 cm. below the sediment-water interface consisted of .24% gravel, 87.57% sand, 4.91% silt, and 7.29% clay. Since this sample was taken from a depth of 54 m., and is directly overlain by

3 cm. of material consisting of .23% sand, 59.15% silt, and 40.62% clay (typical of the deep Skaha sediments), it is obviously anomalous. Direct microscopic examination of this coarse material below 3 cm. revealed sediment of texture and composition strikingly parallel to samples taken from the glacio-lacustrine deposits bordering the lake (plate I). In both cases the material consisted of inequigranular, subspherical, angular particles of a large suite of rock-forming silicates. It seems probable that the material in sample S-18a is derived from the redeposition of the glacio-lacustrine material originally deposited adjacent to the lake. In view of the observed signs of mass wasting of this material discussed above, it further seems probable that this is the mechanism that moved the material from the onshore area to the lake bottom. The mode of the S-18a material, is 3.25 ø (0.105 mm.), a size much too coarse to be moved to this remote part of Skaha Lake by hydraulic activity from a tributary.

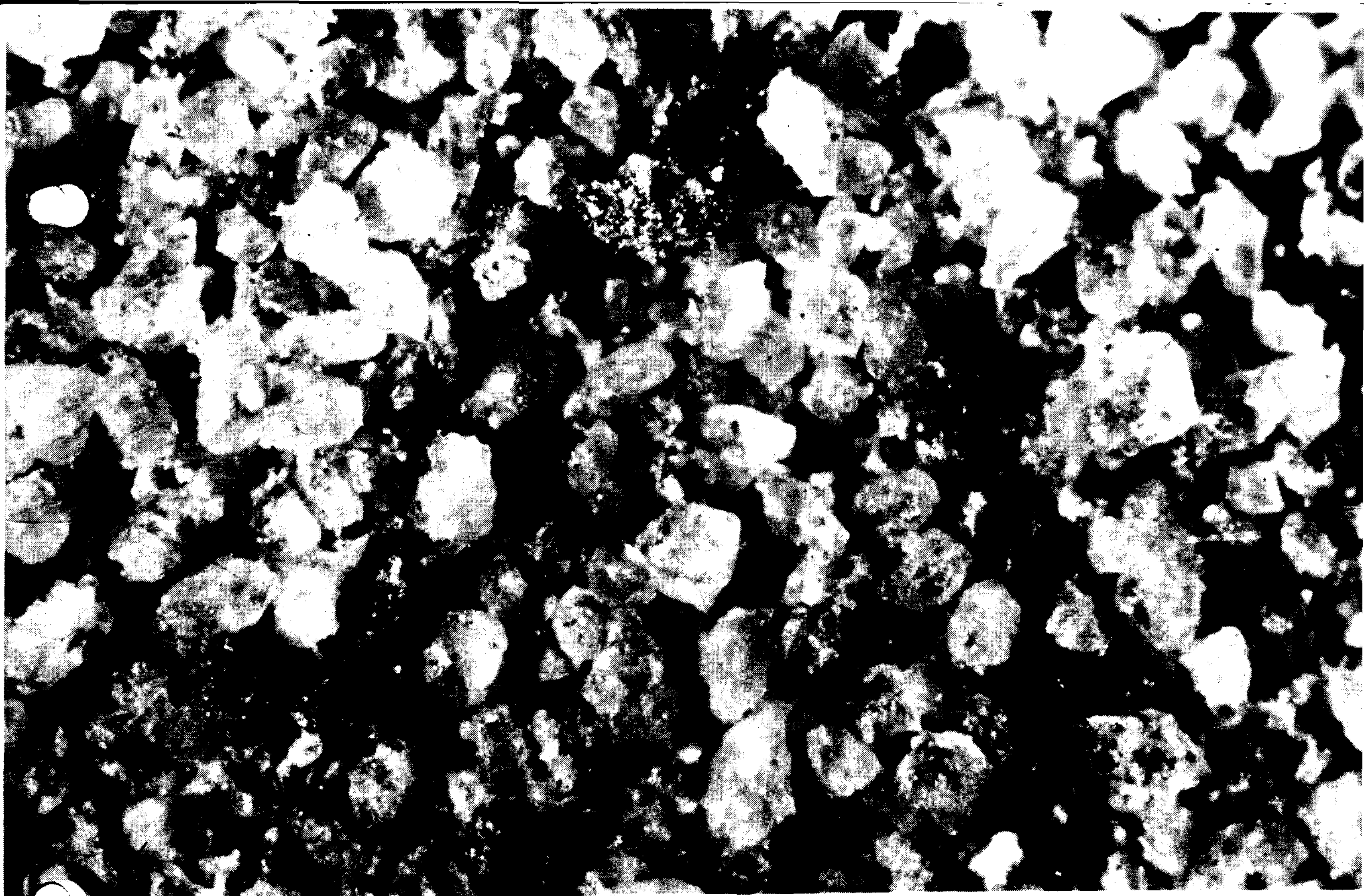
Accordingly evidence exists chat deposition of gravels, sands, and silts occurs in the deepest parts of Skaha Lake from mass wastage of the ancient cliffs around the lake. The lack of similar material in other samples collected in the Task 121 grid, however, suggests that this process must be very local in its effect, and it is probable that lenses of similar material occur in the sedimentary record of Skaha Lake in an apparently random sequence in space and time-equivalence.

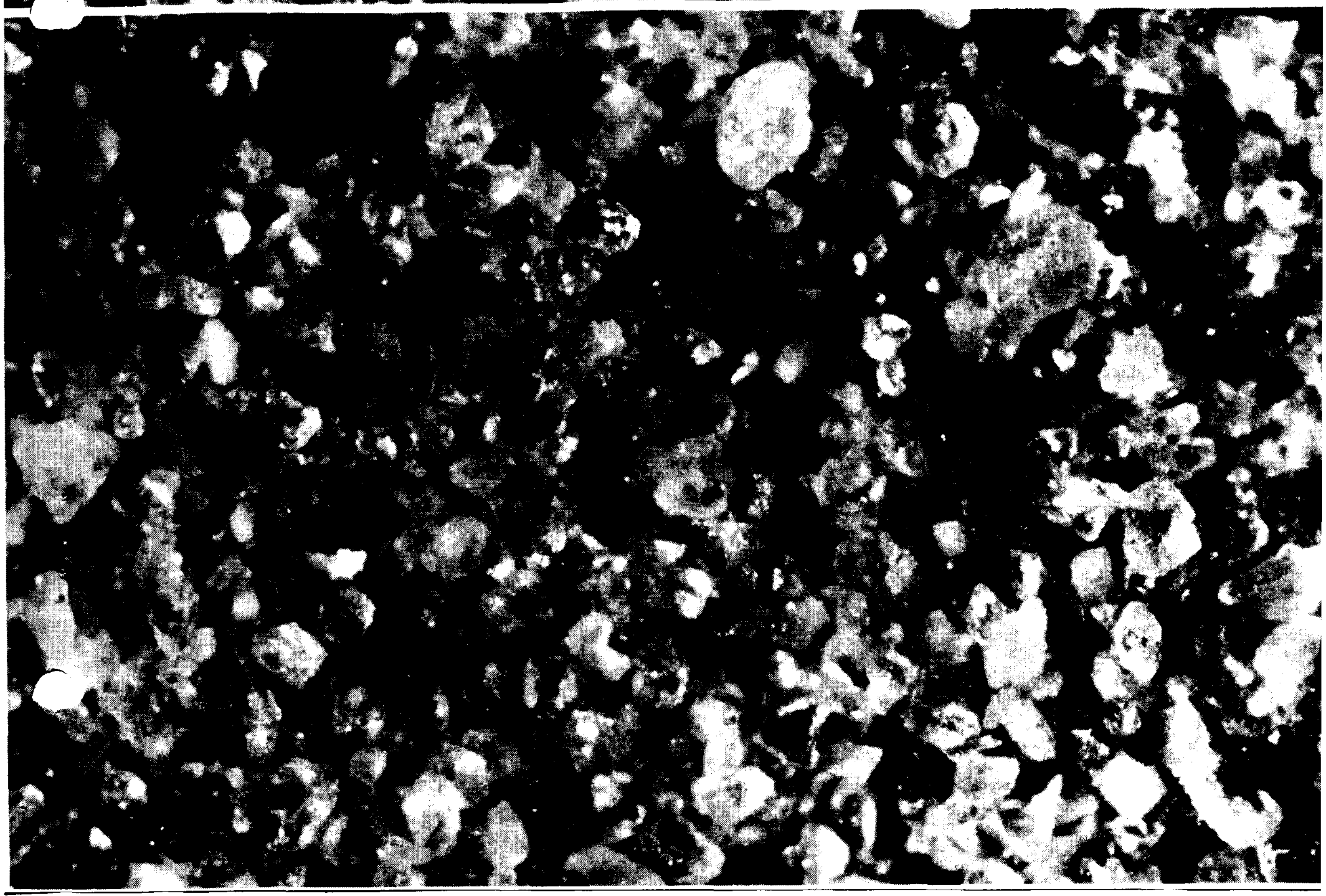
Mineralogical examination of the deep sediments of Skaha Lake revealed an unextraordinary suite of minerals including quartz, microcline and plagioclase feldspars, orthoclase, kaolinite, chlorite, and illite.

PLATE 1

Top: Photomicrograph of sample of silt taken from cliff of ancient glaciolacustrine deposit west of Skaha Lake. Sample station was about 1 mile north of Kaleden and about 50 feet above present lake level. Magnification = 200 x

Bottom: Photomicrograph of sample S-18a, a subsample from S-18 taken from 3 to 5 cm. below the sediment water interface under 54.0 metres of water. Magnification = 200 x





Osoyoos Lake;

Osoyoos Lake consists of three distinct basins, each of which exhibits a classic sediment distribution pattern dependent on basin morphology. Sediment size fractionation in the deep muds from the north and central basins are:

North basin: 4.42% sand, 54.68% silt, and 40.90% clay.

Central Basin: 4.62% sand, 53.46% silt, and 41.92% clay.

Data from the south basin are insufficient to allow accurate values to be computed, but similar fractionations appear to be common.

Coarser material is prevalent in the shallower areas of Osoyoos Lake, and in particular adjacent to the sand bars that make up the boundaries between basin. The mode of the deep muds is 11 microns. A second, weaker mode occurs at 2 microns in the north basin muds.

Mineralogical analysis indicates the presence of quartz, calcite, feldspars, and kaolinite. The sediment sampling grid for Osoyoos Lake is presented in fig. 2.

Rates of Sedimentation

Dr. T.W. Anderson of the Geological Survey of Canada has studied a core from each of the mainstem lakes to assess mean sedimentation rates. This has been accomplished and permits the calculation of the mean annual chemical budgets presented in the next chapter. Dr. Anderson has further agreed to write a brief discussion on his findings, and his comments will be presented as a separate report. A more detailed discussion of his findings will appear in Anderson (1972).

Ranching, and hence man-induced disturbance of the natural flora of the Okanagan Valley, dates back to around 1860 as large ranches were being established to supply beef and horses to miners attracted by the Cariboo gold rush. Cattle were trailed in from the United States through the Okanagan Valley at this time (Laing 1941), and it can be assumed that they contributed to a depletion of grass resources in immediate proximity to the Okanagan Mainstem Lakes.

For the purposes of the present study, a measure of 100 years will be assumed as a basis for calculations involving man's influence on the pollen distributions in the Valley. A brief lag time can be assumed for changes in pollen distributions in the cores after changes in he regional flora, and a date of 1872 for visible changes in the pollen contents of the mainstem lake sediments will be used.

Table 1 presents the calculations for mean annual sedimentation rate in each of the mainstem lakes. Sediment densities calculated from Dr. Anderson's data and mean water contents for the uppermost sediment column (provided by Dr. A.L.W. Kemp of CCIW) have been used to calculate mean net annual sediment accumulations for each lake in terms of dry sediment mass per year. From these figures have been calculated mean net annual accumulation rates for a number of chemical species. These last will be discussed in Chapter IV.

CHAPTER IV - SEDIMENTARY GEOCHEMISTRY OF THE OKANAGAN MAINSTEM LAKES

Introduction

The sedimentary geochemistry of the Okanagan Mainstem Lakes has been the subject of the most intense investigations of the Task 121 studies. Of primary concern has been the cycles of phosphorus, carbon, and a suite of heavy metals including Fe, Mn, Cu, Zn, V, Cr, Co, Cd, As, La, Eu, Sm, Hg, Ti, Pb, Be, Ni, and Sc. Accordingly the major element geochemistry of each of the lakes is discussed independently of the cycles of each of these parameters.

Major Elements

Ground and pelletized subsamples from each of the sediment samples collected during the Task 121 survey were analysed for Ca, Na, Mg, Si, K, and Al using CCIW's X-ray fluorescence spectrometer (APPENDIX II) In addition, acid-extractable (hot, concentrated HCl) Ca, Mg, and K were measured by atomic absorption techniques (APPENDIX III). These analyses were performed to provide baseline data for elucidating the cycles of the biologically reactive nutrient elements as well as the toxic heavy metals. The cycles of these major elements reflect dominant sedimentary regime of each lake, and hence their appreciation is basic to an understanding of the cycles of elements more significant limno-logically. The mean contents of the major elements contained in the surface samples collected in each lake are presented in table 2.

<u>Wood Lake:</u>

Correlation and R-mode factor analyses of these data and other parameters indicate that the following patterns, dominate the

TABLE 1: Depths to man's influence and net accumulation rate of sediment in each of the Okanagan mainstem lakes, (from personal communications with Dr. T.W. Anderson G.S.C.)

LAKE:	DEPTH TO MAN'S INFLUENCE: (CM.)	RATE OF SEDIMENTATION: (MM.)	AVERAGE SURFACE SEDIMENT SPECIFIC GRAVITY:	AVERAGE WATER CONTENT: (%)	AVERAGE ANNUAL NET ACCUMULATION OVER 100 YRS. IN KG.:
Wood	20	2.0	1.20	90.0	2.23×10^6
Kalamalka	29	2.9	1.10	87.0	1.07×10^7
Okanagan	10	1.0	1.14	83.5	6.39×10^7
Skaha	21	2.1	1.25	77.0	1.15×10^7
Osoyoos *	28	2.8	1.20	78.0	1.11×10^7

* Values for Osoyoos Lake based on a core taken in the south basin only.

major element distributions in the sediments of Wood Lake:

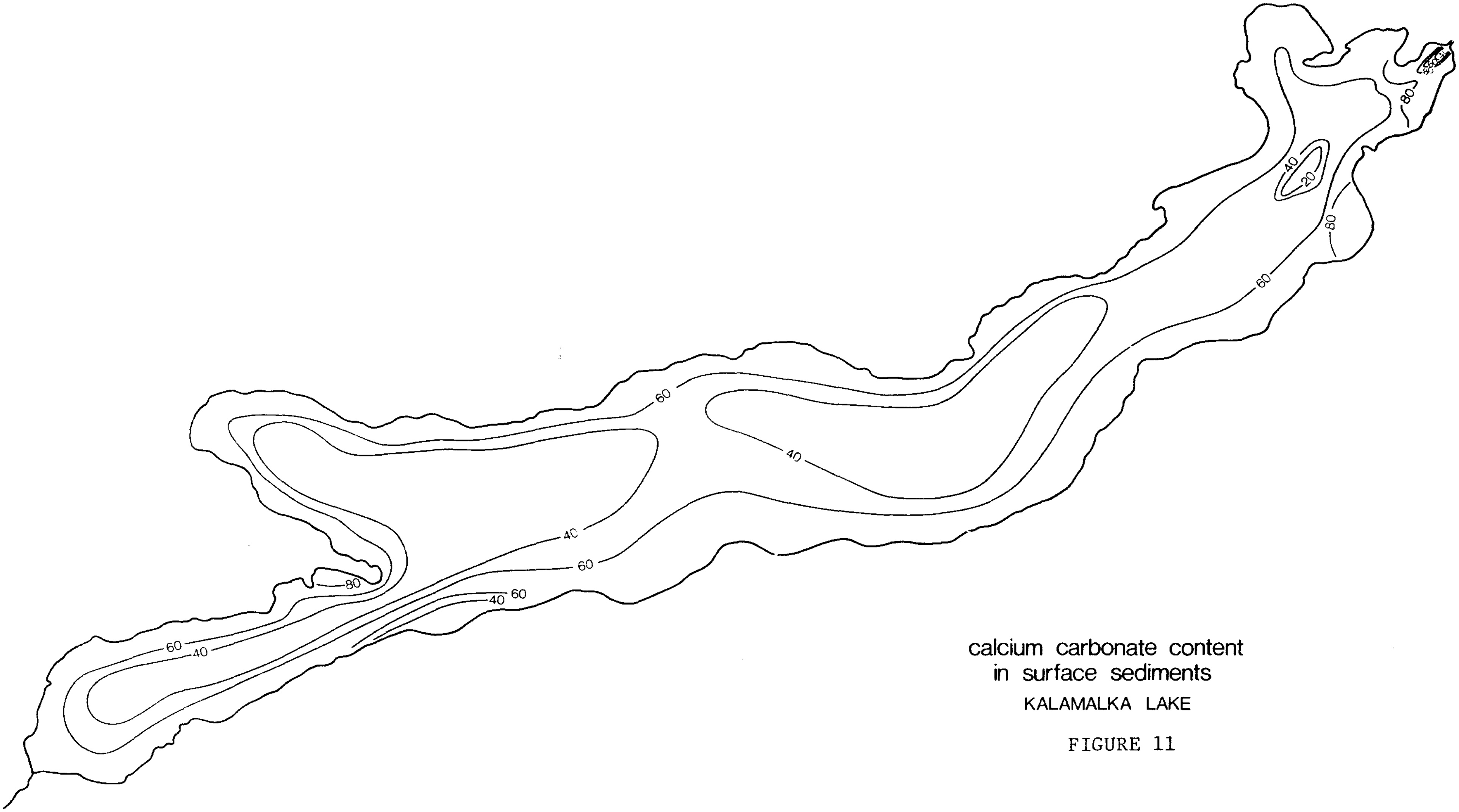
Calcium variance in Wood Lake is closely associated with inorganic carbon variance, and XRD analysis indicates the presence of calcite. An average of 80% of the total calcium in the deep sediments of Wood Lake is extractable by concentrated HCl, and is probably associated with the inorganic carbon in calcite. Inorganic carbon data provided by Dr. A.L.W. Kemp of CCIW (discussed in detail below) indicate that $CaC0_3$ content in Wood Lake sediments is enriched in the uppermost material in Wood Lake. This enrichment could be caused by increasing detrital carbonate deposition, by increasing loading of total carbon followed by increasing mineralization of organic carbon to carbonate in recent years, or by an increasing loading of biogenic carbonate. As there appears to be no significant sources of detrital carbonate in the Wood Lake watershed, it seems probable that alterations in water quality caused the aforementioned $CaC0_3$ increase.

Total sodium, potassium, aluminum, and silicon abundances covary closely in the sediments. This is a reflection of the dominant detrital aluminosilicate content of the sediments. Acid extractable potassium shows a strong negative relationship to total potassium (r =*0.0909) Total K is higher in nearshore areas of the sediment (average of two samples 2.1%) than in deeper environments (average of three samples 1.4%). Acid leachable K is higher in deeper environments (average .26%) than in nearshore areas (average 0.095%).

The increase of acid-extractable K with depth is probably a simple manifestation of the presence of finer material of high ion-exchange capacity in the offshore areas of the lake. However, the absolute and relative reversal of this trend for total K suggests that coarser K-feldspars deposition is significant in the nearshore areas of Wood Lake.

TABLE 2: Mean Concentrations of Major Elements in Surface Samples from Okanagan Mainstem Lakes (all values as percent).

LAKE		TOTAL CaO	TOTAL Na_2O	TOTAL Fe_2O_3	TOTAL MgO	TOTAL MnO	TOTAL SiO_2	TOTAL K_2O	TOTAL S	TOTAL Al_2O_3	ACID EXTRACT-ABLE Fe	ACID EXTRACT-ABLE Mn	ACID EXTRACT-ABLE K	ACID EXTRACT-ABLE Ca	ACID EXTRACT-ABLE Mg
Wood	Mean	7.2	1.5	5.0	1.7	0.18	61.4	1.8	0.95	8.1	2.7	0.12	0.19	3.7	0.67
	Std.Dev.	3.2	1.0	2.1	.44	.11	5.5	.72	.71	2.5	1.37	0.06	0.09	2.8	0.30
Kalamalka	Mean	26.7	.93	2.5	1.6	.17	44.7	1.2	--	4.8	1.32	0.08	0.16	--	0.63
	Std.Dev.	17.1	.64	1.6	.74	.17	18.9	.75	--	2.9	0.95	0.10	0.13	--	0.22
Okanagan	Mean	3.1	1.6	6.1	2.7	.20	61.8	2.5	.21	10.9	3.17	0.12	0.29	0.75	0.77
	Std.Dev.	2.5	.43	1.6	.78	.17	4.4	.31	.25	1.1	1.04	0.12	0.17	0.16	0.31
Skaha	Mean	2.4	2.1	4.2	1.7	.12	67.8	2.6	.20	10.7	2.28	0.07	0.21	--	0.55
	Std.Dev.	.58	.31	1.2	.31	.074	3.8	.18	.14	.72	0.70	0.05	0.09	--	0.19
Osoyoos	Mean	3.0	1.8	5.2	2.3	.18	64.3	2.4	.65	10.3	2.53	0.10	0.25	0.68	0.78
	Std.Dev.	.94	.32	1.6	.61	.20	4.1	.13	1.7	.91	1.02	0.12	0.11	1.11	0.30



calcium carbonate content in surface sediments
KALAMALKA LAKE

FIGURE 11

contour interval - 20% $CaCO_3$ by weight

B.E. St John, Task 121

Iron, magnesium, and manganese variances (both total and acid-leachable) are essentially parallel to each other and to the variance of calcium. These distributions reflect the general trend of increasing abundances with depth. Each of Fe, Mn, and Mg are probably dominantly associated with the fine grained material typically concentrated in the offshore environments of lakes.

Kalamalka Lake:

The dominant process in the sedimentary cycle of Kalamalka Lake is the precipitation of calcium carbonate. $CaCO_3$ concentrations of 95% have been measured in sediments taken from the terraces at the south end of this lake. The terrace sediments represent the greatest concentration of this material, however, and calcium content of the sediments decreases with increasing depth (fig. 11).

XRD analysis, and the strong covariance of Na, K, Mg, Al, and Si in the Kalamalka sediments suggest that the non-carbonate terrigenous components of this lake are unextraordinary.

The iron content of the sediments on the carbonate terraces is very low (average 0.4%) and is probably associated with the calcium carbonate. Iron in the deeper sediments is somewhat higher (average 2.9%) owing to the higher proportion of terrigenous material in these sediments.

Manganese concentrations in Kalamalka Lake appear to be directly proportional to increasing water depth, and inversely proportional to calcium carbonate content.

Okanagan Lake:

Calcium in Okanagan Lake sediments is strongly related with inorganic carbon (r = .897), and it seems probable that most of the calcium is contained in calcite. The origin of this calcite is not clear. It is possible that this Carbonate has precipitated from the water, and it is in fact highly probable that this has occurred in the northern three basins of the Armstrong Arm, where total calcium concentrations up to 2.7X those of the main lake occur. It is also possible that this calcite has formed through diagenesis of organic carbon in the sediment. The actual importance of the carbonate cycle in this lake is unknown.

Potassium and aluminum are related through a strong linear correlation (r = 0.898) in these sediments, but silicon variance is distributed amongst a number of components found in terrigenous silicate detritus.

Iron and magnesium appear to be related through a strong covariance (r = 0.718), but it is probable that this covariance is coincidental rather than syngenetic.

Manganese appear to be related only to water depth.

Skaha Lake:

The geochemistry of the sediments of Skaha Lake is of considerable interest as it bears significantly of the eutrophication problem that initiated the Basin Study.

Calcium in the sediments of Skaha Lake appears to be essentially unrelated to inorganic carbon. This is at variance with the situation in Wood, Kalamalka and Okanagan Lakes. Instead, calcium variance in Skaha sediments appears to be partitioned between silicon and phosphorus. This relationship of calcium to phosphorus is of considerable significance to water quality conclusions in Skaha Lake, as is discussed in the section on phosphorus below.

Sodium, potassium, silicon, and aluminum covary to some extent, and this covariance reflects the dominant terrigenous sediment components.

Iron and manganese variances are dominated by a linear relationship to water depth. Nearly 80% of the iron and manganese in the Skaha sediments is available to acid attack.

Magnesium variance is split between the iron-manganese variance pattern, and the calcium-phosphorus variance pattern discussed above.

Osoyoos Lake:

Variances of sodium, potassium and aluminum are largely accounted for by a single variance vector, while the bulk of the calcium variance and part of the aluminum variance is accounted for by an independent variance vector. It seems probable that these distinct variance vectors reflect the mixing of at least two silicate mineral populations to form the basic terrigenous substrate of the Osoyoos Lake sediments. Silicon variance is related inversely to iron, manganese and depth, and probably reflects silica (quartz) deposition in the near-shore environment.

An average of 70% of the iron and 74% of the manganese of the Osoyoos sediments is acid extractable.

Carbon

The carbon contents of the sediments from the Okanagan mainstem Lakes have been determined by Dr. A.L.W. Kemp of CCIW. Sediment samples were analysed for organic carbon and carbonate carbon using a Leco Induction Furnace. The results from these analyses are presented in the attached table 3, and profiles of carbon content constructed from independent data gained by Dr. Kemp are presented in fig. 12.

The carbon content of a given sediment sample is a measure of the carbon deposited minus the carbon remobilized back into the

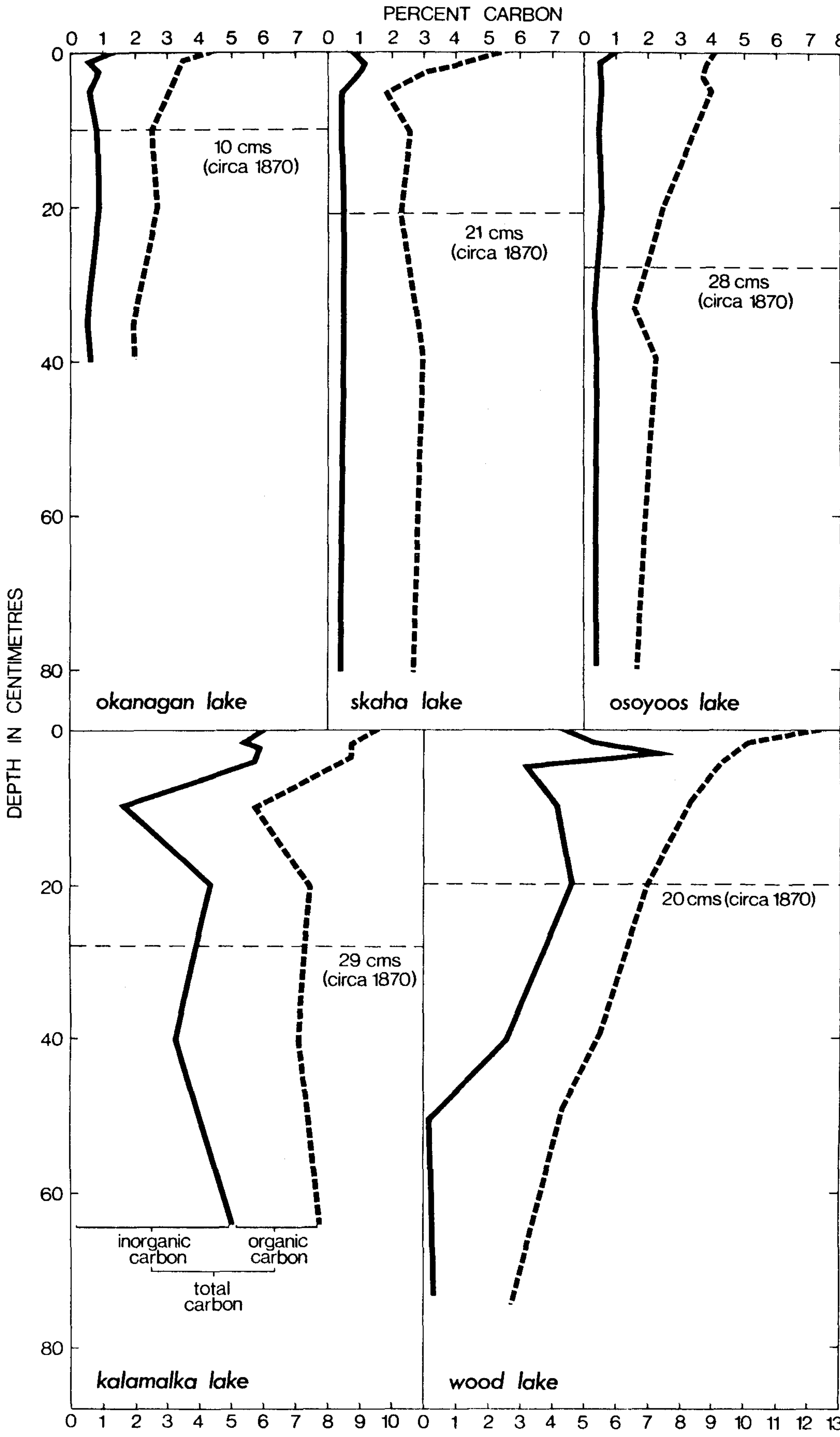
TABLE 3: Mean Carbon Content of Surface Sediments and Mean Carbon Accumulation Rates for Okanagan Mainstem Lakes.

LAKE	ORGANIC CARBON (%)	INORGANIC CARBON (%)	MEAN (OVER 100 YEARS) ANNUAL ACCUMULATION IN LAKE IN KG OF ORGANIC C.	MEAN (OVER 100 YEARS) ANNUAL ACCUMULATION IN LAKE IN KG OF INORGANIC C.
WOOD LAKE			9.8×10^4	1.13×10^5
All samples	3.91	1.63		
Basin muds	5.19	2.41		
KALAMALKA LAKE			* ___	___
All samples	3.08	5.83		
Basin muds	3.32	4.20		
Terraces	2.10	10.23		
OKANAGAN LAKE			1.75×10^6	5.00×10^5
All samples	2.31	0.44		
Basin Muds	2.07	0.30		
Armstrong Arm	2.62	1.14		
Vernon Arm	4.67	0.37		
SKAHA LAKE			3.15×10^5	7.12×10^4
All samples	1.59	0.19		
All (north basin)	1.48	0.21		

TABLE 3 continued...

LAKE	ORG.C %	INORG. C %	MEAN - ORG C (kg)	MEAN - INORG C (kg)
all (south basin)	2.07	0.12		
Basin muds (north)	3.46	0.19		
Basin muds (south)	2.05	0.24		
OSOYOOS LAKE			3.18×10^6	5.77×10^4
All samples	2.49	0.42		
All (north basin)	2.23	0.34		
All (central basin)	3.41	0.64		
All (south basin)	2.26	0.40		
Basin muds (north)	2.61	0.35		
Basin muds (central)	4.65	0.44		
Basin muds (south)	3.24	0.32		

* The carbon sedimentation budget for Kalamalka Lake is being subjected to further study. The simple calculations used for this table are insufficient to provide an accurate figure for this lake.



profiles of carbon content of cores from the okanagan mainstem lakes

carbon data from Dr. A.L.W. Kemp C.C.I.W

FIGURE 12

water. Hence, a given content of carbon in a sediment is a product of a large number of factors including:

1. Quantity of carbon deposited,
2. Gross sedimentation rate,
3. Decomposition rate of sedimentary environment,

and 4. Form of carbon deposited.

Accordingly, high organic carbon content sediments can be produced in a wide range of limnic environments, and organic carbon content in sediments does not necessarily parallel the state of eutrophication of a lake, although a qualitative relationship commonly exists.

Wood Lake:

The total content of organic matter in the sediments of Wood Lake is very high (table 3). The covariance of inorganic carbon distribution and calcium distribution in Wood Lake has been discussed above and reflects the presence of calcite in these sediments. It seems probable that the bulk of this calcite has been precipitated either inorganically or biogenically from the waters of the lake. The gradual increases of both organic and inorganic carbon in the near-surface sediments in Wood Lake (fig. 12) suggest that water quality alterations may have been the operative factor in producing the high surface values currently present in the Wood Lake sediments.

Kalamalka Lake:

The most distinctive geochemical feature of Kalamalka Lake remains its extraordinary calcium carbonate cycle. Each spring, with the formation of the thermocline, the waters of the epilimnion of Kalamalka Lake release microcrystalline calcium carbonate that accumulates on terraces sited around the shores of the lake. The structure of these terraces resembles that of a tropical marine carbonate reef, with a "reef flat" of low relief bounded by a steep "reef slope". The break occurs at a depth of 43 ft. It is probable that this depth approximates the mean depth of the summer thermocline, integrated over recent geologic time. The calcium carbonate composition of the terrace deposits is extremely high, averaging about 85%. Only about 10%, of this deposit is terrigenous material. Surface sediment samples taken from the deeper areas of Kalamalka Lake contain calcium carbonate concentrations that are approximately inversely proportional to water depth (fig. 11). It seems probable that this fact reflects the incomplete dissolution of the carbonate as it passes through the hypolimnion during sedimentation.

Organic carbon results for the Kalamalka Lake sediments are unexceptional and their variance appears to be independent of other parameters.

The core profile for Kalamalka Lake (fig. 12) indicates carbonate and organic carbon deposition rates have not changed much over the past few centuries.

<u>Okanagan Lake:</u>

The concentrations of organic and carbonate carbon in the sediments from the offshore areas of Okanagan Lake are relatively uniform and low (Table 3). Calcium carbonate appears to be precipitating in the three small basins of the Armstrong Arm and the degree of carbonate enrichment of the sediments in these basins appears to parallel their degree of eutrophication as measured by biologic and chemical criteria. The content of organic matter in the sediments of the Armstrong Arm is about 25% greater than that of the deep sediments of the main lake, while sediments of the Vernon Arm (receiving the nutrient loading from Vernon) have 2.25X the organic carbon content of the deep lake sediments.

A gradual increase in organic carbon accumulation rate through the past century is suggested by the Okanagan Lake core profile (fig. 12).

Skaha Lake:

The deep basin sediments from the southern small basin in Skaha Lake (south of the narrows at Kaleden) contain 1.69X greater concentrations of organic matter than the main lake basin sediments, and slightly less $CaCO_3$ (Table 3). This marked increase in the small south basin is probably due to the "dilution" of the organic matter abundance in the main basin by terrigenous material. Mr. D.J. Williams (CCIW) has noted that a disproportionate quantity of the biomass produced in Skaha Lake during a bloom appears to be concentrated in the waters over the small south basin because of the circulation in the lake. If this is so, then the sedimentation from this material would also tend to increase the concentration of organic matter in the south basin relative to the north. No significant precipitation of calcium carbonate appears to occur in Skaha Lake.

Variances of organic carbon and inorganic carbon in Skaha Lake sediments appear to be unrelated to variances of other parameters. The core profiles, however, show a sudden increase of organic carbon content subsequent to man's influence on the Skaha Lake in the top 5 cm. This 5 cm. depth represents 23 years of sediment accumulation, about the length of time that sewage discharge into Skaha Lake has existed.

Osoyoos Lake:

The surface sediments of the three basins that make up Osoyoos Lake manifest organic carbon concentrations of the following ratios:

North Basin: Central Basin: South Basin: = 1 : 1.78 : 1.24. It seems probable that this is indicative primarily of the removal of terrigenous components of the suspended load of the lake in the north basin. The resultant high concentration of organic matter in the sediments of the central basin of this lake is significant in the geochemistry of mercury in this lake (discussed below). Calcium carbonate concentrations in the sediments of Osoyoos Lake are unexceptional. The slightly elevated content of carbonate carbon in the central basin is a manifestation of molluscan skeletal deposition in shallow areas. The gradual increase in carbon content in the core from Osoyoos Lake probably reflects the increasing eutrophication of that lake over the past century (fig. 12).

Summary:

The carbon concentration profiles presented in fig. 12 are of considerable assistance in the investigation of the trophic history of the Okanagan lakes. It can be seen that the lakes can be divided into three groups on the basis of this figure;

1. Osoyoos, Wood, and Okanagan Lakes that have manifested a significant increase in carbon accumulation rate over the past 100 years since the development of settlement in the Valley.
2. Skaha Lake that has registered a sharp increase in carbon accumulation rate over the past 25 years, but little change before that.
3. Kalamalka Lake that has showed an increase in carbonate accumulation over the past 10 to 15 years.

It can be seen that the lakes most affected by the long-term changes (i.e., those changes operative for the duration of man's influence) are the lakes draining the areas of most intense rural development (Wood, Osoyoos, and Okanagan Lakes).

The lake most affected by urban developments of the past 25 years is Skaha Lake, and it seems probable that sewage effluent from Penticton over that period contributed materially to the rapid increase in accumulation rate illustrated in fig. 12. It is of interest to note, however, that no long term increase in accumulation rate is manifested in Skaha Lake, only a short term increase.

Finally, the material from Kalamalka Lake can be interpreted to indicate a relatively minor increase in the rate of carbonate accumulation over the past few years.

From these observations it can be postulated that rural activities have been the prime factor of responsibility for alterations in trophic state of Wood, Okanagan, and Osoyoos Lake, while urban activities (Penticton) have been the prime cause of water quality deterioration in Skaha Lake. The unique carbonate cycle of Kalamalka Lake effectively prevents any conclusions being taken from the data on this lake.

Phosphorus

Extraction by 1N HCl for 16 hours at room temperature solubilizes all forms of inorganic P that may be implicated in exchange between sediments and overlying water. Specifically, it removes apatite (calcium phosphate) and sorbed orthophosphate ions. These forms appear to constitute the bulk of the acid-extractable inorganic P in lake sediments. Forms of inorganic P not extractable by HCl appear to exist in only minor amounts (probably less than 200 ppm) in the sediments collected, and as these forms are unlikely to participate in exchange reactions between sediment and water their presence can be ignored.

The HCl-P values for Okanagan Lakes sediment (Table 4) support much earlier work which indicates that the chemical and mineralogical properties of the sediment are of more importance in controlling the amounts of P which accumulate in them than such properties as trophic state of the lake or concentration of orthophosphate in the overlying waters. A trend noted in each lake for P content to increase with Increasing water depth is the result of decreasing particle size, and higher amounts of colloidal substances capable of sorbing orthophosphate. It is interesting to note that in the Armstrong Arm of the lake HCl-P increased as trophic state decreased southwards.

Values of organic P were determined by the method of Mehta et al (1954) for all Skaha samples. The trend of these values followed organic C very closely, and the two parameters were closely correlated (r = 0.86). The ratio of organic C to organic P by weight averaged about 150, a value close to the centre of the range for lake sediments. The organic P values, therefore, do not indicate any unusual features in the sediments of this lake. The organic C/organic P ratio was no different in near shore samples or samples close to P input sources than in the remainder of the lake.

In lake sediments in which apatite is absent or only a minor contributor to the total P content, correlations between extractable P and Fe are often observed, indicating iron-bound phosphorus as a major form of P in the sediments. An approximate measure of this and other forms of sorbed orthophosphate is obtained by extraction with NaOH solution. The values for 0.1 N NaOH-extractable inorganic P (NaOH-P)

TABLE 4: Phosphorus in Sediments from the Okanagan Mainstem Lakes

LAKE	HCl-P: (ppm)	ORGANIC P: (ppm)	NaOH-P: (ppm)	MEAN ANNUAL HCl-P ACCUMULATION IN EACH LAKE (KG.) (Mean HCl-P content of surface basin muds used for calculation)
WOOD LAKE				1.64×10^3
All samples	786	--	--	
Basin muds	735	--	--	
KALAMALKA LAKE				* _____
All samples	406	--	--	
Basin muds	607	--	--	
Terraces	44	--	--	
OKANAGAN LAKE				7.67×10^4
All samples	1069	--	--	
Basin muds	1200	--	--	
Armstrong north basin	931	--	--	
Armstrong central basin	955	--	--	
Armstrong south basin	1027	--	--	

LAKE	HCl-P (ppm)	ORG P (ppm)	NaOH-P (ppm)	MEAN ANNUAL HCl-P ACCUM.
SKAHA LAKE				1.15×10^4
All samples	864	106	137	
Basin muds	1000	171	243	
OSOYOOS LAKE				1.18×10^4
All (north basin	1056	--	--	
All (central basin	657	--	--	
All (south basin)	781	--	--	
Basin muds (north)	1070	251	--	
Basin muds (central)	876	--	--	
Basin muds (south)	851	--	--	

* The phosphorus sedimentation budget for Kalamalka Lake is being subjected to further study. Thesimple calculations used for this table are insufficient to provide an accurate figure for this lake.

for 24 samples from Skaha Lake were very much less than the HCl-P values, indicating the presence of large amounts of apatite, which probably accounted for well over half the HCl-extractable inorganic P in most samples.

The evidence from this chemical fractionation that large amounts of apatite (presumably hydroxyapatite) exists in the Skaha sediments is supported by the statistical data mentioned in the section on calcium. R-mode factor analysis indicates that the greater part of the phosphorus and calcium variance in the Skaha sediments lie along the same variance vector.

The NaOH-P values increased much more sharply with increasing water depth and/or distance from shore than did HCl-P. The NaOH-P values were also correlated with acid-leachable Fe ($r = 0.65$), indicating that this P was probably predominantly iron-bound in origin, but the ratio acid-leachable Fe to NaOH-P was considerably greater for near shore samples than for those from deeper waters. A similar effect was suspected in an earlier study by Dr. J.D.H. Williams (CCIW) and may be related to differences in the forms of reactive Fe between near shore and off shore sediments.

The suggestion that a significant proportion of the P in the sediments of Skaha Lake may be bound up as apatite or some similar non-reactive phase is of considerable interest. If Skaha Lake is actively precipitating P as apatite at the present time, it may be seen that this lake would possibly clean itself of biologically reactive P if inputs were markedly reduced. This would presumably result in a reversal of eutrophication in this lake. No time scale can be put on this process without further research however. This further research is in progress at the time of writing (June 1972) by Dr. J.D.H. Williams, who will submit an independent report on the cycles of phosphorus in each of the Okanagan Mainstem Lakes at a later date. The lack of these data for lakes other than Skaha at this time (June 1972) is a result of the Severe limitations of the Task 121 budget.

Trace Elements

The sediment samples collected during the Task 121 study have been analysed for acid-extractable Pb, Fe, Mn, Cu, Zn, Ni, Co, Cr, Cd, Be, V, As, La, Sc, Sm, and Eu and for total Hg. The proper analysis of this large amount of data constitutes a major project, and hence cannot be accomplished within the time constraints imposed by the Task 121 study. The analysis of these data will be undertaken by the writer during the latter part of this year, and results will be made available to the Study Committee as they are prepared.

Mean values for each element for each lake and the estimated annual net accumulation over the past 100 years are presented in table 5. These data are presented without further comment at this time, except for the case of the toxic element mercury.

Mercury:

Mercury concentrations appear to be enriched in sediments from certain parts of the Okanagan system. The investigation of mercury is complicated by the fact that these lakes differ in their major element geochemistry. This makes interlake comparisons very difficult. Mercury is usually incorporated into lake sediments in the following forms

1. Adsorbed on to Fe-P, Fe-OH, or Fe-0 amorphous flocs;
2. Adsorbed on to clay minerals;

TABLE 5: Mean concentrations and annual accumulation rates for acid-extractable trace elements in sediments from the Okanagan Mainstem Lakes. Concentrations of mercury in parts-per-billion (ppb). Concentrations of other trace elements in parts-per-million (ppm). Accumulation rates in kilograms are averages over 100 years of accumulation for each lake.

LAKE		Hg	Pb	Cr	Zn	Ni	Co	Cu
Wood	Mean	804.6	31.6	29.4	60.2	23.0	8.0	19.4
	Std. Dev.	800.6	17.5	17.7	24.6	12.1	4.5	14.0
	Mean Accum. Rate	—	89.2	$1.47x10^2$	$1.45x10^2$	$1.70x10^2$	49	$1.30x10^2$
Kalamalka	Mean	661.1	51.1	18.8	42.8	23.4	11.5	20.6
	Std. Dev.	6 13	19.6	10.9	27.0	12.8	4.5	15.4
	Mean Accum. Rate	—	—	—	—	—	—	—
Okanagan	Mean	283.7	32.4	60.2	80.2	56.9	15.5	41.7
	Std. Dev.	216.8	10.4	32.1	21.5	77.9	5.6	16.4
	Mean Accum. Rate	—	$2.005x10^3$	$2.93x10^3$	$5.62x10^3$	$2.36x10^3$	$1.0x10^3$	$4.21x10^3$
Skaha	Mean	390.5	27.8	21.9	54.3	14.9	8.2	20.8
	Std. Dev.	566.3	15.1	6.7	19.3	7.3	2.9	11.7
	Mean Accum. Rate	—	$3.74x10^2$	$3.3x10^2$	$8.16x10^2$	$2.51x10^2$	$1.27x10^2$	$4.2x10^2$
Osoyoos	Mean	293.1	24.6	27.9	61.9	27.7	8.9	33.9
	Std. Dev.	166.5	10.4	12.8	24.3	12.2	3.7	16.0
	Mean Accum. Rate	—	$2.89x10^2$	$5.11x10^2$	$8.10x10^2$	$4.33x10^2$	$1.54x10^2$	$5.11x10^2$

TABLE 5: Continued

LAKE		Cd	Br	V	As	La	Sc	Eu	Sm
Wood	Mean	.54	.16	57.0	4.5	26.0	2.4	.72	4.6
	Std. Dev.	.34	.34	28.8	2.9	9.2	1.6	.29	1.9
	Mean Accum. Rate	2.0	2.8	$1.7x10^{2}$	8.3	$8.0x10^{1}$	9.7	3.2	14.7
Kalamalka	Mean	1.8	.75	33.0	3.5	11.3	1.4	.34	1.9
	Std. Dev.	.91	.32	20.2	2.7	7.5	1.3	.24	1.2
	Mean Accum. Rate	——	——	——	——	——	——	——	——
Okanagan	Mean	1.2	.91	60.6	6.2	32.4	3.2	.88	5.2
	Std. Dev.	2.8	.24	19.2	3.3	6.2	1.7	.27	1.2
	Mean Accum. Rate	48.8	62.5	$5.43x10^{3}$	$3.77x10^{2}$	$2.33x10^{3}$	$1.7x10^{2}$	71.3	$3.6x10^{2}$
Skaha	Mean	.45	.44	47.5	4.8	37.9	1.8	.70	4.5
	Std. Dev.	.20	.18	19.7	3.0	12.9	.89	.33	1.6
	Mean Accum. Rate	8.2	8.6	$8.61x10^{2}$	64.5	$6.41x10^{2}$	31.	13.4	$1.05x10^{2}$
Osoyoos	Mean	.58	.62	52.3	5.3	36.1	2.4	.89	4.7
	Std. Dev.	.22	1.0	21.2	2.0	12.3	1.2	.33	1.5
	Mean Accum. Rate	5.4	8.9	$8.9x10^{2}$	58.6	$4.2x10^{2}$	$1.3x10^{2}$	35.4	68.3

3. Adsorbed on to organic matter;
4. Bound to an organic compound;
5. Bound to sulphur;
6. Coprecipitated into the lattice of an authigenic mineral such as calcite.
7. Incorporated into sediment-dwelling micro-organisms.

In any given lake, each of these processes may be presumed to play at least some part in the fixation of mercury in the sediments. Under equilibrium conditions, however, it is typical for a stable partitioning to develop that distributes mercury in the sediments of a given lake amongst the various possible sites. It is common for the mercury to predominantly be related to only a few of these sites in a given lacustrine environment. In the Okanagan mainstem lakes it is most probable that the distribution of mercury between the various attachment sites in the sediments varies from lake to lake. For example, evidence exists that the bulk of the mercury in the sediment from Osoyoos Lake is related to organic matter, while the bulk of the mercury in the sediments of Wood Lake may exist as a sulphide. A certain proportion of the mercury in the Kalamalka Lake may be contained in the lattice structure of the authigenic calcium carbonate that typifies that lake. Accordingly, comparisons of the mercury content of the sediments from the various mainstem lakes of the Okanagan must be intricate. These comparisons are necessary, however, as evidence discovered during the Task 121 studies indicates that mercury pollution may have occurred in the Okanagan Valley.

Figure 13 illustrates a profile of mercury concentration from sediment samples taken from the median line down the mainstem lakes. Significant peaks above the mean background of about 300 ppb mercury occur at the following localities:

1. Wood Lake;
2. Kalamalka Lake;
3. The Vernon Arm of Okanagan Lake;
4. The Armstrong Arm of Okanagan Lake;
5. Osoyoos Lake - in particular the central basin.

As each of these localities differs somewhat in geochemistry, it is necessary to consider them individually:

1. Wood Lake: Wood Lake unquestionably shows the highest mercury loading in the Okanagan mainstem lakes. The mean mercury concentration for the sediments from the deeper parts of Wood Lake is in excess of 1200 ppb, and one sample contained 2139 ppb Hg. This sample was subjected to differential thermal mercury analysis. The result indicated that essentially all of the merucry was present as a sulphide. Differential analysis of other Wood Lake samples produced inconclusive results, however.
2. Kalamalka Lake: The presence of a sample adjacent to the Vernon Creek inlet to Kalamalka Lake containing 1874 ppb suggests that this Creek (from Wood Lake) provides the main source of Hg to Kalamalka Lake. Sediment samples taken from the carbonate terraces of Kalamalka Lake average 586 ppb while deep sediments average 673 ppb. One sample taken from the deepest point, however, contained 1619 ppb, and as the sample grid from this lake was relatively diffuse, it is possible that this high value may be typical of the deep sediments. Differential thermal mercury analysis performed on sediments from Kalamalka Lake have failed to elucidate the problem of the attachment

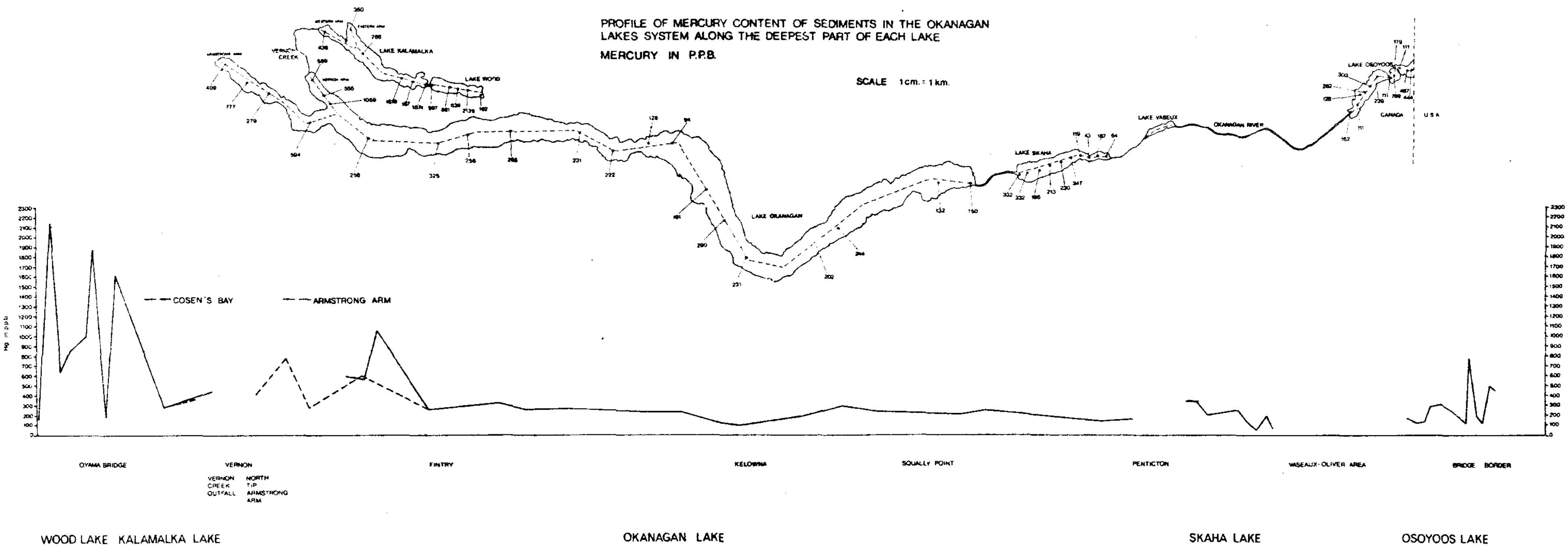

PROFILE OF MERCURY CONTENT OF SEDIMENTS IN THE OKANAGAN LAKES SYSTEM ALONG THE DEEPEST PART OF EACH LAKE
MERCURY IN P.P.B.
SCALE 1 cm. = 1 km.
LAKE KALAMALKA
LAKE WOOD
VERNON CREEK
LAKE OKANAGAN
LAKE SKAHA
LAKE VASEUX
OKANAGAN RIVER
LAKE OSOYOOS
CANADA
U.S.A.
COSEN'S BAY
ARMSTRONG ARM
Hg in p.p.b.
OYAMA BRIDGE
VERNON
VERNON CREEK OUTFALL
NORTH TIP ARMSTRONG ARM
FINTRY
KELOWNA
SQUALLY POINT
PENTICTON
VASEAUX-OLIVER AREA
BRIDGE
BORDER
WOOD LAKE
KALAMALKA LAKE
OKANAGAN LAKE
SKAHA LAKE
OSOYOOS LAKE

FIGURE 13.

sites for Hg. The possibility that some of the Hg is contained in the lattice of the $CaC0_3$ cannot be excluded. However, it can be stated that an appreciable amount of the mercury in these sediments is not in the carbonate lattice, and hence may be readily available for methylation.

3. Vernon Arm of Okanagan Lake: The average mercury content in the sediments of the Vernon Arm is 734 ppb. The elevated organic carbon content of these samples may be related to this enrichment of mercury. It seems probable that there is a relation between the fact of mercury enrichment in the Vernon Arm and enrichment in the other sediments from the Vernon Creek drainage (i.e., from Wood and Kalamalka Lakes).
4. Armstrong Arm of Okanagan Lake: The sediments of the Armstrong Arm contain an average of 515 ppb Hg. This arm receives the drainage from the Armstrong area at the north end of the Okanagan watershed.
5. Osoyoos Lake: The sediments from the three basins of Osoyoos Lake contain markedly different concentrations of Hg. The mean values are: North Basin = 290 ppb; Central Basin = 576 ppb; and South Basin = 450 ppb. The variations in individual samples appear to follow closely variations in organic carbon content, and, in fact, a regression analysis performed on the mercury and organic carbon values for the Osoyoos Lake samples indicated that the two parameters were closely correlated ($r = 0.86$). Hence, it can be concluded that mercury in the sediments of Osoyoos Lake is intrinsically related to organic matter, and the higher Hg values in the southern basins reflects the geological factors discussed in the section of this report on carbon, and does not, in fact, reflect an input near the town of Osoyoos.

6. Conclusions: Other tasks of the Okanagan Basin Study have presented information suggesting that methyl mercury contamination is not a problem in the fish taken from the mainstem lakes of the Valley. In view of the high concentrations of mercury present in certain of the sediment samples collected during this study, it is of interest to consider why the fish have remained safe.

The extreme eutrophication induced in Wood Lake has resulted in an anoxic hypolimnion in that lake for most of the year, and fish populations have been heavily restricted. It seems probable that this simple fact explains the lack of a methyl mercury problem in this lake.

Kalamalka Lake, on the other hand is highly Oligotrophic, and as an appreciable amount of the mercury in the sediments of this lake is presumably available for methylation, it is not easy to explain why the fish are uncontaminated. A marked change in the trophic state of this lake could accelerate methylation, however.

The Armstrong and Vernon Arms of Okanagan Lake occupy only a small volume of the total lake, and it seems probable that any methyl mercury released from the sediments of these two arms would undergo sufficient dilution to be rendered harmless.

The mercury problem in the central basin of Osoyoos Lake requires further study.

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APPENDIX 1

SAMPLE STATION DEPTHS

SAMPLE COLOUR

% GRAVEL-SAND-SILT-CLAY

KALAMALKA LAKE

SAMPLE	DEPTH (in METRES)	COLOUR	% GRAVEL	% SAND	% SILT	% CLAY
K-1	33.0	Grey	0.00	19.79	70.30	9.91
K-2	5.5	Grey	0.00	10.30	61.24	28.46
K-3	5.0	Grey	11.51	82.04	4.67	1.79
K-4	75.0	Grey	0.00	3.73	40.67	55.60
K-5	120.0	Brown	0.00	1.61	43.38	55.01
K-6	142.0	Grey	0.00	2.05	46.88	51.07
K-7	52.0	Grey	20.54	65.30	5.20	8.96
K-8	4.0	Brown	0.25	39.58	38.30	21.86
K-8a		Grey	0.51	18.83	51.48	29.18
K-9	4.0	Grey	0.00	18.26	58.70	23.00
K-10	1.5	Black	0.06	59.39	31.86	8.68

WOOD LAKE

SAMPLE	DEPTH (in METERS)	COLOUR	% GRAVEL	% SAND	% SILT	% CLAY
W-1	8.5	Grey	12.47	94.35	4.95	1.87
W-1a	8.5	Grey	0.00	43.83	32.27	23.90
W-2	27.0	Black	0.00	3.96	64.22	31.82
W-3	32.0	Black	0.00	2.52	59.21	38.27
W-4	32.0	Black	0.00	3.44	62.76	34.79
W-5	6.0	Black	0.00	31.93	58.98	9.09

OKANAGAN LAKE

SAMPLE	DEPTH (in METRES)	COLOUR	% GRAVEL	% SAND	% SILT	% CLAY
OK-1	134.0	Grey	0.00	18.30	50.13	32.57
OK-2	91.0	Grey	0.00	25.38	54.04	20.57
OK-3	136.0	Grey		INSUFFICIENT SAMPLE		
OK-4	1.5	Brown	0.00	18.12	60.98	20.90
OK-5	4.0	Brown		INSUFFICIENT SAMPLE		
Ok-6	7.5	Grey	0.00	59.66	40.34	0.00
OK-7	28.0	Grey	0.00	26.19	49.76	24.05
OK-8	69.0	Grey	0.00	11.50	59.60	28.90
OK-9	20.0	Grey	0.00	18.61	62.87	18.52
OK-9a	20.0	Brown	0.00	30.40	70.18	.59
OK-10	17.0	Black	0.00	10.78	71.69	17.53
OK-11	115.0	Grey	0.00	2.63	55.42	41.95
OK-12	190.0	Grey		INSUFFICIENT SAMPLE		
OK-13	36.0	Grey	0.00	2.67	59.32	38.01
OK-14	80.0	Grey		INSUFFICIENT SAMPLE		
OK-15	26.0	Grey	0.00	3.39	50.26	46.35
OK-16	26.0	Grey	0.00	28.53	30.60	40.87
OK-17	19.0	Grey	0.00	0.00	50.25	49.75
OK-18	16.0	Black	0.00	26.68	49.46	23.87
OK-19	82.0	Grey		INSUFFICIENT SAMPLE		
OK-20	19.0	Black	0.00	2.11	58.12	39.78
OK-21	23.0	Brown	0.00	3.77	54.64	41.59
OK-22	9.0	Brown	0.13	28.12	39.71	32.04
OK-22a	9.0	Brown	0.00	16.75	43.45	39.79
OK-23	28.0	Grey	0.05	7.04	37.01	55.91
OK-24	28.0	Brown	0.00	13.58	42.73	43.69
OK-25	30.0	Brown	0.12	8.69	45.63	45.57
OK-26	69.0	Grey		INSUFFICIENT SAMPLE		

OKANAGAN LAKE

SAMPLE	DEPTH (in METRES)	COLOUR	% GRAVEL	% SAND	% SILT	% CLAY
OK-27	35.0	Grey		INSUFFICIENT	SAMPLE	
OK-28	112.0	Grey		INSUFFICIENT	SAMPLE	
OK-29	57.0	Grey	0.00	3.71	47.41	48.88
OK-30	16.59	Brown	0.20	67.66	22.23	9.90
OK-31	235.0	Grey	0.00	4.54	51.18	44.28
OK-32	19.0	Grey	0.00	.00	3.81	96.19
OK-33	145.0	Grey		INSUFFICIENT	SAMPLE	
OK-34	182.0	Grey		INSUFFICIENT	SAMPLE	
OK-35	184.0	Grey		INSUFFICIENT	SAMPLE	
OK-36	197.0	Grey		INSUFFICIENT	SAMPLE	
OK-37	102.0	Grey	0.00	6.08	57.78	36.14
OK-38	24.0	Brown	9.93	32.67	44.48	13.12
OK-38a	24.0	Brown	0.00	23.35	64.78	11.87
OK-39	27½.0	Brown	0.00	68.67	25.63	5.70
OK-40	51.0	Grey	0.00	0.00	75.96	24.04
OK-41	85.0	Grey	0.00	.20	62.11	37.69
OK-42	24.5	Grey	0.00	36.63	39.88	23.49
OK-43	50.0	Grey		INSUFFICIENT	SAMPLE	
OK-44	31.0	Brown	0.00	71.21	21.69	7.09

SKAHA LAKE

SAMPLE	DEPTH (in METRES)	COLOUR	% GRAVEL	% SAND	% SILT	% CLAY
S-1	6.5	Black	0.11	21.38	67.00	11.50
S-2	14.0	Green	23.95	62.93	6.74	6.37
S-3	34.0	Black	0.36	2.72	63.23	33.69
S-4	39.0	Black	0.00	1.76	68.62	29.62
S-5	19.0	Brown	0.19	75.23	16.11	8.48
S-6	33.0	Brown	0.12	75.79	15.57	8.52
S-7	22.5	Brown	0.00	54.27	34.11	11.62
S-8	23.0	Brown	0.00	53.08	35.51	11.41
S-9	33.0	Black	0.00	1.17	65.13	33.70
S-10	18.0	Green	11.71	20.70	46.90	20.68
S-11	5.0	Brown	0.00	91.17	3.16	5.67
S-12	17.0	Brown	1.12	82.12	9.57	7.19
S-13	48.5	Black	0.00	0.00	54.23	45.77
S-14	52.0	Black	0.00	1.06	57.62	41.31
S-15	16.0	Brown	0.45	84.71	7.61	7.23
S-16	15.0	Brown	2.54	58.91	24.57	13.98
S-17	44.0	Black	0.00	2.78	64.84	32.38
S-18	54.0	Black	0.00	0.23	59.15	40.62
S-19	49.5	Black	0.00	0.00	60.98	39.01
S-20	14.0	Brown	0.00	29.88	56.59	13.52
S-21	18.0	Black	0.00	79.02	12.59	8.39
S-22	52.5	Black	INSUFFICIENT SAMPLES			
S-23	50.0	Black	0.00	1.34	62.11	36.55
S-24	36.0	Black	0.00	5.89	61.41	32.70
S-25	13.0	Black	0.56	82.16	11.04	6.25
S-26	12.0	Brown	1.10	71.99	19.43	7.48
S-27	30.0	Black	0.00	8.18	65.13	26.68
S-28	38.0	Black	0.00	0.00	71.02	28.98
S-29	42.5	Black	0.00	5.16	79.31	15.53
S-30	45.0	Black	0.00	41.31	30.55	8.15
S-31	14.5	Grey	0.00	56.41	39.14	4.25
S-32	10.0	Brown	0.00	59.38	37.27	3.35
S-33	13.0	Black	0.00	20.81	40.65	38.55
S-34	13.4	Grey	0.00	15.90	57.90	26.46
S-35	11.0	Black	0.00	30.06	50.63	19.30
S-36	11.0	Brown	0.00	0.00	69.84	30.16

OSOYOOS LAKE

SAMPLE	DEPTH (in METRES)	COLOUR	% GRAVEL	% SAND	% SILT	% CLAY
OS-1	34.6	Black	0.00	19.27	58.65	22.08
OS-2	4.0	Brown	0.17	16.85	70.73	12.25
OS-3	34.0	Black	0.00	0.20	70.81	28.99
OS-4	26.5	Black	0.00	5.57	64.92	29.52
OS-5	21.0	Black	0.00	13.35	48.01	38.64
OS-6	23.5	Black	0.00	0.00	75.96	24.04
OS-7	36.4	Black	0.00	0.89	50.00	49.12
OS-8	61.5	Black		INSUFFICIENT SAMPLES		
OS-9	15.0	Grey	0.00	9.72	52.06	38.21
OS-10	25.6	Grey	0.00	6.80	49.13	44.06
OS-11	26.0	Black	0.00	4.53	50.36	45.11
OS-12	6.0	Brown	40.58	57.78	1.04	0.59
OS-13	21.0	Black	0.00	4.15	65.60	30.25
OS-14	30.5	Black		INSUFFICIENT SAMPLES		
OS-15	14.5	Black	0.00	4.62	53.46	41.92
OS-16	5.0	Brown	4.94	67.00	20.33	7.73
OS-16a	—	Grey	0.00	5.46	54.12	40.41
OS-17	11.5	Brown	4.71	77.91	12.63	4.75
OS-18	15.0	Grey	0.00	48.23	36.00	15.68
OS-19	27.0	Black		INSUFFICIENT SAMPLES		
OS-20	13.0	Black	28.18	69.93	1.46	0.44
OS-21	18.0	Grey	0.00	2.38	65.66	31.96
OS-22	20.0	Black	0.00	8.51	60.44	31.05
OS-23	26.0	Black	0.00	3.22	64.79	31.99

APPENDIX 2

TOTAL MAJOR ELEMENT CONTENT

OF SAMPLES

FROM OKANAGAN MAINSTEM LAKES

(BY X-RAY FLUORESCENCE SPECTROMETRY)

ALL VALUES AS PER CENT

WOOD LAKE

	CaO	Na_2O	Fe_2O_3	MgO	P_2O_5	MnO	SiO_2	K_2O	S	Al_2O_3	TiO_2
W-1	3.54	3.16	1.46	1.11	0.14	0.06	70.27	2.94	0.19	10.55	0.18
W-1a	18.25	1.30	2.14	1.54	0.15	0.10	50.12	2.64	0.75	6.88	0.25
W-2	8.68	1.21	7.15	2.20	0.38	0.22	55.13	1.56	1.72	1.45	0.76
W-3	9.54	0.93	5.96	1.79	0.37	0.31	60.35	1.24	1.20	5.83	0.61
W-4	10.38	0.47	5.49	1.47	0.29	0.24	59.92	1.24	1.44	5.77	0.65
W-5	3.91	1.93	4.87	2.03	0.29	0.08	61.53	2.08	.22	10.85	0.88
WC-1 0-5 cm.	12.16	0.94	5.32	1.32	0.30	0.36	56.93	1.19	1.96	5.50	0.56
WC-1 20-25 cm.	2.48	1.45	9.84	2.59	0.51	0.31	57.60	1.87	0.48	10.05	1.11
WC-1 45-50 cm.	2.29	1.20	10.21	2.67	0.42	0.31	57.67	1.89	0.42	10.00	1.02
WC-1 70-75 cm.	2.39	1.45	9.84	2.90	0.41	0.26	57.67	2.09	0.21	11.38	1.14
WC-1 85-90 cm.	2.26	1.16	8.80	2.19	0.29	0.25	59.96	1.73	1.29	9.05	0.99

KALAMALKA LAKE

	CaO	Na_2O	Fe_2O_3	MgO	P_2O_5	MnO	SiO_2	K_2O	S	Al_2O_3	TiO_2
K-1	19.57	1.04	3.75	2.26	0.22	0.12	47.95	1.47	0.19	6.33	0.47
K-2	48.59	0.32	0.61	0.54	——	0.02	19.40	0.28	——	1.10	0.05
K-2a	49.67	0.31	0.55	0.52	——	0.02	19.70	0.25	——	1.30	0.04
K-3	13.71	0.71	4.07	2.60	0.23	0.47	59.26	1.34	0.57	5.34	0.37
K-4	21.80	0.88	4.11	2.37	0.25	0.14	44.12	1.57	0.09	6.59	0.49
K-5	26.14	0.86	3.02	1.82	0.19	0.24	43.18	1.22	0.13	4.80	0.32
K-5a	16.32	1.15	4.54	2.67	0.25	0.28	50.38	1.78	0.49	7.11	0.49
K-6	13.65	0.86	4.07	2.05	0.24	0.48	59.15	1.35	0.60	5.42	0.37
K-7	6.11	2.14	3.41	2.08	0.17	0.11	67.51	2.19	0.03	8.88	0.35
K-7a	2.99	1.54	8.31	4.30	0.20	0.20	54.17	3.35	——	13.43	0.65
K-8	50.59	0.21	0.51	0.57	——	0.04	17.02	0.23	——	0.89	0.02
K-8a	51.37	0.27	0.50	0.48	——	0.03	17.61	0.24	——	1.02	0.02
K-9	48.59	0.38	0.62	0.58	——	0.03	20.28	0.29	——	1.21	0.04
K-10	10.00	1.87	1.31	1.35	0.18	0.04	60.78	2.28	0.53	7.91	0.18

KALAMALKA LAKE

	CaO	Na_2O	Fe_2O_3	MgO	P_2O_5	MnO	SiO_2	K_2O	S	Al_2O_3	TiO_2
KC-1 0-5 cm.	26.67	1.14	2.87	1.78	0.18	0.41	51.02	1.18	0.36	4.48	0.27
KC-1 20-25 cm.	20.59	1.10	3.22	2.00	0.20	0.41	48.74	1.60	0.29	5.86	0.36
KC-1 40-45 cm.	17.37	1.18	3.90	2.26	0.23	0.52	55.32	1.34	0.44	5.31	0.37
KC-1 60-65 cm.	25.60	0.88	3.11	1.86	0.20	0.37	42.43	1.35	0.24	5.28	0.34
KC-1 85-90 cm.	5.76	1.02	6.51	2.15	0.50	1.03	60.65	1.85	0.67	7.70	0.54
KC-2 0-5 cm.	47.61	0.27	0.91	0.67	——	0.05	19.13	0.35	——	1.35	0.07
KC-2 20-25 cm.	49.55	0.20	0.40	0.43	——	0.02	18.81	0.20	——	0.76	0.01
KC-2 45-50 cm.	50.64	0.21	0.59	0.53	——	0.03	17.90	0.25	——	0.97	0.03
KC-2 70-75 cm.	50.57	0.20	0.46	0.56	——	0.03	17.90	0.20	——	0.82	0.02
KC-2 95-100 cm.	46.64	0.47	0.46	0.68	——	0.02	24.35	0.22	——	0.95	0.02
KC-2 120-125	47.80	0.33	0.37	0.50	——	0.02	22.89	0.18	——	0.75	0.01

OKANAGAN LAKE

	CaO	Na_2O	Fe_2O_3	MgO	P_2O_5	MnO	SiO_2	K_2O	S	Al_2O_3	TiO_2
Ok-1	2.51	2.08	3.92	1.89	0.17	0.11	67.38	2.55	0.10	11.37	0.49
OK-2	2.14	1.51	5.79	2.58	0.20	0.19	60.40	2.71	0.02	11.66	0.65
OK-3	2.05	1.42	6.37	2.71	0.23	0.42	63.80	2.54	0.07	10.86	0.65
OK-4	5.29	1.10	5.01	2.01	0.21	0.07	60.96	2.43	1.05	10.77	0.59
OK-5	2.30	1.80	3.52	2.06	0.16	0.05	69.35	2.55	0.16	10.71	0.49
OK-6	2.68	2.40	3.18	1.92	0.18	0.05	68.28	2.57	0.13	11.65	0.44
OK-7	2.14	1.83	5.61	2.05	0.18	0.14	65.06	2.56	0.01	11.53	0.55
OK-8	2.09	1.66	6.01	2.77	0.23	0.29	62.02	2.86	0.05	12.70	0.63
OK-9	2.07	1.77	5.27	2.73	0.17	0.08	64.89	2.94	0.02	12.24	0.06
OK-9a	3.56	2.77	3.19	1.28	0.12	0.06	66.08	2.47	0.31	11.19	0.43
OK-10	2.71	2.37	3.15	1.98	0.17	0.05	68.82	2.58	0.11	11.82	0.43
OK-11	2.21	1.34	6.81	2.55	0.35	0.73	62.58	2.50	0.04	10.59	0.69
OK-11a	2.46	1.46	8.69	2.62	0.72	0.31	59.61	2.45	0.04	10.67	0.69
OK-12	1.90	1.22	6.42	2.36	0.25	0.44	66.01	2.25	0.10	9.79	0.66
OK-13	2.42	1.51	6.73	2.75	0.28	0.13	61.37	2.66	0.08	11.36	0.76
OK-14	2.43	1.67	1.62	2.67	0.36	0.18	60.87	2.50	0.09	11.13	0.77
OK-15	8.34	2.12	6.60	3.49	0.34	0.14	52.58	2.47	0.39	10.15	0.67
OK-16	4.97	1.30	7.71	3.92	0.30	0.18	53.82	2.71	0.23	11.73	0.71
OK-17	5.16	1.31	7.08	3.13	0.30	0.12	54.32	2.62	0.17	11.24	0.71
OK-18	3.81	1.49	6.80	5.26	0.30	0.10	56.67	2.40	0.15	10.86	0.75
OK-19	2.04	1.13	7.61	2.92	0.27	0.22	60.82	2.38	0.37	10.55	0.68
OK-20	2.35	1.22	6.71	3.02	0.21	0.09	59.15	2.41	0.66	10.94	0.68
OK-21	2.20	1.24	6.80	2.95	0.22	0.10	60.32	2.36	0.61	10.77	0.69
OK-22	16.78	1.24	3.37	3.37	0.20	0.05	52.86	1.56	0.90	17.21	0.44
OK-22a	21.18	1.13	3.04	1.91	0.18	0.03	50.45	1.33	1.12	6.01	0.38

OKANAGAN LAKE

	CaO	Na_2O	Fe_2O_3	Mgo	P_2O_5	MnO	SiO_2	K_2O	S	Al_2O_3	TiO_2
OK-23	2.13	1.17	6.84	3.88	0.23	0.11	60.46	2.43	0.28	11.06	0.71
OK-24	2.31	1.36	7.20	3.32	0.24	0.09	60.30	3.37	0.88	11.07	0.70
OK-25	2.21	1.27	6.66	3.13	0.22	0.10	59.46	2.54	0.29	11.51	0.69
OK-26	2.32	2.01	4.16	2.14	0.19	0.07	63.67	3.08	0.25	11.62	0.52
OK-27	2.09	1.21	6.84	3.04	0.23	0.12	61.52	2.38	0.19	10.82	0.69
OK-28	2.04	.63	7.68	2127	0.32	0.31	62.26	2.25	0.12	9.94	0.68
OK-29	2.35	1.51	6.61	3.25	0.26	0.11	59.84	2.52	0.22	11.54	0.74
OK-30	3.43	2.06	6.10	4.73	0.26	0.12	58.45	2.88	0.02	11.17	0.66
OK-31	1.87	1.03	7.07	2.62	0.30	0.56	64.62	2.05	0.09	8.97	0.65
OK-32	2.38	1.34	10.35	5.61	0.19	0.17	50.70	3.50	0.00	13.97	0.74
OK-33	2.12	1.17	7.71	3.03	0.31	0.42	61.55	2.24	0.00	10.25	0.70
OK-34	1.99	1.27	7.36	2.57	0.31	0.58	63.44	2.15	0.09	9.72	0.69
OK-35	1.92	1.13	7.27	2.52	0.29	0.54	64.73	2.08	0.08	9.41	0.67
OK-36	2.12	1.22	6.73	2.51	0.27	0.36	64.59	2.10	0.13	9.60	0.70
OK-37	2.39	1.47	7.11	2.63	0.29	0.25	62.29	2.30	0.13	10.60	0.75
OK-38	2.97	1.89	4.44	1.97	0.25	0.08	63.90	2.26	0.15	10.42	0.67
OK-38a	3.28	2.38	4.91	3.20	0.26	0.09	63.28	2.37	0.04	11.62	0.74
OK-39	2.84	2.50	3.42	1.49	0.20	0.07	67.92	2.50	0.04	11.30	0.46
OK-40	3.20	2.40	3.79	1.81	0.20	0.09	66.43	2.40	0.04	11.14	0.49
OK-41	3.00	2.04	5.83	2.23	0.28	0.15	62.65	2.35	0.10	11.37	0.77
OK-42	2.65	1.78	6.54	2.47	0.27	0.13	61.96	2.53	0.09	11.72	0.79
OK-43			INSUFFICIENT SAMPLES								
OK-44	2171	1.69	5.66	7.78	0.24	0.11	63.68	2.23	0.03	11.09	0.66

OKANAGAN LAKE

	CaO	Na_2O	Fe_2O_5	MgO	P_2O_3	MnO	SiO_2	K_2O	S	Al_2O_3	TiO_2
OKC-1 0-5 cm.	2.08	1.45	6.29	2.76	0.21	0.34	63.69	2.61	0.10	11.13	0.66
OKC-1 20-25 cm.	2.02	1.36	6.31	2.46	0.21	0.30	64.46	2.42	0.05	10.63	0.63
OKC-1 45-50 cm.	1.90	1.56	6.39	2.59	0.23	0.30	65.43	2.43	0.06	10.50	0.63
OKC-1 60-63 cm.	2.41	1.41	9.55	3.48	0.32	0.23	53.06	2.02	0.02	14.73	1.25
OKC-1 97-100 cm.	1.93	1.28	6.21	2.01	0.25	0.38	66.37	2.17	0.08	9.41	0.64
OKC-2 0-5 cm.	1.90	1.22	5.42	2.36	0.25	0.44	66.01	2.25	0.10	9.79	0.66
OKC-2 20-25 cm.	2.01	1.10	6.74	2.29	0.25	0.28	65.12	2.24	0.07	9.89	0.67
OKC-2 45-50 cm.	2.04	1.35	6.90	2.43	0.27	0.26	64.41	2.33	0.07	10.43	0.69
OKC-2 70-75 cm.	2.22	1.31	6.51	2.36	0.24	0.23	65.24	2.23	0.10	10.21	0.71
OKC-2 90-95 cm.	2.17	1.40	6.54	2.37	0.26	0.24	65.62	2.26	0.10	10.22	0.71
OKC-3 0-5 cm.	1.93	1.02	7.17	2.67	0.29	0.47	64.57	2.05	0.11	8.97	0.66
OKC-3 20-25 cm.	1.92	1.10	7.24	2.67	0.31	0.36	64.52	2.12	0.07	9.83	0.67
OKC-3 45-50 cm.	1.92	1.15	6.72	2.39	0.29	0.31	66.14	2.05	0.09	9.40	0.66
OKC-3 70-75 cm.	1.89	1.25	6.85	2.50	0.30	0.33	66.09	2.02	0.07	9.38	0.68
OKC-3 95-100 cm.	1.97	1.17	6.70	2.48	0.28	0.30	66.85	2.05	0.06	9.60	0.70
OKC-3 105-110 cm.	1.94	1.07	6.55	2.47	0.28	0.28	67.10	2.02	0.09	9.28	0.67

SKAHA LAKE

	CaO	Na_2O	Fe_2O_3	MgO	P_2O_5	MnO	SiO_2	K_2O	S	Al_2O_3	TiO_2
S-1	4.65	2.10	3.73	1.68	0.24	0.07	61.84	2.34	0.61	10.75	0.43
S-2	1.76	2.44	2.16	1.01	0.08	0.05	73.29	2.79	0.04	10.94	0.19
S-3	2.50	1.64	5.65	2.08	0.26	0.15	63.88	2.48	0.37	10.57	0.58
S-4	2.37	1.46	5.32	1.50	0.21	0.11	66.76	2.28	0.65	9.53	0.53
S-4a	2.65	2.35	5.42	2.56	0.23	0.13	61.36	2.87	0.09	12.74	0.57
S-5	2.08	2.17	2.93	1.24	0.12	0.06	72.22	2.54	0.11	10.32	0.31
S-6	2.58	2.14	3.07	1.44	0.17	0.09	71.59	2.28	0.04	10.60	0.37
S-7	2.51	2.12	3.90	1.61	0.17	0.08	68.98	2.44	0.22	10.59	0.44
S-8	2.02	2.20	3.09	1.56	0.13	0.06	70.68	2.72	0.08	10.66	0.37
S-9	2.39	1.54	5.54	1.90	0.26	0.21	66.33	2.40	0.29	9.71	0.55
S-10	2.85	2.21	6.83	2.13	0.23	0.29	63.66	2.51	0.11	11.40	0.51
S-11	1.69	2.24	1.70	1.01	0.07	0.04	76.03	2.66	0.06	9.69	0.22
S-12	1.95	2.20	2.56	1.26	0.10	0.06	74.30	2.65	0.08	9.98	0.30
S-13	2.09	1.94	5.55	2.12	0.20	0.22	64.18	2.86	0.16	11.81	0.52
S-14	2.09	1.62	5.48	1.90	0.22	0.25	66.25	2.52	0.23	10.11	0.52
S-15	1.82	2.46	2.58	1.20	0.09	0.04	72.16	2.87	0.33	11.02	0.25
S-16	2.09	2.41	3.82	1.76	0.15	0.08	69.26	2.80	0.05	11.13	0.42
S-17	2.33	1.84	5.16	1.99	0.23	0.17	64.34	2.63	0.21	10.76	0.55
S-18	2.14	1.72	5.26	1.88	0.20	0.21	66.28	2.65	0.28	10.67	0.53
S-18a	1.96	2.15	2.68	1.38	0.11	0.05	74.22	2.47	0.10	9.79	0.37
S-19	2.21	1.70	5.55	1.89	0.22	0.26	65.86	2.51	0.23	10.04	0.53
S-20	1.92	1.95	2.68	1.57	0.11	0.06	74.08	2.48	0.09	9.82	0.36
S-21	2.43	1.78	4.77	1.92	0.23	0.09	64.88	2.68	0.18	10.88	0.55
S-22	2.26	2.18	4.98	1.73	0.20	0.17	64.36	2.93	0.13	12.06	0.52
S-23	2.11	1.66	5.37	1.93	0.22	0.22	66.74	2.58	0.24	10.31	0.53
S-24	2.29	1.99	5.25	2.11	0.20	0.16	64.16	2.77	0.18	11.52	0.56

SKAHA LAKE

	CaO	Na_2O	Fe_2O_3	MgO	P_2O_3	MnO	SiO_2	K_2O	S	Al_2O_3	TiO_2
S-25	2.03	2.05	2.81	1.29	0.12	0.05	74.42	2.38	0.17	9.66	0.39
S-26	2.01	2.14	2.68	1.34	0,13	0.05	72.88	2.59	0.29	10.18	0.34
S-27	2.35	1.80	4.86	2.02	0.21	0.11	64.55	2.68	0.13	10.96	0.55
S-28	2.27	1.88	5.08	2.01	0.23	0.15	64.31	2.77	0.14	11.34	0.53
S-29	2.28	1.77	5.18	1.49	0.25	0.24	68.39	2.30	0.38	9.10	0.52
S-30	2.25	1.99	5.06	1.94	0.20	0.14	65.80	2.69	0.27	10.86	0.53
S-31	2.42	2.12	3.80	1.69	0.20	0.07	67.47	2.72	0.11	10.96	0.47
S-32	3.74	2.28	3.78	1.73	0.23	0.07	64.16	2.73	0.12	11.10	0.48
S-33	3.76	2.48	3.54	1.82	0.21	0.06	65.84	2.80	0.17	11.29	0.43
S-34	2.66	2.50	3.53	1.66	0.20	0.07	65.78	2.86	0.11	11.63	0.43
S-35	2.67	2.63	3.45	1.61	0.20	0.06	66.81	2.86	0.07	11.83	0.41
S-36	2.60	2.69	3.51	1.60	0.21	0.06	67.60	2.79	0.06	11.58	0.44
SC-1 0-5 cm.	2.77	1.95	5.57	2.33	0.26	0.13	62.08	2.60	0.14	11.62	0.58
SC-1 35-40 cm.	2.66	1.38	6.31	1.88	0.23	0.14	64.89	2.33	0.45	9.97	0.57
SC-1 72-75 cm.	2.00	1.17	6.09	1.69	0.25	0.14	67.26	2.11	0.37	9.09	0.53
SC-1 81-86 cm.	1.97	1.45	5.99	1.66	0.24	0.13	67.49	2.16	0.44	9.17	0.54
SC-2 6-8 cm.	1.95	1.41	6.32	1.77	0.26	0.23	66.73	2.33	0.23	7.67	0.55
SC-2 32-34 cm.	2.00	1.39	5.95	1.73	0.23	0.21	65.96	2.45	0.19	10.03	0.53
SC-2 50-52 cm.	1.81	1.40	6.31	1.70	0.26	0.24	67.15	2.25	0.21	9.16	0.55

SKAHA LAKE

	CaO	Na_2O	Fe_2O_3	MgO	P_2O_3	MnO	SiO_2	K_2O	S	Al_2O_3	TiO_2
SC-2 72-75 cm.	1.71	1.14	5.93	1.39	0.26	0.24	67.15	2.24	0.21	9.16	0.55
SC-2 96-100 cm.	1.81	1.17	5.53	1.56	0.24	0.22	69.73	2.18	0.18	9.03	0.51

OSOYOOS LAKE

	CaO	Na_2O	Fe_2O_3	MgO	P_2O_3	MnO	SiO_2	K_2O_3	S	Al_2O_3	TiO_2
OS-1	3.29	1.91	4.57	2.20	0.24	0.14	64.25	2.31	0.29	10.55	0.52
OS-2	2.80	2.05	3.57	2.05	0.21	0.07	66.23	2.40	0.11	11.42	0.49
OS-3	2.81	1.80	5.48	2.61	0.26	0.16	62.46	2.39	0.26	10.90	0.58
OS-4	2.80	1.78	5.91	2.98	0.27	0.18	60.82	2.46	0.18	11.20	0.61
OS-5	2.52	1.71	6.05	2.75	0.22	0.16	62.35	2.43	0.22	10.77	0.59
OS-6	2.53	1.66	6.71	2.86	0.27	0.23	61.26	2.41	0.21	10.77	0.62
OS-7	2.65	1.66	6.93	2.98	0.27	0.27	60.43	2.46	0.26	11.02	0.64
OS-8	2.84	1.82	6.45	2.87	0.28	1.00	60.11	2.40	0.18	10.65	0.60
OS-8a	2.70	1.67	6.38	2.73	0.26	1.15	60.63	2.37	0.36	10.58	0.59
OS-9	2.53	1.99	5.98	2.63	0.21	0.15	62.81	2.43	0.51	11.23	0.58
OS-10	2.59	1.56	6.70	2.65	0.25	0.19	60.79	2.42	0.20	10.93	0.63
OS-11	2.48	1.59	6.45	2.56	0.22	0.17	62.50	2.41	0.28	10.76	0.60
OS-12	2.02	2.33	2.00	1.04	0.08	0.06	74.90	2.48	0.20	9.83	0.25
OS-13	3.50	1.35	5.84	2.51	0.25	0.13	61.48	2.16	0.76	9.36	0.58
OS-14	3.87	1.09	5.61	2.08	0.27	0.17	64.29	1.94	0.52	8.22	0.52
OS-15	2.94	1.44	6.30	2.50	0.23	0.13	61.05	2.22	0.47	9.78	0.59
OS-16	6.38	1.90	1.22	1.04	0.14	0.05	70.58	2.40	0.14	8.22	0.18
OS-16a	39.43	0.60	1.19	0.88	0.05	0.10	29.52	0.62	0.11	2.47	0.11
OS-17	2.80	1.80	2.49	1.21	0.12	0.07	72.67	2.39	0.09	9.97	0.29
OS-18	3.01	2.12	5.52	1.82	0.17	0.09	67.79	2.44	0.21	10.81	0.44
OS-19	3.33	1.40	5.13	2.26	0.26	0.15	64.50	2.27	0.49	9.60	0.54
OS-20	4.47	2.43	3.14	1.48	0.18	0.14	68.36	2.31	0.24	9.86	0.40
OS-21	2.49	1.44	5.79	2.68	0.22	0.13	61.91	2.55	0.27	11.03	0.62
OS-22	2.48	1.69	5.85	2.51	0.22	0.18	62.33	2.48	0.22	10.81	0.60
OS-23	3.00	1.43	5.13	2.15	0.23	0.16	65.45	2.24	0.45	9.36	0.54

OSOYOOS LAKE

	CaO	Na_2O	Fe_2O_3	MgO	P_2O_3	MnO	SiO_2	K_2O	S	Al_2O_3	TiO_2
OSC-1 25-30 cm.	2.30	1.74	6.85	2.87	0.21	0.40	62.20	2.29	0.25	10.55	0.16
OSC-1 55-60 cm.	2.33	1.75	7.13	2.99	0.24	0.39	61.60	2.33	0.14	10.87	0.62
OSC-1 80-85 cm.	2.27	1.90	7.49	3.18	0.27	0.36	61.06	2.32	1.14	10.88	0.65
OSC-1 110-115 cm.	4.70	1.03	5.40	2.01	0.29	0.17	63.70	1.88	0.70	7.95	0.52
OSC-2 0-5 cm.	4.69	1.13	5.45	2.08	0.29	0.18	63.93	1.92	0.71	7.90	0.52
OSC-2 25-30 cm.	2.71	1.36	6.39	2.37	0.24	0.17	61.93	2.26	0.49	10.10	0.56
OSC-2 45-50 cm.	3.02	1.30	6.51	2.40	0.21	0.17	62.61	2.06	0.59	9.38	0.56
OSC-2 70-75 cm.	2.28	1.18	7.29	2.40	0.38	0.17	62.56	1.94	0.62	8.93	0.55
OSC-2 90-95 cm.	1.99	1.21	6.45	2.31	0.18	0.13	64.76	2.08	0.76	9.64	0.53
OSC-3 0-5 cm.	2.94	1.39	5.33	2.32	0.24	0.18	63.98	2.35	0.41	9.84	0.56
OSC-3 30-35 cm.	2.02	1.28	5.99	2.46	0.17	0.12	64.24	2.40	0.42	10.34	0.60
OSC-3 55-60 cm.	2.00	1.40	5.77	2.34	0.17	0.11	65.00	2.41	0.28	10.72	0.59
OSC-3 70-75 cm.	1.99	2.23	3.69	1.37	——	0.08	68.32	2.21	0.09	11.29	0.37
OSC-3 90-95 cm.	2.08	1.68	5.18	2.67	0.19	0.13	62.89	2.67	0.17	11.76	0.62

APPENDIX 3

ACID - EXTRACTABLE

MAJOR ELEMENTS

AND TOTAL MERCURY

CONTENT OF SAMPLES

FROM OKANAGAN MAINSTEM LAKES

(BY ATOMIC ABSORPTION SPECTROPHOTOMETRY)

MERCURY VALUES AS PARTS-PER-BILLION

ALL OTHER VALUES AS PARTS-PER-MILLION

WOOD LAKE

	Hg	Mn	Fe	K	Mg	Ca
W-1	222	400	5600	550	1900	16500
W-1a	997	520	6200	710	3900	100000
W-2	861	1330	40700	2850	9700	54000
W-3	639	1860	36900	2780	3700	32000
W-4	2139	1600	27400	2160	7500	75000
W-5	162	600	25000	1370	5500	5000

KALAMALKA LAKE

	Hg	Fe	Mn	K	Mg
K-1	436	22700	694	4000	8800
K-2	863	2840	113	540	5700
K-2a	188	INSUFFICIENT SAMPLES			
K-3	102	8700	301	450	4000
K-4	350	24900	773	3150	9700
K-5	286	19100	1480	1650	8000
K-5a	290	26950	1620	3240	9500
K-6	1619	24600	3210	3150	5500
K-7	187	18400	605	1360	5100
K-7a	77	45400	1210	6050	16500
K-8	315	2885	171	670	5200
K-8a	230	870	60	400	5300
K-9	579	2885	121	540	5000
K-10	1874	5680	174	840	3100

OKANAGAN LAKE

	Hg	Fe	Mn	K	Mg	Ca
OK-1	202	25000	1200	2250	6700	1000
OK-2	112	29500	1000	2500	5100	1200
OK-3	244	33500	2500	2950	9000	950
OK-4	552	15500	250	2500	6900	25000
OK-5	86	16000	200	1500	5400	1660
OK-6	70	12500	140	1100	4000	1000
OK-7	53	29500	660	2000	6700	1200
OK-8	132	32000	1900	2600	8500	1500
OK-9	75	27000	370	2700	8500	1000
OK-9a	112	7500	113	700	2400	15000
OK-10	150	20500	365	2000	6700	1500
OK-11	231	36000	4900	3000	9100	1400
OK-11a	112	48000	222	2600	5800	1500
OK-12	290	33000	2700	2900	8500	1000
OK-13	332	35800	700	2950	9500	1200
OK-14	191	41100	1000	2750	9500	1200
OK-15	409	32300	600	2550	11500	55000
OK-16	777	42500	1000	3900	14000	25000
OK-17	279	36500	600	3000	13500	24000
OK-18	240	32000	300	1400	10800	6400
OK-19	594	36699	1100	2500	11000	1400
OK-20	589	28500	300	3250	10550	1900
OK-21	555	27600	300	3900	10500	1500
OK-22	442	10600	100	1150	4500	11400

OKANAGAN LAKE

	Hg	Fe	Mn	K	Mg	Ca
OK-22a	528	9400	100	1400	5400	17000
OK-23	160	25000	400	2850	10400	4000
OK-24	658	29200	400	2750	10400	1700
OK-25	478	28200	400	2500	10400	1600
OK-26	222	42100	400	11420	6300	5700
OK-27	INSUFFICIENT SAMPLES					
OK-28	256	42100	1900	3750	11500	1500
OK-29	252	34500	700	3500	13000	2400
OK-30	119	39100	650	1900	15510	3000
OK-31	196	39100	3000	3000	12100	1500
OK-32	111	41300	1250	7500	24600	5200
OK-33	256	45700	2750	3500	14100	2000
OK-34	256	42000	3500	3250	11600	1500
OK-35	265	41500	3500	3000	11200	1500
OK-36	231	41000	1400	3000	10800	1500
OK-37	222	40000	1000	3000	10300	1500
OK-38	188	22600	400	1500	6200	1800
OK-38a	34	26500	400	2000	6500	1700
OK-39	128	17600	300	1150	4000	1200
OK-40	65	19000	350	1500	4700	1700
OK-41	120	36000	950	2400	7500	1600
OK-42	120	36000	840	2700	9800	1600
OK-43	INSUFFICIENT SAMPLES					
OK-44	102	29000	570	2400	7800	1500

SKAHA LAKE

	Hg	Fe	Mn	K	Mg	Ca
S-1	1355	11700	60	1400	3300	14000
S-2	64	13800	300	640	2700	———
S-3	2181	29000	900	3300	8100	———
S-4	187	28000	650	3100	7300	———
S-5	60	16000	260	890	3300	———
S-6	43	13200	220	1000	2600	720
S-7	119	21000	380	1300	5100	———
S-8	94	20000	390	1700	5500	———
S-9	247	29000	1500	2800	7500	———
S-10	94	29700	1500	2000	4900	1080
S-11	247	9100	140	870	2300	———
S-12	60	15000	350	980	3700	———
S-13	230	30300	1390	3400	6600	760
S-14	1917	31000	1750	3100	7900	———
S-15	128	28200	1300	3000	5800	1040
S-16	68	24000	450	1400	6100	———
S-17	265	29000	1150	2800	7900	———
S-18	213	28000	1170	2900	5800	720
S-19	256	32000	1850	3500	8200	———
S-20	77	14000	250	1100	4000	———
S-21	196	27000	450	2800	7400	———
S-22	136	28000	820	3000	5700	720
S-23	196	31000	1550	3200	8000	———
S-24	1389	28000	1000	2900	7800	1300

SKAHA LAKE

	Hg	Fe	Mn	K	Mg	Ca
S-25	119	31000	216	980	2900	700
S-26	170	10200	177	950	2000	560
S-27	247	26000	702	2500	6500	1500
S-28	1832	27400	950	2700	6500	1000
S-29	332	28000	1500	2800	7200	1700
S-30	302	28500	950	1600	4900	1400
S-31	196	20400	350	1500	4000	1300
S-32	307	19000	205	1600	4300	5400
S-33	332	19000	300	1700	4400	7900
S-34	187	19000	300	1700	4400	1500
S-35	111	19000	300	1800	4300	1200
S-36	111	27000	510	2400	7000	1800

OSOYOOS LAKE

	Hg	Fe	Mn	K	Mg	Ca
OS-1	162	22000	820	2100	6650	4600
OS-2	252	15000	400	1360	4650	700
OS-3	111	27300	960	3130	8700	1810
OS-4	128	30600	1120	3140	9000	1690
OS-5	316	31200	920	3030	9100	1730
OS-6	333	38500	1400	3930	11500	2380
OS-7	282	36400	1500	3500	10000	1730
OS-8	273	38500	6440	3940	11250	3450
OS-8a	INSUFFICIENT SAMPLE					
OS-9	325	28000	840	2700	8600	1250
OS-10	303	34400	1060	3400	10000	1730
OS-11	239	35000	1000	3300	10600	2200
OS-12	111	7500	200	500	2400	3300
OS-13	529	27500	600	3100	9100	7000
OS-14	769	27000	980	2900	8400	12500
OS-15	436	31000	600	3200	10400	4200
OS-16	179	60000	200	550	2600	52000
OS-16a	——	3500	600	600	6900	33000
OS-17	111	10500	250	600	2000	6200
OS-18	162	15000	400	1550	5100	9700
OS-19	INSUFFICIENT SAMPLE					
OS-20	111	10000	400	500	3200	21500
OS-21	436	30000	720	3000	9800	2100
OS-22	444	31000	1100	2900	9200	2000
OS-23	436	25000	800	3000	8100	5000

APPENDIX 4

ORGANIC CARBON AND INORGANIC

CARBON CONTENT OF

SAMPLES FROM OKANAGAN

MAINSTEM LAKES

(BY COMBUSTION)

ALL VALUES AS PERCENT

WOOD LAKE

	ORGANIC CARBON	INORGANIC CARBON
W-1	1.30	0.56
W-1a	1.48	3.48
W-2	5.54	2.32
W-3	5.06	2.38
W-4	5.06	2.92
W-5	2.69	0.36
WC-1		
0-5 cm.	6.09	2.54
20-25 cm.	4.71	0.45
45-50 cm.	4.14	——
70-75 cm.	2.46	0.16
85-90 cm.	5.58	0.88

KALAMALKA LAKE

	ORGANIC CARBON	INORGANIC CARBON
K-1	3.26	4.02
K-2	1.89	10.02
K-2a	1.89	10.17
K-3	2.59	3.26
K-4	3.54	4.42
K-5	2.90	5.35
K-5a	3.46	3.18
K-6	3.59	3.02
K-7	0.84	0.60
K-7a	0.29	0.67
K-8	2.08	10.32
K-8a	1.73	10.22
K-9	2.33	10.34
K-10	4.54	1.74
KC-1		
0-5 cm.	3.14	4.88
20-25 cm.	3.29	4.39
40-45 cm.	3.64	3.71
60-65 cm.	2.79	5.61
85-90 cm.	4.84	0.93
KC-2		
0-5 cm.	2.83	10.06
20-25 cm.	1.93	0.55
40-45 cm.	2.08	10.36
70-75 cm.	1.98	10.69
95-100 cm.	1.59	10.36
120-125 cm.	2.23	9.96

OKANAGAN LAKE

	ORGANIC CARBON	INORGANIC CARBON
OK-1	1.06	0.35
OK-2	1.50	0.26
OK-3	1.70	0.35
OK-4	2.52	0.02
OK-5	1.11	0.11
OK-6	0.37	0.15
OK-7	1.02	0.15
OK-8	1.79	0.06
OK-9	1.17	———
OK-9a	0.34	0.49
OK-10	0.92	0.69
OK-11	1.95	0.44
OK-11a	1.85	0.15
OK-12	2.19	0.05
OK-13	2.52	0.12
OK-14	1.99	0.01
OK-15	3.16	1.50
OK-16	2.67	0.80
OK-17	2.04	1.13
OK-18	3.55	0.26
OK-19	3.45	0.21
OK-20	5.01	0.09
OK-21	4.32	0.65
OK-22	2.99	3.38
OK-22a	2.76	4.63
OK-23	4.74	0.22
OK-24	3.53	0.07
OK-25	3.67	0.27
OK-26	2.51	0.06
OK-27	3.53	0.03
OK-28	3.09	0.36
OK-29	2.56	0.65
OK-30	1.69	0.01
OK-31	2.70	0.60

OKANAGAN LAKE

	ORGANIC CARBON	INORGANIC CARBON
OK-32	0.53	0.14
OK-33	2.80	0.24
OK-34	2.90	——
OK-35	2.81	0.34
OK-36	3.58	0.16
OK-37	2.78	0.36
OK-38	2.64	0.23
OK-38a	0.87	0.05
OK-39	1.05	0.07
OK-40	1.77	0.08
OK-41	1.39	0.60
OK-42	2.17	——
OK-43	1.32	——

OKANAGAN LAKE

	ORGANIC CARBON	INORGANIC CARBON
OKC-1		
0-5 cm	2.08	0.15
20-25 cm.	1.84	0.14
45-50 cm.	2.43	0.05
60-63 cm.	.58	0.14
97-100 cm.	2.47	——
OKC-2		
20-25 cm.	2.55	0.35
45-50 cm.	2.26	0.01
70-75 cm.	2.55	0.21
90-95 cm.	2.38	0.17
OKC-3		
0-5 cm.	3.14	1.07
20-25 cm.	2.73	0.37
45-50 cm.	2.59	0.02
70-75 cm.	2.25	0.32
95-100 cm.	2.20	0.21
105-110 cm.	2.19	0.22

SKAHA LAKE

	ORGANIC CARBON	INORGANIC CARBON
S-1	3.84	0.31
S-2	0.71	———
S-3	3.39	0.14
S-4	3.16	0.13
S-4a	1.68	0.23
S-5	1.05	———
S-6	0.67	0.04
S-7	1.38	0.19
S-8	0.95	0.05
S-9	2.87	0.09
S-10	0.71	———
S-11	1.05	———
S-12	0.57	0.14
S-13	1.81	0.29
S-14	2.25	0.13
S-15	0.48	0.09
S-16	0.54	0.12
S-17	2.05	0.38
S-18	1.94	0.53
S-18a	———	0.66
S-19	2.46	0.13
S-20	0.71	———
S-21	1.90	0.23
S-22	1.86	0.05
S-23	2.00	0.29
S-24	2.20	0.13
S-25	0.38	0.09
S-26	0.81	0.61
S-27	1.96	———
S-28	1.96	0.23
S-29	2.54	0.37

SKAHA LAKE

	ORGANIC CARBON	INORGANIC CARBON
S-30	2.16	0.32
S-31	1.43	——
S-32	1.67	0.42
S-33	1.48	0.46
S-34	1.62	0.13
S-35	1.09	0.14
S-36	1.05	0.09
SC-1		
0-5 cm.	2.10	1.03
35-40 cm.	3.07	0.17
72-75 cm.	3.45	0.06
81-86 cm.	3.12	0.06
SC-2		
6-8 cm.	2.59	0.05
32-34 cm.	2.49	0.12
50-52 cm.	2.60	0.08
72-75 cm.	2.88	0.17
96-100 cm.	2.53	0.08

OSOYOOS LAKE

	ORGANIC CARBON	INORGANIC CARBON
OS-1	1.84	0.80
OS-2	1.06	0.33
OS-3	2.61	0.11
OS-4	2.40	0.49
OS-5	2.40	0.46
OS-6	2.59	0.41
OS-7	2.69	0.41
OS-8	2.78	0.46
OS-8a	2.69	0.22
OS-9	2.30	0.06
OS-10	2.40	0.41
OS-11	2.78	0.13
OS-12	0.91	0.05
OS-13	4.47	0.21
OS-14	4.76	0.63
OS-15	4.73	0.47
OS-16	1.64	0.69
OS-16a	1.77	8.67
OS-17	0.77	0.46
OS-18	1.20	0.49
OS-19	3.77	0.36
OS-20	0.88	0.56
OS-21	3.17	0.33
OS-22	2.78	0.29
OS 23	3.27	0.28

OSOYOOS LAKE

	ORGANIC CARBON	INORGANIC CARBON
OSC-1		
25-30 cm.	2.71	0.47
55-60 cm.	2.32	0.01
80-95 cm.	2.12	0.19
110-115 cm.	1.76	0.07
OSC-2		
0-5 cm.	5.18	0.41
25-30 cm.	3.58	0.76
45-50 cm.	4.29	0.61
70-75 cm.	4.86	0.35
90-95 cm.	4.22	0.12
OSC-3		
0-5 cm.	3.53	0.26
30-35 cm.	3.58	0.02
55-60 cm.	2.60	0.23
70-75 cm.	1.13	0.07
90-95 cm.	2.21	0.19

CARBON CONTENT OF

SUBSAMPLES FROM CORES

FROM DEEPEST POINTS

OF EACH OF

OKANAGAN MAINSTEM LAKES

(DATA PROVIDED BY DR. A.L.W. KEMP)

WOOD LAKE

	ORGANIC CARBON	INORGANIC CARBON
0-1 cm.	7.92	4.68
1-2 cm.	4.75	5.27
2-3 cm.	2.16	7.76
4-6 cm.	6.02	3.24
9-11 cm.	3.03	5.23
19-21 cm.	2.49	4.35
39-41 cm.	2.78	2.49
73-75 cm.	0.87	0.50
75-77 cm.	1.47	1.17

KALAMALKA LAKE

	ORGANIC CARBON	INORGANIC CARBON
0-1 cm.	3.36	6.30
1-2 cm.	3.41	5.47
2-3 cm.	2.91	6.07
4-6 cm.	2.77	4.91
9-11 cm.	4.14	1.52
19-21 cm.	2.93	4.47
39-41 cm.	3.85	3.17
73-75 cm.	2.34	5.74
96-98 cm.	3.83	2.79

OKANAGAN LAKE

	ORGANIC CARBON	INORGANIC CARBON
0-1 cm.	3.18	1.04
1-2 cm.	2.84	0.58
2-3 cm.	2.46	0.96
4-6 cm.	2.51	0.54
9-11 cm.	1.60	0.64
19-21 cm.	1.89	0.68
32-35 cm.	1.17	0.44
39-41 cm.	1.27	0.53
90-92 cm.	1.10	0.61

SKAHA LAKE

	ORGANIC CARBON	INORGANIC CARBON
0-1 cm.	4.09	1.13
1-2 cm.	3.40	0.63
2-3 cm.	2.29	0.89
4-6 cm.	1.63	0.16
9-11 cm.	2.27	0.28
19-21 cm.	1.96	0.21
39-41 cm.	2.48	0.21
81-83 cm.	2.25	0.39

OSOYOOS LAKE

	ORGANIC CARBON	INORGANIC CARBON
0-1 cm.	3.17	0.77
1-2 cm.	3.13	0.48
2-3 cm.	3.03	0.66
4-6 cm.	3.27	0.61
9-11 cm.	2.62	0.37
19-21 cm.	1.96	0.22
36-37 cm.	1.12	0.23
39-40 cm.	1.88	0.23
101-103 cm.	1.33	0.11

APPENDIX 5

ACID-EXTRACTABLE PHOSPHORUS

IN SAMPLES

FROM OKANAGAN MAINSTEM LAKES

ALL VALUES IN PARTS-PER-MILLION

WOOD LAKE

	W-1	W-1a	W-2	W-3	W-4	W-5
Acid extractable P(1N HCl)	787	609	753	753	698	1085

KALAMALKA LAKE

Acid extractable P(1N HCl)

K-1	K-2	K-2a	K-3	K-4	K-5	K-5a	K-6	K-7	K-8	K-9	K-10
647	58	44	416	672	601	788	625	515	41	51	471

OKANAGAN LAKE

Acid extractable P(1N HCl)

OK-1	OK-2	OK-3	OK-4	OK-5	OK-6	OK-7	OK-8	OK-9	OK-9a
986	884	1068	706	761	870	911	1082	819	379

OK-10	OK-11	OK-11a	OK-12	OK-13	OK-14	OK-15	OK-16	OK-17
911	1485	3130	1181	1171	1675	931	955	1027

OK-18	OK-19	OK-20	OK-21	OK-22	OK-22a	OK-23	OK-24	OK-25
1055	1123	678	705	538	387	744	839	911

OK-26	OK-27	OK-28	OK-29	OK-30	OK-31	OK-32	OK-33	OK-34
890	846	1404	1007	1086	1103	675	1394	1575

OKANAGAN LAKE

Acid extractable
P(1N HCl)

OK-35	OK-36	OK-37	OK-38	OK-38a	OK-39	OK-40	OK-41	OK-42
1473	1425	1339	1188	990	1271	935	1294	1298

OK-43	OK-44
——	1127

SKAHA LAKE

Acid extractable
P(1N HCl)

S-1	S-2	S-3	S-4	S-4a	S-5	S-6	S-7	S-8	S-9	S-10	S-11
967	366	974	898	1130	560	756	801	701	1164	1009	273

S-12	S-13	S-14	S-15	S-16	S-17	S-18	S-18a	S-19	S-20	S-21
522	1033	1078	411	770	1123	991	577	1043	553	1026

S-22	S-23	S-24	S-25	S-26	S-27	S-28	S-29	S-30	S-31	S-32
972	1010	941	568	554	965	1078	1212	1006	928	1013

S-33	S-34	S-35	S-36
876	969	969	989

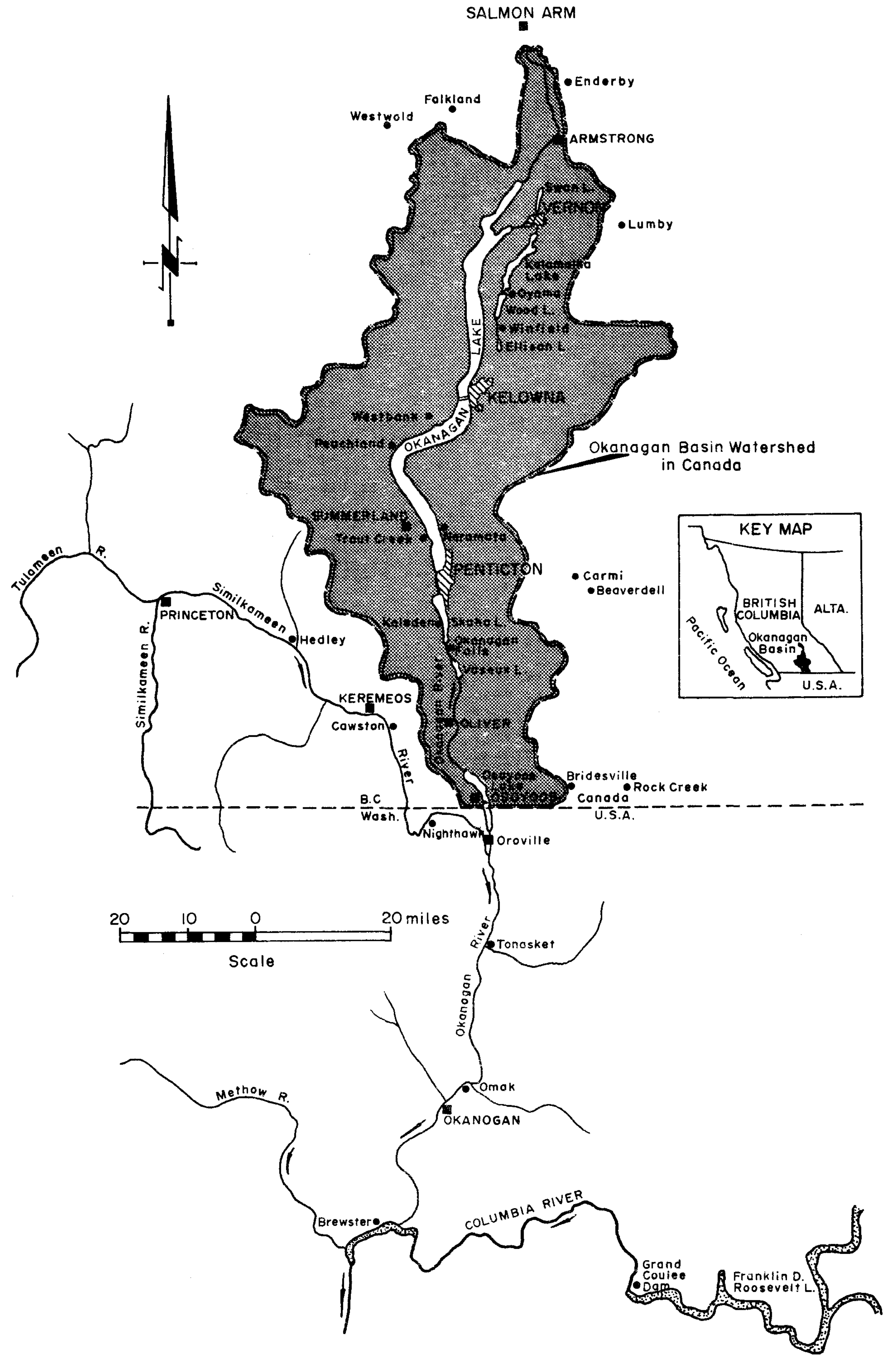
OSOYOOS LAKE

Acid extractable
P(1N HCl)

OS-1	OS-2	OS-3	OS-4	OS-5	OS-6	OS-7	OS-8	OS-8a	OS-9
1086	1086	1121	1141	931	1086	1048	1083	986	1014

OS-10	OS-11	OS-12	OS-13	OS-14	OS-15	OS-16	OS-16a	OS-17
1062	952	351	826	1031	771	308	232	490

OS-18	OS-19	OS-20	OS-21	OS-22	OS-23
715	823	862	862	848	870



OKANAGAN DRAINAGE BASIN IN CANADA