U.S. Department of the Interior
U.S. Geological Survey

Cruise Report: *R/V ALPHA HELIX* CRUISE-173 to western Prince William Sound, Yakutat Bay, and Glacier Bay National Park, northeastern Gulf of Alaska, August 17 - September 3, 1993

by ELLEN A. COWAN[2], ROSS D. POWELL[3], PAUL R. CARLSON[1],
ROBERT E. KAYEN[1], JINKUI CAI[3], KEITH C. SERAMUR[2],
and SARAH D. ZELLERS[4]

OPEN-FILE REPORT OF-94-258

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1 U.S. GEOLOGICAL SURVEY, MENLO PARK, CA
2 APPALACHIAN STATE UNIVERSITY, BOONE, NC
3 NORTHERN ILLINIOS UNIVERSITY, DE KALB, IL
4 UNIVERSITY OF TEXAS AT AUSTIN, AUSTIN, TX

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Introduction

Cruise 173 of the *R/V Alpha Helix* from August 17 until September 3, 1993 was conducted in the fjords of Prince William Sound, Yakutat Bay and Glacier Bay, in southern and southeastern Alaska. This cruise was directed by Ellen A. Cowan of Appalachian State University and Ross D. Powell of Northern Illinois University and funded by the National Science Foundation (OPP-9223990 and OPP-9223992) under the NSF project "Collaborative Research: Definition of High Resolution Seismic Facies for Interpreting Glacial Fluctuations". Cowan's portion of the project is funded through Research in Undergraduate Institutions (RUI) and active participation by three undergraduate students in the cruise and post-cruise research reflects this aspect of NSF funding. USGS participants were funded under a cooperative study agreement with the co-PI's as part of their NSF proposal. This cruise report includes a listing of data and samples collected, maps showing track lines and station locations as well as a summary of significant initial observations.

Scientific Objectives

The overall purpose of this study is to characterize seismic facies for interpreting past glacier behavior, especially during the Last Glacial Maximum (LGM). Glacier Bay is the site of the worlds best documented major marine deglaciation and allows comparisons between glacier terminus stability with changing climate and marine conditions. Upper Yakutat Bay contains deposits produced by the surge of the Hubbard Glacier in 1986 and the subsequent outburst flood from Russell fjord. Historical records of glacier terminus positions provide a datum with which the history of this marine glacial system can be determined from seismic and sedimentary facies.

We are using two techniques to characterize sedimentary assemblages: high-resolution-seismic reflection surveys and coring/grab sampling of sediment. The seismic facies are interpreted from acoustic impedance contrasts imaged within the sediment column portion of high-resolution-seismic reflection profiles. Sedimentary facies, on the otherhand, are determined from physical obervation and analysis of bottom samples. The sediment cores and grab samples are used to interprete sedimentary facies from the seismic facies. We will construct 3-D seismic facies to establish the spatial and temporal distribution of sedimentary facies in the glacimarine environment. This facies distribution will allow us to reconstruct the behavior of the glacial systems during climatic changes within different marine environments. Collection of sediment cores and grab samples will allow us to determine the following additional information:

a) Measurements of physical properties of glacimarine sediment using GRAPE (Gamma Ray Attenuation Porosity Evaluator) including P-wave velocity, wet bulk density and magnetic susceptibility.

b) Determination of lithofacies characteristics including the nature of contacts, color, particle size variations, and lithology. X-radiographs will help to define sedimentary structures that are not easily observed on split core surfaces.

c) Dating of sediments using Pb-210.

d) Fourier shape analysis of silt grains to interpret glacial regime and glacial conditions from glacimarine lithofacies.

e) Identify living foraminifera in glacimarine sediments and document the downcore distribution of foraminifera and associated microfossils.

We also wish to continue to improve our understanding of sedimentary processes in modern temperate glacimarine environments. CTD profiles and water sampling provide a means of accessing the influx of meltwater to the fjords and sediment dispersal processes. These measurements will also allow us to compare glacial fjord systems under different climatic regimes in coastal Alaska.

Personnel and Support

The Chief Scientist was Ellen A. Cowan from Appalachian State University and Co-Chief Scientist was Ross D. Powell from Northern Illinois University. Other scientists included Paul R. Carlson and Robert E. Kayen from the Marine Geology Office of the U.S. Geological Survey in Menlo Park, CA; Jinkui Cai, postdoctoral fellow at Northern Illinois University; Keith C. Seramur, Adjunct research associate at Appalachian State University, and Sarah D. Zellers, Ph.D. student at University of Texas at Austin. Three undergraduate students from Appalachian State University, Jenifer D. Clark, Rafael A. Gutierrez, and Christen A. Nall assisted the Scientific party. Operator of the Huntec Deep towed system was Graham B. Standen from Geoforce Consultants, Nova Scotia. David

Hogg from the U.S.G.S., Menlo Park provided technical assistance. Paul A. Jones, of the Environmental Protection Agency (EPA) joined the cruise in Glacier Bay National Park as a Marine Mammal Observer. Detailed contact information for the scientific staff is presented in Table 1.

We wish to acknowledge the Captain and crew of the *R/V Alpha Helix* who were an important part of the success of this cruise. Despite rough seas in the Gulf of Alaska, rainy weather, icebergs and currents we accomplished our scientific goals because of their hard work and dedication to the job. We especially appreciate the efforts of Captain Tom Callahan and Chief Mate Bill Rook who kept us on track and on station, no matter where it was located. We would also like to thank Tom Smith, Marine Superintendent and his staff, Institute Marine Sciences, Seward, AK for help with pre- and post-cruise logistics. We thank Carolyn Degnan of the USGS for assistance with the navigational corrections and computer plots, and the staff of the USGS Marine Facility in Redwood City, CA, for their logistical support. Monty A. Hampton is thanked for his review of this report.

Cruise Summary

Concern by the National Park Service at Glacier Bay about the affect of sound emitted by the Huntec seismic system on marine mammals caused us to alter our cruise plan from the planned 8 days work in Glacier Bay to 4 days. We were allowed to collect Huntec profiles within a portion of the Bay, but only during daylight hours and periods with visibility of at least 4 km. We were not permitted to run seismic lines in Johns Hopkins Inlet or at the mouth of Glacier Bay. To comply with NPS requirements we added Paul A. Jones, biologist with the U.S. EPA, to our scientific party as a marine mammal observer. While in the Bay, he looked for humpback whales and Stellar sea lions (both endangered species) and monitored behavior of other marine mammals during operation of the seismic system. His observations indicated that we encountered no humpback whales and only three Steller sea lions in the water. The ship passed one sea lion while steaming to the start of a seismic line, therefore no evasive action was necessary. The other siting of Stellar sea lions resulted in interruption of seismic operations immediately. These two animals were not seen again after searching from the ship's crow's nest for 35 min. A total of about 60 harbor seals were encountered, 11 of which were observed with no seismic gear operating at the time. The observer reported that the marine mammals did not appear to be disrupted or harassed by the Huntec system and reacted to our presence as they did to other ships (such as cruise ships) at close range.

We modified our cruise plan to spend less time in Glacier Bay and to include 2.5 days of reconnaissance level seismic surveying and sampling in College fjord and Harriman fjord in upper Prince William Sound. A summary table of of scientific activities is presented in Table 2.

The *R/V Alpha Helix* departed from its home port, Seward Alaska on Tuesday, August 17 at 2100 Alaska Daylight Time (ADT). CTD station 1 was occupied at the mouth of Resurrection Bay at 2248 ADT for the University of Alaska.

For the duration of the cruise, the scientific party operated on two 12-hour watches from 0600 to 1800h and from 1800 to 0600h. Seismic track lines were run from approximately 0800 until 2100h during daylight and sampling stations were occupied at night.

We arrived in Port Wells at 1015 ADT, August 18 and began running seismic lines (Figure 1). At 1655 we deployed a party in an inflatable boat near Harvard Glacier terminus (College Fjord) to collect echosounder profiles. No data were collected because the transducer broke off the transom of the boat while motoring to the terminus. We occupied 6 sampling stations in College and Harriman Fjords (Figure 2) and collected approximately 140 km of seismic lines (Figure 1).

At 0335 ADT, on August 20 we departed for Cordova via Wells and Percy Passages. At 1240 ADT Paul Carlson and Dave Hogg disembarked to fly to Yakutat to prepare gear for loading. After a rough transit through the Gulf of Alaska, we arrived at the Sitka Sound Seafood Dock in Yakutat at 2035 ADT, August 21 to load gear and pick up Paul and Dave. We then steamed to the head of the fjord near the Hubbard Glacier to run seismic lines (Figure 3) . Over the next 5 days we collected 391 km of seismic profiles and occupied 25 sampling stations (Figure 4). We departed for Glacier Bay at 1239 on August 26. We arrived at Bartlett Cove, Park Headquarters at 0620 ADT on August 27. The Scientific party disembarked for meetings with Mary Beth Moss, Resource Management Specialist and Jim Taggert, Marine Biologist at Park Headquarters. Paul Jones, marine mammal observer, joined the ship. We were underway for Muir Inlet by 1348 ADT on August 27. Seismic lines (Figure 5) and stations GB-1 to GB-16 (Figure 6) were collected in Muir Inlet between August 27 until August 29 at 0705 ADT when work in the West Arm of Glacier Bay began (Figure 7). Seven stations (GB-17-GB-23) were occupied in upper West Arm (Figure 8). In Tarr Inlet, seismic profiles were collected (Figure 9) and 11 stations (GB-24-GB-34) were occupied (Figure 10). On August 21 at 1206 ADT we transited to lower Muir Inlet to collect additional seismic data and occupy 4 sampling stations (Figures 5 & 6). In total we occupied 38 stations and collected 350 km of seismic lines in Glacier Bay. We returned to Bartlett Cove on September 1 at 0700 ADT to allow 7 members of the Scientific party to disembark for the airport in Gustavus. The ship departed Bartlett Cove at 1245 ADT on September 1 and transited directly to Seward, AK, arriving at 0955 ADT on September 3, 1993.

Bathymetry and Seismic Profiling

Navigation

GPS was the primary method of navigation for track lines and stations. The ship's location, direction and speed were stored at 30 sec intervals on computer disk. GPS was found to be unreliable for short periods around 0200 ADT in Yakutat Bay and Glacier Bay. New stations were not located during these 20-30 min periods.

Bathymetry

The ship's hull-mounted 12 kHz echosounder provided bathymetric data during all seismic surveys and during sampling. These data are especially important in these glacimarine settings because rapid sedimentation can change the water depth by a measurable amount each year.

Seismic Profiling

The Huntec system was used under a subcontract with Geoforce Consultants from Nova Scotia. The system operated with a deep towed sound source and internal and external hydrophones.

Operating Parameters included:

-power output	4Kv
- firing rate	0.750 sec
- sweep rate	0.250 sec

-filter setting for internal hydrophone - 0.500 - 10.0 Khz and for external hydrophone - 0.700 - 5.0 Khz

-the fish was towed beneath the surface at depths ranging from 15 to 60 m

During profiling in College fjord the transformer in the EPC recorder for the external hydrophone overheated and failed. An EPC unit from the USGS was used in its place after being picked up in Yakutat. The quality of the external record was generally good, the internal record was generally of poorer quality. Both records were affected by irregularities in the ship's 110 VAC power supply that caused regular drops to 105 -107 VAC. We anticipate that this problem will be fixed before our next cruise.

Coring and Grab Sampling

Collecting the longest cores possible was considered the primary objective of bottom sampling during this cruise. A Benthos piston corer (model 2175) with a 2.8 in (7.1 cm) diameter core barrel was used. The lengths of sediment cores obtained were shorter than we had planned. The maximum core length collected was 376 cm, but most cores were less than 250 cm. Several modifications were made to the corer including removing the poorly functioning piston. The system was then used as a gravity corer with a 750 lb weight stand. In all, 6 piston cores and 65 gravity cores were collected (Table 3). Two box cores were collected with a 1 m^3 MKIII™ box corer and subsampled with core tubes. A Van Veen sampler was used to collect 22 grab samples in locations where coring was unsuccessful (Table 3).

Physical properties were measured on all cores with the GRAPE. Cores were then split, described, photographed in black and white, and videotaped in color. Core logs are in Appendix 1. The working half of each core was subsampled for the following analyses:

<u>sample type</u>	<u>sampling interval</u>
Grain size and grain shape	5 cm for uniform lithology and variable for laminated sediment
Pb-210	5 cm
Organic carbon	variable
Moisture content	50 cm
Microfossils	variable

Physical Properties Measurements using a Multi-Sensor Whole Core Sediment Logger

Cores were logged for their physical properties on a multi-sensor whole core sediment logging device, built in Great Britain by Schultheiss Geoteck, Ltd. The logger is controlled by a personal-computer driven software system developed at the U.S. Geological Survey, Branch of Pacific Marine Geology for data acquisition and instrument manipulation. The system logs sediment bulk density, compression wave sound speed, and magnetic susceptibility of whole cores. These measurements are used to develop the physical property profiles for cores presented in Appendix 2. Robert Kayen was responsible for the operation of the logging device.

Micropaleontological Sampling

Eighty-eight samples were obtained from grab samples and trigger cores to document the distribution of living infaunal and epifaunal foraminifera. For trigger cores, subsamples were taken at 1 cm intervals down to 16 cm, then every 3-5 cm. Composite samples of approximately 50 cc were taken from grab samples. Each sample was placed into a sealed plastic bag with a solution of 4% formalin, Rose Bengal, and borax to saturation as a buffer. An additional 342 samples were taken from piston and gravity cores for analysis of downcore distribution of foraminifera. These samples of between 10 and 30 cc were taken at various intervals within the cores depending on the lithology. These samples were not stained. Later at the University of Texas at Austin both sample types were soaked overnight in a solution of calgon and water. The samples were then washed over a 63 micron sieve and dried. The identification of microfossils is being carried out by Sarah D. Zellers.

CTD Casts and Water Samples

A Neil Brown Mark III B CTD profiling system with a Turner Model III fluorometer was used to obtain CTD casts at 14 Stations (Table 4). Fluorometer measurements may be used to indicate relative concentrations of particles within the water column. The salinity, temperature and fluorometer counts collected on each downcast is included in Appendix 3. On the upcast, 12 water samples were collected from various depths with a General Oceanics Rosette sampler (Table 4). Each 1.7 L Niskin bottle was subsampled and vacuum filtered on a 0.8 micron Millipore filter. Suspended sediment concentrations were calculated and plotted by depth (Appendix 4).

Preliminary Results

1. Glacial retreat records indicate that the basins in College Fjord have been deglaciated for at least 300 years, much longer than in Glacier Bay. In College Fjord, preliminary review of seismic profiles indicates much lower total sediment accumulation than in Glacier Bay fjords indicating lower sedimentation rates. This conclusion is also supported by the degree of bioturbation and by the presence of worm tubes in cores. This reconnaissance level survey has given us information on the variability within the modern temperate glacimarine environment and raises questions about the relative importance of climatological, glaciological, and bedrock lithology as controls on sedimentation.

2. Huntec profiles from upper Yakutat Bay show a channel buried from 3 to 6 m beneath the flat fjord floor (Figure 11). The channel appears to originate from the inlet to Russell Fjord and meanders downfjord for 9 to 10 km. The channel cross section is filled with a variable amplitude chaotic seismic facies and is cut into and buried by deposits represented on the seismic profiles by medium to high amplitude, fairly continuous, parallel, horizontal reflections. We were unable to collect cores long enough to penetrate the chaotic channel fill deposits but this seismic facies could be produced by sediment gravity flows deposited by the 1986 outburst flood from Russell Fjord. We are working on bathymetric data from this cruise to compare with bathymetry collected by NOAA prior to the outburst flood to check the timing of channel formation and development. It appears that a small channel existed prior to 1986, but during the outburst event it was rapidly deepened by erosion and then completely infilled with sediment. The rapid burial of this channel aided its preservation in the glacimarine record and, therefore, may be used as an indicator of surge/outburst events in Yakutat Bay.

3. Visual descriptions and x-radiographs of cores collected from upper Yakutat Bay show an apparent regular repetition of thick couplets of diamicton and laminated/homogeneous mud. These apparent cycles occur in cores collected as far as 17 km downfjord from the Hubbard Glacier. In ice-proximal cores (such as AH93YB-GC20 in Appendix 1), the diamictons are approximately 10 cm thick and the laminated mud is greater than 30 cm thick. In cores collected from distal locations (such as AH93YB-GC12 in Appendix 1), the diamictons are from 1 to 5 cm thick and the mud is less than 20 cm thick. We are testing the hypothesis that these cycles represent annual layers formed by seasonal controls on the meltwater system. The diamicton is formed by concentration of ice-rafted debris in winter and spring when there is little suspended sediment input because the meltwater system is

shut down. Although ice rafting continues through summer, suspended sediment and gravity flows deposit thick layers of interlaminated sand and mud. If these couplets are annual they will provide an important dating tool and allow us to infer sedimentation rates at all of our coring stations to better understand glacimarine sedimentary processes. We will also be able to add significant new information on the processes of diamicton formation.

4. In Glacier Bay, Huntec profiles were collected in basins proximal to Muir and Riggs Glaciers. Cores collected from these proximal basins were composed of rhythmic sand and mud laminae and massive sand beds (Figure 12). Seismic lines and sediment cores were also collected from a distal fjord basin at the entrance to Wachusett Inlet. Cores collected from distal basins contain homogeneous mud and silt and mud laminae. These two data sets will be used to compare and contrast sedimentation in both proximal and distal glacimarine environments.

5. Seismic profiles were collected in a 1 km grid pattern over the morainal bank complex at the mouth of Muir Inlet. Both the higher resolution of the Huntec system and the close spatial distribution of these profiles will allow 3-D mapping of the several different seismic facies observed within this complex. We attempted to core the grounding-line fan facies, a stratified moraine facies and a push-moraine facies. The morainal bank complex is covered by a drape of approximately 3 to 4 m of suspension deposits. The longest core collected in this area was 270 cm and did not penetrate the sediment below the drape.

6. Approximately 96 km of high resolution seismic reflection profiles were collected in Tarr Inlet. Seismic profiles were collected along the entire length of the Inlet at a spacing of 1.0 to 1.5 km. Within 2 km of the terminus of Grand Pacific and Margerie Glaciers, the fjord floor has an irregular hummocky surface. The deposits in this proximal area are represented on the profiles by a chaotic seismic facies. The sediment fill in areas further downfjord is represented by a seismic facies that is composed of variable amplitude, fairly continuous, horizontal reflectors. A buried ridge with chaotic seismic facies at the entrance to Tarr Inlet was also observed. The longitudinal profile shows a sudden increase in water depth at the fjord mouth, indicating rapid basin filling inside the inlet.

7. Approximately 80 km of seismic reflection profiles were collected in the West Arm of Glacier Bay. Seismic profiles collected at a spacing of 1 km over the entrance to Queen Inlet show a deep fjord (400 m water depth) fan complex. The sediment source for this fan complex appears to be a major turbidity current channel system from Queen Inlet, a

hanging valley. The high resolution profiles contain evidence of small fan channels that cross the fan. Coring on this fan was unsuccessful; however, grab samples indicate that the surficial sediment on the fan consists of fine to very fine sand. Previous sampling efforts have yielded displaced shallow water benthic foraminifers, reinforcing the hypothesis of turbidity current origin for much of the fan sediment. In the area downfjord from the fan, the seismic profiles appear to indicate two different depositional sequences separated by an unconformity. The lower sequence is acoustically stratified and the upper sequence is a interlayered well stratified seismic facies and a reflection-free facies, with a layer of ponded reflection-free facies directly above the unconformity. At least three buried ridges with chaotic seismic facies, probably morainal banks, can be identified in this part of the West Arm.

8. Surface samples contain a variety of microfossils including benthic foraminifera, a few planktonic foraminifera, diatoms, mollusks (clams and gastropods), ostracodes, copepods, worm tubes, and plant material. Preliminary foraminiferal studies indicate rare, living individuals from the genera: *Cassidulina, Elphidium, Haplophragmoides, Nonionella,* and *Reophax.* Some of these stained individuals occur at depths down to 15 cm within certain trigger cores; however, most of the stained material occurs in shallower intervals (<8 cm) or in surface composites from the grab samplers. Stained clams and copepods are present in several samples.

Preliminary results from total assemblages (living & dead) indicate differences between Prince William Sound, Glacier Bay, and Yakutat Bay. Foraminifera and diatoms are rare to few in surface samples in Prince William Sound, but they are more common in Yakutat and Glacier Bays. Diatoms are abundant in some samples, particularly in Glacier Bay. In Yakutat Bay, foraminifera are more common in distal samples and fewer in samples closer to Hubbard and Turner Glaciers, probably due to dilution by terrigenous sediment near the glaciers.

Brief examination of samples from selected cores in Prince William Sound, Yakutat Bay, and Glacier Bay (one core from each area) indicates downcore changes in abundance and characteristics of the foraminiferal assemblages. The abundances of diatoms and other microfossils also appears to be variable. For example, in core AH93GBGC-7 from Glacier Bay, most samples are either barren, or contain very rare foraminifera and diatoms. From 175 to 200 cm, however, there are common to abundant foraminifera with rare diatoms. Below this interval, at 202-209 cm, diatoms are common, but foraminifera are rare.

9. Distinct downcore variations occur in physical properties in cores from all 3 study areas. Variations in P-wave velocity produce the strong contrasts in acoustic impedance suggesting that massive sand beds overlying mud can produce strong reflectors observed in seismic profiles. Magnetic susceptibility shows great variability in cores from Yakutat Bay and Glacier Bay but has lesser variability in Prince William Sound cores. Bulk density logs and visual core descriptions indicate that mud and diamicton layers generally have low magnetic susceptibility and sands have high magnetic susceptibility. This may prove to be another method of detecting depositional cycles in cores.

10. CTD casts from College fjord show a thick, near surface layer with relatively warm water overlying low temperature, high salinity deep water. Suspended sediment concentrations range from 3 mg/L up to nearly 300 mg/L at the most ice proximal station. Four of the five sediment concentration plots have the highest concentration in the middle of the water column between 60 and 80 m. CTD casts from Yakutat Bay show similarities to those from College Fjord although surface temperatures were generally lower and deep water slightly warmer in Yakutat Bay. Stations YB-1 through YB-4 and YB-21 (all located in upper Yakutat Bay) had a lower salinity surface layer that corresponds to the highest suspended sediment concentration in the profile. Salinity is uniform beneath the surface layer in these profiles. Station YB-7, located near the confluence of the upper Bay (Disenchantment Bay) and the more open part of Yakutat Bay has an unstable salinity profile and its highest sediment concentration occurs at 45 m depth. Concentrations at that depth of 30 mg/L indicates that suspended sediment is dispersed over long distances from the head of the fjord. CTD casts from Glacier Bay show a thin low salinity overflow with stable higher salinity water beneath. The surface overflow corresponds with peaks in near surface sediment concentration. At each of the 3 stations in Glacier Bay suspended sediment gradually increases with depth through the water column. These data provide information about suspended sediment transport in each of the 3 study areas. Our previous work in southeastern Alaska has shown that water column properties and sediment concentrations are greatly influenced by the station location with respect to tidewater glaciers and tidal stage. We are presently considering the influences of these variables on the new data.

Distribution of Samples and Data

Cores and sediment samples:

The archive half of each split core is stored in a cold room at the USGS, Marine Geology Branch at Menlo Park, CA. Subsamples from the working half of each split core were shipped to the following institutions:

Appalachian State University -- samples for grain size analysis and grain shape analysis

Northern Illinois University -- samples for Pb-210 analysis, samples for total organic carbon, and slabs collected for thin sections

USGS, Menlo Park -- samples for moisture content and unsplit cores

University of Texas, Austin -- samples for microfossil identification

Cores were x-rayed at the USGS by Jinkui Cai and Paul Carlson. Original x-ray negatives for cores from Prince William Sound, Yakutat Bay, and Muir Inlet are at ASU. X-ray negatives for the West Arm of Glacier Bay and Tarr Inlet are at NIU.

Bulk samples from box cores and Van Veen grabs were shipped to NIU. Samples collected for microfossil identification from grabs are at University of Texas.

Filters from water samples were shipped to ASU where they were weighed and suspended sediment concentrations were calculated.

Bathymetry, Huntec Profiles and Navigation

All echosounder profiles and Huntec profiles were microfilmed at the USGS and copies were sent to NIU and ASU. The original 12 kHz record is stored at the USGS and the Huntec record is at NIU. All ship's navigation data were taken to the USGS where the track lines were computer plotted.

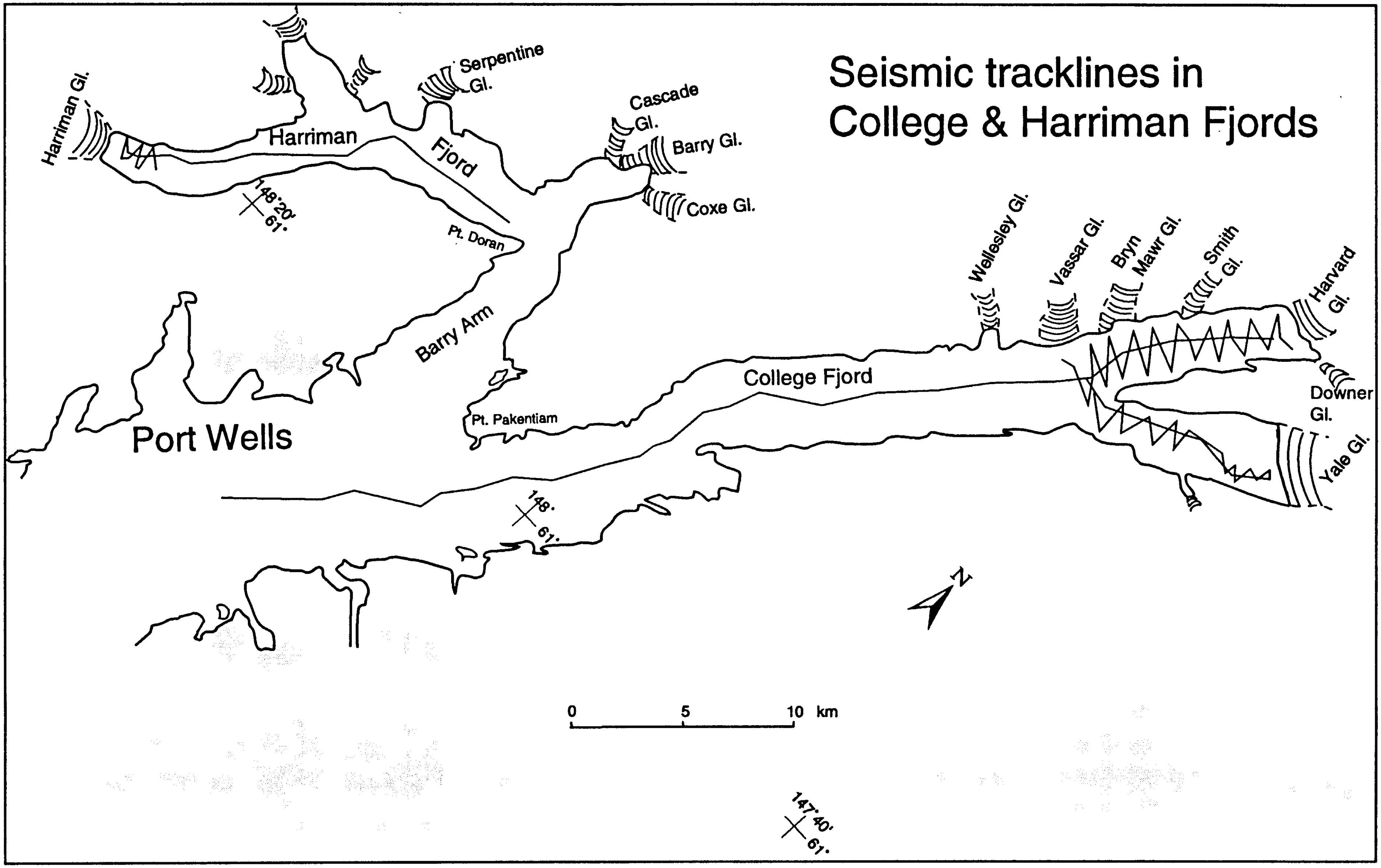


Figure 1. Seismic tracklines in College and Harriman Fjords

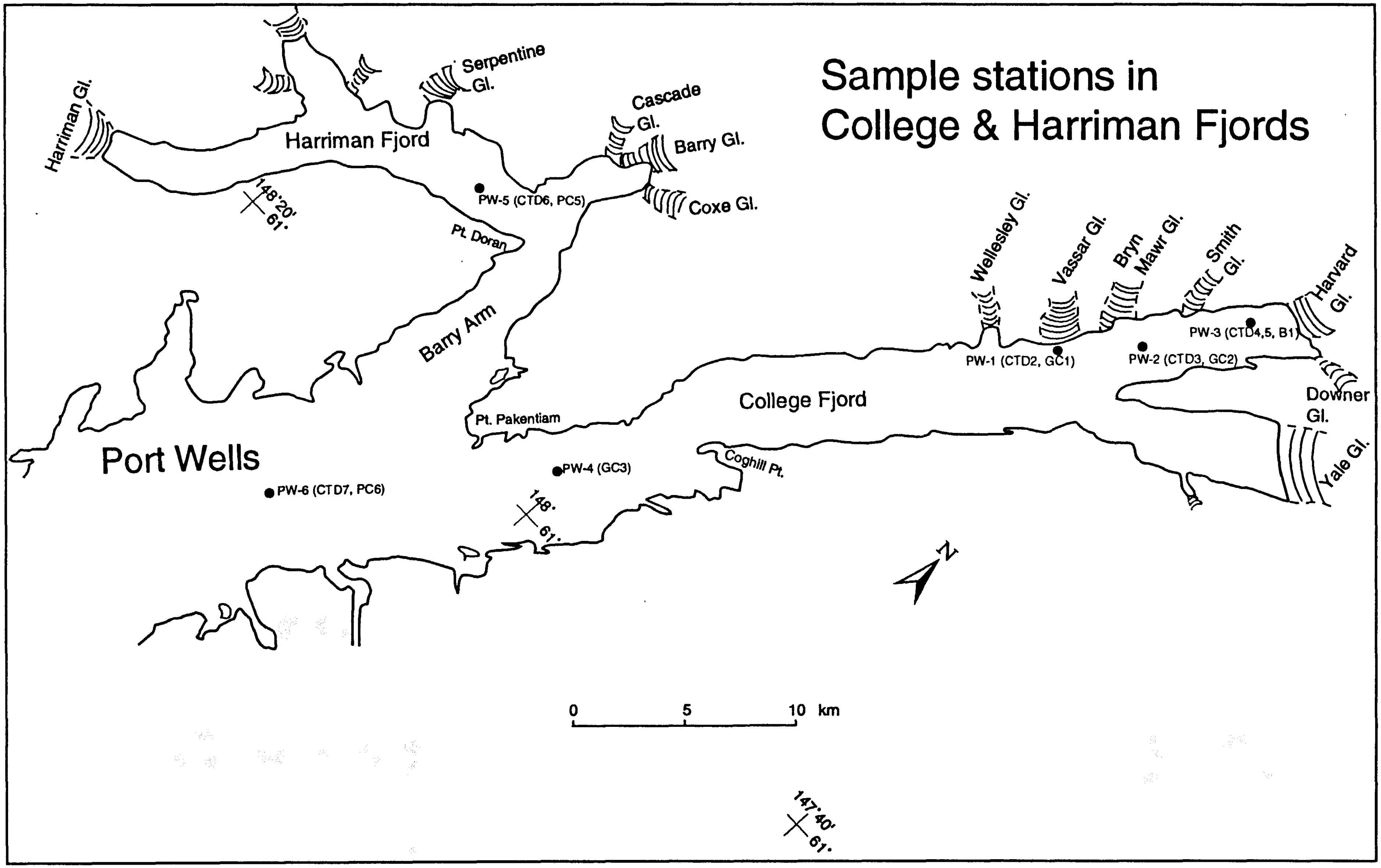


Figure 2. Sample stations in College and Harriman Fjords

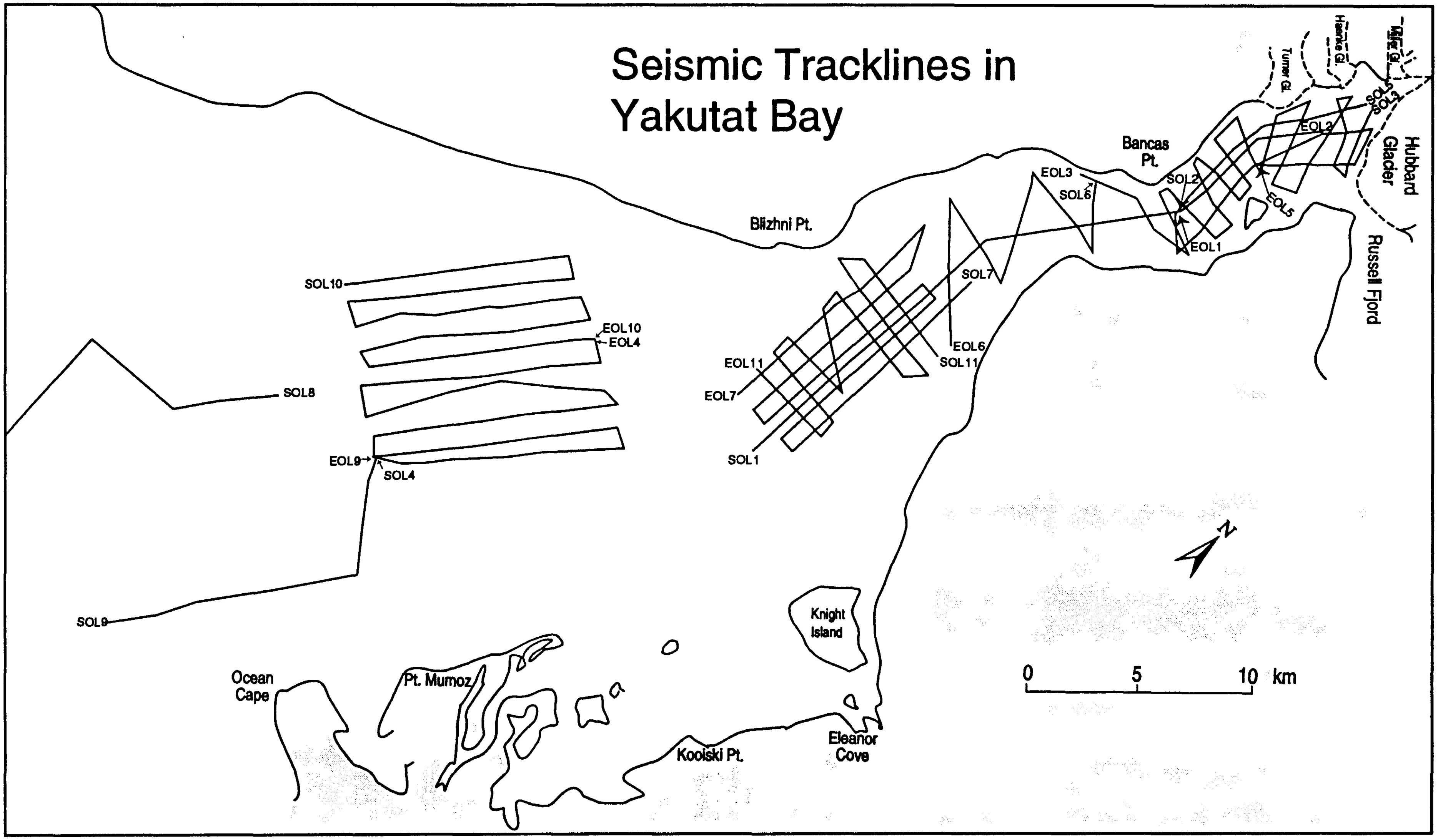


Figure 3. Seismic tracklines in Yakutat Bay

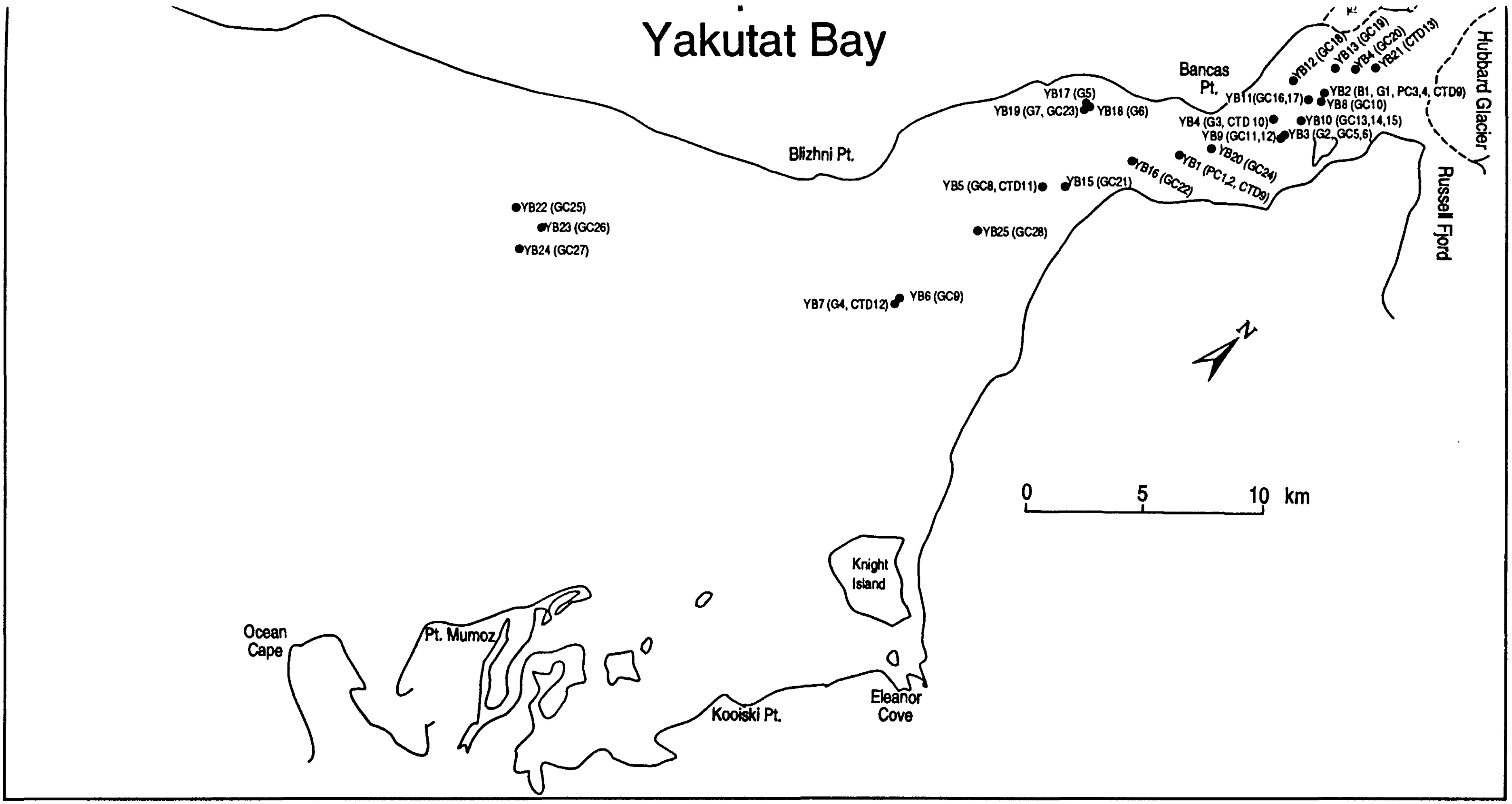


Figure 4. Sample stations in Yakutat Bay

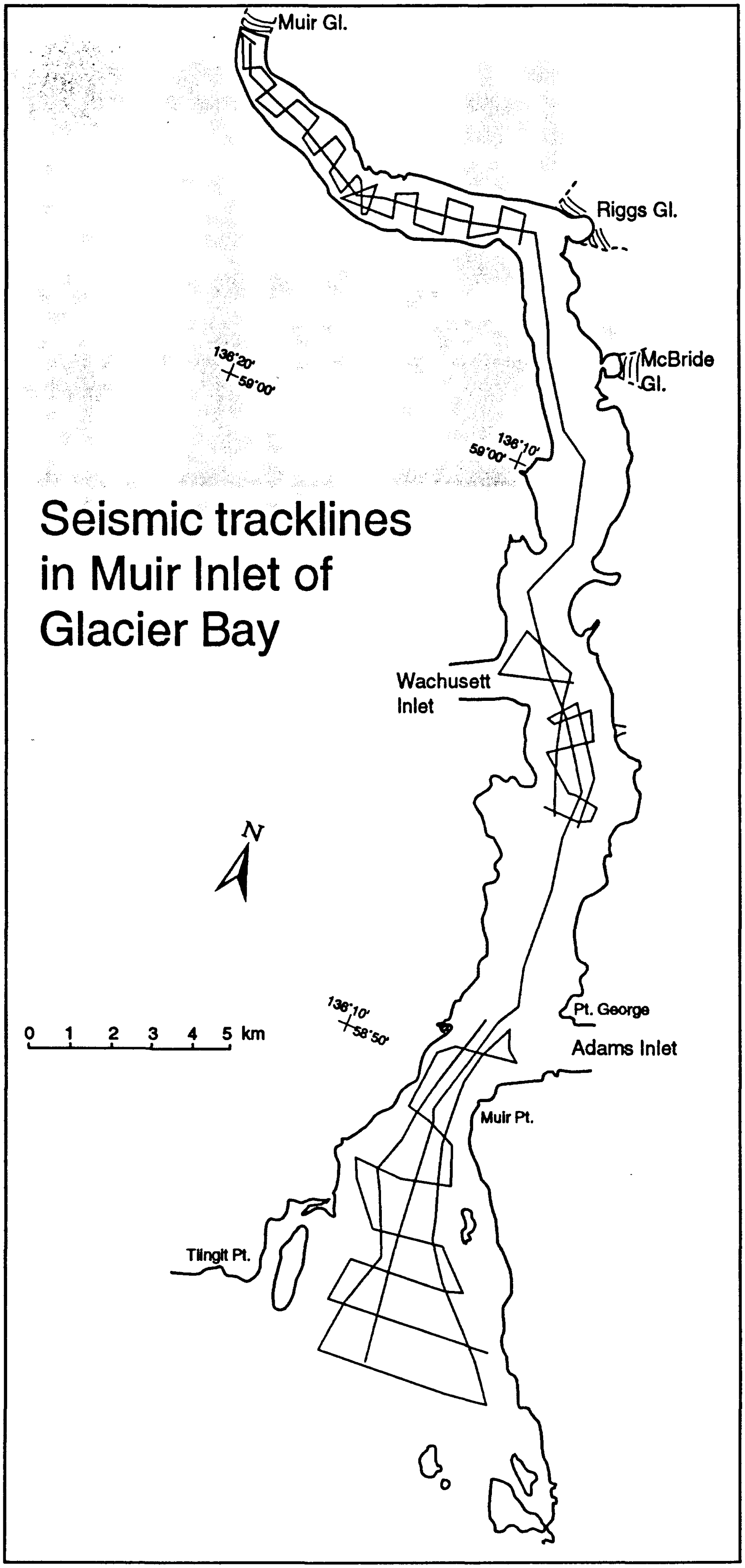


Figure 5. Seismic tracklines in Muir Inlet of Glacier Bay

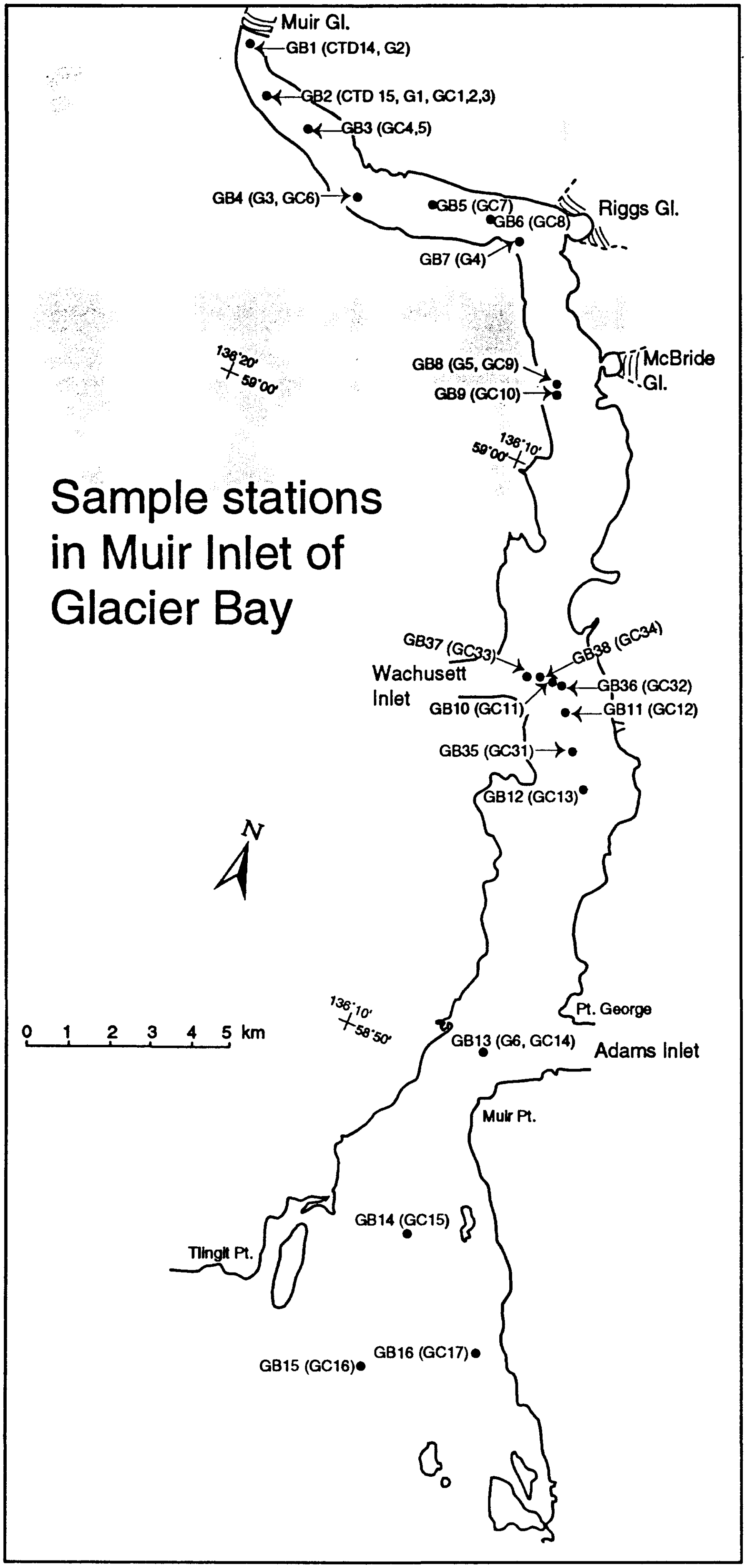


Figure 6. Sample stations in Muir Inlet of Glacier Bay

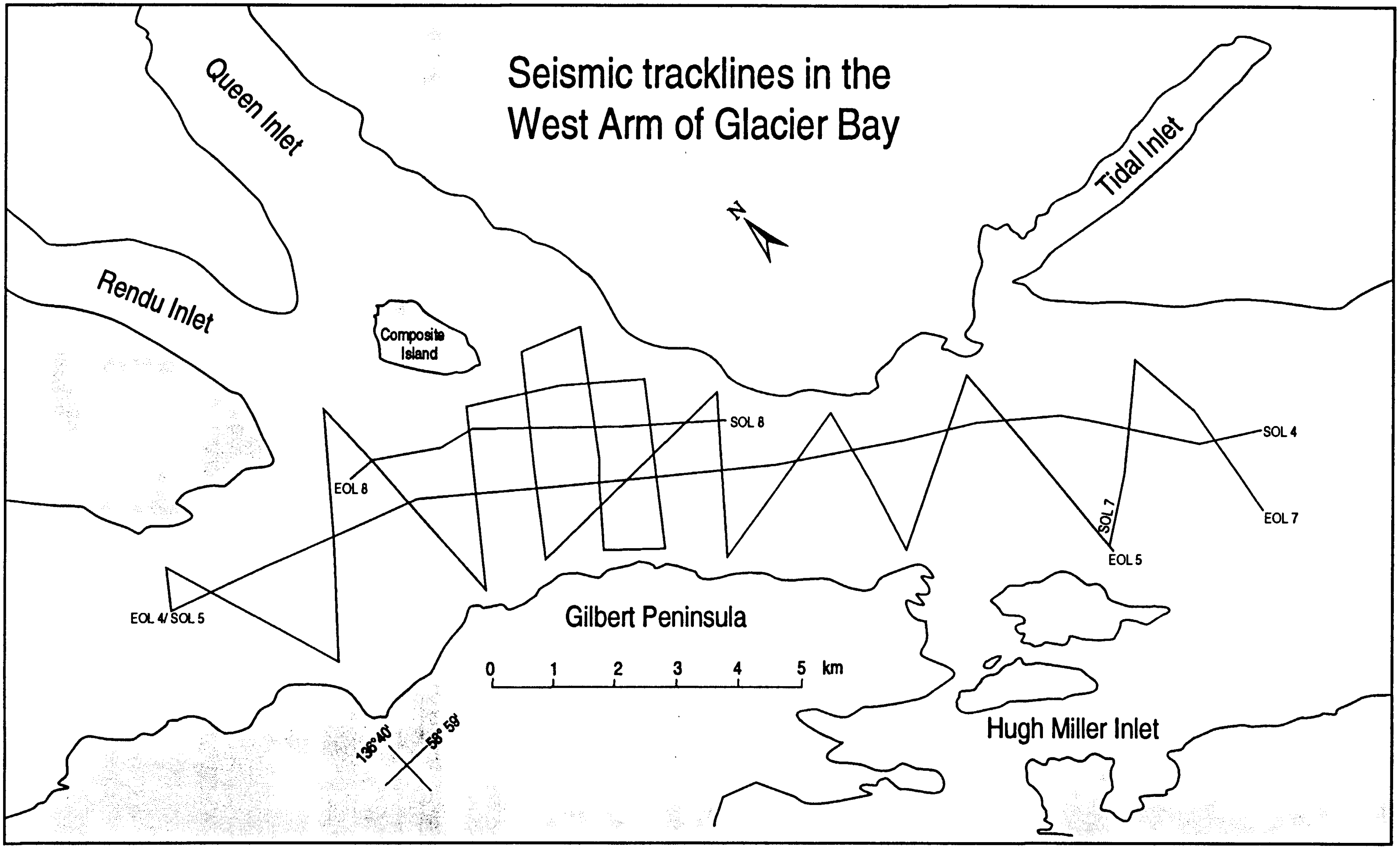


Figure 7. Seismic tracklines in the West Arm of Glacier Bay

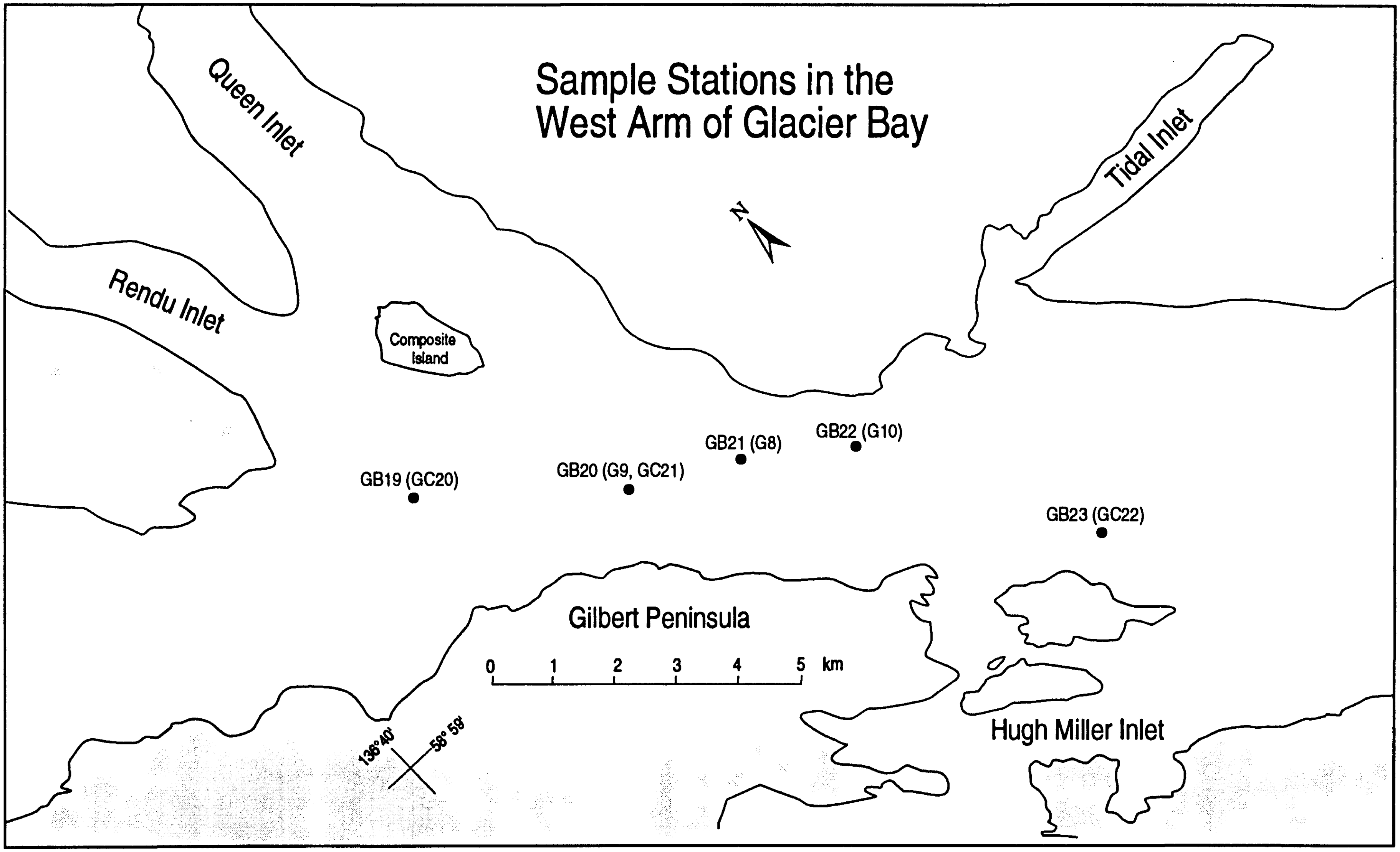


Figure 8. Sample stations in the West Arm of Glacier Bay

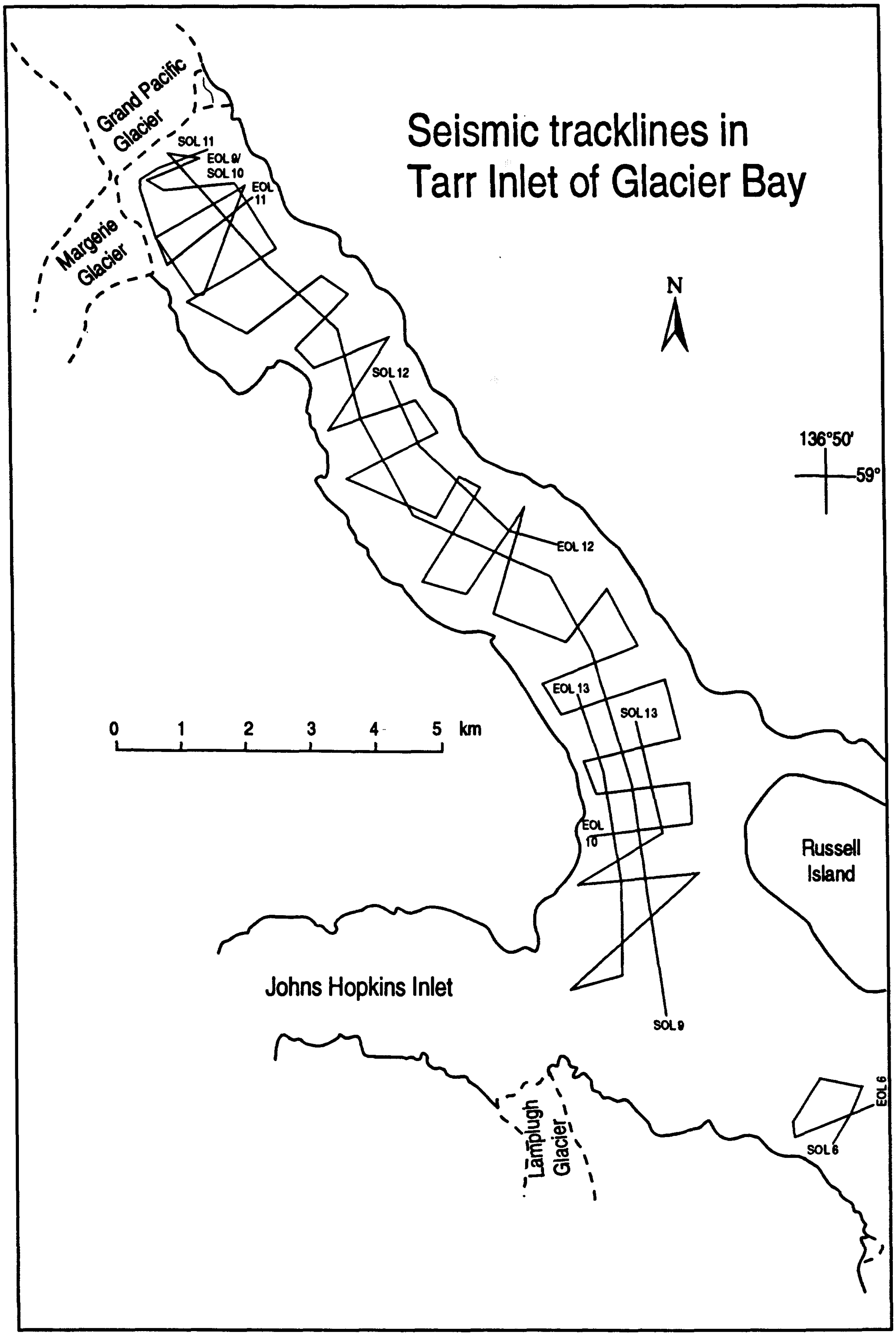


Figure 9. Seismic tracklines in Tarr Inlet of Glacier Bay

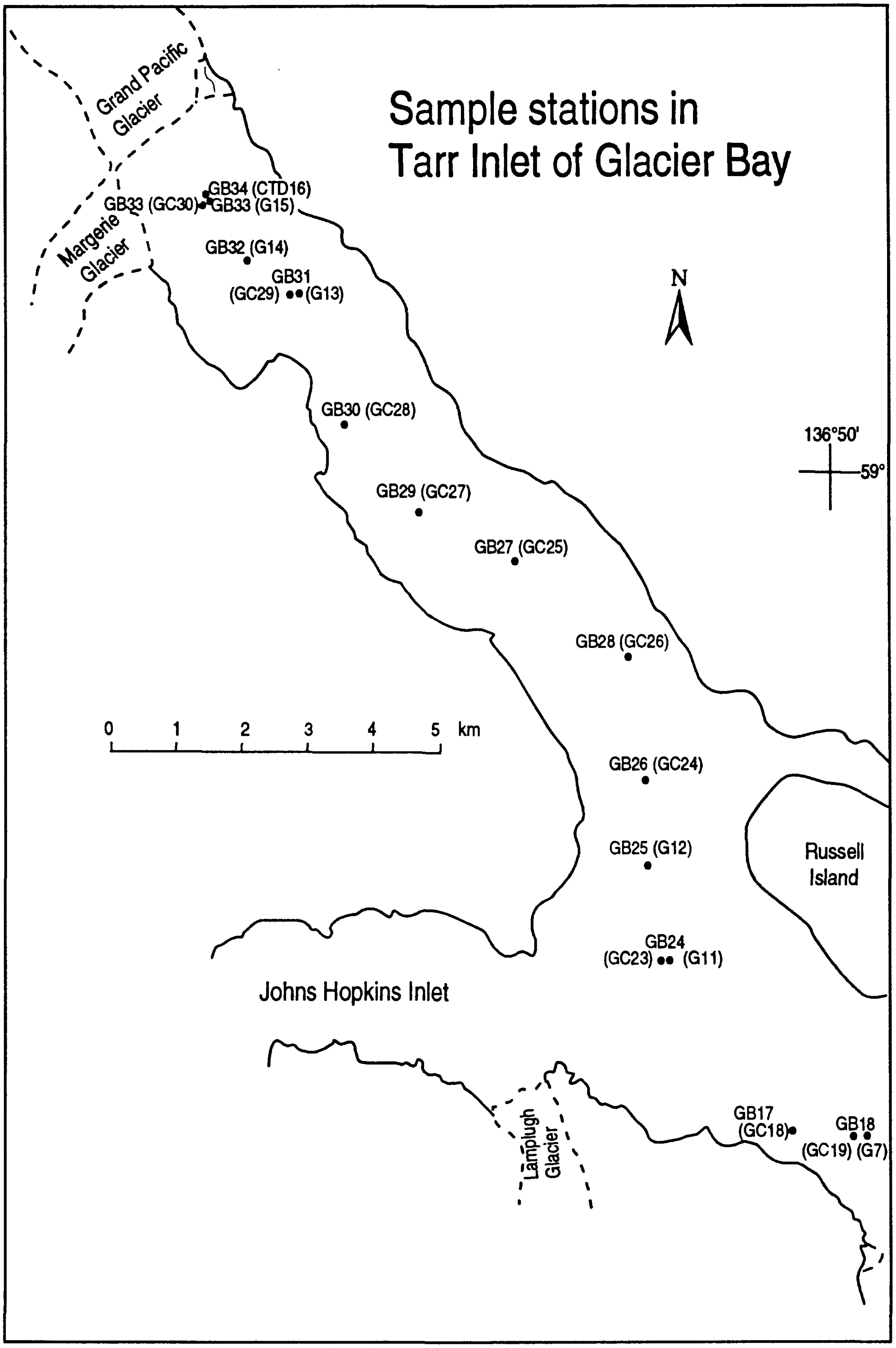


Figure 10. Sample stations in Tarr Inlet of Glacier Bay

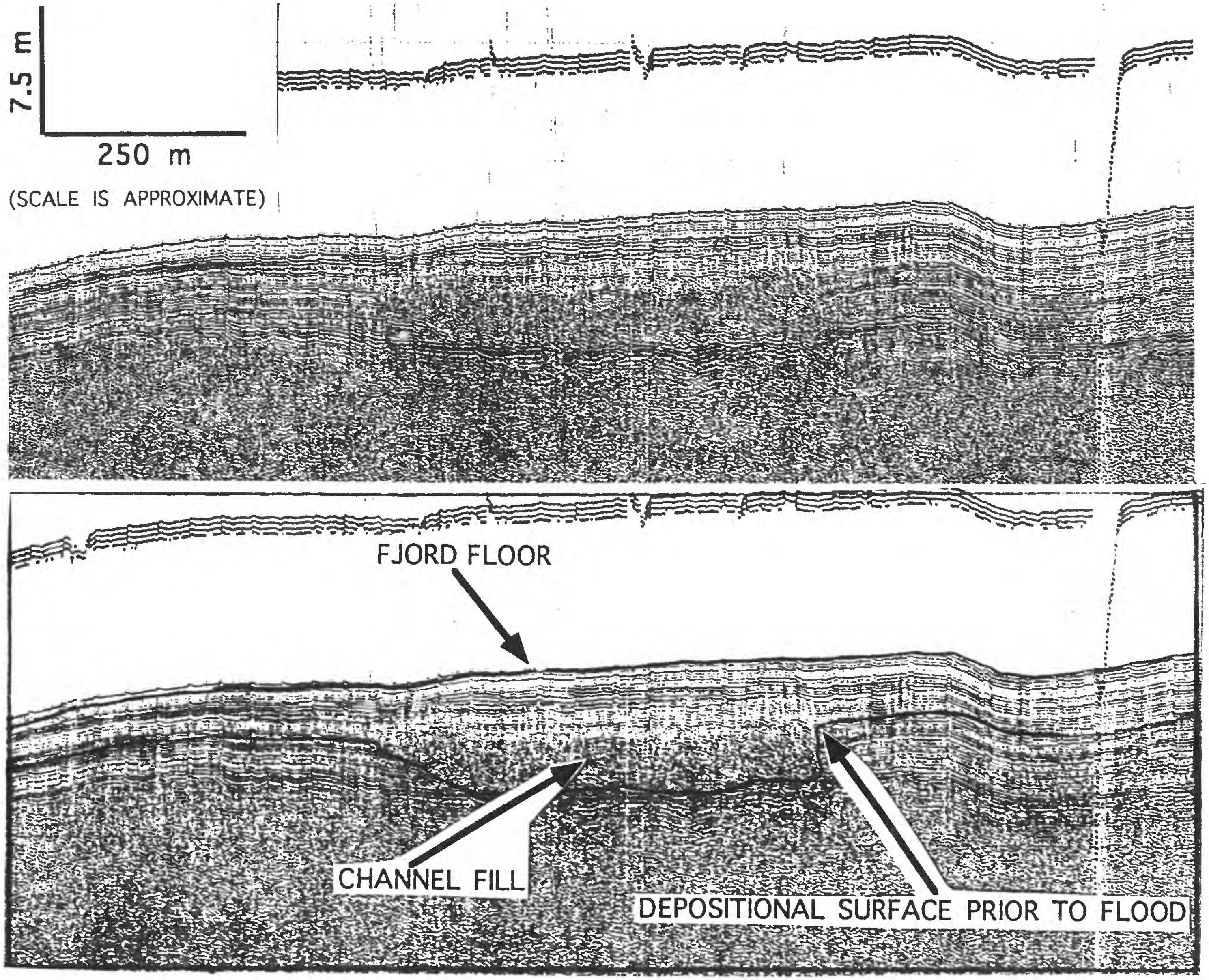


Figure 11. Seismic profile from Yakutat Bay showing buried channel.

Figure 12. Photograph of core from Muir Inlet showing interlaminated sand and mud. This 151 cm long gravity core was collected from 224 m water depth in Muir Inlet. See Figure 6 for location of core GC3 in Muir Inlet.

Table 1 - The Scientific Party

Ellen A. Cowan, Chief Scientist Department of Geology Appalachian State University Boone, North Carolina 28068	Phone: 704-262-2260 FAX: 704-262-2127
Ross D. Powell, Co-Chief Scientist Department of Geology Northern Illinois University DeKalb, Illinois 60115	Phone: 815-753-0523 FAX: 815-753-1945
Paul R. Carlson, Research Geologist Office of Marine Geology U.S. Geological Survey 345 Middlefield Road, MS 999 Menlo Park, California 94025	Phone: 415-354-3066 FAX: 415-354-3191
Robert E. Kayen, Research Civil Engineer Office of Marine Geology U.S. Geological Survey 345 Middlefield Road, MS 999 Menlo Park, California 94025	Phone: 415-354-3036 FAX: 415-354-3191
Keith C. Seramur, Geologist Department of Geology Appalachian State University Boone, North Carolina 28608	Phone: 704-328-2991 FAX: 704-322-2268
Jinkui Cai, Geologist Department of Geology Northern Illinois University Dekalb, Illinois 60115	Phone: 815-753-6272 FAX: 815-753-1945
Sarah D. Zellers, Geologist Department of Geological Sciences University of Texas at Austin Austin, Texas 78712	Phone: 512-471-6955 FAX: 512-471-9425
Graham B. Standen, Geoforce Consultants Bedford Institute of Oceanography P.O. Box 696 Dartmouth, Nova Scotia B2Y 3Y9	Phone: 902-463-0932 FAX: 902-464-9602
Undergraduate Students from Appalachian State University: Jenifer D. Clark Rafael A. Gutierrez Christen A. Nall	
David Hogg, Marine Technician U.S. Geological Survey	
Paul A. Jones, Marine Mammal Observer U.S. EPA, San Francisco, California	

Table 2. Time-table of scientific activities.

Date (1993)	**Time (ADT)**	**Activity**
August, 14-16		Mobilize shipboard equipment onboard the *R/V Alpha Helix*, Seward, AK
August 17	2100	Depart Seward, AK
August 17	2248	CTD cast, mouth of Resurrection Bay
August 18	1015	Arrive at Port Wells, AK. Begin survey of College Fjord.
August 18	1655	Echosounder Profiles of Harvard Glacier Terminous, survey College Fjord.
August 20	0336	Depart College Fjord for Cordova, AK
August 20	1240	Arrive at Cordova, AK, Carlson and Hogg fly to Yakutat,AK. Depart Cordova for Yakutat Bay.
August 21	2035	Arrive at Yakutat, AK, survey Yakutat Bay.
August 26	1239	Depart Yakutat Bay for Glacier Bay Nat'l Park.
August 27	0620	Arrive at Bartlett Cove, AK.
August 27	1348	Begin survey of Muir inlet, West Arm, and Tarr Inlet, Glacier Bay Nat'l. Park
September 1	0700	Return to Bartlett Cove, AK
September 1	1245	Depart Bartlett Cove for transit to Seward, AK.
September 3	0955	Arrive at Seward, AK
September 3-4		Demobilize operations on *R/V Alpha Helix*

Table 3. Core and Grab Samples

STATION NUMBER	SAMPLE NUMBER	DEPTH (meters)	CORE LENGTH (cm)	LATITUDE	LONGITUDE
College Fjord					
PW-1	AH93PWGC-1	230	169	61°11.28	147°48.09
PW-2	AH93PWGC-2	217	209	61°13.25	147°46.38
PW-3	AH93PWB-1	185	63	61°15.25	147°44.11
PW-4	AH93PWGC-3	104	48	61°01.07	148°00.41
PW-5	AH93PWPC-5	124	221	61°04.13	148°13.31
PW-6	AH93PWPC-6	390	234	60°55.46	148°08.46
Yakutat Bay					
YB-1	*AH93YBPC-1	246	90	59°55.24	139°37.11
	AH93YBPC-2	240	121	59°55.24	139°36.54
YB-2	AH93YBPC-3	235	0	59°58.87	139°33.69
	AH93YBG-1	233		59°58.83	139°33.95
	AH93YBB-1	233		59°58.80	139°34.25
	AH93YBPC-4	233	137	59°58.93	139°33.83
YB-3	AH93YBGC-5	237	98	59°57.50	139°33.86
	AH93YBGC-6	236	176	59°57.59	139°33.85
	AH93YBG-2	236		59°57.54	139°33.86
YB-4	AH93YBGC-7	234	277	59°57.68	139°34.76
	AH93YBG-3	234		59°57.68	139°34.83
YB-5	AH93YBGC-8	254	288	59°53.11	139°40.35
YB-6	AH93YBGC-9	86	40	59°48.30	139°41.51
YB-7	AH93YBG-4	82		59°48.46	139°41.51
YB-8	AH93YBGC-10	232	202	59°58.76	139°33.99
YB-9	*AH93YBGC-11	236	123	59°57.54	139°33.80

Table 3. Core and Grab Samples

STATION NUMBER	SAMPLE NUMBER	DEPTH (meters)	CORE LENGTH (cm)	LATITUDE	LONGITUDE
	AH93YBGC-12	236	152	59°57.54	139°33.85
YB-10	*AH93YBGC-13	234	94	59°58.05	139°33.70
	*AH93YBGC-14	234	53	59°58.06	139°33.70
	AH93YBGC-15	234	201	59°58.08	139°33.74
YB-11	AH93YBGC-16	232	80	59°58.59	139°34.19
	*AH93YBGC-17	232	60	59°58.58	139°34.16
YB-12	AH93YBGC-18	229	230	59°58.70	139°35.34
YB-13	AH93YBGC-19	227	236	59°59.54	139°34.31
YB-14	AH93YBGC-20	225	224		
YB-15	AH93YBGC-21	252	255	59°53.20	139°39.83
YB-16	AH93YBGC-22	248	282	59°54.69	139°38.36
YB-17	AH93YBG-5	61		59°54.86	139°41.74
YB-18	AH93YBG-6	90		59°54.80	139°41.34
YB-19	AH93YBG-7	95		59°54.78	139°41.18
	AH93YBGC-23	100	197	59°54.79	139°41.17
YB-20	AH93YBGC-24		150	59°56.17	139°35.99
YB-22	AH93YBGC-25	75	277	59°44.00	139°58.11
YB-23	AH93YBGC-26	80	280	59°44.09	139°56.52
YB-24	AH93YBGC-27	101	278	59°43.30	139°55.62
YB-25	AH93YBGC-28	217	122	59°51.03	139°41.47
Glacier Bay					
GB-1	*AH93GBG-2	190		59°05.11	136°22.45
GB-2	AH93GBGC-1	225		59°04.65	136°21.58
	AH93GBG-1	225		59°04.69	136°21.48
	*AH93GBGC-2	225	135	59°04.68	136°21.49
	AH93GBGC-3	224	150	59°04.69	136°21.55

Table 3. Core and Grab Samples

STATION NUMBER	SAMPLE NUMBER	DEPTH (meters)	CORE LENGTH (cm)	LATITUDE	LONGITUDE
GB-3	*AH93GBGC-4	238	50	59°04.37	136°19.84
	AH93GBGC-5	238	98	59°04.35	136°19.84
GB-4	AH93GBG-3	230		59°03.59	136°17.54
	AH93GBGC-6	228	244	59°03.58	136°17.57
GB-5	AH93GBGC-7	270	240	59°03.68	136°15.24
GB-6	AH93GBGC-8	273	118	59°03.73	136°13.28
GB-7	AH93GBG-4	261		59°03.79	136°12.17
GB-8	AH93GBG-5	240		59°01.53	136°09.64
	AH93GBGC-9	245	144	59°01.44	136°09.66
GB-9	AH93GBGC-10	250	97	59°01.23	136°09.54
GB-10	AH93GBGC-11	290	136	58°56.57	136°06.89
GB-11	AH93GBGC-12	305	245	58°56.16	136°06.22
GB-12	AH93GBGC-13	310	327	58°54.96	136°04.98
GB-13	AH93GBG-6	181		58°50.21	136°05.58
	AH93GBGC-14	180	220	58°50.17	136°05.53
GB-14	AH93GBGC-15	70	254	58°46.89	136°06.19
GB-15	AH93GBGC-16	137	270	58°44.50	136°06.21
GB-16	AH93GBGC-17	186	376	58°45.30	136°02.78
GB-17	AH93GBGC-18	218	268	58°53.32	136°50.70
GB-18	AH93GBGC-19	280	25	58°53.26	136°44.53
	AH93GBG-7	308		58°53.27	136°49.28
GB-19	AH93GBGC-20	426		58°52.08	136°36.09
GB-20	AH93GBGC-21	424	0	58°50.80	136°33.10
	AH93GBGC-21	425	0	58°50.63	136°32.79
	AH93GBG-9	424		58°50.78	136°33.08

Table 3. Core and Grab Samples

STATION NUMBER	SAMPLE NUMBER	DEPTH (meters)	CORE LENGTH (cm)	LATITUDE	LONGITUDE
GB-21	AH93GBG-8	434		58°49.91	136°30.50
GB-22	AH93GBGC-9	434	0	58°49.29	136°28.84
	AH93GBG-10	434		58°49.24	136°28.58
GB-23	AH93GBGC-22	276	145	58°46.80	136°26.10
GB-24	AH93GBGC-23	376	0	58°55.09	136°53.33
	AH93GBGC-23	377	0	58°55.06	136°53.20
	AH93GBG-11	378		58°55.08	136°53.15
	AH93GBGC-23	378	0	58°55.04	136°53.15
GB-25	AH93GBG-12	375		58°56.02	136°53.59
GB-26	AH93GBGC-24	340	177	58°56.76	136°53.58
GB-27	AH93GBGC-25	339	40	58°59.09	136°56.22
GB-28	AH93GBGC-26	245	55	58°58.12	136°53.96
GB-29	AH93GBGC-27	331	171	58°59.64	136°58.12
GB-30	AH93GBGC-28	318	282	59°00.57	136°59.55
GB-31	AH93GBGC-29	296		59°01.79	137°00.67
	AH93GBG-13	296		59°01.77	137°00.55
GB-32	AH93GBG-14	284		59°02.09	137°01.46
GB-33	AH93GBG-15	258		59°02.72	137°02.32
	AH93GBGC-30	265	0	59°02.69	137°02.34
GB-35	AH93GBGC-31	305	232	58°55.53	136°05.74
GB-36	AH93GBGC-32	291	152	58°56.58	136°06.76
GB-37	AH93GBGC-33	150	114	58°56.47	136°07.70
GB-38	AH93GBGC-34	287	56	58°56.55	136°07.24

* = Cores not split, described, or archived

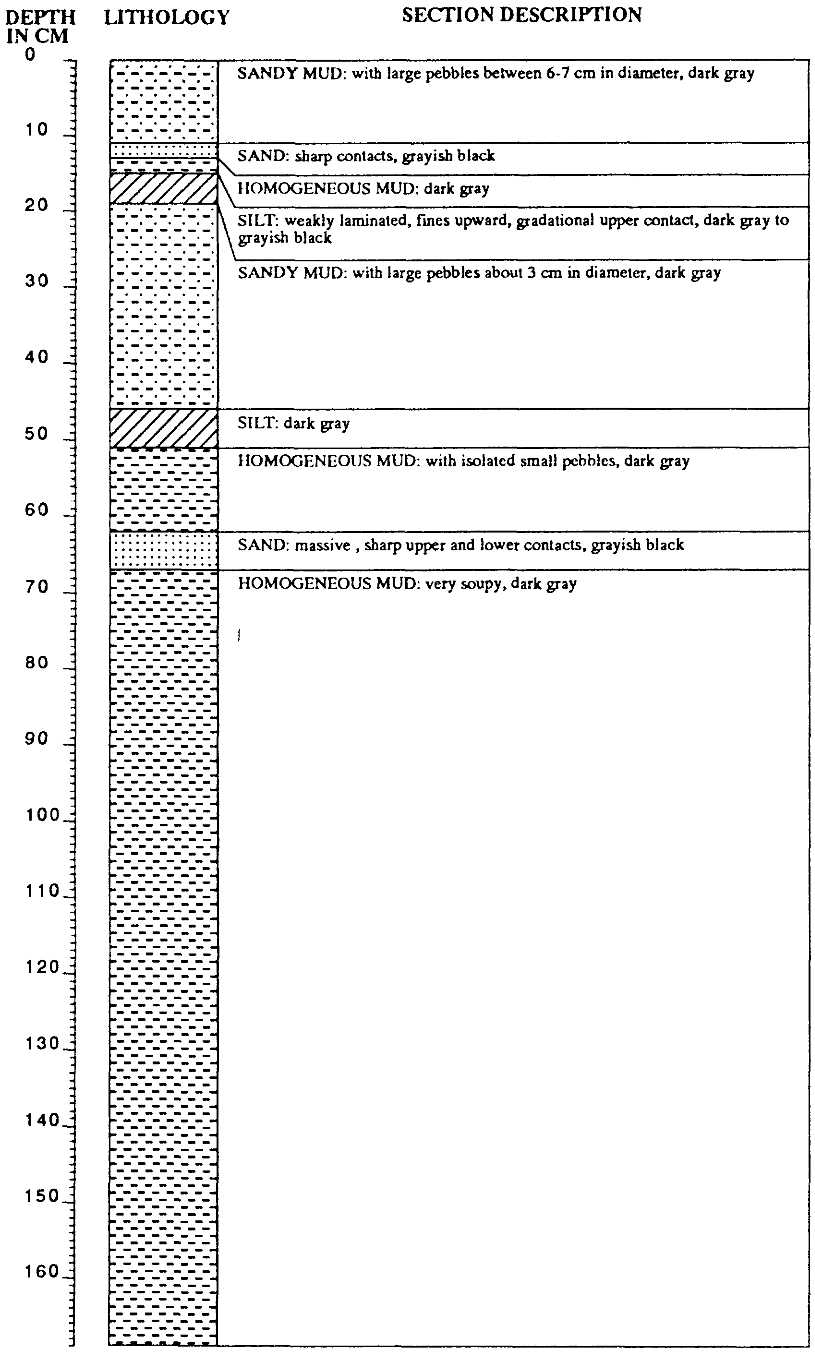
GC = gravity core	B = box core
PC = piston core	G = van veen grab

Table 4. CTD Casts and Water Samples

LOCATION/ STATION #	CAST	DEPTH (meters)	WATER SAMPLES (depth- meters)
College Fjord			
PW-1	2	190	5,10,20,30,40,50,60 100,145,160,190
PW-2	3	211	0,10,20,35,50,70, 110,130,150,190,202
PW-3	4	180	
PW-3	5	180	0,6.5,10,35,50,60,75, 85,110,125,150,182
PW-5	6	118	0,8,10,20,30,40,50,70, 80,92,100,118
Port Wells			
PW-6	7	365	0,10,20,40,55,100, 150,175,200,250,350, 361
Yakutat Bay			
YB-1	8	230	0,25,50,75,100,125, 150,160,180,190,200 230
YB-2	9	215	0,15,20,25,35,45,50, 60,75,100,146
YB-4	10	219	0,8,10,20,50,80,110, 130,150,170,200,219
YB-5	11	235	3.2,10,20,30,50,60, 75,100,125,150, 200,233

APPENDIX 1: CORE LOGS

AH93 PW GC-1



SANDY MUD: with large pebbles between 6-7 cm in diameter, dark gray

SAND: sharp contacts, grayish black

HOMOGENEOUS MUD: dark gray

SILT: weakly laminated, fines upward, gradational upper contact, dark gray to grayish black

SANDY MUD: with large pebbles about 3 cm in diameter, dark gray

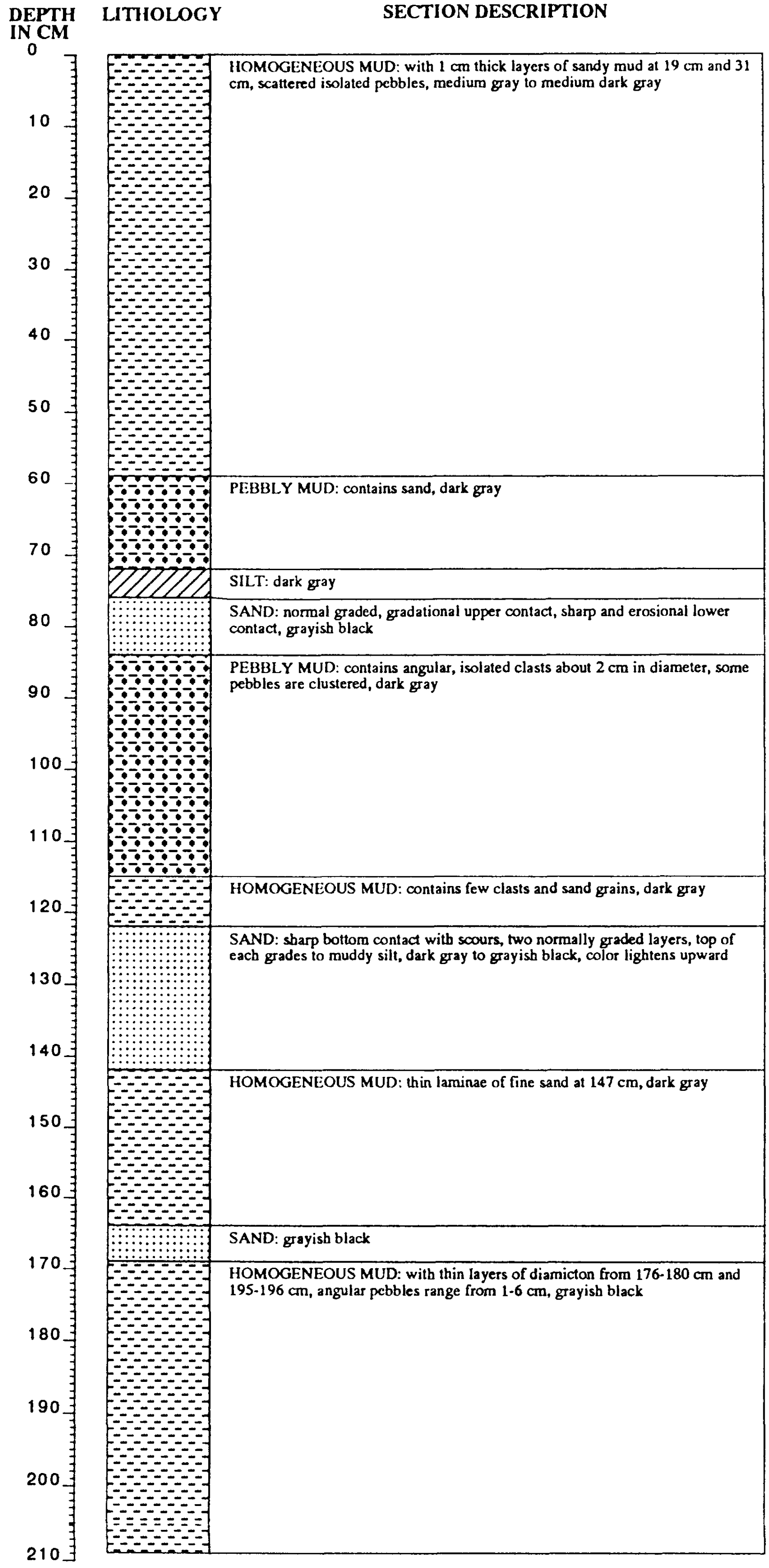
SILT: dark gray

HOMOGENEOUS MUD: with isolated small pebbles, dark gray

SAND: massive , sharp upper and lower contacts, grayish black

HOMOGENEOUS MUD: very soupy, dark gray

AH93 PW GC-2



HOMOGENEOUS MUD: with 1 cm thick layers of sandy mud at 19 cm and 31 cm, scattered isolated pebbles, medium gray to medium dark gray

PEBBLY MUD: contains sand, dark gray

SILT: dark gray

SAND: normal graded, gradational upper contact, sharp and erosional lower contact, grayish black

PEBBLY MUD: contains angular, isolated clasts about 2 cm in diameter, some pebbles are clustered, dark gray

HOMOGENEOUS MUD: contains few clasts and sand grains, dark gray

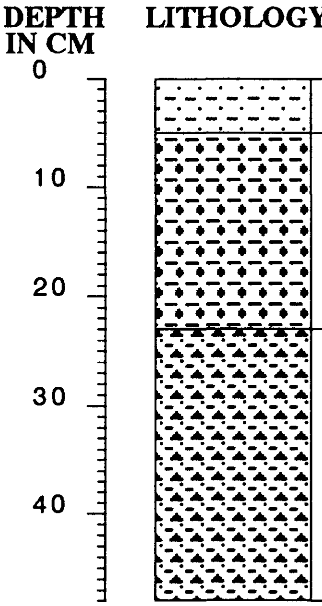
SAND: sharp bottom contact with scours, two normally graded layers, top of each grades to muddy silt, dark gray to grayish black, color lightens upward

HOMOGENEOUS MUD: thin laminae of fine sand at 147 cm, dark gray

SAND: grayish black

HOMOGENEOUS MUD: with thin layers of diamicton from 176-180 cm and 195-196 cm, angular pebbles range from 1-6 cm, grayish black

AH93 PW GC-3



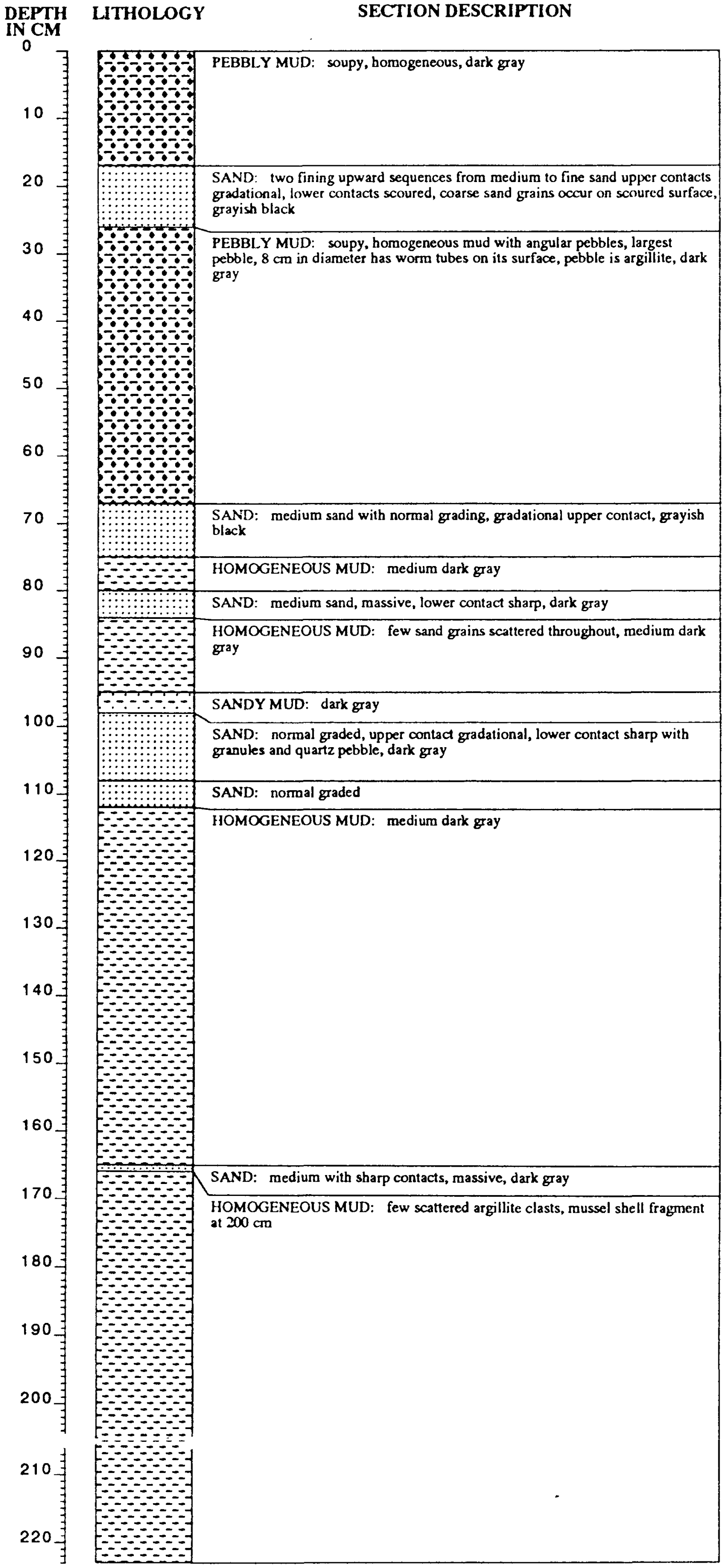
SECTION DESCRIPTION

SANDY MUD: soupy, few scattered small clasts, dark gray

PEBBLY MUD: with sand, angular argillite pebbles, largest is 3.5 cm, lower contact is gradational, black worm tube 10 cm long, 2-3 mm in diameter, dark gray

DIAMICTON: higher percent sand and pebbles than above, largest angular clast is 4 cm, dark gray

AH93 PW PC-5



PEBBLY MUD: soupy, homogeneous, dark gray

SAND: two fining upward sequences from medium to fine sand upper contacts gradational, lower contacts scoured, coarse sand grains occur on scoured surface, grayish black

PEBBLY MUD: soupy, homogeneous mud with angular pebbles, largest pebble, 8 cm in diameter has worm tubes on its surface, pebble is argillite, dark gray

SAND: medium sand with normal grading, gradational upper contact, grayish black

HOMOGENEOUS MUD: medium dark gray

SAND: medium sand, massive, lower contact sharp, dark gray

HOMOGENEOUS MUD: few sand grains scattered throughout, medium dark gray

SANDY MUD: dark gray

SAND: normal graded, upper contact gradational, lower contact sharp with granules and quartz pebble, dark gray

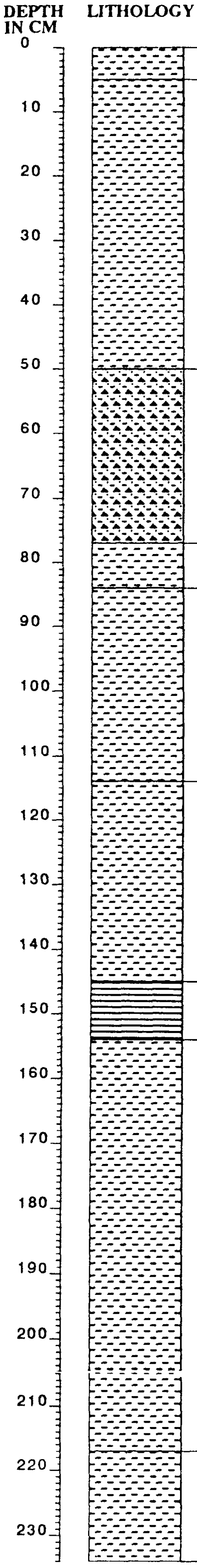
SAND: normal graded

HOMOGENEOUS MUD: medium dark gray

SAND: medium with sharp contacts, massive, dark gray

HOMOGENEOUS MUD: few scattered argillite clasts, mussel shell fragment at 200 cm

AH93 PW PC-6



SECTION DESCRIPTION

HOMOGENEOUS MUD: soupy, dark gray

HOMOGENEOUS MUD: some scattered pebbles and sand grains, abundant worm burrows, shell fragment at 25 cm, dark gray

DIAMICTON: massive, angular argillite pebbles, abundant worm burrows, dark gray

HOMOGENEOUS MUD: few scattered pebbles and sand grains, dark gray

HOMOGENEOUS MUD: few scattered angular pebbles and sand grains, largest pebble is basalt, 7.5 cm in diameter, abundant horizontal worm burrows, small thin shell at 112 cm, dark gray

HOMOGENEOUS MUD: few scattered angular argillite pebbles, dark gray

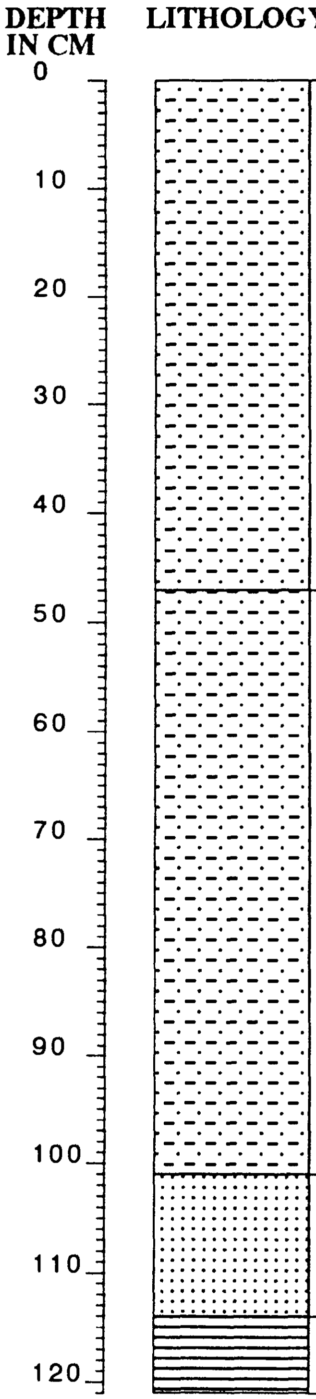
LAMINATED MUD: 1 mm in thickness, laminae are shown by alternation from grayish black to dark gray, upper contact is gradational, lower contact obscured

HOMOGENEOUS MUD: few dispersed pebbles and sand grains, larger pebbles (up to 7.5 cm in diameter) are angular, pebble lithologies are diorite and slate, grayish black to dark gray

HOMOGENEOUS MUD: scattered angular slate pebbles with sand grains around them, abundant horizontal worm burrows, shell fragment found near bottom, grayish black to dark gray

(page 42 follows)

AH93 YB PC-2



SECTION DESCRIPTION

SANDY MUD: very soupy and disturbed, medium dark gray

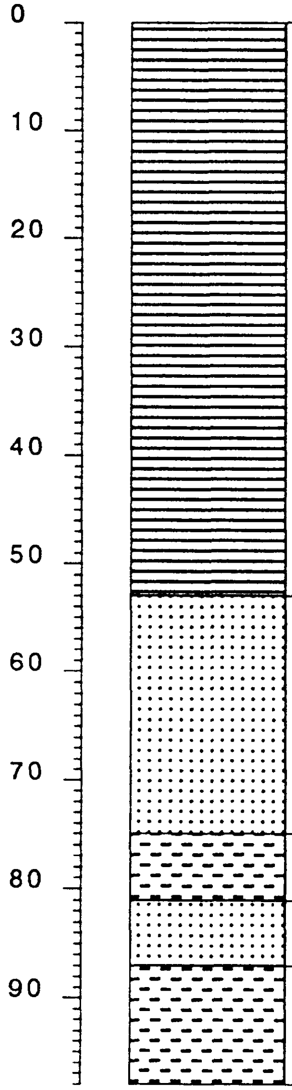
SANDY MUD: less soupy, not disturbed, medium dark gray

SAND: fine sand, normal graded, upper contact is gradational, lower contact is sharp, medium dark gray

LAMINATED MUD: 1-2 mm in thickness, scattered sand grains and pebbles up to 2 cm

AH93 YB GC-5

DEPTH IN CM **LITHOLOGY** **SECTION DESCRIPTION**



LAMINATED MUD: very soupy at top of interval, unevenly spaced dark laminae spaced at a mm scale, several thin silt laminae with gradational contacts between 25 and 40 cm, a pebble 3.5 cm in diameter at 40 cm, medium gray

SAND: fining upward, medium to fine sand, weakly stratified toward the top, sharp contacts, dark gray

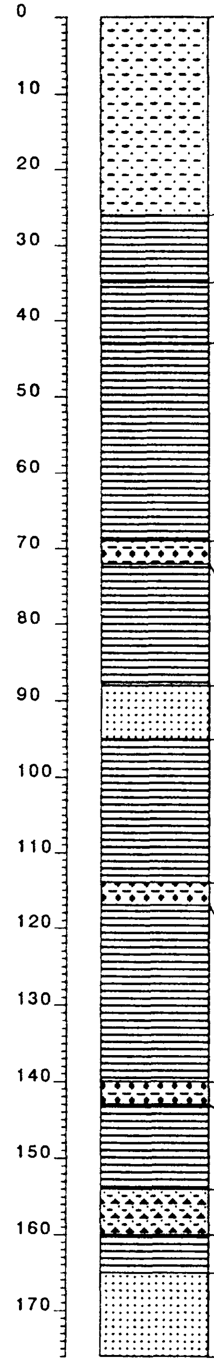
HOMOGENEOUS MUD: contains a few scattered sand grains, medium gray

SAND: massive medium sand, sharp contacts, medium dark gray

HOMOGENEOUS MUD: contains a few scattered sand grains, medium gray

AH93 YB GC-6

DEPTH IN CM **LITHOLOGY** **SECTION DESCRIPTION**



SANDY MUD: very soupy, laminated by color, contains a few pebbles, largest pebble diameter is 3.5 cm, has sand and gravel around it, olive gray

LAMINATED MUD: soupy, contains silt laminae with dispersed sand grains, olive gray

LAMINATED MUD: medium dark gray

LAMINATED MUD: 3, 2 cm thick units that are medium dark gray at base grading to olive gray at the top (from 43 to 49 cm), thin laminae with lighter shade, darker laminae are silty (from 49 to 56), 2 mm thick dark silty lamina at 57 cm, olive gray

PEBBLY MUD: contains a pebble 2.5 cm in diameter with sand and gravel, medium dark gray

LAMINATED MUD: contains dispersed sand grains, darker laminae browinsh-tan in color between 75-85 cm, olive gray

SAND: fining upward from medium to fine sand, weakly stratified, sharp lower contact

LAMINATED MUD: silt laminae with dipsersed sand grains, olive gray

PEBBLY MUD: contains some sand grains, sharp lower contact, medium dark gray

LAMINATED MUD: silt laminae with dispersed sand grains, grades from dark greenish gray up to olive gray

PEBBLY MUD: sharp lower contact, medium dark gray

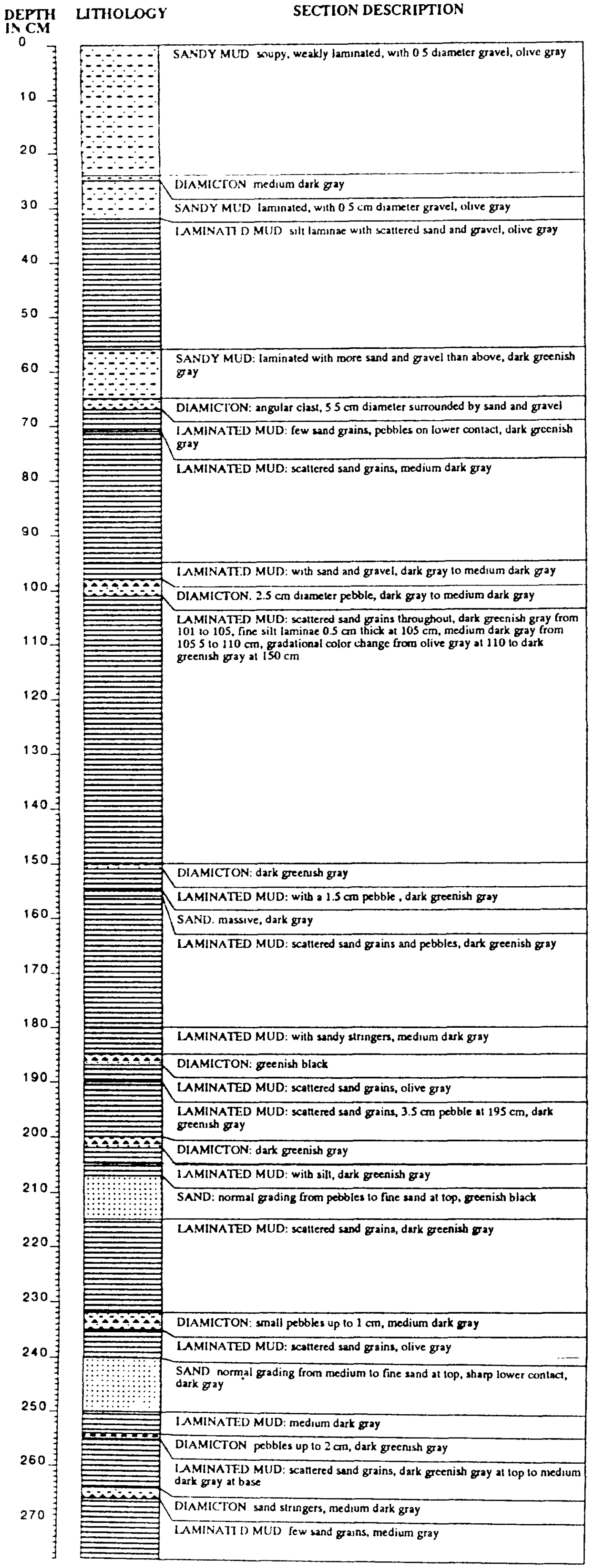
LAMINATED MUD: silt laminae with dispersed sand, grades from dark greenish gray up to olive gray

DIAMICTON: 1 pebble 6 cm in diameter, olive gray

LAMINATED MUD: gravel found at base of this unit, olive gray

SAND: massive medium to fine sand, 3.5 cm pebble at top, sharp lower contact, grayish black

AH93 YB GC-7



SECTION DESCRIPTION

SANDY MUD soupy, weakly laminated, with 0 5 diameter gravel, olive gray

DIAMICTON medium dark gray

SANDY MUD laminated, with 0 5 cm diameter gravel, olive gray

LAMINATED MUD silt laminae with scattered sand and gravel, olive gray

SANDY MUD: laminated with more sand and gravel than above, dark greenish gray

DIAMICTON: angular clast, 5 5 cm diameter surrounded by sand and gravel

LAMINATED MUD: few sand grains, pebbles on lower contact, dark greenish gray

LAMINATED MUD: scattered sand grains, medium dark gray

LAMINATED MUD: with sand and gravel, dark gray to medium dark gray

DIAMICTON. 2.5 cm diameter pebble, dark gray to medium dark gray

LAMINATED MUD: scattered sand grains throughout, dark greenish gray from 101 to 105, fine silt laminae 0.5 cm thick at 105 cm, medium dark gray from 105 5 to 110 cm, gradational color change from olive gray at 110 to dark greenish gray at 150 cm

DIAMICTON: dark greenish gray

LAMINATED MUD: with a 1.5 cm pebble , dark greenish gray

SAND. massive, dark gray

LAMINATED MUD: scattered sand grains and pebbles, dark greenish gray

LAMINATED MUD: with sandy stringers, medium dark gray

DIAMICTON: greenish black

LAMINATED MUD: scattered sand grains, olive gray

LAMINATED MUD: scattered sand grains, 3.5 cm pebble at 195 cm, dark greenish gray

DIAMICTON: dark greenish gray

LAMINATED MUD: with silt, dark greenish gray

SAND: normal grading from pebbles to fine sand at top, greenish black

LAMINATED MUD: scattered sand graina, dark greenish gray

DIAMICTON: small pebbles up to 1 cm, medium dark gray

LAMINATED MUD: scattered sand grains, olive gray

SAND normal grading from medium to fine sand at top, sharp lower contact, dark gray

LAMINATED MUD: medium dark gray

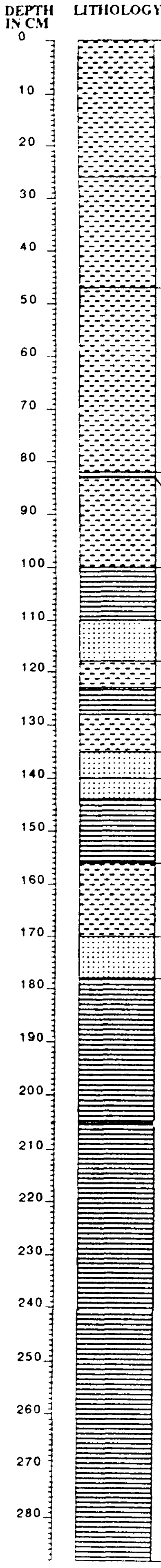
DIAMICTON pebbles up to 2 cm, dark greenish gray

LAMINATED MUD: scattered sand grains, dark greenish gray at top to medium dark gray at base

DIAMICTON sand stringers, medium dark gray

LAMINATED MUD few sand grains, medium gray

AH93 YB GC-8



SECTION DESCRIPTION

HOMOGENEOUS MUD. soupy, color laminated, 0-6 5 cm dk greenish gray, 6 5-15 cm lt olive gray, 15-16 cm med. dk. gray, 16-26 cm dk.greenish gray

HOMOGENEOUS MUD. 26-26 5 med dk gray, 26 5-32 cm greenish gray, 32-36 cm lt olive gray, 36-47 cm dk greenish gray, stiff mud clast at 40 cm with pebbles

HOMOGENEOUS MUD: dark greenish gray

LAMINATED MUD. fine sand to silt laminae, dark greenish gray

HOMOGENEOUS MUD: dark greenish gray

LAMINATED MUD dark greenish gray

SAND: normally graded fine to very fine sand, sharp lower contact, gradational upper contact, ripple cross bedding at 114 cm, olive gray

HOMOGENEOUS MUD: dark greenish gray

LAMINATED MUD: olive gray

HOMOGENEOUS MUD dark greenish gray

SAND· massive very fine sand, olive gray

SAND. laminated fine sand with silt, dark greenish gray

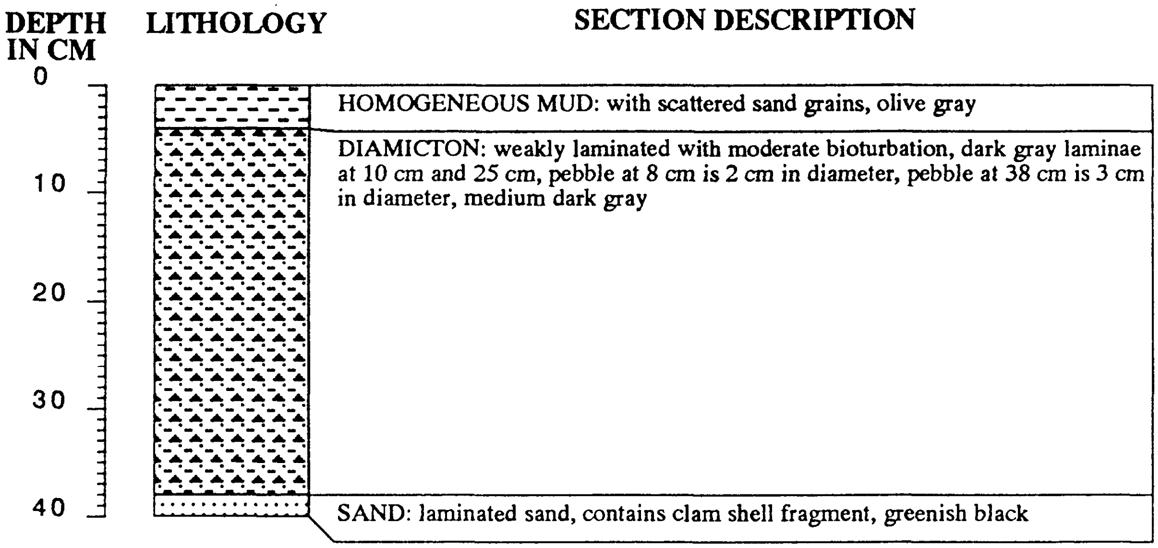
LAMINATED MUD: with sand, olive gray 1 cm thick dark greenish gray lamina at 156 cm

HOMOGENEOUS MUD: with scattered sand grains, dark greenish gray

SAND. weakly stratified fine sand to silt, sharp contact at base, dark gray

LAMINATED MUD: very weak lamination, dark greenish gray

AH93 YB GC-9

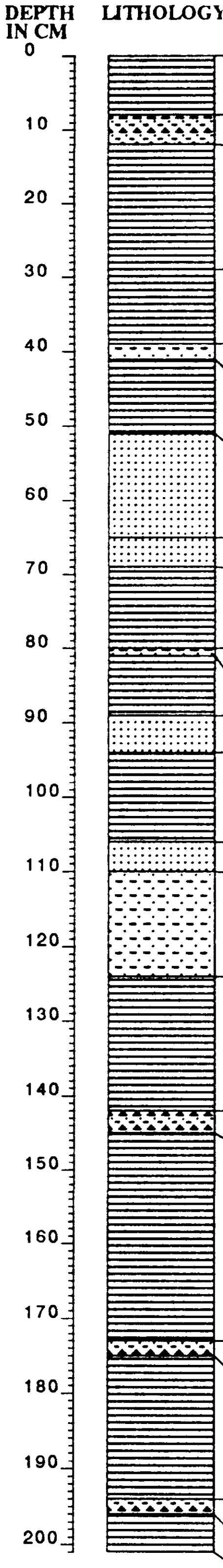


HOMOGENEOUS MUD: with scattered sand grains, olive gray

DIAMICTON: weakly laminated with moderate bioturbation, dark gray laminae at 10 cm and 25 cm, pebble at 8 cm is 2 cm in diameter, pebble at 38 cm is 3 cm in diameter, medium dark gray

SAND: laminated sand, contains clam shell fragment, greenish black

AH93 YB GC-10



SECTION DESCRIPTION

LAMINATED MUD: soupy, with a few sand grains, dark greenish gray

DIAMICTON: olive gray

LAMINATED MUD: soupy, few scattered sand grains, dark greenish gray

LAMINATED MUD: more scattered sand grains than above unit, 5 cm diameter pebble at 35 cm, olive gray

SANDY MUD: laminated, olive gray

LAMINATED MUD: 2 couplets 2.5 cm thick of dark greenish gray mud at base and lighter olive gray mud above, 1 lamina above is dark greenish gray, pebble at 42 cm is 1 cm in diameter

SAND: laminated medium sand, well sorted, greenish black

SAND: laminated fine sand with mud, less than 0.5 cm thick, greenish black

LAMINATED MUD: dark greenish gray

DIAMICTON: angular pebbles up to 1.5 cm, medium dark gray

LAMINATED MUD: pebbles up to 0.5 cm diameter, lighter medium dark gray

SAND: laminated fine to medium sand, dark greenish gray

LAMINATED MUD: between 94 and 97, 2 couplets of dark greenish gray mud at base and lighter olive gray mud above; between 97 and 106, scattered sand grains, dark greenish gray

SAND: normally graded fine sand at base, dark gray

SANDY MUD: laminated, gradational lower contact, dark greenish gray

LAMINATED MUD: 3 couplets, 5.5 cm thick of medium dark gray mud at base and olive gray mud above

DIAMICTON: pebbles up to 2.5 cm in diameter, black

LAMINATED MUD: between 145 and 147 cm yellowish green mud laminated with sand, between 147 and 150 cm olive gray mud is darker and brownish, between 150 and 171 cm is olive gray, between 171 and 173 cm laminated mud is medium dark gray

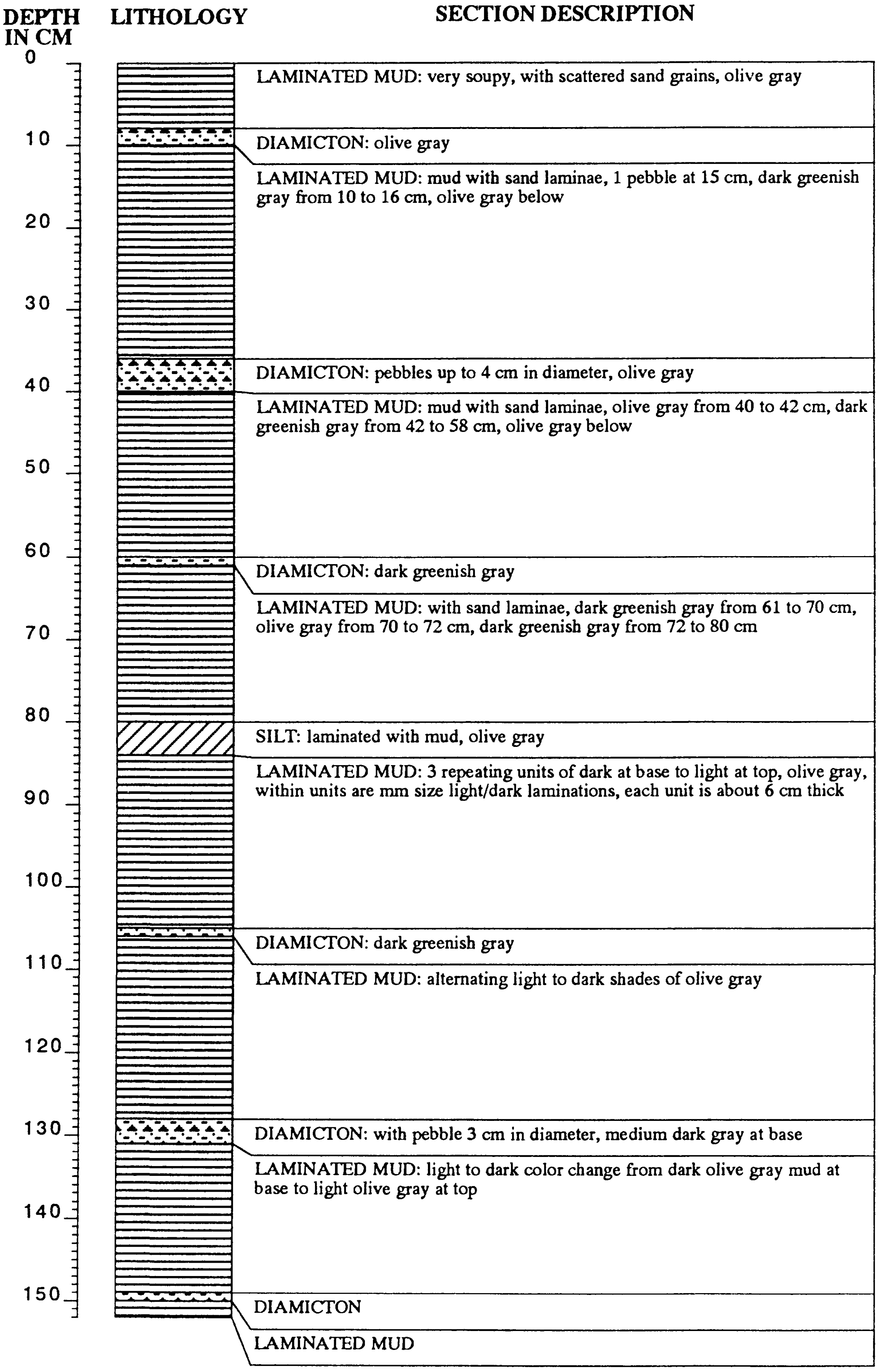
DIAMICTON: very angular pebbles up to 3 cm diameter, medium dark gray

LAMINATED MUD: scattered sand grains, color changes - 175 to 178 cm is grayish olive, 178 to 190 cm is olive gray, and 190 to 194 is medium dark gray

DIAMICTON: medium dark gray

LAMINATED MUD: grayish olive

AH93 YB GC-12



LAMINATED MUD: very soupy, with scattered sand grains, olive gray

DIAMICTON: olive gray

LAMINATED MUD: mud with sand laminae, 1 pebble at 15 cm, dark greenish gray from 10 to 16 cm, olive gray below

DIAMICTON: pebbles up to 4 cm in diameter, olive gray

LAMINATED MUD: mud with sand laminae, olive gray from 40 to 42 cm, dark greenish gray from 42 to 58 cm, olive gray below

DIAMICTON: dark greenish gray

LAMINATED MUD: with sand laminae, dark greenish gray from 61 to 70 cm, olive gray from 70 to 72 cm, dark greenish gray from 72 to 80 cm

SILT: laminated with mud, olive gray

LAMINATED MUD: 3 repeating units of dark at base to light at top, olive gray, within units are mm size light/dark laminations, each unit is about 6 cm thick

DIAMICTON: dark greenish gray

LAMINATED MUD: alternating light to dark shades of olive gray

DIAMICTON: with pebble 3 cm in diameter, medium dark gray at base

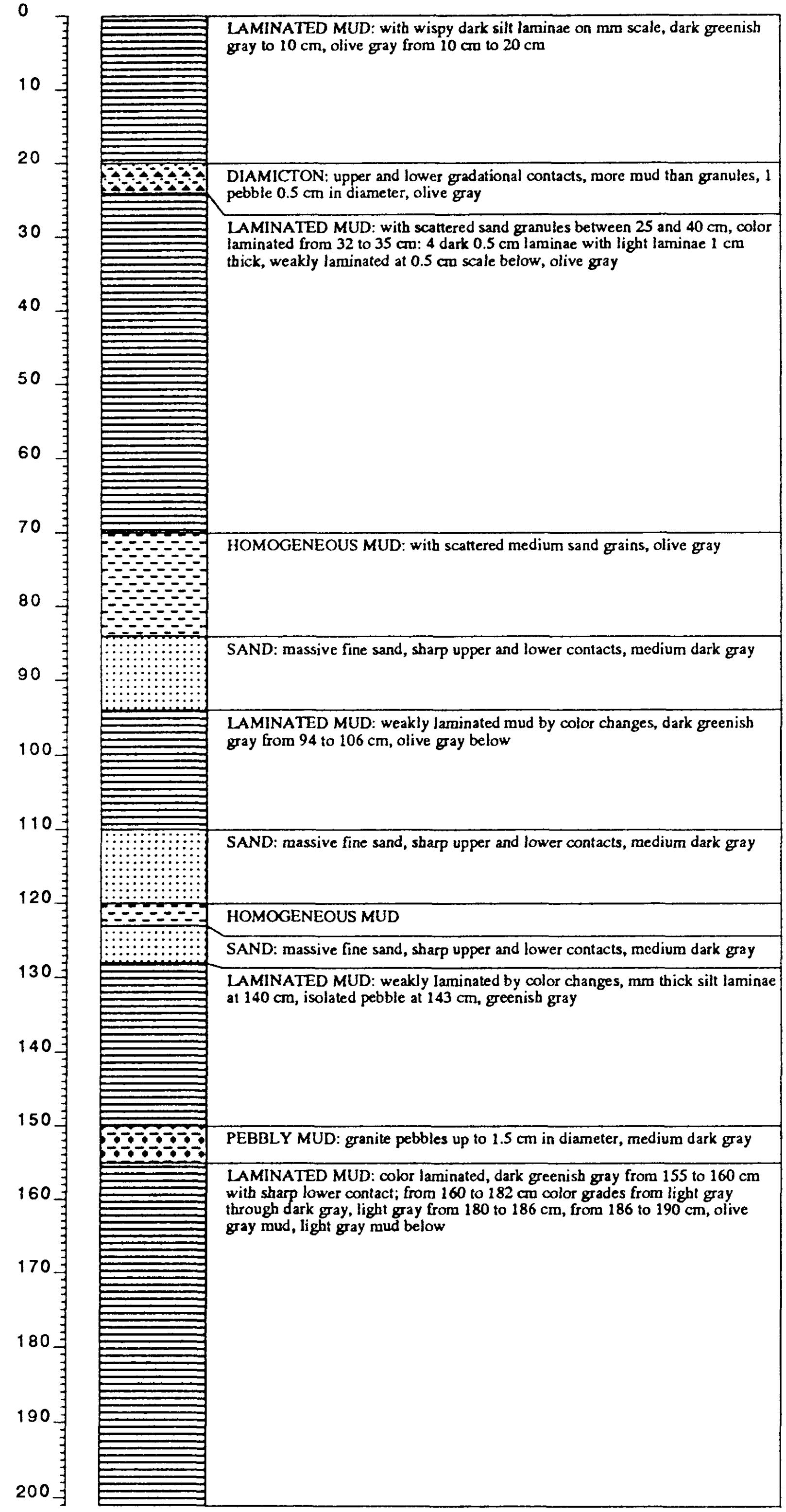
LAMINATED MUD: light to dark color change from dark olive gray mud at base to light olive gray at top

DIAMICTON

LAMINATED MUD

AH93 YB GC-15

DEPTH IN CM **LITHOLOGY** **SECTION DESCRIPTION**



LAMINATED MUD: with wispy dark silt laminae on mm scale, dark greenish gray to 10 cm, olive gray from 10 cm to 20 cm

DIAMICTON: upper and lower gradational contacts, more mud than granules, 1 pebble 0.5 cm in diameter, olive gray

LAMINATED MUD: with scattered sand granules between 25 and 40 cm, color laminated from 32 to 35 cm: 4 dark 0.5 cm laminae with light laminae 1 cm thick, weakly laminated at 0.5 cm scale below, olive gray

HOMOGENEOUS MUD: with scattered medium sand grains, olive gray

SAND: massive fine sand, sharp upper and lower contacts, medium dark gray

LAMINATED MUD: weakly laminated mud by color changes, dark greenish gray from 94 to 106 cm, olive gray below

SAND: massive fine sand, sharp upper and lower contacts, medium dark gray

HOMOGENEOUS MUD

SAND: massive fine sand, sharp upper and lower contacts, medium dark gray

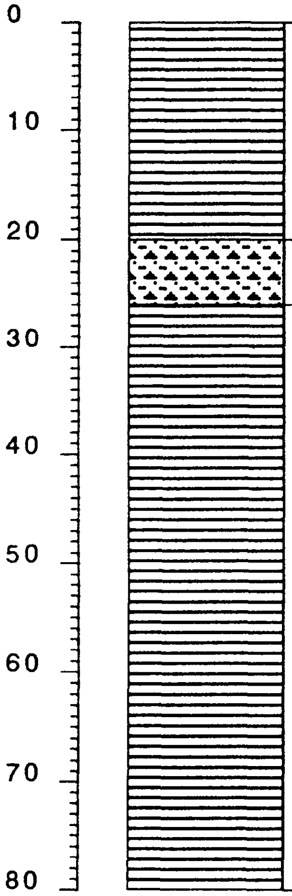
LAMINATED MUD: weakly laminated by color changes, mm thick silt laminae at 140 cm, isolated pebble at 143 cm, greenish gray

PEBBLY MUD: granite pebbles up to 1.5 cm in diameter, medium dark gray

LAMINATED MUD: color laminated, dark greenish gray from 155 to 160 cm with sharp lower contact; from 160 to 182 cm color grades from light gray through dark gray, light gray from 180 to 186 cm, from 186 to 190 cm, olive gray mud, light gray mud below

AH93 YB GC-16

DEPTH IN CM **LITHOLOGY** **SECTION DESCRIPTION**

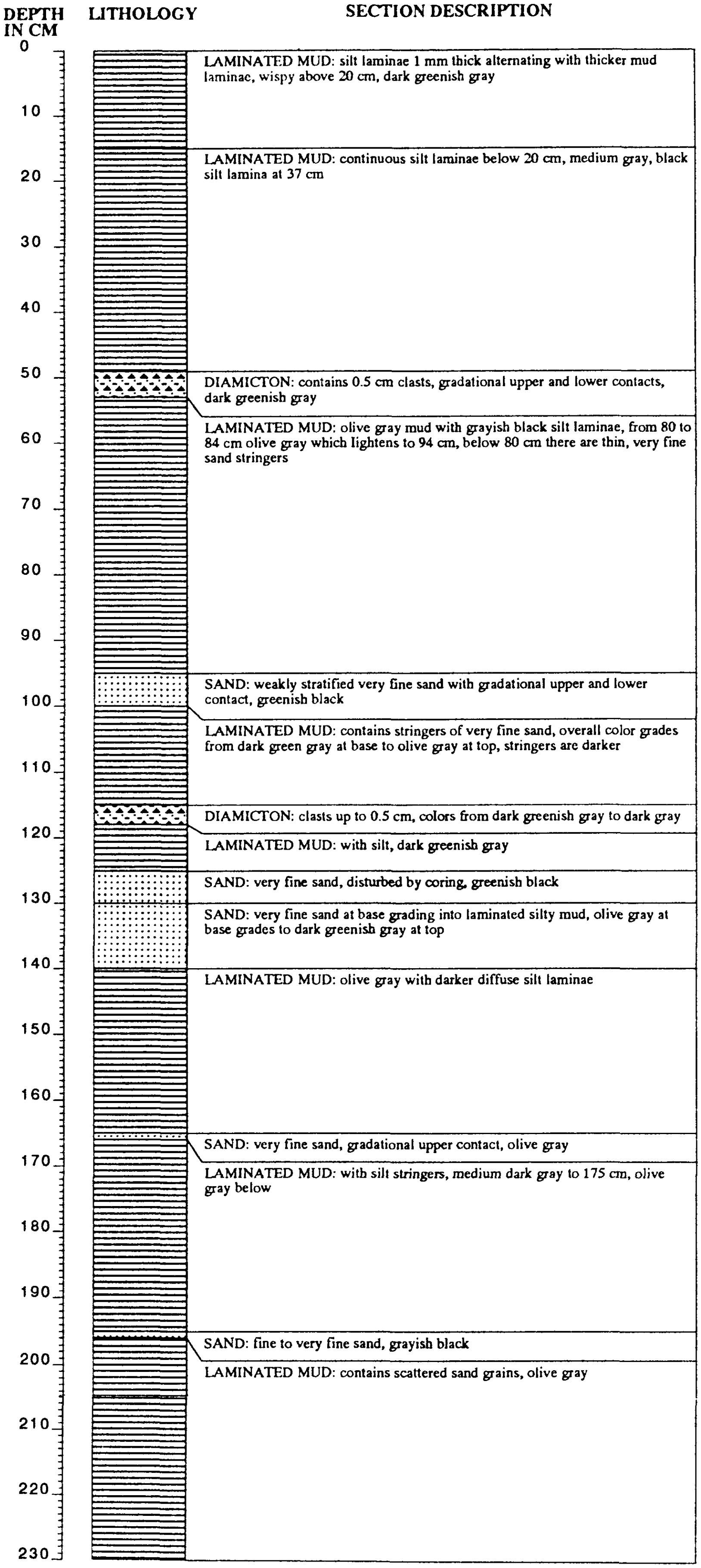


LAMINATED MUD: soupy, weakly laminated with silt, contains a few sand grains, dark greenish gray from 0-19 cm, dark gray from 19 to 20 cm

DIAMICTON: gradational upper and lower contacts, light olive gray

LAMINATED MUD: light olive gray from 26 to 35 cm, light gray from 35-36, 1 mm thick silt lamina below, 2 mm thick silt lamina at 42 cm, diffuse silt lamina below, dark greenish gray from 50 to 70 cm, light greenish gray from 70 to 80 cm

AH93 YB GC-18



SECTION DESCRIPTION

LAMINATED MUD: silt laminae 1 mm thick alternating with thicker mud laminae, wispy above 20 cm, dark greenish gray

LAMINATED MUD: continuous silt laminae below 20 cm, medium gray, black silt lamina at 37 cm

DIAMICTON: contains 0.5 cm clasts, gradational upper and lower contacts, dark greenish gray

LAMINATED MUD: olive gray mud with grayish black silt laminae, from 80 to 84 cm olive gray which lightens to 94 cm, below 80 cm there are thin, very fine sand stringers

SAND: weakly stratified very fine sand with gradational upper and lower contact, greenish black

LAMINATED MUD: contains stringers of very fine sand, overall color grades from dark green gray at base to olive gray at top, stringers are darker

DIAMICTON: clasts up to 0.5 cm, colors from dark greenish gray to dark gray

LAMINATED MUD: with silt, dark greenish gray

SAND: very fine sand, disturbed by coring, greenish black

SAND: very fine sand at base grading into laminated silty mud, olive gray at base grades to dark greenish gray at top

LAMINATED MUD: olive gray with darker diffuse silt laminae

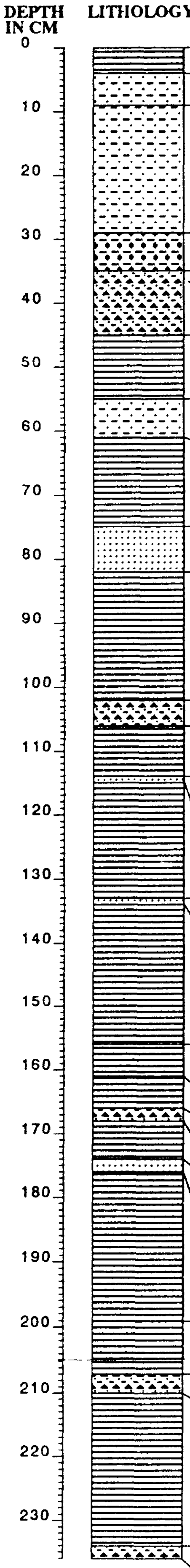
SAND: very fine sand, gradational upper contact, olive gray

LAMINATED MUD: with silt stringers, medium dark gray to 175 cm, olive gray below

SAND: fine to very fine sand, grayish black

LAMINATED MUD: contains scattered sand grains, olive gray

AH93 YB GC-19



SECTION DESCRIPTION

LAMINATED MUD: with mm scale laminae, dark greenish gray

SANDY MUD: with 1 cm pebble at base, dark greenish gray

SANDY MUD: with mm scale laminae, olive gray

PEBBLY MUD: with angular pebbles up to 1.5 cm, olive gray

DIAMICTON: laminated, pebbles are between 1.0 and 1.5 cm, olive gray

LAMINATED MUD: with sand laminae, olive gray

SANDY MUD: laminated, with pebbles up to 0.5 cm, pebble at 61 cm is 2 cm, olive gray

LAMINATED MUD: from 61 to 68 cm: 3 sets of color cycles from olive gray at base to lighter grayish olive above, laminae throughout, below 68 cm several silt laminae, grayish olive

SAND: 2 fining upward units of very fine sand to muddy silt, greenish black at base, dark greenish gray at top

LAMINATED MUD: silt laminae are 1-2 mm thick, laminae are olive gray in dark greenish gray mud

DIAMICTON: with pebbles up to 3 cm, dark greenish gray

LAMINATED MUD: olive gray

SAND: fine sand with sharp lower contact and gradational upper contact, olive black

LAMINATED MUD: olive gray silt laminae at 120 to 121 cm grading into dark greenish gray at base

SAND: very fine sand, dark greenish gray

LAMINATED MUD: silt laminae on mm scale, olive gray to 136 cm, dark greenish gray from 136 to 143, olive gray below

LAMINATED MUD: with fine sand laminae, gradational upper and lower contact, olive gray

LAMINATED MUD: with silt laminae dark greenish gray

DIAMICTON: pebbles up to 1 cm, medium dark gray

LAMINATED MUD: with silt, olive gray at base, dark greenish gray at top

SAND: interbedded fine to very fine sand with mud with ripple cross laminae, sands are olive black

LAMINATED MUD: mm thick silt laminae, silt laminae are dark, mud laminae are light, dark greenish gray

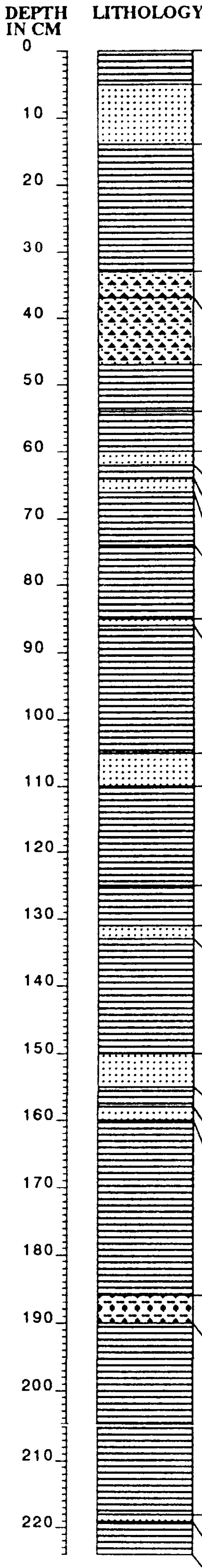
LAMINATED MUD: less silt than above, dark greenish gray

DIAMICTON: with pebbles up to 4 cm, medium dark gray

LAMINATED MUD: with silt laminae, pebble at 215 cm, dark greenish gray

DIAMICTON: with pebble up to 3 cm, olive gray

AH93 YB GC-20



SECTION DESCRIPTION

LAMINATED MUD: sand laminae, olive gray

SAND: laminated fine sand, lower contact gradational, upper contact disturbed, dark greenish gray

LAMINATED MUD: with dispersed gravel up to 0.5 cm and sand, laminae are 2mm thick, medium dark gray

DIAMICTON: with pebbles up to 3 cm, dark gray near base, olive gray near top, weakly laminated near the base

DIAMICTON: weakly laminated angular pebbles up to 2.5 cm, gradational contacts, olive gray

LAMINATED MUD: with silt laminae, 2.5 units based on color, olive gray on bottom with dark greenish gray above

LAMINATED MUD: with fine sand laminae, 2-3 cm thick, olive gray

SAND: fine sand, sharp upper and lower contacts

LAMINATED MUD: with sand, angular pebble 5 cm diameter, olive gray

SAND: stratified fine sand with mud streamers, sharp contacts, dark gray

LAMINATED MUD: sand laminae 2 mm thick, olive gray

LAMINATED MUD: silt laminae 1 mm thick, light olive gray

SAND: fine sand, sharp upper contact, gradational lower contact, dark gray

LAMINATED MUD: silt laminae 1 mm thick, light olive gray

SAND: fine sand, sharp upper and lower contacts, dark gray

LAMINATED MUD: dark coarse silt lamina 2 mm thick at 117 cm, several pebbles at 124 cm, dark mud lamina 0.5 cm beneath, olive gray

LAMINATED MUD: weakly laminated, olive gray

SAND: dark fine sand, sharp upper and lower contacts

LAMINATED MUD

SAND: massive fine sand, darker lense in upper corner, no size change between colors, dark gray

LAMINATED MUD: dark gray

SAND: massive fine sand, sharp upper and lower contacts, dark gray

LAMINATED MUD: fine sand laminae evenly spaced throughout, 2 mm thick fine sand lamina at 162 cm, 2 mm thick fine sand lamina at 164 cm, coarse silt between

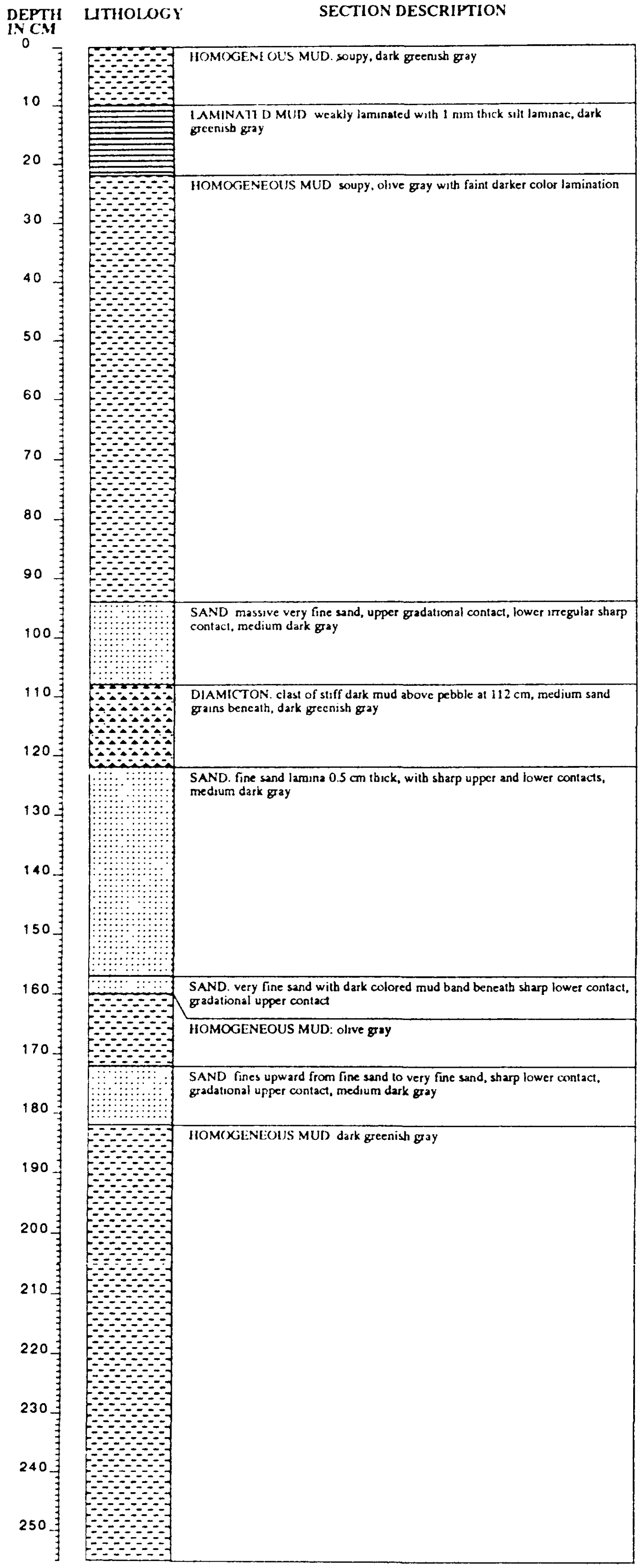
PEBBLY MUD: zone with pebbles and dark muddy laminae throughout, medium dark gray

LAMINATED MUD: fine sand laminae, olive gray

SAND: fine sand lamina 0.5 cm thick

LAMINATED MUD: fine sand laminae, olive gray

AH93 YB GC-21



HOMOGENEOUS MUD. soupy, dark greenish gray

LAMINATED MUD weakly laminated with 1 mm thick silt laminae, dark greenish gray

HOMOGENEOUS MUD soupy, olive gray with faint darker color lamination

SAND massive very fine sand, upper gradational contact, lower irregular sharp contact, medium dark gray

DIAMICTON. clast of stiff dark mud above pebble at 112 cm, medium sand grains beneath, dark greenish gray

SAND. fine sand lamina 0.5 cm thick, with sharp upper and lower contacts, medium dark gray

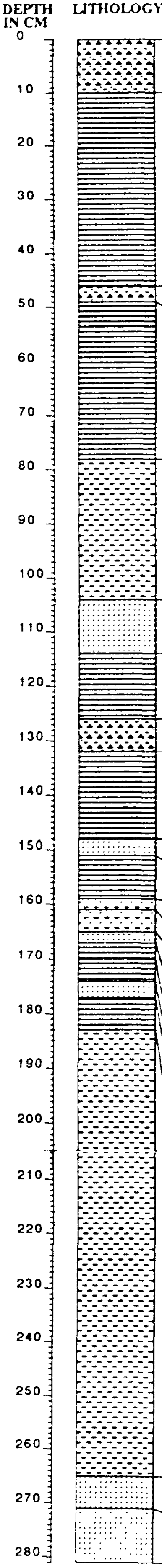
SAND. very fine sand with dark colored mud band beneath sharp lower contact, gradational upper contact

HOMOGENEOUS MUD: olive gray

SAND fines upward from fine sand to very fine sand, sharp lower contact, gradational upper contact, medium dark gray

HOMOGENEOUS MUD dark greenish gray

AH93 YB GC-22



SECTION DESCRIPTION

DIAMICTON with pebbles up to 4 cm long, dark greenish gray

LAMINATED MUD with dark greenish gray laminae alternating with olive gray laminae, units are up to 3 cm thick, darker units are more silty

DIAMICTON: with pebbles up to 0 5 cm, olive gray

LAMINATED MUD: dark greenish gray with darker silt laminae, leaf at 65 cm, dark color around leaf

HOMOGENEOUS MUD very few dispersed silt grains, lower contact gradational, dark greenish gray

SAND fining upward from fine to very fine sand, color grades upward from dark gray to medium dark gray

LAMINATED MUD dark greenish gray with darker silt laminae

DIAMICTON with pebbles up to 0 5 cm, olive gray

LAMINATED MUD: weakly laminated, few burrows, scattered granules

SAND disturbed, dark gray

LAMINATED MUD: with 2 pebbles, 5-6 cm width at 156 cm with sand grains around them, dark greenish gray

SANDY MUD. darker greenish gray than above

SANDY MUD: laminated with pebbles up to 0.5 cm, dark greenish gray

SAND fine sand fining upward to muddy silt, sharp lower contact, gradational upper contact, dark gray at base lightens to dark greenish gray at top

LAMINATED MUD. contains some sand, medium dark gray, grayish black mud stringer at base

LAMINATED MUD dark greenish gray

SAND laminated with sharp upper and lower contacts, dark gray

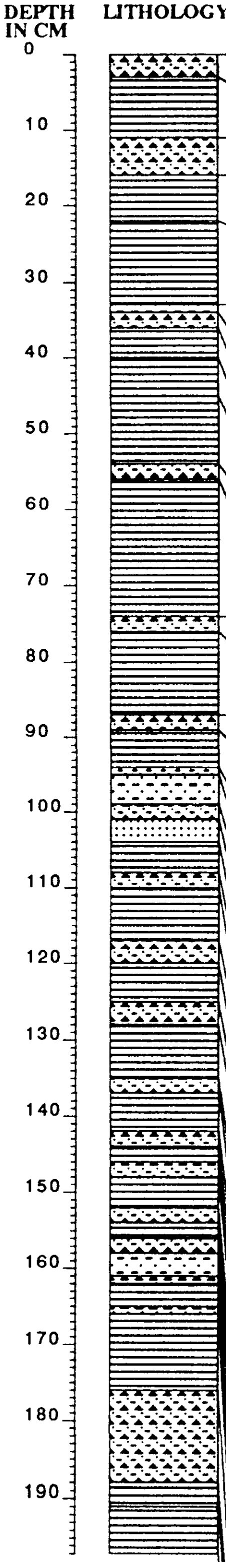
LAMINATED MUD thin mud lamina at bottom with pebbles up to 1 cm and scattered sand grains, middle has 1 cm of brownish gray mud

HOMOGENEOUS MUD: contains some scattered sand grains, olive gray

SAND fining upward from fine sand to muddy silt, gradational upper and lower contacts, dark greenish gray

SAND fining upward fine sand to muddy very fine sand, dark gray

AH93 YB GC-23



SECTION DESCRIPTION

DIAMICTON: pebbles greater than 1 cm, olive gray

LAMINATED MUD: sand laminae, olive gray to 8 cm, dark greenish gray below

DIAMICTON: pebbles up to 1 cm at base, top is muddy, olive gray

LAMINATED MUD: 3 units, each unit is 2 cm thick, olive gray at base to dk. greenish gray at top, more silt in bottom layer, sharp color change at base of unit

LAMINATED MUD: 3 units, each unit is 2.5 to 3.0 cm

SANDY MUD: olive gray

DIAMICTON: sharp lower contact, olive gray

LAMINATED MUD: olive gray at base, greenish gray on top

LAMINATED MUD: 4 units, each unit is 1 to 1.5 cm thick

LAMINATED MUD: 4 units, each is up to 2 cm, grades from olive gray at base to greenish gray at top

DIAMICTON: darker olive gray than above

LAMINATED MUD: less than 1 cm thick laminae are defined by color changes, few sand grains at top and 2 units with gradational color change as above, olive gray above 60 cm, dark greenish gray above 71 cm, olive gray below 71 cm

DIAMICTON: pebbles up to 1.5 cm, olive gray

LAMINATED MUD: becomes lighter olive gray upward

DIAMICTON: pebbles up to 1 cm, olive gray

LAMINATED MUD: base is dark olive gray, lighter toward the top, 1 cm pebble, scattered sand

DIAMICTON: pebbles up to 1 cm, olive gray

SANDY MUD: with silt stringers

DIAMICTON: pebbles up to 1 cm , olive gray

SAND: fine sand, sharp lower contact, gradational upper contact

LAMINATED MUD: with sand, olive gray

DIAMICTON: pebbles at the base

LAMINATED MUD: with sand, dark greenish gray

DIAMICTON: pebbles up to 2 cm

LAMINATED MUD: 1 dark to light unit

DIAMICTON: pebbles up to 1.2 cm, olive gray

LAMINATED MUD: 3 cycles of dark above light mud, cycles become thinner upward, from 2.5 cm to 2 cm to 1.5 cm, below 133 cm lighter greenish gray with sand

DIAMICTON: pebbles up to 1.5 cm

LAMINATED MUD: 1 cycle of dark above light mud

DIAMICTON

LAMINATED MUD: light laminated mud with 2 pebbles

DIAMICTON

LAMINATED MUD: 1 dark above light unit

DIAMICTON: pebbles up to 3.5 cm

LAMINATED MUD: darker laminae, 1 pebble 1 cm diameter

DIAMICTON: pebbles up to 1.5 cm

SANDY MUD

DIAMICTON: with 2 pebbles (3.5 and 5 cm) which cross into underlying muds

LAMINATED MUD

DIAMICTON: 1 cm thick, pebbles are less than 1 cm

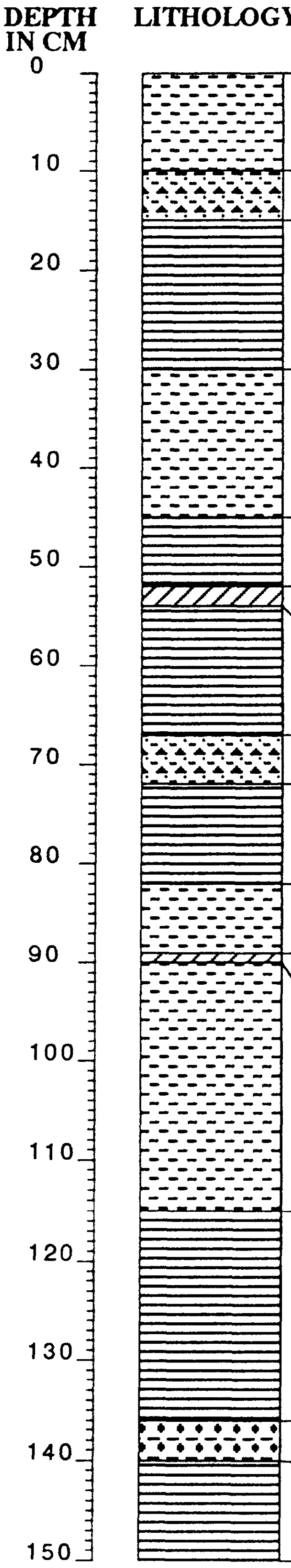
LAMINATED MUD: dark greenish gray

DIAMICTON: pebble 7 cm diameter, medium dark gray

LAMINATED MUD: dark above light with few sand grains, olive gray

LAMINATED MUD: olive gray

AH93 YB GC-24



SECTION DESCRIPTION

HOMOGENEOUS MUD: dark greenish gray

DIAMICTON: weakly stratified, dark greenish gray at top to olive gray at base

LAMINATED MUD: with faint silt laminae on a mm scale, medium gray

HOMOGENEOUS MUD: contains scattered sand grains from 30 to 35 cm, dark greenish gray

LAMINATED MUD: with thin silt laminae, diffuse in appearance, medium gray

SILT: sharp contacts, medium dark gray

LAMINATED MUD: with thin silt laminae, diffuse in appearance, medium gray

DIAMICTON: pebbles up to 3.5 cm, dark greenish gray

LAMINATED MUD: 2 couplets of light colored mud laminae and dark colored silt laminae

HOMOGENEOUS MUD: dark greenish gray

SILT: dark with wispy mud

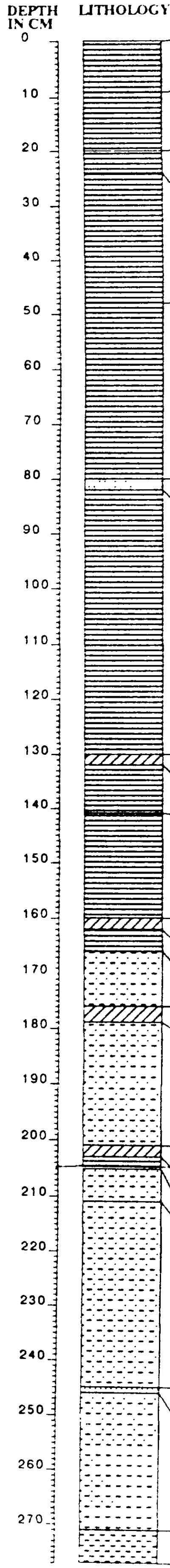
HOMOGENEOUS MUD: contains a few silt laminae, dark greenish gray to 110 cm, olive gray below

LAMINATED MUD: with silt laminae 1 mm thick or less, medium gray forms a sharp contact with olive gray above

PEBBLY MUD: dark greenish gray

LAMINATED MUD: medium gray

AH93 YB GC-25



SECTION DESCRIPTION

LAMINATED MUD. soupy, contains worm tubes, alternating laminae of brownish gray and dark greenish gray, bottom is darker than above

LAMINATED MUD slightly darker olive gray at bottom than at the top, contains worm tubes

LAMINATED MUD· thin laminae, dark greenish gray above olive gray, with worm tubes

LAMINATED MUD weakly laminated 24 -38 cm, contains burrows, pebble 3.5 cm at 33 cm, below 38 cm strongly laminated mud with dark gray laminae, medium dark gray overall

LAMINATED MUD: olive gray to 60 cm, medium dark gray below

SAND olive gray

LAMINATED MUD medium dark gray, weakly laminated with mottled slightly darker color, scattered pebbles and a small pocket of fine sand about 1 cm in diameter, black organic lense at 100 cm

SILT poorly sorted, sharp upper and lower contacts, dark greenish gray

LAMINATED MUD with one silt stringer at 138 cm, olive gray, 1 cm thick silt lamina at 140 cm, medium dark gray

LAMINATED MUD· weakly laminated with pebbles and 1-2 mm silt lenses, olive gray

SILT sharp upper and lower contacts, olive gray

LAMINATED MUD: olive gray

SANDY MUD laminated, small burrows, worm tube at 170 cm, color change from olive gray to dark greenish gray at the base

SILT· poorly sorted, muddy at top and bottom contact, olive gray

SANDY MUD. weakly laminated, small worm burrows, scattered gravel, silt lenses 1 mm to 1 cm in diameter, shell fragment at 195 cm, olive gray

SILT sharp upper and lower contacts, medium dark gray

LAMINATED MUD: weakly laminated with silt, olive gray

SANDY MUD· laminated with scattered pebbles, medium dark gray

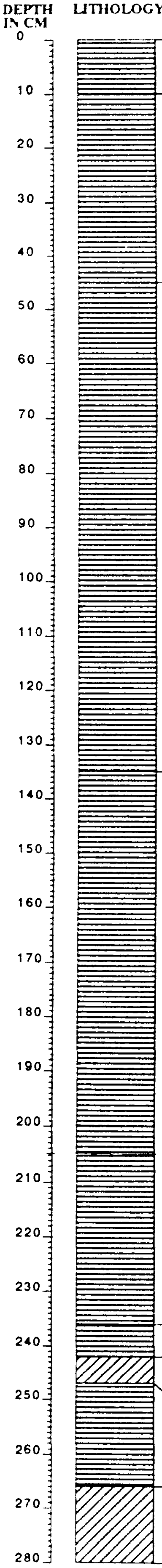
SANDY MUD alternating sandy mud 1 to 3 cm thick with silt to fine sand laminae from 2 mm to 4 mm thick, sharp contacts between sand and silt, scattered pebbles and silt lenses

SAND very fine sand, with sharp contacts, medium dark gray

SANDY MUD alternating sandy mud 1 to 3 cm thick with silt to fine sand laminae from 2 mm to 4 mm thick, sharp contacts between sand and silt, scattered pebbles and silt lenses

HOMOGENEOUS MUD stiff mud, medium dark gray

AH93 YB GC-26



SECTION DESCRIPTION

LAMINATED MUD worm tube at top, soupy, shades of olive gray

LAMINATED MUD from 10 to 20 cm grayish olive, light olive laminae 1 mm thick to 29 cm, olive gray below, silt stringer at 27 cm

LAMINATED MUD with worm burrows, organic stringers with mottled texture, diffuse or gradational color changes between dk. greenish gray and olive gray, 1 cm thick sand lamina at 80 cm, organic layer at 95 cm, pebbles at 115 cm

LAMINATED MUD less organic material than above, pebbles at 150, 190, 230 cm, worm burrows filled with silt or organics are common, scattered sand grains

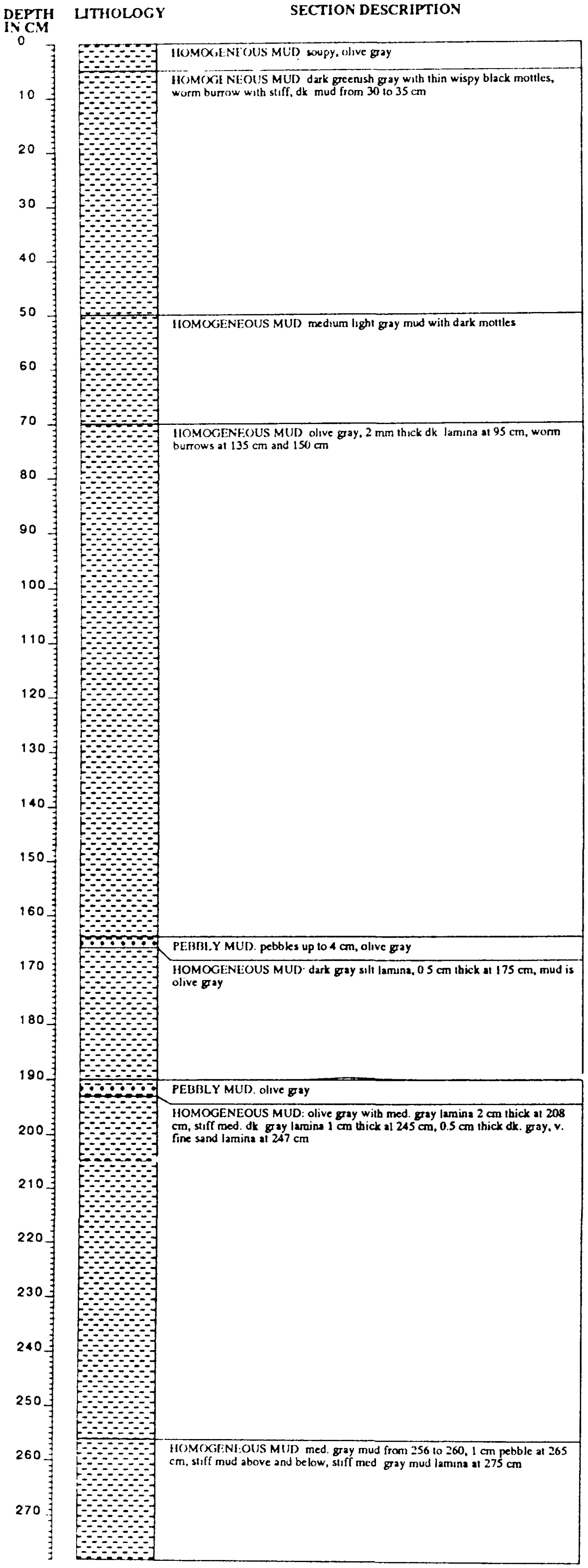
LAMINATED MUD. with more organic material than above, greenish black

SILT: 1 cm pebble at top, 2 silt clasts, 3.5 cm long and 1 cm wide, 1 cm long and 0 5 cm wide, silt clasts are cross laminated, olive gray

LAMINATED MUD· with burrows at 258 cm and scattered sand grains, olive gray

SILT fines upward to clay, olive gray

AH93 YB GC-27



HOMOGENEOUS MUD soupy, olive gray

HOMOGENEOUS MUD dark greenish gray with thin wispy black mottles, worm burrow with stiff, dk mud from 30 to 35 cm

HOMOGENEOUS MUD medium light gray mud with dark mottles

HOMOGENEOUS MUD olive gray, 2 mm thick dk lamina at 95 cm, worm burrows at 135 cm and 150 cm

PEBBLY MUD. pebbles up to 4 cm, olive gray

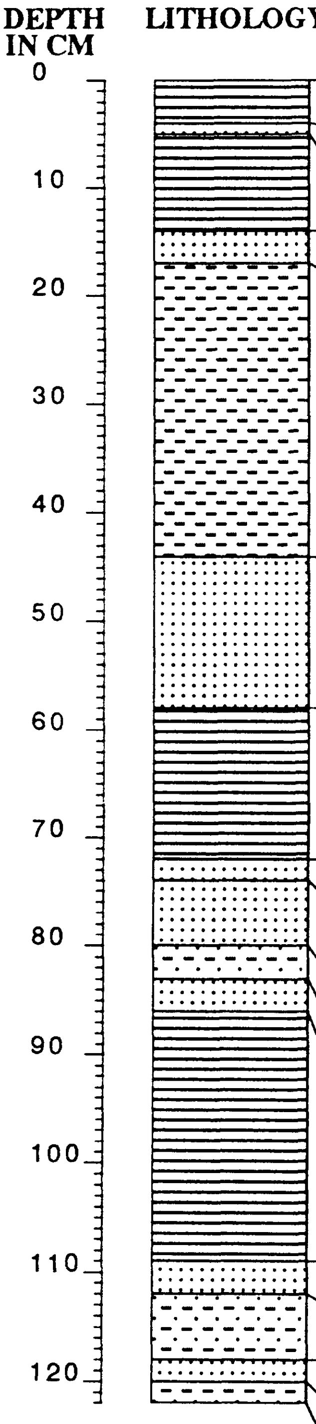
HOMOGENEOUS MUD· dark gray silt lamina, 0 5 cm thick at 175 cm, mud is olive gray

PEBBLY MUD. olive gray

HOMOGENEOUS MUD: olive gray with med. gray lamina 2 cm thick at 208 cm, stiff med. dk gray lamina 1 cm thick at 245 cm, 0.5 cm thick dk. gray, v. fine sand lamina at 247 cm

HOMOGENEOUS MUD med. gray mud from 256 to 260, 1 cm pebble at 265 cm, stiff mud above and below, stiff med gray mud lamina at 275 cm

AH93 YB GC-28



SECTION DESCRIPTION

LAMINATED MUD: with silt, olive gray

SAND: medium sand, greenish black

LAMINATED MUD: dark greenish gray

SAND: fines upward into greenish gray mud

HOMOGENEOUS MUD: olive gray to 19 cm, dk. greenish gray to 22 cm, olive gray to 44 cm, mottled sandy mud lamina from 35 to 36 cm, worm tube at 31 cm, burrows below 35 cm

SAND: 3 sand units with the following - sharp lower contact, dark greenish gray medium to fine sand with a sandy mud lamina between the sand laminae

LAMINATED MUD: sand in mud between 65 and 66 cm, sand stringer at 65 cm, dark greenish gray with mottles

SAND: fining upward medium to fine sand, olive gray

SAND: 3 medium to fine sand laminae separated by thin sandy mud laminae, sand laminae are greenish black, mud is olive gray

SANDY MUD: with burrows at the top, sand stringers

SAND: silt to fine sand

LAMINATED MUD: with burrows and sand stringers, 2 cm pebble at 96 cm, olive gray

SAND: medium to fine sand, fines upward to silt and mud stringers

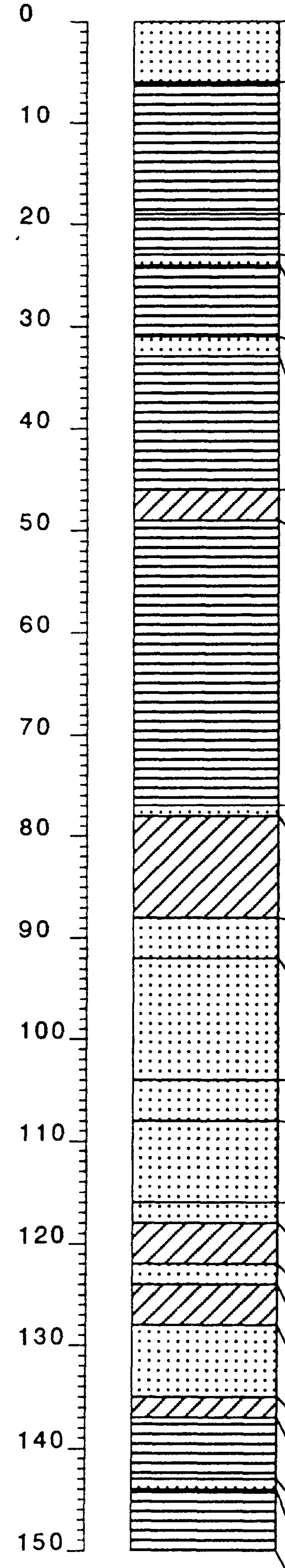
SANDY MUD: with burrows, olive gray

SAND: medium sand, sharp contact, greenish black

SANDY MUD: with 1 cm diameter pebble

AH93 GB GC-3

DEPTH IN CM **LITHOLOGY** **SECTION DESCRIPTION**



SAND: fine sand, olive gray

LAMINATED MUD: with up to 1 cm thick sand stringers, light olive

LAMINATED MUD: silty mud with fine sand stringers, grayish olive

SAND: fine to medium sand, olive gray

LAMINATED MUD: grayish olive

SAND: medium sand at base with laminated silt above, sharp upper contact, olive gray

LAMINATED MUD: interlaminated sand and mud, laminae of about equal thickness, mud is grayish olive, sand is olive gray

SILT: upward fining silt, sharp lower contact, gradational upper contact

LAMINATED MUD: interlaminated fine sand and mud, mud is grayish olive, sand is olive gray, more mud than between 33 and 46 cm, below 61 cm more silt than sand

SAND: graded, olive gray

SILT: laminated silt and fine sand, 1 mm thick at the base, toward the top there are 3 couplets of silt capped with fine sand, olive gray

SAND: 8 couplets of sand fining upward to silt, lower couplets are thicker (1 cm), upper contacts are thinner (0.5 cm). Sharp lower contacts, olive gray

SAND: laminated sand, some laminae up to 1 cm thick, higher sand content overall

SAND: 3 couplets of sand fining upward to silt

SAND: laminated sand, some laminae up to 1 cm thick

SAND: fines upward from medium to fine sand, olive gray

SILT: alternating sand and silt laminae, 1.7 cm sand lamina in middle

SAND: fines upward from medium to fine sand, olive gray

SILT: laminated with fine sand stringers

SAND: laminated sand with silt, sand is grayish olive green, silt is grayish olive

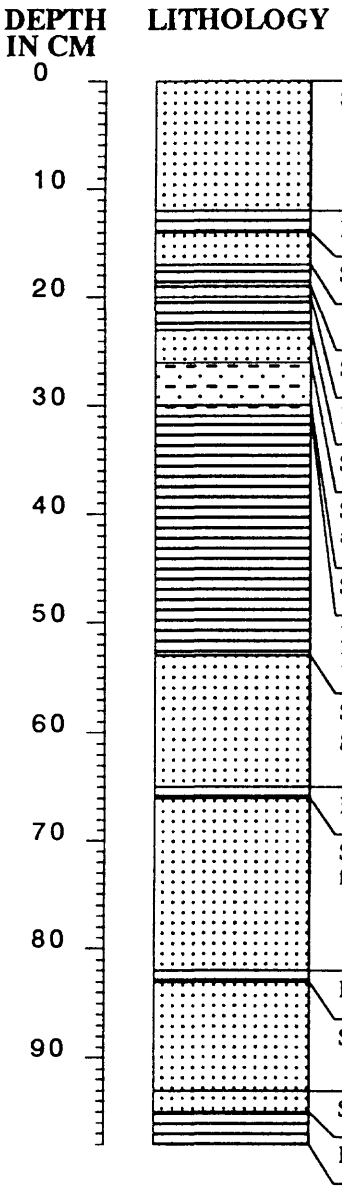
SILT: sandy silt, grayish olive green

LAMINATED MUD: with fine sand laminae, grayish olive

SAND: grayish olive

LAMINATED MUD: with fine sand laminae, grayish olive

AH93 GB GC-5



SECTION DESCRIPTION

SAND: disturbed, laminated fine sand, olive gray

LAMINATED MUD: grayish olive

SAND: laminated fine sand, olive gray

LAMINATED MUD: grayish olive

SAND: fine sand, olive gray

LAMINATED MUD: olive gray

SAND: fines upward, sharp lower contact, olive gray

SANDY MUD: laminated with fine sand, mud lighter grayish olive than mud above

SANDY MUD: dark greenish gray

LAMINATED MUD: 6 fine sand laminae in grayish olive mud, thinnest sand is 1 mm, thickest is 0.5 cm

SAND: medium sand, stratified at top, weakly graded at base, darker sand at top, greenish black

LAMINATED MUD: grayish olive

SAND: 3 couplets that fine upward from medium sand to mud, lower couplet is finer and 2 cm, other couplets are 6 cm thick

LAMINATED MUD: with sand, grayish olive

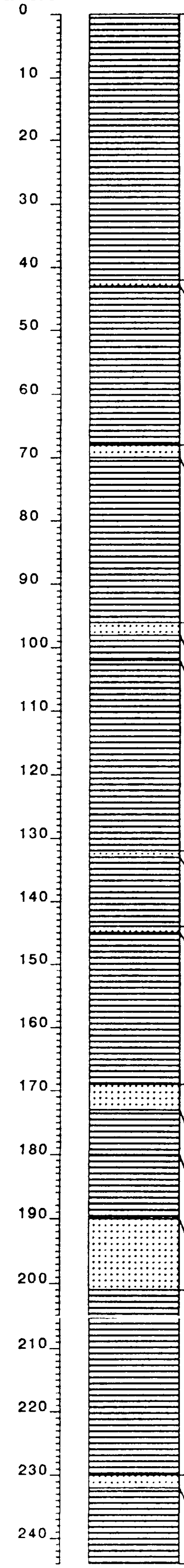
SAND: medium sand, fines upward, greenish black

SAND: fine sand: fines upward, greenish black

LAMINATED MUD: grayish olive

AH93 GB GC-6

DEPTH IN CM **LITHOLOGY** **SECTION DESCRIPTION**



LAMINATED MUD: faint 1 mm thick laminae, shades of grayish olive, few scattered sand grains, 0.5 cm thick dark greenish gray mud lamina at 10 cm

SAND: normally graded sand, olive gray, with black, organic (?) layer on top

LAMINATED MUD: with some thin sand stringers, grayish olive

SAND: interlaminated fine sand and mud, sand is thicker, up to 0.5 cm on top, 7 to 8 sand laminae, olive gray

LAMINATED MUD: with scattered sand grains, olive gray

SAND: medium sand grading into fine sand, sharp upper contact, erosional lower contact (?), olive gray

LAMINATED MUD: soupy, olive gray

LAMINATED MUD: top is 1 cm thick brown shade of grayish olive, color becomes a grayer shade of dark greenish gray at base, sand stringers occur at 105 and 117 cm

SAND: fine sand, olive gray, with a thin olive gray mud lamina beneath

LAMINATED MUD: grayish olive

SAND: medium sand

LAMINATED MUD: grayish olive, 0.4 cm thick sand lamina at 151 cm, thin dark greenish gray mud and sand couplet at 156 cm, sand stringer at 165 cm

SAND: alternating sand and mud laminae above a 1 cm thick sand lamina, sand is reverse graded from fine to med. sand to the middle and fine sand above, dk. greenish gray

LAMINATED MUD: dark greenish gray, 0.5 cm olive gray fine sand lamina at base

LAMINATED MUD: with thin silt to sand stringers, shades of grayish olive, at 184 cm color changes over 1 cm from a blackish layer to greenish gray to olive gray

SAND: fining upward from medium to fine sand

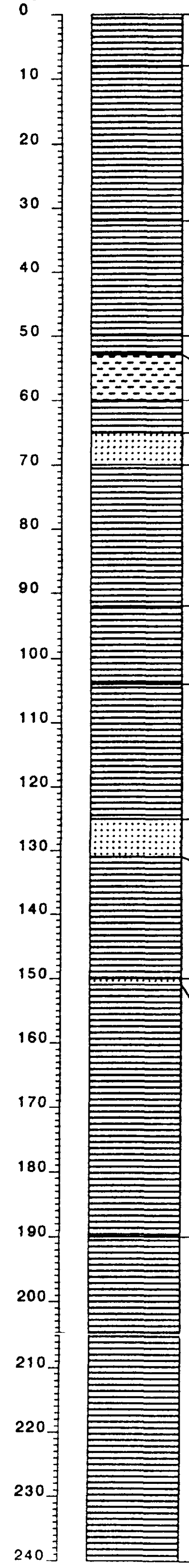
LAMINATED MUD: with a few sand stringers, grayish olive

SAND: 2 mm fine sand layer at top, laminae color change from black to greenish gray to olive gray

LAMINATED MUD: grayish olive

AH93 GB GC-7

DEPTH IN CM **LITHOLOGY** **SECTION DESCRIPTION**



LAMINATED MUD: dark laminae mm thick, greenish gray

LAMINATED MUD: 6 sand laminae 2-3 mm thick at 1.5 to 2.0 cm spacing from 20 to 32 cm, light olive gray

LAMINATED MUD: thick sand laminae above thin laminae, between 32 to 38 cm there are 8, 0.2-0.3 cm sand laminae, gradational upper and lower contacts, 40 to 46 cm fine silt laminae, from 46 to 50 cm there are 5, 2-5 mm thick sand laminae, greenish gray

LAMINATED MUD: weakly laminated

HOMOGENEOUS MUD: light olive gray

LAMINATED MUD: weakly laminated with silt, light olive gray

SAND: normal graded from coarse sand to silt, medium dark gray

LAMINATED MUD: from 70 to 76 cm light olive gray with brown and black 1 mm thick laminae, pebble at 72 cm, below 76 cm faintly laminated mud, greenish gray

LAMINATED MUD: silty laminae that range from 1 to 5 mm thick, dark greenish gray

LAMINATED MUD: sand laminae from 2 to 4 mm thick, olive gray

SAND: fine sand, sharp contacts above and below, muddy lamina 3 mm thick at 128 cm, very fine sand from 128 to 131 cm

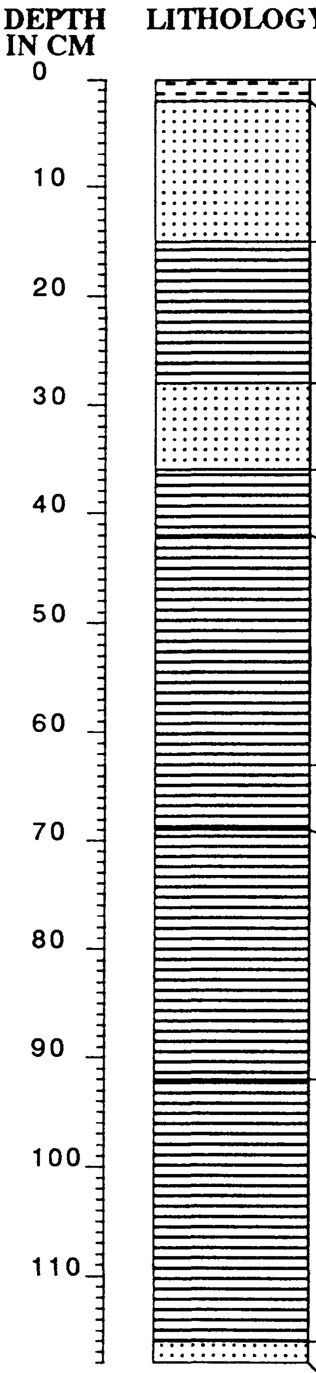
LAMINATED MUD: alternating olive gray and greenish gray, 2mm thick very fine sand lamina at 139 cm, greenish gray mud with 1 mm thick silt laminae

SAND: fine sand lamina 0.5 cm

LAMINATED MUD: olive gray mud with faint laminae and dispersed sand grains

LAMINATED MUD: color laminae in shades of olive gray with a 6 mm black lamina at 229 cm, thicker sand laminae occur at 195, 197, 205, 210, 212, 216, 225, 232, 235, 238 cm

AH93 GB GC-8



SECTION DESCRIPTION

HOMOGENEOUS MUD: light olive gray

SAND: normal graded medium to very fine sand, sharp lower contact, disturbed upper contact, medium gray

LAMINATED MUD: 15 sand and mud couplets, each couplet ranges in thickness between 2 mm to 1.5 cm, mud is thicker than sand

SAND: normal graded medium to very fine sand, sharp upper and lower contacts, medium gray

LAMINATED MUD: 4 couplets of fine sand laminae and 0.5 cm thick mud laminae, sharp lower contact, medium gray

LAMINATED MUD: 25 couplets of very fine sand and mud, mud thickness is about 2 cm, sand thickness is less than 1 mm, mud thickness is more variable than sand, light olive gray

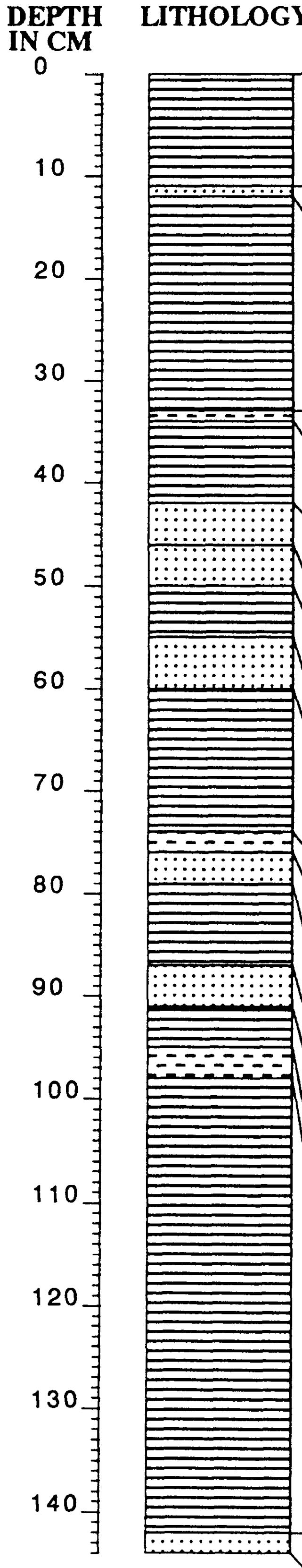
LAMINATED MUD: 10 couplets of regularly spaced fine sand laminae (2 mm to 1 cm thick) with 5 mm mud between

LAMINATED MUD: 51 couplets of fine sand laminae and mud, sand laminae range in thickness from a few grains to 0.5 cm, mud laminae thicker than corresponding sand laminae

LAMINATED MUD: weakly laminated mud with silt to very fine sand laminae at 93, 93.5, and 106 cm

SAND: fine sand

AH93 GB GC-9



SECTION DESCRIPTION

LAMINATED MUD: laminae are olive gray in grayish olive mud

SAND: massive fine sand laminae, dark grenish gray

LAMINATED MUD: weakly laminated, dark greenish gray

HOMOGENEOUS MUD: mottled dark mud layer

LAMINATED MUD: 1 mm thick very fine sand laminae, appear discontinuous, dark greenish gray

SAND: normal graded, medium to fine sand, medium to dark color, mud laminae from 46 to 46.4 cm, dark greenish gray

SAND: massive fine sand, sharp upper and lower contacts

LAMINATED MUD: 13 couplets of fine sand and mud, mud lamine are olive gray and thicker, sand laminae are dark gray

SAND: fine sand with wispy mud laminae

LAMINATED MUD: rhythmically laminated fine sand or silt 1 mm to 3 mm thick in dark greenish mud, couplets are 2 mm thick, laminae are more regular and abundant between 66 and 74 cm

HOMOGENEOUS MUD: gray

SAND: normal graded coarse sand to silt, sharp lower contact, gradational upper contact, medium dark gray

LAMINATED MUD: rhythmically laminated greenish gray mud, sand laminae are 2 mm to 1 grain thick

SAND: medium to fine sand, dark gray

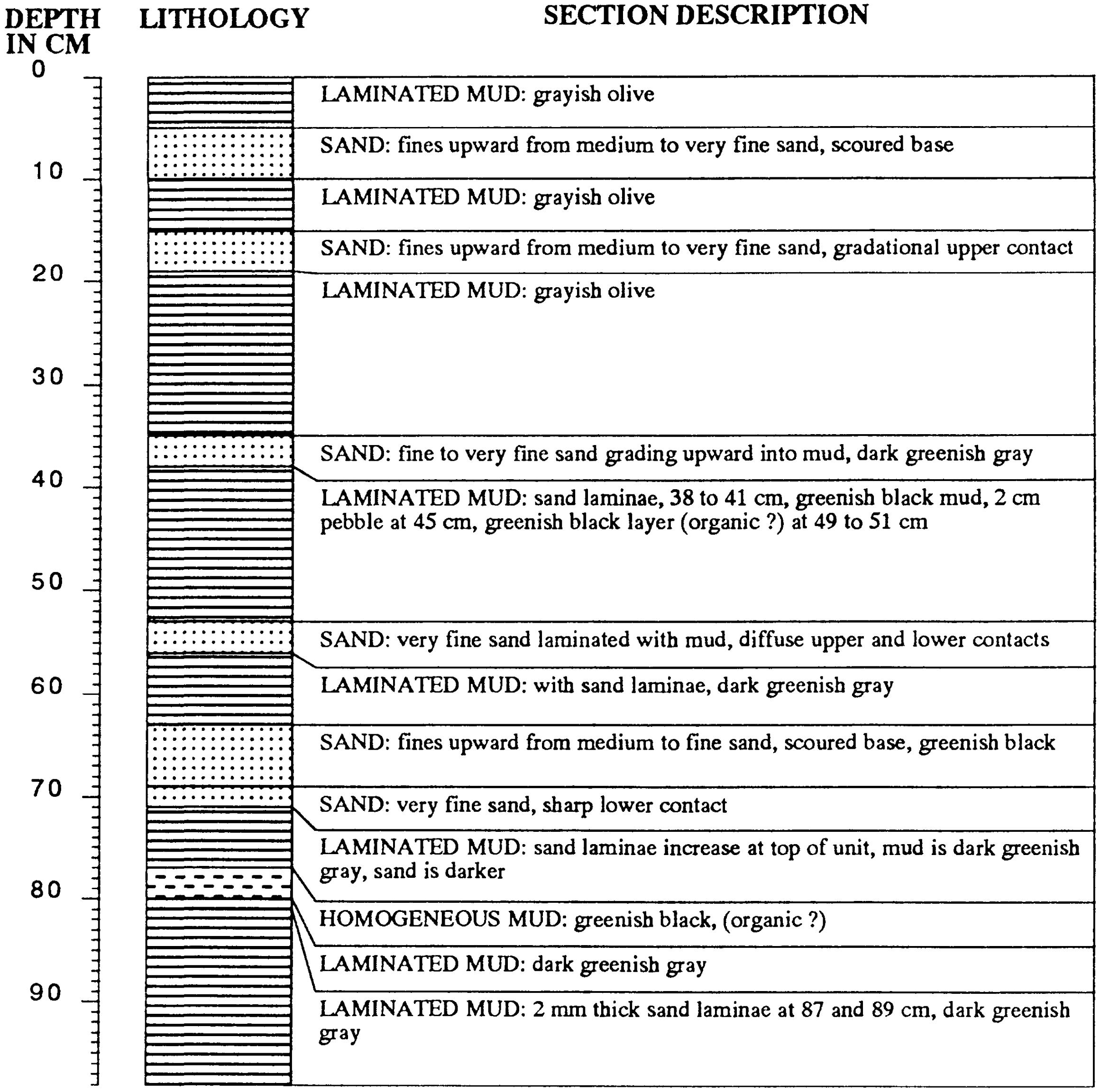
LAMINATED MUD: 37 couplets 2 mm thick with fine to very fine sand lamina, dark greenish gray

HOMOGENEOUS MUD: dark gray "organic layer"

LAMINATED MUD: rhythmically laminated mud with fine sand laminae 2 mm to single grain thick, dark greenish gray

SAND: grayish black

AH93 GB GC-10



LAMINATED MUD: grayish olive

SAND: fines upward from medium to very fine sand, scoured base

LAMINATED MUD: grayish olive

SAND: fines upward from medium to very fine sand, gradational upper contact

LAMINATED MUD: grayish olive

SAND: fine to very fine sand grading upward into mud, dark greenish gray

LAMINATED MUD: sand laminae, 38 to 41 cm, greenish black mud, 2 cm pebble at 45 cm, greenish black layer (organic ?) at 49 to 51 cm

SAND: very fine sand laminated with mud, diffuse upper and lower contacts

LAMINATED MUD: with sand laminae, dark greenish gray

SAND: fines upward from medium to fine sand, scoured base, greenish black

SAND: very fine sand, sharp lower contact

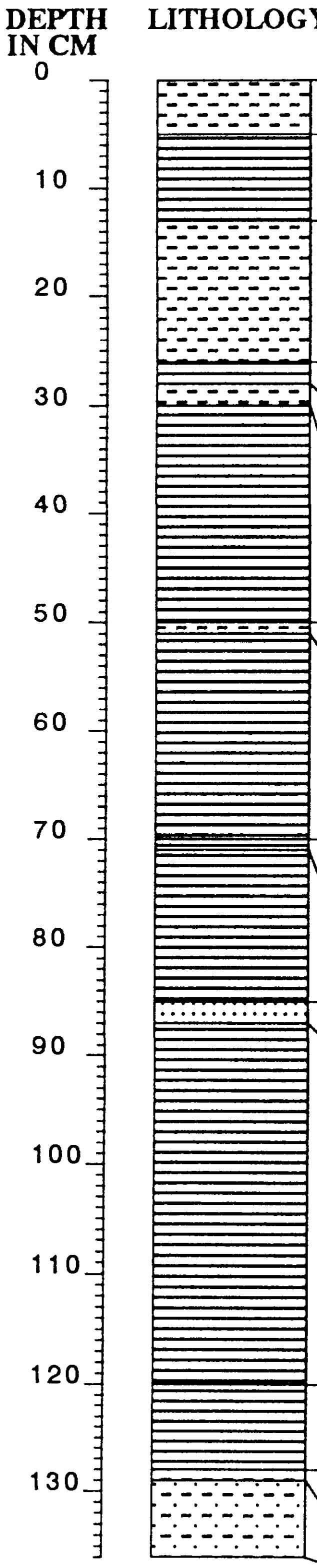
LAMINATED MUD: sand laminae increase at top of unit, mud is dark greenish gray, sand is darker

HOMOGENEOUS MUD: greenish black, (organic ?)

LAMINATED MUD: dark greenish gray

LAMINATED MUD: 2 mm thick sand laminae at 87 and 89 cm, dark greenish gray

AH93 GB GC-11



SECTION DESCRIPTION

HOMOGENEOUS MUD: scattered sand grains, grayish olive

LAMINATED MUD: faint laminae, dark greenish gray

HOMOGENEOUS MUD: contains horizontal burrows, mud clasts, organic rich, olive gray

LAMINATED MUD: olive gray

HOMOGENEOUS MUD: very light grayish olive mud with a moderate olive brown patch

LAMINATED MUD: with scattered sand grains, 2.5 cm pebble with sand grains around it at 47 cm, olive gray

HOMOGENEOUS MUD: black (organic ?)

LAMINATED MUD: olive gray

LAMINATED MUD: olive black mud above grayish olive with olive gray beneath, black mud may be organic

LAMINATED MUD: olive gray, 4.5 cm pebble at 80 cm with gravel around it

SAND: medium sand

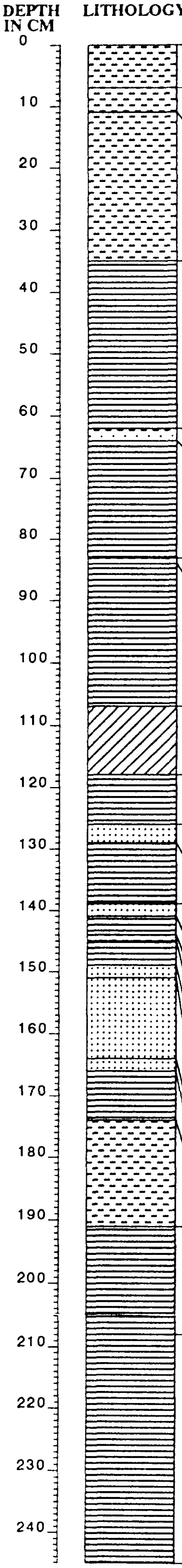
LAMINATED MUD: with several thin sand stringers greater than 1 mm, color is various shades of grayish olive

LAMINATED MUD: interlaminated fine sand and mud, sand laminae are up to 1 mm, mud laminae up to 2 mm, grayish olive

HOMOGENEOUS MUD: black (organic ?)

SANDY MUD: grayish olive

AH93 GB GC-12



SECTION DESCRIPTION

HOMOGENEOUS MUD: with few burrows, dark greenish gray

HOMOGENEOUS MUD: few laminae at bottom, black mud, possibly organic matter inside burrows

HOMOGENEOUS MUD: with burrows and black laminae or stringers, dark greenish gray

LAMINATED MUD: grayish olive, lighter near the top, darker near the base, few burrows except at 61 cm, gravel smaller than 0.5 cm near 45 cm

SANDY MUD: greenish black

LAMINATED MUD: grayish olive

SANDY MUD: greenish black

LAMINATED MUD: dark greenish gray

SILT: laminated, grayish olive

LAMINATED MUD: with 1 cm pebbles at 120 cm

SAND: thin graded sand alternating with thin mud laminae, mud is dark greenish gray, sand is darker

LAMINATED MUD: with thin sand stringers, dark greenish gray

SAND: thin graded sand alternating with mud, higher percent sand, dark greenish gray

LAMINATED MUD: equal percent of each, dark greenish gray

HOMOGENEOUS MUD: black (organic ?)

LAMINATED MUD: with sand and some rounded pebbles

SAND: massive medium sand, sharp upper and lower contacts, greenish black, thin black mud layer at the base

SAND: stratified fine sand with silt laminae, 3 cm pebble at 158 cm, dark greenish gray

SAND: black

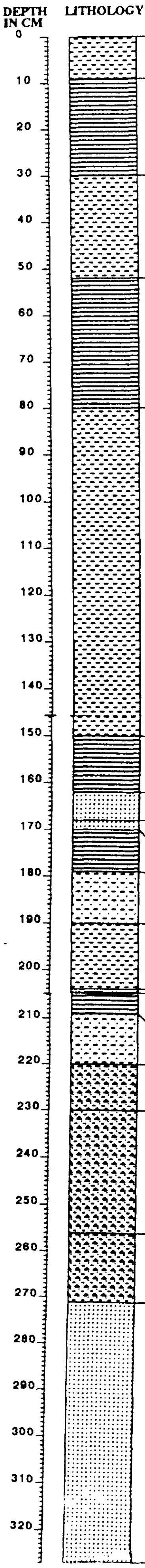
LAMINATED MUD: dark greenish gray

HOMOGENEOUS MUD: massive, grayish olive

LAMINATED MUD: with silt, silt at base fining up to mud at top, sharp lower contact, gradational upper contact, grayish olive

LAMINATED MUD: muddy very fine sand at base which fines upward into mud/silt laminae near the top, olive gray

AH93 GB GC-13



SECTION DESCRIPTION

HOMOGENEOUS MUD: few fine sand grains scattered throughout dark greenish gray

LAMINATED MUD weakly laminated mud with dark gray mottling with sulfur odor, mottled silt zones are stiff, sand lamina at 26 5 cm, fine sand and mud couplets between 30 and 31.5 cm

HOMOGENEOUS MUD: massive to weakly laminated mud, dark greenish gray

LAMINATED MUD: rhythmically laminated mud with fine sand 1 mm thick, mud is generally thicker than sand, fine sand grains are dispersed throughout, dark greenish gray, black mottled laminae at 76 cm

HOMOGENEOUS MUD: dark greenish gray, 1 grain thick fine sand lamina at 97 cm, 1 mm thick fine sand lamina at 142 cm

LAMINATED MUD: weakly laminated with a few silt to very fine sand laminae between 1 and 3 mm thick

SAND: massive very fine sand to silt, dark greenish gray

SAND: massive coarse to medium sand, medium dark gray

LAMINATED MUD. with fine sand to silt laminae, inclined at about 30 degrees, olive gray

SANDY MUD: with sand laminae up to medium sand, 2-3 mm thick

HOMOGENEOUS MUD: with lenses of fine to medium sand, orientation of sand lenses appears chaotic

LAMINATED MUD: dark greenish gray mud and muddy sand laminae 3 to 4 mm thick, laminae are subhorizontal

SANDY MUD: with lenses of muddy sand, lenses are 1-7 mm thick and are subhorizontal

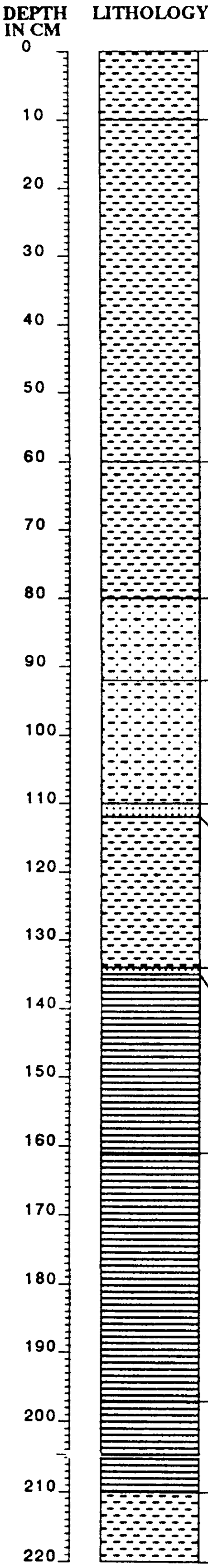
DIAMICTON: massive mud to sandy mud with clasts of fine to very fine sand, dark greenish gray

DIAMICTON: very fine to coarse massive sand with clasts of mud, dark greenish gray

DIAMICTON: massive mud with clasts of medium sand, sand clasts are poorly sorted containing mud to medium sand, contacts between sand clasts and mud are sharp, wood fragment at 266 cm

SAND: fine to medium massive sand, few lenses and clasts of massive mud, dark greenish gray

AH93 GB GC-14



SECTION DESCRIPTION

HOMOGENEOUS MUD: with dark pods and wispy laminae, olive gray

HOMOGENEOUS MUD: dark greenish gray

HOMOGENEOUS MUD: black mud lamina from 63 to 66 cm, wispy laminae below, dark greenish gray

SANDY MUD: poorly sorted with 7 pebbles up to 3 cm long, pebbles, granules and coarse sand are scattered throughout, planar sharp upper contact, irregular, sharp contact below

SANDY MUD: silt laminae from 92 to 100 cm, dark lamina with 2 pebbles inside its thickness from 100 to 102 cm, olive gray

SAND: fine sand, black, diffuse upper and lower contacts

HOMOGENEOUS MUD: olive gray

SAND: fine sand, black, gradational upper and lower contacts

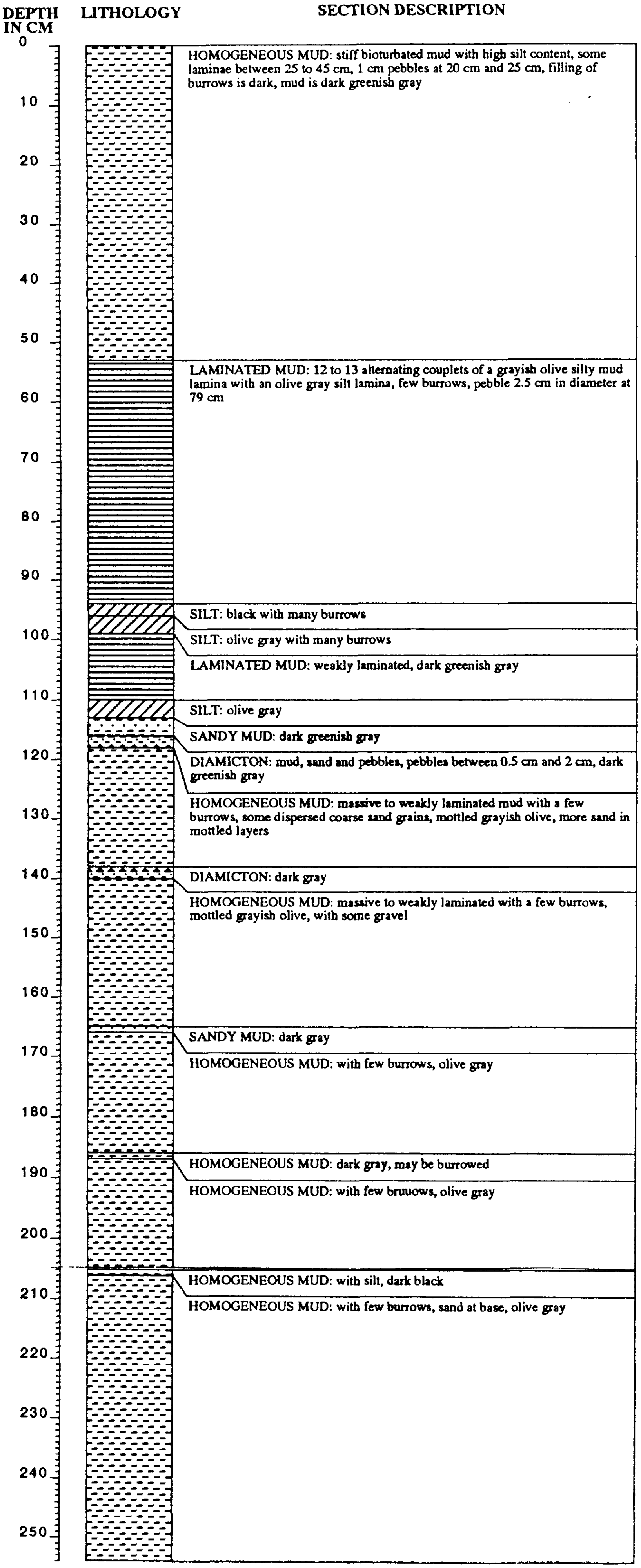
LAMINATED MUD: weak laminae of fine sand, coarse sand grains scattered throughout, olive gray

LAMINATED MUD: with fine sand and silt, fine sand lamina 0.5 cm thick at 173 cm, black fine sand lamina at 184 cm (small organic), black lamina at 197 cm

LAMINATED MUD: with fine sand lamina 1-3 mm thick

HOMOGENEOUS MUD: dark greenish gray

AH93 GB GC-15



HOMOGENEOUS MUD: stiff bioturbated mud with high silt content, some laminae between 25 to 45 cm, 1 cm pebbles at 20 cm and 25 cm, filling of burrows is dark, mud is dark greenish gray

LAMINATED MUD: 12 to 13 alternating couplets of a grayish olive silty mud lamina with an olive gray silt lamina, few burrows, pebble 2.5 cm in diameter at 79 cm

SILT: black with many burrows

SILT: olive gray with many burrows

LAMINATED MUD: weakly laminated, dark greenish gray

SILT: olive gray

SANDY MUD: dark greenish gray

DIAMICTON: mud, sand and pebbles, pebbles between 0.5 cm and 2 cm, dark greenish gray

HOMOGENEOUS MUD: massive to weakly laminated mud with a few burrows, some dispersed coarse sand grains, mottled grayish olive, more sand in mottled layers

DIAMICTON: dark gray

HOMOGENEOUS MUD: massive to weakly laminated with a few burrows, mottled grayish olive, with some gravel

SANDY MUD: dark gray

HOMOGENEOUS MUD: with few burrows, olive gray

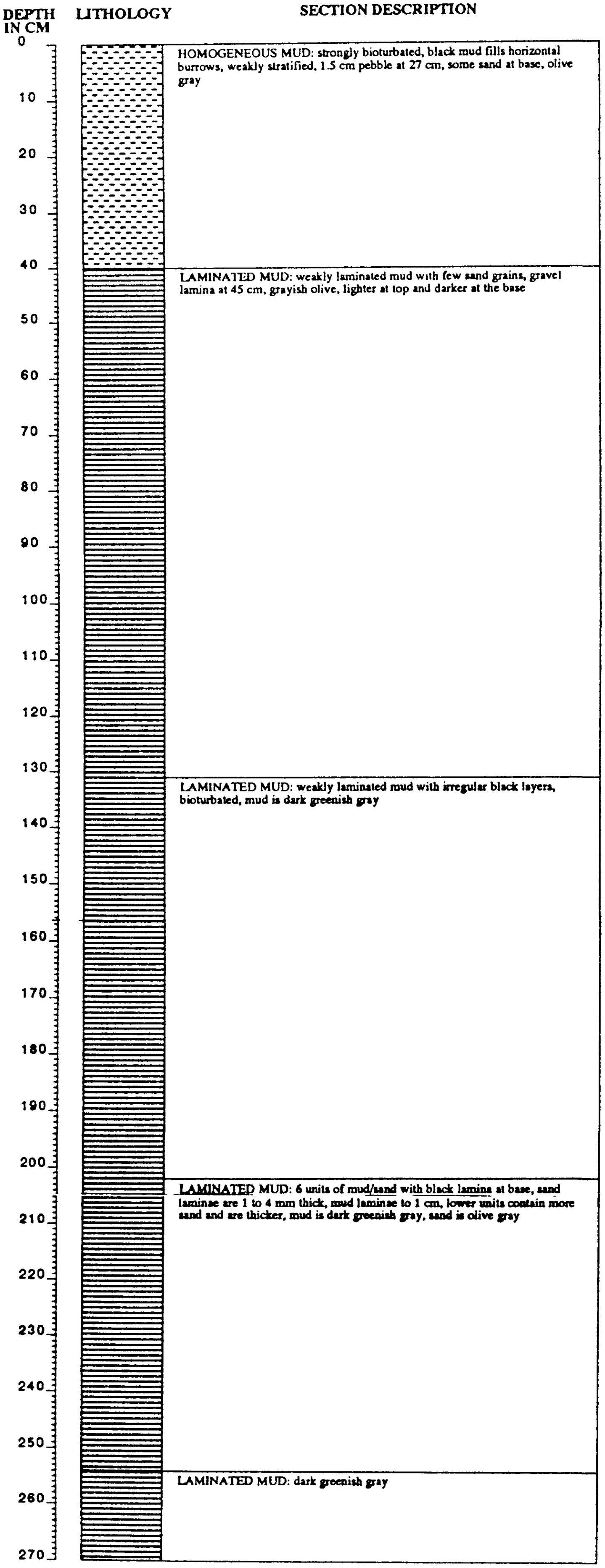
HOMOGENEOUS MUD: dark gray, may be burrowed

HOMOGENEOUS MUD: with few bruuows, olive gray

HOMOGENEOUS MUD: with silt, dark black

HOMOGENEOUS MUD: with few burrows, sand at base, olive gray

AH93 GB GC-16



HOMOGENEOUS MUD: strongly bioturbated, black mud fills horizontal burrows, weakly stratified, 1.5 cm pebble at 27 cm, some sand at base, olive gray

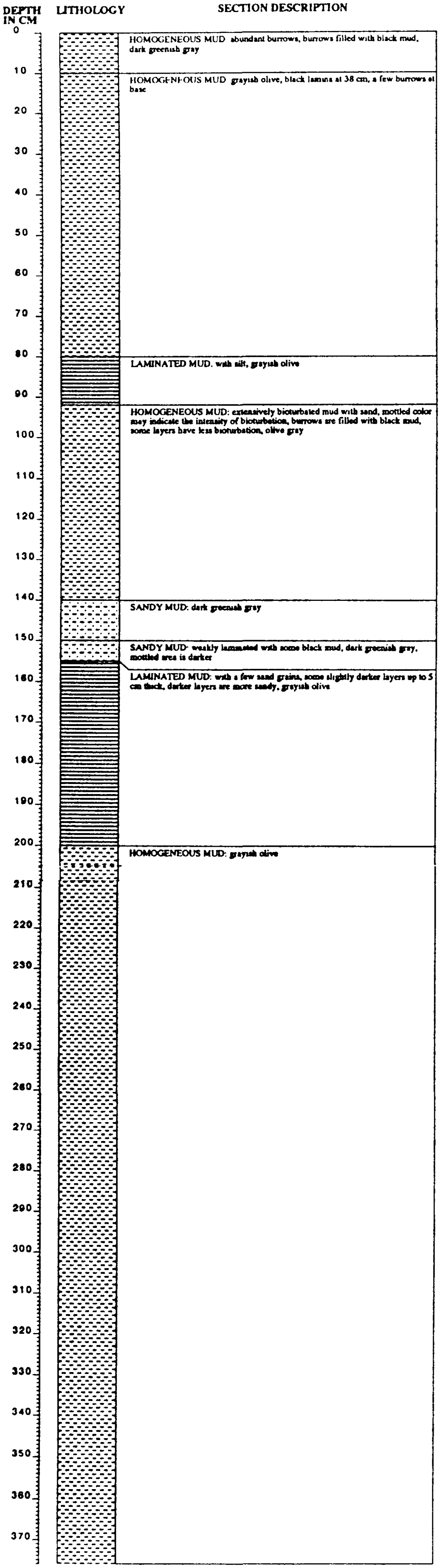
LAMINATED MUD: weakly laminated mud with few sand grains, gravel lamina at 45 cm, grayish olive, lighter at top and darker at the base

LAMINATED MUD: weakly laminated mud with irregular black layers, bioturbated, mud is dark greenish gray

LAMINATED MUD: 6 units of mud/sand with black lamina at base, sand laminae are 1 to 4 mm thick, mud laminae to 1 cm, lower units contain more sand and are thicker, mud is dark greenish gray, sand is olive gray

LAMINATED MUD: dark greenish gray

AH93 GB GC-17



SECTION DESCRIPTION

HOMOGENEOUS MUD abundant burrows, burrows filled with black mud, dark greenish gray

HOMOGENEOUS MUD grayish olive, black lamina at 38 cm, a few burrows at base

LAMINATED MUD. with silt, grayish olive

HOMOGENEOUS MUD: extensively bioturbated mud with sand, mottled color may indicate the intensity of bioturbation, burrows are filled with black mud, some layers have less bioturbation, olive gray

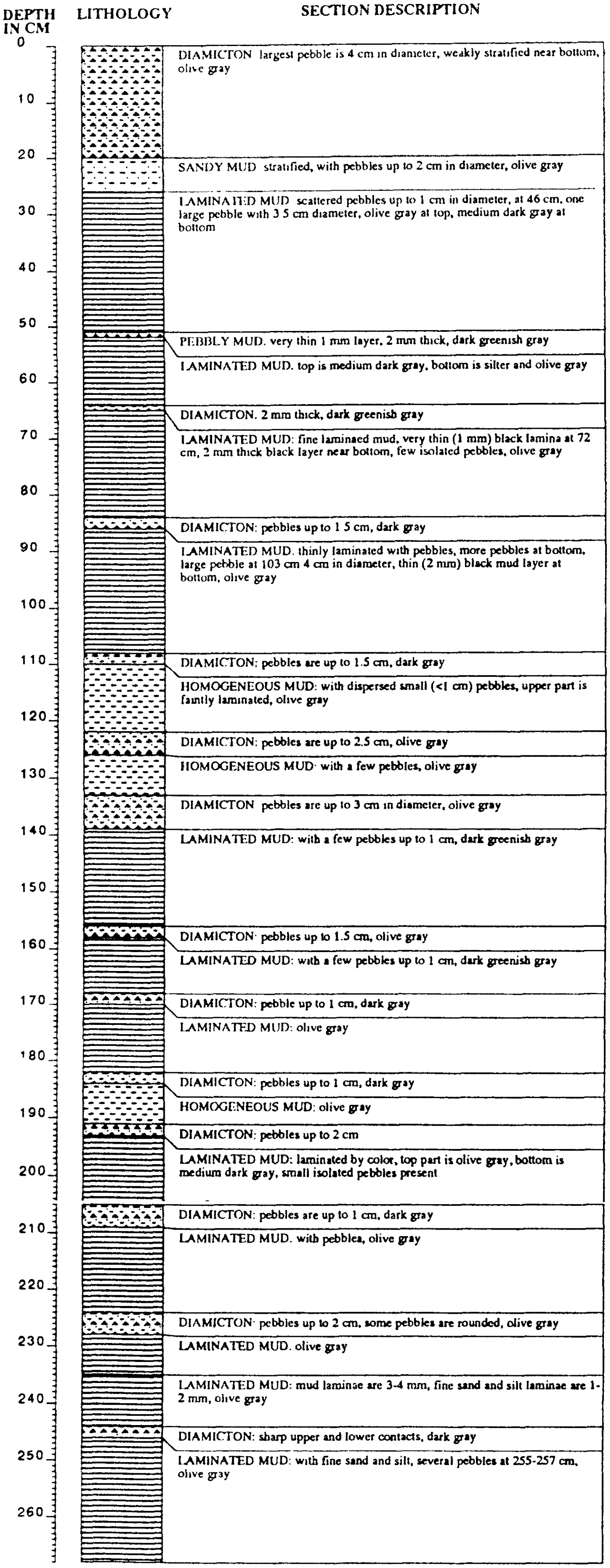
SANDY MUD: dark greenish gray

SANDY MUD: weakly laminated with some black mud, dark greenish gray, mottled area is darker

LAMINATED MUD: with a few sand grains, some slightly darker layers up to 5 cm thick, darker layers are more sandy, grayish olive

HOMOGENEOUS MUD: grayish olive

AH93 GB GC-18



SECTION DESCRIPTION

DIAMICTON largest pebble is 4 cm in diameter, weakly stratified near bottom, olive gray

SANDY MUD stratified, with pebbles up to 2 cm in diameter, olive gray

LAMINATED MUD scattered pebbles up to 1 cm in diameter, at 46 cm, one large pebble with 3 5 cm diameter, olive gray at top, medium dark gray at bottom

PEBBLY MUD. very thin 1 mm layer, 2 mm thick, dark greenish gray

LAMINATED MUD. top is medium dark gray, bottom is silter and olive gray

DIAMICTON. 2 mm thick, dark greenish gray

LAMINATED MUD: fine laminaed mud, very thin (1 mm) black lamina at 72 cm, 2 mm thick black layer near bottom, few isolated pebbles, olive gray

DIAMICTON: pebbles up to 1 5 cm, dark gray

LAMINATED MUD. thinly laminated with pebbles, more pebbles at bottom, large pebble at 103 cm 4 cm in diameter, thin (2 mm) black mud layer at bottom, olive gray

DIAMICTON: pebbles are up to 1.5 cm, dark gray

HOMOGENEOUS MUD: with dispersed small (<1 cm) pebbles, upper part is faintly laminated, olive gray

DIAMICTON: pebbles are up to 2.5 cm, olive gray

HOMOGENEOUS MUD with a few pebbles, olive gray

DIAMICTON pebbles are up to 3 cm in diameter, olive gray

LAMINATED MUD: with a few pebbles up to 1 cm, dark greenish gray

DIAMICTON pebbles up to 1.5 cm, olive gray

LAMINATED MUD: with a few pebbles up to 1 cm, dark greenish gray

DIAMICTON: pebble up to 1 cm, dark gray

LAMINATED MUD: olive gray

DIAMICTON: pebbles up to 1 cm, dark gray

HOMOGENEOUS MUD: olive gray

DIAMICTON: pebbles up to 2 cm

LAMINATED MUD: laminated by color, top part is olive gray, bottom is medium dark gray, small isolated pebbles present

DIAMICTON: pebbles are up to 1 cm, dark gray

LAMINATED MUD. with pebblea, olive gray

DIAMICTON pebbles up to 2 cm, some pebbles are rounded, olive gray

LAMINATED MUD. olive gray

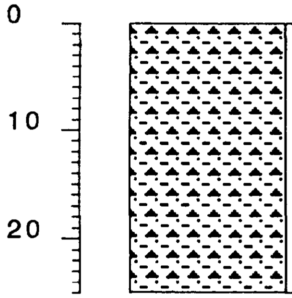
LAMINATED MUD: mud laminae are 3-4 mm, fine sand and silt laminae are 1-2 mm, olive gray

DIAMICTON: sharp upper and lower contacts, dark gray

LAMINATED MUD: with fine sand and silt, several pebbles at 255-257 cm, olive gray

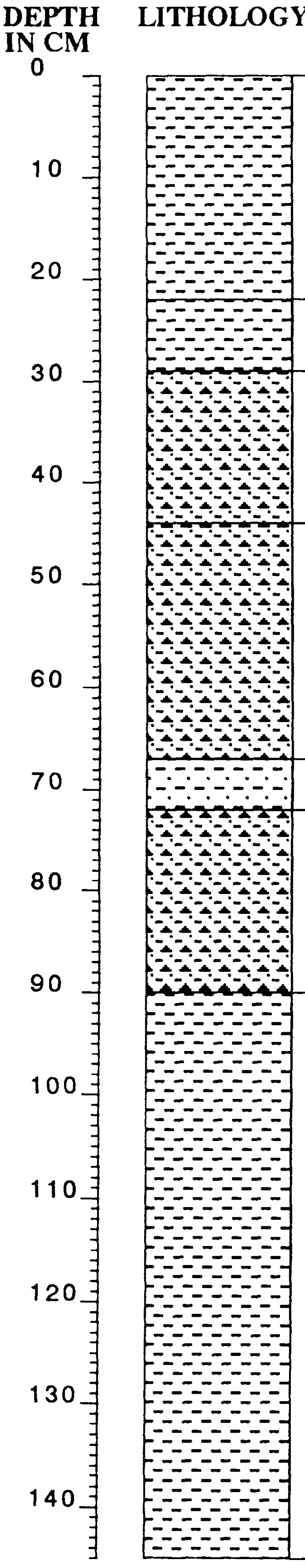
AH93 GB GC-19

DEPTH IN CM **LITHOLOGY** **SECTION DESCRIPTION**



DIAMICTON: largest pebble is 4 cm, pebbles are subrounded to angular, worm tubes present near top, dark greenish gray

AH93 GB GC-22



SECTION DESCRIPTION

HOMOGENEOUS MUD: burrowed mud with pebbles up to 3.5 cm in diameter, top 5 cm is grayish olive, olive gray below

HOMOGENEOUS MUD: extensively burrowed mud, black material present in the burrows, dark greenish gray

DIAMICTON: with burrows, most pebbles are <1 cm in diameter, olive gray

DIAMICTON: pebbles are up to 2.5 cm in diameter, olive gray

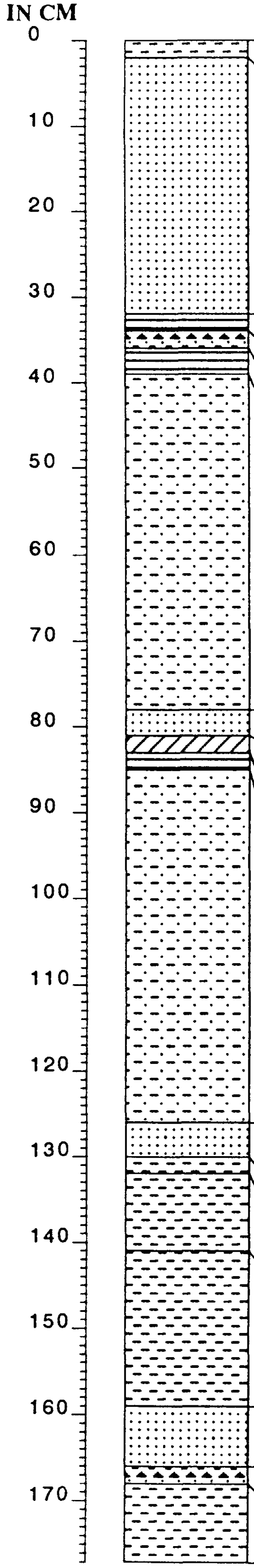
SANDY MUD: muddy coarse sand with sharp contacts, dark gray

DIAMICTON: largest pebble is 0.5 cm in diameter, subrounded and occurs at 85 cm depth, dark greenish gray

HOMOGENEOUS MUD: pebbly mud, with dispersed sand, two large pebbles (5, 7 cm) occur at 106-109 cm, another large pebble with 7 cm diameter occurs at 122-126 cm, pebbles are angular, other relatively small (<1 cm) pebbles present

AH93 GB GC-24

DEPTH IN CM **LITHOLOGY** **SECTION DESCRIPTION**



HOMOGENEOUS MUD: grayish olive green

SAND: fine to medium sand with sharp upper and lower contacts, two thin (2 mm) mud layers present at about 18 and 25 cm, very faint laminae, dark gray

LAMINATED MUD: olive gray

DIAMICTON: largest pebble is about 3.5 cm, olive gray

LAMINATED MUD

SANDY MUD: structureless muddy medium sand, mud contact increases toward the top, upper and lower contacts are gradational, olive gray

SAND: medium sand with normal grading, sharp lower contact, dark greenish gray

SILT: laminated at bottom, fining upward to silty mud, sharp upper and lower contacts, dark gray

LAMINATED MUD: dark greenish gray

SANDY MUD: some planar laminae near top, gradational upper and lower contacts, dark gray

SAND: medium sand with normal grading, sharp lower contact, gradational upper contact

HOMOGENEOUS MUD: with isolated clasts, largest pebble is 2 cm

HOMOGENEOUS MUD: with burrows, grayish black material inside the burrows, some pebbles up to 1 cm, olive gray

HOMOGENEOUS MUD: with little silt, occasional burrows, olive gray

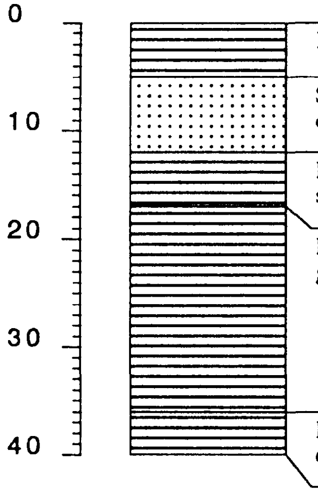
SAND: fine sand near bottom, fining upward to muddy silt near top, lower contact is sharp, upper contact is gradational, dark gray

DIAMICTON: largest pebble is about 3.5 cm

HOMOGENEOUS MUD: olive gray

AH93 GB GC-25

DEPTH IN CM **LITHOLOGY** **SECTION DESCRIPTION**



LAMINATED MUD: with one thin muddy silt layer, dark greenish gray

SAND: medium sand fining upward to fine sand, lower contact is sharp, upper contact is gradational, bottom has normal grading, dark gray

LAMINATED MUD: interlaminated mud and sand, mud laminae are 2-6 mm, sand laminae are 1-3 mm, 1 cm sand layer present in middle

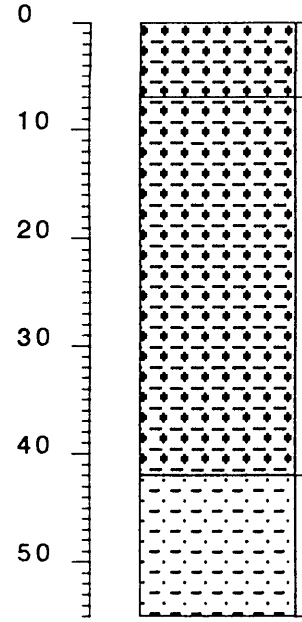
LAMINATED MUD: with a black layer 1.5 cm thick at bottom, dark greenish gray

LAMINATED MUD: with one fine sand layer (3 mm thick) at about 38.5 cm, dark greenish gray

(page 83 follows)

AH93 GB GC-26

DEPTH IN CM **LITHOLOGY** **SECTION DESCRIPTION**

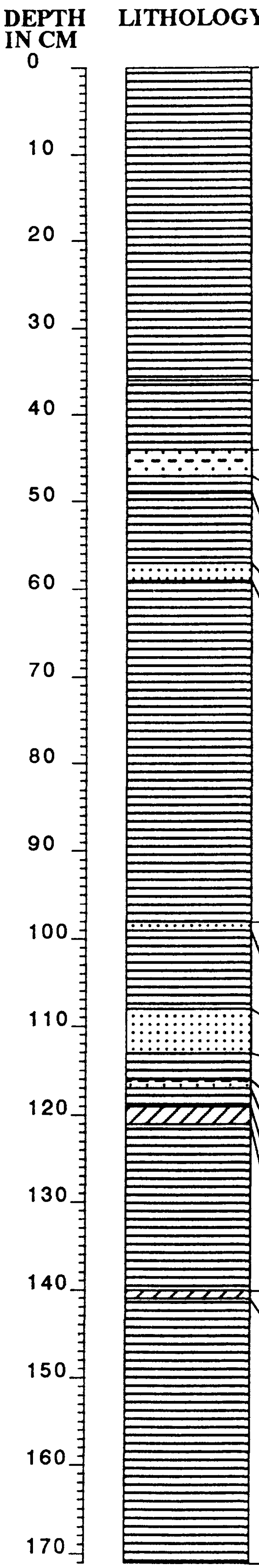


PEBBLY MUD: mud with angular pebbles up to 4 cm, becomes sandy near bottom, olive gray

PEBBLY MUD: pebbles are up to 3 cm in diameter, some worm tubes present between 15 and 20 cm, olive gray

SANDY MUD: with some small pebbles (<1 cm), olive gray

AH93 GB GC-27



SECTION DESCRIPTION

LAMINATED MUD: with 2, 3-4 mm thick sand layers at 13 and 16 cm, dark greenish gray

LAMINATED MUD: silt occurs between 36 and 37 cm, dark greenish gray

SANDY MUD: greenish black

LAMINATED MUD: dark greenish gray, 1 cm thick greenish black fine sand at 47 to 48 cm

LAMINATED MUD: dark greenish gray

SAND: fining upward fine sand to silt, olive gray

LAMINATED MUD: with scattered pebbles up to 0.5 cm, dark greenish gray

SAND: fining upward from fine sand, sharp lower contact, gradational upper contact

LAMINATED MUD: dark greenish gray

SAND: fining upward from medium sand, sharp lower contact

LAMINATED MUD: dark greenish gray

DIAMICTON: pebbles up to 1 cm, olive gray

LAMINATED MUD: dark greenish gray

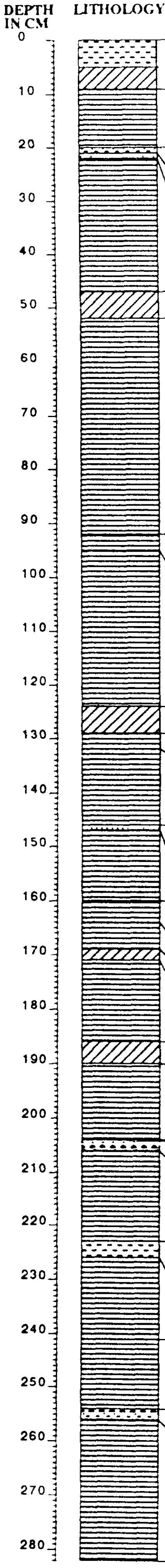
SILT

LAMINATED MUD: dark greenish gray

SILT

LAMINATED MUD: dark greenish gray, silt laminae at 145 and 169 cm

AH93 GB GC-28



SECTION DESCRIPTION

HOMOGENEOUS MUD

SILT with laminae, olive gray

LAMINATED MUD olive gray

DIAMICTON dark greenish gray

SANDY MUD muddy fine sand with laminations, grayish olive green

LAMINATED MUD one fine sand layer 5 mm thick present at 35 cm, olive gray

SILT muddy laminated silt, olive gray

LAMINATED MUD olive gray

LAMINATED MUD. two black layers (4-5 mm thick) occur at top and bottom, olive gray

LAMINATED MUD with a thin silt layer at about 96 cm depth, olive gray

SILT laminated muddy silt, olive gray

LAMINATED MUD olive gray

LAMINATED MUD laminated silty mud, olive gray

SAND fine sand at bottom fining upward to silt, top has laminae, bottom contact is sharp, top contact is gradational, dark gray

LAMINATED MUD: with silt and laminations, olive gray

LAMINATED MUD: with dark gray sand lenses and pebbles, pebbles are up to 1 5 cm, olive gray

LAMINATED MUD. olive gray

SILT with laminae, dark gray

LAMINATED MUD. olive gray

SILT. laminated with gradational contacts, dark gray

LAMINATED MUD· interlaminated mud and silt, mud laminae are 2-3 mm thick, silt laminae are 1 mm or less, near top there is one fine sand layer 1.5-2 mm thick, sharp contacts, olive gray

DIAMICTON: olive gray

LAMINATED MUD: color changes from upper olive gray to lower dark gray

HOMOGENEOUS MUD: with fining upward sand lens, base contact of sand lens is sharp, upper contact is gradational, grayish black

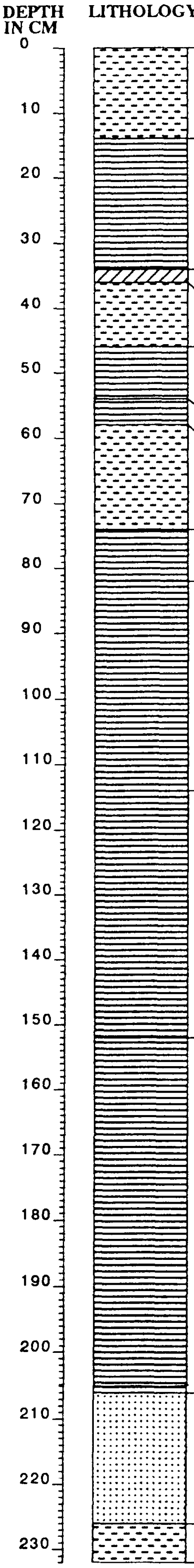
LAMINATED MUD: laminated silty mud towards top, gradually changes downward to muddy silt, dark gray

LAMINATED MUD· olive gray

DIAMICTON: pebbles are up to 3.5 cm, angular, olive gray

LAMINATED MUD olive gray

AH93 GB GC-31



SECTION DESCRIPTION

HOMOGENEOUS MUD: massive to weakly stratified mud, few organic mottles, very fine sand throughout, olive gray

LAMINATED MUD: laminated mud, with burrows and small pebbles (0.5 cm), olive gray

SILT: laminated, muddy silt, laminae are slightly wavy, medium dark gray

HOMOGENEOUS MUD: with pebbles up to 1 cm, dark greenish gray

LAMINATED MUD: interlaminated mud and fine sand, mud laminae are 1-4 mm thick, sand laminae are <1.5 mm thick, some small pebbles up to 5 mm, dark greenish gray

LAMINATED MUD: black layer at bottom about 1 cm thick, dark greenish gray

HOMOGENEOUS MUD: black 5 mm thick layer at bottom, dark greenish gray

LAMINATED MUD: olive gray

LAMINATED MUD: with a few dispersed sands, a thin 5 mm silt layer present at 102 cm, medium dark gray

LAMINATED MUD: interlaminated mud and fine to medium sand, mud laminae are 1-3 mm thick, sand laminae are <2 mm thick, the relative ratio of mud and sand varies with depth, thin black layer at 129-130 cm, dark greenish gray

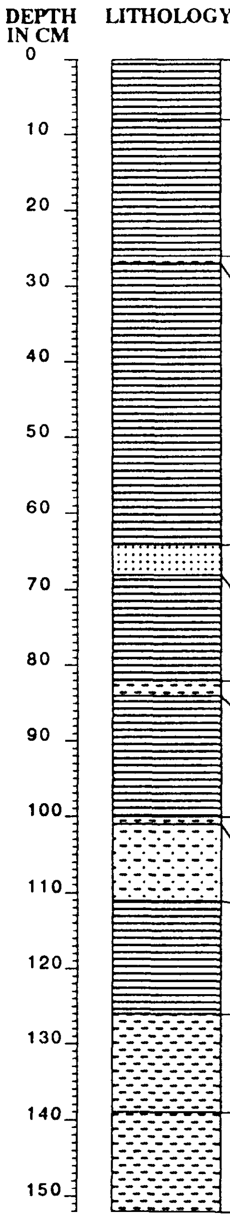
LAMINATED MUD: with very low silt content, high percent clay, dark greenish gray

SAND: medium sand at bottom, fining upward to muddy silt near top, with planar lamination, lower contact is sharp, upper contact is gradational, dark gray

HOMOGENEOUS MUD: dark greenish gray

AH93 GB GC-32

SECTION DESCRIPTION



LAMINATED MUD: very thin (8 mm) grayish black orgainc (?) layer at bottom, dark greenish gray

LAMINATED MUD: interlaminated mud and medium sand, mud laminae are 1-5 mm thick, sand laminae are 1-3 mm thick, contacts are relatively sharp, olive gray

HOMOGENEOUS MUD: very thin layer of grayish black mud

LAMINATED MUD: interlaminated mud and medium sand, olive gray

SAND: medium sand with two thin mud layers (5 mm thick), sand layers have sharp contacts, olive gray

LAMINATED MUD: with sand stringers (<1 mm thick), several thin sand layers 1-2 mm thick near bottom, isolated pebbles up to 2.5 cm, olive gray

HOMOGENEOUS MUD: black organic (?) mud layer, grayish black

LAMINATED MUD: with sand stringers <1 mm thick, olive gray

HOMOGENEOUS MUD: grayish black mud layer about 1 cm thick

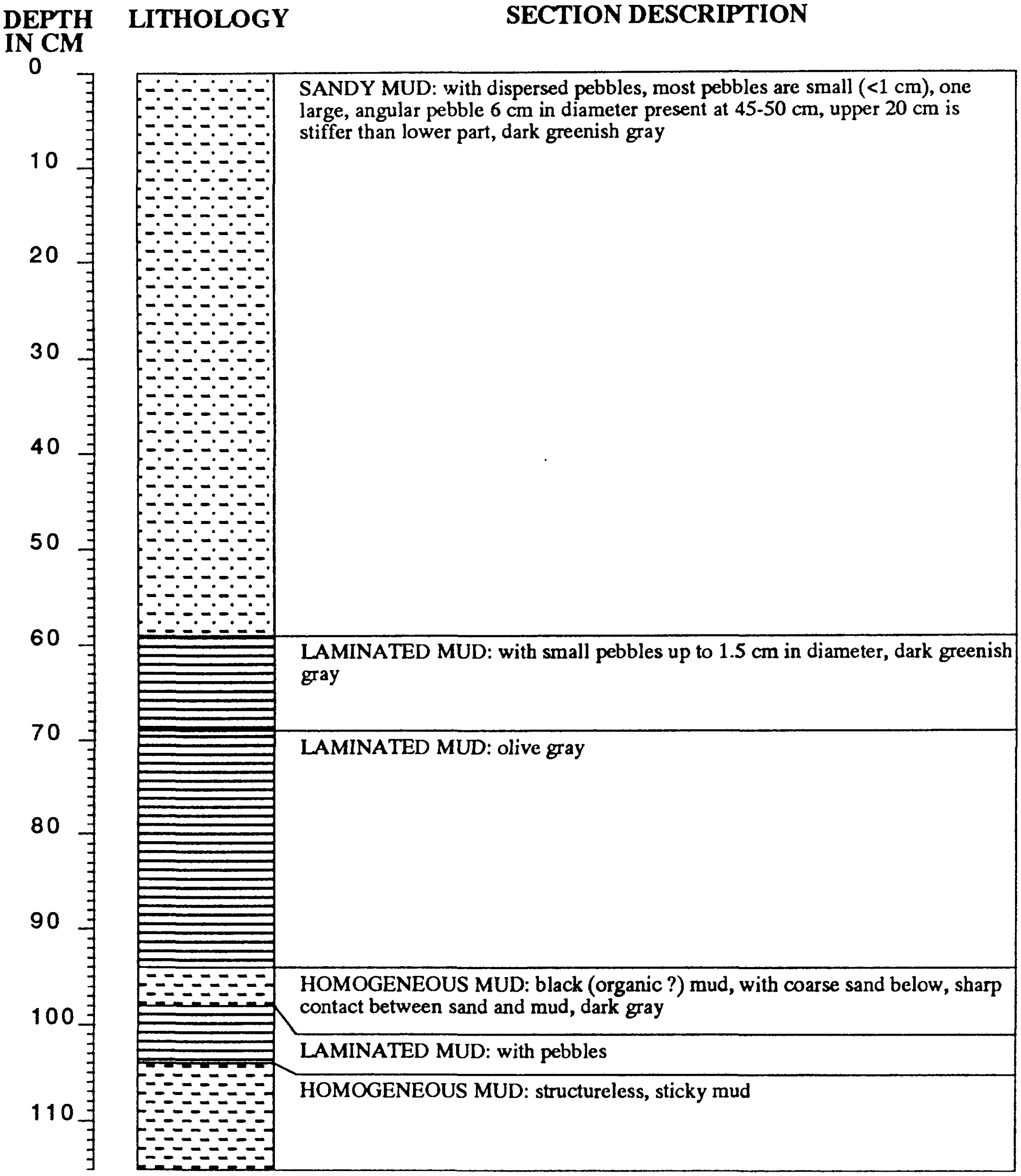
SANDY MUD: with laminations, a black lens present near bottom with sulfur odor, olive gray

LAMINATED MUD: laminated silty mud, near top is one thin sand layer of about 8 mm thick, olive gray at top, medium gray at bottom

HOMOGENEOUS MUD: abundant burrows filled with black material, mottled black color, olive gray

HOMOGENEOUS MUD: burrowed mud, burrows are fewer than above, medium gray

AH93 GB GC-33



SANDY MUD: with dispersed pebbles, most pebbles are small (<1 cm), one large, angular pebble 6 cm in diameter present at 45-50 cm, upper 20 cm is stiffer than lower part, dark greenish gray

LAMINATED MUD: with small pebbles up to 1.5 cm in diameter, dark greenish gray

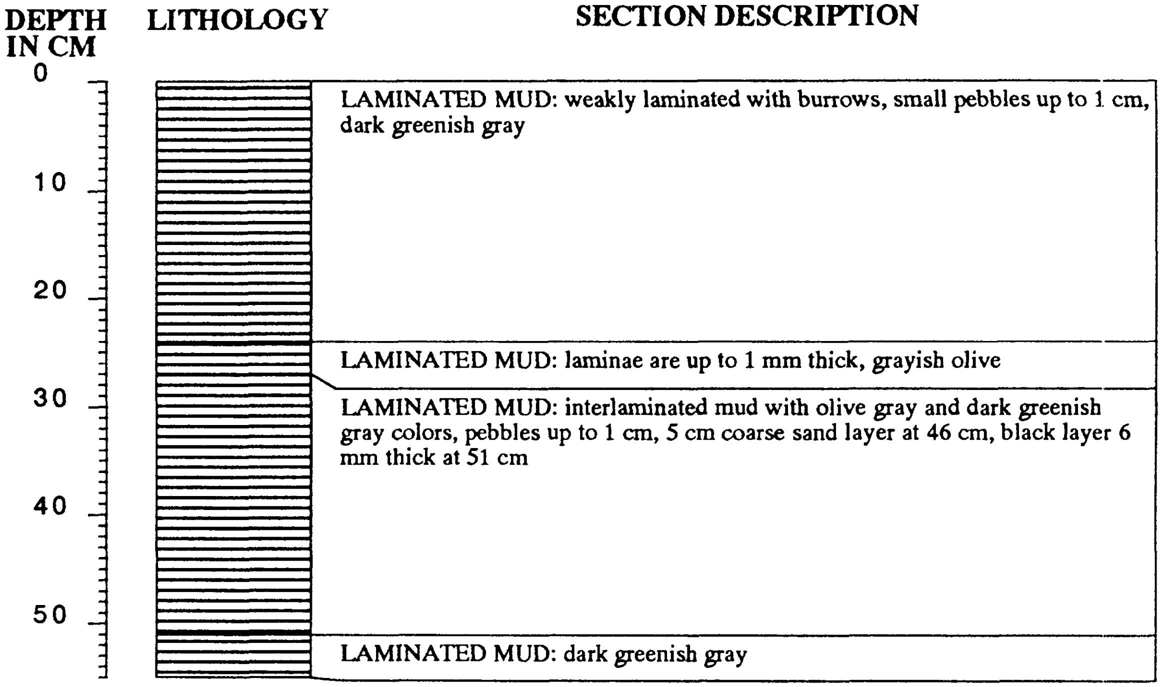
LAMINATED MUD: olive gray

HOMOGENEOUS MUD: black (organic ?) mud, with coarse sand below, sharp contact between sand and mud, dark gray

LAMINATED MUD: with pebbles

HOMOGENEOUS MUD: structureless, sticky mud

AH93 GB GC-34



LAMINATED MUD: weakly laminated with burrows, small pebbles up to 1 cm, dark greenish gray

LAMINATED MUD: laminae are up to 1 mm thick, grayish olive

LAMINATED MUD: interlaminated mud with olive gray and dark greenish gray colors, pebbles up to 1 cm, 5 cm coarse sand layer at 46 cm, black layer 6 mm thick at 51 cm

LAMINATED MUD: dark greenish gray

APPENDIX 2: PHYSICAL PROPERTIES MEASUREMENTS AND GRAPE LOGS

Physical Properties Measurements of Sediment Sampled from Western Prince William Sound, Yakutat Bay, and Glacier Bay, Southeastern Gulf of Alaska.

R.E. Kayen

Cores sampled during AH93 were logged for their physical properties on a multi-sensor whole core sediment logging device. The physical property logging device was built in Great Britain by Schultheiss Geoteck, Ltd. This device is controlled by a personal-computer driven software system, developed at the U.S. Geological Survey, Branch of Pacific Marine Geology (USGS-BPMG), for data acquisition and instrument I/O manipulation. The system logs sediment bulk density, compression wave sound speed, and magnetic susceptibility of unsplit whole sediment cores. These properties are used to develop physical property profiles for the cores.

Whole-section sealed sediment cores are placed horizontally upon a transport sled. This sled is transported through a frame supporting sensors in incremental fashion by a computer-controlled stepper motor. Sensor readings of cores were logged in this manner at 1 centimeter increments, within the first day after the cores were collected. The transport sled is capable of carrying core sections up to 1.50 m long.

Sediment bulk density (ρ_b) is calculated from the gamma ray attenuation characteristics of the cores according to Lambert's law. The configuration of our device allows for a core to pass between a vessel containing the radio-isotope Cesium-137 and a scintillation counter. For a defined time period, the number of gamma decays emitted from the Cesium-vessel that pass though the core and are received at the scintillation detector are counted. If gamma rays are transmitted to the scintillation counter through air, we refer to the number of scintillation counts as an unattenuated measure, I_o. For the case where a material of some thickness, d, lies between the Cesium source and sensor, the attenuated gamma ray counts, I, can be related to the unattenuated number of gamma decays, I_o, the material thickness, d, the material bulk density, ρ_b, and the Compton scattering coefficient, μ, by Lambert's Law:

$$I = I_o \exp.\{-\mu \rho_b d\}$$

The bulk density of the material can be determined as follows:

$$\rho_b = \frac{1}{\mu d} \ln\left(\frac{I_o}{I}\right)$$

For whole sediment cores, we need to account for the influence of the core liner to get an accurate estimation of the sediment density. As such, we determine separate Compton scattering coefficients, material thicknesses, and bulk densities, for the sediment and core liner. Doing so, we can determine the sediment bulk density from the following equation:

$$\rho_b = \frac{\left(\ln\left(\frac{I_o}{I}\right) - 2L\ \rho_{liner}\mu_{liner}\right)}{\mu_{sed}(D-2L)}$$

where D is the whole core outer diameter (Sediment diameter plus two liner wall thicknesses), L is the liner thickness, ρ_{liner} is the liner density, μ_{liner} is the liner Compton scattering coefficient, and μ_{sed} is the sediment Compton scattering coefficient.

The compression wave velocity, V_p, of sediment is calculated from the measured core diameter and wave travel time, correcting for the liner thickness, electronic signal delays, and core liner travel time. The velocity is calculated as:

$$V_p = \frac{D\text{-}2L}{T - 2T_{liner} - T_{delay}}.$$

Parameters for the velocity calculation are the total travel time, T, the liner travel time, Tliner, and the electronic signal delay within the transducer, Tdelay, all measured in µsec.

The magnetic susceptibility of sediment is measured directly through a transducer hoop. No liner corrections are required on cores collected during cruise AH93, as the liners are composed of non-magnetically susceptible polymers.

System Calibration

Calibration of the logger system with standards is required in order to present physically meaningful values of sediment properties. For each of the properties we measure, we have developed a set of standards to correctly attune the transducer and computer system to output calibrated physical property data.

Density & Velocity Calibration:

Density and compression-wave velocity measurements of whole core sediment are calibrated to the known standards of water and aluminum. These two standards serve as end-members which fully bracket seafloor sediment density, with water serving as the lower-bound and aluminum serving as the upper-bound. These standards also serve to nearly bracket sediment compression-wave velocity (near surface fine-grained deposits of low density may have velocities below that of water.). The added advantage of using these materials is that their respective Compton scattering coefficients are similar to those of sediment which is composed of a liquid-phase of water and a solid-phase, typically, of alumina-silicate minerals. To account for the influence of the liner, the Compton scattering coefficient for empty core liner was determined prior to cruise AH93, by measuring the attenuation of gamma rays transmitted through the liner relative to the unattenuated air count, measuring the liner thickness and density, and using Lambert's law, above.

A water-aluminum standard was prepared by inserting a solid-cylinder of 6250-Aluminum into an unsplit section of core liner identical to the liner used for sediment sampling. The length of milled aluminum fills one-half the total length of the ‘calibration standard’-core liner and distilled water fills the remaining portion. During density calibration, the numbers of scintillation's-per-second were logged during transmission of gamma rays through the liner and water, the liner and aluminum, and through air. Finally, an empirical Compton scattering coefficient was determined for the water, and aluminum which gave water densities of 1.00 g/cc and aluminum densities of 2.70 g/cc. Calibration studies, perfomed in the geotechnical engineering laboratory of the USGS-BPMG, indicate that the standard deviation for density measurements is on the order of 0.6-1.0% of the standard measured value (1.00 and 2.70 g/cc).

Calibration standards were run repeatedly during the logging of the cores, onboard the Alpha Helix. That is, in order to calibrate the sediment-core profiles for density, we took attenuated gamma-ray measurements from our water and aluminum filled liner standard, and unattenuated measurements through air, after every core section was logged on our device. For each sediment-core file, we applied the same Compton scattering parameters that corrected the corresponding calibration-file standards, water and aluminum, to their known values to the gamma decay-counts measured through the sediment collected from the fjords of the Southeastern Gulf of Alaska.

To calibrate compression wave velocity measurements in our water-filled standard, we needed to measured the temperature of the water. We then corrected the raw calculated velocity to the velocity at 23°C at standard pressure using known correction factors (U.S. Naval Oceanographic Office, 1962). The known velocity of distilled water at standard pressure and temperature is 1.4917 km/sec. An empirically determined travel time delay ($2T_{liner}$ - T_{delay}) was determined which corrects the measured p-wave velocity to the known standard velocity. This empirical travel-time delay, from the calibration files, was then applied to the corresponding sediment-core file. Prior studies indicate that the standard deviation of our sediment velocity measurements is on the order of 0.16% of the measured value.

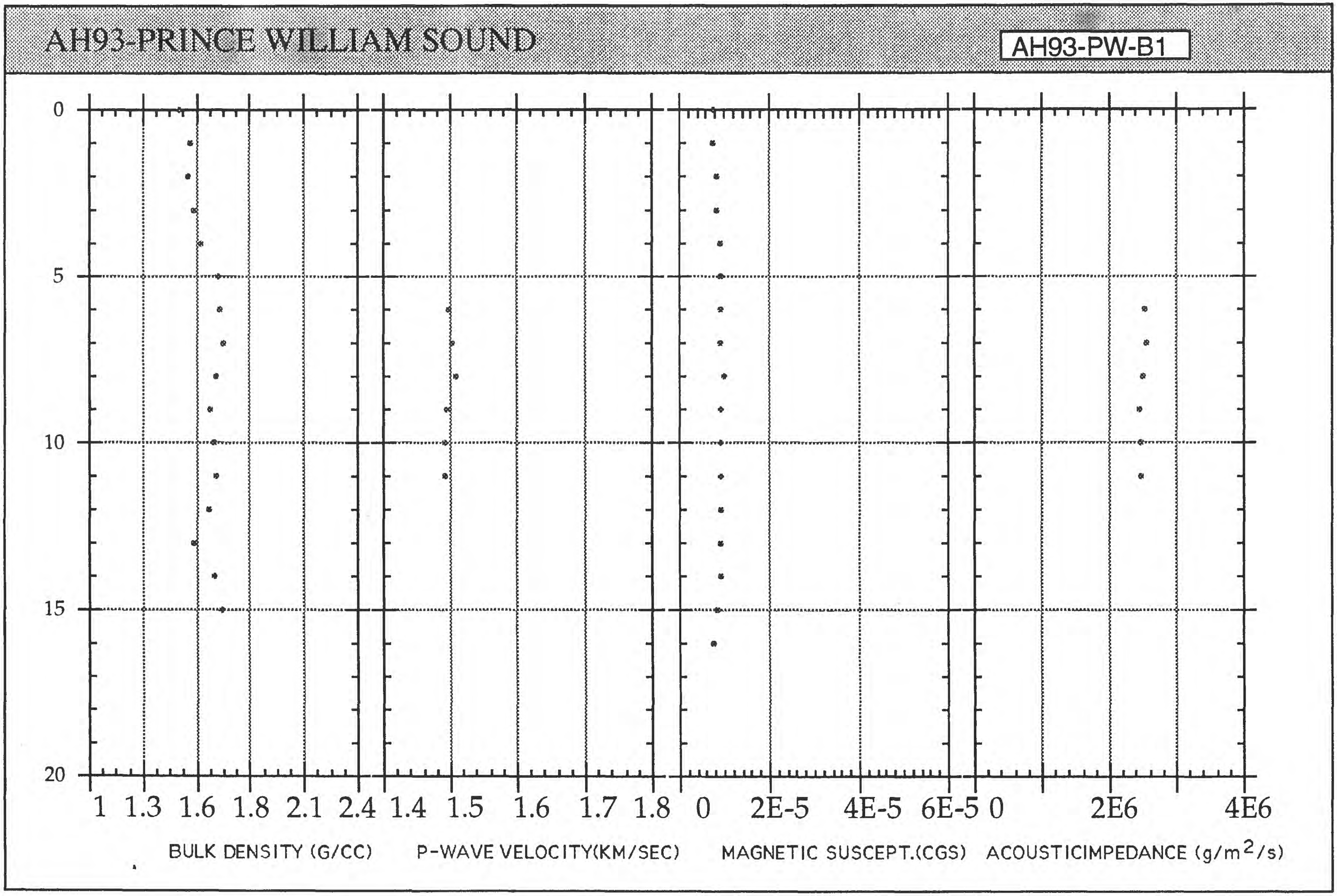
Magnetic Susceptibility Calibration:

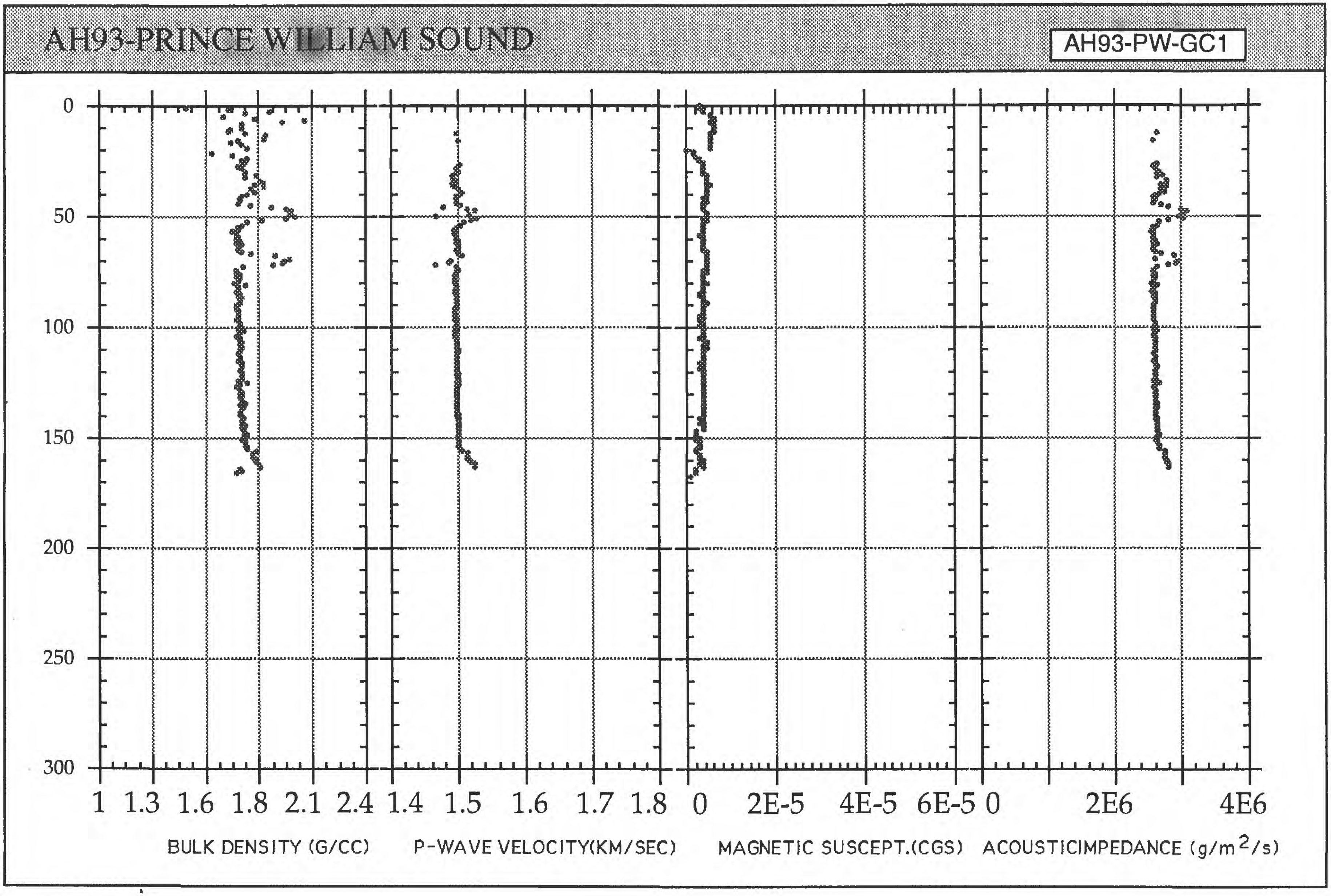
Calibration of magnetic susceptibility measurements is done by suspending a standard of known susceptibility within the magnetic susceptibility hoop transducer and determining the correct linear proportionality constant which scales the measured value of the standard to the known value. The known standard that we used to calibrate the system was supplied by the manufacturer of the logger system. This correction factor was then used to adjust the measured magnetic susceptibility of sediment to a calibrated value. Unlike the discrete measurements made for density and velocity at each one centimeter interval in a core, the magnetic susceptibility hoop senses a broader section of the core (several centimeters outside the hoop). This sensitivity has the effect of smoothing the magnetic susceptibility curves and reducing the logger resolution of fine scale variations of magnetically-influenced minerals (magnetite, etc.) in the sediment cores.

References:

CRC Handbook of Chemistry and Physics, 1969, R.C. Weast, ed. The Chemical Rubber Co., Cleveland, Ohio.

U.S. Naval Oceanographic Office, 1962, TABLES OF SOUND SPEED IN SEA WATER, Oceanographic Analysis Division, 47p. (SP-58).


AH93-PRINCE WILLIAM SOUND
AH93-PW-B1
0
5
10
15
20
1
1.3
1.6
1.8
2.1
2.4
1.4
1.5
1.6
1.7
1.8
0
2E-5
4E-5
6E-5
0
2E6
4E6
BULK DENSITY (G/CC)
P-WAVE VELOCITY(KM/SEC)
MAGNETIC SUSCEPT.(CGS)
ACOUSTICIMPEDANCE (g/m2/s)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AH93-PW-GC1
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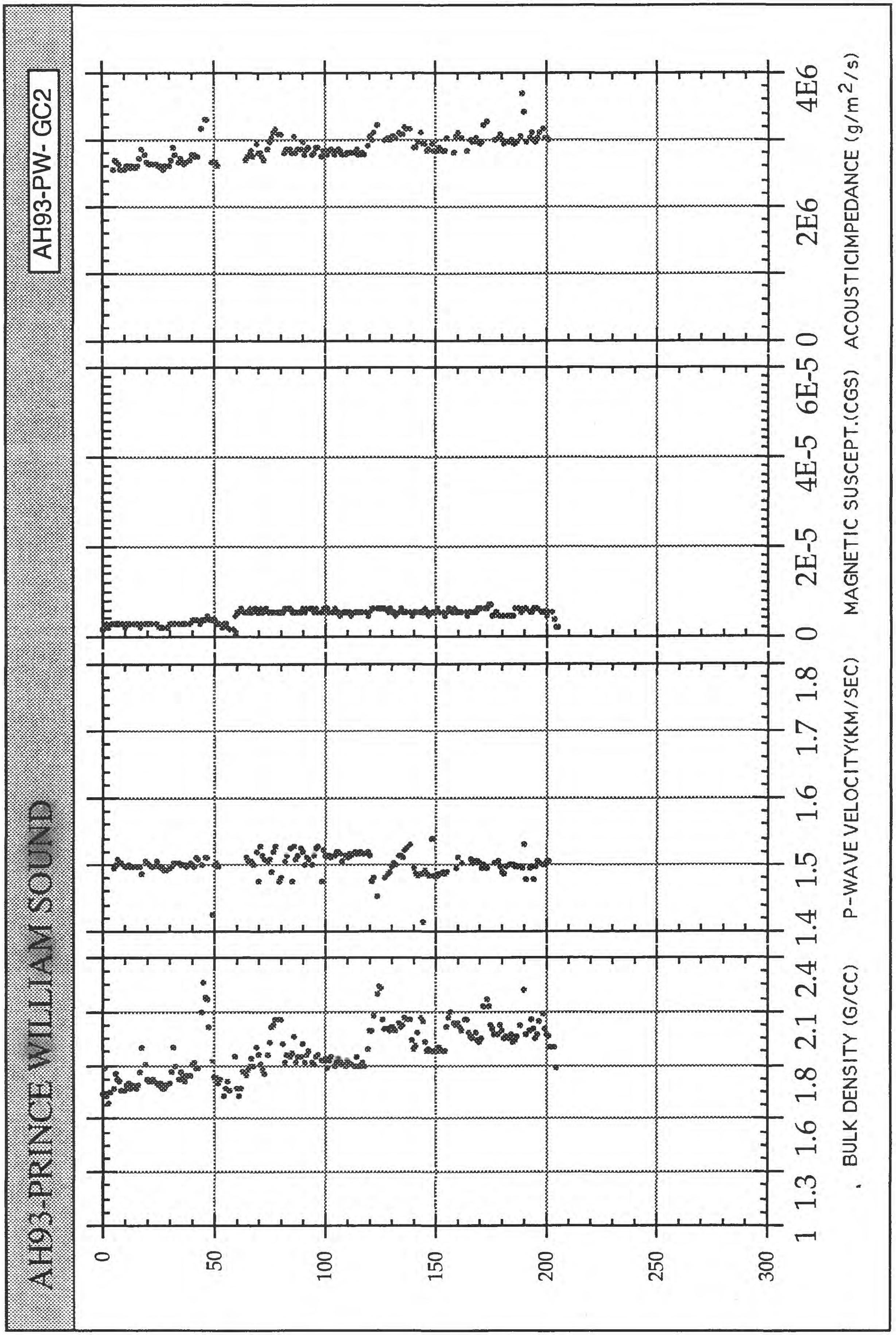
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
1.4
1.5
1.6
1.7
1.8
0
2E-5
4E-5
6E-5
0
2E6
4E6
BULK DENSITY (G/CC)
P-WAVE VELOCITY(KM/SEC)
MAGNETIC SUSCEPT.(CGS)
ACOUSTICIMPEDANCE (g/m2/s)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AH93-PW- GC2
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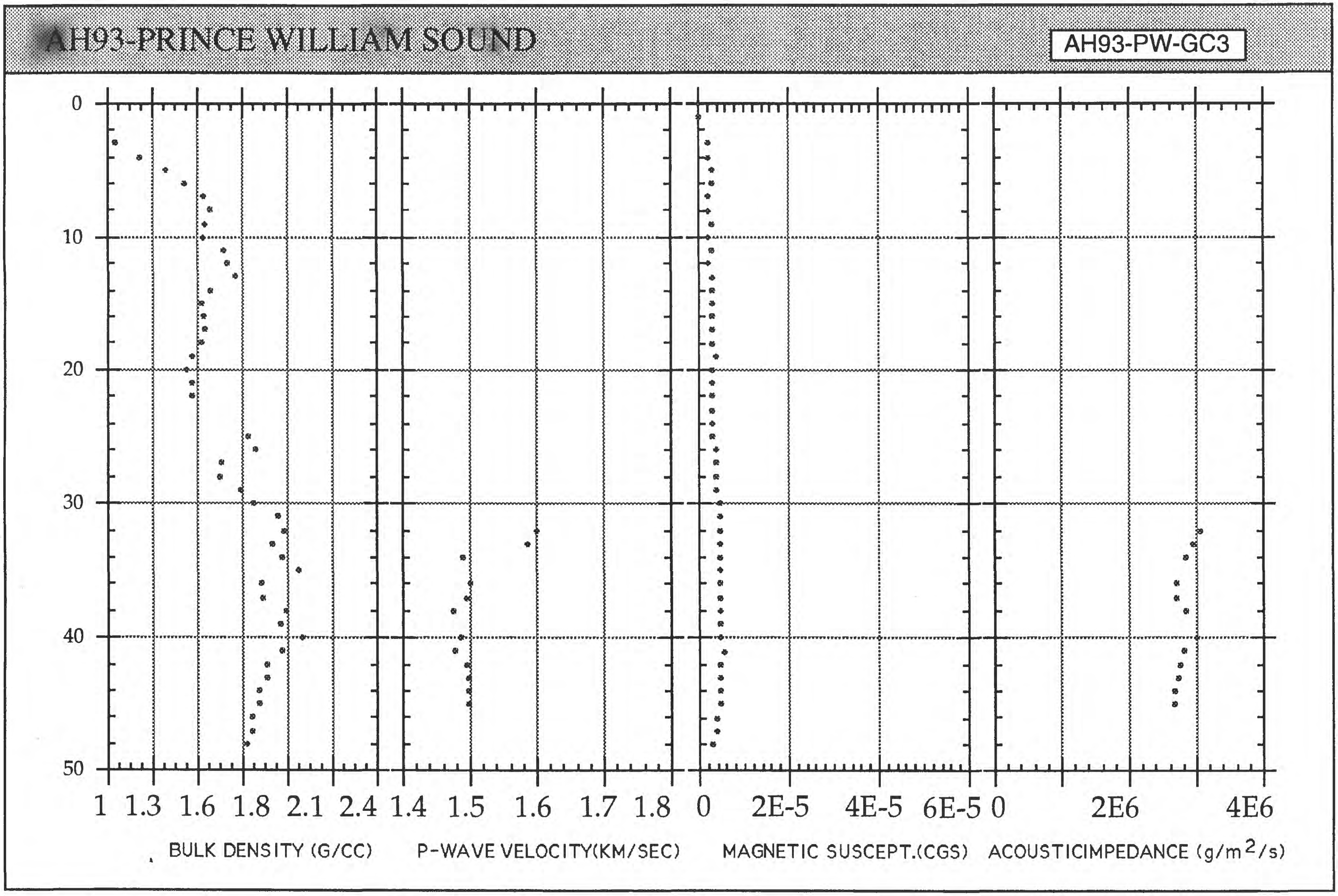
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
0
2E-5
4E-5
6E-5
MAGNETIC SUSCEPT.(CGS)
0
2E6
4E6
ACOUSTICIMPEDANCE (g/m2/s)


AH93-PRINCE WILLIAM SOUND
AH93-PW-GC3
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10
20
30
40
50
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
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2E-5
4E-5
6E-5
MAGNETIC SUSCEPT.(CGS)
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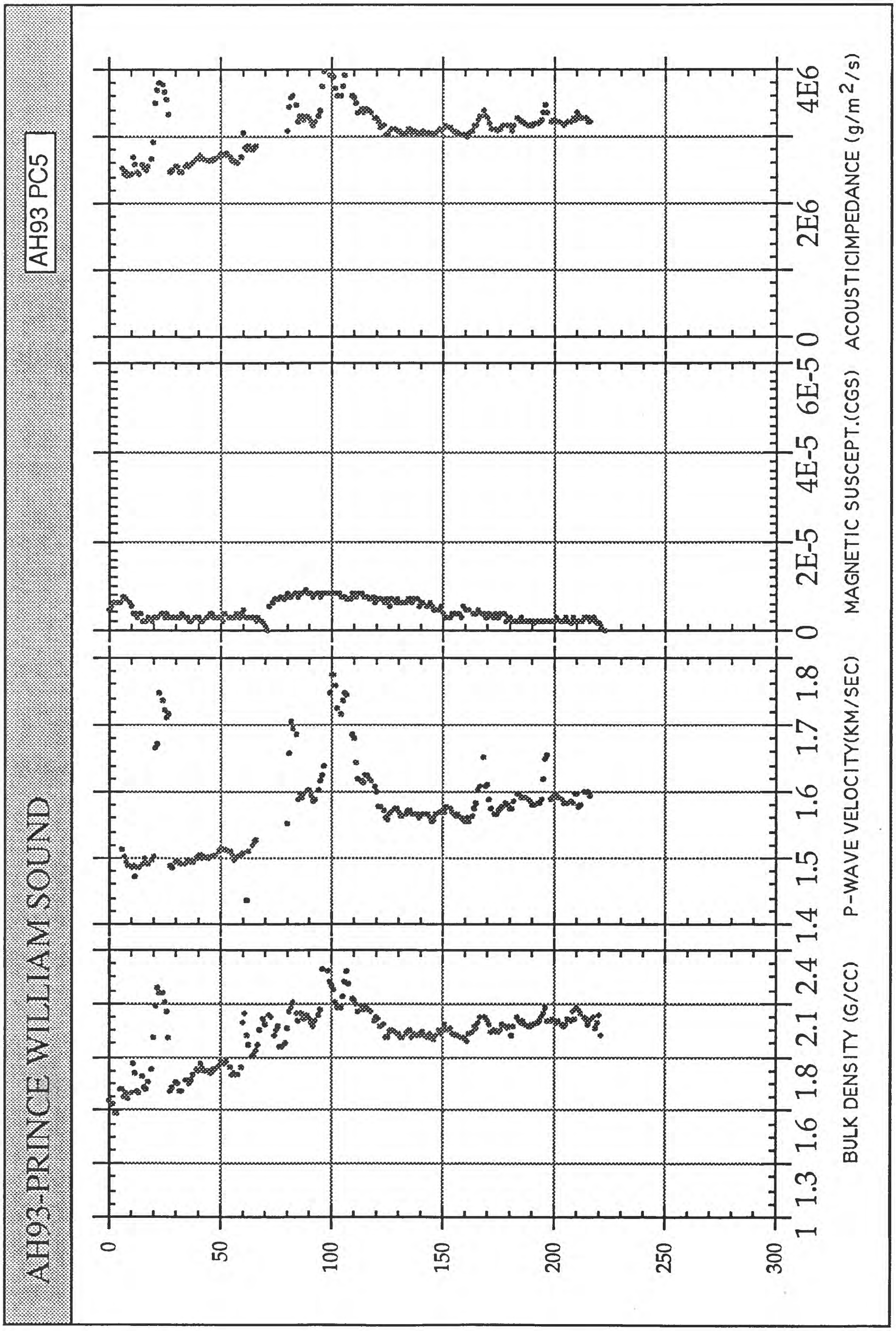
2E6
4E6
ACOUSTICIMPEDANCE (g/m2/s)


AH93-PRINCE WILLIAM SOUND
AH93 PC5
0
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100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
0
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4E-5
6E-5
MAGNETIC SUSCEPT.(CGS)
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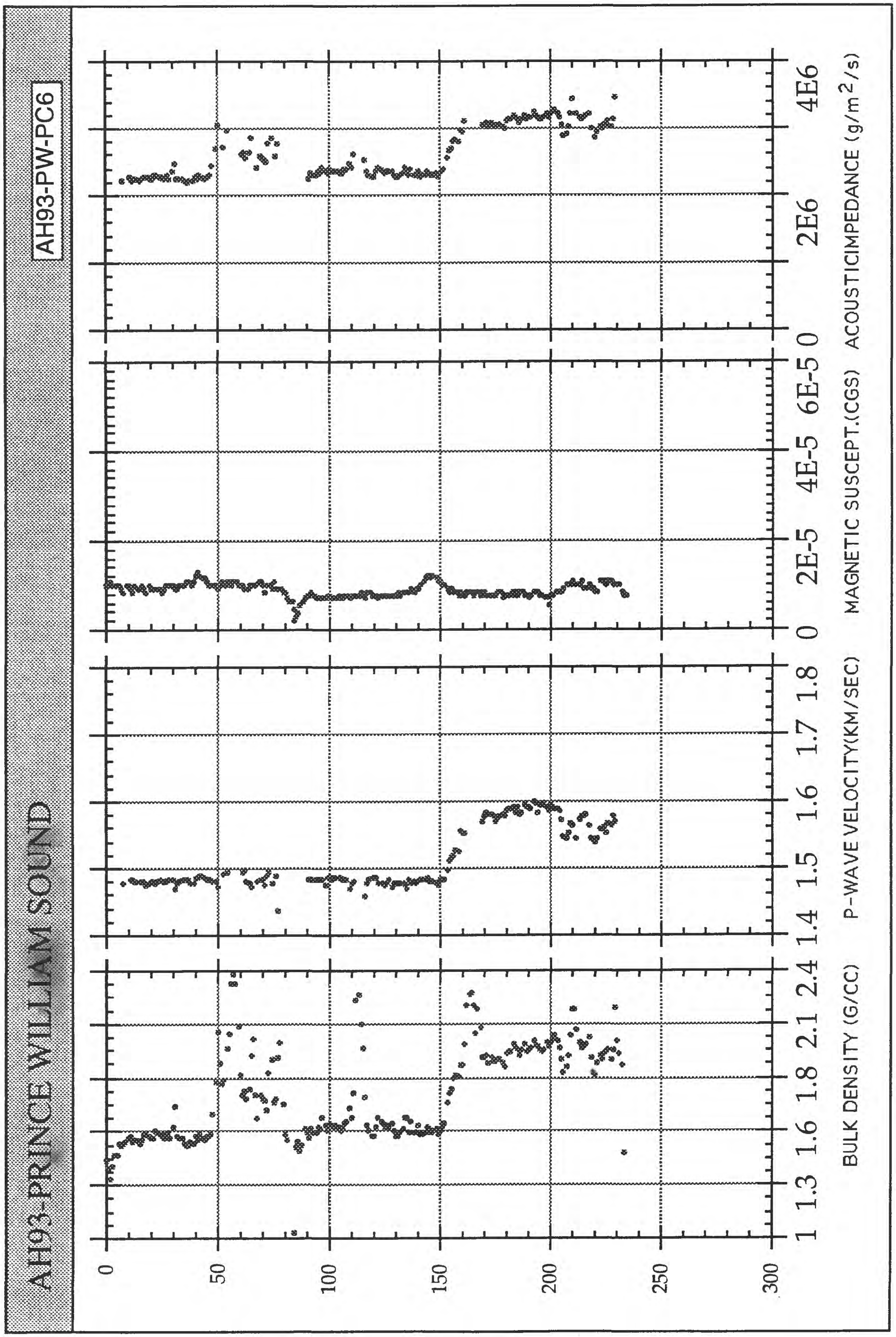
4E6
ACOUSTICIMPEDANCE (g/m^2/s)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AH93-PW-PC6
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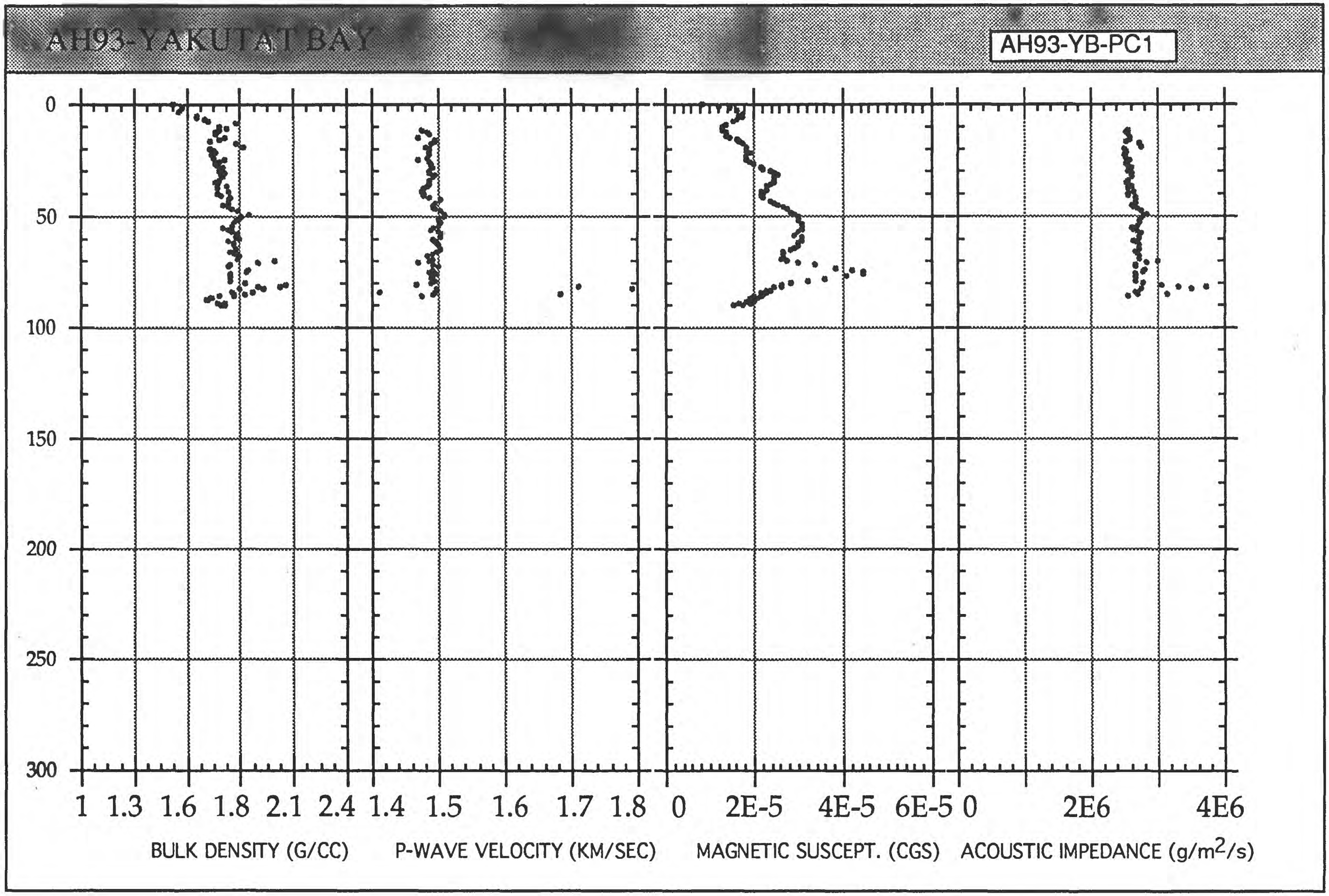
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
0
2E-5
4E-5
6E-5
MAGNETIC SUSCEPT.(CGS)
0
2E6
4E6
ACOUSTICIMPEDANCE (g/m2/s)


AH93-YAKUTAT BAY
AH93-YB-PC1
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY (KM/SEC)
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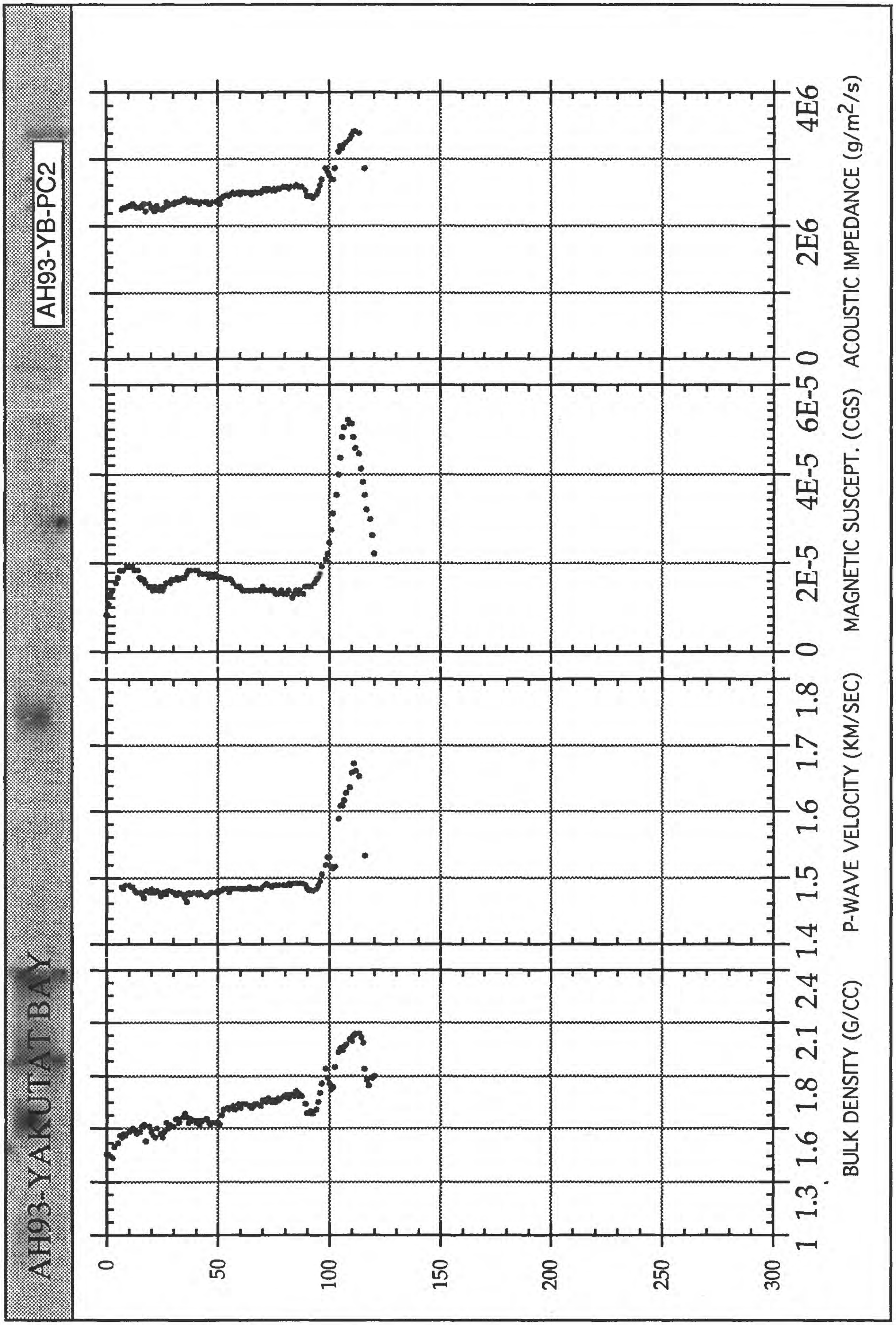
MAGNETIC SUSCEPT. (CGS)
0 2E6 4E6
ACOUSTIC IMPEDANCE (g/m2/s)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AH93-YB-PC2
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150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY (KM/SEC)
0
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4E-5
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MAGNETIC SUSCEPT. (CGS)
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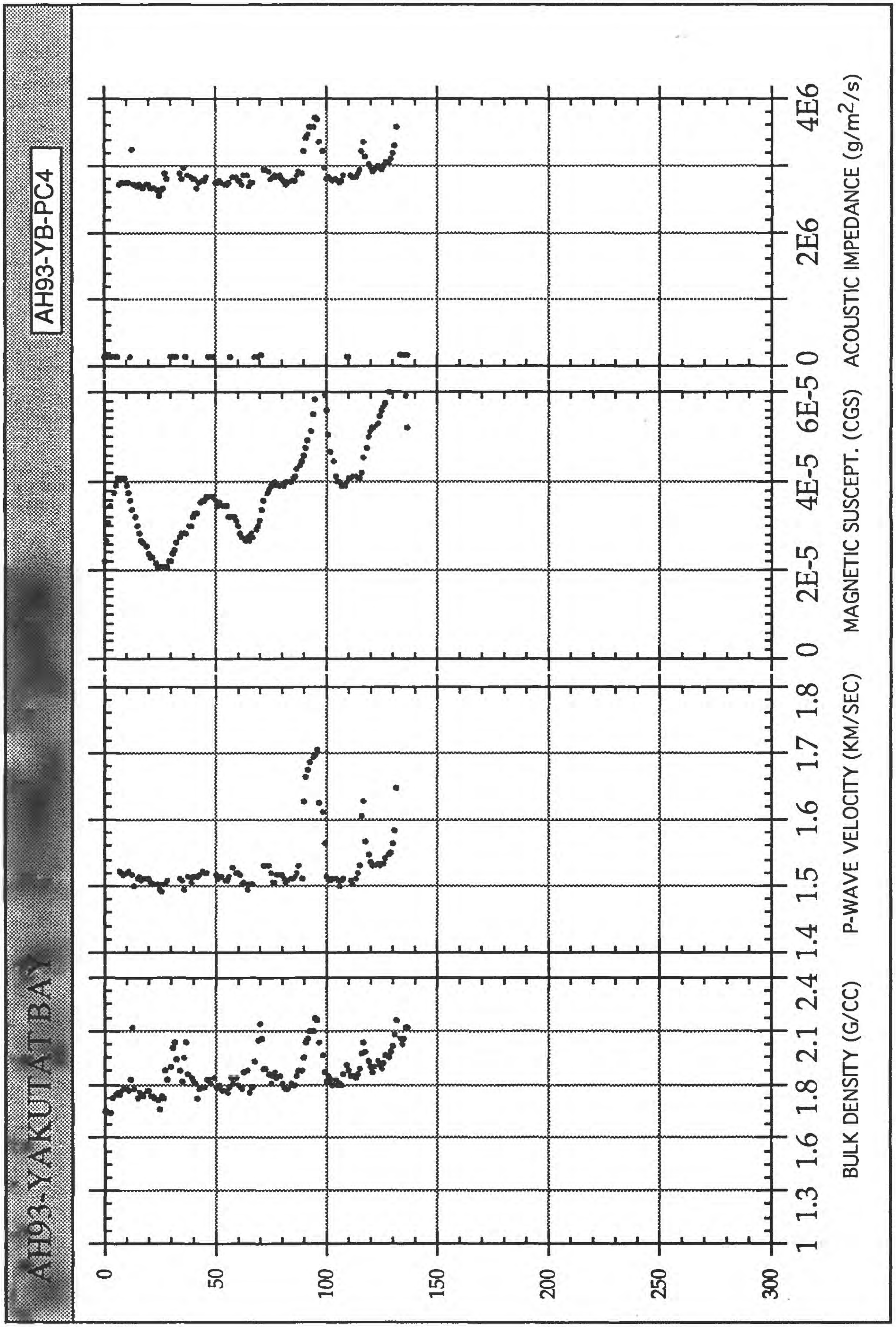
2E6
4E6
ACOUSTIC IMPEDANCE (g/m^2/s)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AH93-YB-PC4
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300
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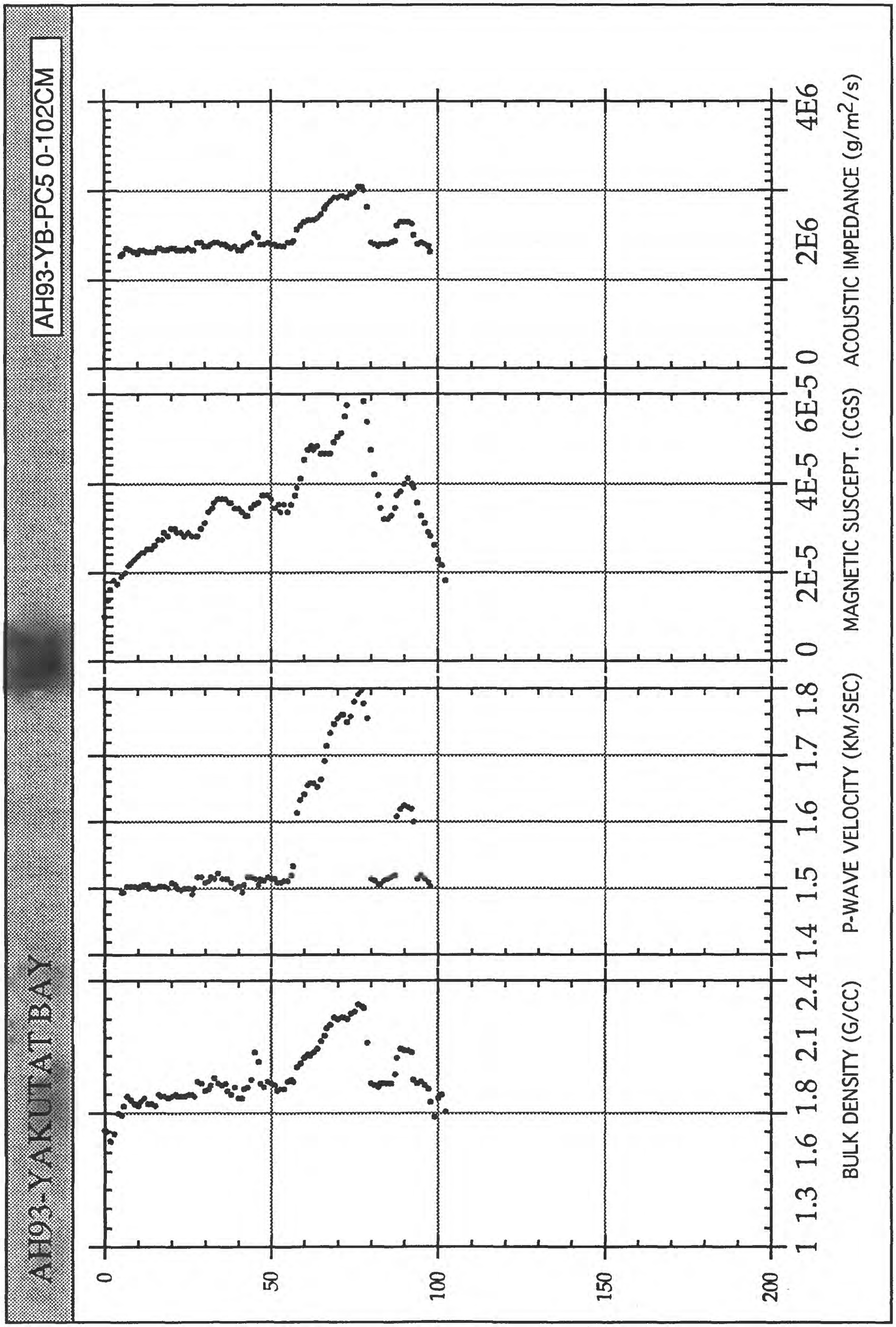
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY (KM/SEC)
0
2E-5
4E-5
6E-5
MAGNETIC SUSCEPT. (CGS)
0
2E6
4E6
ACOUSTIC IMPEDANCE (g/m^2/s)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AH93-YB-PC5 0-102CM
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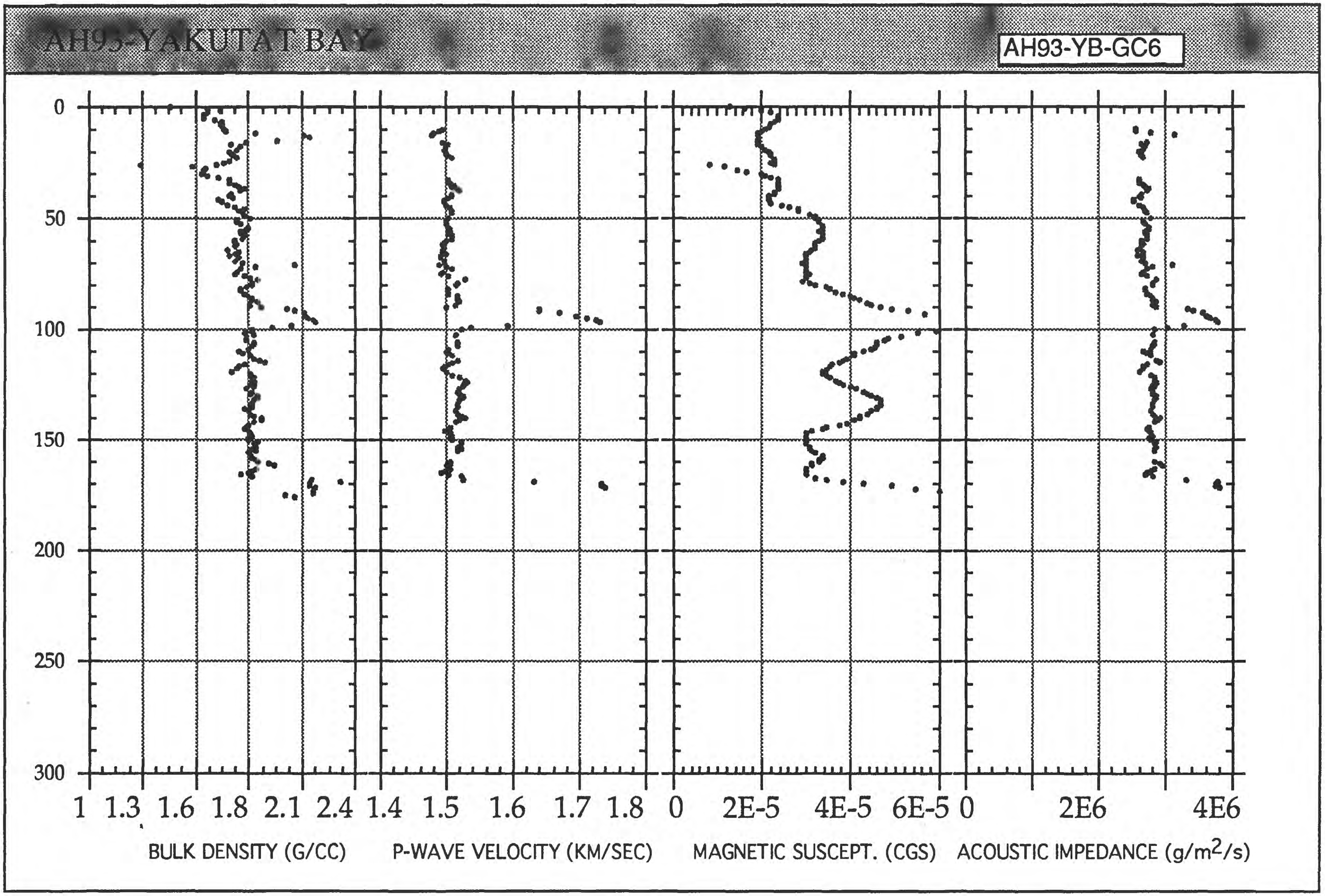
50
100
150
200
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY (KM/SEC)
0 2E-5 4E-5 6E-5
MAGNETIC SUSCEPT. (CGS)
0 2E6 4E6
ACOUSTIC IMPEDANCE (g/m^2/s)


AH93-YAKUTAT BAY
AH93-YB-GC6
0
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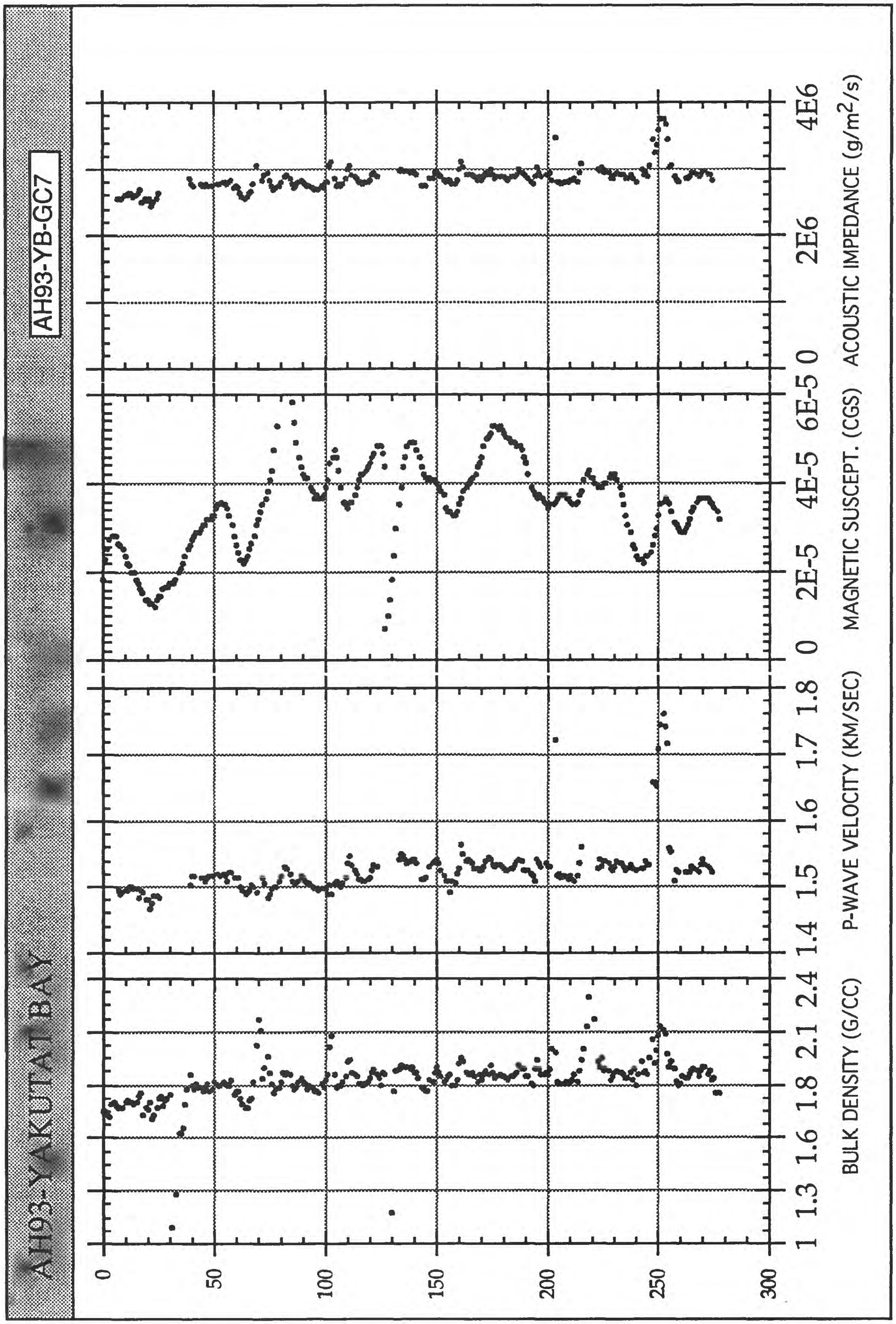
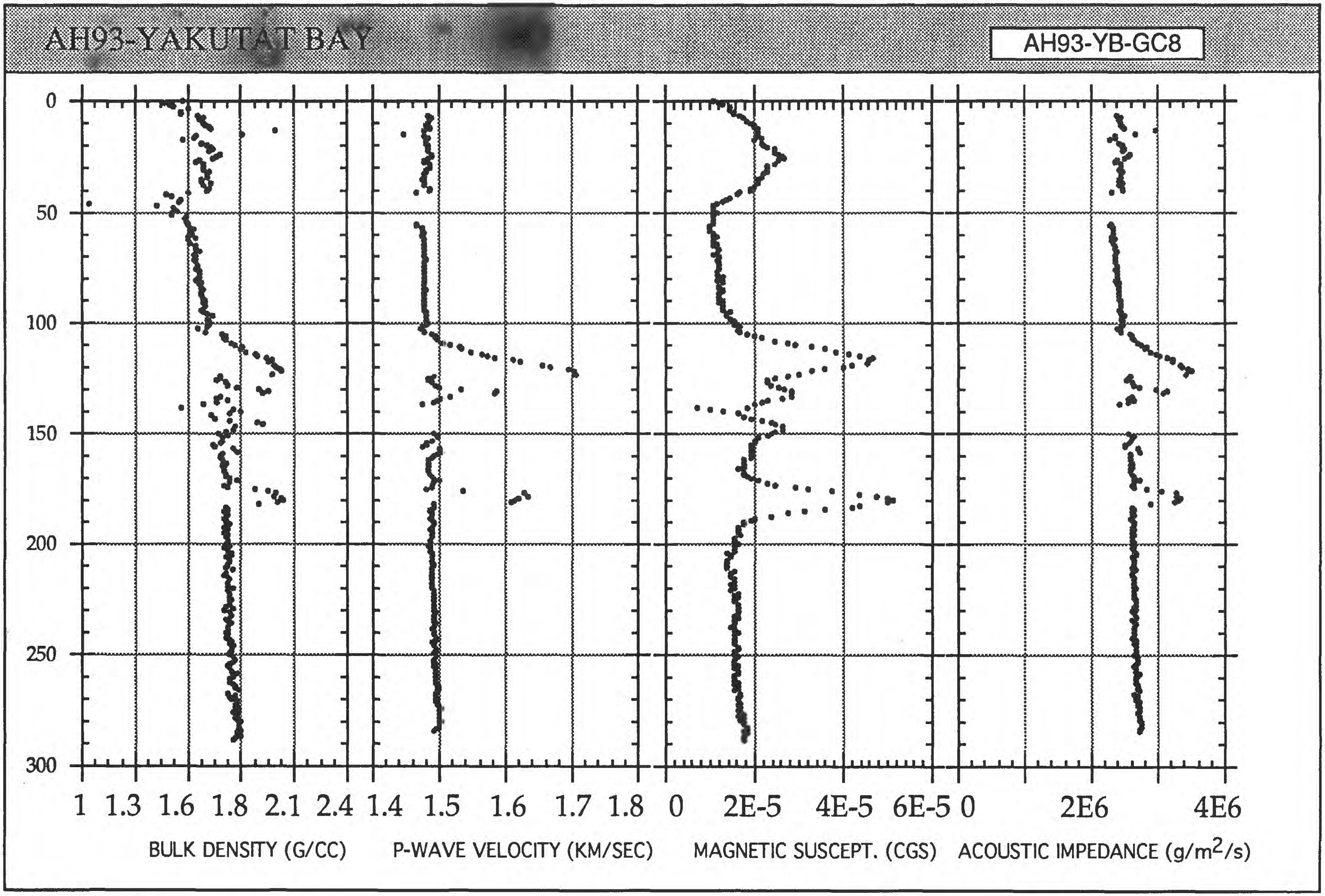
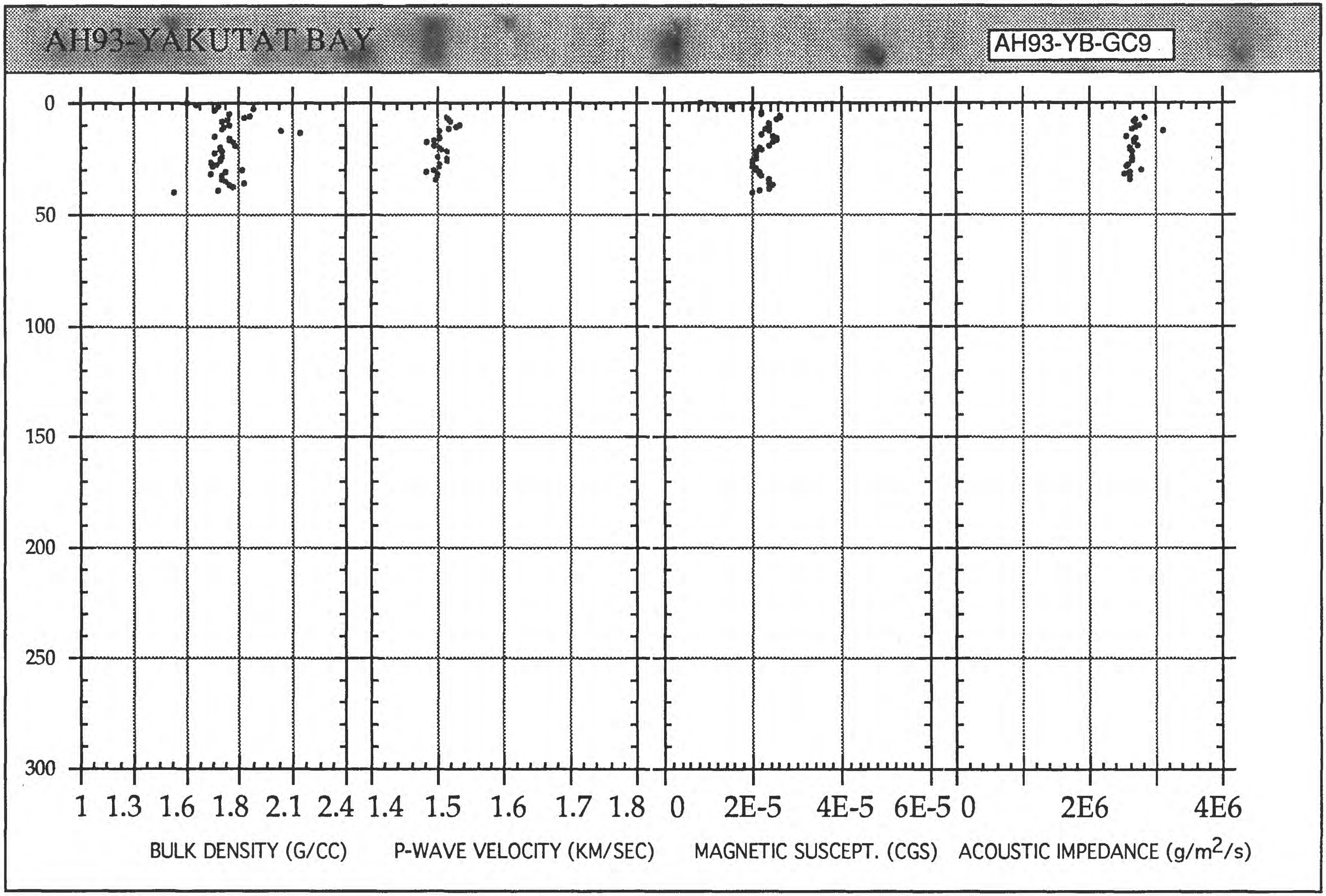
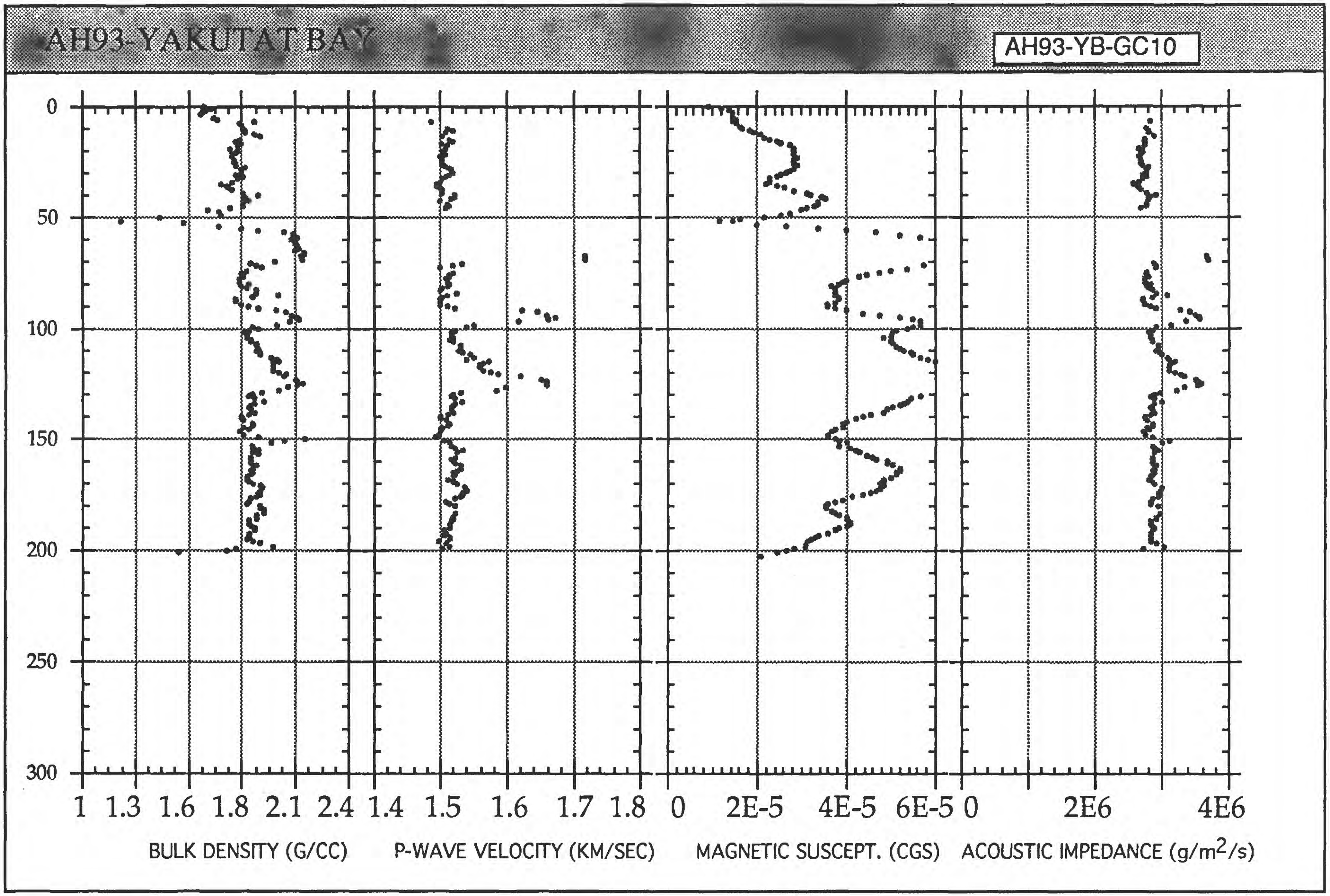
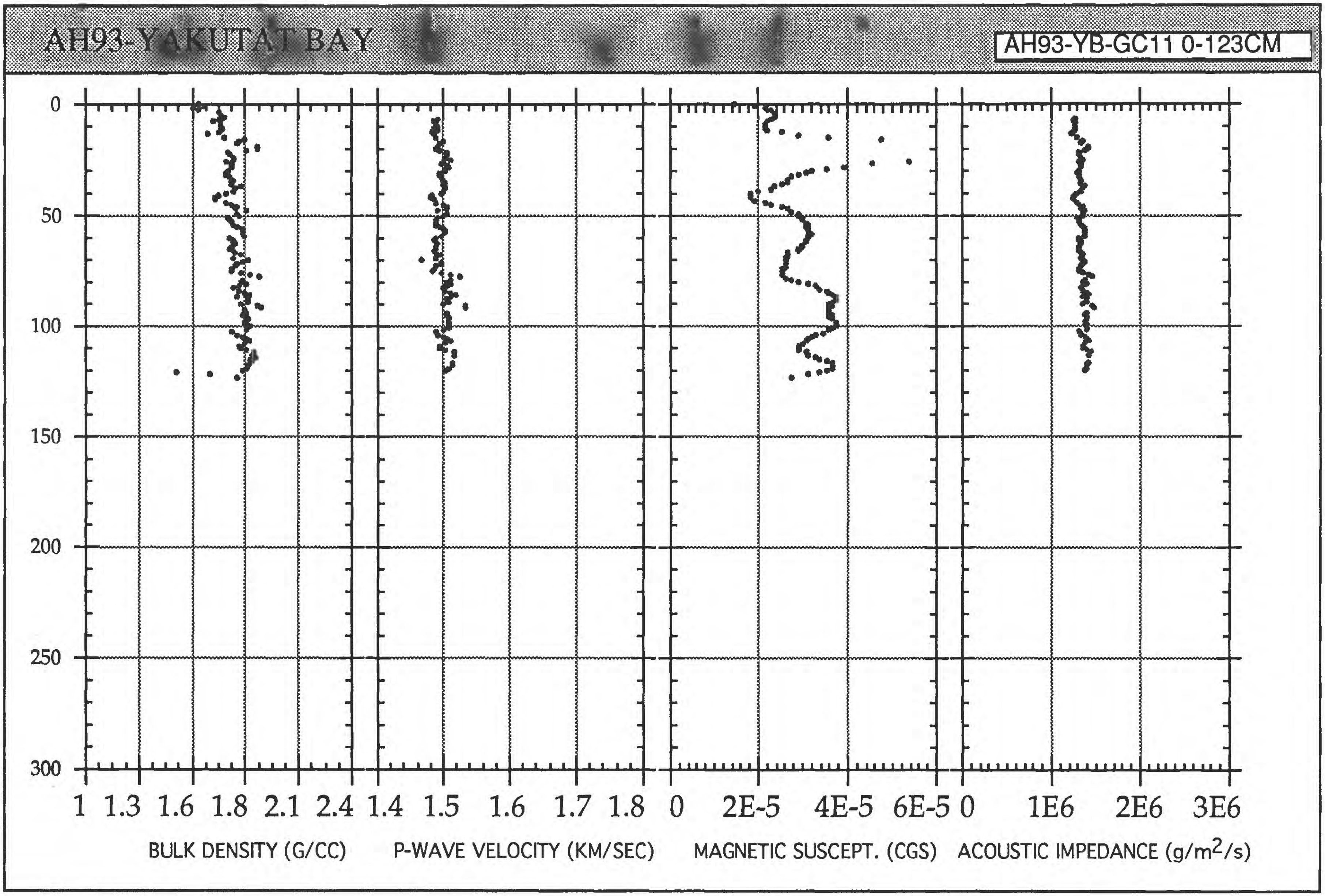
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY (KM/SEC)
0
2E-5
4E-5
6E-5
MAGNETIC SUSCEPT. (CGS)
0
2E6
4E6
ACOUSTIC IMPEDANCE (g/m2/s)

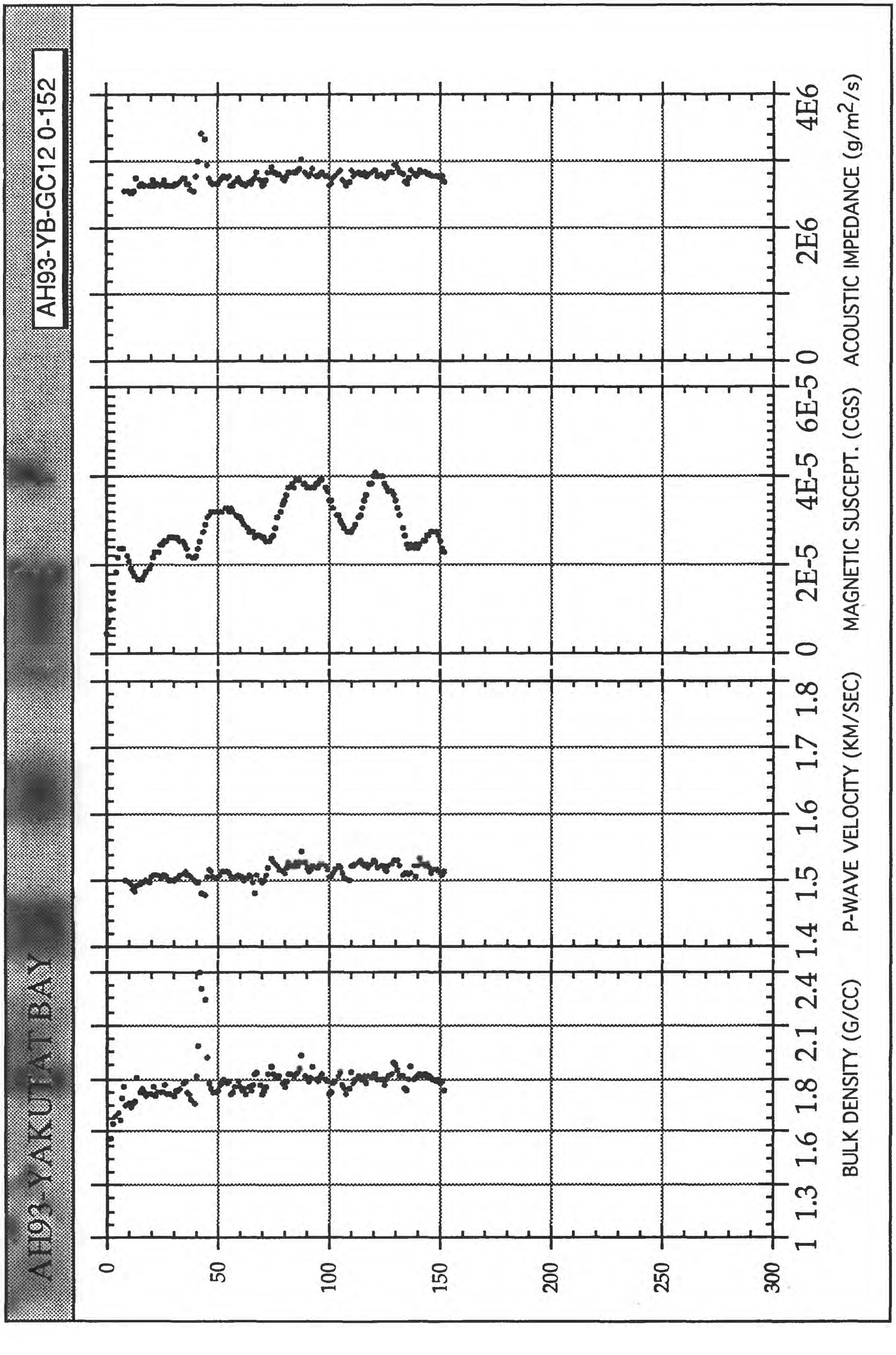

AH93-YAKUTAT BAY
AH93-YB-GC7
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY (KM/SEC)
0 2E-5 4E-5 6E-5
MAGNETIC SUSCEPT. (CGS)
0 2E6 4E6
ACOUSTIC IMPEDANCE (g/m^2/s)

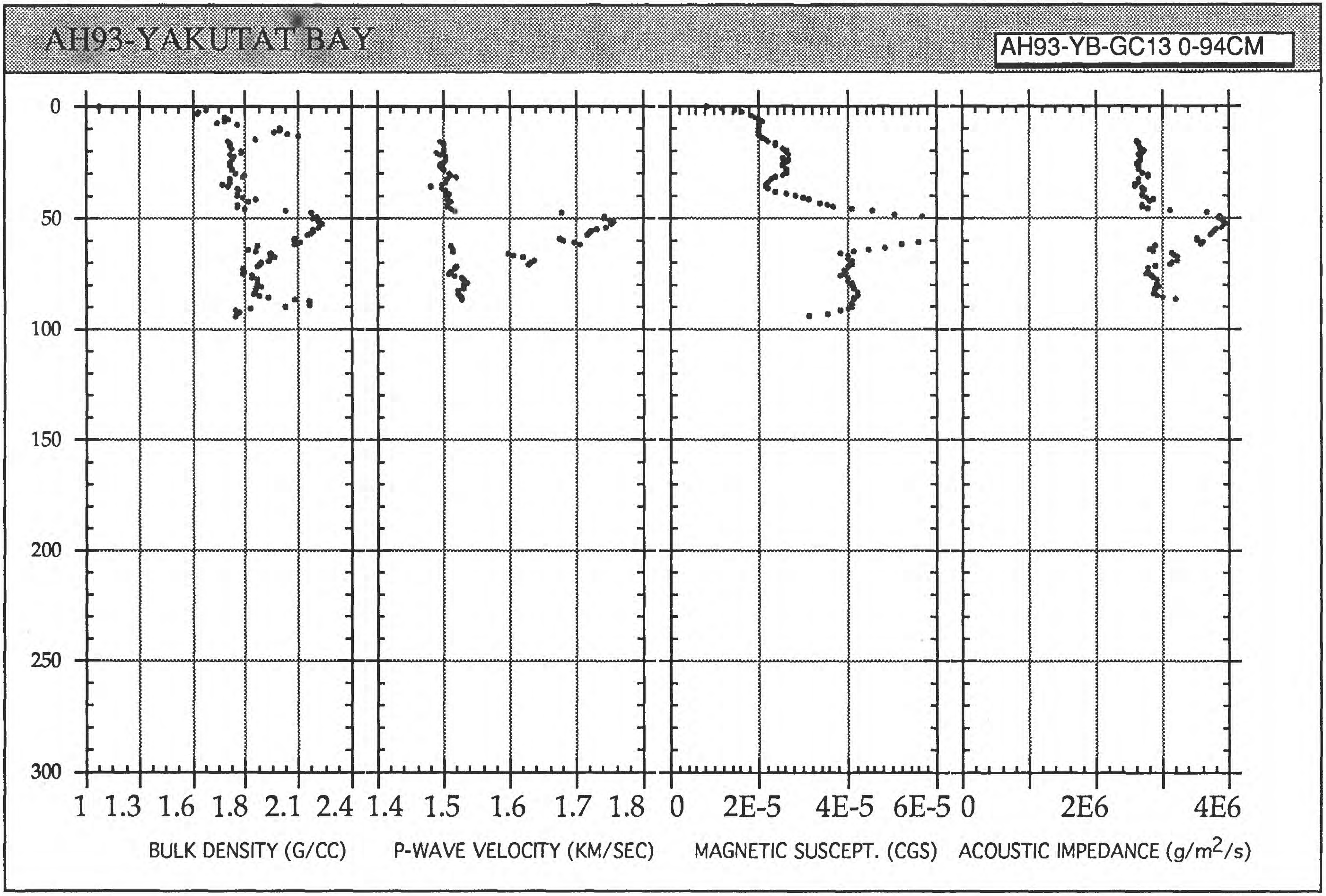

AH93-YAKUTAT BAY
AH93-YB-GC8
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY (KM/SEC)
0 2E-5 4E-5 6E-5
MAGNETIC SUSCEPT. (CGS)
0 2E6 4E6
ACOUSTIC IMPEDANCE (g/m²/s)

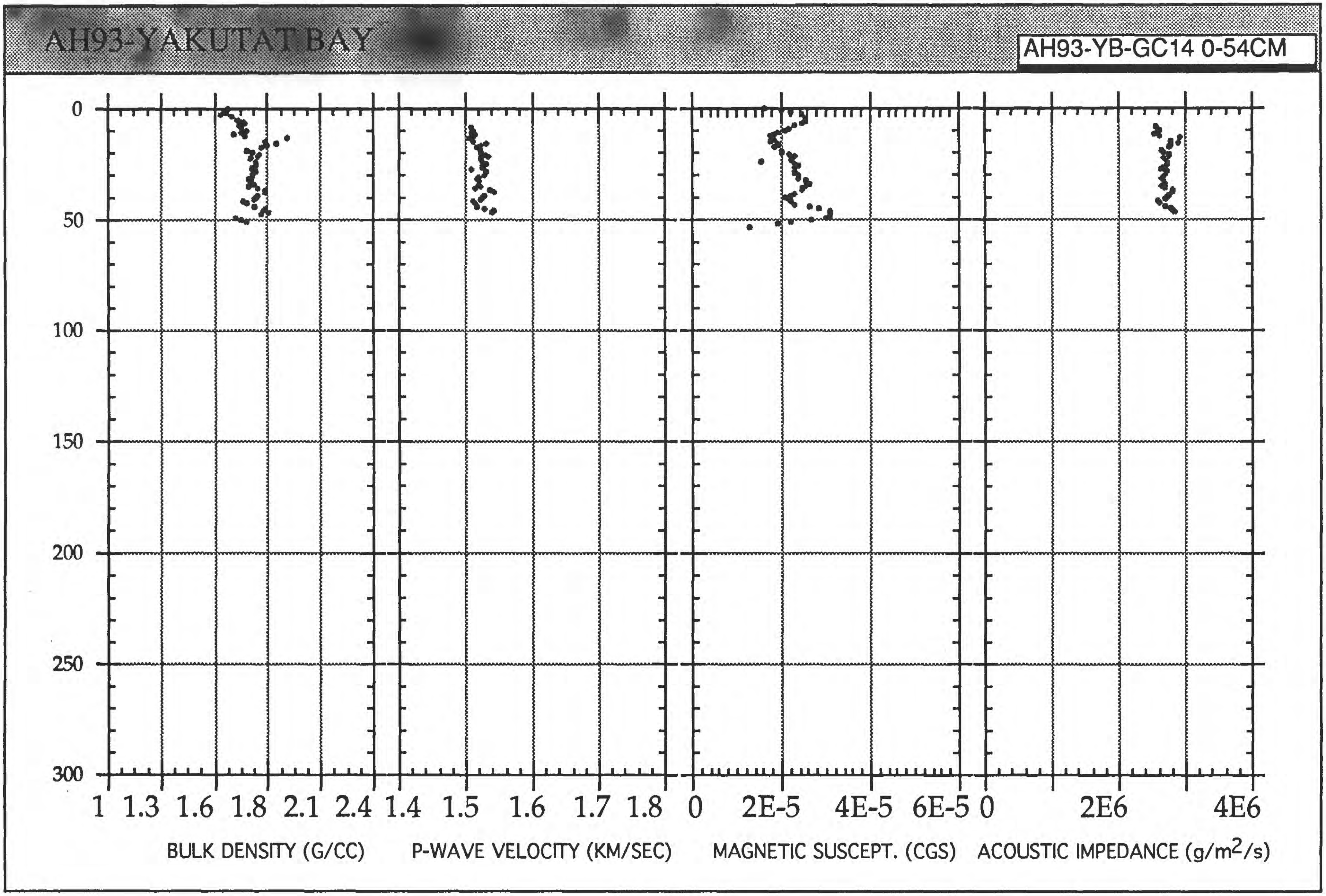

AH93-YAKUTAT BAY
AH93-YB-GC9
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY (KM/SEC)
0
2E-5
4E-5
6E-5
MAGNETIC SUSCEPT. (CGS)
0
2E6
4E6
ACOUSTIC IMPEDANCE (g/m2/s)

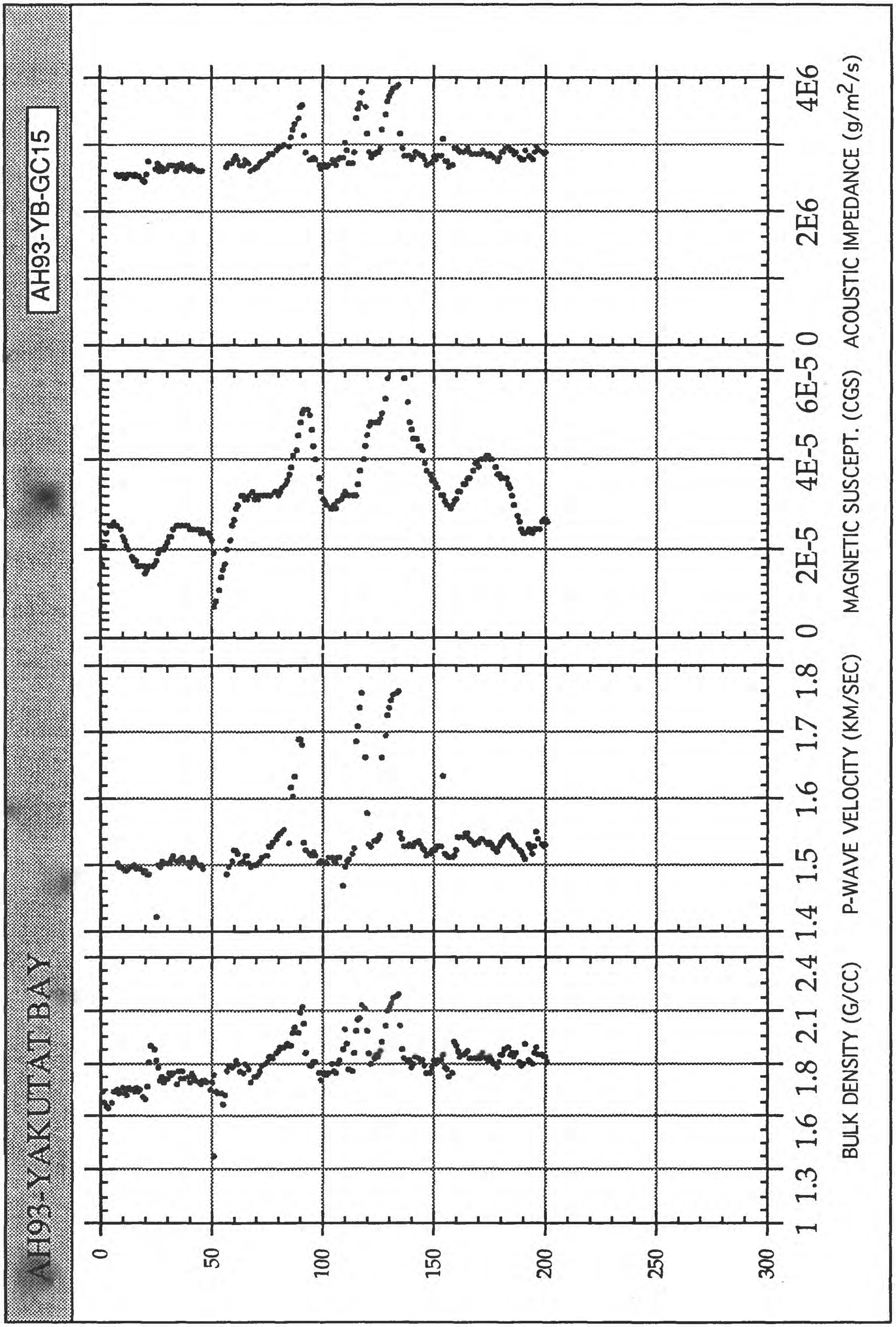

AH93-YAKUTAT BAY
AH93-YB-GC10
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
1.4
1.5
1.6
1.7
1.8
0
2E-5
4E-5
6E-5
0
2E6
4E6
BULK DENSITY (G/CC)
P-WAVE VELOCITY (KM/SEC)
MAGNETIC SUSCEPT. (CGS)
ACOUSTIC IMPEDANCE (g/m2/s)

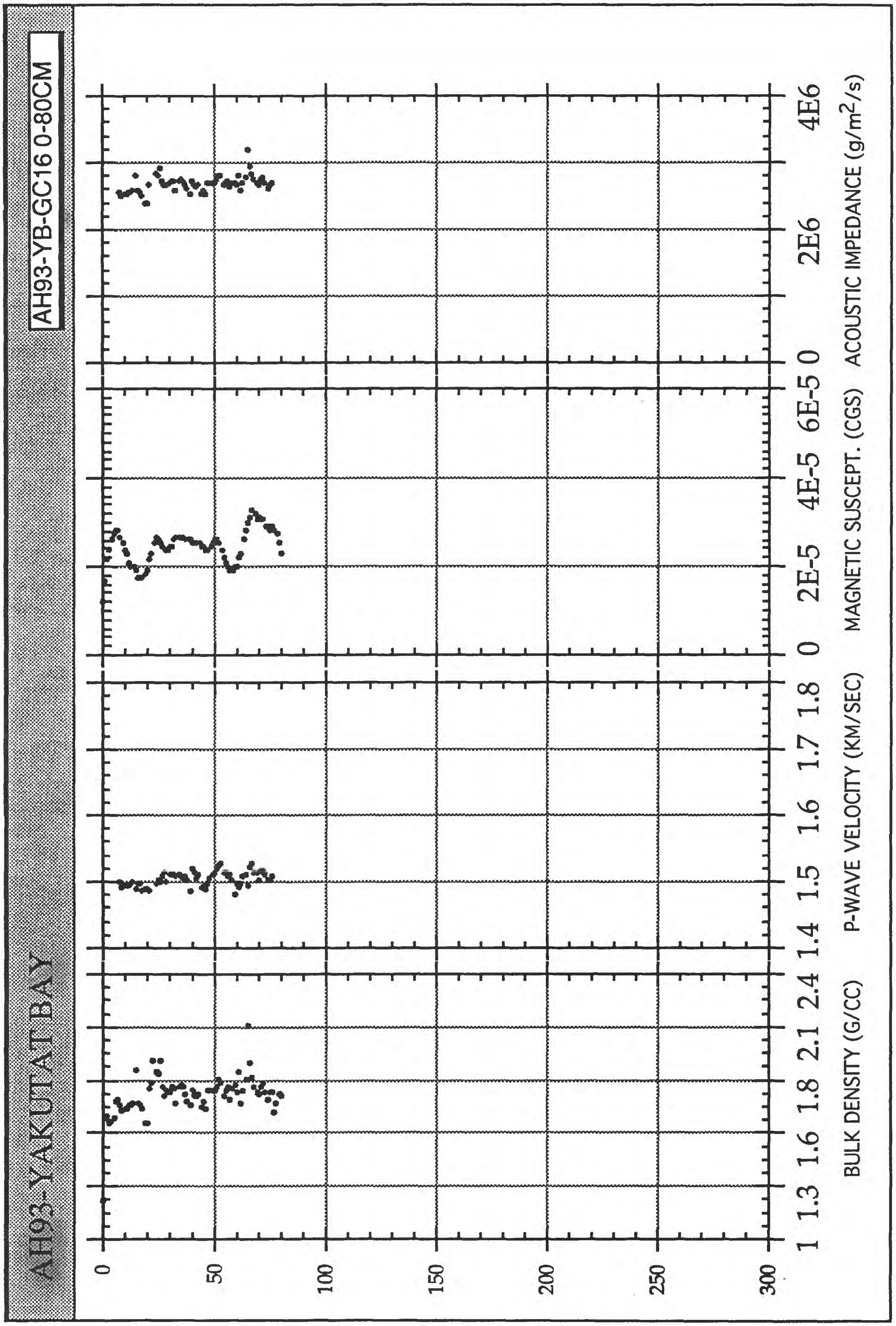

AH93-YAKUTAT BAY
AH93-YB-GC11 0-123CM
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
1.4
1.5
1.6
1.7
1.8
0
2E-5
4E-5
6E-5
0
1E6
2E6
3E6
BULK DENSITY (G/CC)
P-WAVE VELOCITY (KM/SEC)
MAGNETIC SUSCEPT. (CGS)
ACOUSTIC IMPEDANCE (g/m2/s)

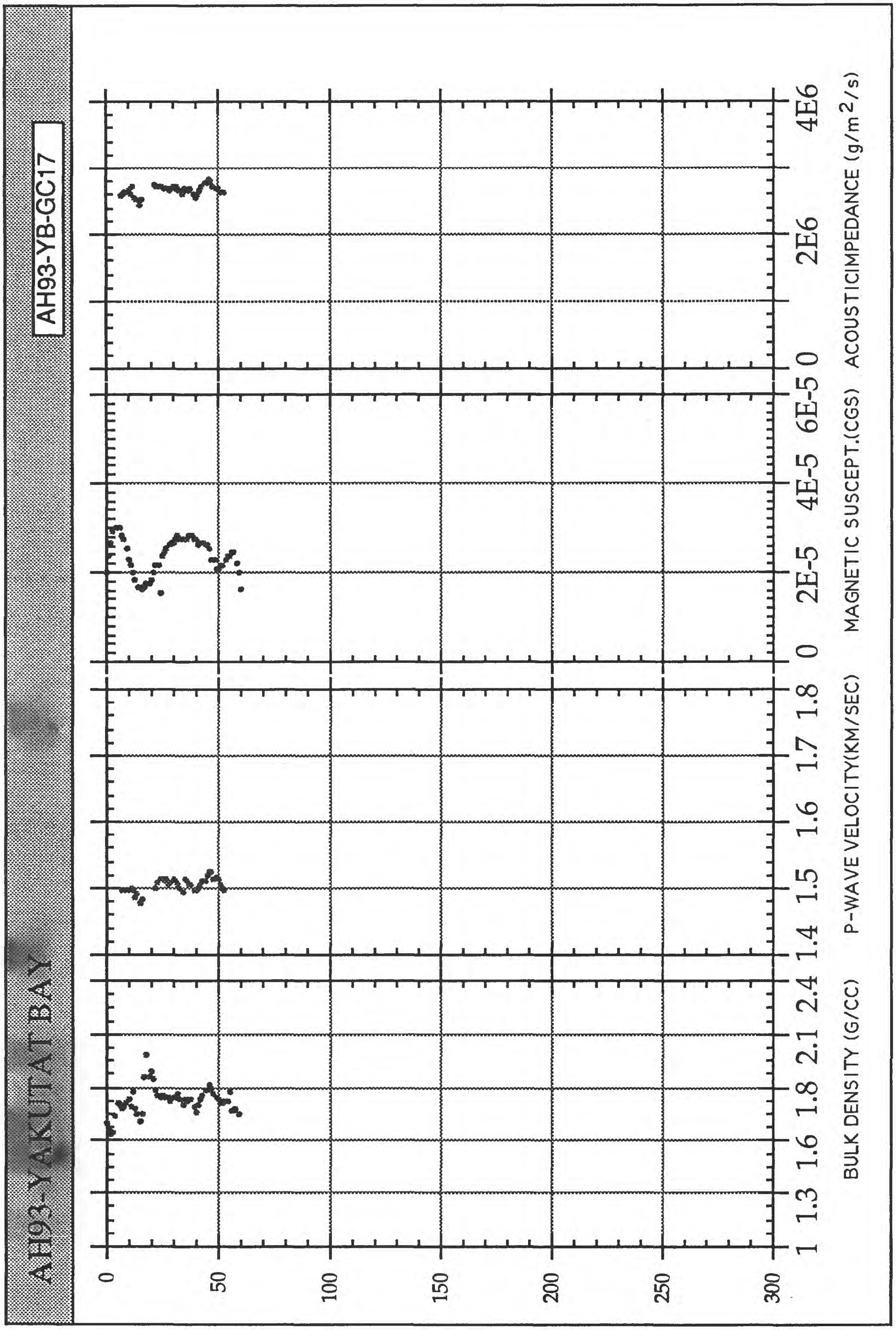

AH93-YAKUTAT BAY
AH93-YB-GC12 0-152
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY (KM/SEC)
0
2E-5
4E-5
6E-5
MAGNETIC SUSCEPT. (CGS)
0
2E6
4E6
ACOUSTIC IMPEDANCE ($g/m^2/s$)

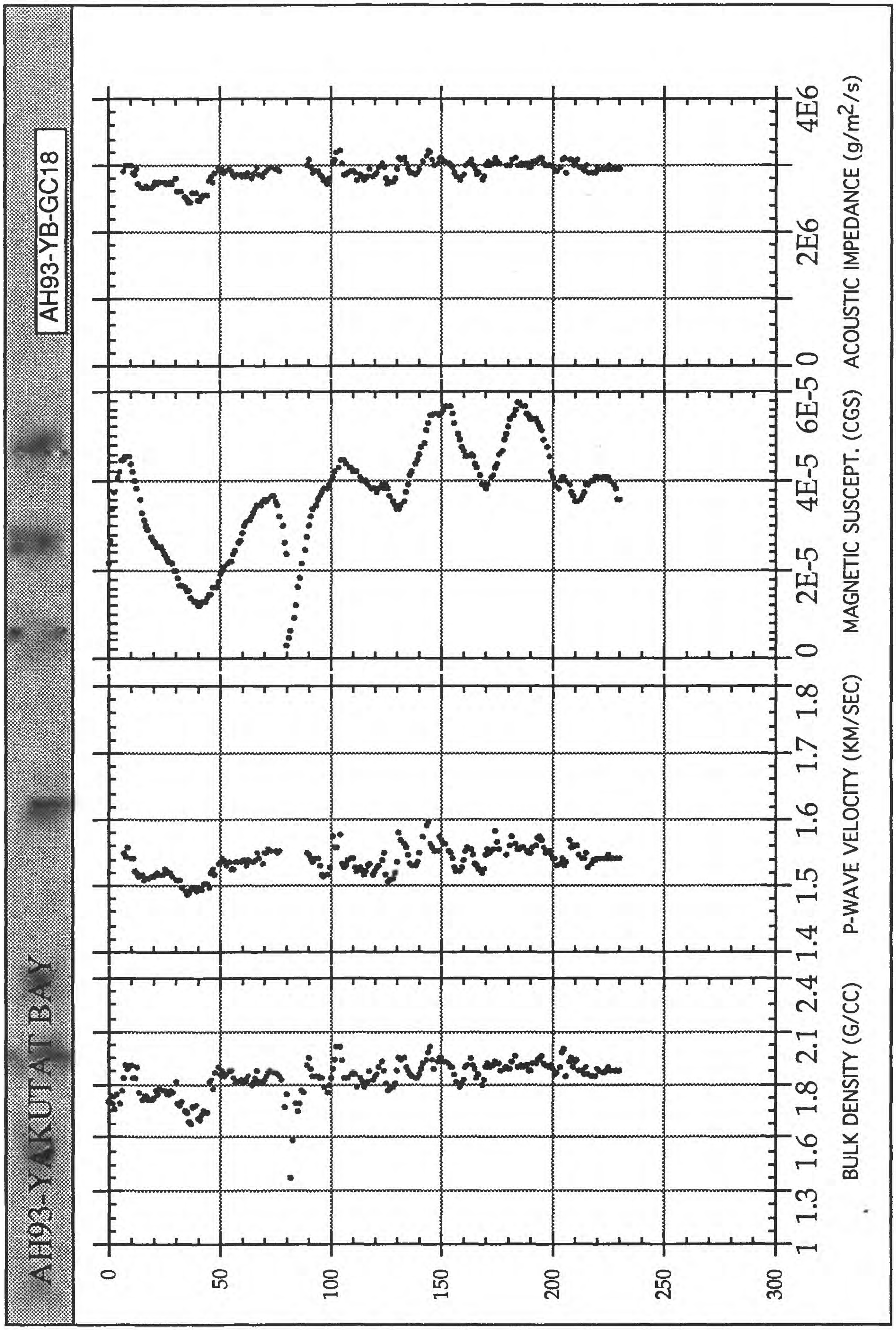

AH93-YAKUTAT BAY
AH93-YB-GC13 0-94CM
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY (KM/SEC)
0 2E-5 4E-5 6E-5
MAGNETIC SUSCEPT. (CGS)
0 2E6 4E6
ACOUSTIC IMPEDANCE (g/m2/s)

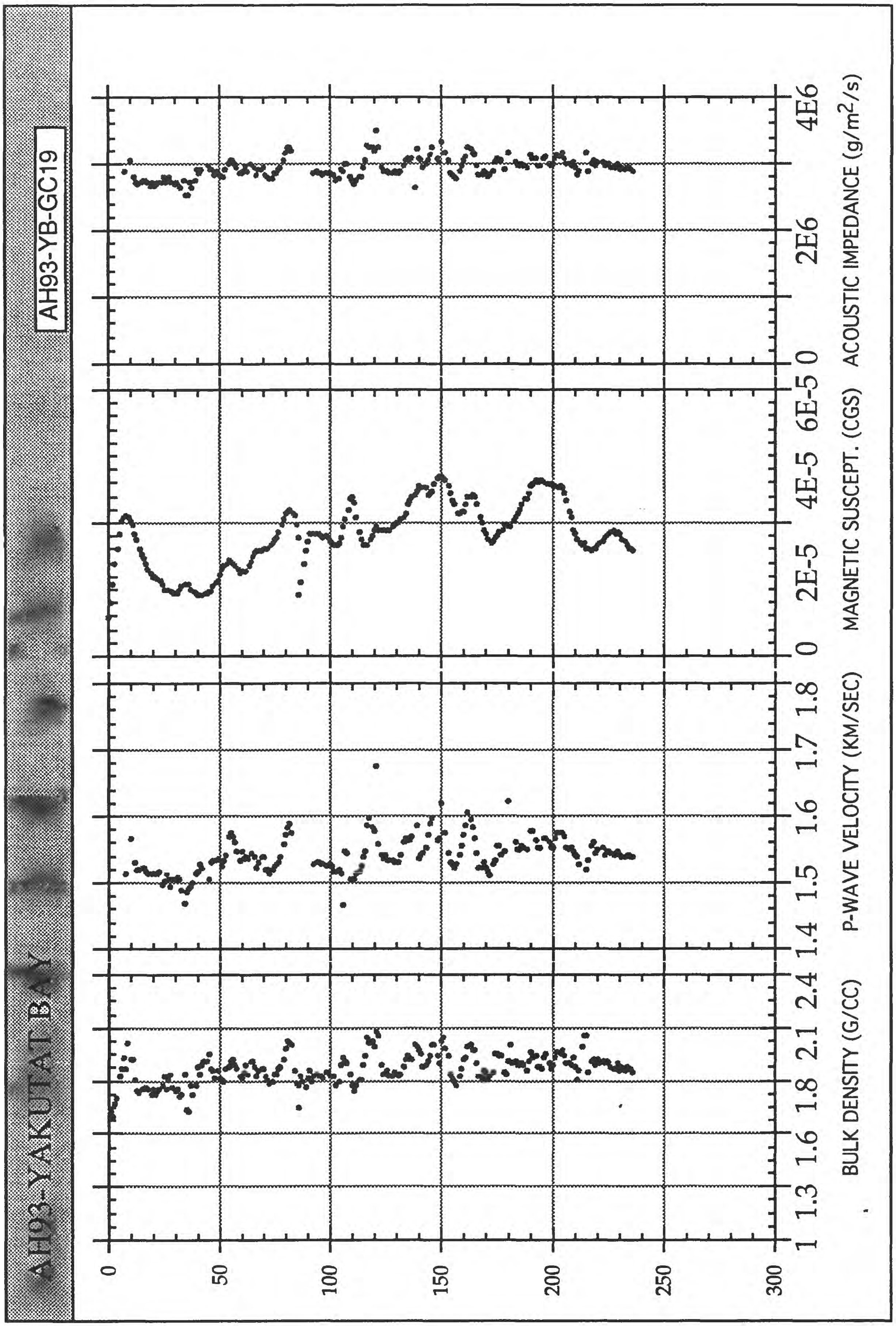

AH93-YAKUTAT BAY
AH93-YB-GC14 0-54CM
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY (KM/SEC)
0
2E-5
4E-5
6E-5
MAGNETIC SUSCEPT. (CGS)
0
2E6
4E6
ACOUSTIC IMPEDANCE (g/m2/s)

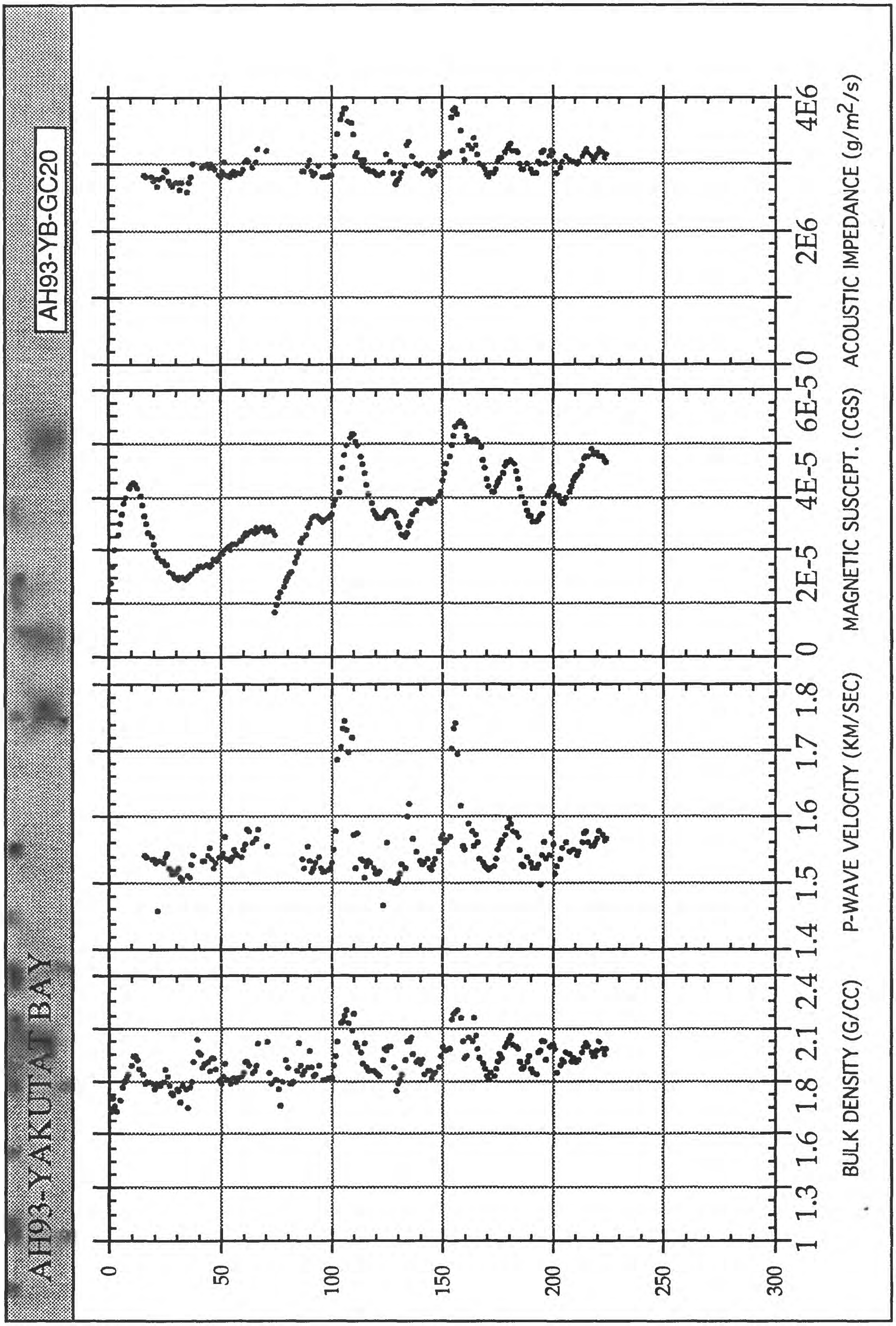

AH93-YAKUTAT BAY
AH93-YB-GC15
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY (KM/SEC)
0 2E-5 4E-5 6E-5
MAGNETIC SUSCEPT. (CGS)
0 2E6 4E6
ACOUSTIC IMPEDANCE (g/m^2/s)

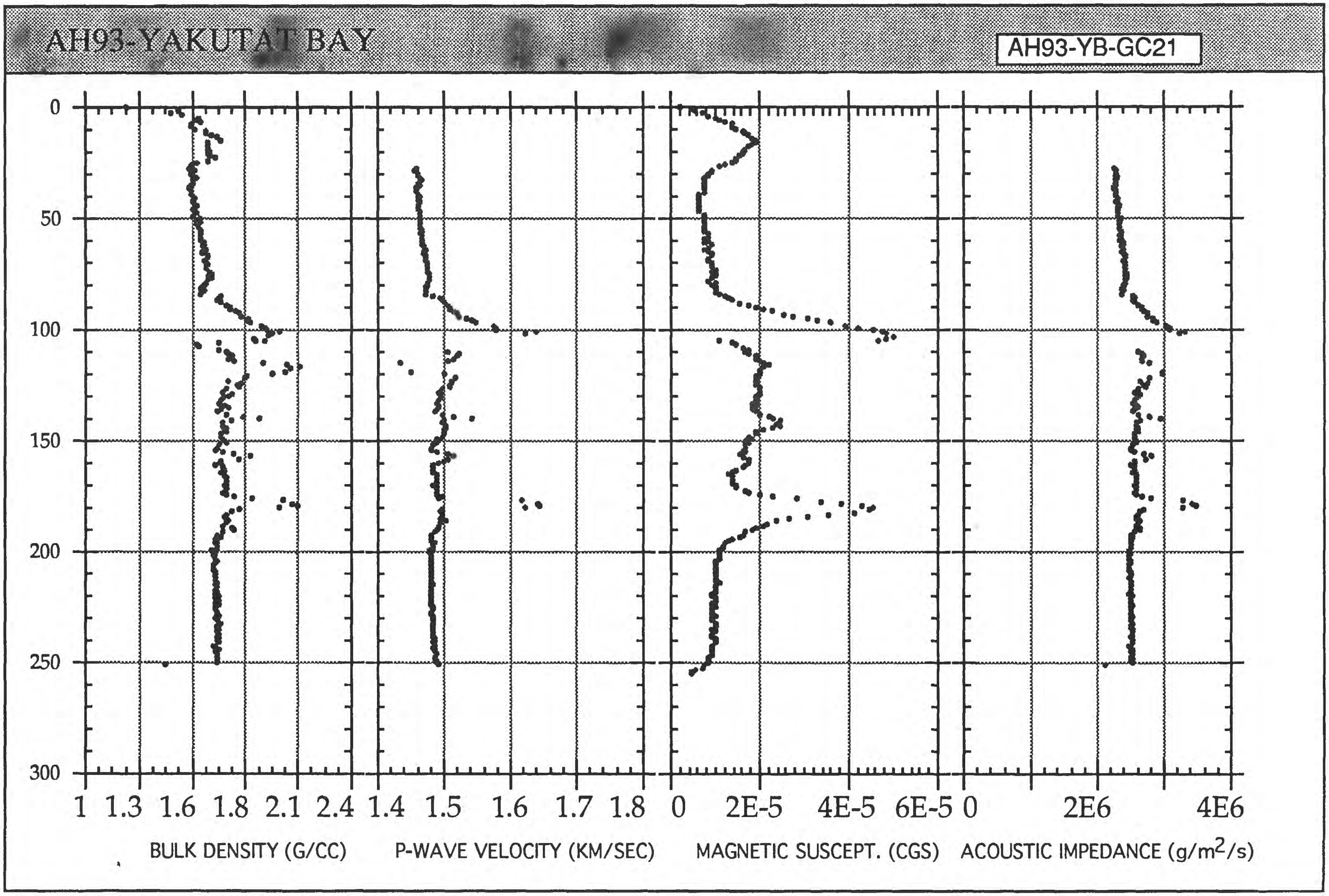

AH93-YAKUTAT BAY
AH93-YB-GC16 0-80CM
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY (KM/SEC)
0
2E-5
4E-5
6E-5
MAGNETIC SUSCEPT. (CGS)
0
2E6
4E6
ACOUSTIC IMPEDANCE (g/m^2/s)

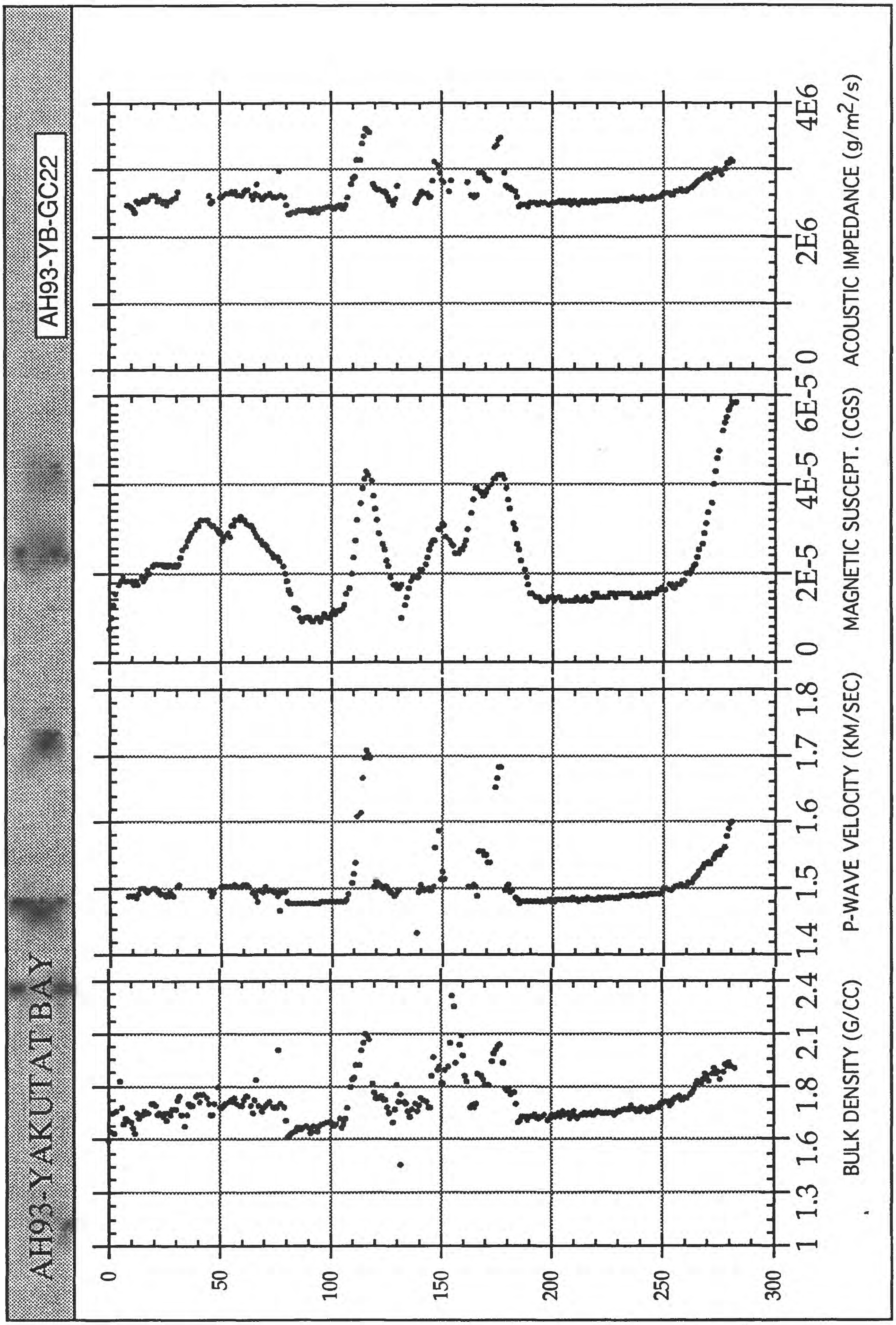

AH93-YAKUTAT BAY
AH93-YB-GC17
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY(KM/SEC)
0 2E-5 4E-5 6E-5
MAGNETIC SUSCEPT.(CGS)
0 2E6 4E6
ACOUSTICIMPEDANCE (g/m2/s)

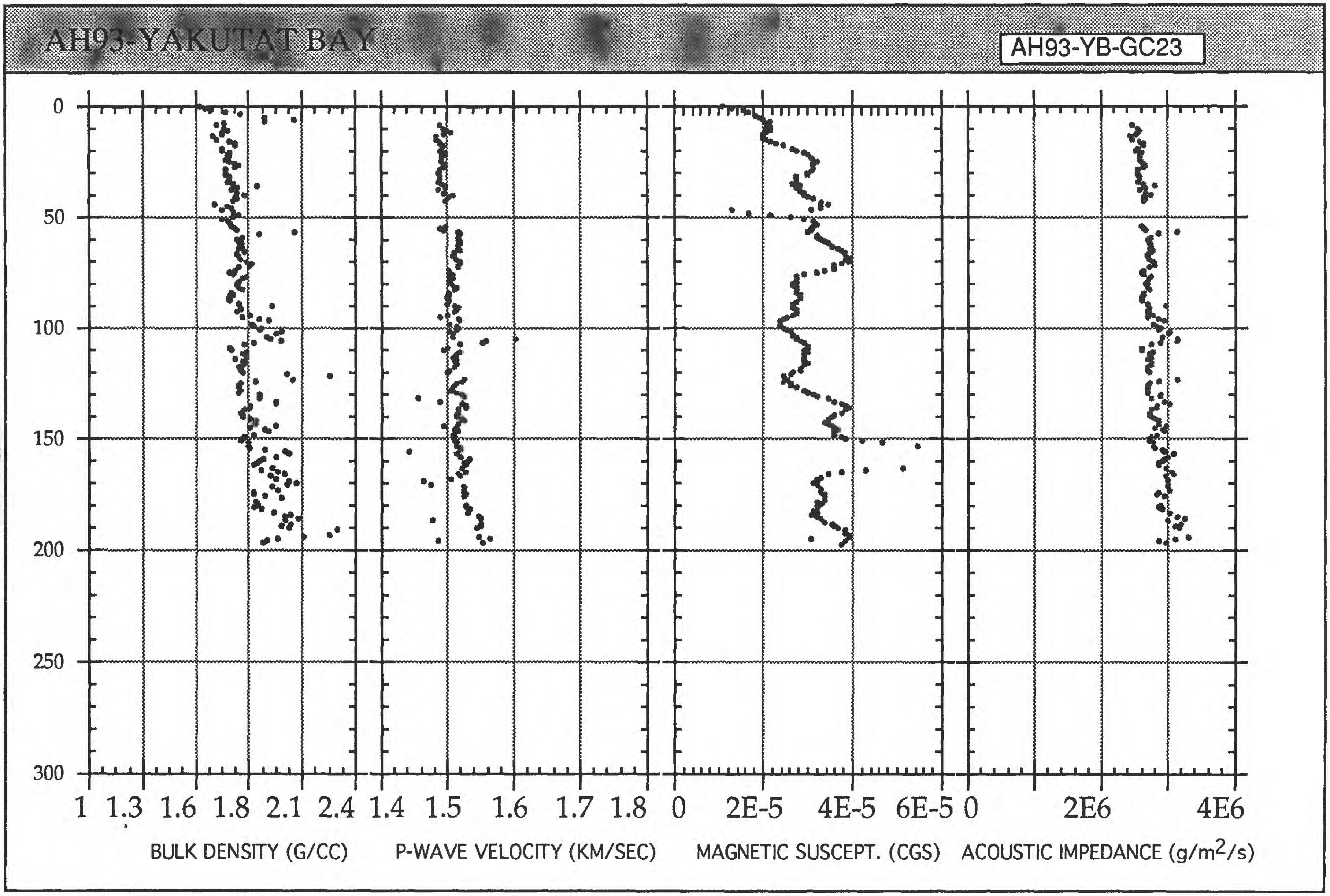

AH93-YAKUTAT BAY
AH93-YB-GC18
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY (KM/SEC)
0 2E-5 4E-5 6E-5
MAGNETIC SUSCEPT. (CGS)
0 2E6 4E6
ACOUSTIC IMPEDANCE (g/m^2/s)

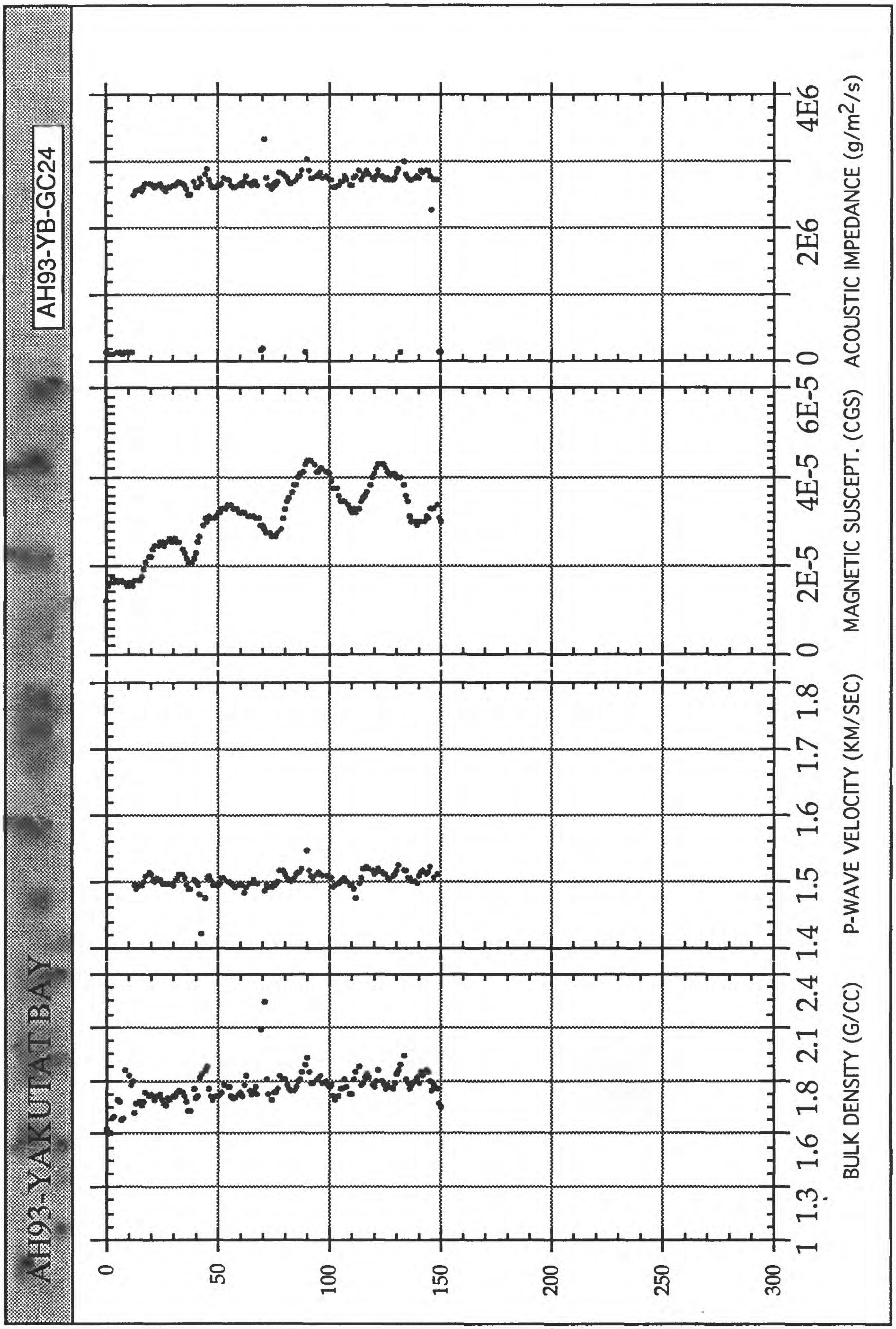

AH93-YAKUTAT BAY
AH93-YB-GC19
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY (KM/SEC)
0
2E-5
4E-5
6E-5
MAGNETIC SUSCEPT. (CGS)
0
2E6
4E6
ACOUSTIC IMPEDANCE (g/m^2/s)


AH93-YAKUTAT BAY
AH93-YB-GC20
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY (KM/SEC)
0 2E-5 4E-5 6E-5
MAGNETIC SUSCEPT. (CGS)
0 2E6 4E6
ACOUSTIC IMPEDANCE (g/m^2/s)

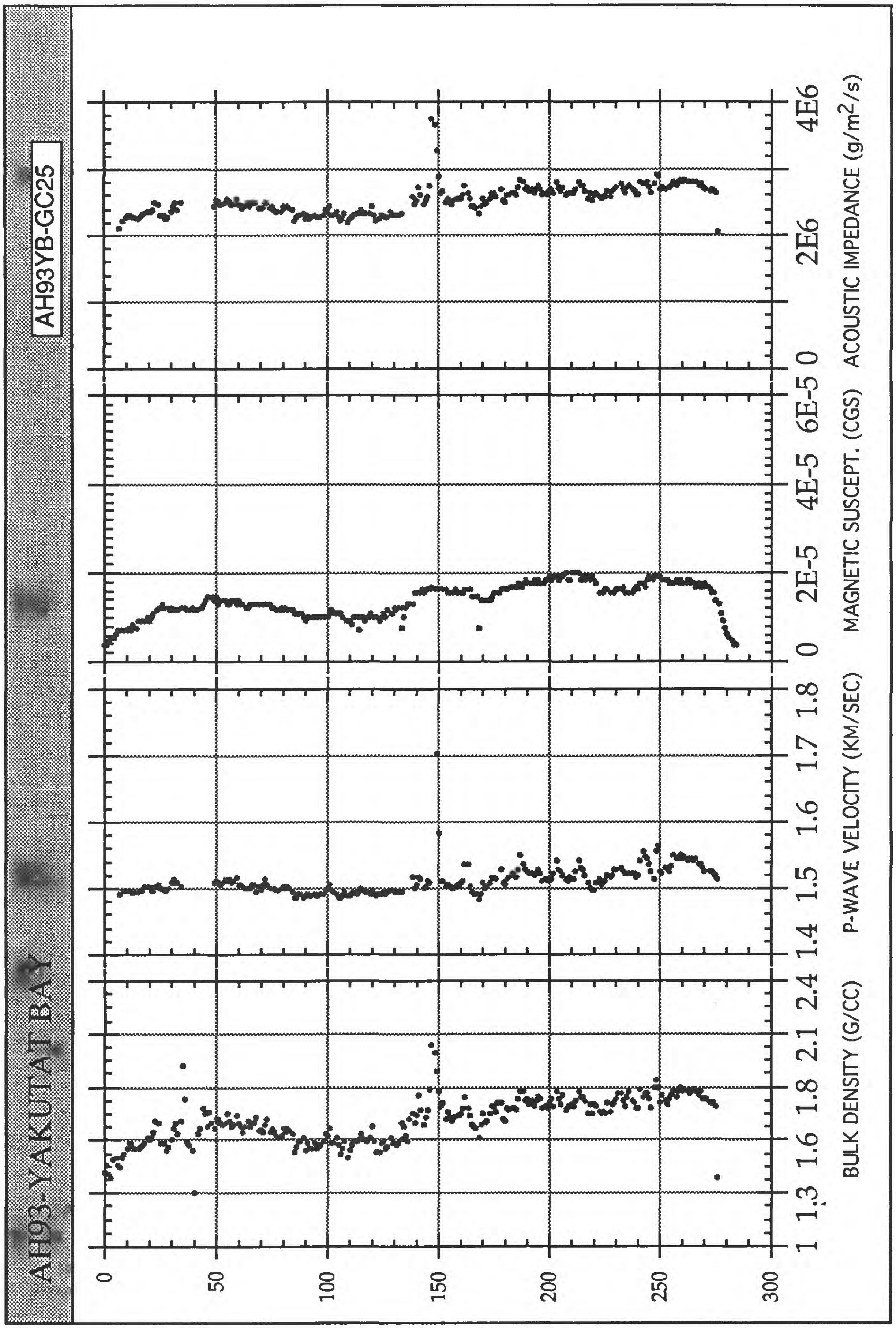

AH93-YAKUTAT BAY
AH93-YB-GC21
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY (KM/SEC)
0 2E-5 4E-5 6E-5
MAGNETIC SUSCEPT. (CGS)
0 2E6 4E6
ACOUSTIC IMPEDANCE (g/m^2/s)

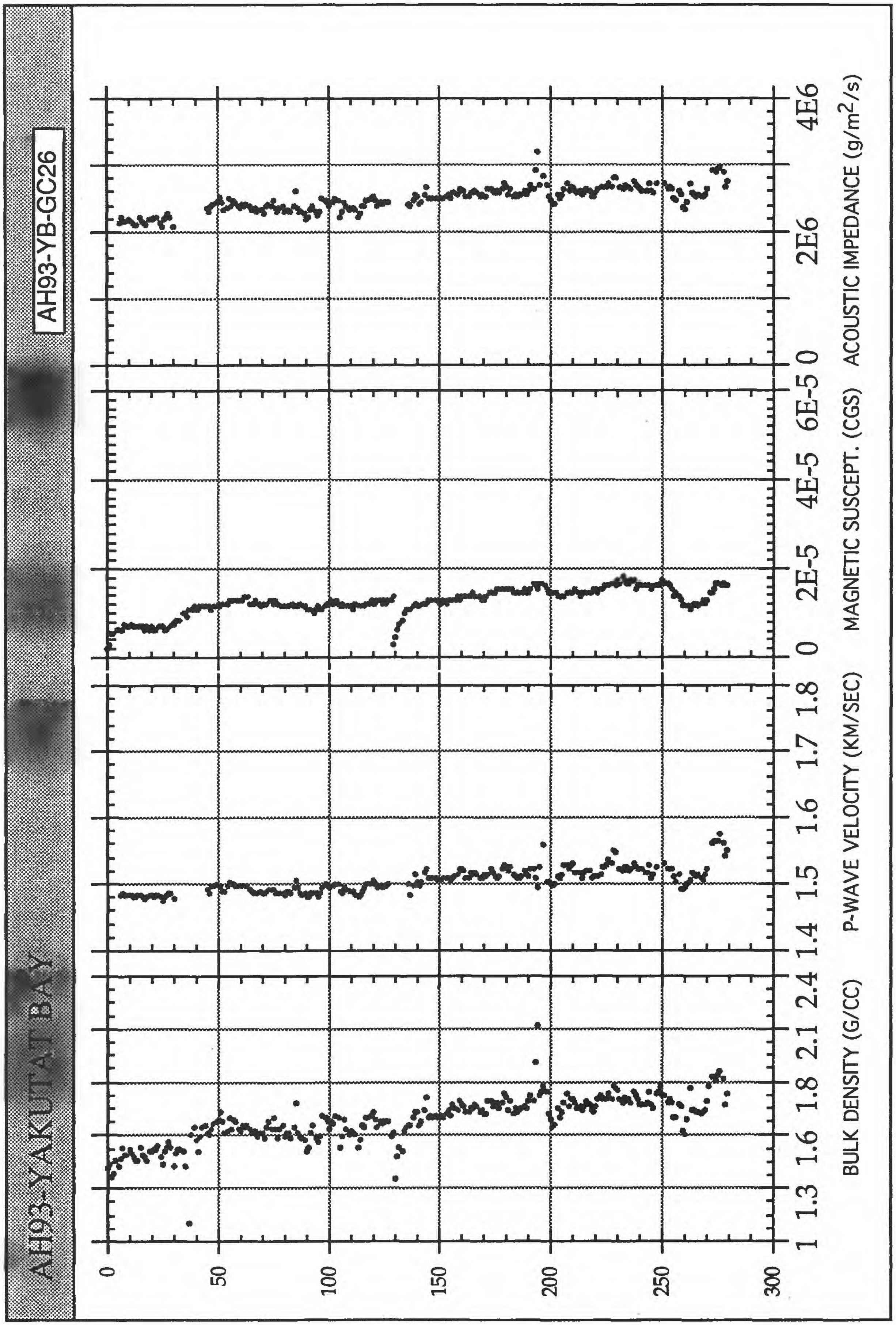

AH93-YAKUTAT BAY
AH93-YB-GC22
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY (KM/SEC)
0
2E-5
4E-5
6E-5
MAGNETIC SUSCEPT. (CGS)
0
2E6
4E6
ACOUSTIC IMPEDANCE (g/m^2/s)

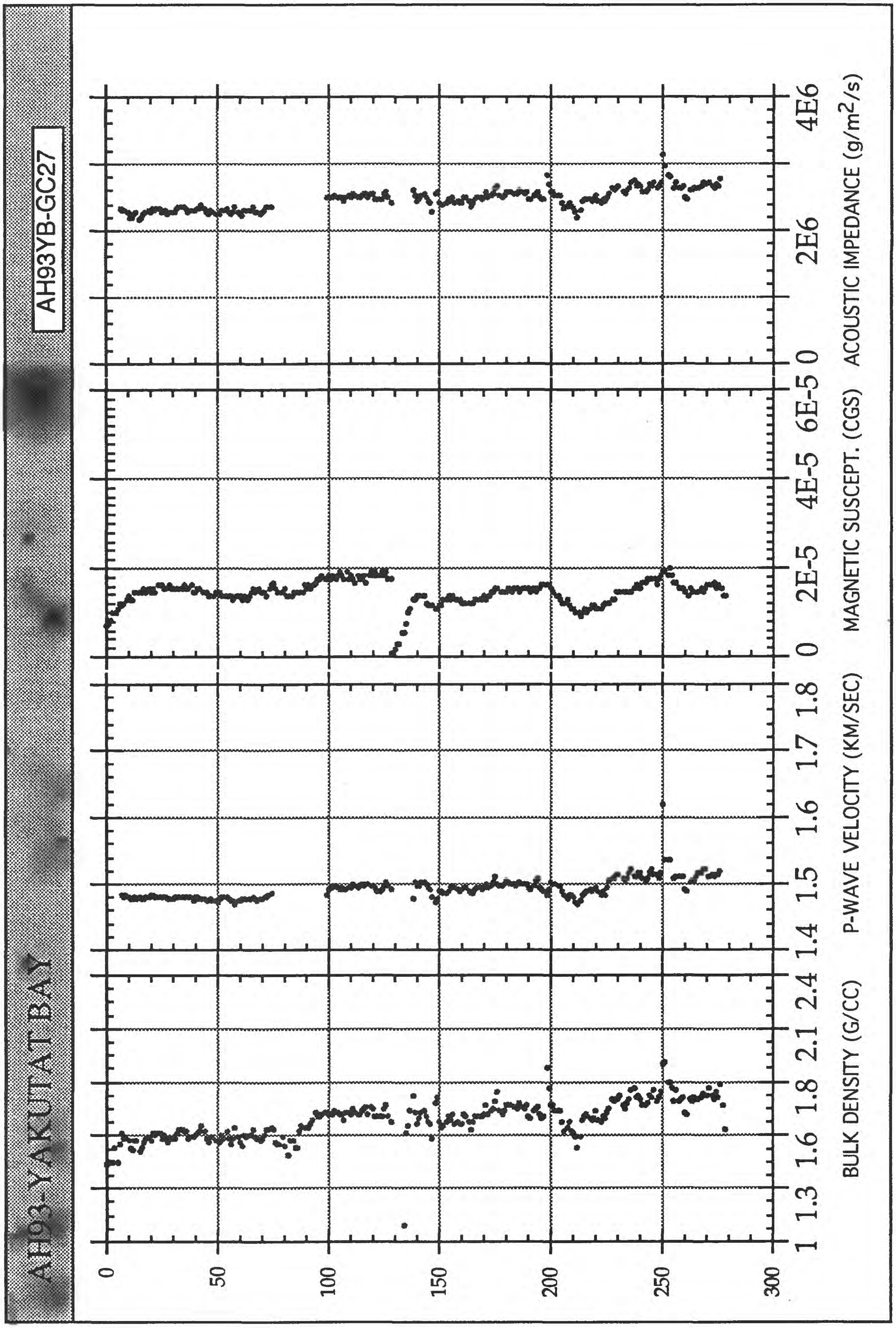

AH93-YAKUTAT BAY
AH93-YB-GC23
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY (KM/SEC)
0
2E-5
4E-5
6E-5
MAGNETIC SUSCEPT. (CGS)
0
2E6
4E6
ACOUSTIC IMPEDANCE (g/m2/s)

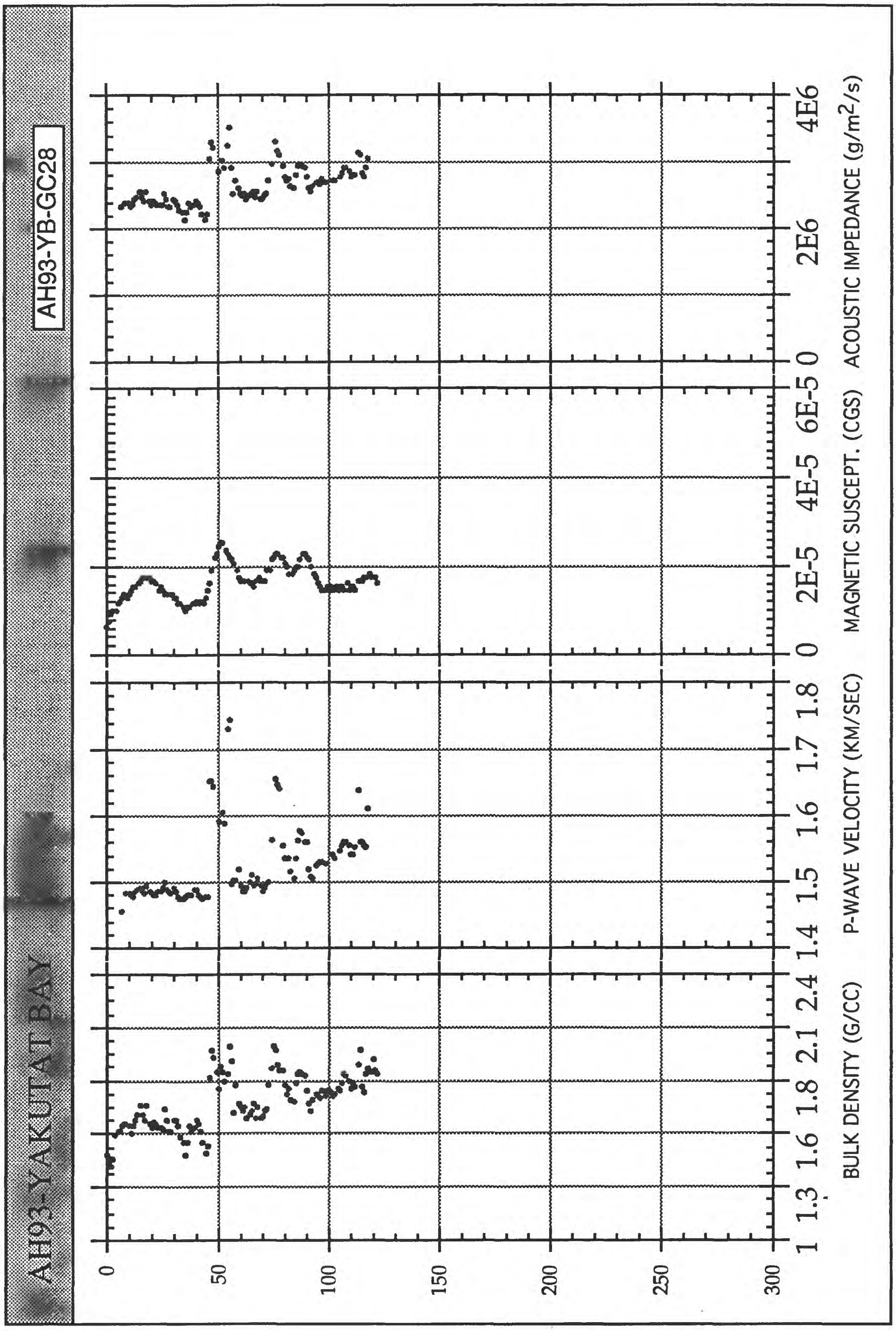


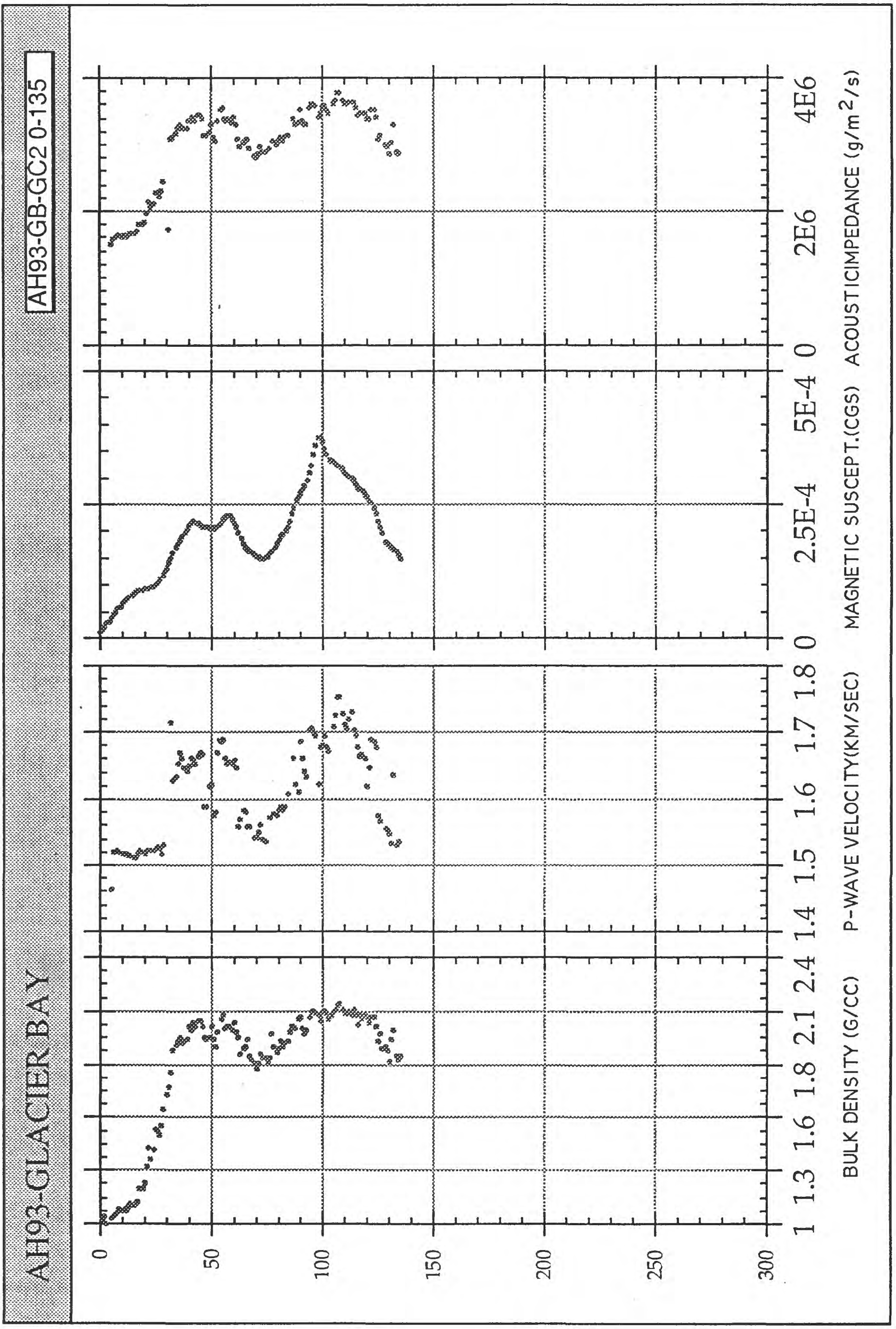
AH93-YAKUTAT BAY
AH93-YB-GC24
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY (KM/SEC)
0
2E-5
4E-5
6E-5
MAGNETIC SUSCEPT. (CGS)
0
2E6
4E6
ACOUSTIC IMPEDANCE (g/m2/s)

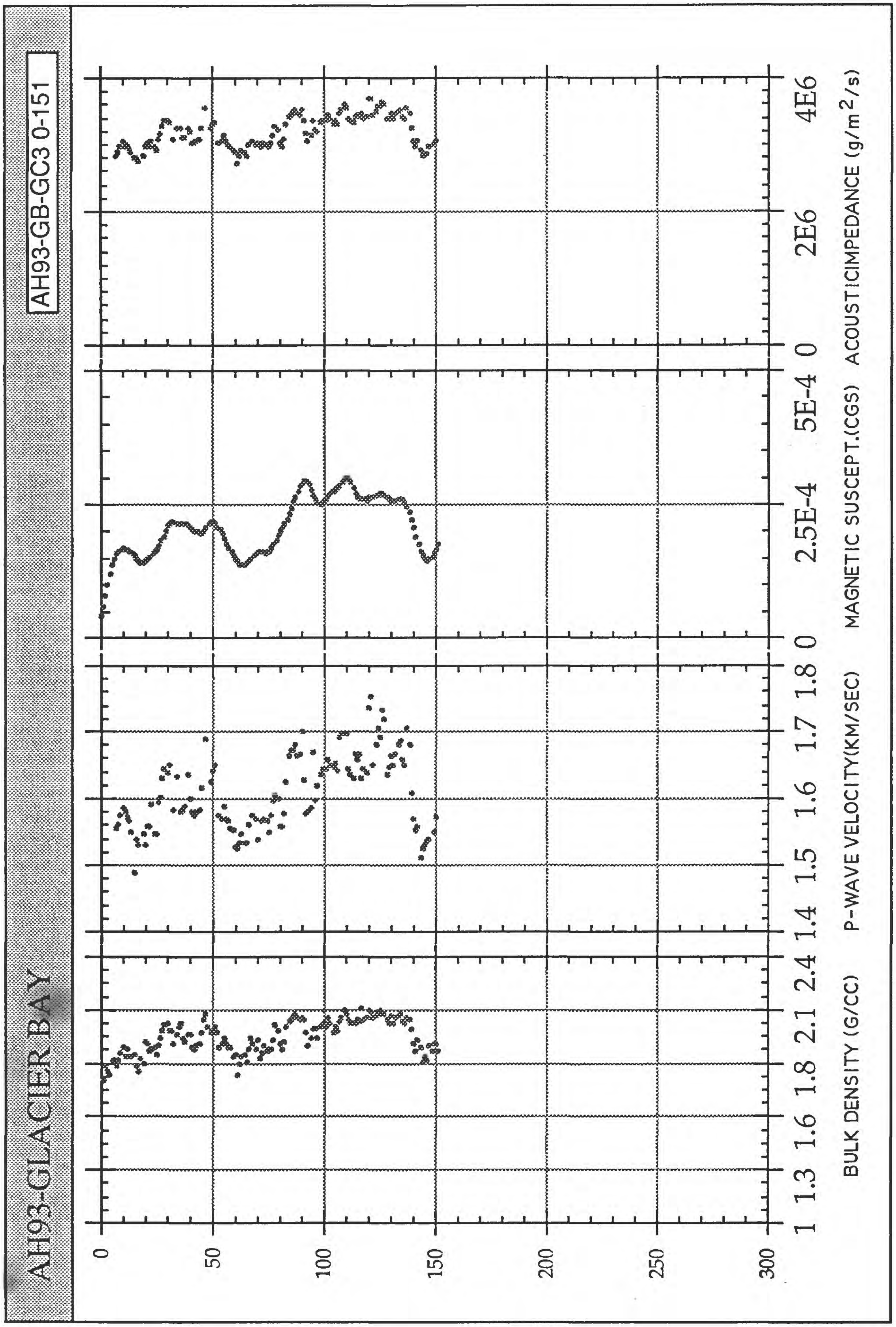

AH93-YAKUTAT BAY
AH93YB-GC25
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY (KM/SEC)
0
2E-5
4E-5
6E-5
MAGNETIC SUSCEPT. (CGS)
0
2E6
4E6
ACOUSTIC IMPEDANCE (g/m^2/s)

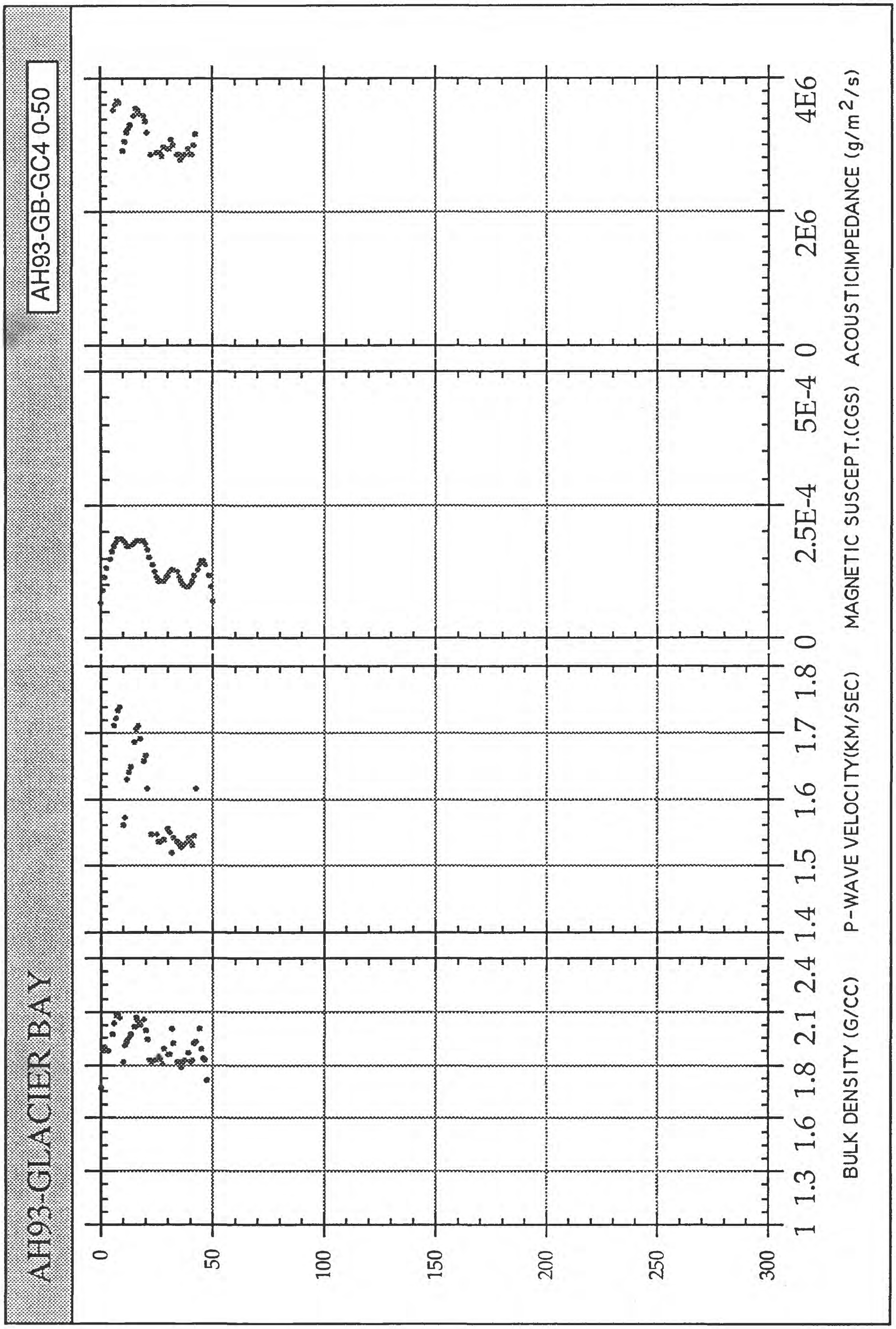

AH93-YAKUTAT BAY
AH93-YB-GC26
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY (KM/SEC)
0 2E-5 4E-5 6E-5
MAGNETIC SUSCEPT. (CGS)
0 2E6 4E6
ACOUSTIC IMPEDANCE (g/m²/s)

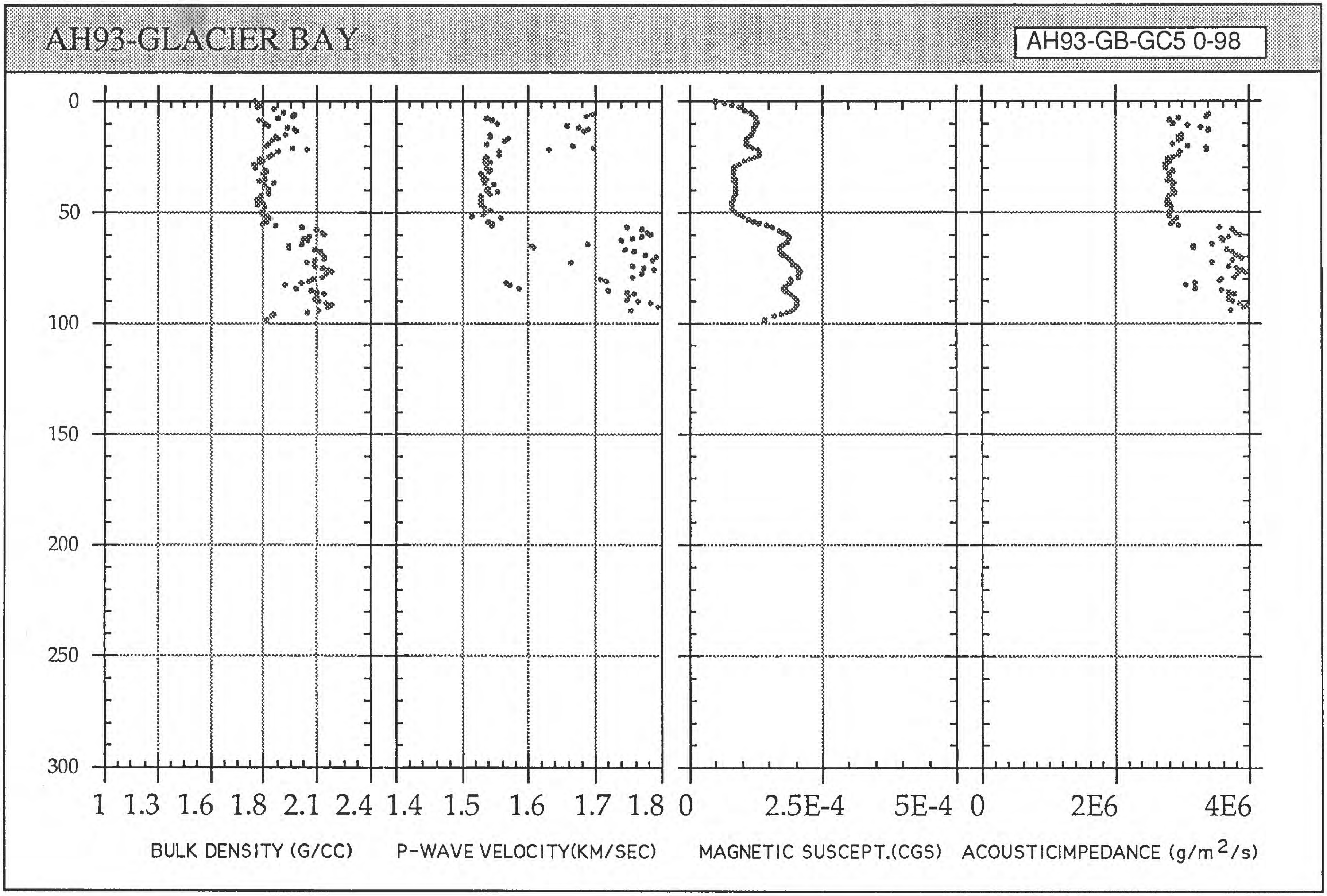

AH93-YAKUTAT BAY
AH93YB-GC27
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY (KM/SEC)
0
2E-5
4E-5
6E-5
MAGNETIC SUSCEPT. (CGS)
0
2E6
4E6
ACOUSTIC IMPEDANCE (g/m^2/s)

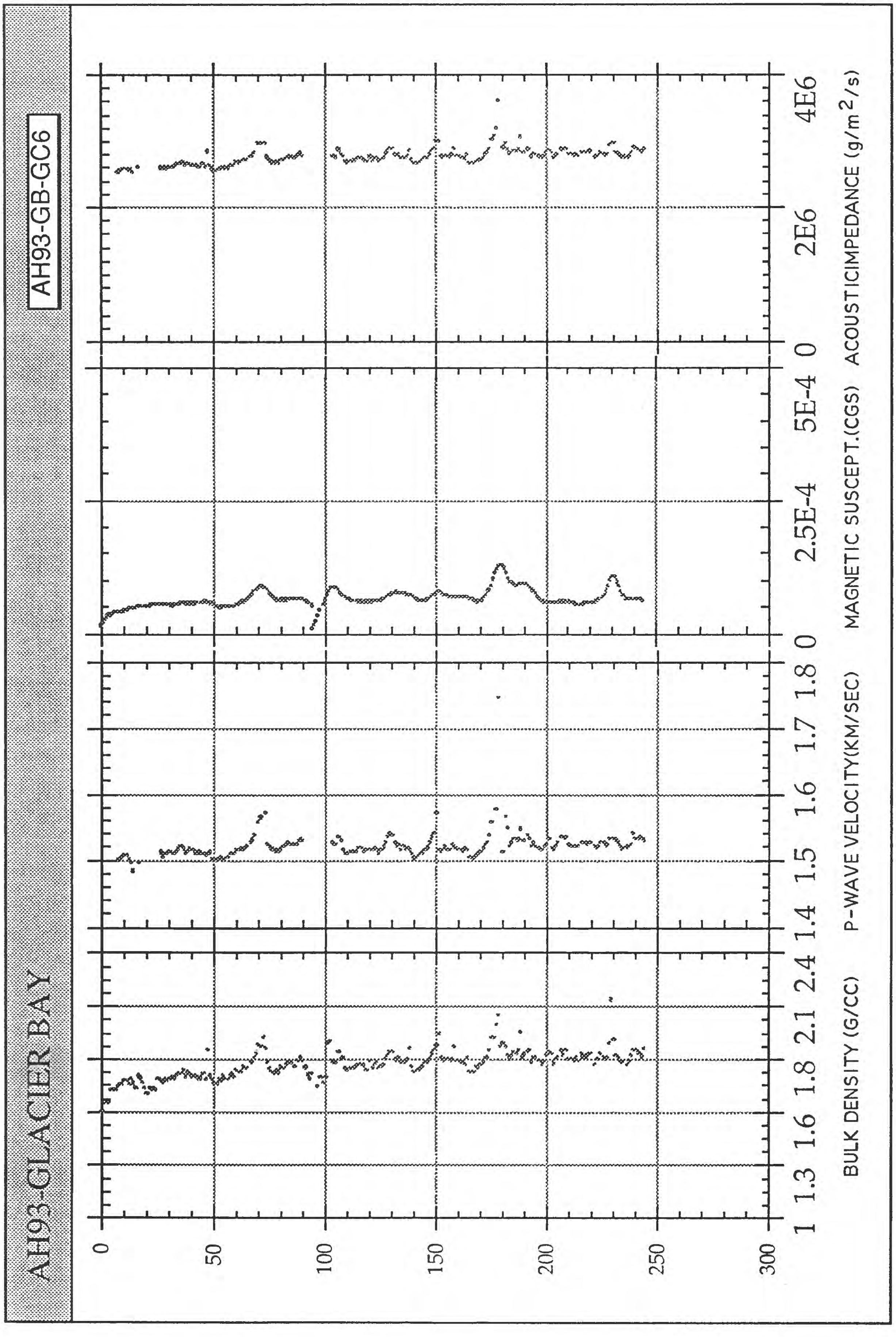

AH93-YAKUTAT BAY
AH93-YB-GC28
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY (KM/SEC)
0
2E-5
4E-5
6E-5
MAGNETIC SUSCEPT. (CGS)
0
2E6
4E6
ACOUSTIC IMPEDANCE (g/m^2/s)

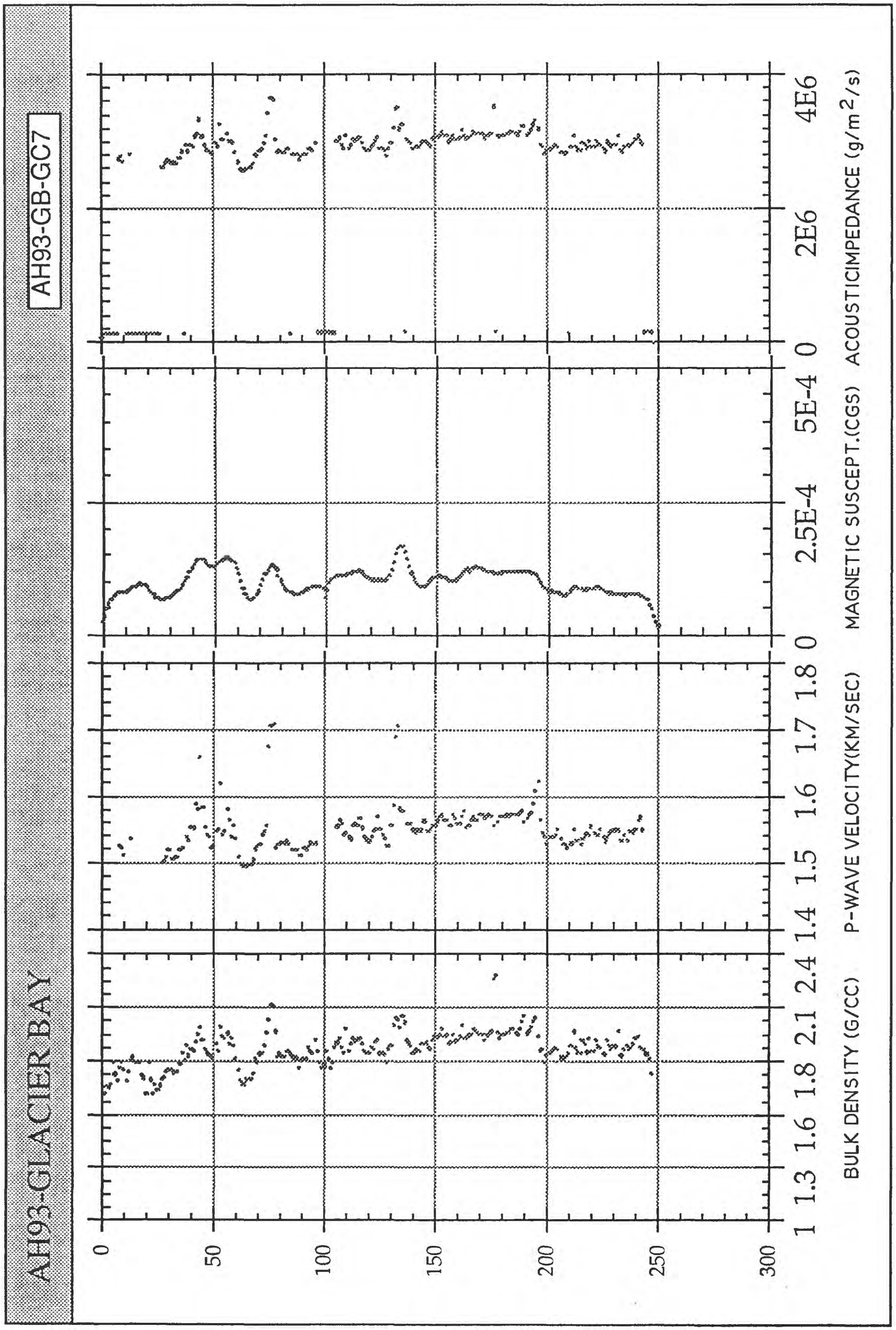

AH93-GLACIER BAY
AH93-GB-GC2 0-135
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
0
2.5E-4
5E-4
MAGNETIC SUSCEPT.(CGS)
0
2E6
4E6
ACOUSTICIMPEDANCE (g/m^2/s)

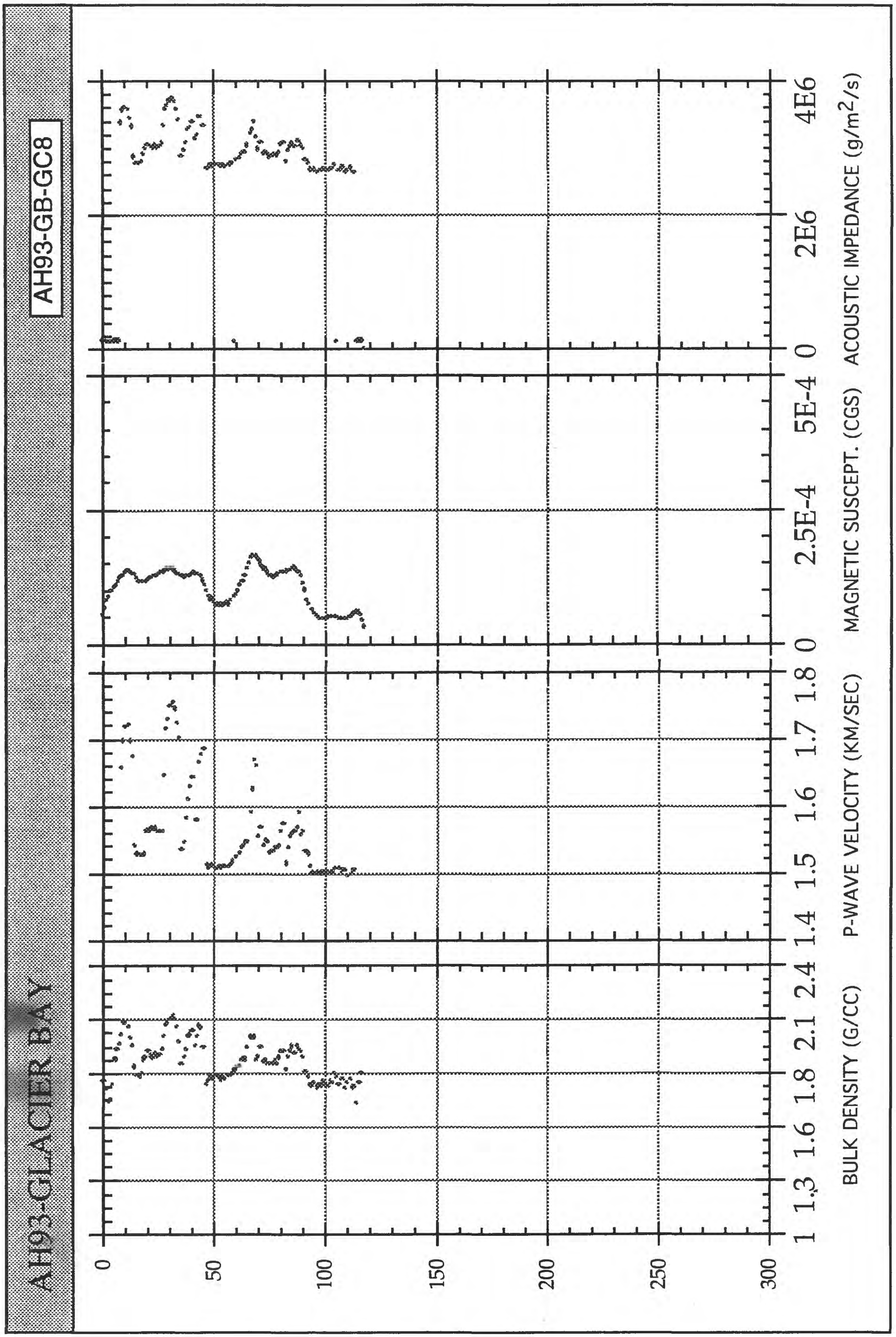

AH93-GLACIER BAY
AH93-GB-GC3 0-151
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
0
2.5E-4
5E-4
MAGNETIC SUSCEPT.(CGS)
0
2E6
4E6
ACOUSTICIMPEDANCE $(g/m^2/s)$

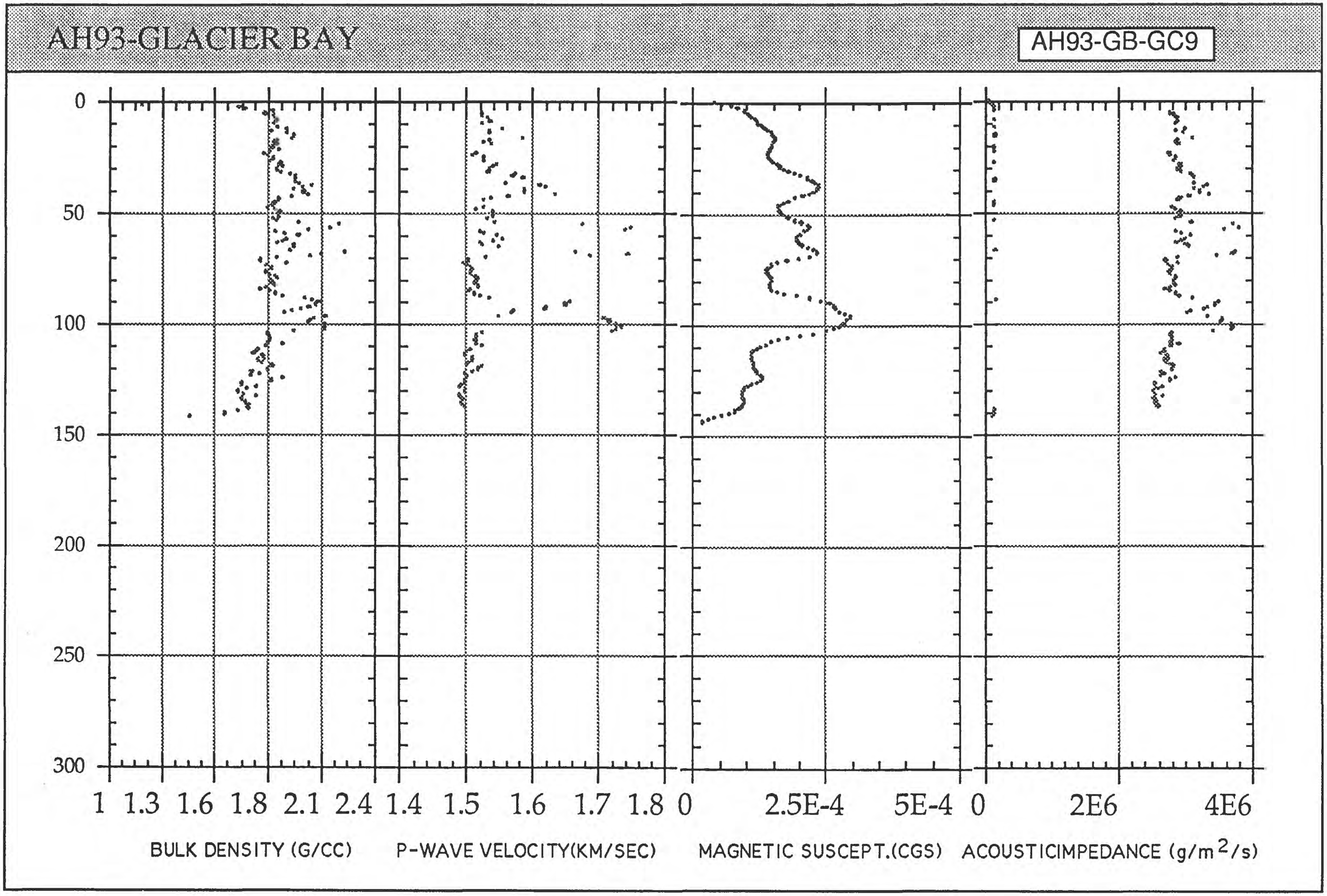

AH93-GLACIER BAY
AH93-GB-GC4 0-50
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY(KM/SEC)
0 2.5E-4 5E-4
MAGNETIC SUSCEPT.(CGS)
0 2E6 4E6
ACOUSTICIMPEDANCE (g/m2/s)

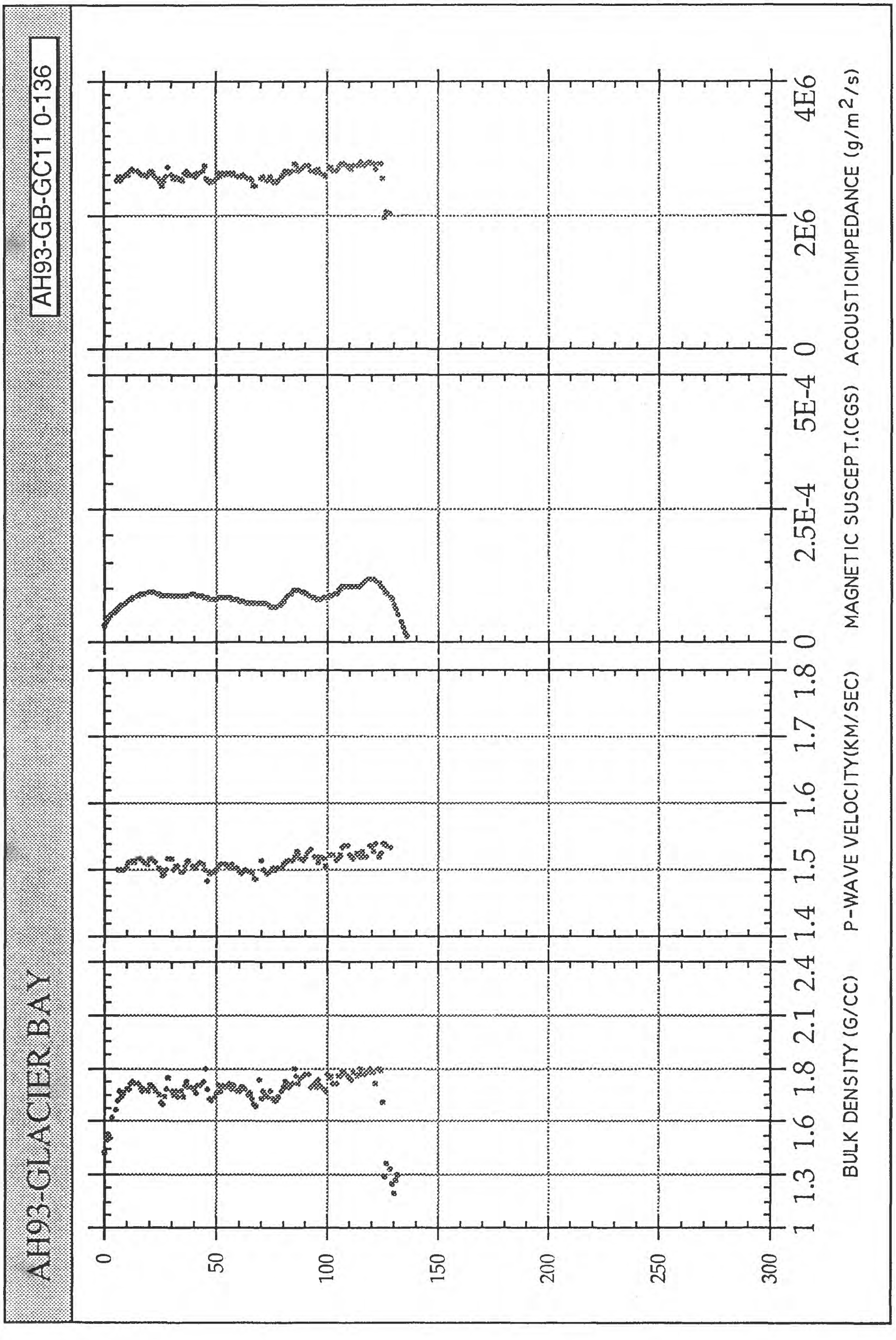

AH93-GLACIER BAY
AH93-GB-GC5 0-98
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
1.4
1.5
1.6
1.7
1.8
0
2.5E-4
5E-4
0
2E6
4E6
BULK DENSITY (G/CC)
P-WAVE VELOCITY(KM/SEC)
MAGNETIC SUSCEPT.(CGS)
ACOUSTICIMPEDANCE (g/m2/s)

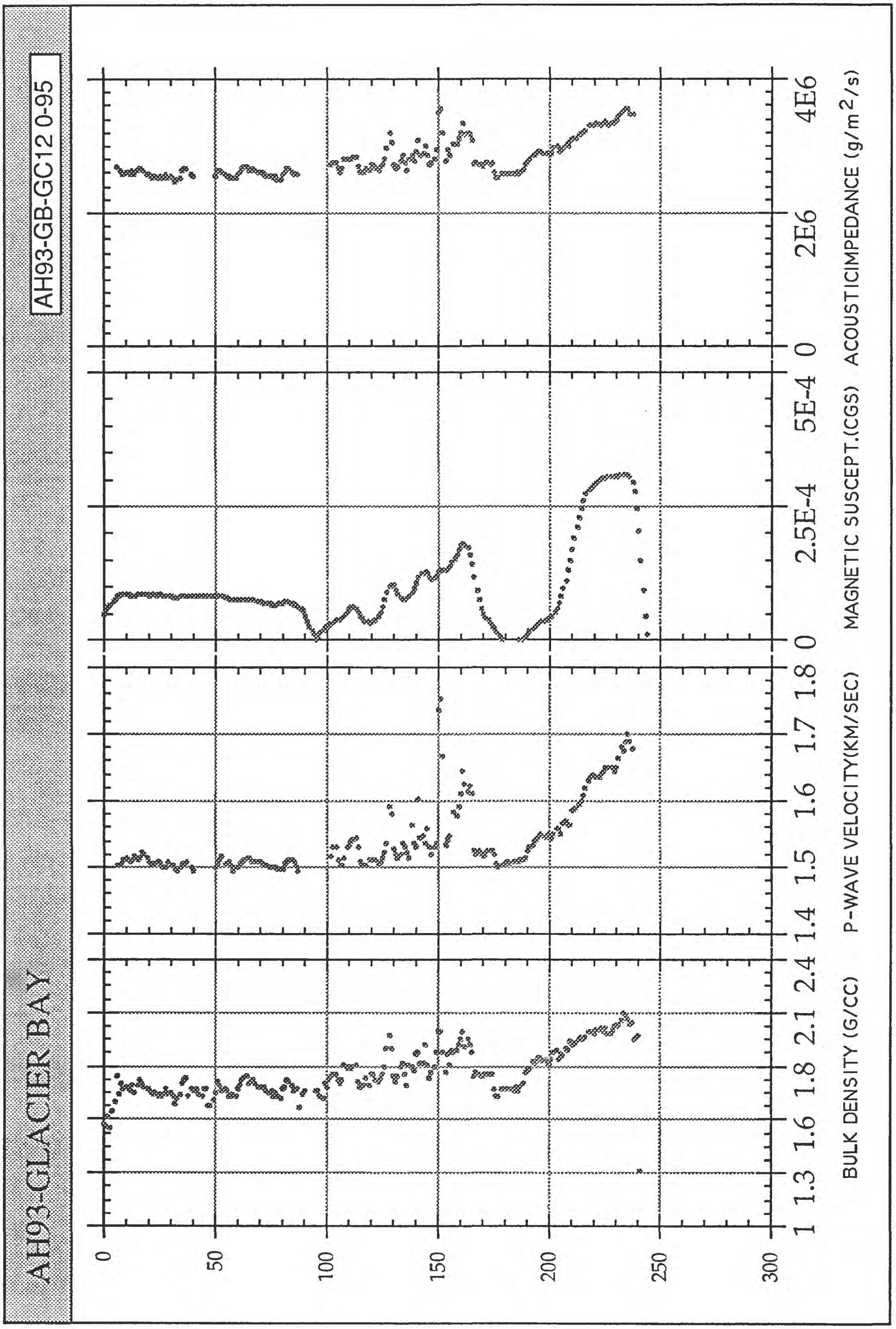

AH93-GLACIER BAY
AH93-GB-GC6
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY(KM/SEC)
0 2.5E-4 5E-4
MAGNETIC SUSCEPT.(CGS)
0 2E6 4E6
ACOUSTICIMPEDANCE (g/m2/s)

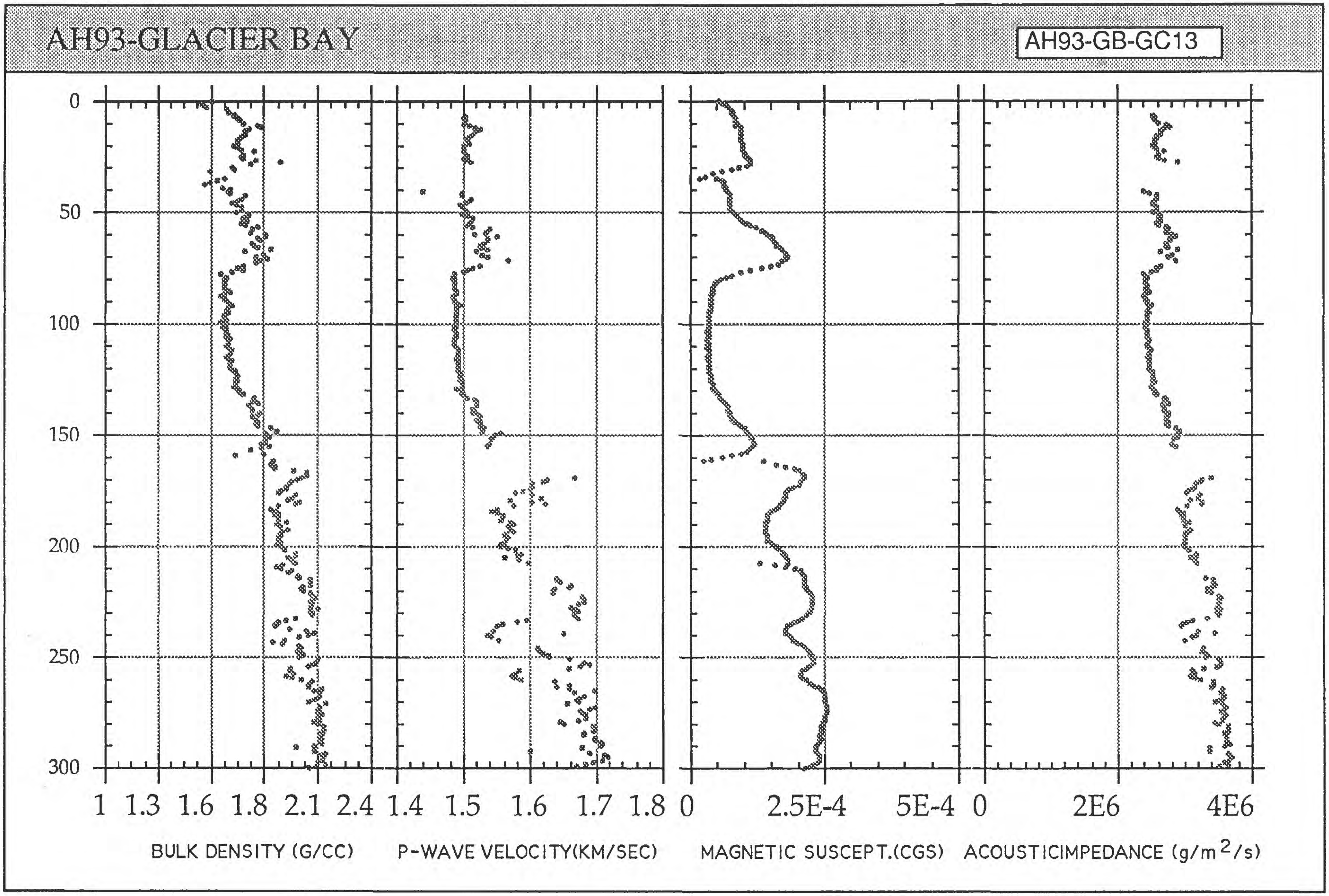

AH93-GLACIER BAY
AH93-GB-GC7
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY(KM/SEC)
0 2.5E-4 5E-4
MAGNETIC SUSCEPT.(CGS)
0 2E6 4E6
ACOUSTICIMPEDANCE (g/m2/s)

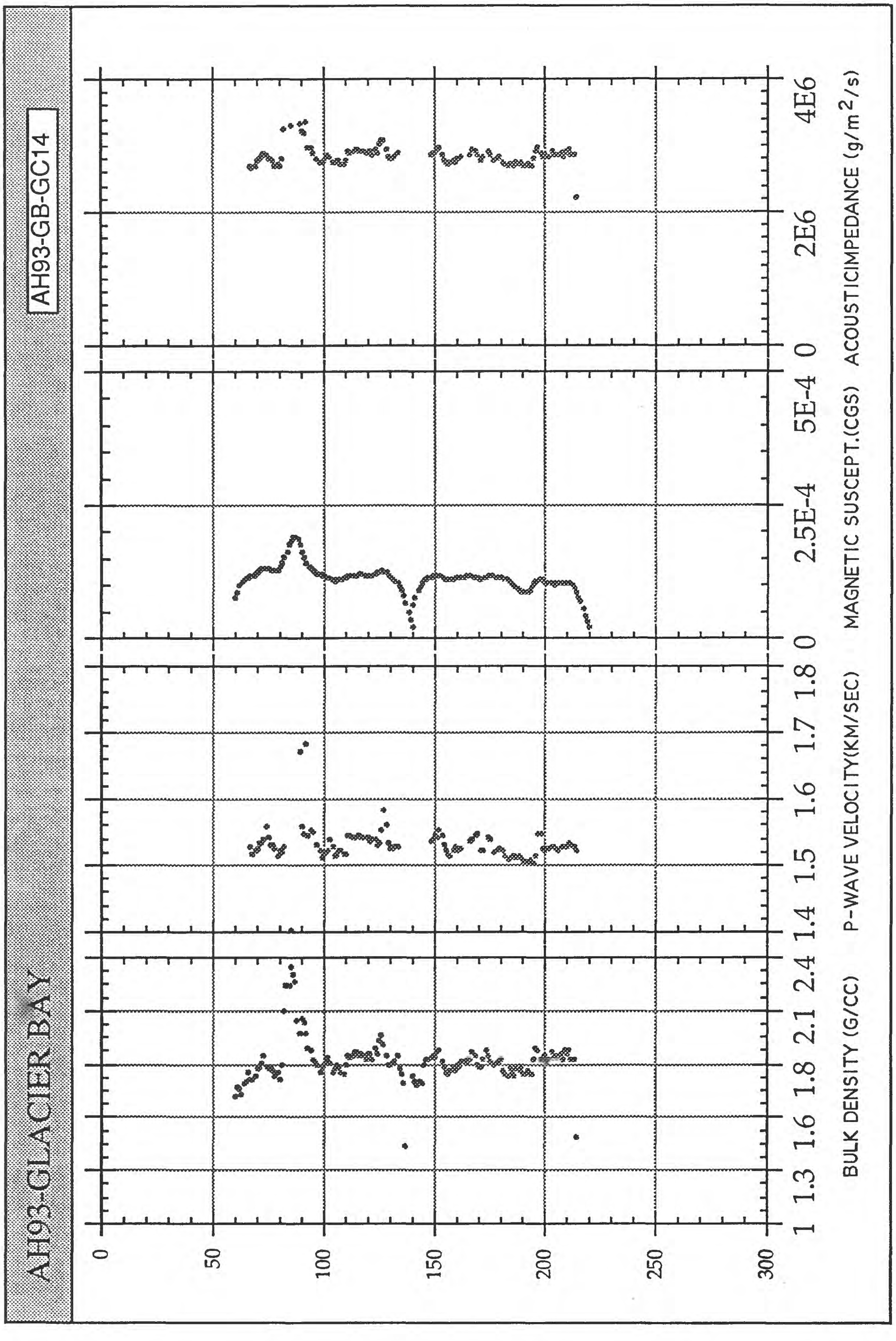

AH93-GLACIER BAY
AH93-GB-GC8
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY (KM/SEC)
0 2.5E-4 5E-4
MAGNETIC SUSCEPT. (CGS)
0 2E6 4E6
ACOUSTIC IMPEDANCE (g/m2/s)

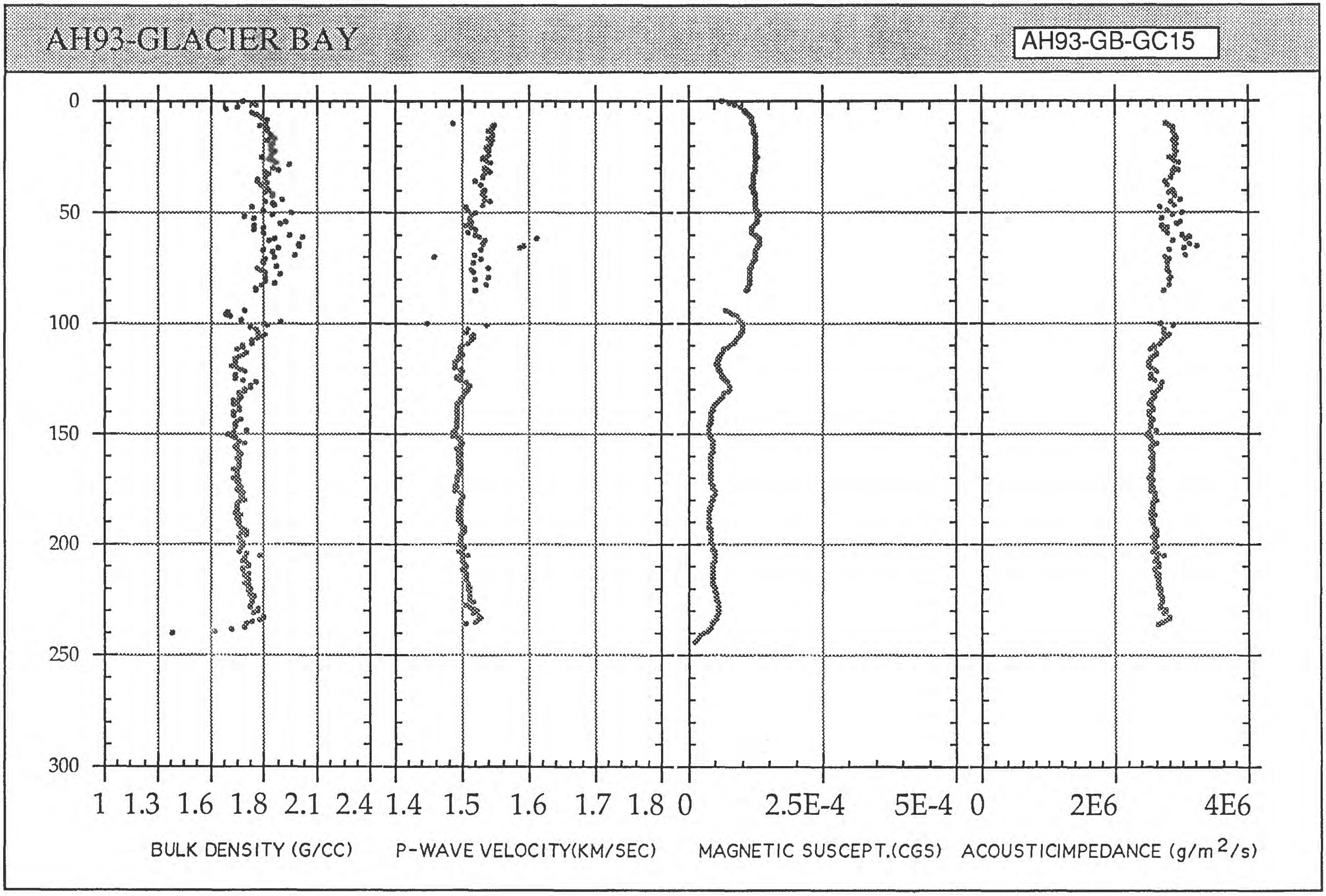

AH93-GLACIER BAY
AH93-GB-GC9
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
0
2.5E-4
5E-4
MAGNETIC SUSCEPT.(CGS)
0
2E6
4E6
ACOUSTICIMPEDANCE (g/m2/s)

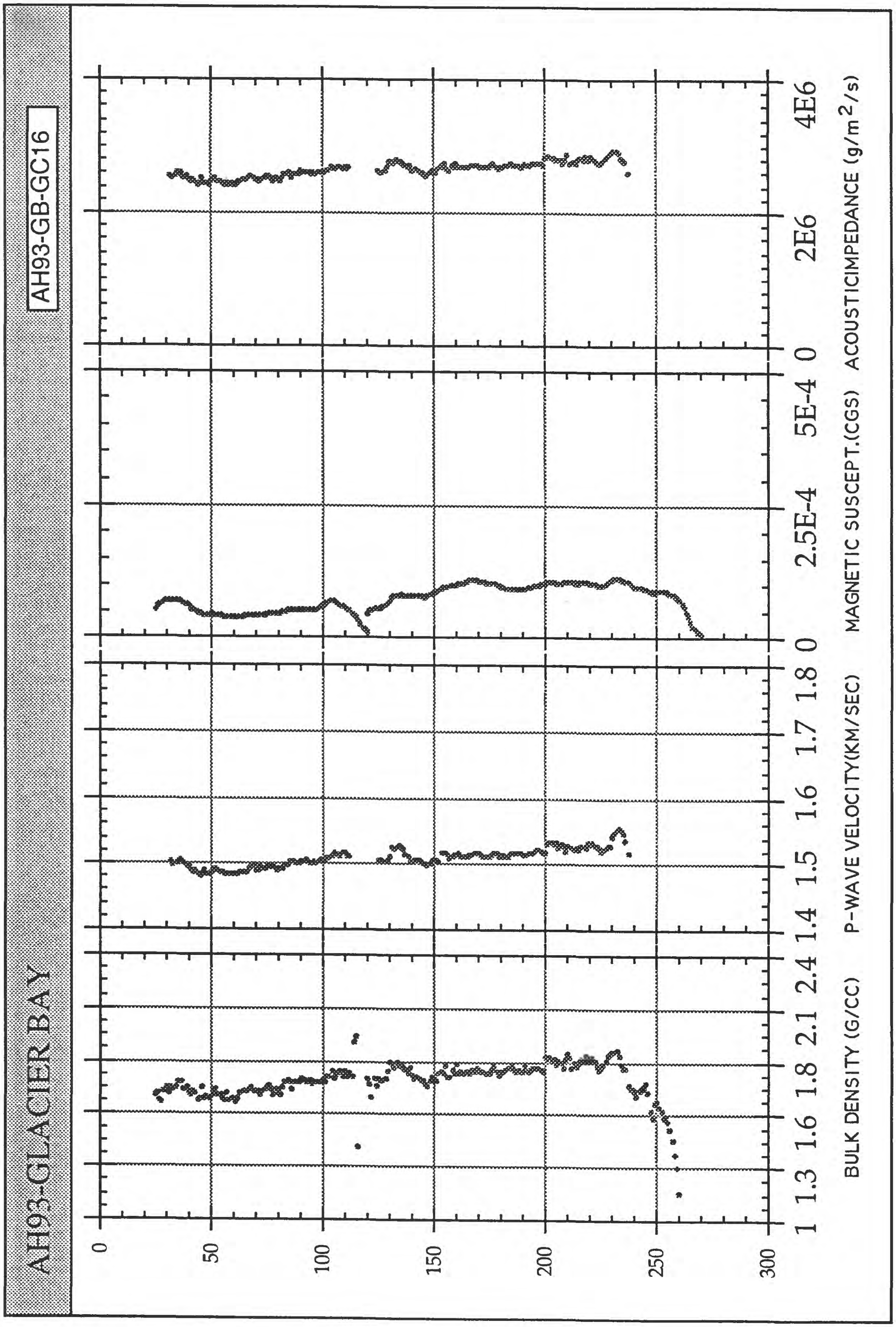

AH93-GLACIER BAY
AH93-GB-GC11 0-136
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
0
2.5E-4
5E-4
MAGNETIC SUSCEPT.(CGS)
0
2E6
4E6
ACOUSTICIMPEDANCE (g/m^2/s)

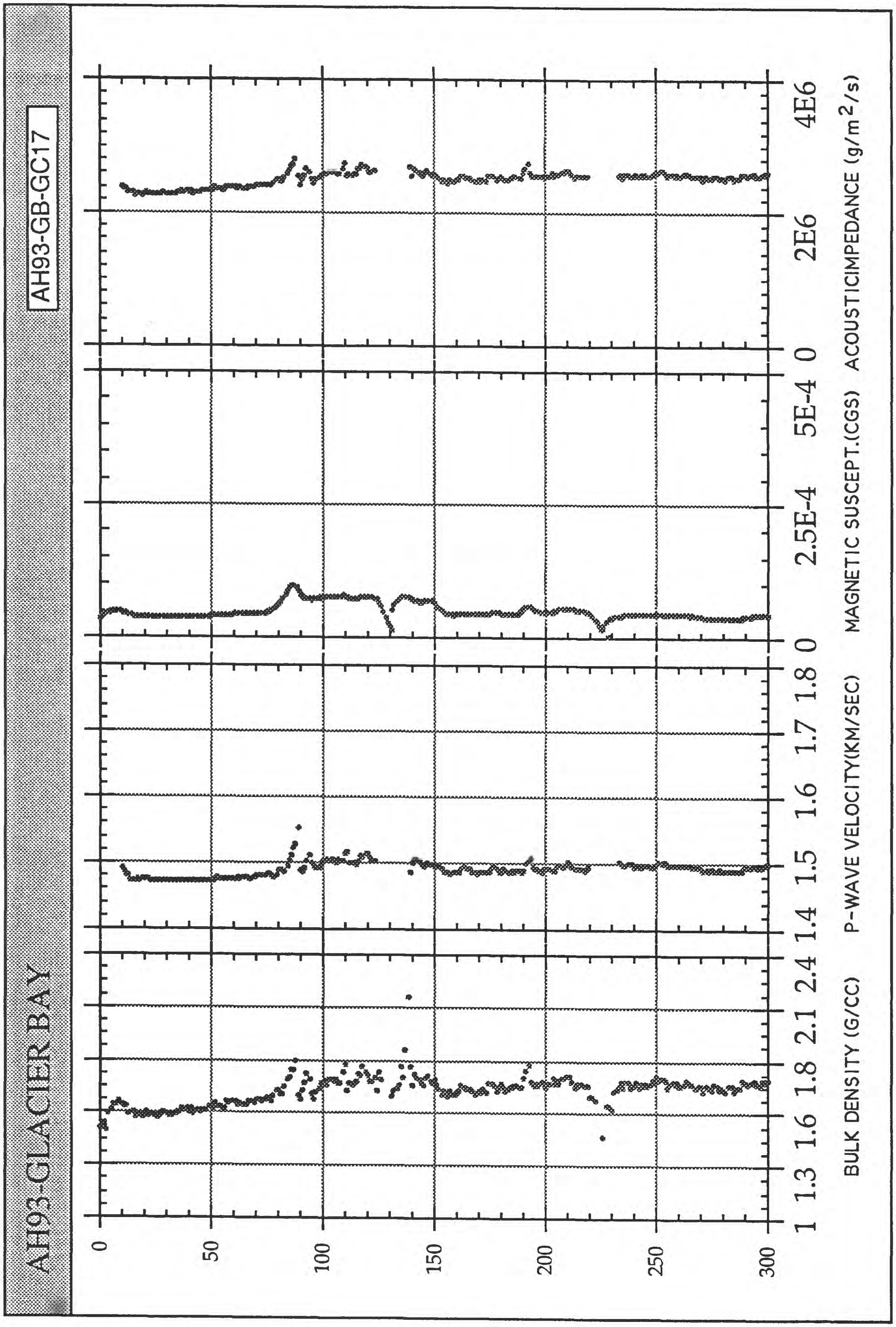

AH93-GLACIER BAY
AH93-GB-GC12 0-95
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
0
2.5E-4
5E-4
MAGNETIC SUSCEPT.(CGS)
0
2E6
4E6
ACOUSTICIMPEDANCE ($g/m^2/s$)

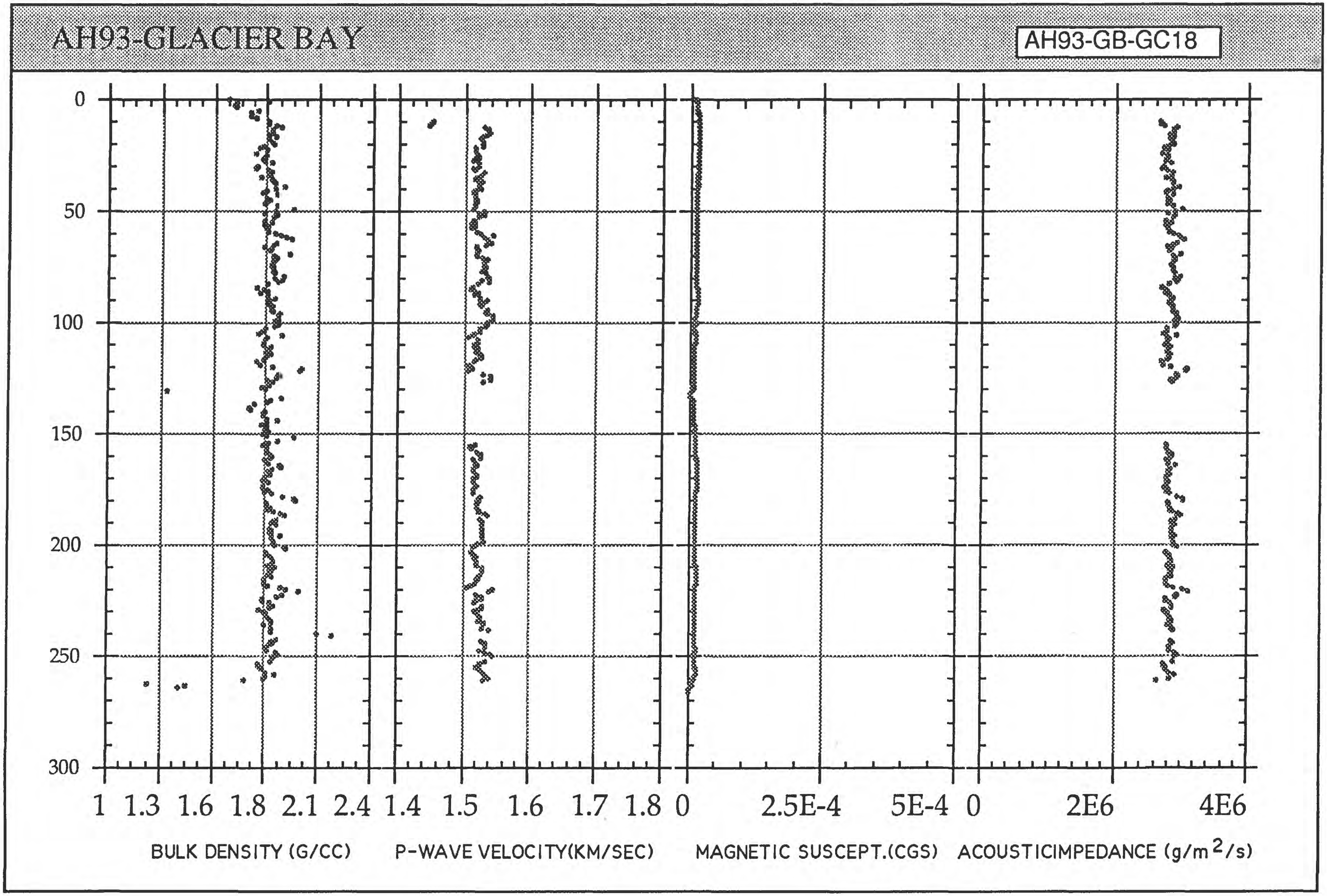

AH93-GLACIER BAY
AH93-GB-GC13
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
0
2.5E-4
5E-4
MAGNETIC SUSCEPT.(CGS)
0
2E6
4E6
ACOUSTICIMPEDANCE (g/m2/s)

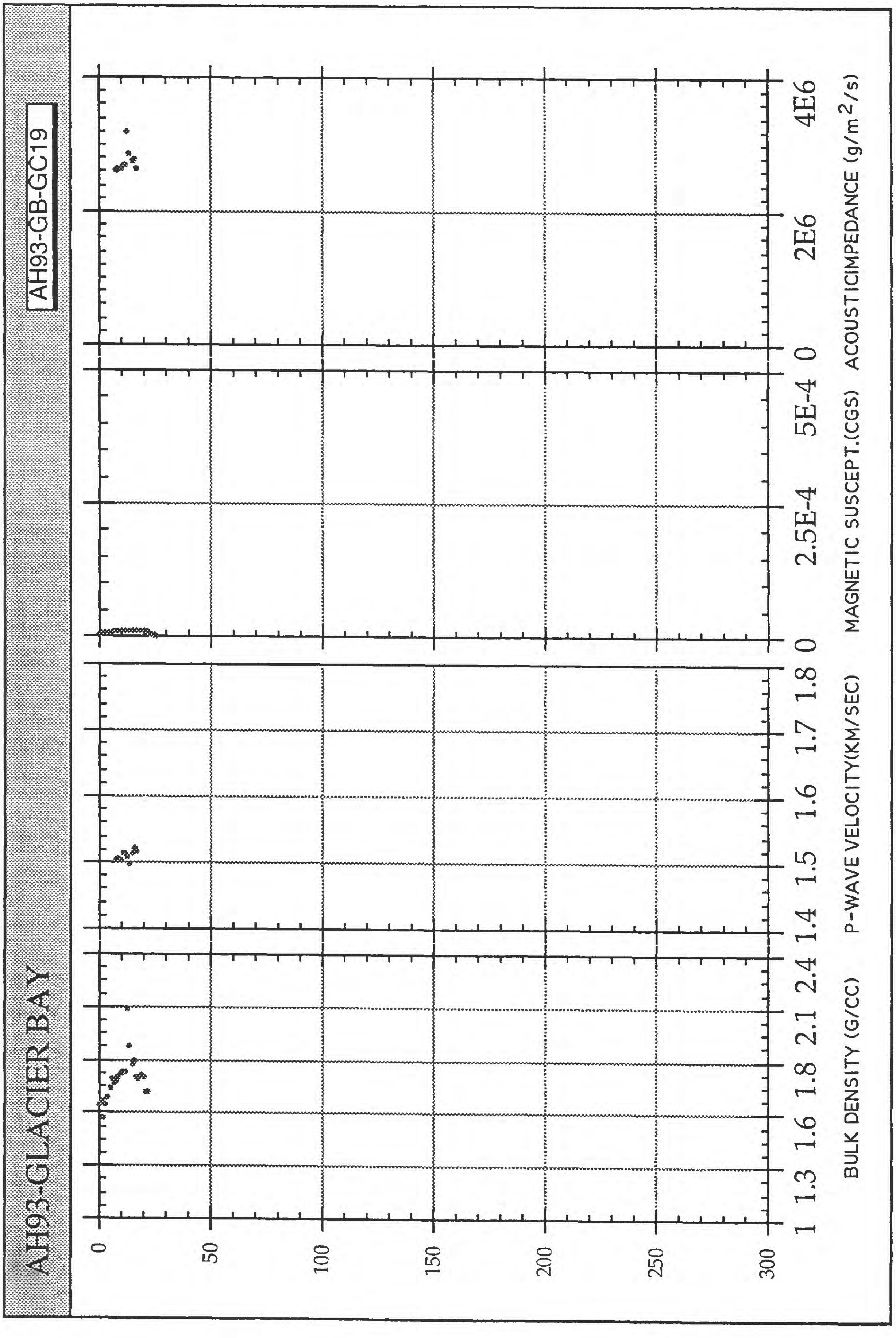

AH93-GLACIER BAY
AH93-GB-GC14
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
0
2.5E-4
5E-4
MAGNETIC SUSCEPT.(CGS)
0
2E6
4E6
ACOUSTICIMPEDANCE (g/m2/s)

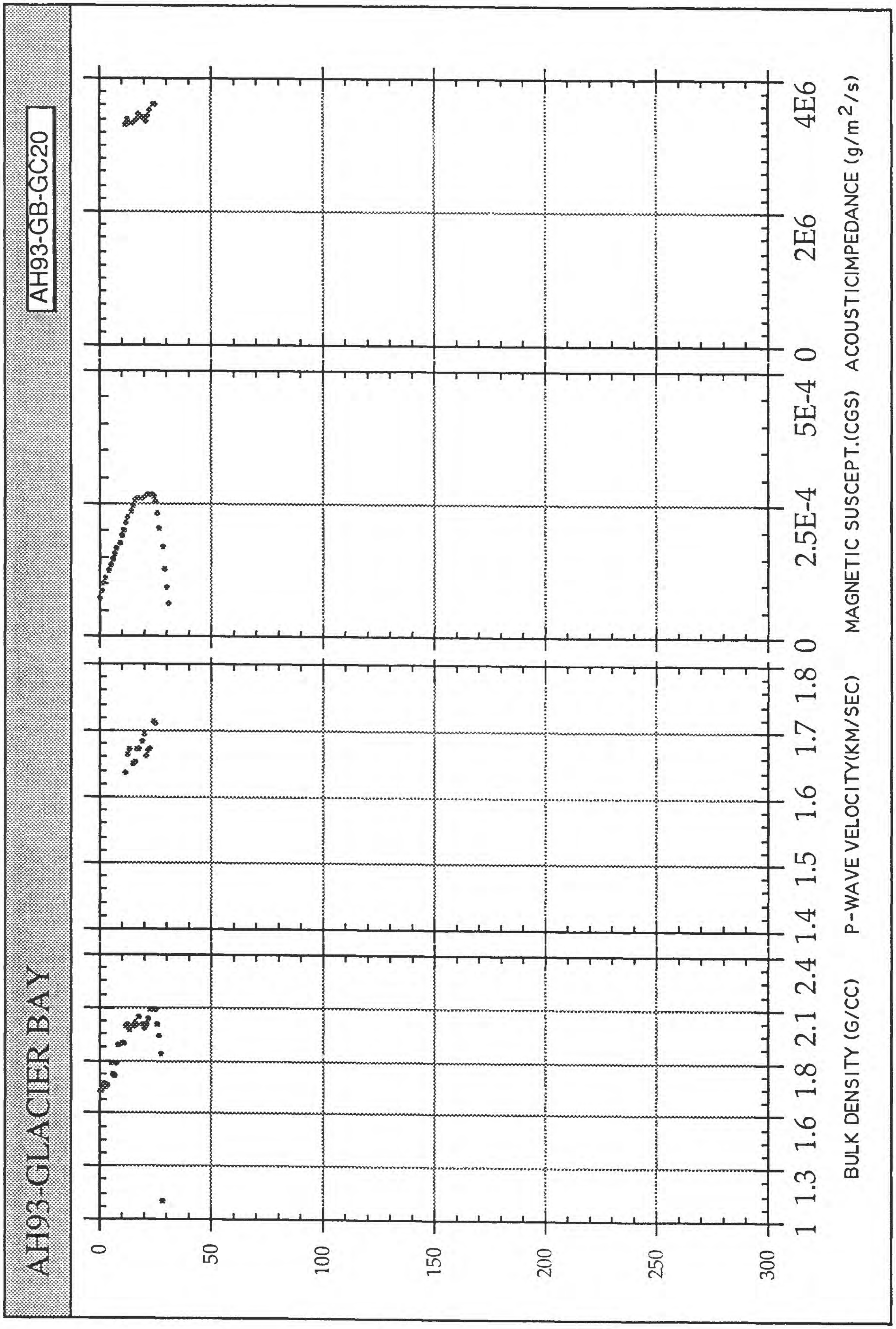

AH93-GLACIER BAY
AH93-GB-GC15
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY(KM/SEC)
0 2.5E-4 5E-4
MAGNETIC SUSCEPT.(CGS)
0 2E6 4E6
ACOUSTICIMPEDANCE (g/m 2/s)

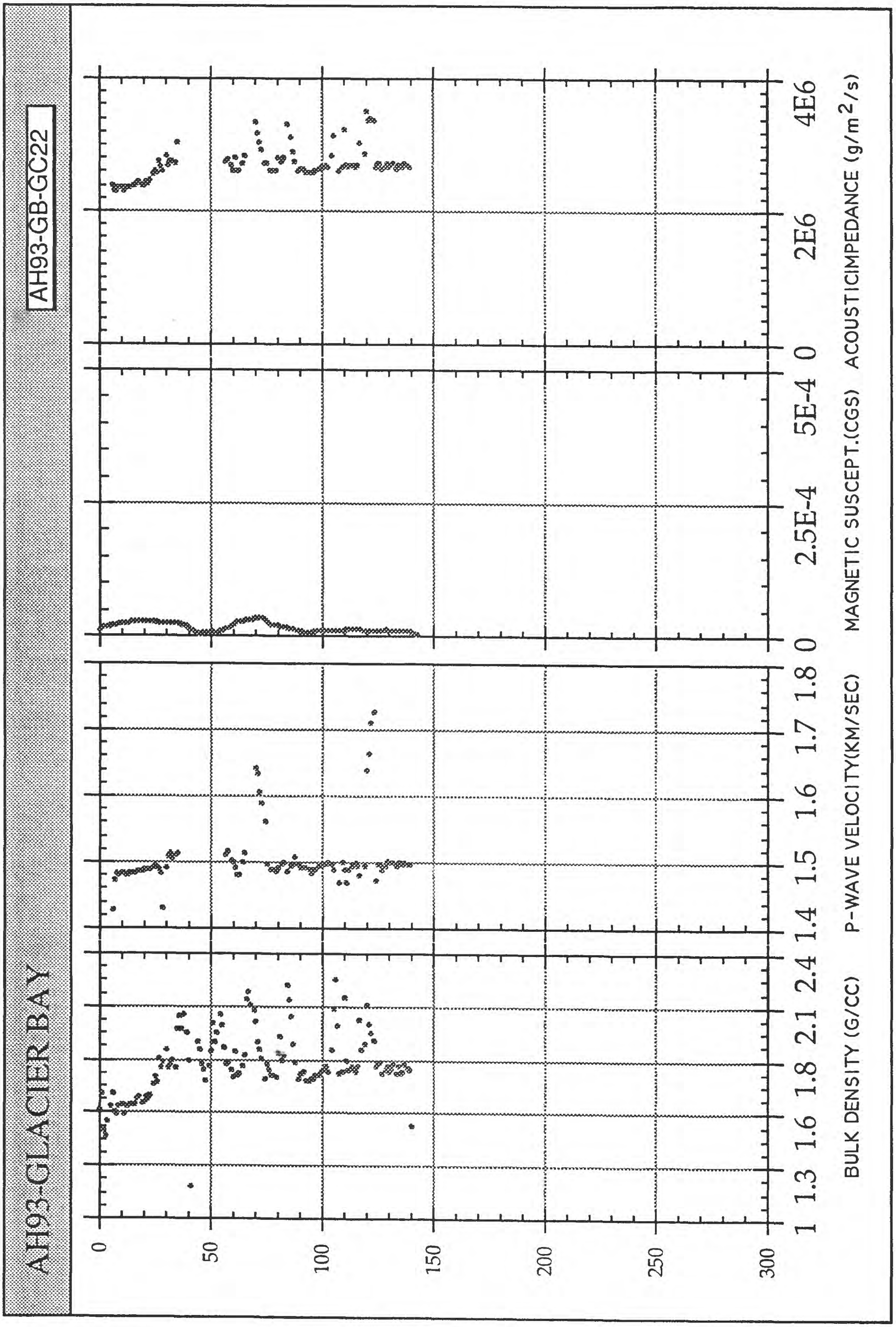

AH93-GLACIER BAY
AH93-GB-GC16
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
0
2.5E-4
5E-4
MAGNETIC SUSCEPT.(CGS)
0
2E6
4E6
ACOUSTICIMPEDANCE (g/m2/s)

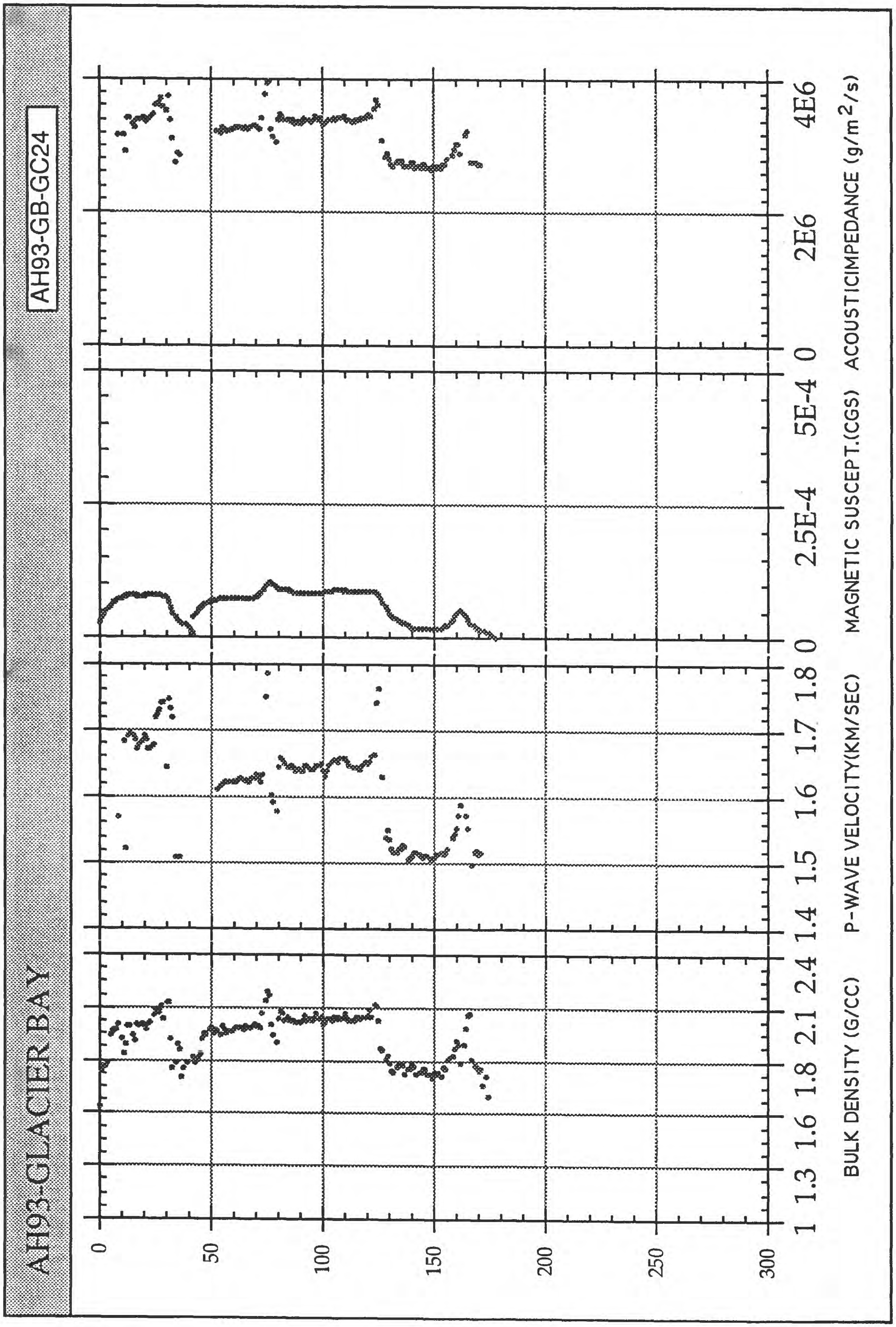

AH93-GLACIER BAY
AH93-GB-GC17
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY(KM/SEC)
0 2.5E-4 5E-4
MAGNETIC SUSCEPT.(CGS)
0 2E6 4E6
ACOUSTICIMPEDANCE (g/m2/s)

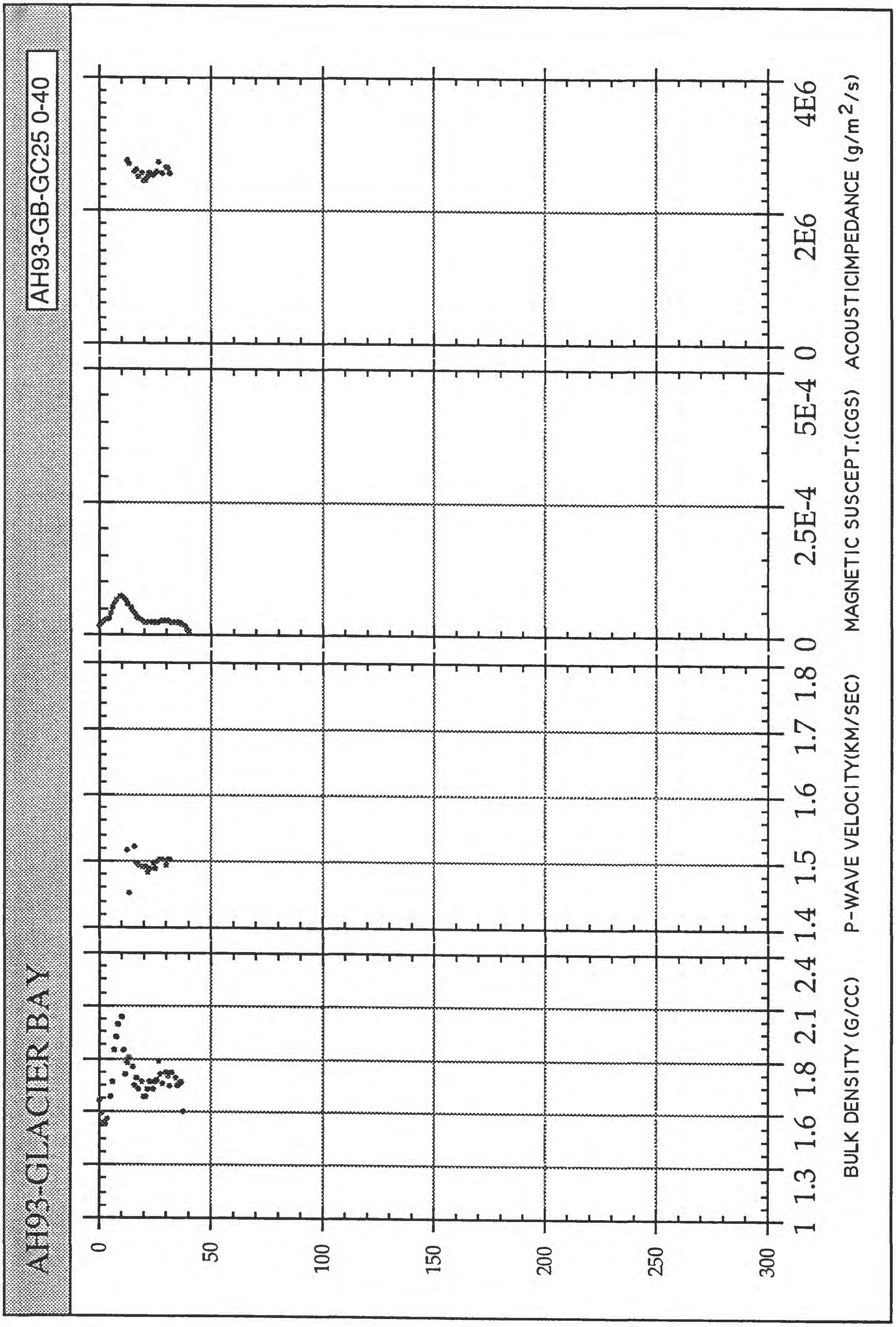

AH93-GLACIER BAY
AH93-GB-GC18
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
0
2.5E-4
5E-4
MAGNETIC SUSCEPT.(CGS)
0
2E6
4E6
ACOUSTICIMPEDANCE (g/m2/s)

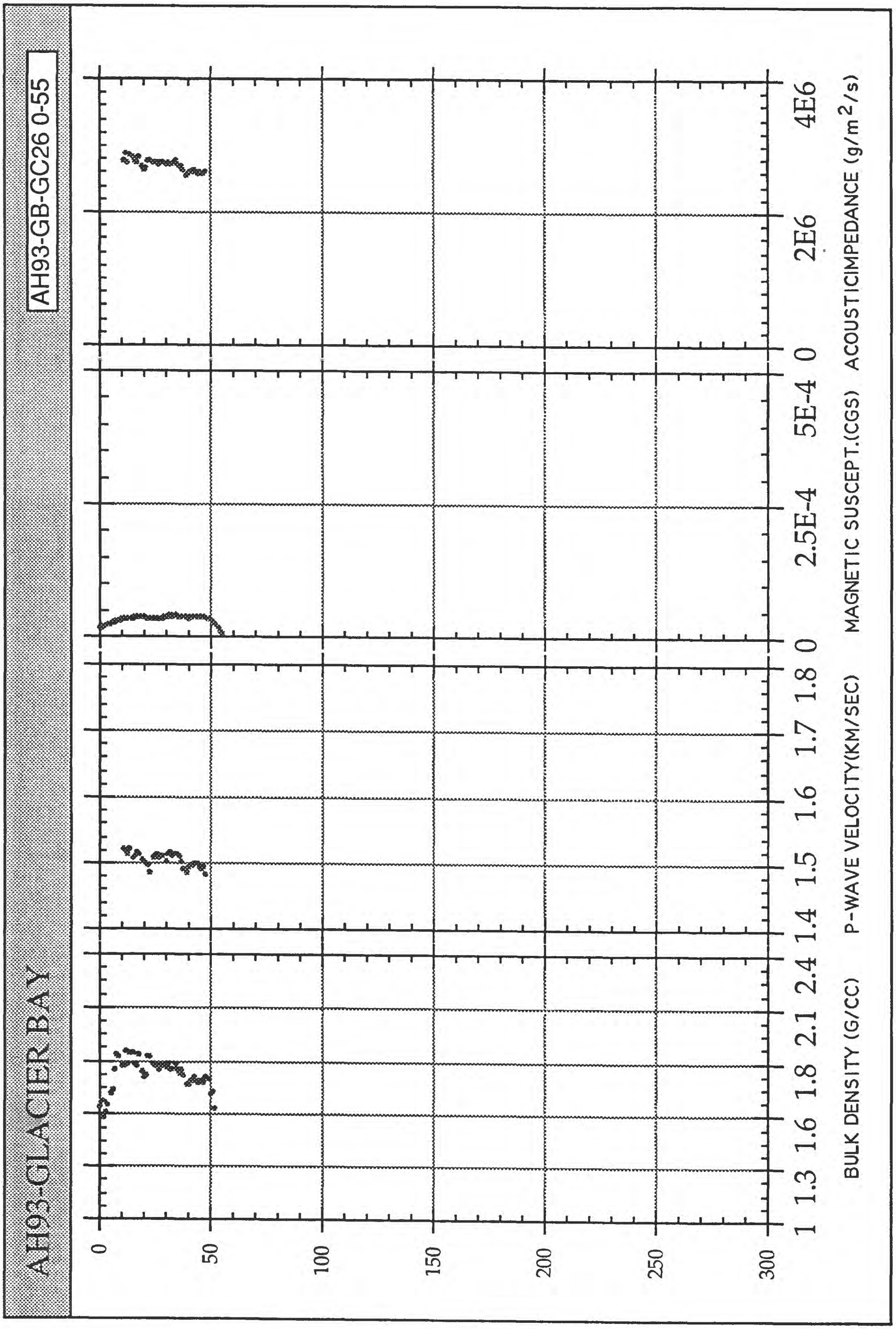

AH93-GLACIER BAY
AH93-GB-GC19
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
0
2.5E-4
5E-4
MAGNETIC SUSCEPT.(CGS)
0
2E6
4E6
ACOUSTICIMPEDANCE (g/m2/s)

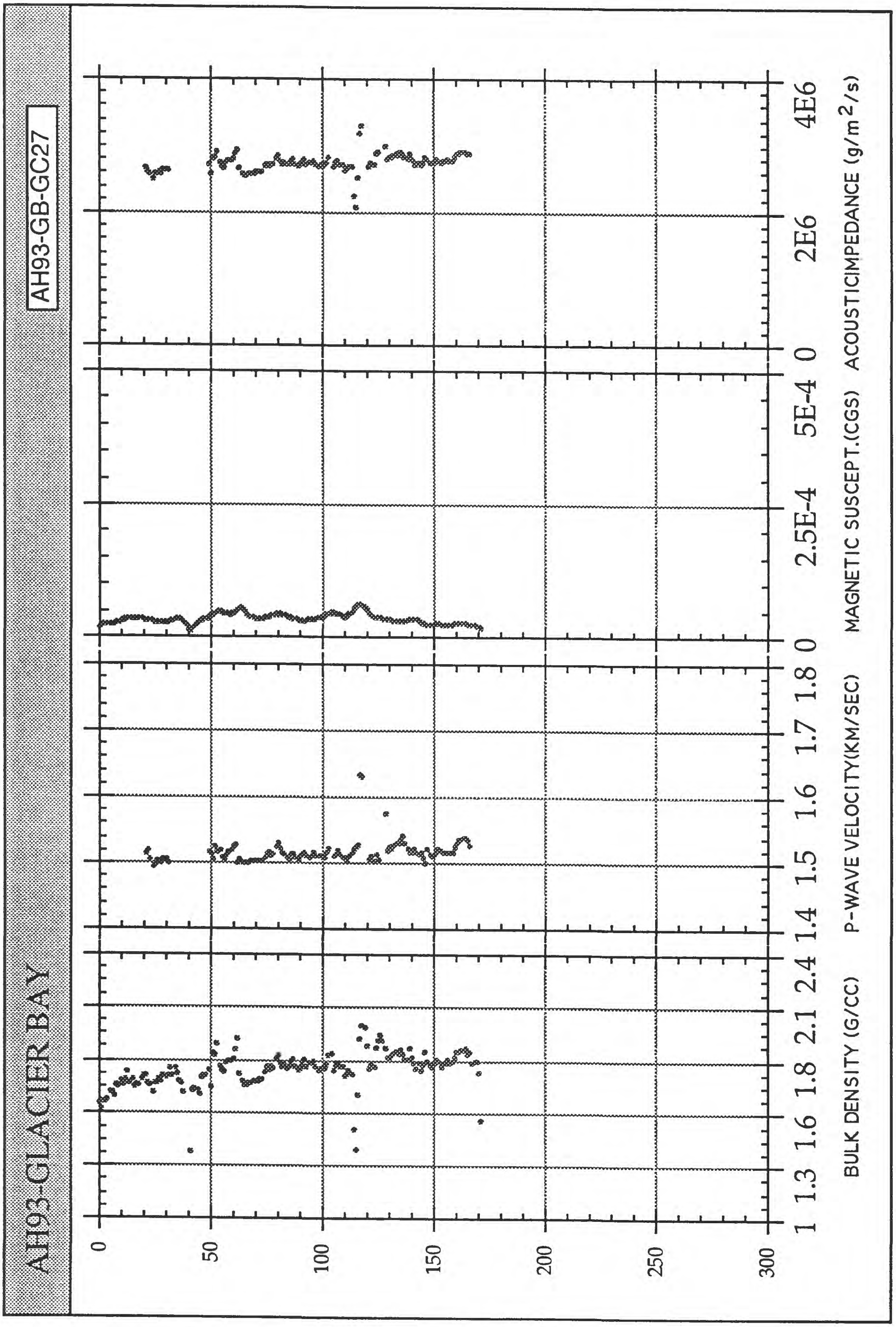

AH93-GLACIER BAY
AH93-GB-GC20
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY(KM/SEC)
0 2.5E-4 5E-4
MAGNETIC SUSCEPT.(CGS)
0 2E6 4E6
ACOUSTICIMPEDANCE (g/m2/s)

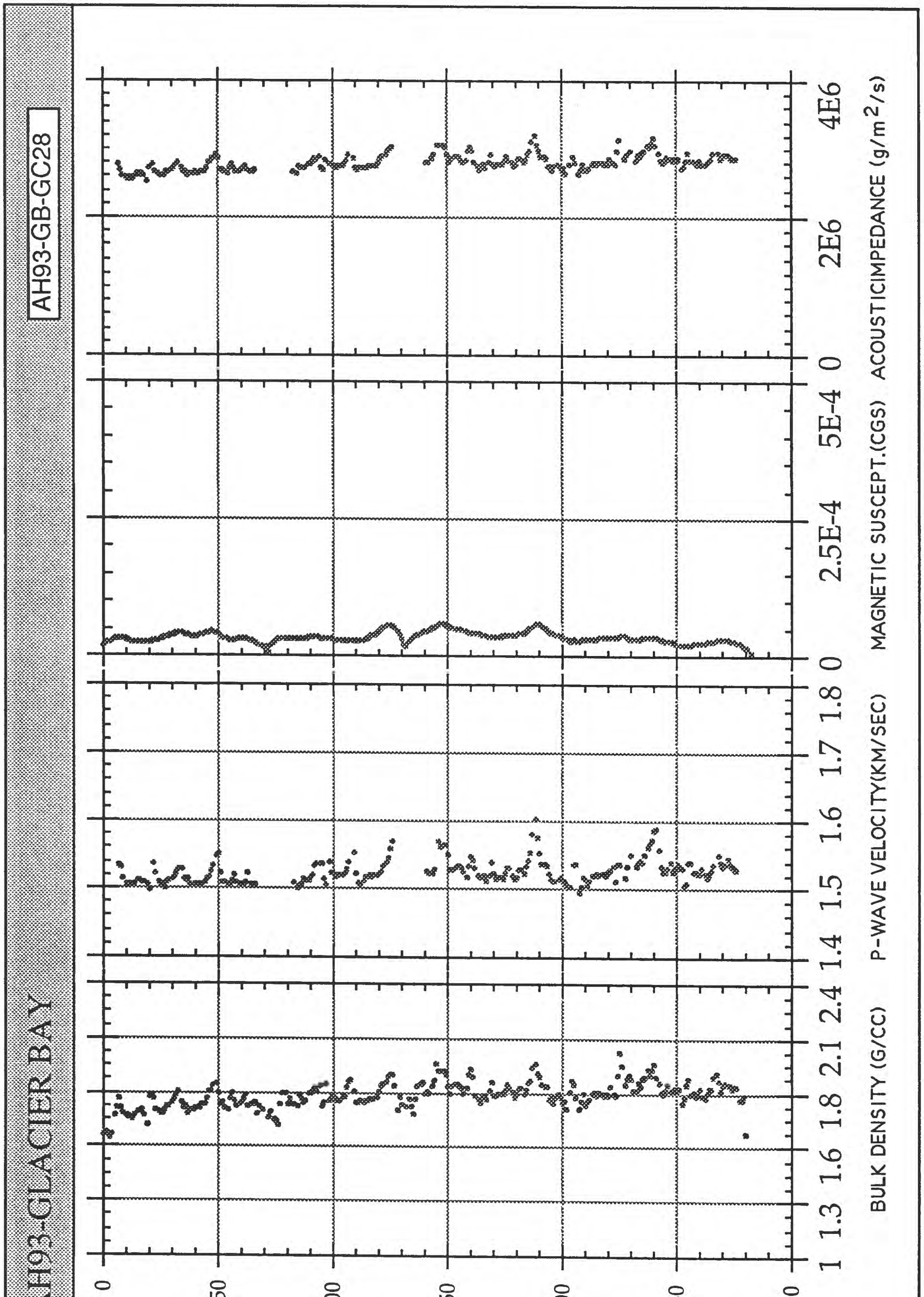

AH93-GLACIER BAY
AH93-GB-GC22
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY(KM/SEC)
0 2.5E-4 5E-4
MAGNETIC SUSCEPT.(CGS)
0 2E6 4E6
ACOUSTICIMPEDANCE (g/m2/s)

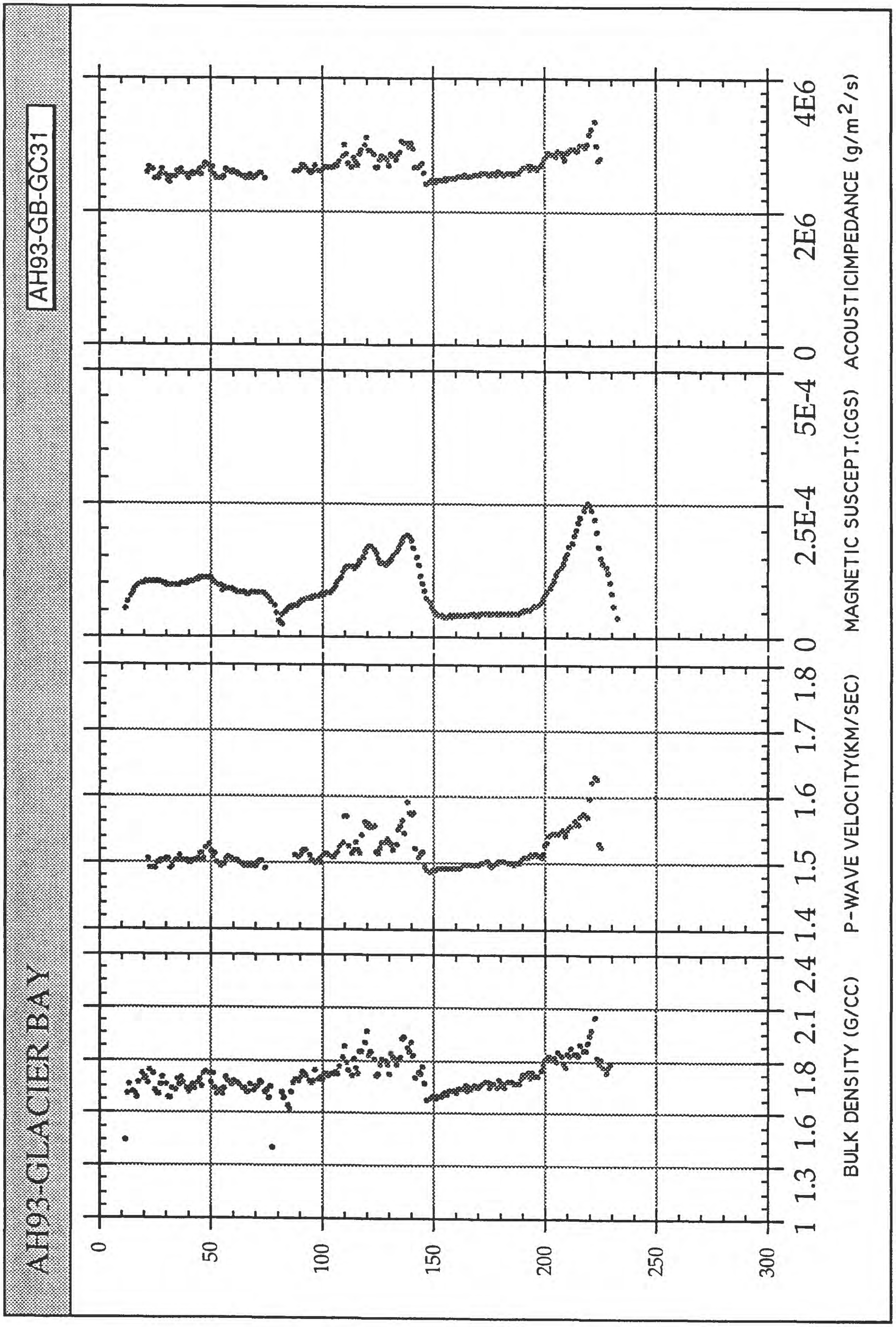

AH93-GLACIER BAY
AH93-GB-GC24
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY(KM/SEC)
0 2.5E-4 5E-4
MAGNETIC SUSCEPT.(CGS)
0 2E6 4E6
ACOUSTICIMPEDANCE (g/m^2/s)

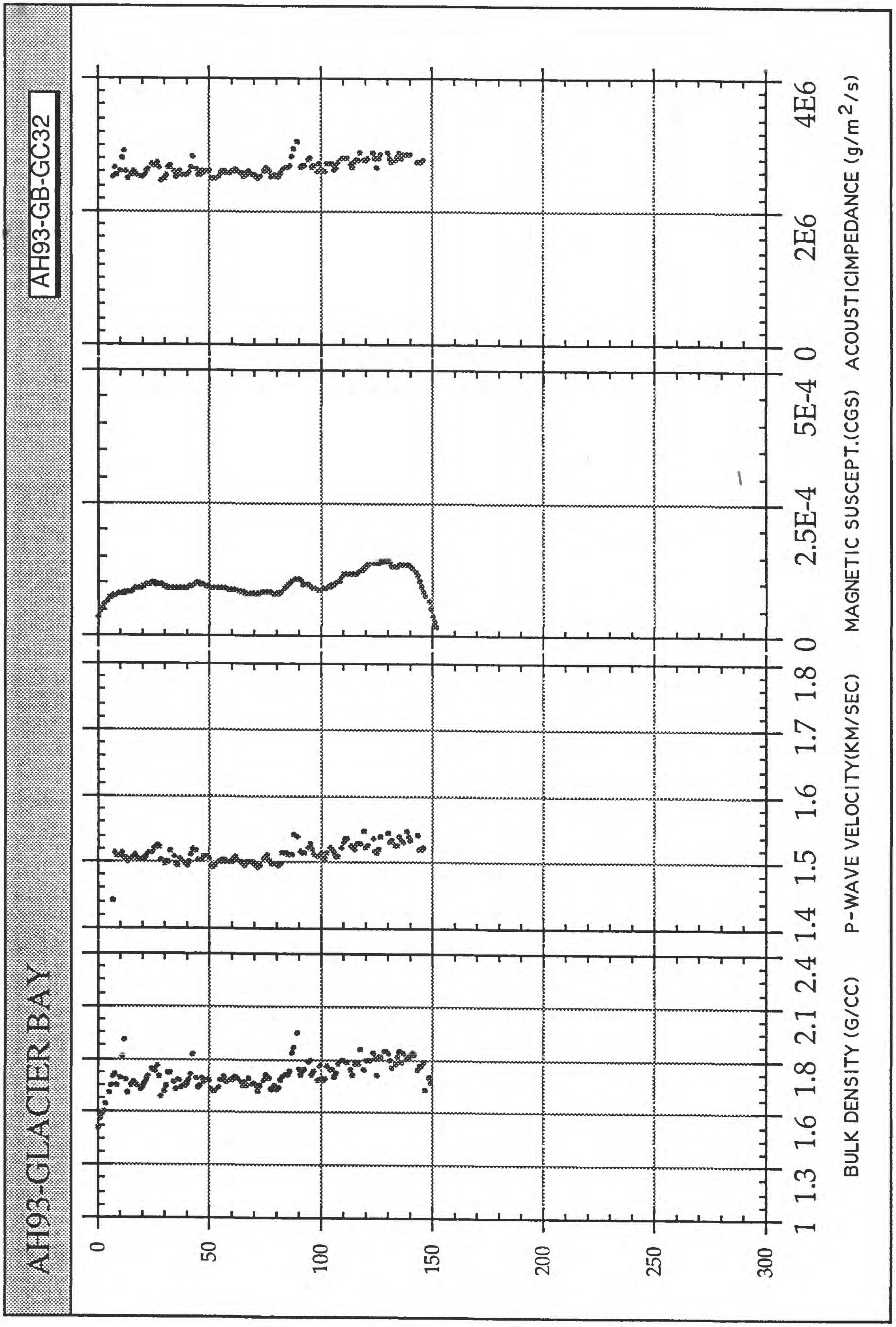

AH93-GLACIER BAY
AH93-GB-GC25 0-40
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
0
2.5E-4
5E-4
MAGNETIC SUSCEPT.(CGS)
0
2E6
4E6
ACOUSTICIMPEDANCE ($g/m^2/s$)

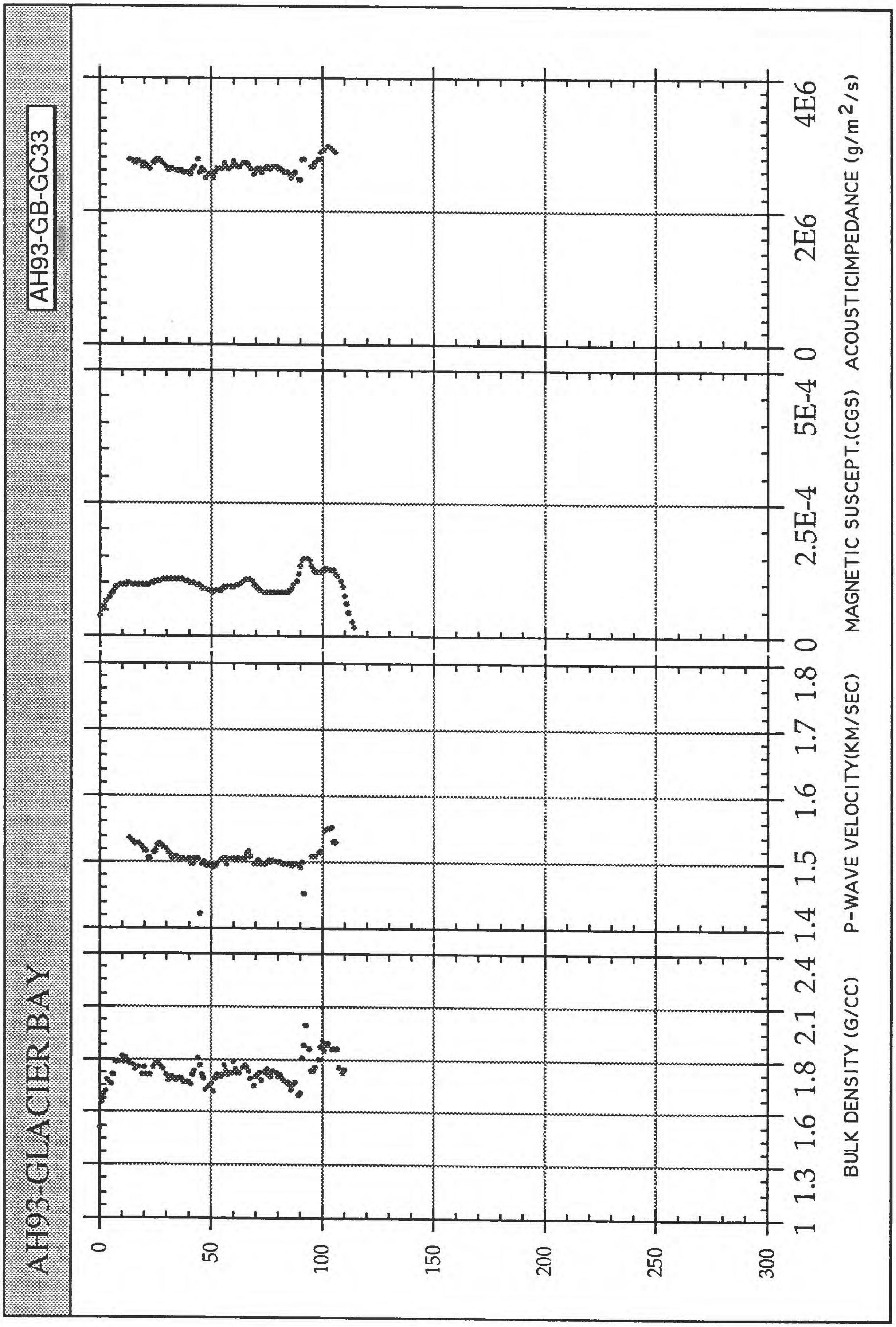

AH93-GLACIER BAY
AH93-GB-GC26 0-55
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY(KM/SEC)
0 2.5E-4 5E-4
MAGNETIC SUSCEPT.(CGS)
0 2E6 4E6
ACOUSTICIMPEDANCE (g/m2/s)

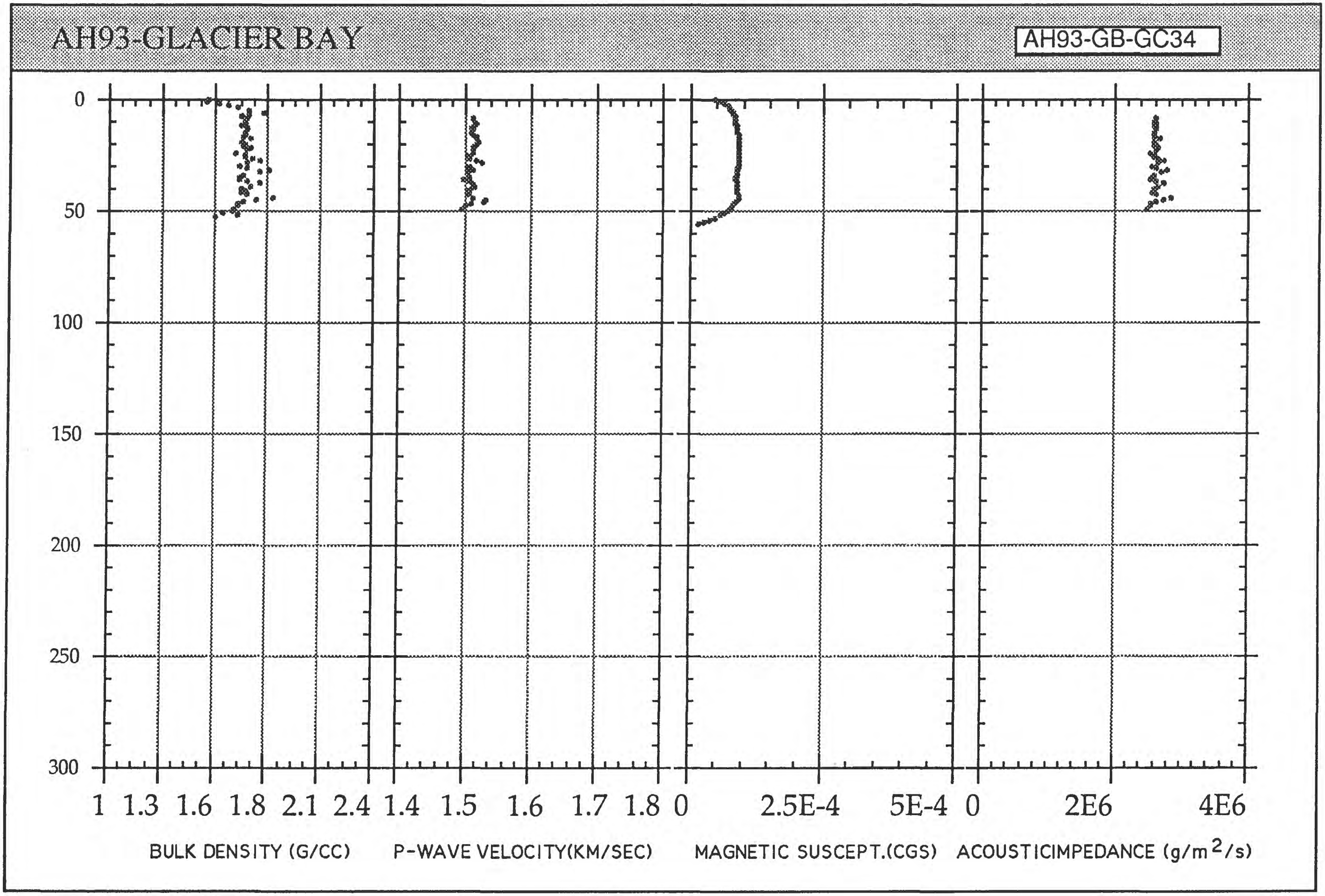

AH93-GLACIER BAY
AH93-GB-GC27
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY(KM/SEC)
0 2.5E-4 5E-4
MAGNETIC SUSCEPT.(CGS)
0 2E6 4E6
ACOUSTICIMPEDANCE (g/m^2/s)


AH93-GLACIER BAY
AH93-GB-GC28
0
50
100
150
200
250
300
1
1.3
1.6
1.8
2.1
2.4
BULK DENSITY (G/CC)
1.4
1.5
1.6
1.7
1.8
P-WAVE VELOCITY(KM/SEC)
0
2.5E-4
5E-4
MAGNETIC SUSCEPT.(CGS)
0
2E6
4E6
ACOUSTICIMPEDANCE ($g/m^2/s$)

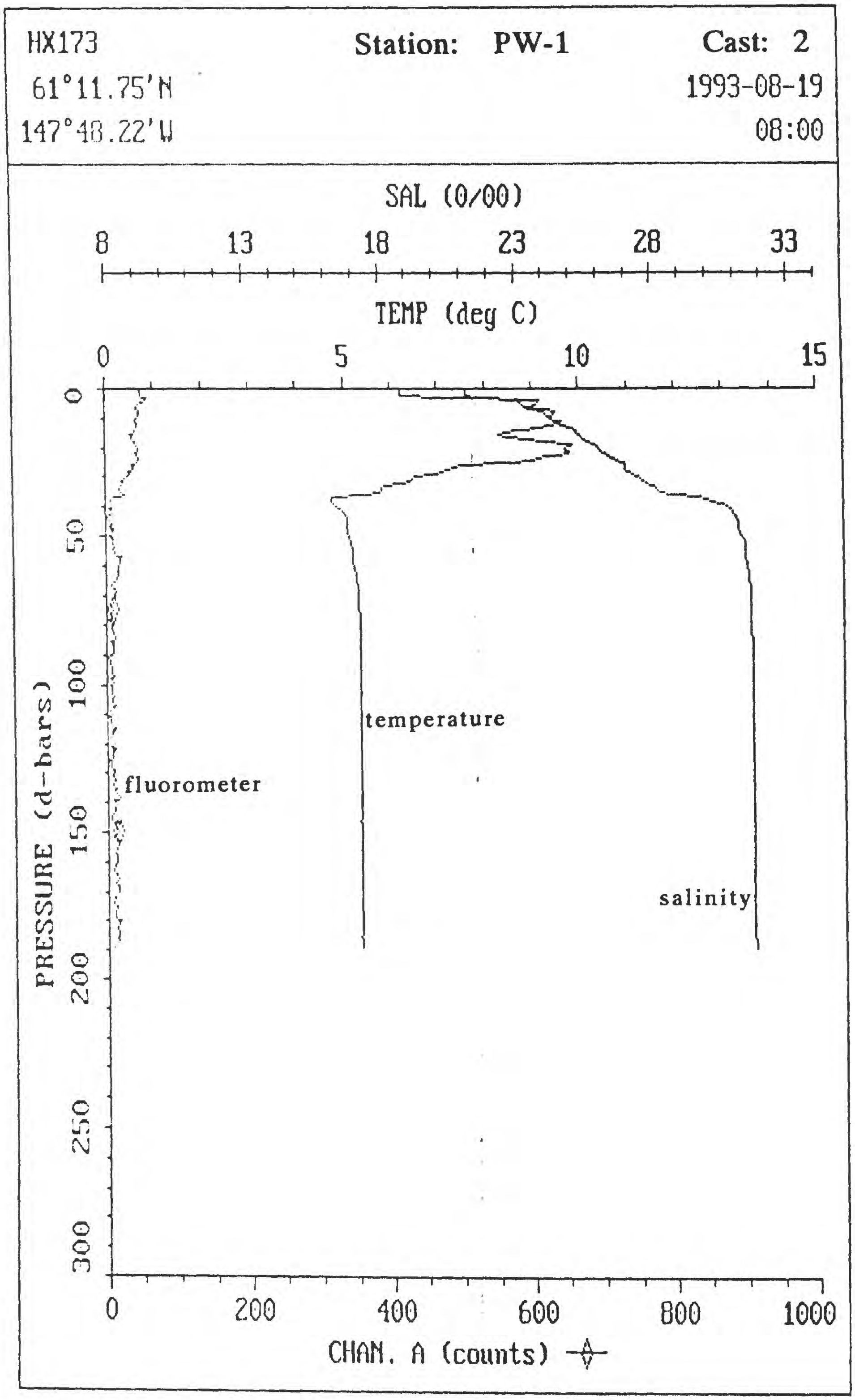

AH93-GLACIER BAY
AH93-GB-GC31
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY(KM/SEC)
0 2.5E-4 5E-4
MAGNETIC SUSCEPT.(CGS)
0 2E6 4E6
ACOUSTICIMPEDANCE $(g/m^2/s)$

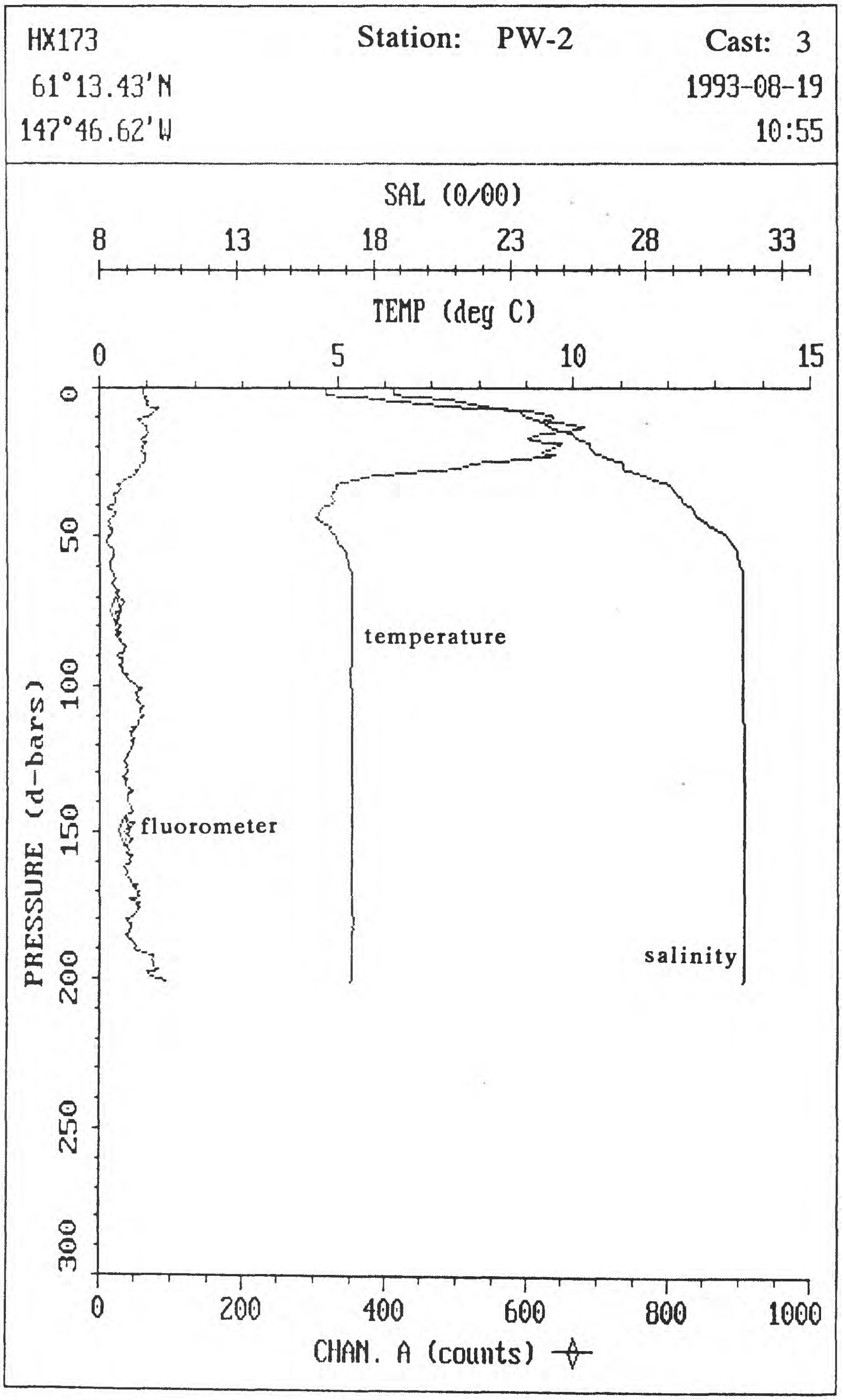

AH93-GLACIER BAY
AH93-GB-GC32
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY(KM/SEC)
0 2.5E-4 5E-4
MAGNETIC SUSCEPT.(CGS)
0 2E6 4E6
ACOUSTICIMPEDANCE (g/m2/s)

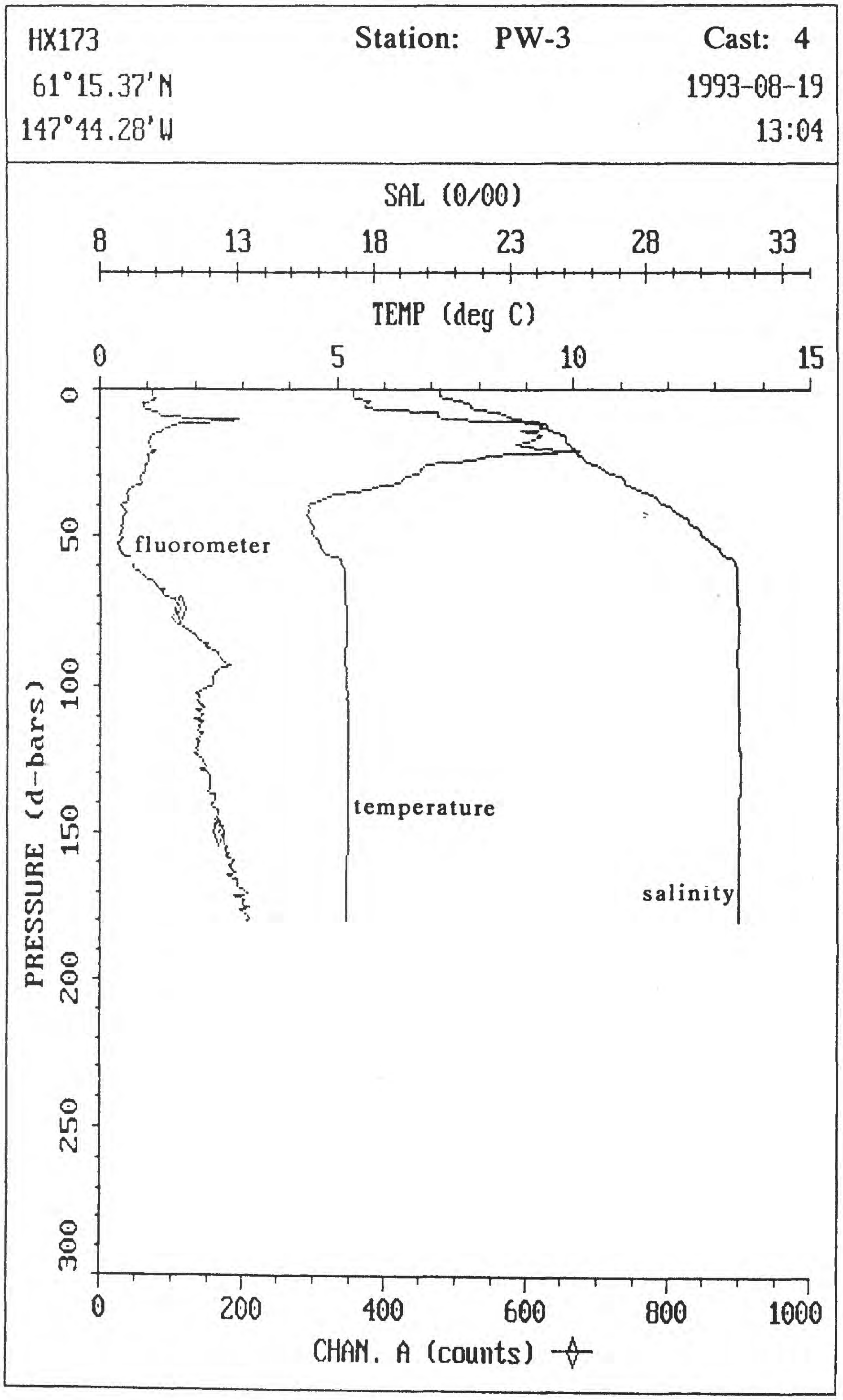

AH93-GLACIER BAY
AH93-GB-GC33
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY(KM/SEC)
0 2.5E-4 5E-4
MAGNETIC SUSCEPT.(CGS)
0 2E6 4E6
ACOUSTICIMPEDANCE (g/m^2/s)

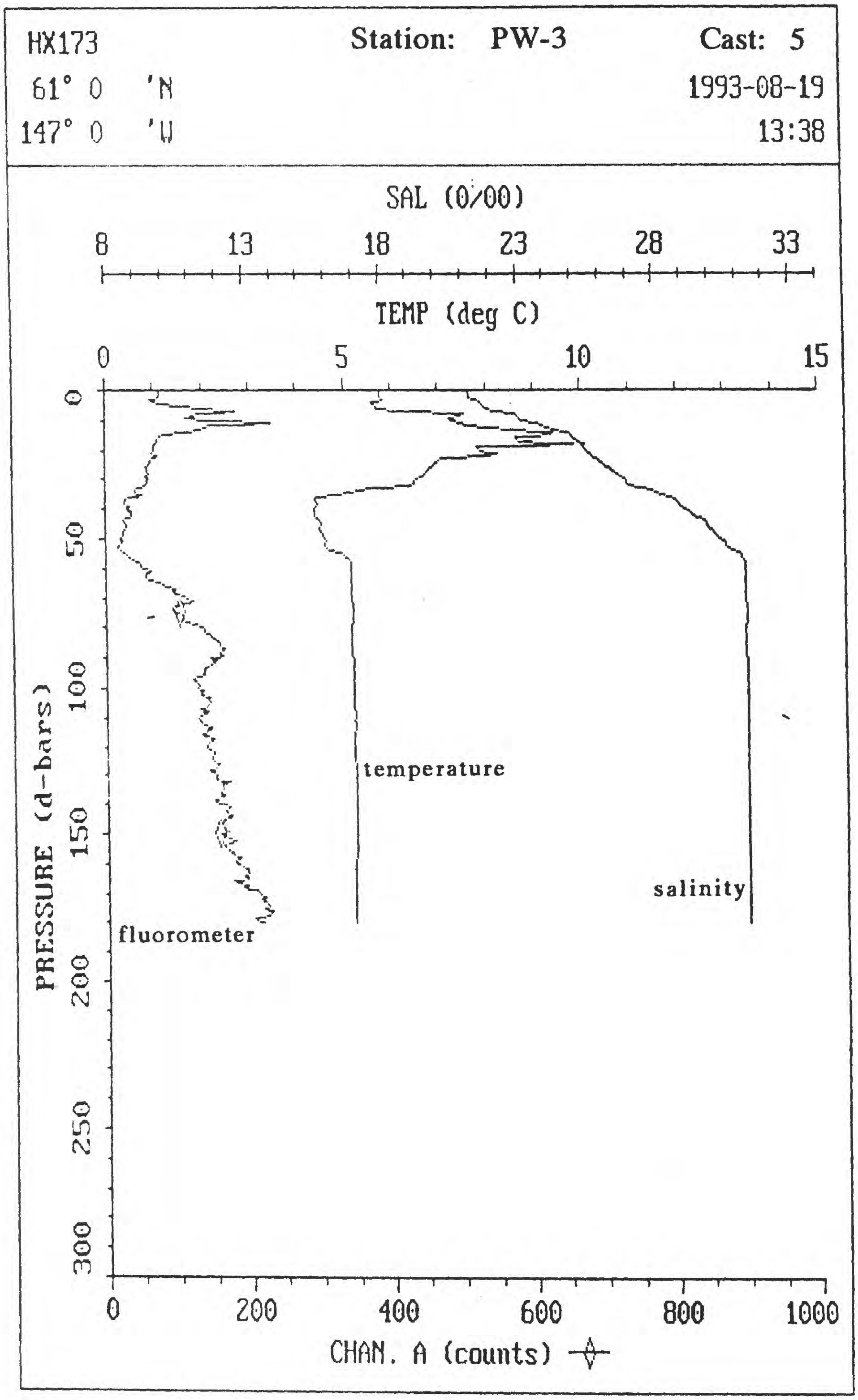

AH93-GLACIER BAY
AH93-GB-GC34
0
50
100
150
200
250
300
1 1.3 1.6 1.8 2.1 2.4
BULK DENSITY (G/CC)
1.4 1.5 1.6 1.7 1.8
P-WAVE VELOCITY(KM/SEC)
0 2.5E-4 5E-4
MAGNETIC SUSCEPT.(CGS)
0 2E6 4E6
ACOUSTICIMPEDANCE (g/m 2/s)

APPENDIX 3: CTD PROFILES

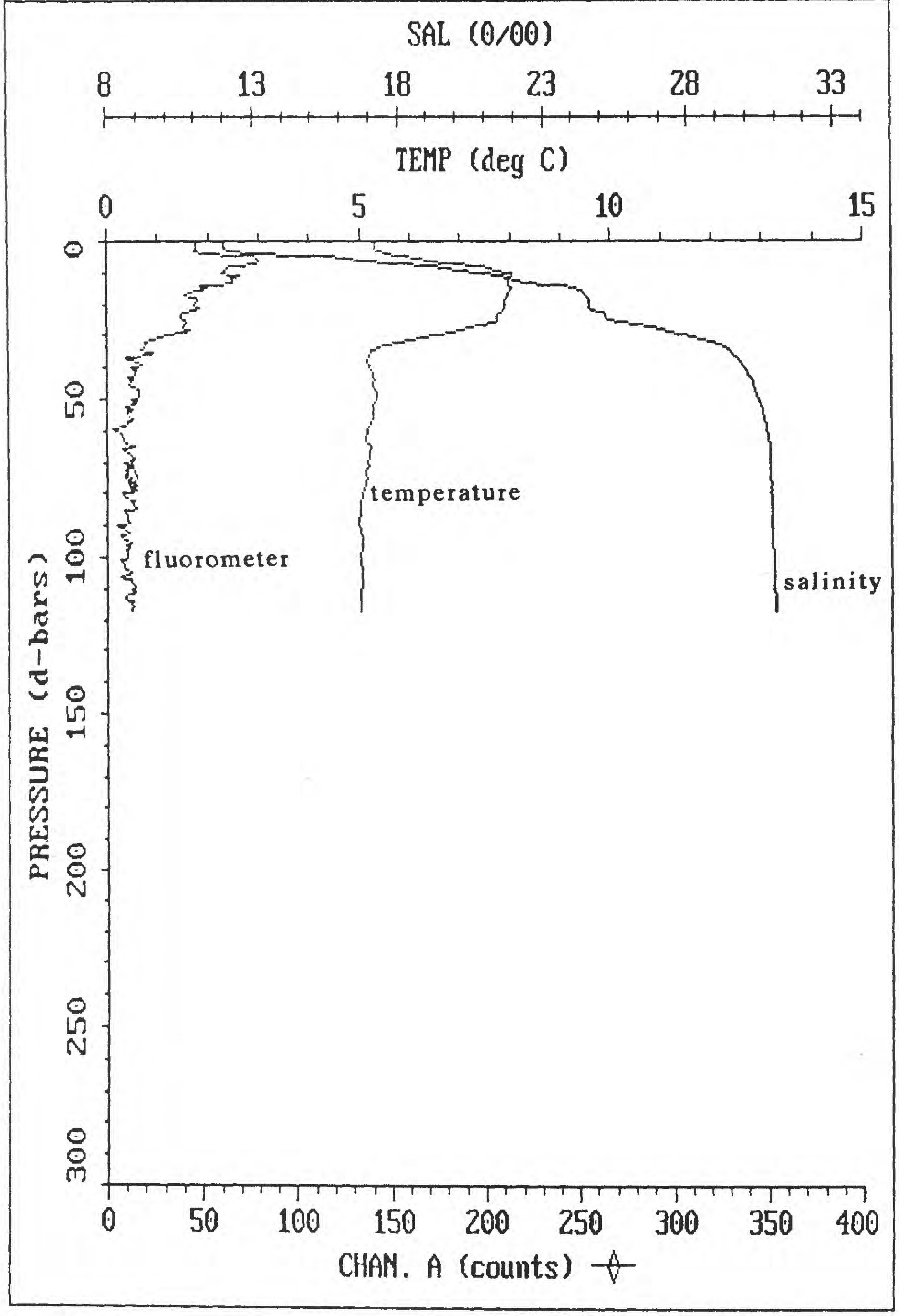

HX173
Station: PW-1
Cast: 2
61°11.75'N
147°48.22'W
1993-08-19
08:00
SAL (0/00)
8
13
18
23
28
33
TEMP (deg C)
0
5
10
15
PRESSURE (d-bars)
0
50
100
150
200
250
300
temperature
fluorometer
salinity
0
200
400
600
800
1000
CHAN. A (counts)

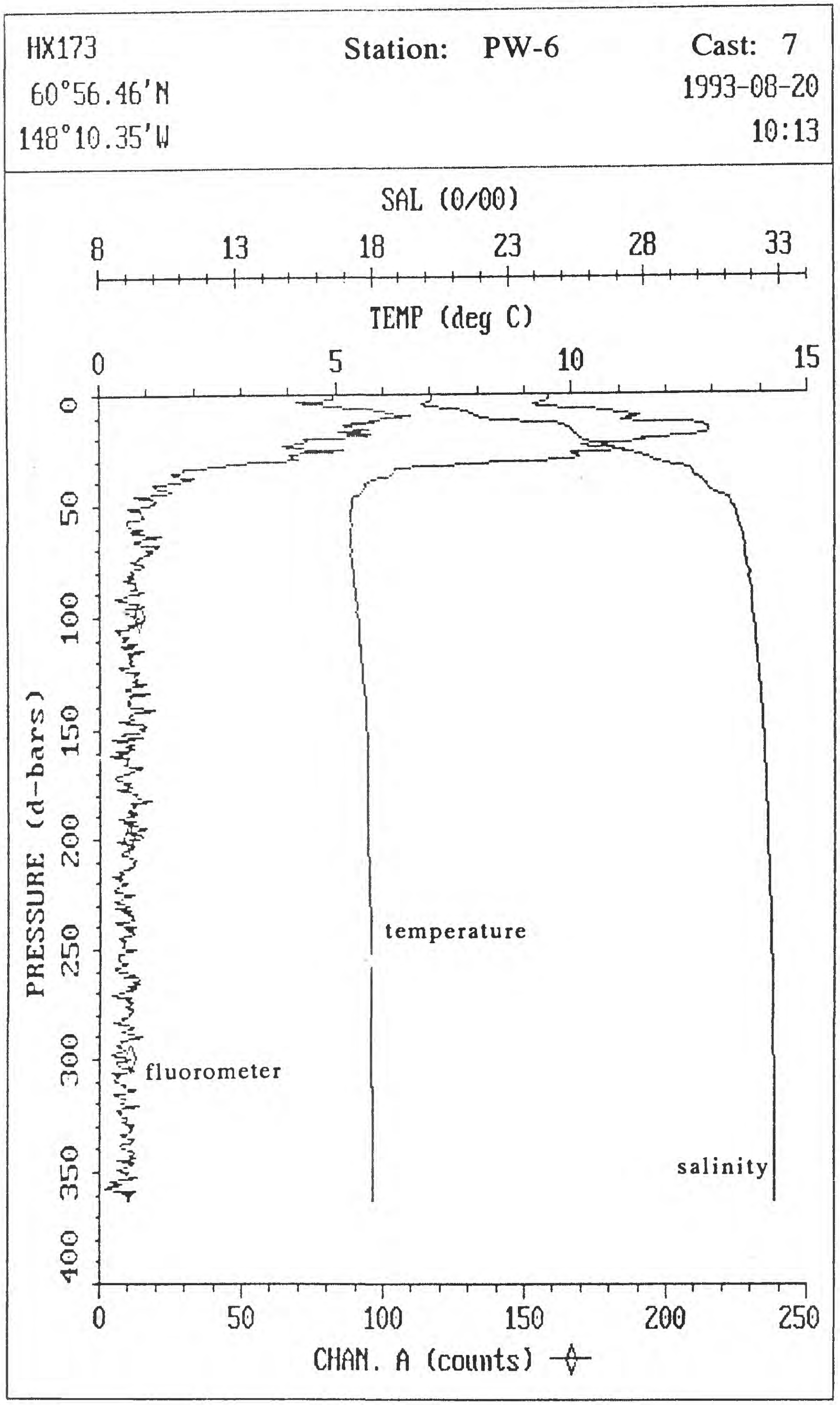

HX173
Station: PW-2
Cast: 3
61°13.43'N
147°46.62'W
1993-08-19
10:55
SAL (0/00)
8
13
18
23
28
33
TEMP (deg C)
0
5
10
15
PRESSURE (d-bars)
0
50
100
150
200
250
300
temperature
fluorometer
salinity
0
200
400
600
800
1000
CHAN. A (counts)

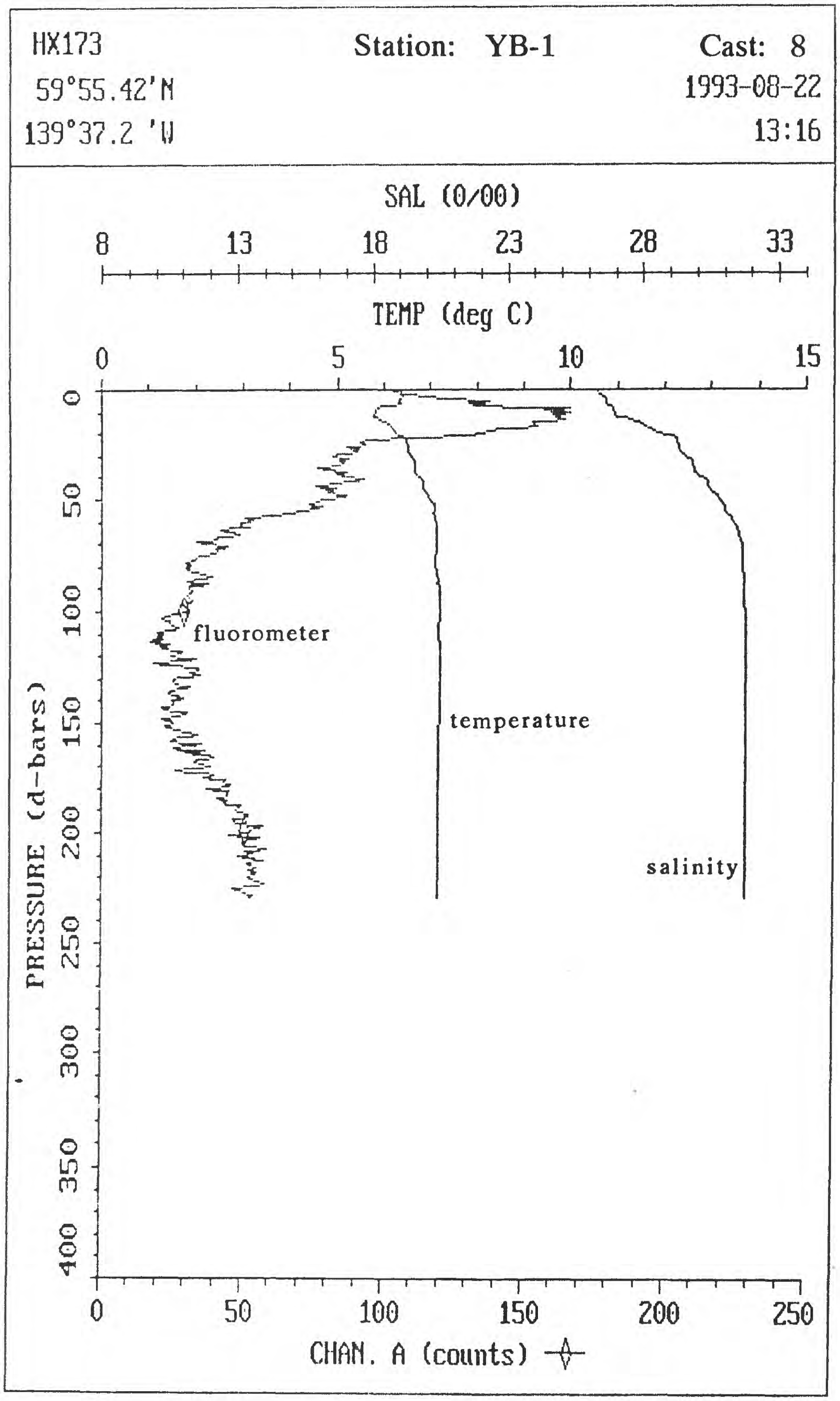

HX173
Station: PW-3
Cast: 4
61°15.37'N
1993-08-19
147°44.28'W
13:04
SAL (0/00)
8
13
18
23
28
33
TEMP (deg C)
0
5
10
15
PRESSURE (d-bars)
0
50
100
150
200
250
300
fluorometer
temperature
salinity
0
200
400
600
800
1000
CHAN. A (counts)

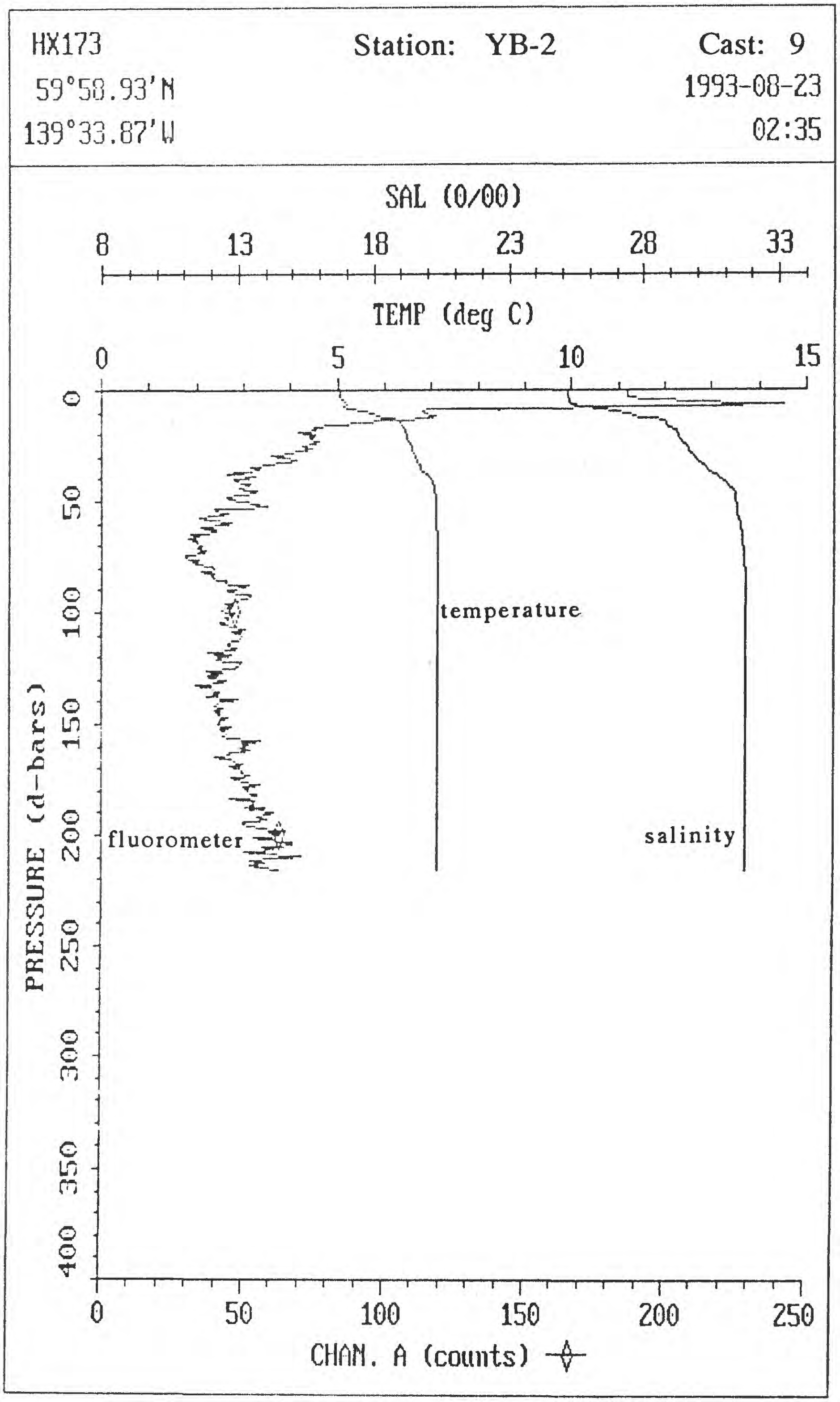

HX173
Station: PW-3
Cast: 5
61° 0 'N
147° 0 'W
1993-08-19
13:38
SAL (0/00)
8
13
18
23
28
33
TEMP (deg C)
0
5
10
15
PRESSURE (d-bars)
0
50
100
150
200
250
300
temperature
salinity
fluorometer
0
200
400
600
800
1000
CHAN. A (counts)

HX173 | Station: PW-5 | Cast: 6
61° 4.09'N | | 1993-08-20
148°13.34'W | | 08:03




HX173
60°56.46'N
148°10.35'W
Station: PW-6
Cast: 7
1993-08-20
10:13
SAL (0/00)
8
13
18
23
28
33
TEMP (deg C)
0
5
10
15
PRESSURE (d-bars)
0
50
100
150
200
250
300
350
400
temperature
fluorometer
salinity
0
50
100
150
200
250
CHAN. A (counts)

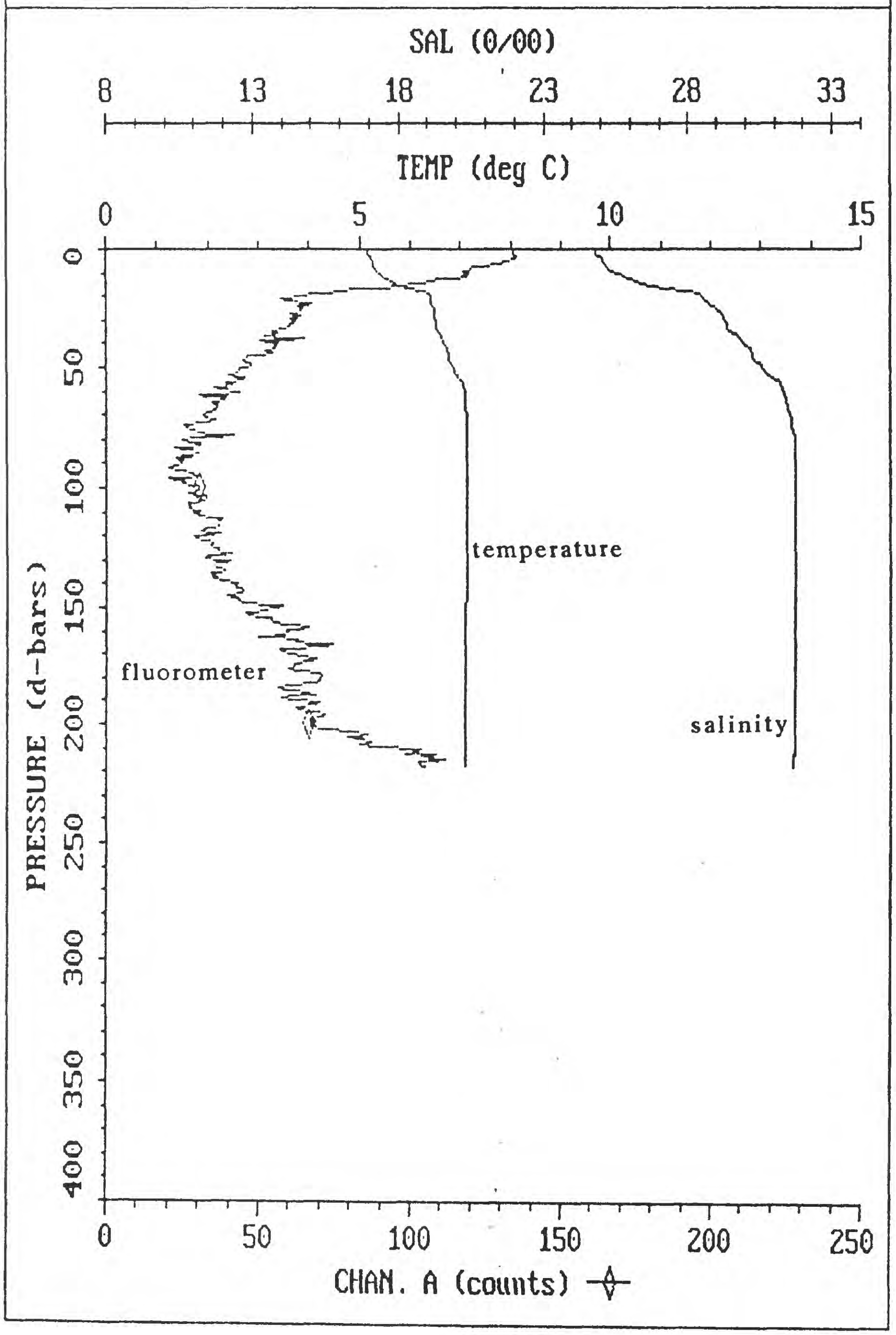

HX173
Station: YB-1
Cast: 8
59°55.42'N
1993-08-22
139°37.2 'W
13:16
SAL (0/00)
8
13
18
23
28
33
TEMP (deg C)
0
5
10
15
PRESSURE (d-bars)
0
50
100
150
200
250
300
350
400
fluorometer
temperature
salinity
0
50
100
150
200
250
CHAN. A (counts)

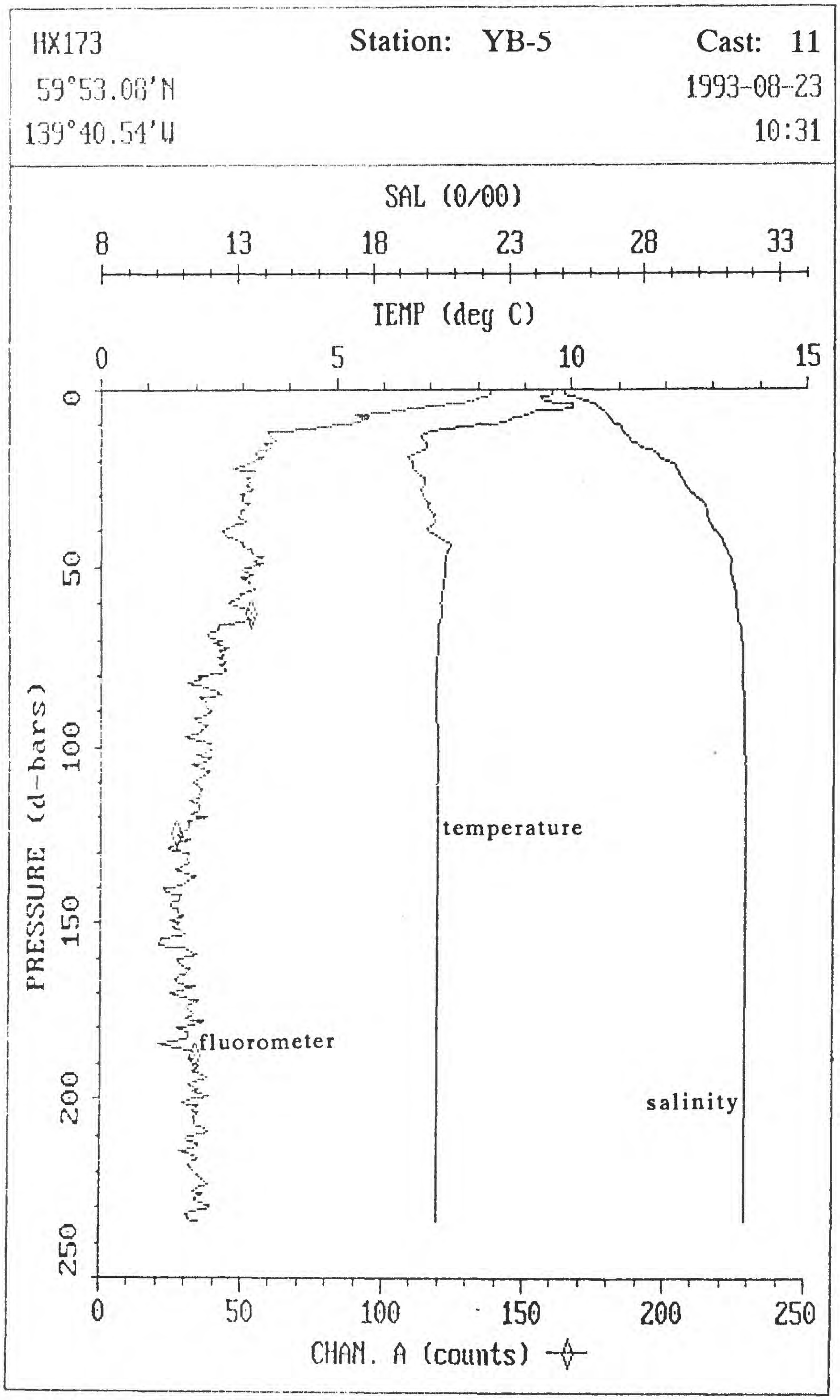

HX173
Station: YB-2
Cast: 9
59°58.93'N
1993-08-23
139°33.87'W
02:35
SAL (0/00)
8
13
18
23
28
33
TEMP (deg C)
0
5
10
15
PRESSURE (d-bars)
0
50
100
150
200
250
300
350
400
temperature
fluorometer
salinity
0
50
100
150
200
250
CHAN. A (counts)

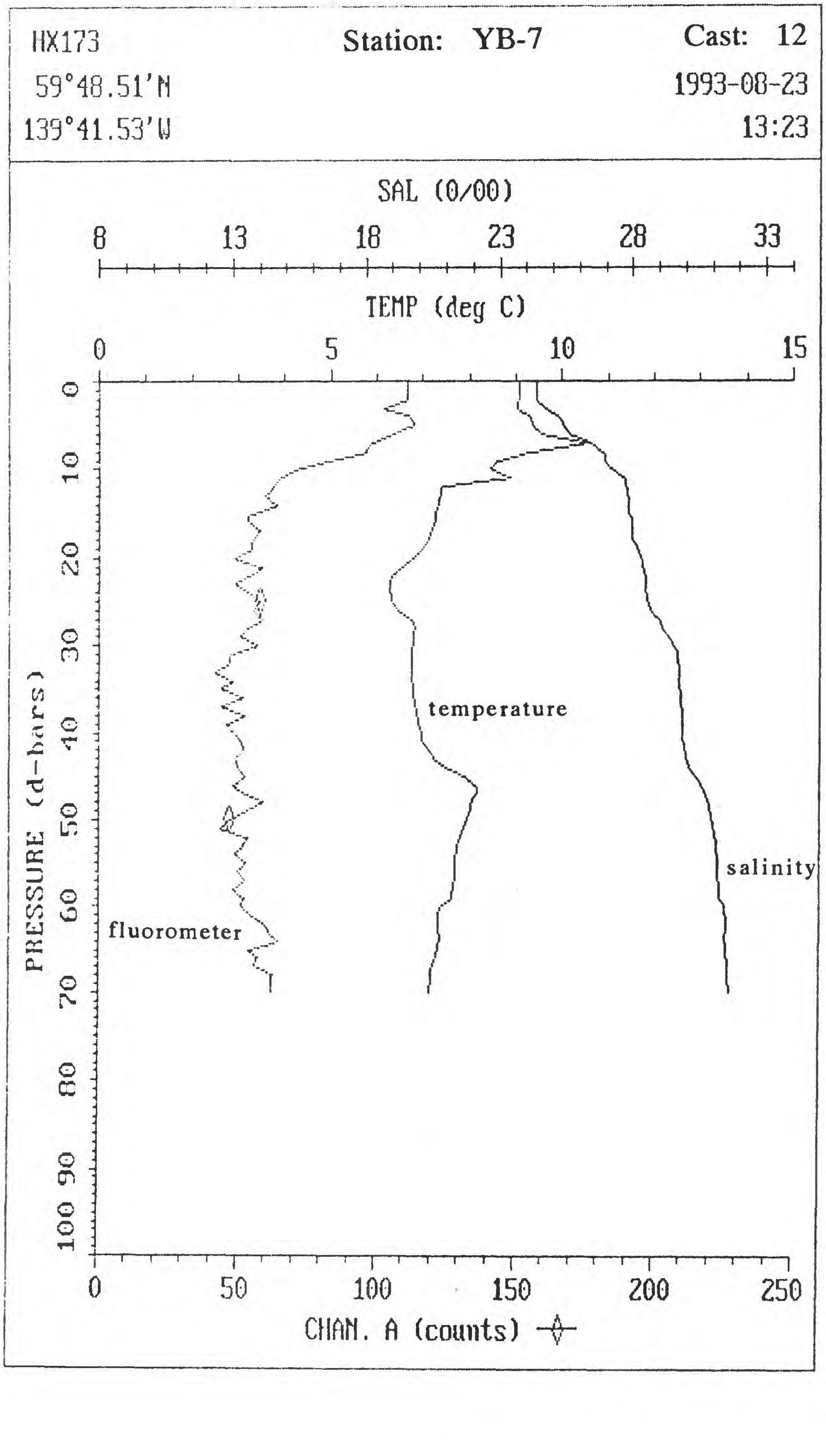
HX173
59°57.73'N
139°34.77'W

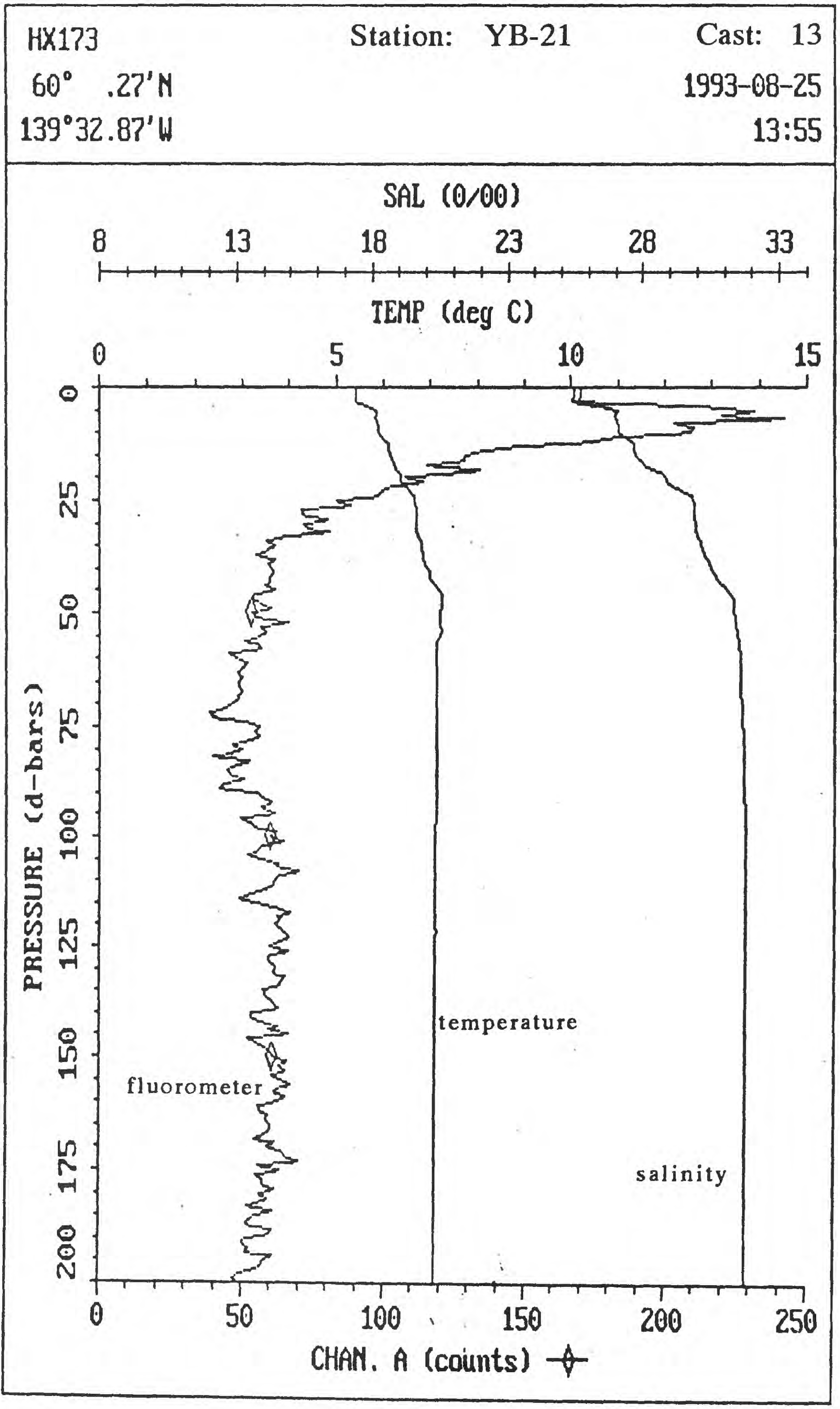
Station: YB-4

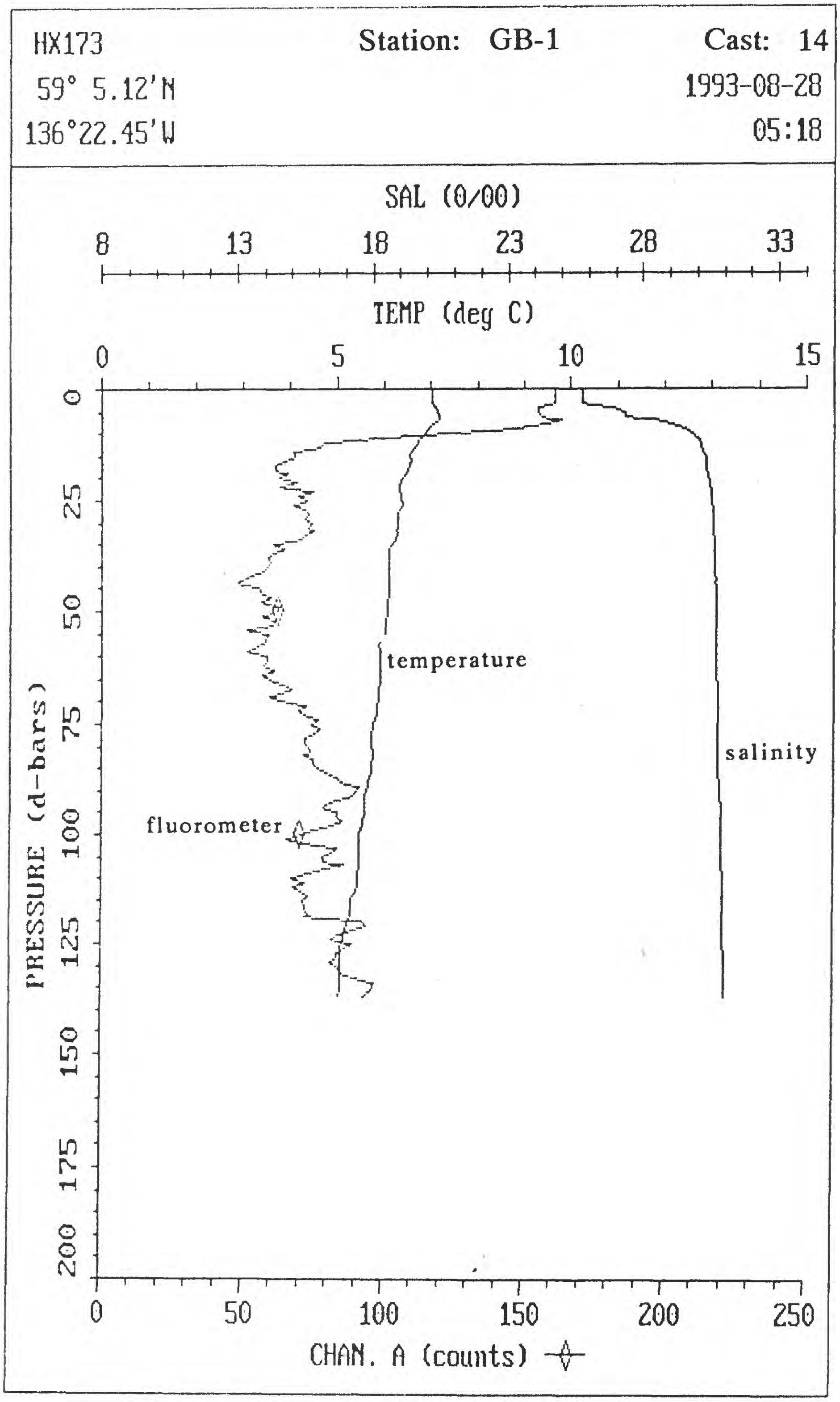
Cast: 10
1993-08-23
09:23

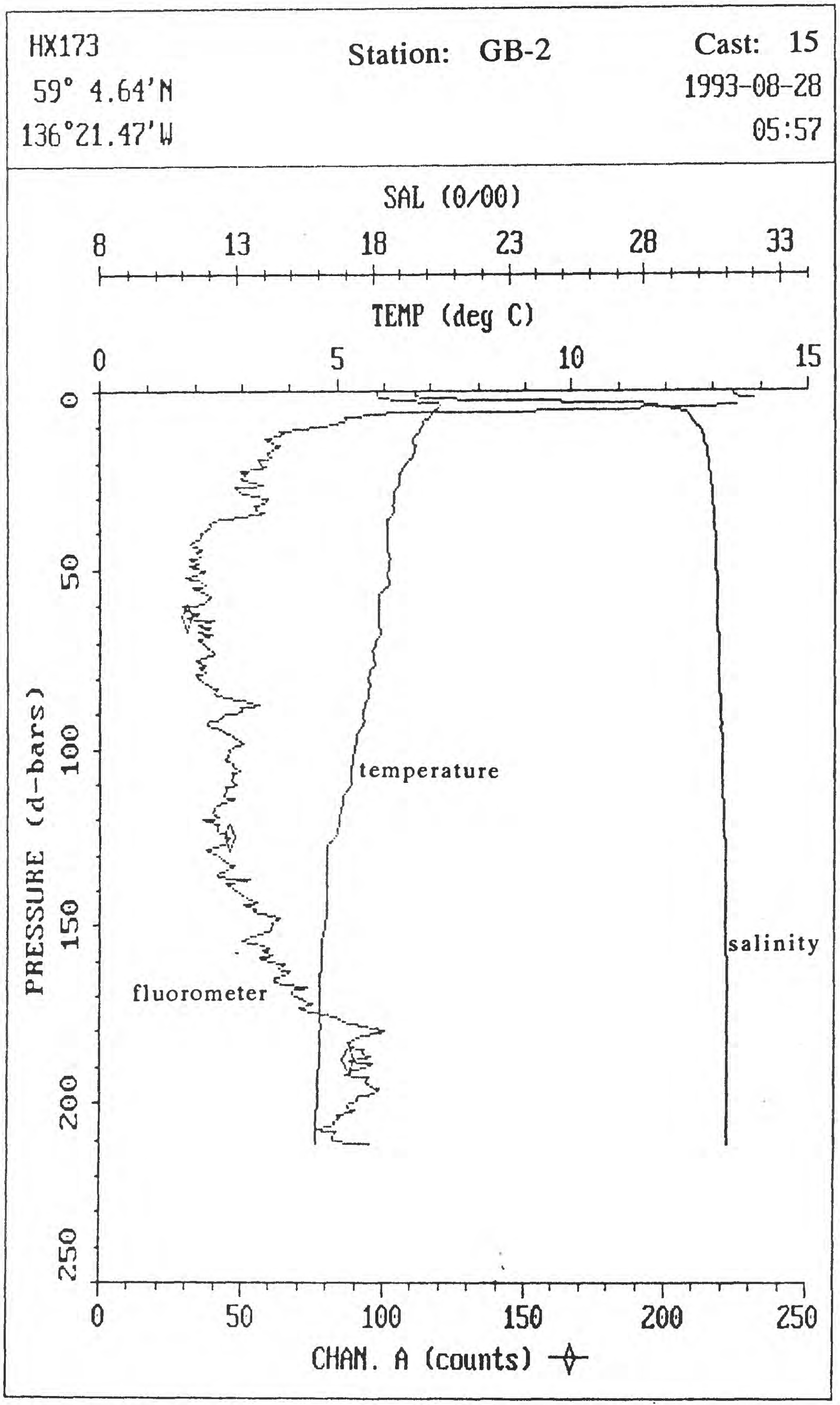



HX173
Station: YB-5
Cast: 11
59°53.08'N
1993-08-23
139°40.54'W
10:31
SAL (0/00)
8
13
18
23
28
33
TEMP (deg C)
0
5
10
15
PRESSURE (d-bars)
0
50
100
150
200
250
temperature
fluorometer
salinity
0
50
100
150
200
250
CHAN. A (counts)

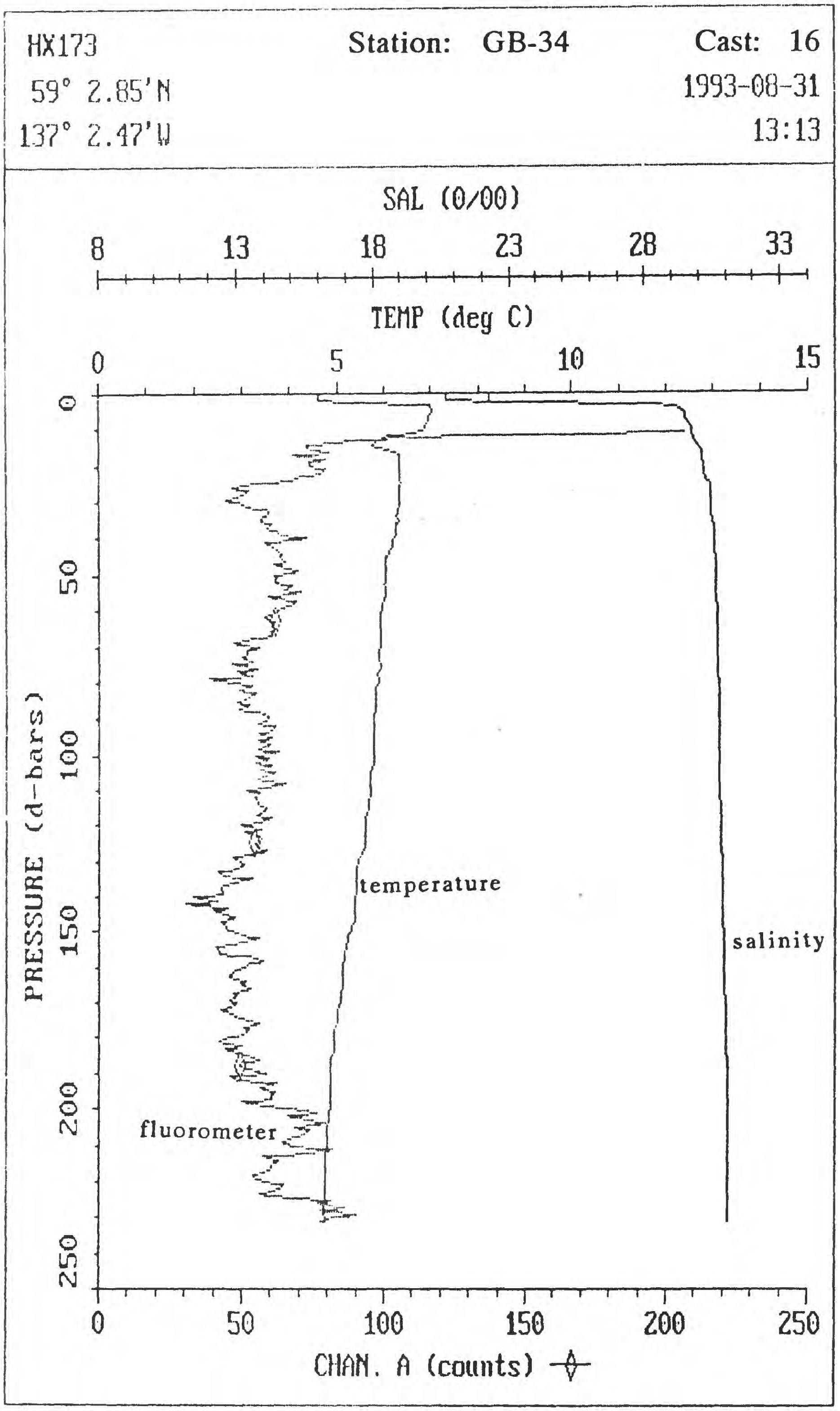

HX173
Station: YB-7
Cast: 12
59°48.51'N
1993-08-23
139°41.53'W
13:23
SAL (0/00)
8
13
18
23
28
33
TEMP (deg C)
0
5
10
15
PRESSURE (d-bars)
0
10
20
30
40
50
60
70
80
90
100
temperature
salinity
fluorometer
0
50
100
150
200
250
CHAN. A (counts)


HX173
Station: YB-21
Cast: 13
60° .27'N
1993-08-25
139°32.87'W
13:55
SAL (0/00)
8
13
18
23
28
33
TEMP (deg C)
0
5
10
15
PRESSURE (d-bars)
0
25
50
75
100
125
150
175
200
temperature
fluorometer
salinity
0
50
100
150
200
250
CHAN. A (counts)


HX173
Station: GB-1
Cast: 14
59° 5.12'N
1993-08-28
136°22.45'W
05:18
SAL (0/00)
8
13
18
23
28
33
TEMP (deg C)
0
5
10
15
PRESSURE (d-bars)
0
25
50
75
100
125
150
175
200
temperature
salinity
fluorometer
0
50
100
150
200
250
CHAN. A (counts)

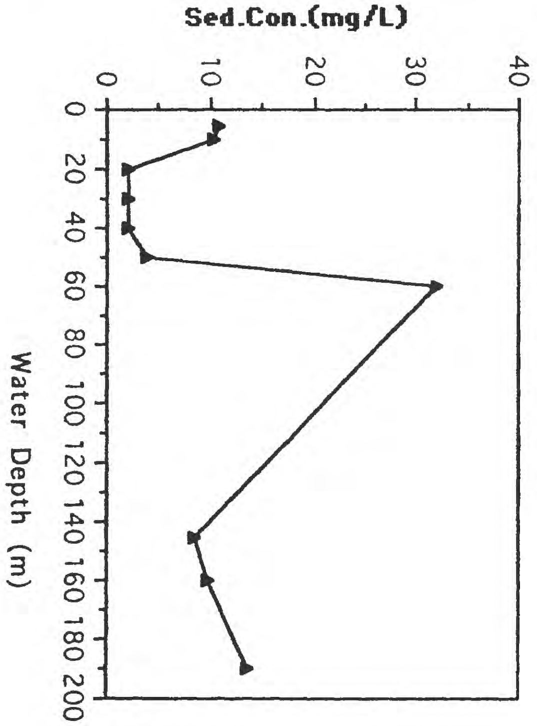


HX173
59° 4.64'N
136°21.47'W
Station: GB-2
Cast: 15
1993-08-28
05:57
SAL (0/00)
8
13
18
23
28
33
TEMP (deg C)
0
5
10
15
PRESSURE (d-bars)
0
50
100
150
200
250
temperature
salinity
fluorometer
0
50
100
150
200
250
CHAN. A (counts)

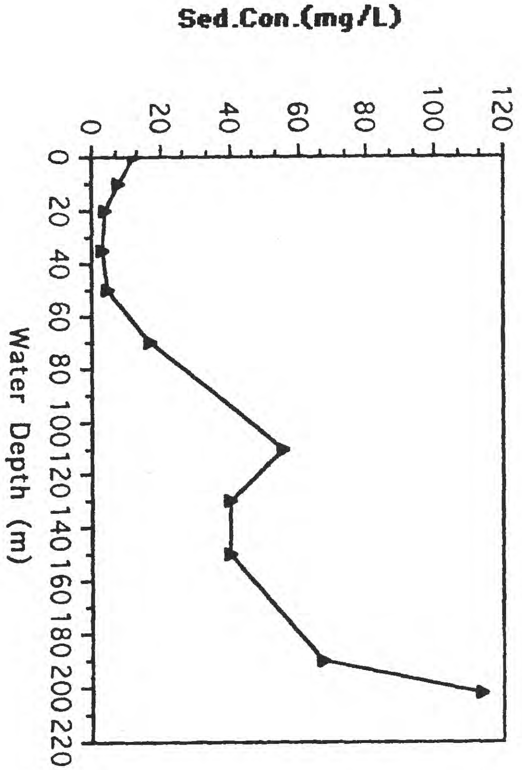

HX173
Station: GB-34
Cast: 16
59° 2.85'N
1993-08-31
137° 2.47'W
13:13
SAL (0/00)
8
13
18
23
28
33
TEMP (deg C)
0
5
10
15
PRESSURE (d-bars)
0
50
100
150
200
250
temperature
salinity
fluorometer
0
50
100
150
200
250
CHAN. A (counts)

APPENDIX 4: PLOTS OF SUSPENDED SEDIMENT CONCENTRATIONS

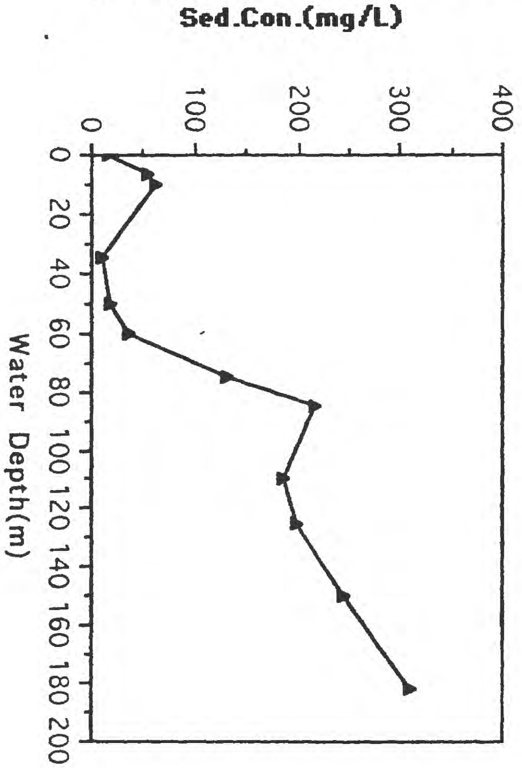
Station: PW-1 Cast: 2



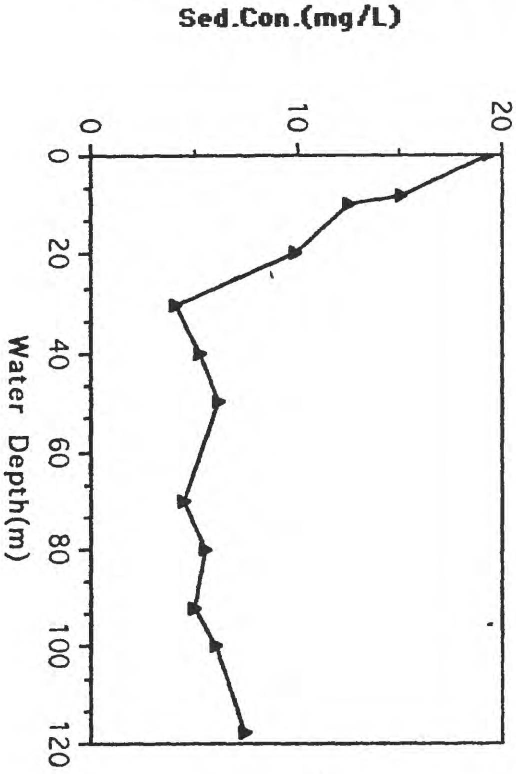
Station: PW-2 Cast: 3



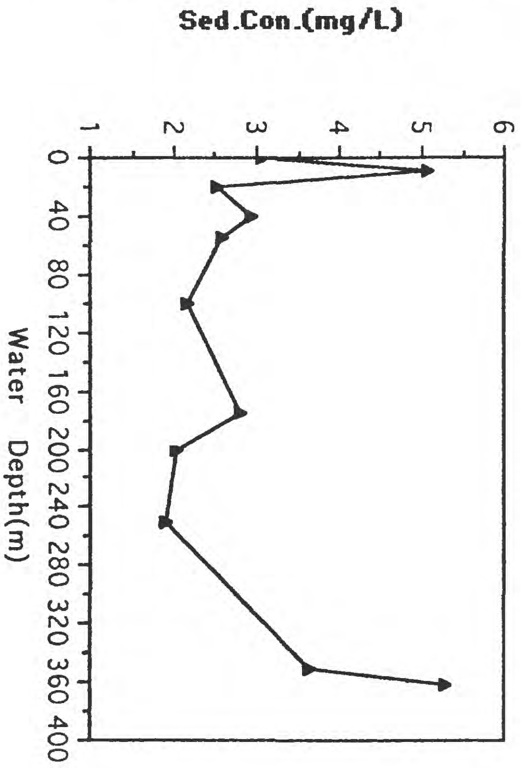
Station: PW-3 Cast: 5



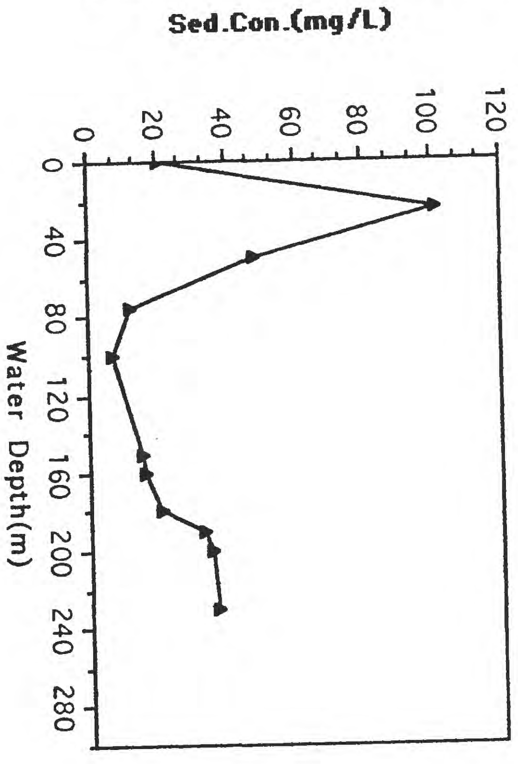
Station: PW-5 Cast: 6



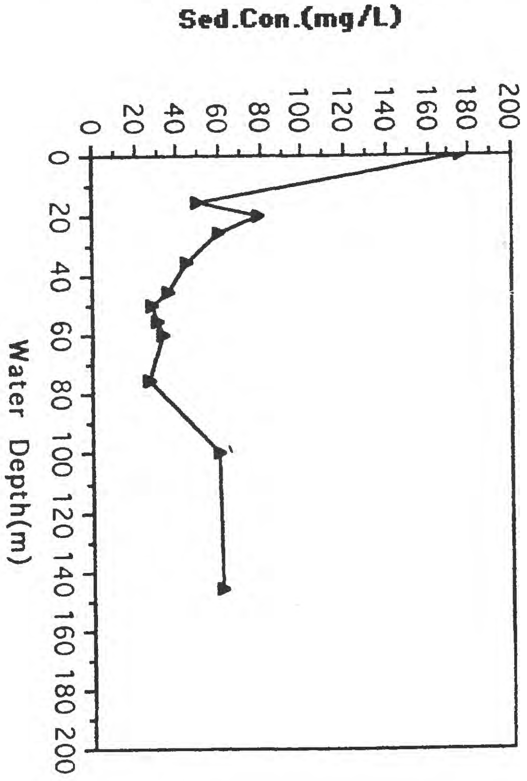
Station: PW-6 Cast: 7



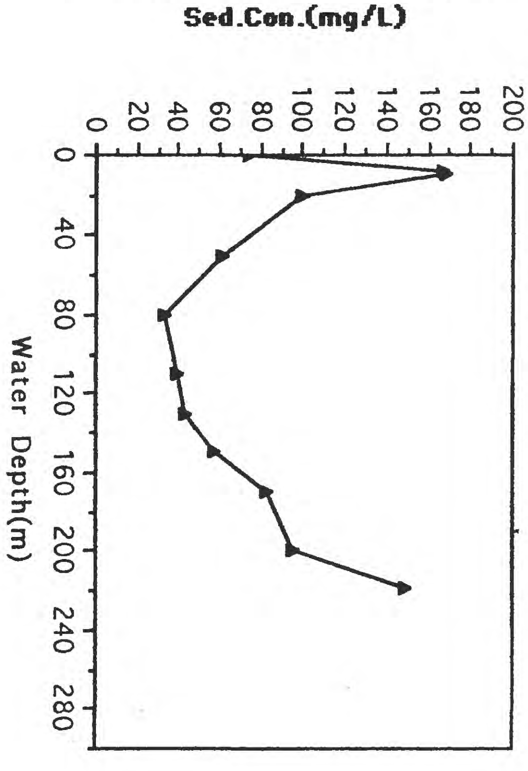
Station: YB-1 Cast: 8



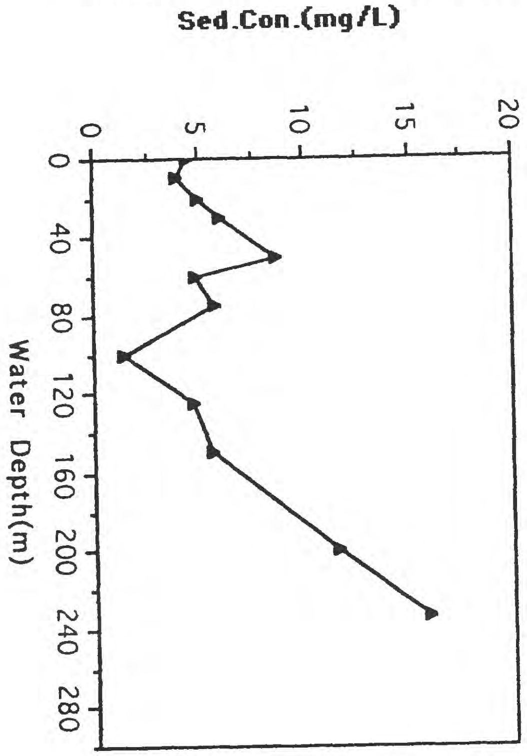
Station: YB-2 Cast: 9



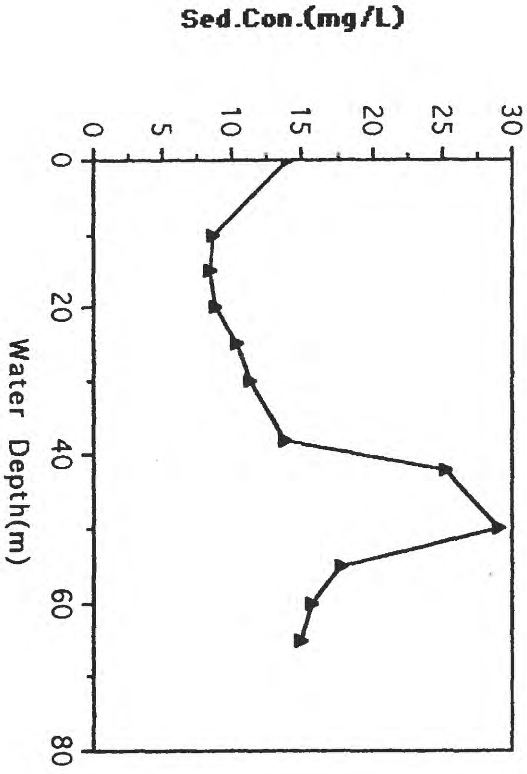
Station: YB-4 Cast: 10



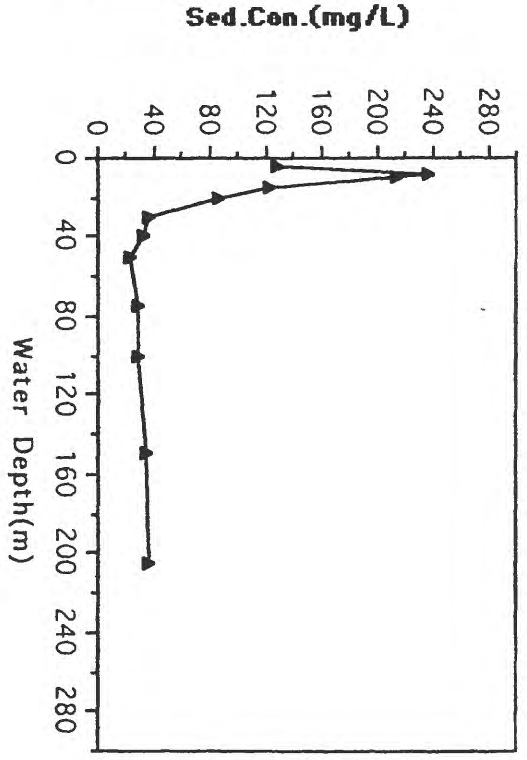
Station: YB-5 Cast: 11



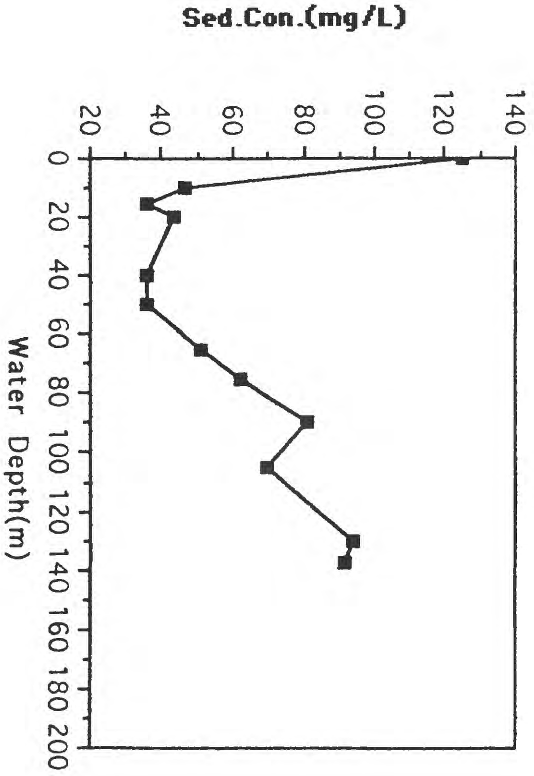
Station: YB-7 Cast: 12



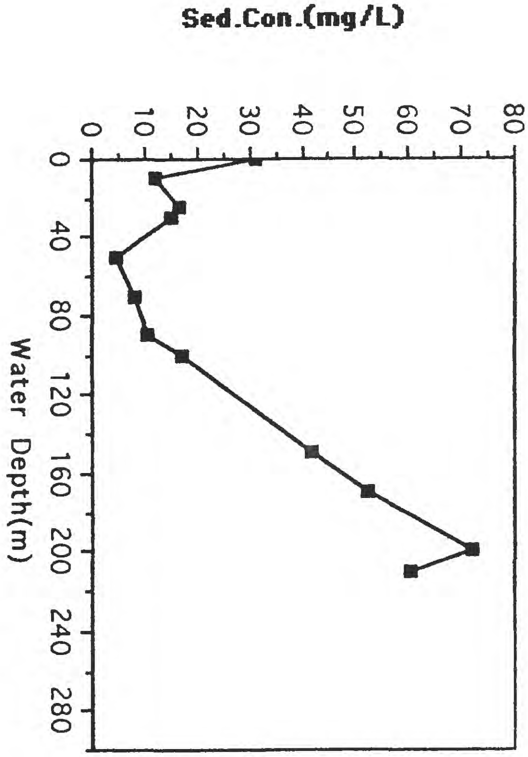
Station: YB-21 Cast: 13



Station: GB-1 Cast: 14



Station: GB-2 Cast: 15



Station: GB-34 Cast: 16