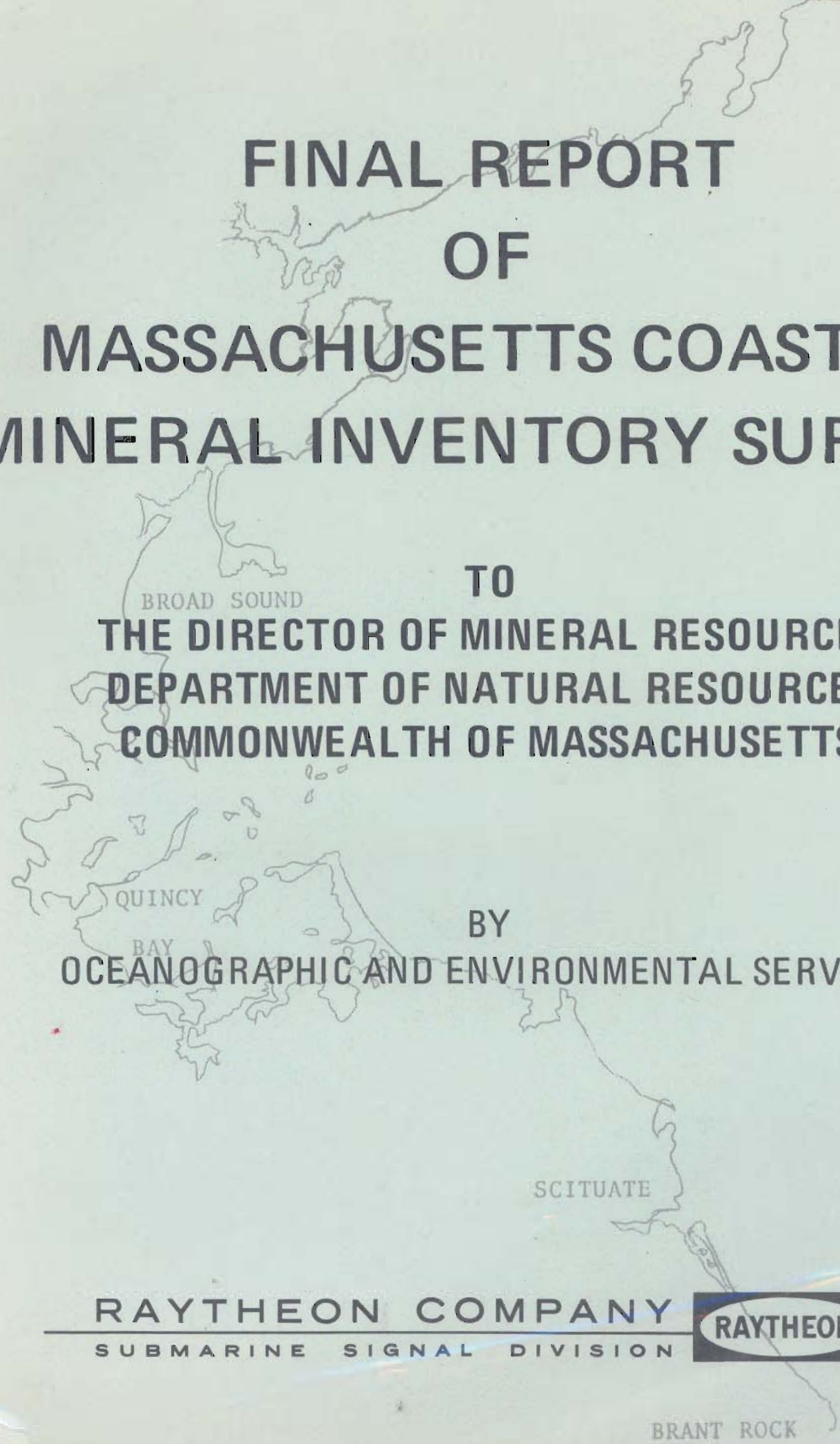

FINAL REPORT OF MASSACHUSETTS COASTAL MINERAL INVENTORY SURVEY

TO

THE DIRECTOR OF MINERAL RESOURCES
DEPARTMENT OF NATURAL RESOURCES
COMMONWEALTH OF MASSACHUSETTS

BY

OCEANOGRAPHIC AND ENVIRONMENTAL SERVICES

RAYTHEON COMPANY
SUBMARINE SIGNAL DIVISION

The Commonwealth of Massachusetts

Department of Natural Resources

Division of Mineral Resources

Leverett Saltonstall Building, Government Center

100 Cambridge Street, Boston 02202

The Division of Mineral Resources is not responsible for statements of navigational accuracy made in this report.

Final Report

of

Massachusetts Coastal Mineral
Inventory Survey

Errata Sheet

Page 4-4 Section 4.3, add sentence: The water depths recorded with core and grab samples in appendices II and III were approximate depths taken upon approach to each station and were for operational use at the time.

Page 4-7 Last paragraph, add sentence: Due to an error in LORAC operational procedures which was later corrected, the positions of all sample positions north of 48° - 25.75' N, phase I survey lines 27 through 45 and phase II survey lines 233 through 241 are accurate approximately ±100 feet.

~~Appendix VII Replace all pages with those enclosed.~~

Page VII-1- Correct site 0012 data to read:
Green 9314
Red 32819
X Blank
Y Blank
Lat 42.21722
Long 70.69027
Page VII - 3 add photo site 0042 with data:
Green 12350
Red 46076
X blank
Y blank
Lat 42.10388
Long 70.54444

~~Appendix VIII Replace drawing with drawing number 45920-1 Revision 2~~

Appendix IV Drawing 45920-6, the longitude values should read 70° vice 72°

~~Appendix X Replace drawing with drawing number 45920-4 Revision 1.~~

R1229

RAYTHEON

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REPORT

MASSACHUSETTS COASTAL MINERAL INVENTORY SURVEY

Conducted under contract with:

Division of Mineral Resources
Department of Natural Resources
The Commonwealth of Massachusetts
Boston, Massachusetts

Report prepared by: [signature]
C.F. Willett
Program Manager
7/31/72

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1.0 INTRODUCTION

The Commonwealth of Massachusetts faces a critical problem regarding its reserves of sand and gravel. These materials, essential in highway construction and in almost every aspect of commercial and private development, are in extremely short supply. The principal sources, currently found in New Hampshire, are now limited due to depletion and land-use ordances.

With a rapidly growing demand and an increasingly restricted supply of an ingredient essential to the well-being of the people, the Commonwealth of Massachusetts has been forced to look towards sea-bed aggregates to satisfy future needs. However, since mining of marine sediments may have harmful effects on the marine ecological balance, and may result in damage to beach property, a moratorium has been placed on all commercial dredging operations in Commonwealth waters. Assessment of the ecological damage is currently under way[1]. The survey described in this report was undertaken to establish if, in fact, exploitable aggregate resources exist in Massachusetts waters. A positive answer to these studies will have implications for sound development of the economy for the Commonwealth.

In October of 1971, the Commonwealth of Massachusetts advertised for proposals to conduct a mineral inventory survey off the coast of Massachusetts. In December, Raytheon Company's Ocean Systems Center responded with a comprehensive proposal designed to answer the Commonwealth's need for information concerning offshore geology. This program was designed to first, conduct a reconnaissance survey of the entire area from Cape Ann to Brant Rock (generally between the 40 foot and 150 foot contours to ascertain the general geologic conditions offshore). From this reconnaissance, detailed survey and physical sampling operations were planned to delineate potential areas of economic aggregate deposits.

Over 500 line miles of acoustic surveys were accomplished along with one or more cores at 45 sites, grab samples at 66 sites and 103 bottom photographs. Analysis of the acoustic

[1] Project "NOMES"- The National Off-Shore Mining Environment Study in Massachusetts Bay.

records, samples, and photos commenced during the second phase of the survey and continued into the third-phase report. The results of these analyses form the basis of information presented in the various maps and tables of this report. These efforts resulted in the identification of over 110 million cubic yards of deposits which display characteristics of economical aggregates. However, their exploitation will require further detailed study before major financial commitments can be made.

Recognition must be given to Mr. Robert Blumberg, Director of the Division of Mineral Resources, for his leadership and insight in guiding this program. Mr. R. Wilkins, Head Administrative Assistant; and Mr. J. Jackimovicz, Geologist; of the same office, acted as Commonwealth Program Manager and Assistant, respectively, and were of invaluable assistance in all phases of the operational and analysis effort. Their willingness to make on-the-spot decisions guiding program direction was greatly appreciated. David Bell and Dr. David Cook of Raytheon Company provided outstanding assistance in carrying out the geological aspects of the survey operations and analysis effort. Dr. J.S. Schlee and Dr. R.N. Oldale, USGS, Woods Hole, spent numerous evening hours assisting in the evaluation of Phase I acoustic records and the planning of the sampling and survey efforts of Phase II. Without their assistance and sage advice this survey effort would certainly not have been so complete or successful in delineating appreciable amounts of aggregate.

The survey program was carried out by the following personnel:

- C. F. Willett, Program Manager, Raytheon Co.
- Dr. D. O. Cook, Geologist, Raytheon Co.
- D. L. Bell, Geologist, Raytheon Co.
- L. C. Britton, Survey Engineer, Raytheon Co.
- S. Sternberg, Survey Technician, Raytheon Co.
- B. Brasher, Navigation Party Chief, Lorac Service Corp.
- J. Kotsolis, Corer Operator, Alpine Geophysical Assoc.
- W. Wood, Photo Team Leader, Sea Tech, Inc.,
- W. Van Horn, Master of M/V ATLANTIC TWIN
- D. Phipps and J. Phipps, Alternate Masters, M/V PHIPPS

The untiring efforts and complete professional preparedness of all these people are responsible for the quality and quantity of this survey.

2.0 BACKGROUND

For some time the Commonwealth has been aware of the shortage of hard aggregates on shore in Massachusetts and of the desirability of developing offshore resources. The shortage or depletion is due in large part to local governmental restrictions or denials of permission to develop aggregate resources within their jurisdiction. No indication is evident that this attitude will change inasmuch as land values are higher (therefore of higher tax value) as residential or commercial property than when used as an aggregate borrow area. Thus, producers are being forced to go even further from the metropolitan areas, which are the prime requirement areas, for resources. Present low-cost sources are forecasted to be completely depleted in 10 to 15 years.

The marine geology of the area designated in the specification could not be considered as undefined. Various aspects of the offshore Massachusetts geology have been investigated by the U.S. Geological Survey, the Woods Hole Oceanographic Institute, U.S. Army Coastal Engineering Research Center and others. Voluminous background material existed as potential information sources. Although some sub-bottom profiling had been undertaken, efforts thus far have centered on broad-scale investigations of regional geology.

Recently, the Commonwealth declared a complete moratorium on all offshore mineral recovery until a complete study of the resources and the effects of recovery could be conducted. This survey was the first phase required by this action in that potential resource deposits have been identified and grossly depicted. The follow-on phases will, out of necessity, be a detailed study of these potential deposits as to specific content and the impact of recovery on the marine environment.

3.0 OPERATIONS

Operations were divided into two distinct phases. Phase I was planned and carried out as an acoustical reconnaissance operation from which an optimum allocation of resource could be made for Phase II.

3.1 Subsystem Descriptions

Acoustic operations were carried out from on board the motor vessel WALTER E. PHIPPS, a 60-foot steel hulled vessel with 16 1/2-foot beam and 6-foot draft. Acoustic systems installed on board the PHIPPS and utilized during both Phases I and II were:

- The Boomer System—consisted of an EG&G Uniboom sound source transducer and capacitance energy source, Raytheon receiving system and model PFR 196B dry paper 19" graphic recorder and an EG&G hydrophone streamer. The system was operated at a 300 watt=second level providing an acoustic signal of 0.4 millisecond duration with a frequency spectrum of 500 to 10,000 Hz. The unique electromechanical design of the Uniboom transducer eliminates the strong cavitation or ringing pulse associated with standard boomers and sparkers. This, combined with the broad frequency spectrum, permits the high degree of resolution and penetration characterized by the records of this survey. Figure 3-1 depicts the boomer system transducer and recorder in operation.
- The Side Scan System—was an EG&G Mark 1A side-scan sonar system which consisted of a dual-channel graphic recorder, a towfish and associated cables. This system transmits short 105 kHz bursts of sound in fan-shaped beams which are 1° wide and 40° high to each side of the towed fish. The sound pulses, reflected from the bottom terrain, are received, processed, and continuously recorded graphically to display their lateral displacement from the towfish. As the vessel proceeds, a plan view of the area covered is produced on the chart. During this survey, the side scan sonar was operated on the scale which afforded a 500-foot wide search area to either side with the sonar transmitting a signal every 1/5 second. The recorder presents a graphic record 5 inches wide for each side and affords range resolution of 2 feet at the 500' scale of operation. The side-scan recorder on board the PHIPPS is shown in Figure 3-2.
- The Precision Echo Sounder—was a Raytheon (model DE-719) precision survey fathometer. This unit transmitted a 6° wide beam of a 200 kHz signal and afforded depth determination on the graphic recorder within ±0.25% of full-scale depth. The unit has controls to adjust motor speed, signal delay, and zero calibration to afford the accuracy in assumed standard sea water with a sound speed of 4800 feet per second.

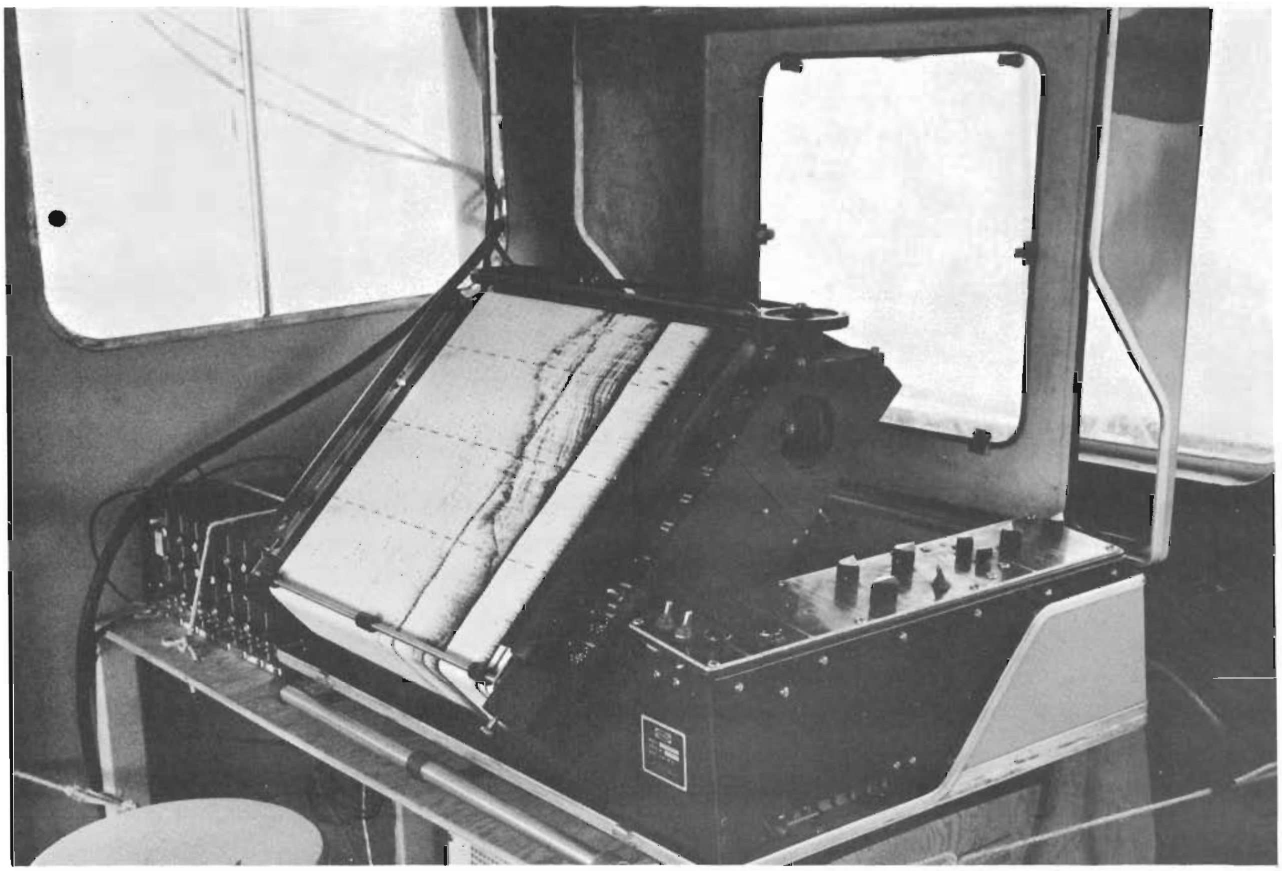

Figure 3-1. Boomer System On Board M/V PHIPPS

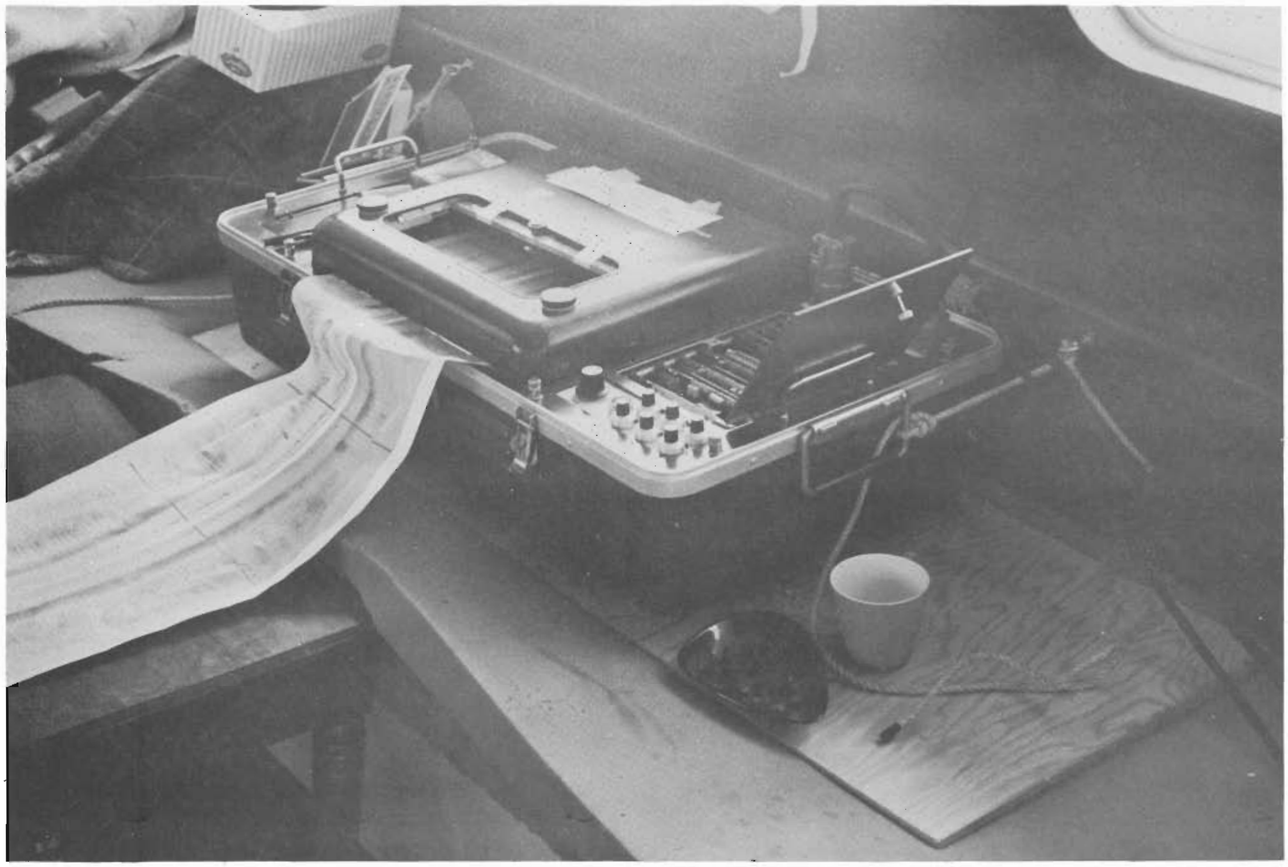

Figure 3-2. Side Scan Recorder On Board M/V PHIPPS

The coring program was carried out from on board the M/V ATLANTIC TWIN, a 90'-long twin hulled motor vessel with a 28-foot beam and 6 1/2-foot draft. The vessel was equipped with a hydraulic crane and was further modified to handle the Alpine "Vibracore." Grab sampling and bottom photography were accomplished from the M/V PHIPPS, in conjunction with the acoustic data collection.

The Alpine "Vibracore" is a bottom resting vibrating corer which utilizes a pneumatic impacting piston vibrator on top of a core pipe fitted with a 3 1/2" I.D. plastic liner. The vibrator and core pipe are supported and guided by a vertical H-beam supported on the sea bed by 4 legs. The unit is 46 feet in height and is capable of obtaining a 40-foot core sample. The working weight of the unit is 4000 pounds and requires as much as a 30-ton pullout force to retract the 40-foot core from some sediment structures.

When driving the core pipe into the bottom, a point of refusal may be reached (or the core cutter may clog with the sample) and although further downward progress may be achieved, no additional sample enters the pipe. This limitation is overcome by a combination of vibration sampling and jetting. Here, vibration sampling is performed until refusal; at which time, the corer is returned to the surface; the partially filled core liner removed and a new one fitted. On the second run, a jet pump which is mounted on the guide is used to jet the corer to previous refusal depth, than jetting is shut down and vibrating done until either refusal or a full core is achieved. This process can be repeated as often as needed. Figures 3-3 and 3-4 show the ATLANTIC TWIN with the corer on board.

The Shipek Grab Sampler was used on the PHIPPS. Basically, this sampler is composed of 2 concentric half cylinders. The inner semi-cylinder, or sample bucket, is rotated at high torque by 2 helically wound springs. Upon contact with the bottom, it is automatically triggered by inertia. The sample bucket then rotates 180° and is held closed by residual spring pressure. The unit, equipped with the side closure, prevents washout. Figure 3-5 shows the sampler in use on board the PHIPPS.

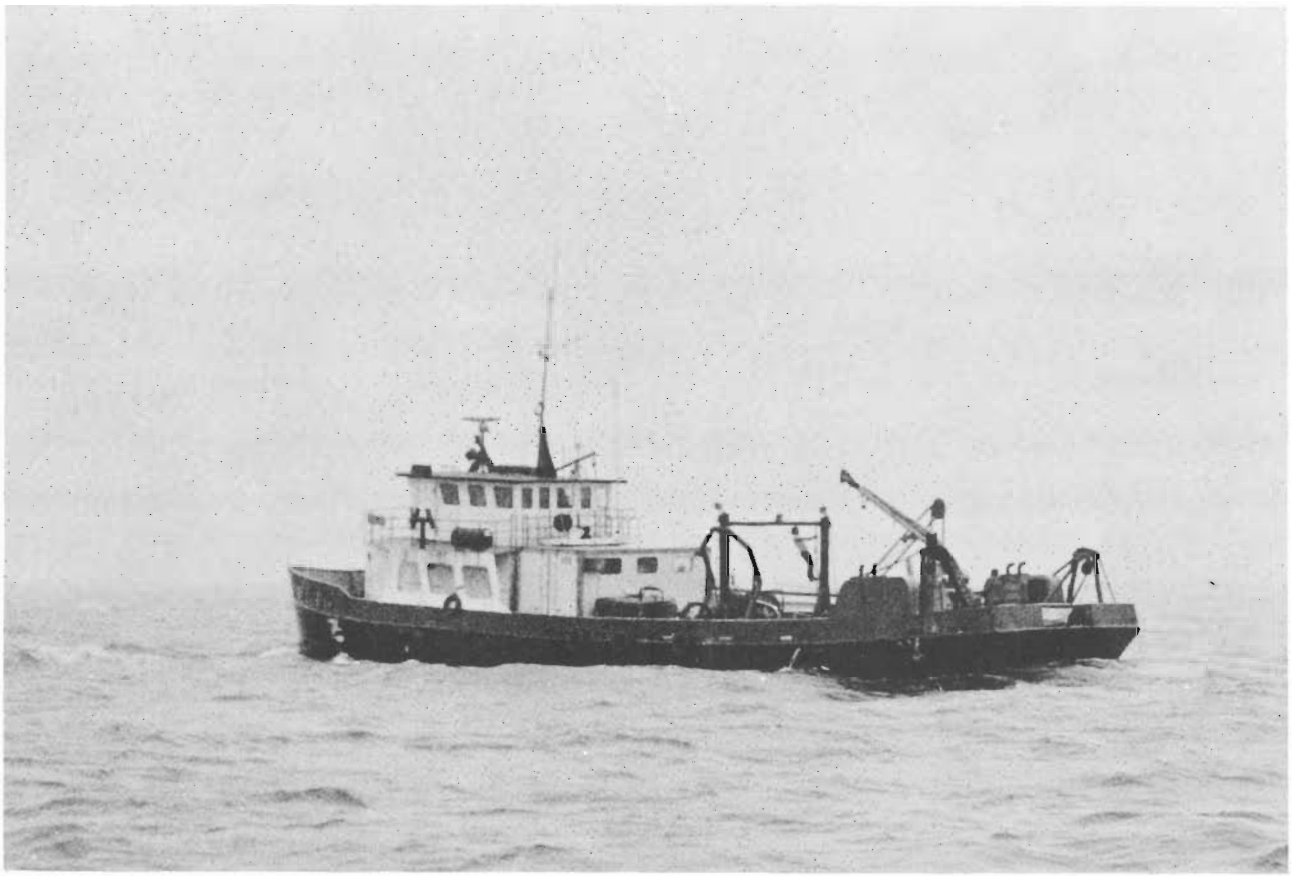

Figure 3-3. M/V ATLANTIC TWIN with Corer On Board

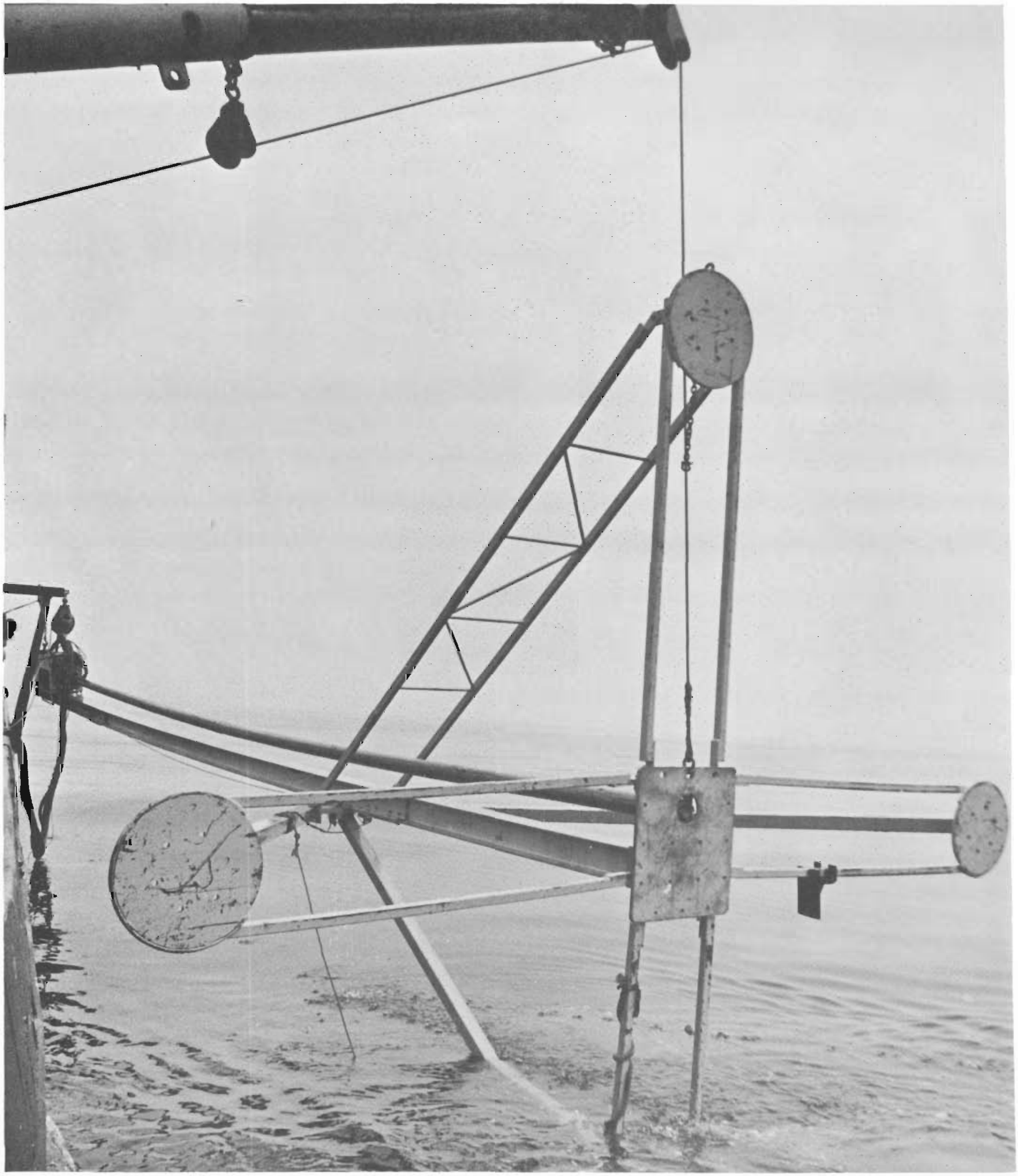

Figure 3-4. Alpine "Vibracore" Corer Being Hoisted On Board M/V ATLANTIC TWIN

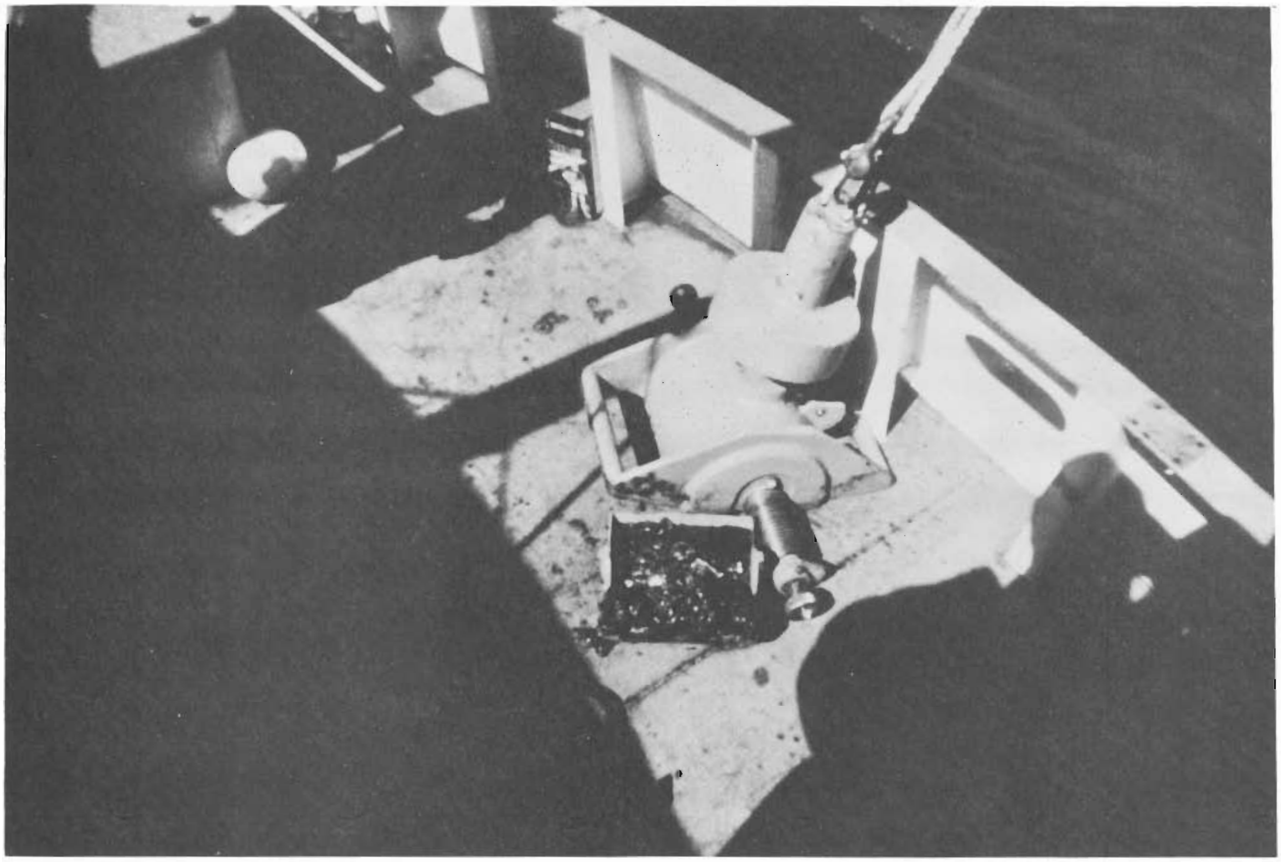

Figure 3-5. Shipek Sediment Sampler With Sample Obtained

The bottom photography was done under subcontract by Seatech, Inc., Rochester, N.Y., utilizing a highly advanced proprietary technique to obtain very clear photographs of 16" x 24" areas of the sea floor at all grab sites, most core sites, and other selected areas. Figure 3-6 shows the bottom photography equipment.

The LORAC Type "B" Radiolocation System is a compact, solid state, low power hyperbolic system and was used for all position control on this program. The system is comprised of three base stations—one reference station and any number of mobile receiving stations.

LORAC base stations provide continuous wave (cw) signals such that the frequency separation between the center and green stations is a certain frequency and between center and red is another frequency. These heterodyne signals are phase compared with the constant phase reference signal to establish position information at the receiver. The accuracy of any position within the survey area was ±25 feet or better. Figure 3-7 shows the navigation system on board the PHIPPS. Figure 3-8 is a functional diagram of the entire LORAC B system. LORAC is a widely used navigation system owned by Raytheon Company.

3.2 Phase I Planning Procedures

The planning for Phase I was essentially included in the Raytheon proposal.

This plan called for immediate mobilization of the LORAC navigation system with base stations at Rockport, Nahant, and Brant Rock (a reference station at Scituate). The PHIPPS was to be mobilized at Scituate with the LORAC receiver, boomer sub-bottom profiling system, side scan sonar, and precision echo sounder on board.

It was decided that a series of survey lines would be run one mile apart at approximately right angles to the shore line throughout the assigned survey area. The survey area was from Cape Ann Light to Brant Rock, eastward to the 150-foot depth contour and generally inshore to the 40-foot depth contour, and was comprised of approximately 250 line miles.

Figure 3-6. Sea Tech Camera System On Board M/V PHIPPS

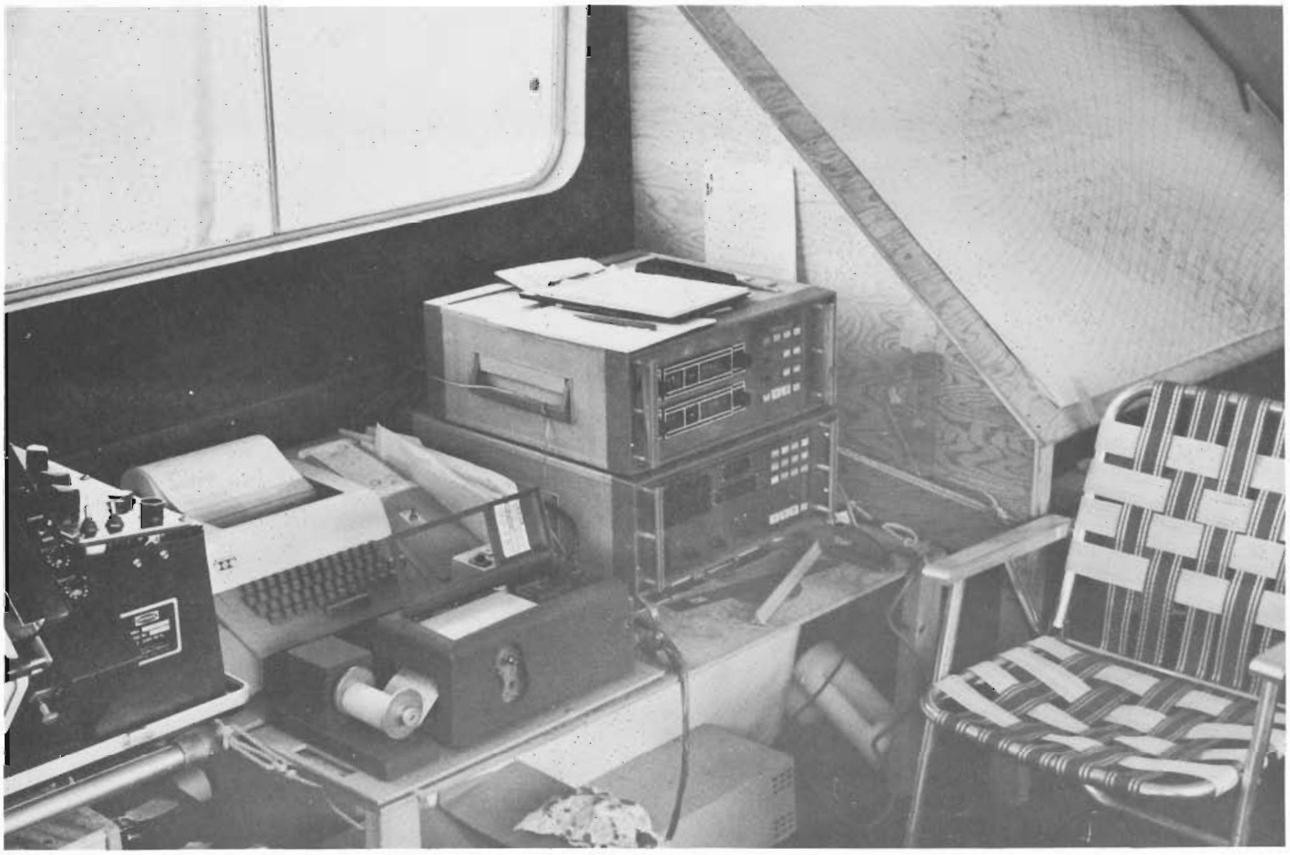

Figure 3-7. LORAC Navigation Receiver Including Digital and Analog Recorders With Plotting Table on M/V PHIPPS

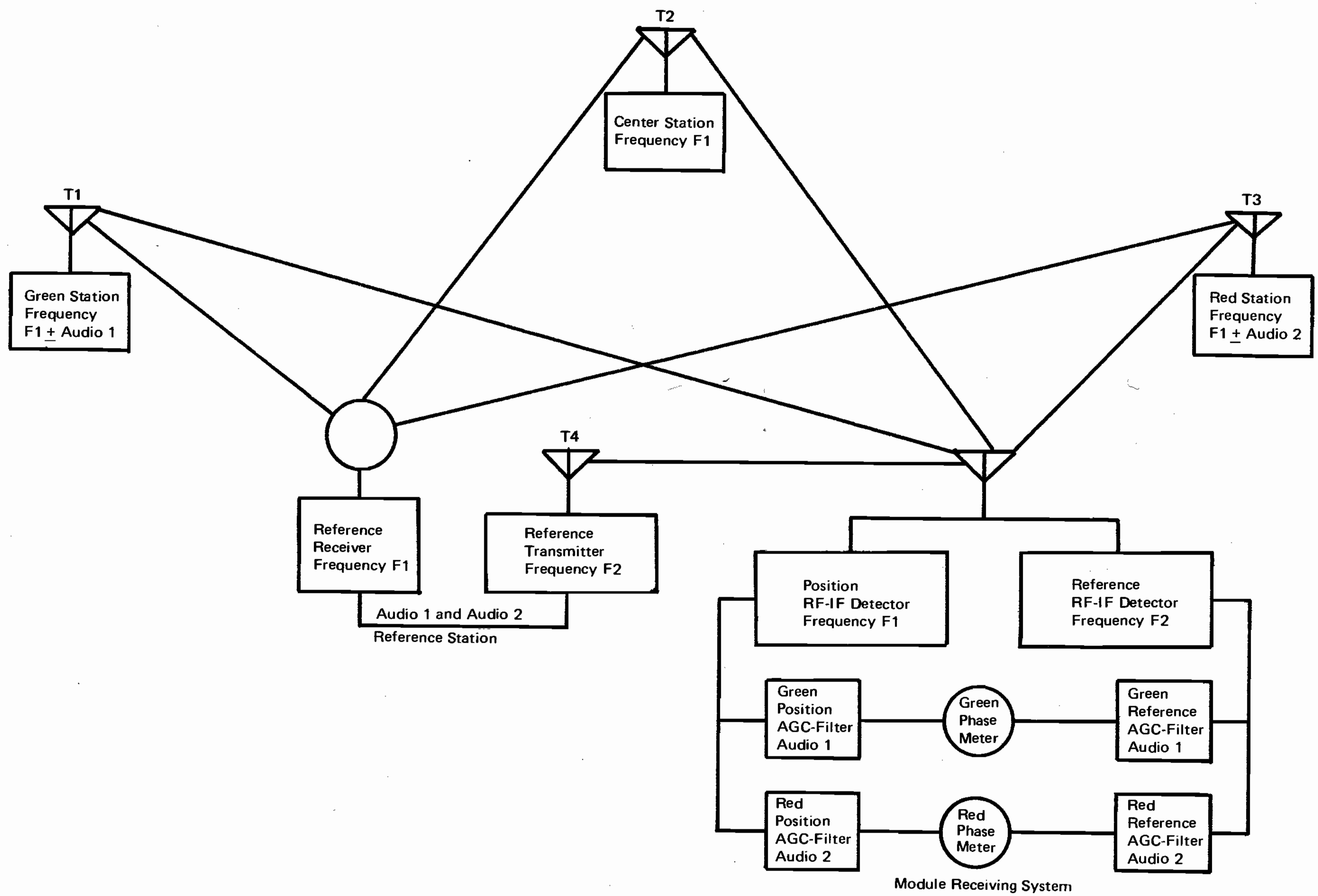

Figure 3-8. LORAC Type "B" System, Functional Block Diagram

All acoustic sensors were to be employed in the running of these survey lines. The side scan was to be operated on a 500 foot (each side) scale, thus affording 1/6 coverage on one mile spacing of survey lines.

3.2.2 Phase I Operations

Phase I operations commenced in advance of formal receipt of the contract in order to permit start up of the survey as per the Commonwealth schedule.

The first effort was the precise location of antenna sites for the three LORAC base stations and a calibration point in Scituate Harbor. This was done by transit and survey tape measurements to existing survey monuments with locations registered by the U.S. Army Corps of Engineers, Waltham. All survey work was completed to fourth-order accuracy standards which were sufficient to support ±25' accuracy throughout the survey area.

With precise geodetic locations established for the navigation system transmitters and calibration point, the network was computer-programmed and plotting sheets were constructed for real-time plotting and control of survey work. On April 28, the mobilization of all acoustic systems onto the M/V PHIPPS and of the navigation system ashore was commenced. All mobilization progressed satisfactorily except for the location of the reference station in Scituate. After considerable effort to arrange a site, numerous objections were received upon arrival of the equipment on site adjacent to the U.S. Coast Guard Station, Scituate. Finally, use of land belonging to St. Mary's Roman Catholic Church was arranged and seemed to be agreeable to all residents of Scituate.

During Phase I, lines were run every mile at right angles to the coast line from Brant Rock to Cape Ann, and generally between the 40' and 150' contours. A cross-tie line was run, generally north—south, across all these lines from Cape Ann to Brant Rock to provide continuity of information. The boomer performed superbly providing excellent resolution of major interfaces at all depths of sub-bottom penetration into the sea floor. The EG&G side-scan sonar produced very vivid pictures of the sea floor with marked delineation between the various sedimentary zones of the bottom. The Raytheon DE-719 precision echo sounder was also operated all during Phase I operations providing an excellent data source for precise bathymetric depiction of the survey area. These data were not to be reduced under this contract, in accordance with the terms of the agreement.

3.3 Phase II Planning Procedures

At the conclusion of Phase I of the Massachusetts offshore sand and gravel inventory, an operating plan for the second phase was generated. Elements of Phase II were to include vibratory coring, grab sampling, bottom photography, and continued acoustical surveying (subbottom profiling and side-scan sonar). Under the flexible framework of the overall program, efforts related to the various elements were to be balanced so that indications of potential sand and gravel deposits, emerging from Phase I, could be explored in the most efficient manner. The Phase I acoustical reconnaissance, previous knowledge of the area, and predetermined planning criteria formed the basis for generating the Phase II operating plan. The survey program was designed so that coring, grab sampling, and bottom photography would commence at the conclusion of the Phase I activity. The ATLANTIC TWIN, was committed solely to vibratory coring, while grab sampling and bottom photography were to be accomplished from the PHIPPS. Subsequently, the PHIPPS was to revert to acoustical surveying. Thus, the selection of bottom sampling and photographic sites was the first Phase II planning task to be addressed.

3.3.1 Bottom Sampling and Photographic Decisions

The purposes of bottom sampling was twofold: 1) to provide a physical interpretation of the acoustical records and 2) to permit assessment of the quality of sand and gravel deposits. It was recognized that coring would be more valuable in achieving such purposes than grab sampling because of the added dimension of depth. Grab sampling was therefore relegated to a supporting role. The role of bottom photography was to document sedimentary conditions and biologic activity at the sea floor.

In the early stages of the program, a series of criteria for selecting coring sites was developed by Raytheon and the Division of Mineral Resources. These criteria were consistent with the aforementioned purposes of bottom sampling. According to the guidelines, cores would be taken where:

- Acoustical information and other sources of data indicated the possible presence of a significant sand and gravel deposit at or near the sea floor.
- It was desired to delineate the boundaries of important deposits or to gain a better understanding of local marine geology.
- Water depth was between 40 to 150 feet, the bottom was within Massachusetts territorial limits, and no active dumping was taking place. Sites deeper than 150 feet were considered unlikely to be commercially exploitable and were not studied.

A meeting between Raytheon and a representative of the Division of Mineral Resources was held on May 6 to delineate initial coring sites. Upon reviewing the Phase I acoustics it became apparent that sand and gravel zones were not readily identifiable, and initial coring efforts should be addressed to the identification of subbottom units. Several coring sites were then delineated in the southern section of the study area in accordance with the selection criteria. Sites were chosen in sedimentary basins which might contain sand and gravel, and at locations where a core would indicate both the identity of sedimentary fill and underlying basement material.

At subsequent meetings held May 8 and 9, the reconnaissance acoustical records from the entire study area were reviewed. A total of 40 core sites was established using a rationale based on the original selection critiera. Again, it was deemed necessary to collect samples before definite correlations between acoustics and subbottom units could be made.

Sixty-two sites for grab sampling were delineated during these meetings. Whereas subbottom profiles were of primary importance in planning coring operations, the side scan sonar records were relied upon heavily to select grab sites. This was because both the side scan sonar and the grabs provide information solely on the surface of the sea floor. An effort was made to distribute the grab sites throughout the entire study area and also to sample the various textural patterns present on side scan sonar records. A knowledge of surficial sediment composition was judged to be of considerable value in assessing the potential value of subbottom layers.

It was also decided at these meetings that the core and grab sites should also serve as locations for bottom photography. This was consistent with the documentary role assigned to phogography in the program.

After the initial Phase II decision-making meetings, data from bottom sampling, photography, and, subsequently, additional acoustics began to accumulate. This information served as a basis for frequency reassessment of the coring sites. Some new core sites were established where grab samples indicated the presence of "clean" sand and gravel, while others deleted where a high silt/clay content seemed probable.

The presence of at least four significant sand and gravel bodies was ascertained mid-way through the coring program. Subsequent coring was than oriented towards delineation of the boundaries of these deposits and to exploration of other areas having similar acoustical signatures.

3.3.2 Acoustic Survey Decisions

Acoustical surveying was scheduled to resume after the M/V PHIPPS had completed the grab sampling and bottom photography. The purpose of Phase II acoustic surveying was: 1) to more precisely delineate the geometry of potential sand and gravel deposits, and 2) to clarify geologic transition areas to gain a better understanding of local geologic history. Both the side scan sonar and subbottom profiling systems were to be employed again in Phase II.

By the time the grab sampling and photographic missions were completed, significant bottom sampling data had accumulated. A knowledge of the locations of major sand and gravel deposits and an understanding of offshore geology were developing. Indications grew that sand and gravel were present only as a surface skin in the southern end of the study area. However, significant deposits seemed to be located in the geologically-complex central region. Sandy surface sediments were widespread in the northern zone, but the sea floor sloped offshore abruptly in this area and the potential for commercial sand and gravel recovery seemed low.

On the basis of these indications, Phase II acoustic surveying was focused on the central portion of the study area. Uncertainty concerning the locations of major sand and gravel deposits in this region and incomplete exploratory bottom sampling precluded the limitation of "fine-grained" acoustical surveying to discrete areas. As a result, it was decided that reconnaissance track lines from line 16 to the low thirties (see map, Appendix VIII) should be filled in with additional parallel lines to achieve quarter-mile line spacing. This course of action was chosen to: 1) provide adequate coverage for delineating the geometry of suspected deposits, 2) insure coverage for deposits not yet discovered in the central region, and 3) generate side scan information for much of the sea floor in the area.

3.4 Phase II—Operations

3.4.1 Coring

Coring operations were conducted from ATLANTIC TWIN carrying a crew of five. The ATLANTIC TWIN was selected as a platform for the Alpine "Vibracore" on the basis of size, deck area, laboratory space, and stability. The 40-foot corer was positioned along the starboard side of the boat with the base resting on deck at the stern and the top suspended from a gallows amidship. Core liners, winches, and air compressor were placed on the after deck. A laboratory used for analyzing cores was located just aft of the cabin on the weather deck. The LORAC navigation system receiving set was placed in the wheelhouse. The scientific party included a Raytheon geologist, a vibracore operator, a LORAC navigator, and a representative of the Division of Mineral Resources.

Several steps were involved in the collection of a core. The coring site which had been delineated during planning activities had to be located. This was accomplished with the use of the LORAC equipment, and the site was marked with a buoy. The corer requires a stable platform, so considerable effort was devoted to anchoring the boat. Anchors were set at the bow and stern of the ATLANTIC TWIN in positions such that wind and tidal currents would keep the boat at the coring site. During the anchoring procedure, the corer was prepared for operation. A new core liner and cutting edge were loaded into the barrel, the penetrometer was calibrated, and the air compressor was started.

Coring operations began when the boat was securely anchored and on station. The base of the corer was lifted over the side of the vessel with a hydraulic crane and lowered until it was suspended vertically from the amidship gallows. The corer was then slowly lowered until it came to rest on the sea floor. At this time, a final position was taken with the LORAC equipment.

Collection of the core itself was begun by starting the vibrator. Progress of the operation was monitored on the penetrometer by the corer operator, the Raytheon geologist, and the state representative. During the survey, an operating policy for the corer was developed. This policy may be summarized as follows:

- Vibration was discontinued after less than one additional foot had been penetrated in 3 to 4 minutes. Continuing longer might have caused the barrel to become stuck or damage the tip.
- Vibration was abandoned after 30 to 35 feet of core penetration. Vibration frequently caused the contents of the corer to expand, and there was concern that the critical uppermost part of the core would be lost through the top.
- If the corer fell over after 0 to 3 feet of penetration, a bedrock bottom was indicated and no further attempts were made.
- In cases where a short core, brought on deck, seemed to contain sand and gravel, an attempt for increased penetration was made. This was accomplished either by jetting to the depth previously obtained, and then vibrating, or again vibrating down from the surface.
- Attempts for greater penetration were not made if sand and gravel failed to be obtained on the first try. The success ratio for repeated attempts was low, as was the likelihood of subsurface sand and gravel being of economic value.

After a core had been collected, the corer was raised to its original position on deck. The core liner was extended, sawed into 5 to 10 foot sections, capped, and labeled. The sections were then brought into the core laboratory for analysis.

In the laboratory each section was laid in a wooden trough and a longitudinal strip, 1 to 1 1/2 inches wide, was cut out of the liners. The contents were then examined, described, and sampled. Principal elements of the description were sediment texture, color, thickness of layers, and any outstanding characteristics such as hardness, reduced zones, or heavy minerals. Sampling was carried out so that economically-promising deposits could be further described by subsequent laboratory analysis. Samples were therefore collected principally from layers of sand and gravel which were substantial in thickness. In some cases, layers containing a mixture of sand and gravel with finer sediments (silt and clay) were sampled with the thought that they might be of marginal economic value.

After the cores had been described, the longitudinal strips were replaced and taped. The cores were sealed, relabeled, and stored. As the core examination proceeded, the ATLANTIC TWIN would retrieve anchors and steam for the next coring site.

Coring operations began on May 7 and terminated on May 24. During this period, 45 coring sites were occupied. Operations had to be suspended after 4 days, principally because of weather. On operating days, cores were retrieved from an average of 3.2 and a maximum of 5 sites. Coring was conducted during daylight hours for an average of 12 hours a day.

3.4.2 Acoustic Operations

All acoustic operations were conducted on board the M/V PHIPPS. The prime area of interest (in the center of the assigned survey area) was surveyed at 1/4 mile spacing running parallel to lines completed during Phase I. Some 500-line miles of survey was conducted during the period of this contract.

The boomer system continued to perform in an excellent manner. The receiver was optimally adjusted to observe depth to bedrock, as required in the original specifications, meanwhile developing the stratifications present near the sea floor. The acquired subbottom records provided excellent subbottom descriptions with depth measurement to bedrock or compacted till as deep as 250 feet below the sea floor.

The side scan sonar continued to develop outstanding records with marked contrast between various areas of differing sediment characteristics on the bottom. The patterns observed on the graphic records were highly indicative of the sediment characteristics and correlated very well with bottom photos and samplings.

The DE-719 precision fathometer was also operated on the PHIPPS during all acoustic survey lines. The records from its operation were not processed but submitted to the Commonwealth as a data bank. These records provide depth measurements which, when corrected for a 6-foot draft and the state of the tide, will afford measurement of precise bathymetry to within $\pm 1/2$ foot.

3.4.3 Bottom Photography

Bottom photography (shown in Figures 3-9 through 3-17) afforded an outstanding opportunity to positively identify the surficial sediments of the sea floor. Photographs were acquired at all but 5 of the grab sample sites, at 24 core sample sites and at 18 other stations, for a total of 103 bottom photographs distributed throughout the survey area.

3.4.4 Shipek Sediment Sampler

The Shipek Sediment Sampler, operated from on board the PHIPPS, was very effective except for the failure of a defective unit which had to be jerry-rigged. With minimal loss of time, the sampler gave continuously reliable service. At numerous sites the samples were small or nonexistent but this was due to the rocky or cobbly bottom; verified in bottom photos.

3.4.5 LORAC Navigation System

The LORAC navigation system proved to be highly reliable and the accuracy was aptly demonstrated on one occasion. Due to material failure the sediment sampler was lost in 120 feet of water with LORAC position reading having been taken as it struck bottom. After the PHIPPS had reoccupied the position by the LORAC reading a diver was sent in and, after only 23 minutes in the water found the sampler with essentially zero visibility due to bottom sediments. Receivers were used on both the ATLANTIC TWIN and PHIPPS and no difficulties were encountered. A few system casualties did occur but, due to the preparedness and hard work of the assigned operating team, no interference with operations resulted.

Figure 3-9. 16" x 24" Area of Bottom at Grab Site No. 50

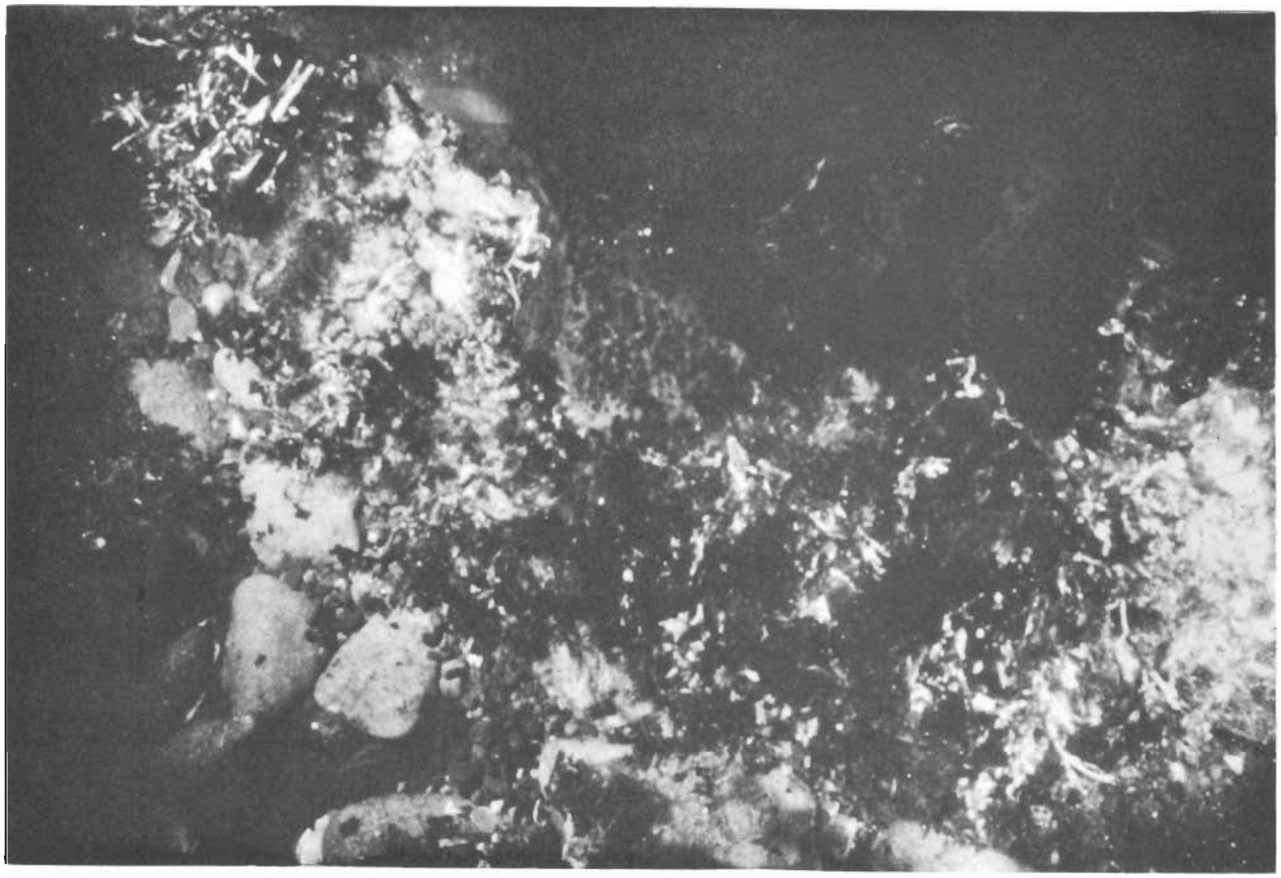

Figure 3-10. 16" x 24" Area of Bottom at Grab Site No. 21

Figure 3-11. 16" x 24" Area of Bottom at Grab Site No. 46

Figure 3-12. 16" x 24" Area of Bottom at Grab Site No. 2

Figure 3-13. 16" x 24" Area of Bottom at Grab Site No. 55

Figure 3-15. 16" x 24" Area of Bottom at Grab Site No. 24

Figure 3-16. 16" x 24" Area of Bottom at Grab Site No. 45

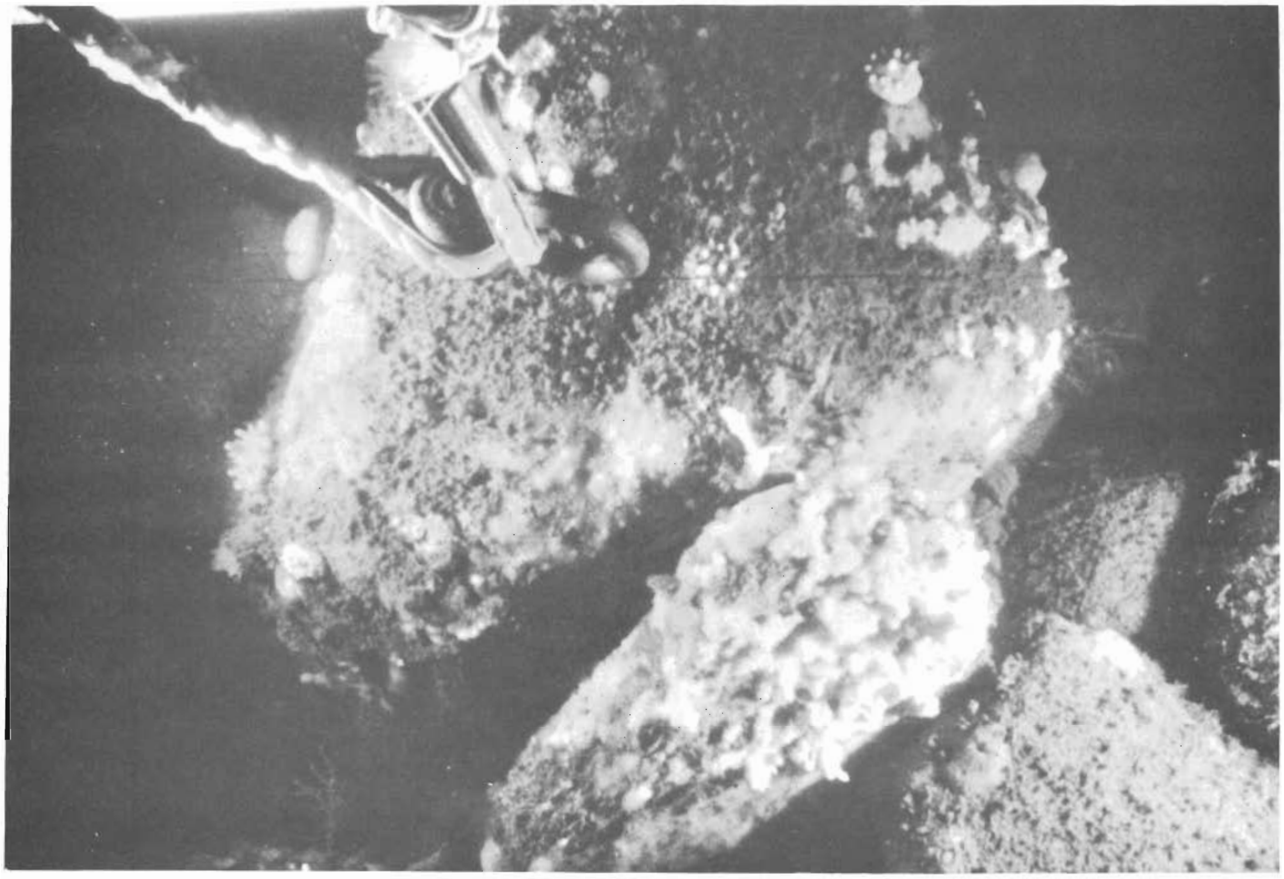

Figure 3-17. 16" x 24" Area of Bottom at Grab Site No. 63

4.0 ANALYSIS

4.1 Isopach Map Development

The development of the isopach map which presents areas of equal information or geology unit thickness, commenced with a thorough examination of the acoustic records in the areas where coring had shown sand and/or gravel. The records were initially examined to ascertain if the sand and gravel occurred consistently in similar morphologic deposits or environments. Examination of the cores and the acoustic records further suggested that the sand and the gravel occurred not as separate and distinct deposits, but generally in an heterogeneous accumulation which commonly had irregular boundaries. Thus, the occurrence of sand and gravel has been mapped as a single unit for presentation in this report.

One other general aspect of this analysis should be pointed out. Specifically, the Holocene reworking of previously deposited offshore tills has produced a thin veneer of sand, gravel, and cobbles over much of the ocean bottom, particularly south of Boston Harbor. This areally extensive veneer, generally less than 2 1/2' thick at any point, made it particularly difficult to determine a "zero-thickness" at the perimeter of sand and gravel accumulations. The dotted lines which appear on Appendix IX, represent a proforma boundary to allow assessment of the local deposits' volumetric contact. Several of these deposits, especially those in the southern half of the survey area, may be interconnected by a veneer of sand and gravel crossing the outcrops of bedrock and/or till which generally bound the sand and gravel accumulations.

Following the initial examination of the acoustic records for general characteristics, the subbottom profiles were re-examined in detail and mylar overlays of both known and potential sand and gravel deposits were constructed. These records were also marked for occurrence of seafloor bedrock and for till outcrops as the location of sand and gravel deposits, sampled by coring, demonstrated a high correlation with proximity to these outcrops.

The lineal occurrence of sand and gravel, together with bedrock and/or till outcrops occurring in the individual acoustic track line records, were then transferred to a base map

It should also be pointed out that only one potentially economic sand and gravel deposit occurred outside the central area. This deposit, number IV, has been contoured on the smaller scale map maintaining the same 3-foot contour interval. To present a comprehensive picture and facilitate direct comparison of various deposit orientation and area extent, all fifteen identified potentially economic sand and gravel accumulations have been presented on drawing number 45920-6 (Appendix X). Other than deposit number IV, which has also been contoured here as it does not appear on the larger scale presentation, only deposit perimeters have been included.

4.2 Surficial Sediment Map

One of the principal intents of the Massachusetts sand and gravel inventory was to develop a map of surficial sediments on the sea floor. This was accomplished using the side scan sonar records, coring data, grab results, and bottom photographs. The first step in generating the map involved the examination of the side scan records and cataloging the various textural patterns encountered. Several patterns occurred which could be differentiated from each other. The distribution of these patterns along the track lines was marked on a base map. The types of bottom materials encountered at the tops of cores, in grab samples, and depicted in bottom photographs were noted at each sampling and photographic site. This enabled the correlation of side scan patterns with bottom sediment types. Six different bottom types could be recognized in the study area: 1) boulders or bedrock with patches of coarse sediment, 2) cobbles with sand and gravel, 3) sand and gravel, 4) sand, 5) silty sand, and 6) a heterogenous mixture of sediments ranging from cobbles to silt or clay. Silt and clay were also occasionally found with types 1, 3, and 4. The final step in creating the map involved drawing in boundaries of the bottom types by referring to the distribution of side scan sonar patterns. The result is shown in Appendix X.

The positions of sand and gravel deposits (as shown on the isopach map) bears a reasonably close, but not perfect, resemblance to the surficial sediment map. This apparent disagreement does not mean that either of the maps is in error. The isopach map is derived from subbottom profiling records on which the uppermost few feet of the bottom are difficult to resolve. The surficial sediment maps are based on side scan records, samples, and photographs which show only the materials exposed on the sea floor. Examination of the core descriptions frequently indicates that surface sediments represent only a thin "skin" superimposed on deposits of a different composition.

A noteworthy phenomenon observed during preparation of the surficial sediment map is that both the corer and the grab sampler tends to sample bottom materials selectively. At many sites, numerous cobbles appearing in photographs were not retained in corresponding grabs or cores. This undoubtedly reflects the fact that cobbles are similar in size to the core barrel or open grab sampler. When the samples were being collected, these larger particles tended to be pushed aside. Thus, the photographs provide the most accurate indication of the appearance of the sea floor.

4.3 Core, Grab, and Photographic Analysis Procedures

At the conclusion of the Phase II field operations, the bottom samples, logs, and photographs were brought back to the lab for analysis. Laboratory operations included:

- a review of core and grab field descriptions
- grain size analysis of core and grab samples
- plotting of vibracore penetration rates
- visual description of individual bottom photographs.

These operations and the results generated are discussed in the following paragraphs.

The water depths recorded with core + grab samples in appendices I + II were approximate depths taken upon approach to each station + were for operational use at the time.

4.3.1 Core Descriptions

The methods by which cores were described in the field have previously been mentioned in the chapter on Phase II operations. These descriptions are presented in Appendix II. A more detailed discussion of the various elements of the core logs is given below.

- Basic information relating to collection of a core is noted at the top of each log sheet. Cores are identified by a number and a letter; the number refers to the site while the letter indicates the attempt at that site. For example, 17C denotes the third coring attempt at site 17. The date of core collection, latitude and logitude, and beginning and end times of corer penetration are listed. The depth of penetration was taken from the penetrometer and does not always coincide with core length because of the effects of vibration on the corer contents. Both consolidation and dilation of the contents were observed, and these phenomena relate to original packing, grain shape, and clay minerology. The observer was the Raytheon geologist who described the core in question.

- The cores were divided into sections or sedimentary units primarily on the basis of sediment texture and in some cases by color. In general, the vertical changes in core texture occurred rather abruptly, and assignment of boundaries to the section was straightforward. Zones exhibiting cyclic variations of thin layers having different textures were usually called a single section and the variability was noted in the description. It is interesting to note that in cases where two cores were taken at the same location, the thicknesses of corresponding sedimentary units were not identical. This phenomenon was probably caused by small-scale areal variations in the depositional or erosional process. Caution should therefore be exercised in extrapolating coring results over large distances.
- The boundaries of sedimentary sections are presented in terms of depth below the sea floor. The section thicknesses were measured directly from the core, and no attempts have been made to correct for consolidation or dilation effects. Depths at which samples were taken are noted with layer boundaries.
- Colors of sedimentary sections were derived from the Geological Society of America's Rock Color Chart. The numbers refer to hue, value, and chroma. Corresponding color names are given in Appendix XII.
- Textures were assigned by visual inspection on the basis of the following grade scale: greater than 2mm = gravel, .08mm—2mm = sand, .002 mm—.08mm = silt, 0—.002mm = clay. If more than one size grade was present, the subsidiary grade is given as an adjective. For example, "sandy gravel" indicates that the section is compared predominantly of gravel with an admixture of sand.
- The comments category on the logs was reserved for further notes on texture and any other noteworthy information about a section. Unusual hardness or softness, presence of hydrogen sulfide, and unusual mineralogic constituants were remarked upon where appropriate.

4.3.2 Grab Descriptions

The grab samples may be considered analogous to the uppermost few inches of a core, and they were described in the same fashion as the cores. The grab descriptions are presented in Appendix III. Basic elements of the descriptions are texture, color, and comments. Colors were taken from the Geological Society of America's Rock Color Chart. Names corresponding to the numerical designations are given in Appendix XII. Textural classifications were based on the standard grade scale: larger than 2mm = gravel, .08mm—2mm = sand, .002—.08mm = silt, and less than .002 mm = clay. If more than one size grade was present, the subsidiary grade was used as a descriptive adjective for the predominant size. As in the core descriptives, comments were made upon further textural details, presence of hydrogen sulfide odor, unusual mineralogical constituants, grain shape, and sample size. A small sample indicates the presence of bedrock, boulders, or cobbles on the sea floor.

4.3.3 Grain Size Analysis of Core and Grab Samples

The sediment samples taken from the cores and the grab samples were subjected to a grain size analysis by sieving. Four sieves were used which had the following screen diameters: 9.5mm, 2.36mm, 0.60mm, and 0.08mm. These correspond to 3/8", #8, #30, and #200 in the ASTM sieve series. Use of these four sieves enables the quantitative determination of the percentages of gravel (2.36—9.5mm), coarse sand (.60—2.36mm), fine sand (.08—.60mm), and silt and/or clay (less than .08mm). Standard sieving procedures were employed and these techniques are given in Appendix XIII.

Results of the sieving analysis are presented in Appendix IV. These data take the form of weight precentages of sediment in the various size grades. The size grades are only reported in terms of grain diameter in order to prevent misconceptions arising from different nomenclatural systems. Note is made in the appendix when analysis procedures deviated from the techniques described.

When interpreting the results of these analysis, it should be noted that sea floor in Massachusetts Bay is quite irregular in many locations. This leads to significant local variations in surface sediment texture.

4.3.4 Bottom Photographs

The bottom photographs were projected on a screen and described by a Raytheon geologist. Particular emphasis was placed on sediment texture. For descriptive purposes, the following grade scale was employed: greater than 25cm = boulders, 9—25cm - cobbles, 2mm—9cm = gravel, .08—2mm = sand, and less than .08mm = silt and clay. Biological phenomena such as marine algae, invertebrates, grain encrustations, trails, mounds, and burrows were noted when present.

Descriptions of the photographs are given in Appendix I. Photographs are listed by core site, grab site, and photo site. The latter category resulted from changes in planned coring locations after the photographs had been taken. Thus there are no photographs to accompany some of the latter cores.

4.3.5 Penetrometer Records

It was thought that the rate of corer penetration into the sea floor might provide useful information on civil engineering properties of sediments. For this reason, records from the penetrometer were replotted on graphs to show the number of seconds required for each foot of penetration. In this format, the data are analagous to "blows per foot"; a common engineering term for describing certain dynamic properties of soil. The graphs of penetration rate are given in Appendix VI.

4.4 Navigational Data

Appendix VIII (Navigational Plot Sheet) contains all the navigation information from the various survey sensors and samplers. All the track lines are plotted by line number with the clock times noted on positions recorded every three minutes. All physical sample and bottom photograph positions are also plotted so that they can be related to appropriate acoustic records. All plotting on this sheet was done in accordance with national map accuracy standards resulting in ± 80-foot accuracy.

Appendix VII (Sample and Photo Positions) contains precise positions of all sample and bottom photograph sites to an accuracy of ± 25 feet. Original records of the digital recording of navigational information, which will be delivered to Commonwealth along with all acoustic records, provide LORAC coordinates of all navigational data to ± 25 feet. These data can be converted to geographic positions at any future date. Due to an error in LORAC operational procedures which was later corrected, the positions of all sample positions north of 48° - 25.15' N, phase I survey lines 27 through 45 + phase II survey lines 233 - 241 are accurate approximately ± 100 ft.

5.0 RESULTS

5.1 Marine Geology

The acoustic and bottom sampling data generated by the sand and gravel inventory can be used to evaluate the marine geology of the nearshore region in Massachusetts Bay. While the principal purpose of the inventory was to investigate the characteristics of sand and gravel deposits, the distribution of other types of sediments and geologic formations was ascertained. An understanding of the overall geologic composition of the study area is valuable from an academic standpoint and can also be used to gain further insight into the sand and gravel bodies.

The principal types of geologic units which occur in the study area and their probable origin can be described as follows:

- Bedrock consists of crystalline Pre-Cambrian and Paleozoic formations in the northern and southern portions of the study area and Paleozoic sedimentary rocks in the region off Boston Harbor. Bedrock crops out frequently offshore, particularly in the northern and southern sections. Its composition is extrapolated from onshore geology and the acoustic signature.
- During the Pleistocene, continental glaciers advanced through the region at least twice, extending to and possibly beyond the Cape Cod—Georges Bank area. A heterogenous deposit of boulders, gravel, sand, silt, and clay categorized as glacial till was laid down beneath the glacier as a ground moraine. The ground moraine had a hummocky surface and did not completely cover the pre-existing bedrock. Separate episodes of glacial advance caused at least two till units to be superimposed on each other in some regions. At the present time, till occurs in the southern and particularly the central parts of the study area.
- The nearshore portion of Massachusetts Bay underwent two cycles of valley cutting and filling during the Pleistocene. A series of large valleys up to 3500 yards wide and 300 feet below present-day sea level were cut into the unconsolidated till. These were either cut by rivers issuing from the glacier during an episode of retreat or by the scouring action of the ice as the glacier advanced. The axis of these valleys as depressions was northwest-southeast. Subsequently, the region was submerged beneath the ocean and the former valleys were filled with interbedded glaciomarine silts and clays. Emergence then took place and the filled valleys were partially

re-excavated during a period of less intense subaerial erosion. Another submergence led to a deposition of more uniform glaciomarine silty clays in the second generation of valleys. Because these periods of glaciomarine deposition occurred during inter-glacial periods, they are partially covered by a layer of till laid down as the glacier re-occupied the area.

- After (or possibly concurrent with) the final retreat of the glacier from Massachusetts Bay, the region was submerged beneath the sea. A new cycle of glaciomarine silty clay deposition occurred and depressions in the sea floor were filled with this uniform sediment.

- This submergence was followed by temporary emergence caused by isostatic rebound of the earth's crust. It is generally recognized by geologists that the sea fell approximately 70 feet below the present level. Till in the central and southern portions of the study area was reworked by shoreline and nearshore processes, resulting in the deposition of nearshore marine sand and gravel. The sand and gravel was laid down in thin, areally extensive, sheets located 70 to 100 feet below present sea level. These deposits will be discussed in depth later in the text.

- The rise of sea level to its present position has subjected nearshore Massachusetts Bay to continuing marine reworking. This caused the previously more continuous sand and gravel sheets to become separated and irregular in configuration. The reworking has also distributed a surface "skin" of reworked marine sand and gravel over much of the central and southern portions of the study area.

- Subaerial erosion and wave attack on land have been contributing sediments offshore since sea level rose to its present position. In the northern portion of the study area, a continuous sheet of nearshore marine silty sand has extended outward from the coast. Marine silts and clays, largely organic in composition, are being contributed to inshore parts of the central study area from Boston Harbor. This influx of modern fine sedimentation is exagerated by dumping practices.

In summary, eight geologic units can be recognized in the nearshore region of Massachusetts Bay. These are listed as follows:

Geologic Age	Unit
Holocene	marine silts and clays
Holocene	nearshore marine silty sand
Holocene	reworked marine sand and gravel
Holocene	nearshore marine sand and gravel
Pleistocene	glaciomarine silty clay
Pleistocene	glaciomarine silts and clays
Pleistocene	glacial till
Pre-Cambrian, Paleozoic	crystalline and sedimentary bedrock

The regional marine geology of nearshore Massachusetts Bay is illustrated by six acoustical cross-sections shown in Appendix XI. These cross-sections represent east-west subbottom profiling lines 8, 15, 21, 26, 34, and 41, which were chosen because they typify the geology of the northern, central and southern portions of the study area. In constructing the cross-sections, subsurface acoustical reflectors have been traced and multiple reflections were omitted. The results show geologic units below the sea floor in a more readily-interpreted format than the original records.

The typical cross-sections may be discussed as follows:

- Line 8—The bedrock which is so prevalent in the southern part of the study area crops out along much of this transect. The most extensive outcrop extends from 1817.5 to 1753.7. Depressions in the bedrock surface are filled with glacial till. A thin veneer of sand and gravel covers both bedrock and till at the sea floor.
- Line 15—Irregularities on the bottom are caused by outcroppings of bedrock and possibly till. Two episodes of glaciomarine silty clay deposition have filled the depression between 0821 and 0827. Coarse sediment on the sea floor has resulted from reworking of glacial till.
- Line 21—The most prominent feature along this transect is the large system of depressions at the outer end filled with glaciomarine sediment. It can be seen that the lowest fill deposit has been truncated, apparently by subaerial erosion. These former stream valleys were in turn buried by sedimentation. Either bedrock or till crops out at the sea floor along much of the shoreward end. Fine sand resulting from marine reworking of glacial deposits extends to a depth of several feet over the sediment filled basins. Elsewhere, a thin veneer of coarser reworked sediment partially covers the surface.
- Line 26—Several sediment-filled depressions are interspersed with outcrops of bedrock or, more probably, till. The outermost depression is filled with interbedded glaciomarine silts and clays. The depression between 1251 and 1306 appears to contain glaciomarine silty clay overlying glacial till. Both reworked coarse sediment and fine sand contributed from shore-based sources compose the surficial veneer.
- Line 34—The irregular surface of the strong basement reflector which crops out occasionally suggests that it is crystalline bedrock reappearing in the northern portion of the study area. Depressions in the bedrock are filled with fine glaciomarine sediment. A thin sheet of silty sand has prograded out from the modern shoreline and covered most of the sea floor.
- Line 41—This line is short because the bottom slopes steeply offshore. Crystalline bedrock crops out near shore and then has been eroded to create two depressions which contain fine glaciomarine deposits. Modern silty sand blankets the glaciomarine material.

5.2 Existing Economic Deposits

The reconnaissance survey and subsequent analysis has resulted in the identification of fifteen areas of potentially economic sand and gravel which are identified in Appendix IX by roman numerals. These numbers indicate an approximate economic ordering based upon volumetric extent, aggregate composition, and general logistic considerations.

Numbering is not intended to be a final ranking as many other factors must be considered in arriving at this decision. Additionally, there is the very real need to do extensive local developmental coring and additional acoustic profiling to definitively ascertain each deposit's economic value. For presentation, deposits have been divided into three groups based primarily upon the amount of deposit definition possible using the available acoustical and physical data.

Five deposits have been identified which contain appreciable quantities of aggregate. These deposits have been determined based upon their occurrence on several parallel acoustic profiling tracklines and multiple core site samplings within each deposit. These accumulations have individual areal extents which may approach fifteen million (15×10^6) square yards and local thicknesses in excess of 30 feet.

The second series of seven deposits have been identified based on acoustic characteristics and similarity to those deposits substantiated by physical (core) samples. These accumulations, like the five major deposits, are indicated by dashed lines enclosing irregular shaped bodies. The areal extent of these latter deposits is generally slightly smaller than those of the first category. Maximum area, however, approaches eight million (8×10^6) square yards. As there were no cores taken in this series of deposits, it was not deemed advisable to attempt thickness and volumetric determinations. However, based upon the acoustic profiles acquired, thicknesses of these deposits do not exceed twenty feet.

The last series of three potential deposits is indicated by closed geometric shapes. While the existence of sand and gravel in these areas is uncertain, geographic areas have been indicated. As a class, these deposits are characteristically smaller in areal extent averaging two million (2×10^6) square yards and appear to be much thinner (i.e., less than fifteen feet).

Geographically, all the identified deposits except one are located in the area directly seaward of Boston Harbor essentially lying between the 10 and 20 fathom depth contours. Significantly, twelve of the fifteen identified potential deposits of sand and gravel occur between latitudes 42° 17' N and 42° 27' N.

A word of caution must be injected at this point as, in almost all cases, these assessments are based on a very limited number of cores from each individual area. Caution must also be exercised in extending the areal extent of these deposits which generally are less than six feet thick over extensive areas. This is especially true in the offshore Boston Harbor area where recurrent glaciation and till deposition have been followed by multiple stands of sea level allowing substantial reworking and redistribution of deposited sediments. These factors must be remembered in examining the potential deposits presented in Appendix IX. Additional coring and profiling is essential to accurately deliniate the described deposits.

Within the first class of five deposits, care must be used in evaluating areas III, IV, and V. Specifically, though both cores and the acoustic records indicate thicknesses in excess of twelve feet, these deposits are essentially local concentrations of the more extensive veneer covering much of the southern portions of the study area. Additionally, while individual layers can be tracked outward from the core sites, the complex glaciomarine deposition history of these nearshore areas provides substantial reason to suspect lateral grading within the identified units. Thus, there is a strong requirement for more detailed acoustical and physical sampling to define those potential deposits identified in this reconnaissance survey.

The five primary areas of potential sand and gravel occurrence presented in Appendix IX are discussed below:

I. (30.5 MM yds^3)—The deposit, which trends generally NW-SE, is approximately 4500 yards long by 1500 yards wide, and has an average depth of 14 feet. It is the second largest deposit of sand and gravel identified during the investigation and is centered at 42° 22' N, 70° 47° W. Based on the core data, surface sediments within the irregularly shaped boundary consist primarily of sandy gravel which extend to depths in excess of 30 feet. Within the deposit, a layer of medium sand up to three feet in thickness may locally cover the sandy gravel accumulations. As displayed, two subareas having sandy gravel in excess of 15 feet; occur one in the north-central and the second in the southern portion of this deposit. The deposit itself appears to sit above the level of the general bathymetry and may represent a residual glacial feature. Cores 34 and 39 are from within this deposit.

II. (27.3 MM yds^3)—This deposit, which trends more WNW-ESE, is approximately 6500 yards long by 1500 yards wide and has an average depth of 8 feet. It is centered at 42°18' N, 70°43' W. Based on the five cores (numbers 14, 15, 32, 36 and 37) which sampled this deposit, the material of this second surface deposit consists principally of gravelly sands which reach thicknesses of 20.5 feet. Over portions of the area, however, the gravelly sands are covered by a two to three foot thick veneer of fine to medium sand. Both the overlying sand and the underlying gravelly sand have been mapped as one unit. Additionally, there are four places within the confines of this deposit where seafloor outcrops of till and/or bedrock occur. These are depicted as hatchered areas.

III. (10.6 MM yds^3)—The third area which appears to contain a significant accumulation of aggregate is a very irregular shaped deposit, again of general NW-SE orientation. Its rough demensions are 6000 yards long by 1200 yards wide and has an average depth of roughly 4 feet. The deposit is centered at 42°24' N, 70°47' N. Four cores (numbers 24, 27, 28 and 45) were taken within the boundary of this deposit. The cores from area III sampled the greatest variability of sediment within any one deposit being primarily sandy gravel and sands in the north and apparently grading into finer material; fine to medium sands in deeper water. This is particularly evident in the lobate feature which forms the southeastern portion of this deposit. Acoustic records from this area maintain the general characteristics of the deposit farther north, however, core number 27 from within this subfeature indicates a fine sand overlying silts and clays. As the deposit is bounded by numerous seafloor outcrops of bed rock and till, these features probably both control its areal expression and have contributed the sediments, respectively. It should also be noted that this deposit does not anywhere attain even moderate thicknesses and probably should be considered more as an area of local thickening of the extensive sand and gravel veneer previously discussed.

IV. (35.2 MM yds^3)—The fourth deposit which maintains the NW-SE orientation of the previous deposits is approximately 7000 yards long by 2400 yards wide and has an average thickness of 7 feet. This deposit which is centered at 42° 07.5' N, 70°34' W contains the largest computed quantity of potential aggregate. Within the deposit bounds, three cores (numbers 1, 2 and 4) were obtained. As in area III, a rather high degree of variability was observed in these samples which were all situated along the southwestern perimeter of the deposit. The areal extent has been determined primarily by acoustic records and the possibility thus exists that while the individual layers can be traced throughout the deposit, sediments may grade into finer material to seaward.

The cores indicated sandy gravel in the thicker central area with gravelly sands occurring at both the NW and SE extremities. Core #2 also indicated a four foot thick zone of fine-to-medium sand overlying the central area sandy gravels. Maximum thicknesses measured from the acoustic records locally reach fifteen feet with the sand, gravelly sand, and sandy gravel all plotted as a single unit.

V. (11.1 MM yds^3)—The last of the five major areas of potential sand and gravel reserves is centered at 42°18', 70°49'W. Again displaying the general NW-SE orientation of the majority of the identifiable areas, the deposit is roughly 4500 yds long by 1400 yds wide and 4 1/2 to 5 feet in average thickness. The deposit itself is very similar to III. The acoustic profiles show a hummocky underlying surface of till covered bedrock with a large outcrop occurring on the seafloor in the north central portion of this deposit. For this reason and because the one core (number 2) indicated only 3 to 3 1/2 feet of gravelly sand underlying an eighteen inch thick fine sand veneer, the deposit is considered marginal. The deposit has been included, as one of the first class of five, primarily based upon the acoustic records which indicate increased thicknesses of the gravelly sand member to the south and southeast of the core location.

APPENDIX I

DESCRIPTIONS OF BOTTOM PHOTOGRAPHS

Grab Sta. Number	Description
1	The photograph is cloudy and difficult to interpret. The bottom appears to consist of fine sand or silt with an admixture of gravel particles 1—3 cm in diameter. This apparent gravel could also represent a biological overgrowth.
2	Most of the photograph shows clean gravel 1—5 cm in diameter. Three well-rounded cobbles with a diameter of 12 to 18 cm are present at one side. Broken pelecypod (clam) shells are also in evidence.
3	The bottom at this site consists of medium sand with oscillation ripple marks. The ripples have a wavelength of 6 to 12 cm.
4	The sea floor is covered with well-rounded gravel 3 to 8 cm in diameter. Fine gravel fills the interstices. The surfaces of the gravel particles are partially covered with biological growth, and two echinoids (sea urchins) are present.
5	Sediment in this area is well-rounded medium gravel 3 to 5 cm in diameter. The bottom is partially obscured by attached brown algae, and echinoderm (starfish) can be seen.
6	The photographs from this site are cloudy and difficult to interpret. The sea floor seems to consist of fine sand or silt partially covered with a biological overgrowth.
7	Large boulders or a bedrock outcropping appear in this picture. The rock in question is gray in color and does not appear to be stratified. Gravel is present in the interstices, and attached algae is abundant.
8	The photo is cloudy, but a gravel and cobble bottom is evident. The particles are well rounded and have diameters of 5 to 15 cm. The cloudiness suggests that silt or clay may occupy the interstices.
9	It is difficult to interpret this photograph because of suspended sediment. The bottom seems to consist of homogeneous fine sand or silt.
10	Bottom sediment ranges in size from fine gravel to 10 cm coarse gravel which is well rounded. The gravel appears to be relatively free of finer material.
11	A large boulder, 25 cm in diameter and partially encrusted with biological matter, occupies the center of this photo. It is surrounded by sediments ranging in size from cobbles to fine gravel.

Grab Sta. Number	Description
12	A few cobbles, 9–12 cm in diameter, are partially buried in what appears to be coarse sand. The sand seems to exhibit faint ripple marks.
13	The picture is partially obscured by a cloud of suspended sediment, but a bottom containing coarse (up to 8 cm dia.) to fine gravel can be distinguished. Silt or clay probably forms a matrix in which the coarser material is lodged.
14	Bottom sediment seems to consist of relatively homogeneous silt. Numerous dark spots may be related to biological activity.
15	Silt appears to be predominant at this bottom site. Dark blotches in the photo may represent partially buried gravel, but probably reflect biological activity.
16	Sediments in this photograph range in size from 12 cm cobbles to fine gravel. The cobbles are well rounded and are partially encrusted with biological material.
17	Suspended sediment restricts the view of the bottom in this photo. Cobbles seem to be embedded in a mixture of silt or clay.
18	Coarse sediments are in abundance, with material grading in size from 12 cm cobbles to fine gravel. It is uncertain whether sand and silt lie in the interstices.
19	Rounded coarse gravel up to 8 cm in diameter and fine gravel seem to occur in a matrix of finer sediment (probably silt). An echinoderm (starfish) can be seen on a boulder.
20	The photograph is entirely obscured by suspended fine sediment. It is probable that silt or clay composes the sea floor.
21	Part of a large boulder or bedrock outcrop extends over most of the photograph. The rock is heavily encrusted with biological organisms and algae, and is surrounded by cobbles and gravel.
22	Cobbles ranging to 12 cm in diameter occur with gravel in this photograph. The coarse sediments seem to be heavily encrusted with biological material.
23	The photograph shows either bedrock or part of a large boulder. A few cobbles are present, and joints seem to be present in the rock. Heavy biological encrustation covers the entire surface.
24	In this photo, rounded and encrusted cobbles up to 15 cm in diameter lie on fine gravel. The gravel is free of finer sediment.

Grab Sta. Number	Description
25	Coarse sediments occur at this site, ranging in size from fine to coarse (9 cm) gravel. No fine sediment or biological encrustation is in evidence. A small echinoid (starfish) can be seen.
26	Suspended fine sediment obscures the bottom in this photograph. The bottom probably consists principally of silt or clay, although some gravel particles may be present.
27	The sea floor is covered with well-rounded heavily encrusted gravel and cobbles ranging to 15 cm in diameter. Medium gravel lies in the interstices.
28	Large cobbles up to 20 cm diameter cover the bottom with coarse gravel in the interstices. The cobbles are heavily encrusted with biologic growth.
29	In this photograph, the sea floor is difficult to see because of suspended sediment. Bottom material seems to consist of fine sand or silt, and several echinoderms (starfish) can be recognized.
30	The bottom is completely obscured by suspended matter. It is assumed that the sediments at this site are fine-grained (silt or clay).
31	Large fronds of brown algae project upwards from cobbles or an outcrop at the sea floor. The algae is so widespread that little comment can be made on the rocks.
32	Gravel up to 5 cm in diameter is lying on a matrix of fine sand or silt. Numerous pelecypod fragments (broken clam shells) are present.
33	The photograph is cloudy because of suspended sediment, but gravel can be recognized at the sea floor. One or two small cobbles with a diameter of 10—12 cm are present, and an echinoderm (starfish) is in the picture.
34	The bottom consists of cobbles 9 to 12 cm in diameter. These are heavily encrusted with brown and other types of algae.
35	Medium gravel and cobbles with a maximum diameter of 18 cm characterize this site. Both brown algae and broken pelecypod shells can be seen in the photograph.
36	The bottom is covered with cobbles 10 to 18 cm in diameter. The cobbles are heavily encrusted, and some echinoderms (starfish) are present.
37	Gravel which seems to be free of fine sediment forms a matrix in which a few cobbles are lodged. The cobbles are 9 to 12 cm in diameter and are partially encrusted with biologic matter.
38	The sea floor consists of coarse sediment ranging in size from coarse gravel (10 cm) to fine gravel. Brown algae and other biological encrustation is widespread. A large echinoderm (10 legged starfish) appears in the picture.

Grab Sta. Number	Description
39	Sediment at this site is a mixture of gravel (maximum of 5 cm diameter) and coarse sand. Gravel particles are partially encrusted, and a small pelecypod (clam) shell can be seen.
40	Cobbles up to 16 cm in diameter are mixed with gravel at this locale. The sediments are heavily encrusted with biologic matter.
41	The photograph shows a mixture of cobbles (maximum diameter of 16 cm) and gravel, with a possible admixture of coarse sand. Biological encrustations are widespread.
42	The bottom at this site consists of homogeneous fine sand or silt. Some faint ripple marks can be seen, and a few animal burrows and trails interrupt the smooth sediment surface.
43	A mixture of small cobbles (up to 12 cm in diameter) and gravel characterizes this locale. Much of the bottom is covered with biological encrustations. Two echinoderms (starfish) can be recognized.
44	Fine sediment, probably fine sand or silt, covers the sea floor. Both ripple marks and animal burrows characterize the surface of the sediment.
45	Cobbles up to 12 cm in diameter, and gravel are lodged in a medium sand matrix. Pelecypod (clam) shells and an echinoderm (starfish) are present in the picture.
46	The sea floor consists of fine sand or silt and is partially obscured by suspended sediment. The bottom exhibits mounds and burrows resulting from biological activity and possibly ripple marks.
47	Well-rounded cobbles, gravel, and coarse sand occur at this site. The gravel and cobbles are heavily encrusted with biological material.
48	The photograph is difficult to interpret because the bottom appears to slope and suspended sediment has been stirred up. Numerous well-rounded, heavily encrusted coarse gravel and cobble particles can be seen with diameters up to 10 cm. Fine gravel and silt seem to lie in the interstices.
49	An accumulation of gravel and cobbles, ranging in size from 5 to 20 cm, occurs at this locale. The cobble surfaces are encrusted with barnacles and other biological matter.
50	A heterogeneous grain size population including a boulder, cobbles, and sand is seen in this photograph. The cobbles and boulder surface are heavily encrusted.

Grab Sta. Number	Description
51	This picture shows a mixture of coarse gravel (maximum diameter 9 cm), fine gravel, coarse sand, and silt. Biological phenomena include an echinoderm (starfish) and encrustations on larger particles.
52	Much of the sea floor is obscured by suspended sediment. The bottom seems to consist of homogenous silt. Burrows and trails resulting from biological activity cover the surface.
53	Silt or fine sand characterizes this location. A variety of worm-like organisms and burrows cover the sediment surface. The bottom may also be faintly rippled.
54	The photograph indicates a bottom of fine sand or silt. Worm-like organisms, burrows and mounds, and ripple marks characterize the surface.
55	A bottom of sand and silt is littered with empty and possibly some live pelecypod (clam) shells. The shells are 3 to 6 cm in diameter.
56	Fine sand or silt occurs on the sea floor, which is partially obscured by suspended sediment. Ripple marks and biological trails can be recognized on the sediment surface.
59	All that can be seen in this photo is suspended fine sediment. It is assumed that silt is abundant on the bottom.
60	The sea floor is partially hidden by suspended matter, but a silty surface can be recognized. The surface shows evidence of biological activity in the form of mounds and trails.
63	A boulder and large cobbles can be seen at this site. The rock surfaces are heavily encrusted with biological matter.
65	A bottom of fine sand or silt is partly obscured by suspended sediment. The surface seems to be irregular as a result of biological activity.
66	The bottom cannot be seen because of suspended sediment, and it is inferred that fine sand or silt predominates.

Description of Bottom Photographs

Photo Sta. Number	Description
1	The bottom at this locality is composed of sand which has an irregular surface suggesting biological activity. What appear to be fecal pellets are widely distributed on the sediment.
3	The photograph shows a bottom consisting of sand. Numerous mounds, tracks, and burrows, and an echinoderm (starfish), are present at the sediment surface.
4	Much of the sea floor is hidden by suspended sediment in this picture. Sand or silt, with a surface characterized by mounds, burrows, and trails seems to predominate.
8	A hummocky sand bottom with numerous burrows appears in this photograph. A large echinoderm (starfish) is present.
11	Bottom material includes gravel and cobbles up to 15 cm in diameter. The grain surfaces are heavily overgrown with biological matter.
13	The bottom consists of coarse sand and gravel with a few particles up to 8 cm in diameter. Pelecypod (clam) shell fragments can be seen, and grain surfaces are free of encrustations.
14	A mixture of coarse sand and gravel (maximum diameter 5 cm) occurs at this locality. Broken and whole pelecypod (clam) shells are present.
16	The bottom is obscured by suspended sediment. Presumably bottom material is silt or clay.
17	The photograph depicts a rippled sand bottom. Small-scale burrows, mounds, and trails can be seen at the surface.
18	Bottom materials range in size from medium gravel (diameter 3 cm to a boulder. Particle surfaces are heavily encrusted with biologic matter.
20	The sand or silt bottom at this site has an irregular surface reflecting biological activity. What appear to be small fecal pellets are unambiguous.
21	This picture shows a faintly rippled sand or silt bottom. The surface contains many burrows including one 3 cm in diameter.
22	A medium sand bottom with occasional pieces of gravel occurs at this locality. The bottom is faintly rippled, and also exhibits burrows and trails. A large echinoderm (starfish) is present.
24	Coarse sand and gravel up to 5 cm in diameter occur at this site. The gravel is partially encrusted, and an echinoderm (starfish) is on the bottom.

Description of Bottom Photographs (Cont)

Photo Sta. Number	Description
25	The sea floor consists of a clean fine gravel with some sand in the interstices. A small echinoderm (starfish) is visible.
29	The bottom consists of medium to coarse rounded gravel up to 8 cm in diameter. Some encrustations are present on the larger particles.
42	The picutre shows a band of coarse sand adjacent to a band of gravel up to 5 cm in diameter. The lineation is probably caused by segregation of different grain sizes in ripple marks.

Description of Bottom Photographs

Core Sta. Number	Description
1	A mixture of sand, fine gravel, and rounded coarse gravel up to 8 cm in diameter is present. Some biologic encrustations exist on the coarse gravel.
2	The picture shows coarse sand with patches of gravel. The sediment appears to be faintly rippled.
3	Sand and gravel up to 4 cm in diameter occupy the sea floor. The particles appear relatively free of encrustations.
4	The sea floor consists principally of sand with some gravel and cobbles (maximum diameter 12 cm). The sand surface contains trails, and an echinoid (sea urchin) is present.
5	A mixture of sand, fine gravel, and rounded coarse gravel (maximum diameter 10 cm) are depicted by the photograph. The larger particles are partially encrusted with biological matter.
6	A sand bottom with an irregular surface is shown. Biologically-derived mounds and burrows contribute to the surface roughness.
7	The sea floor consists predominantly of gravel with some grains up to 3 cm in diameter and sand. Algae is widespread, with a kelp holdfast included in the picture.
8	The bottom contains sand and rounded gravel with a maximum diameter 4 cm. Grain surfaces are relatively clean. A large echinoderm (starfish) is present at the center of the photograph.
9	Coarse gravel up to 10 cm in diameter occurs with fine gravel at this locality. Surfaces of the larger grains are partially encrusted.
10	A mixture of fine and medium gravel (maximum diameter 4 cm) lies on the bottom. The sediment is free of silt and encrustations.
11	Boulders occur at this site with cobbles and gravel. The boulders are partially encrusted with biologic material and algae.
12	The photograph shows a gradation from rounded cobbles (maximum diameter 12 cm) to medium gravel. The larger particles are encrusted with biological matter.
13	Rounded cobbles up to 12 cm in diameter are mixed with coarse gravel. Surfaces of the larger particles are heavily encrusted with biological matter.
14	The sea floor contains sand with an admixture of gravel (maximum diameter 4 cm). Some biological trails can be seen on the sand surface.

Description of Bottom Photographs (Cont)

Core Sta. Number	Description
15	A bottom of sand and gravel (maximum diameter 5 cm) is shown in the photograph. A few pelecypod (clam) shell fragments are present.
16	The photograph depicts a bottom of coarse sand and gravel with particles up to 4 cm in diameter. The sediment may be rippled, with coarse material composing crests. A large echinoid (starfish) is present, and a few pelecypod fragments can be seen.
17	Heavily overgrown gravel and cobbles, with diameters of 4 to 16 cm cover the bottom. The particle surfaces are littered with small invertebrates which are mostly gastropods (snails and limpets).
18	Sand with a surface made irregular by biological activity composes the bottom. Numerous worm-like organisms protrude from the sediment.
19	The sea floor consists of sand with a surface marked by hummocks and burrows. What appear to be fecal pellets and an echinoderm (starfish) can be recognized.
20	Numerous empty pelecypod (clam) shells lie in a matrix of sand. The shells are overgrown with biological matter.
21	The sand bottom occurring at this site has an irregular surface characterized by burrows, mounds, and trails. Small worm-like organisms protrude from the sediment surface.
22	Coarse sand, fine gravel, and coarse gravel (maximum diameter 9 cm) appear in the photograph. Biological activity is evidenced by heavy encrustations and a small echinoderm (starfish).
29	A sand bottom has a surface marked by mounds, burrows, and trails. Two echinoderms (starfish) can be recognized.
30	Fine to coarse gravel (maximum diameter 9 cm) covers the sea floor, and sand may be present in the interstices. The grain surfaces are relatively free of encrustations.

APPENDIX II

MASSACHUSETTS MINERAL INVENTORY SURVEY

CORE DESCRIPTIONS

42° 06.9'
70° 34.3'

CORE LOG

Date: 5/8/72 Core No.: 1 Penetration: 19'6"

Water Depth: 85' Observer: D. Cook Length: 26'4"

Time: Start: 1102 Stop: 1116 Attempts: 2-2nd not anal.

Section No.	Interval, Sample	Color	Texture	Comments
A	0-1'1"	5Y 4/1	Med-fine sand	Top care probably washed
B	1'1" to 1'11"	5Y 4/1	Med. sand	
C	1'11" to 2'6"	5Y 4/1	Sandy gravel	Med. sand pebbles up to 3 cm
D	2'6" to 3'3" / 2'9"	5Y 4/2	Gravelly sand	Pebbles to 1.5 mm sand
E	3'3" to 4'8"	5GY 4/1	Clayey gravelly sand	Med. sand Some shell fragments
F	4'8" to 13'7"	5Y 4/1	Sandy clay	Scattered pebbles <1 cm hard
G	13'7" to 13'10"	5GY 5/2	Clayey sand	
H	13'10" to 17'6"	5Y 4/1	Sandy clay	Similar to F
I	17'6" to 17'11"	5GY 4/1	Sandy clay	Higher % sand
J	17'11" to 26'4"	5GY 5/1	Sandy clay	Hard sand decreases with depth

H

Tr

P

42° 07.3'
70° 35.5'

CORE LOG

Date: 5/8/72 Core No.: 2 Penetration: 10'5"

Water Depth: 68' Observer : D. Cook Length: 13'8"

Time: Start: 1549 Stop: 1603 Attempts: 2 (2nd not anal)

Section No.	Interval, Sample	Color	Texture	Comments
A	0–1'1"	10Y 5/2	Fine sand	Probably washed shell fragments
B	1'1" to 1'10"	10Y 5/2	Medium sand	Shell fragments
C	1'10" to 2'5" / 2'3"	10Y 5/2	Medium to coarse sand	Shell fragments
D	2'5" to 3'5"	5Y 5/2	Medium sand	Shells present
E	3'5" to 3'8"	10Y 5/2	Medium to	
F	3'8" to 4'4"	5Y 5/2	Coarse sand	
G	4'4" to 6'5" / 5'9"	5Y 6/4	Sandy gravel	Pebbles up to several cm
H	6'5" to 8'9" / 7'8"	5Y 5/2	Sandy gravel	More sand than G
I	8'9" to 9'4"	5Y 6/2	Sandy gravel	Pebbles up to several cm — Red oxidited regions
J	9'4" to 13'8" / 11'11"	5Y 6/2	Gravelly sand	Pebbles up to 2 cm Pebbles diminish towards base

H

T

42° 09.5'
70° 38.5'

CORE LOG

Date: May 11 | Core No.: 3A | Penetration: 34'

Water Depth: 80' | Observer: D. Cook | Length: 30'10"

Time: Start: 0844 | Stop: 0857 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0-1"	5Y 3/2	Clay	More may have been washed out
B	1" - 6"	5GY 3/2	Medium sand	
C	6"- 10"	5GY 3/2	Sandy gravel	Gravel to 1 cm dig
D	10"- 16'7"	5GY 5/2	Clay, sandy clay	Sand washed down along edge core hard clay occasional sand/gravel admixed
E	16'7" to 26'6" / 21'7"	10Y 4/2	Gravelly sandy clay	Same clay as D with admixture of sand, gravel up to several cm
F	26'6" to 27'9"	5Y 5/2	Gravelly sandy clay	More sand/gravel then E
G	27'9" to 29'6"	5Y 5/2	Gravelly sandy clay	Similar to E
H	29'6" to 30'10" / 30'2"	5Y 5/2	Clayey gravelly sand	Med. sand, gravel to 6 cm

42° 08.2'
70° 36.2'

CORE LOG

Date: May 11 Core No.: 4A Penetration: 22'

Water Depth: 85' Observer : D. Cook Length: 20'

Time: Start: 1026 Stop: 1034 Attempts: 3 (1st analyzed)

Section No.	Interval, Sample	Color	Texture	Comments
A	0-10" / 6"	5Y 5/6	Gravelly sand	Coarse sand, gravel up to 3 cm
B	10"-3'3" / 2'	5Y 4/1	Medium sand	Grades to finer texture with depth
C	3'3"-4'4"	5GY 3/2	Clayey sand	Fine sand
D	4'4"-5'	5Y 3/2	Sandy clay	Shell fragments present
E	5'-6' / 5'6"	5GY 3/2	Sandy clayey gravel	
F	6'-19'10" / 13'6"	5GY 5/2	Sandy clay	Clay loosely consolidated sand increasing increasing at 15' pebbles interspersed throughout
G	19'10"-19'12"	5GY 5/2	Sandy clayey gravel	

42° 09.0'
~~70° 06.2'~~ 70° 37.1°

CORE LOG

Date: May 11 | Core No.: 5A | Penetration: 30'

Water Depth: 85' | Observer: D. Cook | Length: 26'9"

Time: Start: 1519 | Stop: 1532 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0-9"	5Y 3/2	Medium sand	Possibly washed during extraction
B	9"-1'9"	5GY 3/2	Coarse sandy gravel	
C	1'9"-23'	5Y 4/1	Clay	H_2S Odor
D	23'-24	5Y 3/2	Medium sand	H_2S Odor
E	24'-26'3"	5Y 3/2	Clayey sandy gravelly	
F	26'3"-26'9"	5Y 3/2	Gravelly medium sand	

42° 09.2'
70° 39.3'

CORE LOG

Date: May 12 | Core No.: 6A | Penetration: 14'

Water Depth: 76' | Observer : D. Cook | Length: 11'

Time: Start: 1705 | Stop: 1710 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0-9"	5Y 2/1	Medium sand	
B	9"-2'5" / 1'8"	5Y 4/1	Fine sand	
C	2'5"- 3'2"	4 N4	Gravelly sandy clay	
D	3'2"- 3'9"	5Y 4/1	Sandy clay	
E	3'9"- 11'0 / 7'	5Y 5/2	Clayey gravelly sand	Gravel to 4 cm

42° 11.1'
70° 40.5'

CORE LOG

Date: May 13 Core No.: 7A Penetration: 2'

Water Depth: 46' Observer: D. Cook Length: 1'4"

Time: Start: 1840 Stop: 1842 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0-11"	5Y 5/2	Clean medium sand	
B	11" to 1'4"	5Y 5/2	Coarse sand and gravel	Probably lies on bedrock/till — large cobble in core mouth

42° 05.8'
70° 33.9'

CORE LOG

Date: May 13 Core No.: 8A Penetration: 24'

Water Depth: 92' Observer : D. Cook Length: 25'

Time: Start: 0927 Stop: 0932 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0-9"	5YR 3/4	Sandy gravel	May have been washed gravel up to 4 cm
B	9" to 6'4" / 2'6"	5GY 3/2	Fine sand	
C	6'4" to 10'10" / 8'11"	5GY 4/1	Silty sand	
D	10'10" to 18'7" / 12'11"	5GY 4/1	Sandy clay	
E	18'7" 22'10" / 21'10"	5Y 4/1	Gravelly sandy clay	Gravel 3-4 cm — sample taken from matrix only
F	22'10" to 25' / 23'11"	5Y 5/2	Gravelly sand	Medium sand

42° 07.4'
70° 35.7'

CORE LOG

Date: May 13 | Core No.: 9C | Penetration: 4'

Water Depth: 72' | Observer: D. Cook | Length: 3'1"

Time: Start: 1153 | Stop: 1157 | Attempts: 3

Section No.	Interval, Sample	Color	Texture	Comments
A	0- 1'8"	5GY 3/2	Clayey gravelly sand	Washed
B	1'8" to 3'11"	5Y 6/1	Clayey sand	Occasional chunks of gravel whole core disturbed probably bottomed on bedrock

42° 12.0'
70° 41.1'

CORE LOG

Date: May 13 | Core No.: 10A | Penetration: 31'

Water Depth: 68 | Observer : D. Cook | Length: 39'4"

Time: Start: 1356 | Stop: 1420 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0-7"	5GY 4/1	Clayey sand	May have been washed
B	7"-11"	10Y 4/2	Medium sand	
C	11" - 1'8"	5Y 4/1	Clay	Pure clay
D	1'8"- 2'2"	2N2	Clayey sandy gravel	
E	2'2"- 39'4"	5Y 4/1	Clay	Pure clay uniform color and texture similar to 11-E

42° 12.3'
70° 40.5'

CORE LOG

Date: May 13 | Core No.: 11A | Penetration: 35'

Water Depth: 58' | Observer: D. Cook | Length: 38'2"

Time: Start: 1558 | Stop: 1609 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0-10"	5Y 4/1	Medium sand	
B	10" to 1'10" / 1'3"	5Y 4/1	Sandy clayey gravel	
C	1'10" to 2'6"	5Y 5/2	Sandy clay	
D	2'6" to 3' 1"	56Y 4/1	Clayey sand	
E	3'1" to 38'2"	56Y 5/2	Clay	Sandy zones 1" thick near top homogenous clay in bottom 20'

42° 13.0' (?)
70° 41.4' (?)

CORE LOG

Date: May 14　　Core No.: 12 A　　Penetration: 18'

Water Depth: 70'　　Observer : D. Cook　　Length: 6'10"

Time: Start: 0927　　Stop: 0932　　Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	Approx. 0-10'		Supposed loose silt and clay	Not recovered - presumably "blown" out top
B	10'-11'1" actual 0-1'1"	5Y 4/1	Sandy clay	
C	11'1"- 14'5" actual 1'1"-4'5"	5GY 4/1	Clay	Moderately cohesive No sand
D	14'5"- 15'7"actual 4'5"-5'7"	5Y	Clayey sand	Fine sand and clay
E	15'7"- 16'10" actual 5'7"-6'10"	5B 5/1	Clay	Quite hard no sand

42° 14.2'
70° 41.5'

CORE LOG

Date: May 14 Core No.: 13A Penetration: 35'

Water Depth: 80' Observer : D. Cook Length: 34'10"

Time: Start: 1056 Stop: 1101 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0-9"	5GY 4/1	Clay	Top of core may have been lost
B	9"-11"	5GY 3/2	Clayey sand	Med. sand
C	11"x1'11"	5Y 5/2	Silty Clay	Hard
D	1'11" - 2'3"	N1	Clayey sand	Reduced
E	2'3" - 6'2"	5Y 5/2	Silty Clay	Hard
F	6'2"- 15'6"	5Y 4/1	Silty Clay	
G	15'6"- 16'7"	5Y 4/1	Silty sand	Fine sand
H	16'7"- 33'6"	5GY 4/1	Silty Clay	Similar to F
I	33'6"to 34'2"	5Y 5/2	Clayey sand	Medium sand
J	34'2" to 34'10"	5Y 5/2	Clayey gravelly sand	Gravel to 4 cm

Section No.	Interval, Sample	Color	Texture	Comments
K	34'10" to 36'6"	5GY 5/2	Gravelly sandy clay	
L	36'6" to 39'10"	5GY 6/1	Clayey gravelly sand	

42° 17.6'
70° 41.8'

CORE LOG

Date: May 14 Core No.: 14 A Penetration: 11

Water Depth: 126' Observer: D. Cook Length: 11'6"

Time: Start: 1452 Stop: 1502 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0-9" 6"	5GY 4/1	Gravelly sand	Partially washed
B	8"-1'6"	5GY 4/1	Sandy clay	
C	1'6"-1'9"	5GY 4/1	Silty sand	Medium sand
D	1'9" to 2'4"	10Y 4/2	Clay	Very compact, minor silt
E	2'4"-2'6"	5GY 4/2	Silty sand	Similar to C
F	2'6"-3'1"	10Y 4/2	Clay	Similar to D
G	3'1"-3'3"	5GY 4/1	Silty sand	Similar to C, E
H	3'3"-11'6"	5GY 4/1	Clay	Hard minor silt slightly darker than D, F admixture of gravel near bottom

42°18.4'
70° 42.9' (?)

CORE LOG

Date: May 14 Core No.: 15A Penetration: 12'

Water Depth: 120' Observer: D. Cook Length: 10'

Time: Start: 1427 Stop: 1433 Attempts: 3 (1st, 3rd analyzed)

Section No.	Interval, Sample	Color	Texture	Comments
A	0-10"	5Y 5/2	Coarse to medium sand	Probably washed
B	10"-2'3" / 1'6"	5Y 5/2	Sandy gravel	Well rounded gravel 1-4 cm medium sand matrix
C	2'3"-3'1" / 2'9"	5Y 5/2	Coarse sand	Some rock fragments
D	3'1"-10' / 7'	5Y 5/2	Medium sand	Occasional pieces of gravel - color at bottom grades to 5Y 2/1

42° 18.4'
70° 42.9'

CORE LOG

Date: May 15　　Core No.: 15C　　Penetration: 35'

Water Depth: 120'　　Observer: D. Cook　　Length: 24'10"

Time: Start: 1547　　Stop: 1557　　Attempts: 3 (1st, 3rd analyzed)

Section No.	Interval, Sample	Color	Texture	Comments
A	0-2' / 1'	5Y 5/2	Medium sand	May be washed
B	2'-4'11" / 3'6"	5Y 4/1	Sandy gravel	Matrix of medium sand gravel fragments to 4 cm
C	4'11" to 12'3" / 7'9"	5Y 5/2	Gravelly sand	Medium sand matrix color grades to 5Y 2/1 near bottom
D	12'3" to 13'10" / 12'3"	5Y 2/1	Gravelly sand	Coarse sand matrix
E	13'10" to 15'0"	5Y 5/2	Gravelly sand	Medium sand matrix
F	15'0" to 15'11"	5GY 4/1	Medium sand	
G	15'11" to 19'10" / 17'10"	5Y 4/1	Gravelly sand	Medium to coarse sand as matrix - occasional shells
H	19'10" to 24'10"	5GY 4/1	Silty clay	Soft

42° 20.0'
70° 44.4'

CORE LOG

Date: May 15 Core No.: 16A Penetration: 35'

Water Depth: 118' Observer: D. Cook Length: 37'6"

Time: Start: 1749 Stop: 1754 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 3"	5G 2/1	Sandy gravel	More may have been washed out
B	3" to 5"	N1	Silty clay	H_2S odor
C	0'5" to 8'3" / 2'6", 6'0"	5Y 4/1	Fine sand	
D	8'3" to 11'0" / 9'5"	5GY 4/1	Sandy silt	
E	11'0" to 16'0" / 13'11"	10Y 4/2	Fine sand silty	
F	16'0" to 18'7"	5GY 4/1	Clay	Soft
G	18'7" to 22'2" / 20'5"	5Y 4/1	Gravelly sand	Pea sized gravel
H	22'2" to 37'6"	5GY 4/1	Silty clay	Hard clay
I			Medium sand	In cutting edge corer

42° 33.4'
70° 38.4'

CORE LOG

Date: May 16 — Core No.: 17A — Penetration: 2'

Water Depth: 155' — Observer: D. Bell — Length: 4'6"

Time: Start: 0915 — Stop: 0921 — Attempts: 3—1st analyzed

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 1'4" / 0'8"	5Y 4/2	Fine to medium sand	Entire section washed Zones result from vibratory sorting
B	1'4" to 4'0" / 2'0"		Coarse sand	Admixture of medium to coarse shell fragments and pebbles
C	4'0" to 4'6"		Gravel	Fine to 8 cm gravel, granite and feldspar

42° 31.7'
70° 42.2'

CORE LOG

Date: May 16 | Core No.: 18A | Penetration: 30'

Water Depth: 155' | Observer: D. Bell | Length: 24'8"

Time: Start: 1710 | Stop: 1715 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 9'7" / 1'6"	10Y 4/2	Very fine sand	Section mixed by vibration and subsequent washing Some shells present
B	9'7" to 12'0"	N3	Sandy clay	Admixture of pebbles and shells in upper half Black color from organics
C	12'0" to 19'7"	N5	Silty clay	Color more bluish than N5 Some black streaks from organics
D	19'7" to 24'8"	5Y 5/2	Gravelly clay with silty sand	Becomes more consolidated towards bottom

42° 31.2'
70° 43.5'

CORE LOG

Date: May 16 | Core No.: 19A | Penetration: 38'

Water Depth: 155' | Observer : D. Bell | Length: 35'5"

Time: Start: 1530 | Stop: 1540 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0'0" to 5'10"	5Y 4/2	Medium to coarse silt	Scattered large shell fragments and whole shells Mercenaria sp. and reddish brown worm tubes
B	5'10" to 35'5"	5GY 4/1	Silty clay	Occasional organic blebs

42° 29.5'
70° 44.7'

CORE LOG

Date: May 17 Core No.: 20A Penetration: 37'6"

Water Depth: 150' Observer : D. Bell Length: 37'10"

Time: Start: 0930 Stop: 0940 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 0'10"	5Y 5/1	Sandy coarse silt	Coarse sediment could result from washing
B	0'10" to 37'10"	5Y 6/1, 5Y 4/2	Silty clay	Grades from 5Y 6/1 to 5Y 4/2 at 18'10"

42° 27.9'
70° 48.2'

CORE LOG

Date: May 17 Core No.: 21A Penetration: 38'

Water Depth: 120' Observer : D. Bell Length: 36'8"

Time: Start: 1100 Stop: 1115 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0'0" to 36'8"	10Y 5/2, 5GY 5/1	Silty clay	Upper few feet washed, higher 0/0 silt Color grades from 10Y 5/2 to 5GY 5/1 at 8'6"
				Silt content decreases with depth

42° 27.5'
70° 47.0'

CORE LOG

Date: May 17 Core No.: 22A Penetration: 36'

Water Depth: 160' Observer : D. Bell Length: 36'3"

Time: Start: 1301 Stop: 1308 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0'0" to 36'3"	5Y 5/1	Clay	Minor silt, scattered sand

42° 25.1'
70° 49.1'

CORE LOG

Date: May 17   Core No.: 23A   Penetration: 33'0"

Water Depth: 120'   Observer: D. Bell   Length: 37'2"

Time: Start: 1400   Stop: 1430   Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0' to 6'7" / 10", 4'0", 6'0"	5Y 4/1	Fine to medium sand	Minor silt, shells Sand grades to fine at bottom of section
B	6'7" to 10'10" / 7'0", 8'2"	5Y 3/1	Clayey silt	Medium silt
C	10'10" to 12'8" / 11'4"	N3	Medium sand	Admixture of small pebbles Occasional shell fragments Black odor from organics?
D	12'0" to 26'5"	N2	Silty clay	
E	26'5" to 28'1"	5Y 5/2	Sandy silt/clay	Could be coarse clay or fine silt
F	28'1" to 28'3" / 28'2"	5Y 5/1	Medium sand	
G	28'3" to 28'8"	5Y 5/1	Fine sand	
H	28'8" to 29'3"	5Y 5/1	Fine to medium sand	
I	29'3" to 30'5" / 29'4"—30'3"	5Y 5/1	Medium sand with pebbles	
J	30'5" to 31'2"	5Y 5/1	Fine sand with pebbles	

Section No.	Interval, Sample	Color	Texture	Comments
K	31'2" to 33'0" 32'1"	5Y 5/1	Sandy gravel	
L	33'0" to 35'2"	5Y 5/1	Fine sand with pebbles	
M	35'2" to 37'2"	5GY 6/1	Silty clay	No pebbles visible

42° 24.2'
70° 48.4'

CORE LOG

Date: May 17 | Core No.: 24A | Penetration: 21'6"

Water Depth: 118' | Observer: D. Bell | Length: 28'1"

Time: Start: 1600 | Stop: 1610 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 6"		Fine sand	Washed
B	6" to 4'3" 1'0"	Clay 5Y 6/4	Sandy gravel with clay zones	Clay zones: 2' to 2'2", 2'6" to 3'0", 3'6" to 3'10"
C	4'3" to 5'10" 4'	5Y 6/2	Sandy gravelly clay	
D	5'10" to 6'6"	5Y 4/2	Sandy clay	
E	6'6" to 6'8"		Gravel	
F	6'8" to 7'0"	5Y 4/2	Sandy clay	
G	7'0" to 7'3"	5Y 3/2	Sandy gravel	
H	7'3" to 8'0"	5Y 4/2	Sandy gravelly clay	
I	8'0" to 8'8"	5Y 5/2	Medium sand with gravel	
J	8'8" to 28'1"	5Y 5/2	Sandy silty gravelly clay	Local 1" to 2" zones of increased gravel content

42° 21.1'
70° 49.4'

CORE LOG

Date: May 18 Core No.: 25A Penetration: 30'

Water Depth: 108' Observer : D. Cook Length: 31'4"

Time: Start: 0903 Stop: 0904 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 2'11" 1'6"	5Y 3/2	Silty sand	Slightly reduced, well sorted Some gravel near top—may have been washed
B	2'11" to 4'10"	5GY 4/1	Clay	Some silt
C	4'10" to 5'1"	5GY 4/1	Silty sand	Fine sand
D	5'1" to 31'4"	5GY 4/1	Clay	Below 10' color changes to N3, reduced Color changes back to 5GY 4/1 at 15'6" Occasional pebbles

42° 23.1'
70° 47.8'

CORE LOG

Date: May 18 Core No.: 26A Penetration: 25'

Water Depth: 104' Observer : D. Cook Length: 24'9"

Time: Start: 1008 Stop: 1017 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 3"	5Y 4/1	Medium sand	Washed
B	3" to 11" / 7"		Gravel	Gravel 1/2—2cm No fines Admixture of sand
C	11" to 18'6"	5Y 4/1	Clay	Hard with occasional zones of gravel less than 1" thick
D	18'6" to 24'9"	5Y 4/1	Sandy pebbly clay	Pebbles to 3 cm—material is very hard

42° 24.2'
70° 46.8'

CORE LOG

Date: May 18 | Core No.: 27A | Penetration: 26'

Water Depth: 120' | Observer : D. Cook | Length: 36'1"

Time: Start: 1133 | Stop: 1145 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 7" / 4"	5Y 4/1	Medium sand	Well sorted, washed
B	7" to 8"		Pea gravel	Maximum size 1 cm
C	8" to 2'4" / 1'6"	5Y 4/1	Medium sand	Well sorted, clean
D	2'4" to 3'4"	5GY 4/1	Silt	
E	3'4" to 7'3"	5GY 4/1	Clay	Appears to be pure Soft
F	7'3" to 7'10"	5GY 4/1	Clayey sand	
G	7'10" to 36'1"	5GY 4/1	Clay	Hard and partially oxidized

42° 25.1'
70° 47.9'

CORE LOG

Date: May 18 | Core No.: 28A | Penetration: 32'

Water Depth: 112' | Observer: D. Cook | Length: 36'8"

Time: Start: 1320 | Stop: 1324 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 7"	5Y 4/1	Medium sand	Washed
B	7" to 1'1" 10"	5Y 4/1	Gravelly sand	Medium to coarse sand—gravel to 1—2 cm
C	1'1" to 5'7" 2'6", 4'6"	5Y 4/1	Medium sand	Clean and well sorted, has shell fragments
D	5'7" to 7'3"	5GY 4/1	Sandy silt	Becomes finer towards base
E	7'3" to 7'6"	5Y 4/1	Fine sand	
F	7'6" to 7'8"	5Y 4/1	Sandy silt	
G	7'8" to 7'9"	5Y 4/1	Fine sand	
H	7'9" to 8'10"	5Y 4/1	Sandy silt	
I	8'10" to 9'7"	5GY 4/1	Silty clay	
J	9'7" to 11'3"	5Y 4/1	Sandy silt	

Section No.	Interval, Sample	Color	Texture	Comments
K	11'3" to 12'3"	N3	Clay	
L	12'3" to 12'6"	N2	Silty sand	
M	12'6" to 30'0"	N3	Clay	
N	30'0" to 33'6"	5GY 4/1	Silty clay	
O	33'6" to 33'11"	N4	Medium sand	
P	33'11" to 36'8"	5GY 4/1	Gravelly sand clay	Hard

42° 26.2'
70° 51.8'

CORE LOG

Date: May 18 Core No.: 29A Penetration: 25'

Water Depth: 110' Observer : D. Cook Length: 29'10"

Time: Start: 1432 Stop: 1439 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 9"	5Y 4/1	Medium sand	Washed
B	9" to 1'2" / 1'0"	5Y 4/1	Gravelly sand	Medium sand with large shell fragments
C	1'2" to 5'9" / 3'6"	5GY 4/1	Sandy silt	
D	5'9" to 7'4"	N3	Clay	Soft
E	7'4" to 20'10"	5GY 4/1	Clay	Hard Sandy towards base with occasional pebbles

42° 18.9',
70° 50.0'

CORE LOG

Date: May 19 | Core No.: 30A | Penetration: 27'

Water Depth: 68' | Observer: D. Cook | Length: 29'7"

Time: Start: 0857 | Stop: 0915 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 9" / 6"	5GY	Medium sand	Washed
B	9 to 1'6" / 1'	N3	Coarse sand	Well sorted Abundant rock fragments
C	1'6" to 4'1" / 2'9"	5GY 2/1	Sandy gravel	Coarse sand gravel 1/2—3 cm
D	4'11" to 5'11"	10Y 4/2	Hard clay	No silt
E	5'11" to 6'3"	5GY 4/1	Clayey sandy gravel	
F	6'3" to 6'11"	5GY 4/1	Pure clay	Hard
G	6'11" to 7'9"	10Y 4/2	Gravelly clay	Gravel 1—2 cm
H	7'9" to 29'7"	10Y 4/2	Pure clay	Hard

42° 20.1'
70° 51.1'

CORE LOG

Date: May 19 Core No.: 31A Penetration: 23'

Water Depth: 70' Observer : D. Cook Length: 31'11"

Time: Start: 1035 Stop: 1038 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 5'10" / 1', 3', 5'	N2	Silty fine sand	Well sorted Contains shell fragments
B	5'10" to 9" / 6'9", 8'	N4	Fine sand	Well sorted
C	4' to 31'11"	5GY 4/1	Clay	Rel. pure, moderately soft High H_2S content

42° 18.8'
70° 41.9'

CORE LOG

Date: May 21   Core No.: 32A   Penetration: ≈17.5'

Water Depth: 102'   Observer: D. Cook   Length: 21'7"

Time: Start: 1051   Stop: 1105   Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 3'8" / 2'	5Y 3/2	Medium sand	Clean, well sorted Partially washed Abundant rock fragments
B	3'8" to 8' / 6'	5Y 3/2	Sandy gravel	Hard; pea-sized gravel Medium-coarse sand matrix Some coarse gravel
C	8' to 11'2" / 9'6"	5Y 5/2	Gravelly sand	Sand matrix medium grained; pea-sized gravel
D	11'2" to 14' / 12'	5Y 3/2	Sandy gravel	Zones rel. pure gravel At 13'4" to 13'10" purple mineral tale? 5 RP 812
E	14' to 14'8"	N4	Medium sand	
F	14.8' to 16'5" / 15'6"	5Y 4/1	Silty clay	
G	16'5" to 21'7" / 19'	N5 & 5Y 5/2	Medium sand	Well sorted; color gradation

42° 18.9'
70° 44.2'

CORE LOG

Date: May 21　　Core No.: 33A　　Penetration: 20'

Water Depth: 120'　　Observer: D. Cook　　Length: 18'6"

Time: Start: 1315　　Stop: 1328　　Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 9" / 6"	5Y 2/1	Medium sand	Probably washed
B	9" to 2'4" / 1'6"	Matrix Color 5Y 2/1	Sandy gravel	Medium sand matrix Gravel pea size to 4 cm
C	2'4" to 4'2" / 3'6"	N3	Medium coarse sand	Well sorted
D	4'2" to 13'8"	N3 5GY 4/1	Silty clay	Sharp contact with sand at top; soft; grades to 5GY 4/1
E	13'8" to 14'4"	5GY 4/1	Gravelly clay	Pea size
F	14'4" to 18'6"	5Y 5/2	Silty clay	Very hard

42° 21.1'
70° 47.4'

CORE LOG

Date: May 21 Core No.: 34A Penetration: 33'

Water Depth: 80' Observer : D. Cook Length: 26'4"

Time: Start: 1450 Stop: 1505 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 2'2" 1'6"	5GY 4/1	Medium sand	Probably washed Well sorted
B	2'2" to 25'8" 4'6" 8'11" 13'5" 17'8" 22'4"	N3	Sandy gravel	Gravel to 4 cm Possible admixture of silt Medium to coarse sand matrix Few cobbles Some zones sandier than others—sand increases in bottom before grading to medium gravel member @ very bottom
C	25'8" to 26'4"	5GY 4/1	Sandy gravelly clay	

[redacted]

42° 26.1'
70° 52.1'

CORE LOG

Date: May 21 | Core No.: 35A | Penetration: 9'4"

Water Depth: 98' | Observer : D. Cook | Length: 10'8"

Time: Start: 1632 | Stop: 1644 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 2'7" / 1'6"	5Y 3/2	Silty sand	Washed Poorly sorted
B	2'7" to 10'8" / 7'	5Y 5/2	Sandy gravelly silt	

42° 18.1'
70° 41.9'

CORE LOG

Date: May 22 Core No.: 36A Penetration: 25'

Water Depth: 110' Observer: D. Cook Length: 28'10"

Time: Start: 0953 Stop: 1003 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 1'4" / 9"	5GY 4/1	Medium sand	Probably washed Well sorted
B	1'4" to 11'3" / 5', 9'11"	N4	Sandy gravel	Medium to coarse sand Gravel 2mm—4 cm Clean
C	11'3" to 11'9"	5GY 4/1	Silty sand	Fine sand
D	11'9" to 16'2"	5GY 4/1	Silty clay	Strong H_2S smell Soft
E	16'2" to 17'1"	5Y 4/1	Sandy silt	
F	17'1" to 20'2" / 18'5"	5GY 4/1	Silty sand	Fine sand
G	20'2" to 22'11"	5GY 4/1	Sandy silt	Strong H_2S smell Some brown oxidized zones
H	22'11" to 27'7"	5GY 4/1	Silty clay	Hard
I	27'7" to 28'10"	5GY 4/1	Fine sand	Hard

42° 18.7'
70° 44.9'

CORE LOG

Date: May 22 | Core No.: 37A | Penetration: 13'

Water Depth: 105' | Observer: D. Cook | Length: 15'1"

Time: Start: 1152 | Stop: 1204 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 7" / 5"	5Y 4/1	Medium coarse sand	Abundant rock fragments
B	7" to 6'4" / 3'	5Y 4/1	Sandy gravel	Medium to coarse sand matrix Gravel to 3—4 cm Appears clean
C	6'4" to 15'1"	10Y 4/2	Silty clay	Hard Abrupt contact w/B

42° 19.1
70° 46.6'

CORE LOG

Date: May 22 Core No.: 38A Penetration: 9'

Water Depth: 86' Observer : D. Cook Length: 8'

Time: Start: 1407 Stop: 1416 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 2'9" / 1'	5Y 5/2	Silty sand and gravel	Clay zones intermixed Gravel pea sized to 1 cm
B	2'9" to 3'10"	5Y 5/2	Silty clay	Hard
C	3'10" to 5'10"	5Y 5/2	Sandy silt	Fine sand and silt
D	5'10" to 8'	5Y 5/2	Gravelly silty clay	Hard Probably till

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42° 21.3',
70° 47.5'

CORE LOG

Date: May 22 Core No.: 39A Penetration: 34' est.

Water Depth: Observer : D. Cook Length: 33'8"

Time: Start: 1708 Stop: 1721 Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 8" / 6"	5Y 4/1	Medium sand	Well sorted Abundant rock fragments
B	8" to 9' / 3', 6'2"	5Y 4/1	Sandy gravel	Medium sand matrix Gravel to 4 cm Appears clean Slightly sandier @ base
C	9' to 9'4"	5GY 4/1	Sandy silt	
D	9'4" to 11'4"	5GY 4/1	Silty clay	Cl, to cl, s
E	11'4" to 11'9"	5GY 4/1	Silty sand	
F	11'9" to 20'5"	5GY 4/1	Silty clay	Soft
G	20'5" to 33'8"	5GY 4/1	Silty clay	Hard—otherwise same as F

42° 16.6'
70° 41.5'

CORE LOG

Date: May 23 | Core No.: 40A | Penetration: 16'

Water Depth: 95' | Observer: D. Cook | Length: 18'4"

Time: Start: 0818 | Stop: 0829 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 1'6" / 1	5GY 4/1	Gravelly sand	Possible admixture of silt Pebbles to 2 cm Medium sand matrix
B	1'6" to 2'6"	5GY 4/1	Silty sand	Sand fine to medium
C	2'6" to 5'8" / 4'	5GY 4/1	Sandy silt	Soft; maybe due to vibration
D	5'8" to 9'5"	N5	Silt	Harder
F	9'5" to 13'5"	5Y 5/2	Sandy silt	
G	13'5" to 17'4" / 15'5"	5GY 4/1	Fine silty sand	
H	17'4" to 18'4"	N5	Sandy gravelly silt	Hard

42° 26.6'
70° 41.5'

CORE LOG

Date: May 23 | Core No.: 41A | Penetration: 33'

Water Depth: 140' | Observer: D. Cook | Length: 36'9"

Time: Start: 1049 | Stop: 1055 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 36'9"	5G 4/1	Pure clay	Surface skin probably lost Soft

42° 28.3'
70° 47.1'

CORE LOG

Date: May 23 | Core No.: 42A | Penetration: 30'

Water Depth: | Observer : D. Cook | Length: 40'2"

Time: Start: 1206 | Stop: 1216 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 2'5" 1'	N4	Silty sand	Fine sand Top of core lost fm vibration
B	2'5" to 40'2"	5GY 4/1	Clay	

42° 30.6'
70° 44.3'

CORE LOG

Date: May 23 | Core No.: 43A | Penetration: 30'

Water Depth: 152' | Observer: D. Cook | Length: 30'6"

Time: Start: 1506 | Stop: 1509 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 3'1" / 1'6"	5Y 4/1	Silty sand	
B	3'1" to 23'5"	5Y 4/1	Pure clay	Occasional sand zones at bottom
C	23'5" to 26'5"	5Y 4/1	Clayey sand	Medium sand
D	26'5" to 30'6" / 28'5"	5Y 5/2	Coarse sand	Clean, well sorted 30" additional were lost at bottom due to malfunction of core retainer

42° 32.2'
70° 43.0'

CORE LOG

Date: May 23 | Core No.: 44A | Penetration: 31'

Water Depth: 130' | Observer: D. Cook | Length: 26'3"

Time: Start: 1631 | Stop: 1633 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 21'8" / 3', 8', 13'5", 18'	10Y 4/1	Fine sand	Well sorted, rel. clean Strong H_2S odor Grades to silty sand at base
B	21'8" to 23'5" / 22'7"	10Y 4/1	Sandy silt	
C	23'5" to 26'3"	10Y 4/1	Silty clay	

42° 24.8'
70° 47.1'

CORE LOG

Date: May 24 | Core No.: 45A | Penetration: 30' est.

Water Depth: 111' | Observer : D. Cook | Length: 39'11"

Time: Start: 1010 | Stop: 1012 | Attempts: 1

Section No.	Interval, Sample	Color	Texture	Comments
A	0 to 1'1" / 6"	5GY 4/1	Sandy gravel	Medium sand Gravel to 3 cm Unknown amount lost @ top
B	1'11" to 3'8" / 2'6"	5Y 4/1	Medium sand	Many large shell fragments
C	3'8" to 5'2" / 4'6"	5GY 4/1	Silty sand	
D	5'2" to 39'11" / 39'11"	5GY 4/1	Silty clay	Fairly soft Occasional sandy zones 1" thick Color switch to N1 at ~25 feet

APPENDIX III

GRAB SAMPLE LOG

Grab #	Depth (ft)	Line	Station	Description
1	90	3	1050.0	— Mixture of sand and gravel — Size range—4 cm gravel to medium sand — Few shell fragments present — Color 5Y 4/1
2	75	4	1218.4	— Medium to coarse sand with admixture of gravel 2—3 cm in diameter — Few shell fragments present — Color 5Y 4/4
3	100	4	1215.4	— Well-sorted medium sand — Shells and shell fragments in sample — Color 5Y 5/2
4	100	4	1209.0	— Mixture of sand and gravel — Size range—4 cm gravel to fine sand — Color 5Y 5/2
5	75	4	1200.0	— Fine sand with admixture of fine gravel and shell fragments — Small sample-area assumed rocky — Color 5Y 5/2
6	70	5	1332.5	— Mixture of coarse to fine gravel with some fine sand — Color 5Y 5/6
7	50	6	1528.0	— Sample consists of marine algae—presumably was attached to rock
8	75	6	1534.0	— Fine to coarse gravel, subangular — Mixture of fine sand — Color 5Y 4/2
9	60	6	1543.6	— Mixture of coarse to fine gravel with some fine sand — Color 5Y 4/2
10	60	7	1615.0	— Heterogeneous mixture of clay, sand, and gravel up to 8 cm — Color 5Y 4/1

Grab Sample Log (Cont)

Grab #	Depth (ft)	Line	Station	Description
11	55	7	1618.5	– Coarse to fine gravel in a matrix of very fine sand – Color 5Y 4/2
12	70	8	1820.5	– Heterogeneous mixture ranging from fine sand to coarse gravel – Few shell fragments – Color 5Y 4/2
13	65	8	1826.5	– Fine sand with some fine to medium gravel and shell fragments – Color 5Y 4/4
14	60	8	1832.5	– Fine sand to silty clay – H_2S odor – Color 5Y 3/2
15	55	9	0810.0	– Fine sand with one particle of coarse gravel – Small sample-area assumed rocky
16	65	9	0819.5	– Principally fine sand with admixture of medium gravel – Small sample bottom probably rocky – Color 5Y 5/2
17	55	9	0822.5	– Medium sand with some fine to coarse gravel and shell fragments – Color 5Y 5/2
18	60	9	0831.5	– Fine to medium sand with admixture of medium gravel – Color 5Y 4/2
19	70	10	1049.8	– Medium to coarse sand predominant, some gravel up to 5 cm and shell fragments – Color 5Y 5/2
20	80	10	1046.0	– Medium to coarse sand with gravel to 5 cm and shell fragments – Marine life—echinoderm (starfish) and worms – Two attempts—both small samples – Color 5Y 3/2
21 ~~24~~	55	11	1151.0 ~~1130.8~~	– Only marine algae obtained, rock bottom assumed

Grab Sample Log (Cont)

Grab #	Depth (ft)	Line	Station	Description
~~21~~ 22	65	11	~~1151.0~~ 1130.8	– Gravel with a maximum diameter of 5 cm, admixture of medium sand – Color 5Y 4/2
23	60	12	1416.7	– Medium to coarse gravel (largest grains 8 cm) – Some shell fragments
24	70	13	1503.5	– Gravel up to 4 cm with small amount of coarse sand – Color 10Y 3/2
25	70	13	1454.0	– Medium to coarse gravel (maximum diameter 8 cm) with some coarse sand – Some shell fragments
26	55	14	1701.4	– Fine sand with similar-sized shell fragments – Color 5Y 3/2
27	70	15	0809.5	– Medium to coarse sand with some fine gravel and shell fragments – Two attempts, both small samples—hard bottom – Color gray
28	80	17	1030.0	– Principally medium to coarse sand, some gravel to 4 cm and shell fragments – Color gray
29	120	18	1127.0	– Sludge with fine sand, silt, and shell fragments – Sludge appears to underly other sediments – Color 5Y 4/2
30	110	19	1259.5	– Sludge with fine sand, silt, and shell fragments – Color 5Y 5/2
31	50	18	1149.6	– Two attempts, no sample—bottom assumed rocky
32	80	17	1012.3	– Mixture of fine to coarse subangular gravel and clay – Clay contains organic matter – Color 5Y 2/1
33	65	18	1210.0	– Heterogeneous sediment—gravel to 8 cm, sand, and clay – Two attempts—small samples – Color 5Y 3/2

Grab Sample Log (Cont)

Grab #	Depth (ft)	Line	Station	Description
34	75	19	1244.0	– Subangular medium to coarse gravel with shell fragments in a fine sand matrix – Color 5Y 3/2
35	50	20	1430.5	– Medium gravel (maximum diameter 4 cm) and shell fragments with medium sand – Diver reported boulders at bottom
36	60	21	1524.0	– Mixture of medium gravel and medium sand – Two attempts–one small sample–assumed rocky
37	110	22	1713.0	– Coarse sand and medium gravel with some fine sand and clay – Color 5YR 2/1
38*	85	23	0923.0	– Medium to coarse sub-angular gravel, admixture of fine sand and shell fragments – Color 5Y 3/2
39	95	24	1051.0	– Mixture ranging from fine sand to coarse gravel – Two attempts yielded one small sample–bottom assumed rocky – Color 5Y 3/2
40	105	24	1042.0	– Fine to medium sand with medium to coarse gravel – Color 5Y 5/2
41		23	0945.5	– Size gradation from medium sand to coarse gravel – Shell fragments present – Color 10Y 3/2
42	100	24	1021.0	– Fine to coarse gravel with shell fragments in a matrix of clay – Clay contains organic matter – Color 10Y 4/2
43	70	25	1219.5	– Mixture of fine sand and shell fragments
44	90	26	1242.5	– Mixture of fine sand and clay – Cohesive – Color 5Y 3/2

Grab Sample Log (Cont)

Grab #	Depth (ft)	Line	Station	Description
45	105	26	1303.0	— Fine grain, well-sorted sand with small quantity sludge — Color 5Y 3/2
46	100	25	1149.75	— Fine, well-sorted sand — Color 10YR 4/2
47	100	25	1146.0	— Sandy gravel — Fine sand matrix — Gravel 1—2 cm to several cm — Occasional shells — Color 5Y 5/2
48	126	26	1330.0	— Sandy gravel (small sample) — Sand medium to coarse — Gravel large particles (several cm) with biological matter attached — Color 5Y 5/2
49	130	27	1403.0	— Clayey sandy gravel — Medium sand matrix — Large chunks gravel—several cm—encrusted with various organisms — Color 5Y 4/4
50	90	27	1406.0	— No sample—3 tries
51	132	28	0818.5	— Sandy gravel, admixture of silt — Sand fine to coarse — Gravel large—several cm — Poorly sorted — Color 5Y 5/2
52	150	28	0806.5	— No sample
53	120	28	0748.0	— Fine sand, admixture of silt — Well sorted, packs hard — Color 5Y 5/2
54	135	29	0915.2	— Fine sand, admixture of silt — Well sorted, packs hard — Color 5Y 5/2
55	135	30	0934.5	— Fine sand, some silt — Well sorted, hard packed — Significant content of heavy minerals — Color 5Y 5/2

Grab Sample Log (Cont)

Grab #	Depth (ft)	Line	Station	Description
56	135	31	1004.0	— Fine sand, relatively clean — Well sorted, hard-packed — Significant content heavy minerals — Color 5Y 5/2
57	180	34	1131.0	— Sandy silt—close to fine sand — Well sorted — Color 5Y 5/2
58	180	35	1145.4	— Gravelly sand — Fine sand, admixture of silt — Pea-size gravel to several cm particles — Mixture of two grain size populations — Color 5Y 5/2
59	160	35	1154.7	— Fine sand, admixture of silt — Well sorted — Hard-packed — Color 5Y 4/4
60	130	35	1203.0	— Fine sand, relatively clean — Well sorted — Some heavy minerals — Color 5Y 5/2
61	183	36	1233.5	— Fine sand, admixture of silt — Well sorted — Color 5Y 5/2
62	180	37	1255.0	— Fine sand, admixture of silt — Well sorted — Hard-packed (as are others) — Color 5Y 4/4
63	140	38	1329.0	— Sandy gravel — Medium sand, some coarse — Gravel pea size—several cm — Shells, encrustations on gravel — Color 5Y 5/2
64	170	40	1427.5	— Fine sand, admixture of silt — Well sorted, hard packed — Color 5Y 5/2

Grab Sample Log (Cont)

Grab #	Depth (ft)	Line	Station	Description
65	155	42	1526.0	— Fine sand, admixture of silt — Well sorted — Dark reduced zones — Color 5Y 5/2
66	130	43	1548.0	— Fine sand, admixture of silt — Well sorted — Not many heavy minerals — Color 5Y 5/2

APPENDIX IV

(4.6)

CORE SAMPLE ANALYSIS LOG

Grain Size Analysis

Core Sample	Weight Percentage				
	>9.50mm	2.36-9.50	0.60-2.36	0.075-0.60	<0.075
1-D	7%	32%	41%	16%	4%
2-C	0%	1%	17%	80%	2%
2-G	63%	14%	5%	16%	2%
2-H	23%	23%	17%	31%	6%
2-J	20%	5%	16%	48%	11%
3-E	0%	13%	16%	45%	26%
3-H	8%	10%	16%	50%	16%
4-A	19%	28%	39%	14%	~0%
4-B	0%	8%	3%	88%	1%
4-E	34%	30%	19%	14%	3%
4-F*	13%	7%	12%	38%	30%
6-B	0%	2%	9%	82%	7%
6-E	26%	22%	14%	22%	16%
8-B*	0%	1%	2%	89%	8%
8-C	0%	7%	3%	50%	40%
8-D	0%	0%	~0%	29%	71%
8-E	5%	11%	19%	45%	20%
8-F	14%	21%	15%	34%	16%
11-B	20%	47%	22%	7%	4%
14-A	5%	56%	12%	24%	3%
15-A-B	67%	11%	8%	13%	1%
15-A-C	0%	9%	44%	47%	~0%
15-A-D	8%	23%	8%	61%	~0%
15-C-A	0%	2%	12%	85%	1%
15-C-B	12%	16%	19%	52%	1%
15-C-C	10%	15%	8%	66%	1%
15-C-D	11%	22%	19%	47%	1%
15-C-G	8%	28%	16%	47%	1%
16-C-1*	0%	0%	1%	95%	4%
16-C-2	0%	0%	~0%	89%	11%

*Excluded one or more unusually large pebbles, shells (relative to rest of sample) from sieved sample.

CORE SAMPLE ANALYSIS LOG (Cont)

Core Sample	Weight Percentage				
	>9.50mm	2.36-9.50	0.60-2.36	0.075-0.60	<0.075
16-D	0%	0%	2%	48%	50%
16-E	0%	0%	~0%	45%	55%
16-G	12%	33%	38%	13%	4%
17-A-1	0%	0%	34%	58%	8%
17-A-2	6%	53%	38%	2%	1%
17-A-3	0%	28%	52%	17%	3%
18-A	0%	1%	~0%	46%	53%
23-A-1	10%	9%	9%	68%	4%
23-A-2	0%	0%	1%	86%	13%
23-A-3	0%	0%	~0%	61%	39%
23-A-4	0%	0%	~0%	37%	63%
23-A-5	0%	0%	~0%	26%	74%
23-A-6	0%	~0%	~0%	51%	49%
23-A-7	0%	1%	1%	39%	59%
23-A-8	0%	2%	3%	51%	44%
23-A-9	0%	5%	5%	33%	57%
23-A-10	56%	13%	17%	9%	5%
24-A-1*	15%	46%	19%	18%	2%
24-A-2	13%	1%	7%	59%	20%
25-A	0%	~0%	1%	59%	40%
26-B	52%	33%	5%	7%	3%
27-A	0%	~0%	6%	90%	4%
27-C	0%	3%	9%	76%	12%
27-D	0%	0%	~0%	11%	89%
28-B	26%	35%	10%	28%	1%
28-C-1	0%	~0%	~0%	94%	6%
28-C-2	0%	0%	~0%	97%	3%
28-D	0%	0%	~0%	68%	32%
29-B	29%	13%	4%	35%	19%
29-C	0%	4%	3%	44%	49%
30-A	0%	0%	3%	94%	3%
30-B	0%	6%	53%	39%	2%
30-C*	45%	29%	13%	11%	2%

*Excluded one or more unusually large pebbles, shells (relative to rest of sample) from sieved sample.

CORE SAMPLE ANALYSIS LOG (Cont)

Core Sample	Weight Percentage				
	>9.50mm	2.36-9.50	0.60-2.36	0.075-0.60	<0.075
31-A-1	0%	2%	16%	80%	2%
31-A-2*	4%	7%	21%	66%	2%
31-A-3	3%	1%	1%	83%	12%
31-A-B-1	0%	0%	0%	58%	42%
31-A-B-2	0%	0%	~0%	64%	36%
32-A	0%	~0%	22%	72%	6%
32-B	13%	31%	34%	20%	2%
32-C	15%	6%	24%	54%	1%
32-D	60%	35%	3%	1%	1%
32-F	5%	3%	8%	14%	70%
32-G	0%	~0%	2%	92%	6%
33-A	0%	~0%	19%	76%	5%
33-B	79%	10%	4%	6%	1%
33-C	0%	18%	35%	38%	9%
34-A	0%	~0%	35%	63%	2%
34-B	65%	25%	17%	1%	0%
34-B-2	63%	16%	10%	10%	1%
34-B-3	23%	30%	13%	32%	2%
34-B-4	21%	40%	29%	8%	2%
34-B-5	36%	26%	18%	18%	2%
35-A	7%	11%	15%	47%	20%
35-B	0%	21%	9%	25%	45%
36-A	0%	6%	34%	57%	3%
36-B-1*	18%	31%	23%	27%	1%
36-B-2	0%	31%	41%	23%	5%
36-F	0%	1%	1%	69%	29%
37-A	0%	11%	47%	39%	3%
37-B*	60%	18%	8%	12%	2%
38-A	0%	31%	19%	20%	30%
39-A	0%	6%	33%	59%	2%
39-B-1	34%	21%	21%	22%	2%
39-B-2	45%	38%	8%	8%	1%
40-A	0%	33%	29%	29%	9%

*Excluded one or more unusually large pebbles, shells (relative to rest of sample) from sieved sample.

CORE SAMPLE ANALYSIS LOG (Cont)

Core Sample	Weight Percentage				
	>9.50mm	2.36-9.50	0.60-2.36	0.075-0.60	<0.075
40-C	10%	13%	15%	25%	37%
40-G	0%	0%	1%	49%	50%
42-A	0%	0%	~0%	40%	60%
43-A	0%	1%	4%	54%	41%
43-D	4%	6%	49%	39%	2%
44-A-1	0%	0%	1%	71%	28%
44-A-2	0%	0%	~0%	40%	60%
44-A-3	0%	0%	~0%	12%	88%
44-A-4	0%	0%	1%	10%	89%
44-B	0%	0%	~0%	3%	97%
45-A	62%	7%	6%	20%	5%
45-B	17%	14%	4%	62%	3%
45-C	0%	3%	6%	57%	34%

4.6

APPENDIX V

GRAB SAMPLE ANALYSIS LOG - Grain Size Analysis

Color	Grab Sample	Weight Percentage				
		>9.50 mm	2.36-9.50	0.60-2.36	0.075-0.60	<0.075
5Y4/1	G1	52%	20%	13%	15%	~0%
5Y4/4	G-2	21%	43%	34%	2%	~0%
5Y5/2	G-3*	5%	6%	59%	30%	~0%
5Y5/2	G-4**					
5Y5/2	G-5	5%	23%	44%	27%	1%
5Y5/6	G-6**					
5Y4/2	G-8	49%	21%	13%	17%	0%
5Y4/2	G-9*	23%	46%	15%	16%	~0%
5Y4/1	G-10*	53%	32%	6%	9%	~0%
5Y4/2	G-11**					
5Y4/2	G-12	41%	25%	15%	19%	~0%
5Y4/4	G-13*	19%	21%	15%	45 ~~95%~~	~0%
5Y3/2	G-14	0%	0%	1%	88%	11%
†	G-15** (alge & pebbles only)					
††	G-16	61%	22%	4%	13%	~0%
5Y5/2	G-17**					
5Y4/2	G-18	70%	23%	3%	4%	0
5Y5/2	G-19**					
5Y3/2	G-20*	44%	28%	15%	13%	~0%
5Y4/2	G-22**					
†	G-23**					
10Y3/2	G-24**					
†	G-25**					
5Y3/2	G-26	0%	0%	~0%	90%	10%
††	G-27	14%	28%	17%	40%	1%
5Y3/2	G-28**					
5Y4/2	G-29	0%	~0%	2%	15%	83%

*Excluded one or more unusually large pebbles, cobbles, shells (relative to rest of sample) from sieved sample

**Sample not sieved due to dominance of coarser sediment (> 9.50 mm)

†Color not assigned due to dominance of coarser sediment (Note: where color is assigned to coarse sediment, it refers to the small amount of sand)

††Color not assigned—entire sample previously removed and sieved.

GRAB SAMPLE ANALYSIS LOG (Cont)

Color	Grab Sample	Weight Percentage				
		>9.50 mm	2.36-9.50	0.60-2.36	0.075-0.60	< 0.075
5Y5/2	G-30	~0%	~0%	0%	25%	75%
5Y2/1	G-32	64%	11%	2%	13%	10%
5Y3/2	G-33**					
5Y3/2	G-34**					
††	G-35	48%	34%	16%	2%	~0%
††	G-36	71%	15%	9%	5%	~0%
5YR2/1	G-37	39%	40%	17%	4%	~0%
5Y3/2	G-38	77%	10%	6%	7%	~0%
5Y3/2	G-39	27%	40%	22%	11%	~0%
5Y5/2	G-40	57%	16%	8%	18%	1%
10Y3/2	G-41	47%	30%	13%	10%	0%
10Y9/2	G-42*	0%	5%	3%	28%	64%
†	G-43**					
5Y3/2	G-44	0%	3%	1%	57%	39%
5Y3/2	G-45	0%	~0%	2%	83%	15%
10YR4/2	G-46	0%	3%	~0%	95%	2%
††	G-47*	58%	20%	5%	16%	1%
††	G-48*	0%	53%	29%	17%	1%
(No color	G-49** (Consolidated clay & pebbles)					
assigned	G-51*	23%	32%	32%	12%	1%
after G-48)	G-52	0%	2%	1%	41%	56%
	G-53*	0%	0%	1%	58%	41%
	G-54	0%	4%	~0%	58%	38%
	G-55	0%	0%	~0%	96%	4%
	G-56	0%	9%	2%	85%	4%
	G-57	0%	0%	~0%	40%	60%
	G-58*	0%	5%	3%	35%	57%
	G-59	0%	0%	~0%	73%	27%
	G-60	0%	1%	~0%	81%	18%
	G-61	0%	0%	1%	63%	36%
	G-62	0%	6%	1%	43%	50%
	G-63*	19%	26%	45%	8%	2%
	G-64	0%	0%	~0%	46%	54%
	G-65	0%	~0%	~0%	59%	41%
	G-66	0%	0%	1%	52%	47%

*Excluded one or more unusually large pebbles, cobbles, shells (relative to rest of sample) from sieved sample

**Sample not sieved due to dominance of coarser sediment (> 9.50 mm)

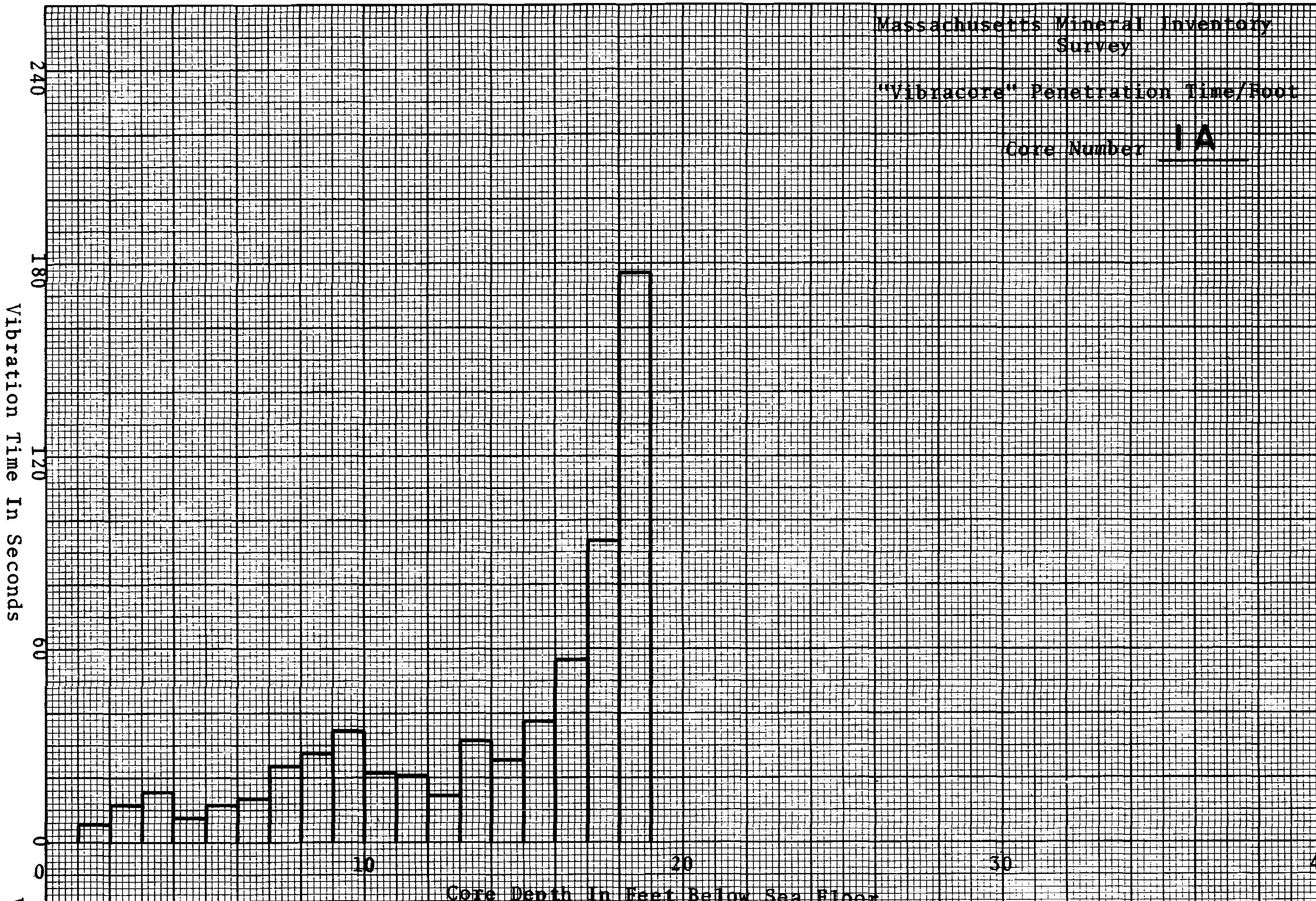
†Color not assigned due to dominance of coarser sediment (Note: where color is assigned to coarse sediment, it refers to the small amount of sand)

††Color not assigned—entire sample previously removed and sieved.

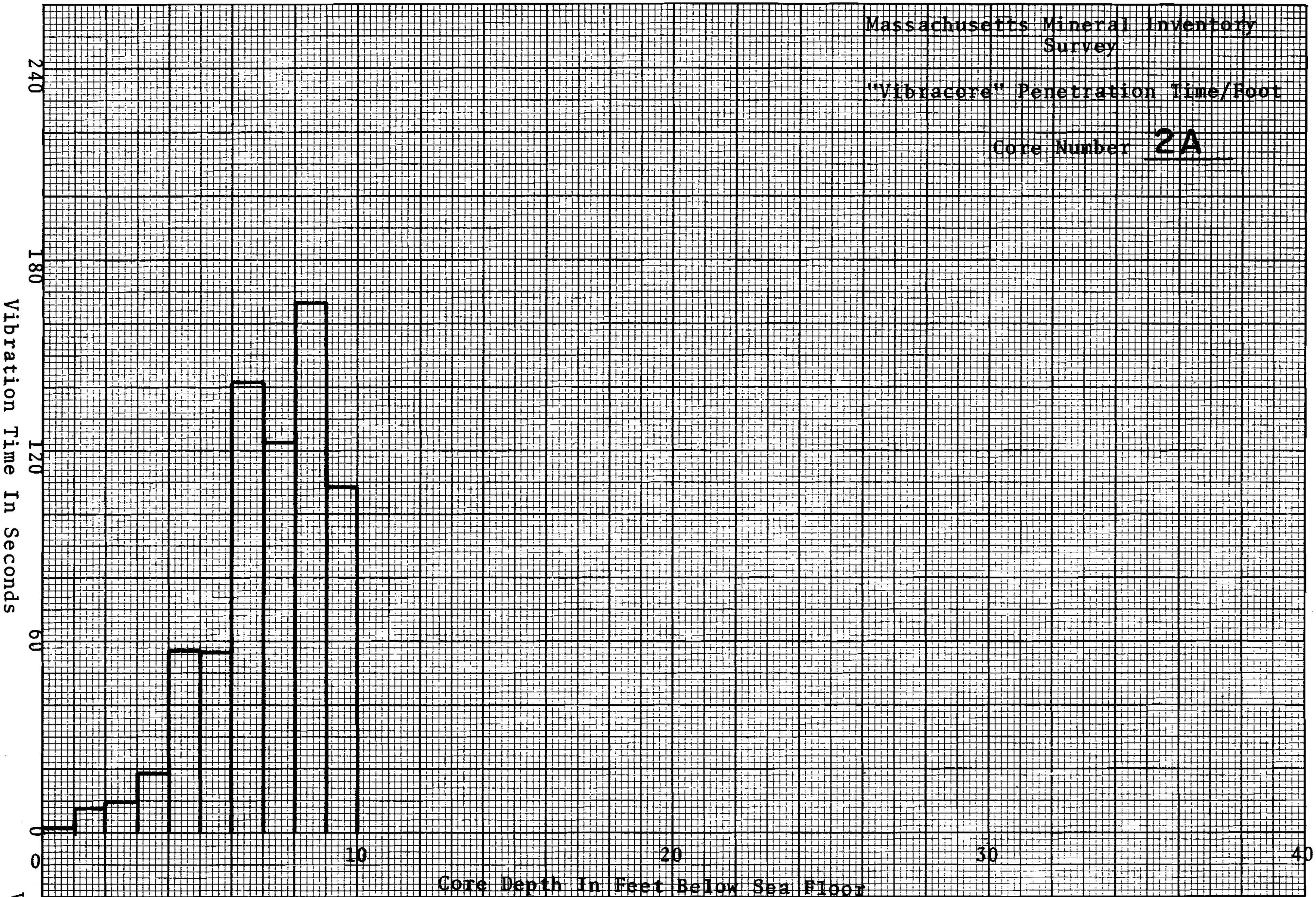
APPENDIX VI

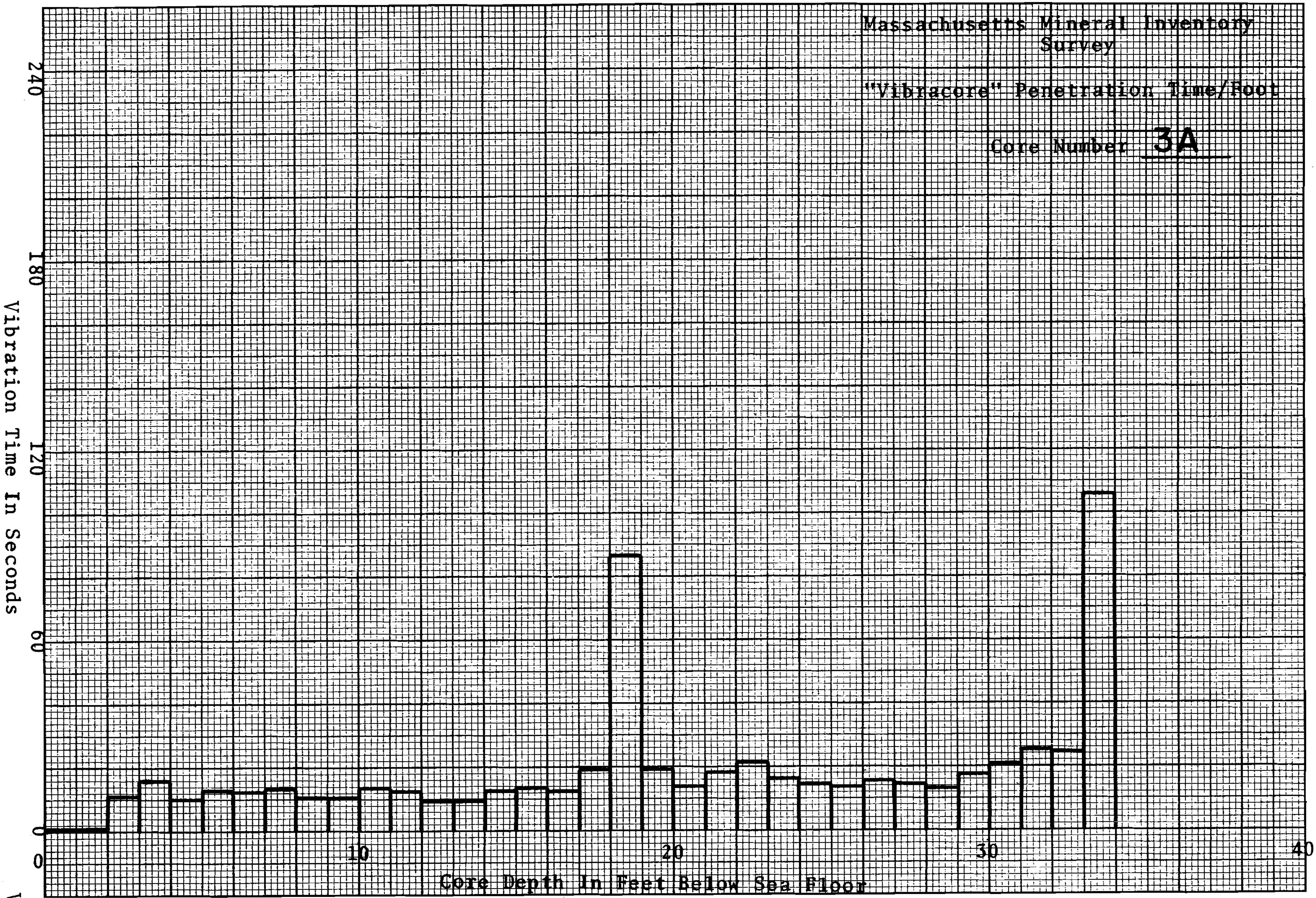
MASSACHUSETTS MINERAL INVENTORY SURVEY

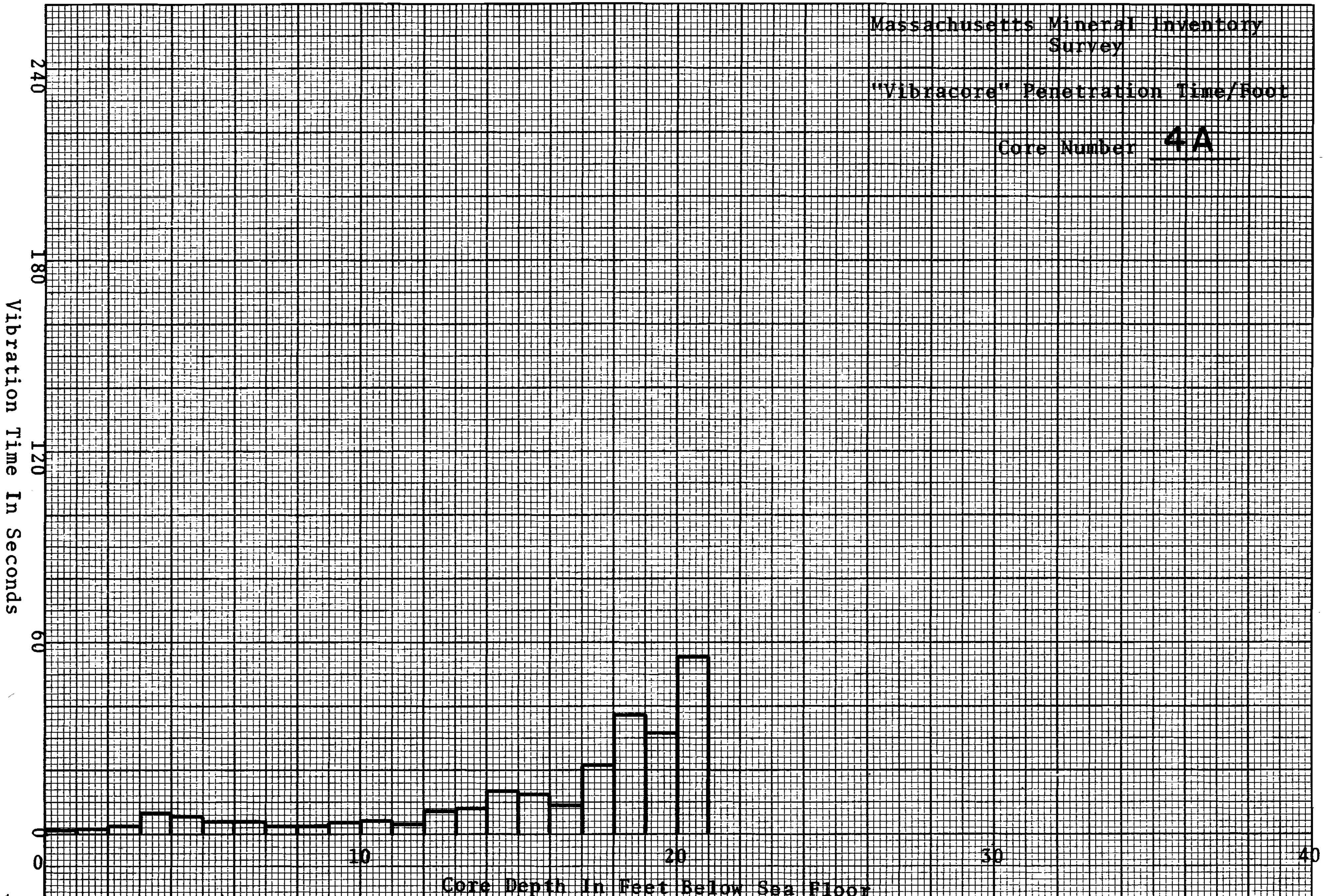
CORE PENETROMETER GRAPHS



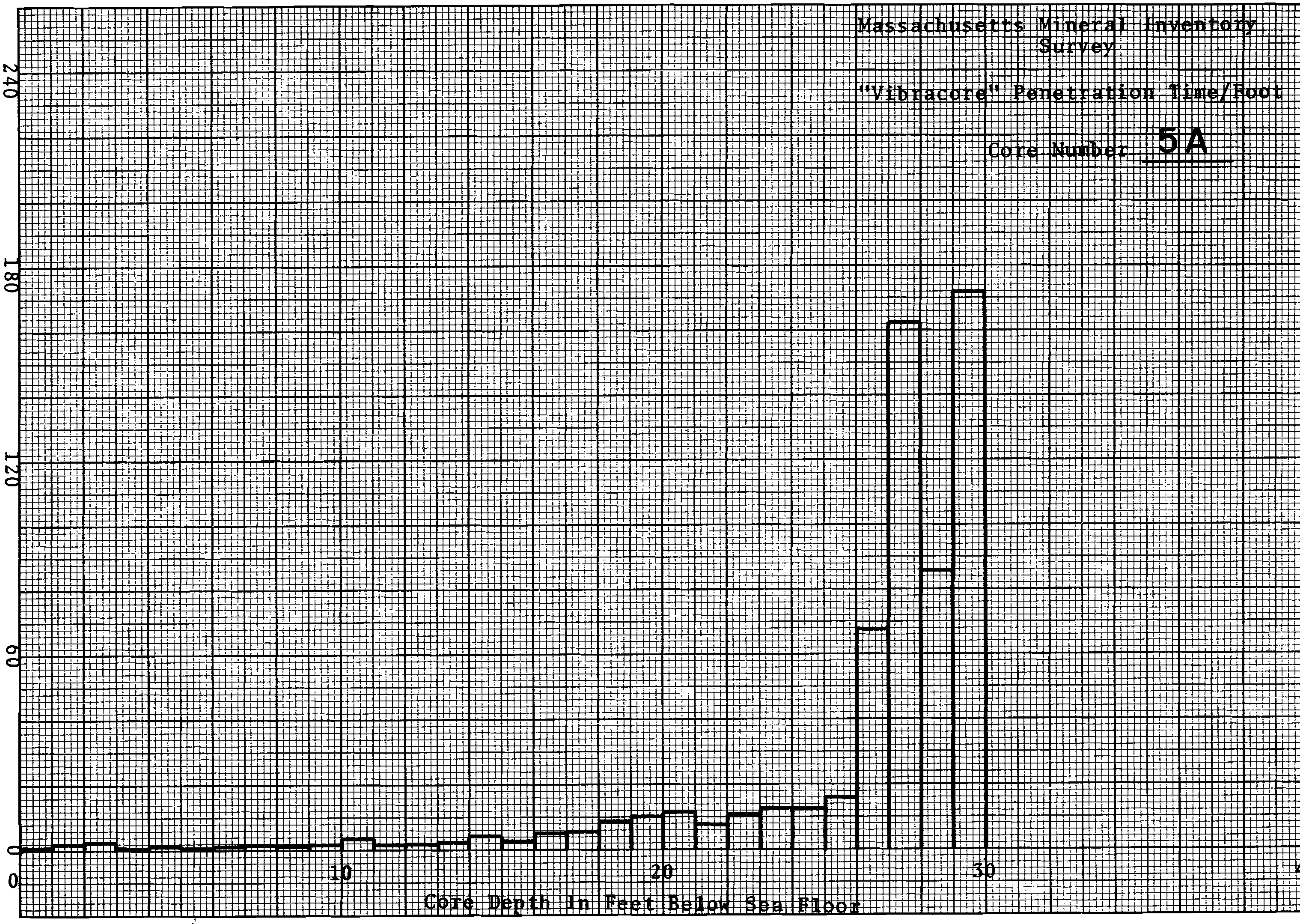
Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 1A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor


Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 2A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

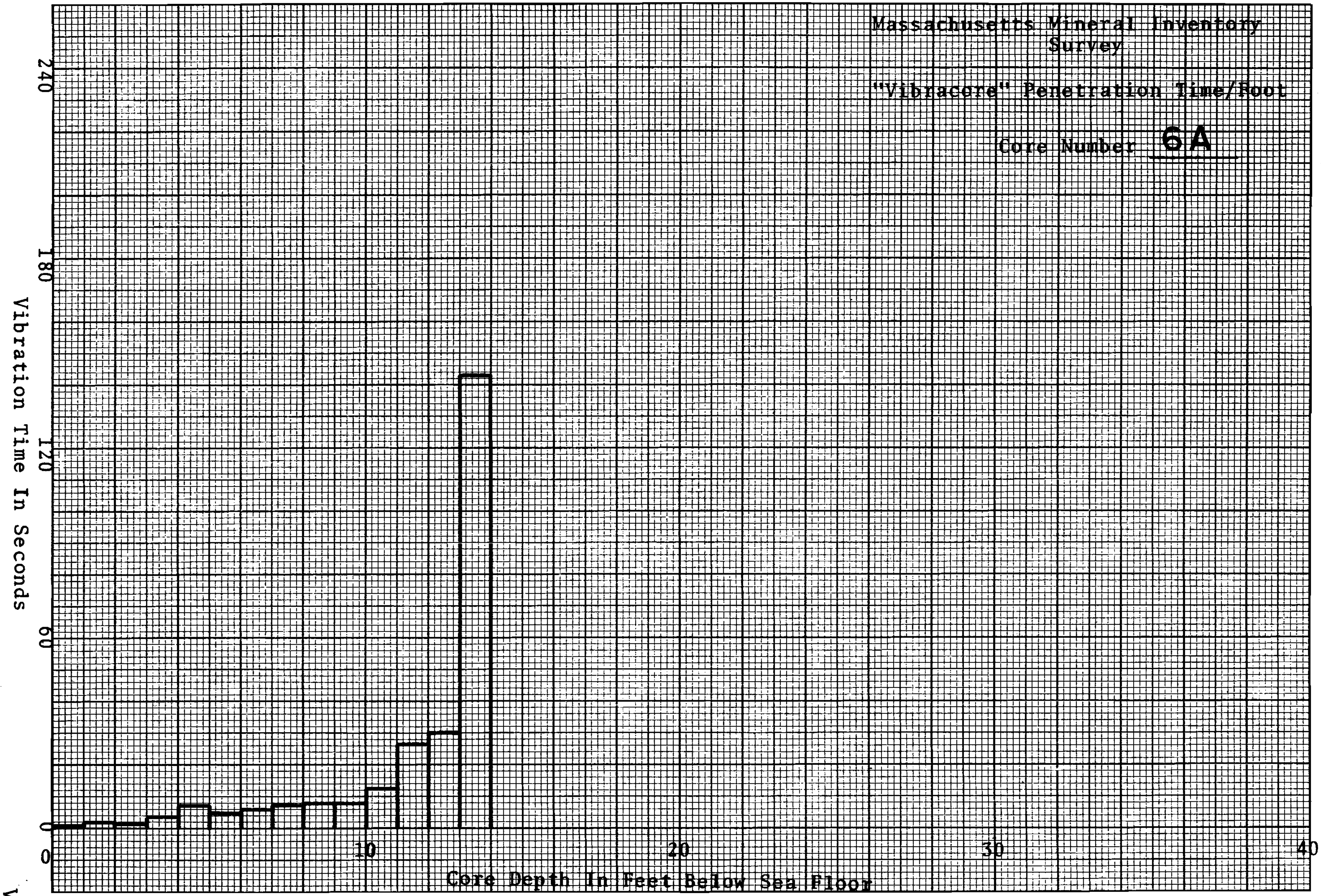

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 3A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

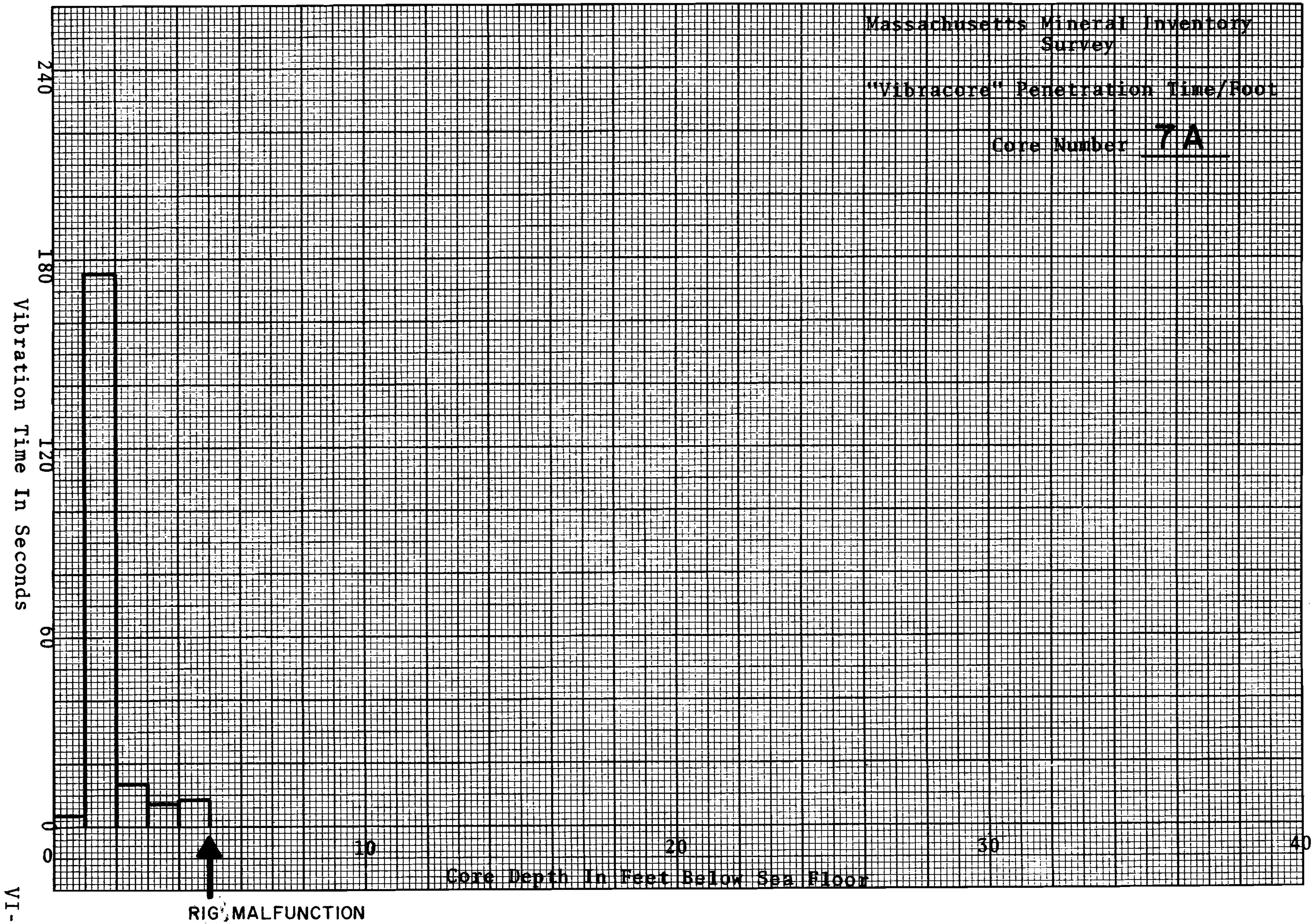


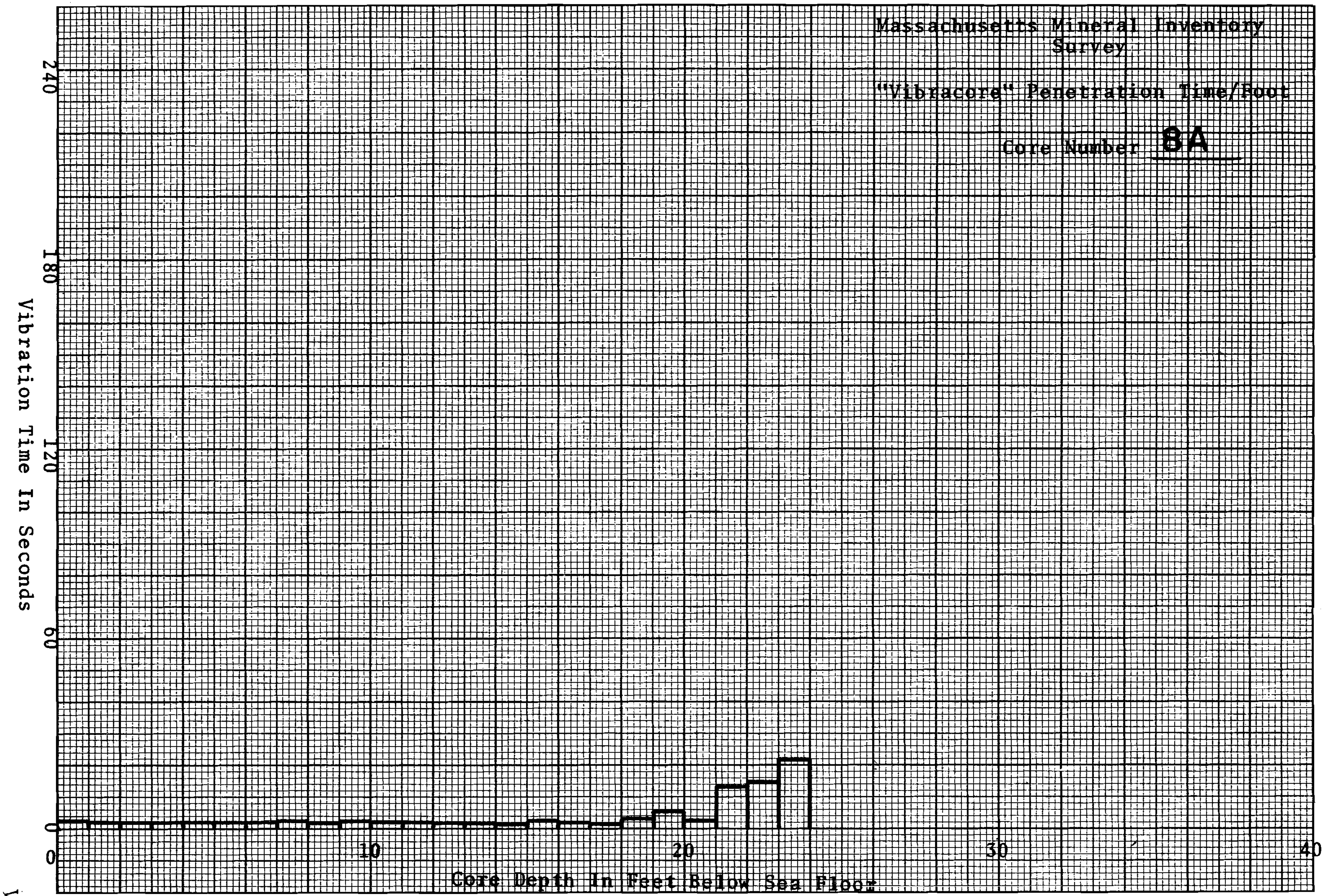
Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 4A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor



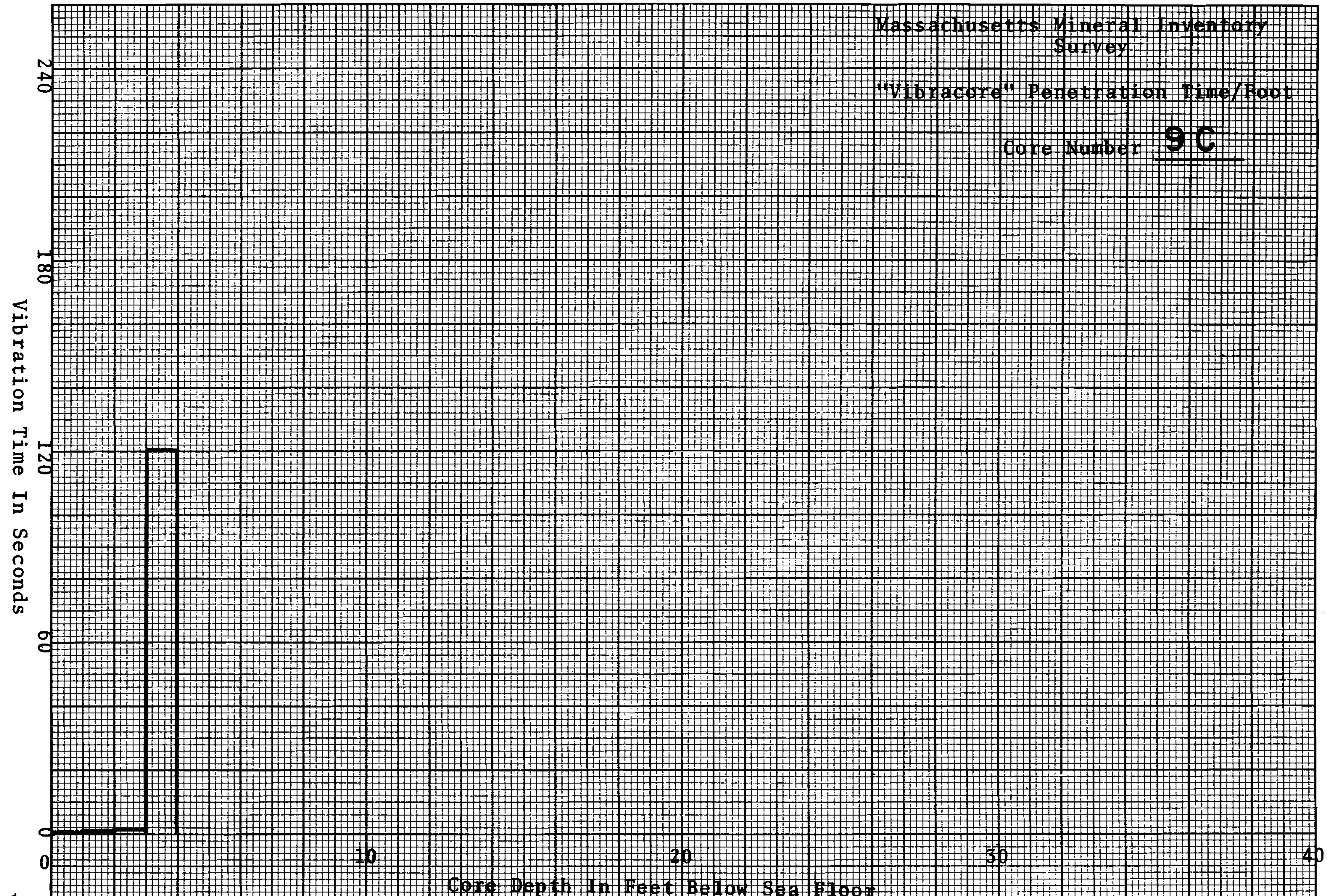
Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 5A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

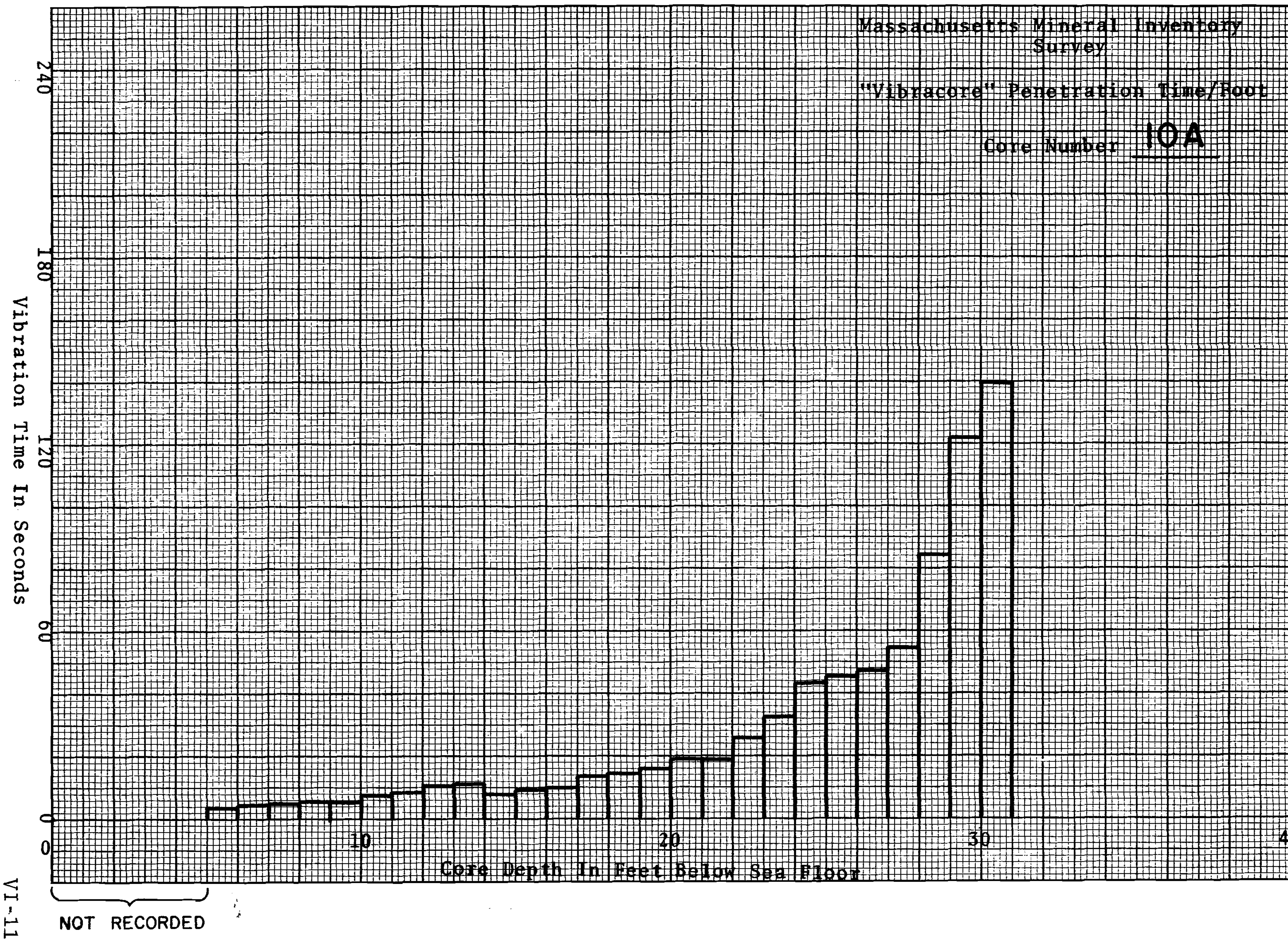

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 6A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

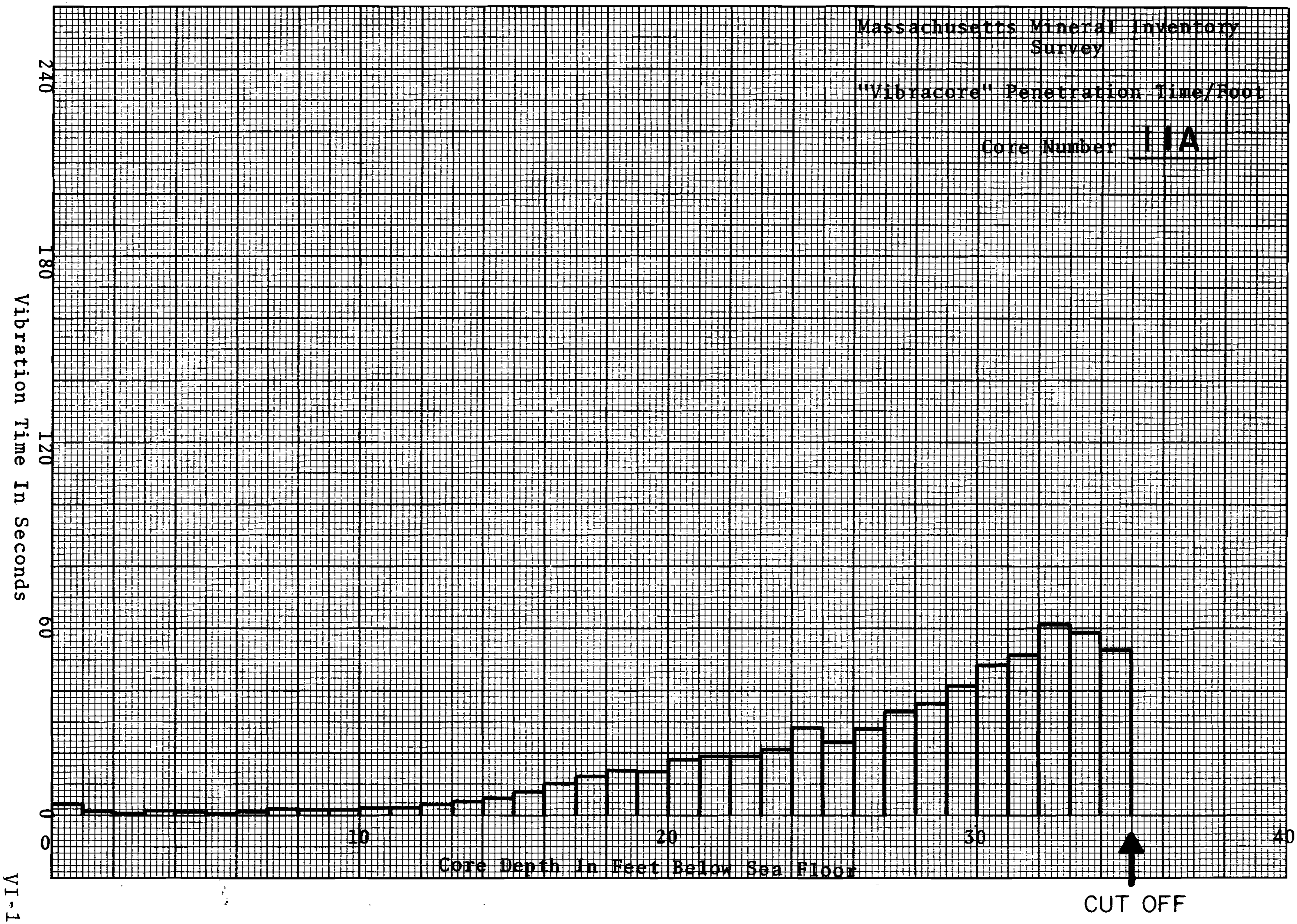

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 7A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor
RIG MALFUNCTION

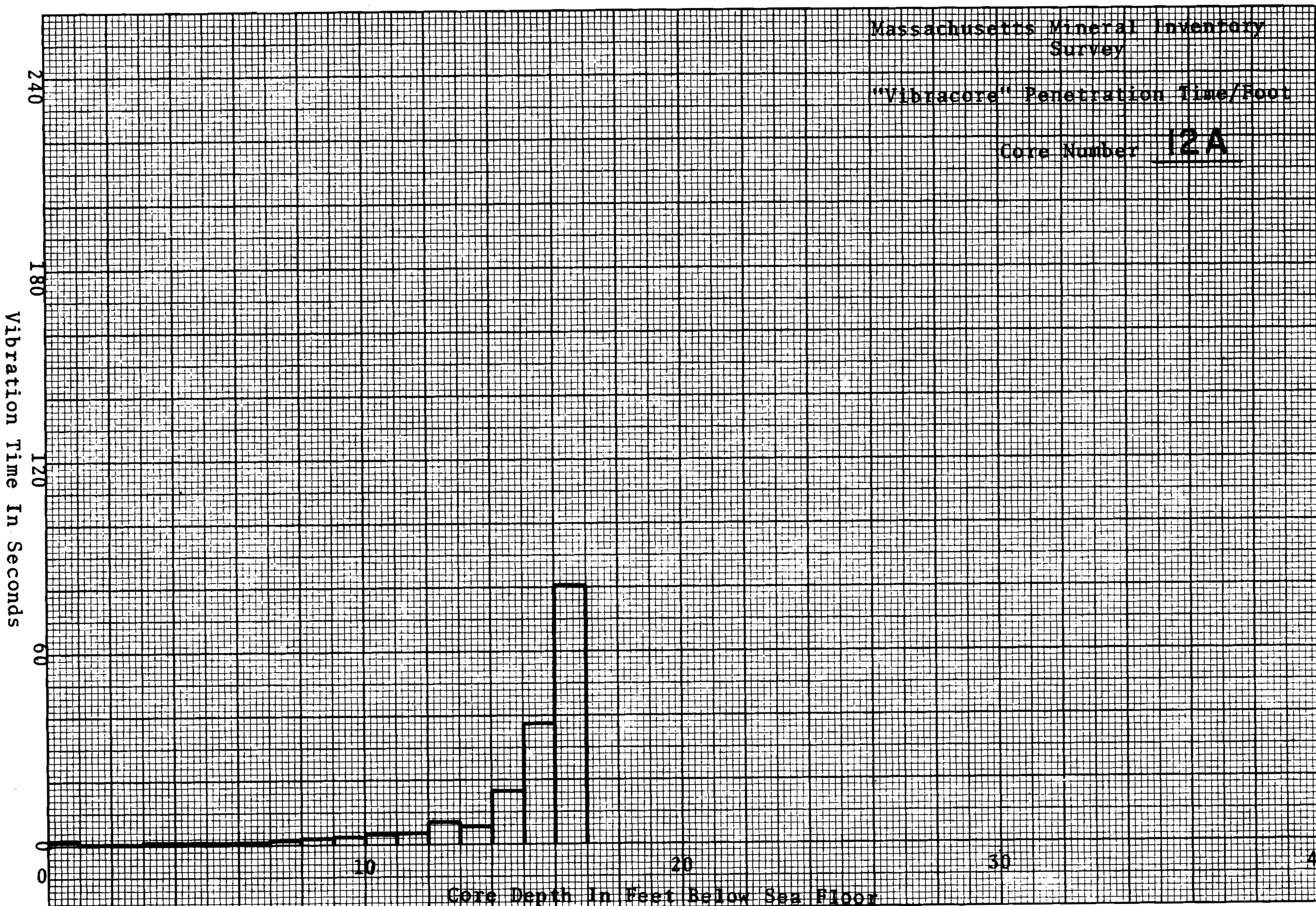


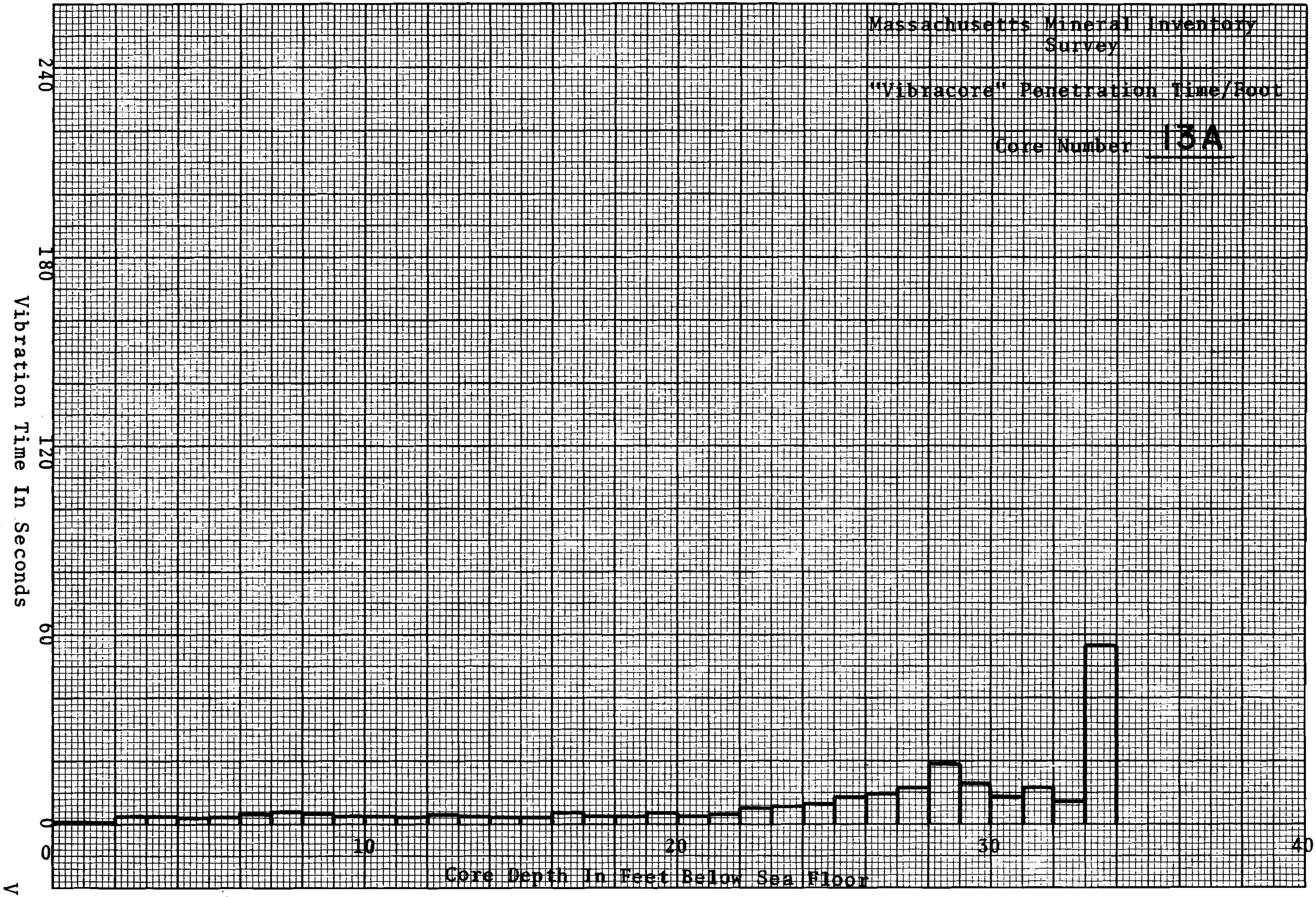
Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 8A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor


Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 9C
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

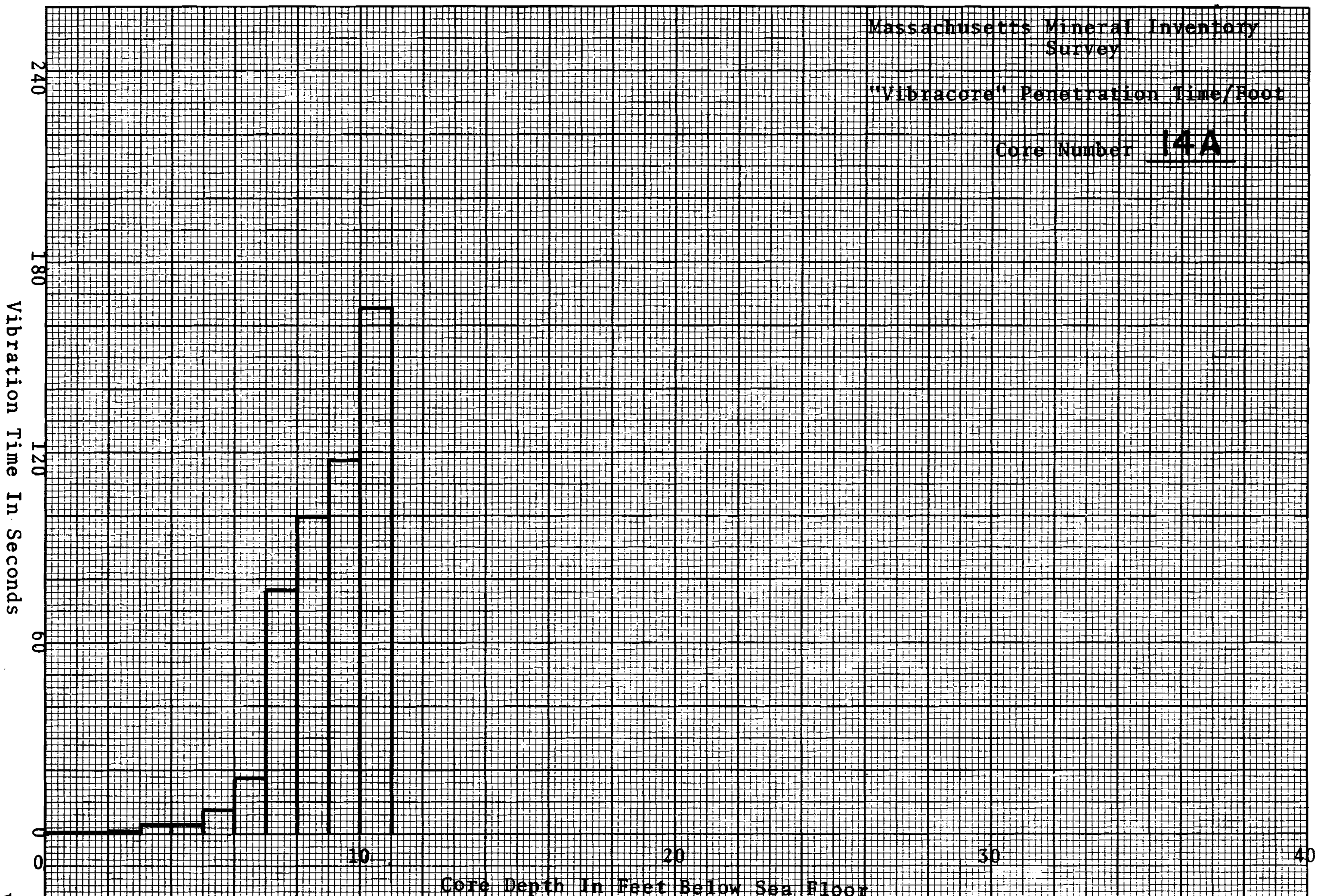

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 10A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor
NOT RECORDED


Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 11A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor
CUT OFF

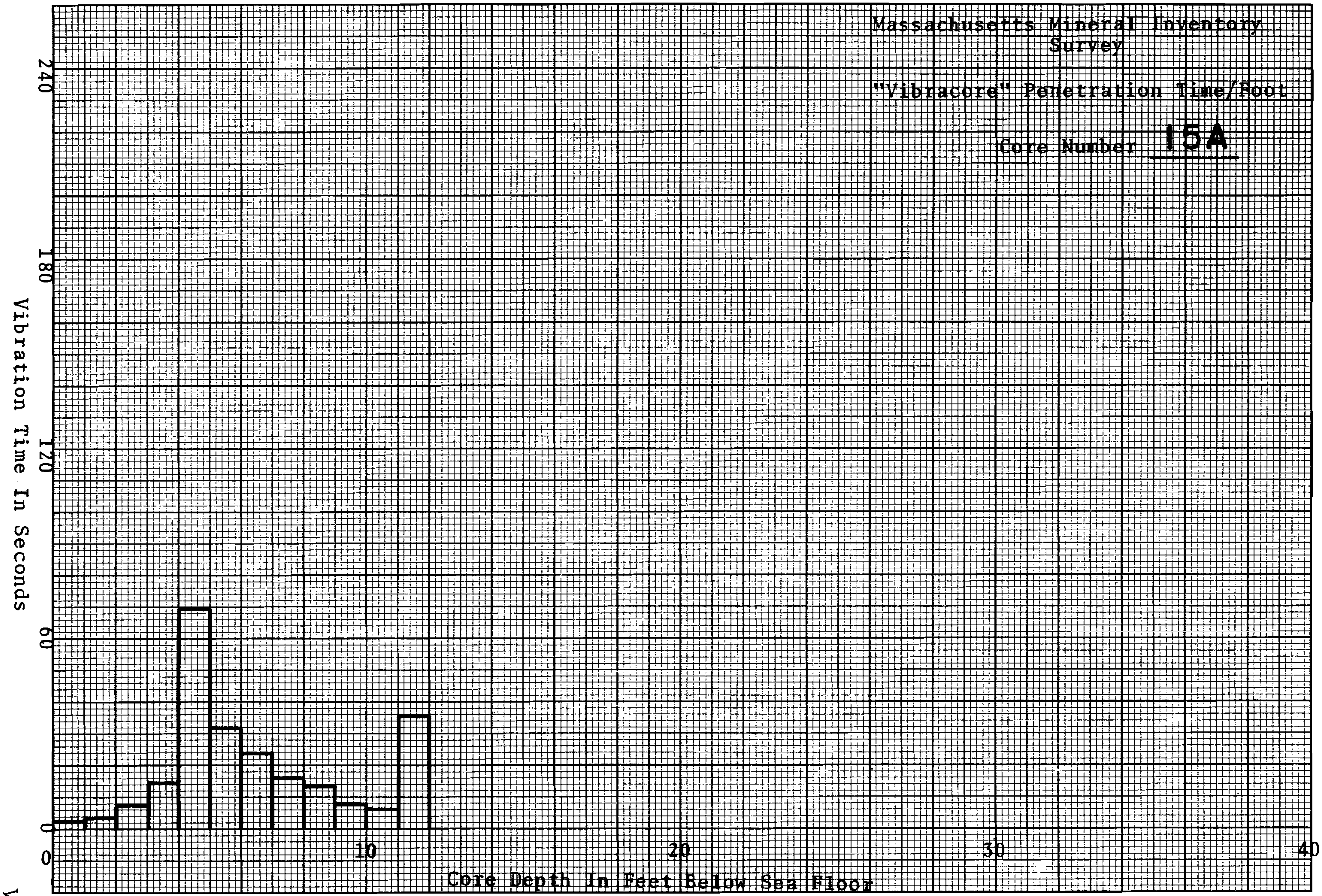

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 12A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor



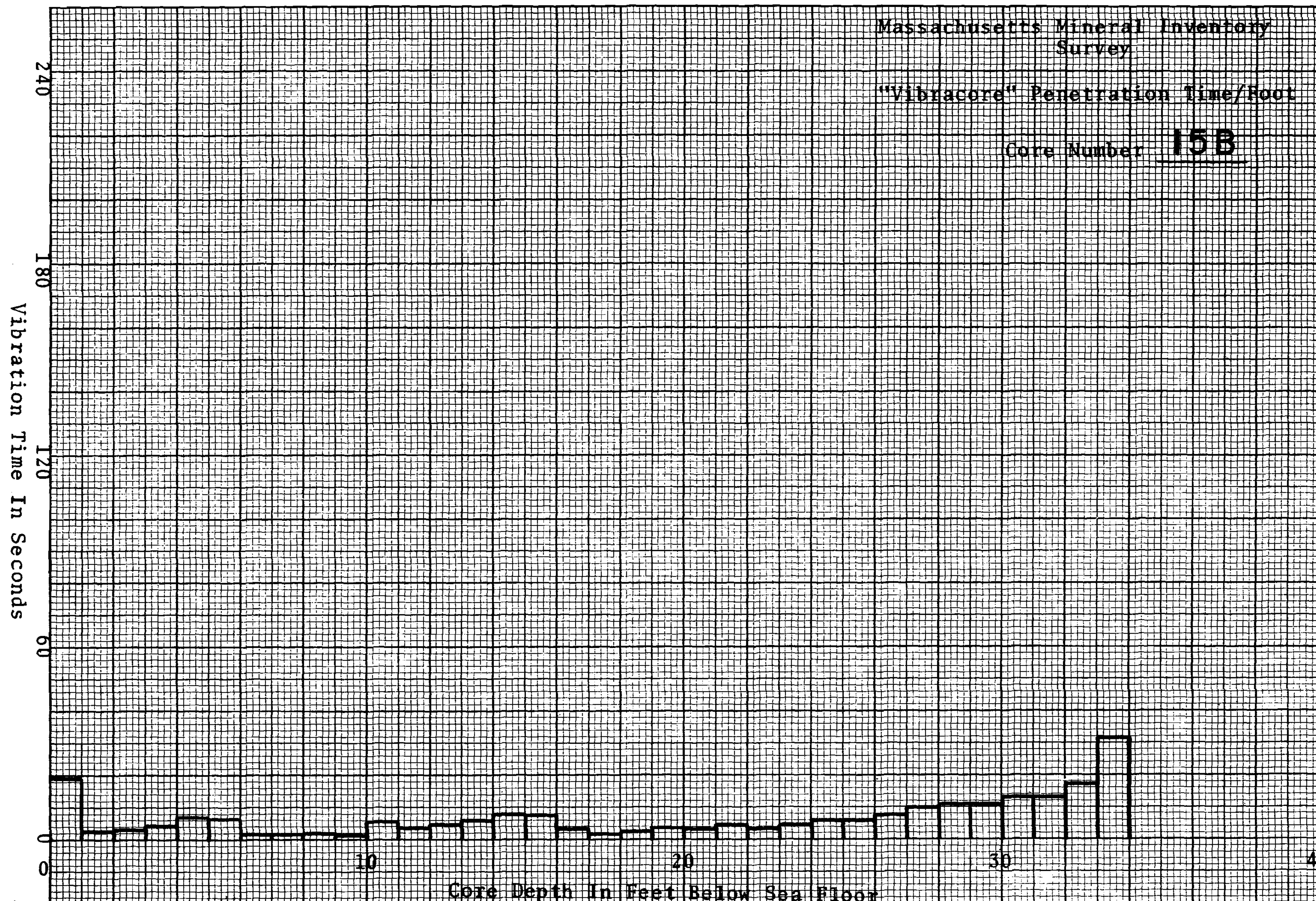
Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 13A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor



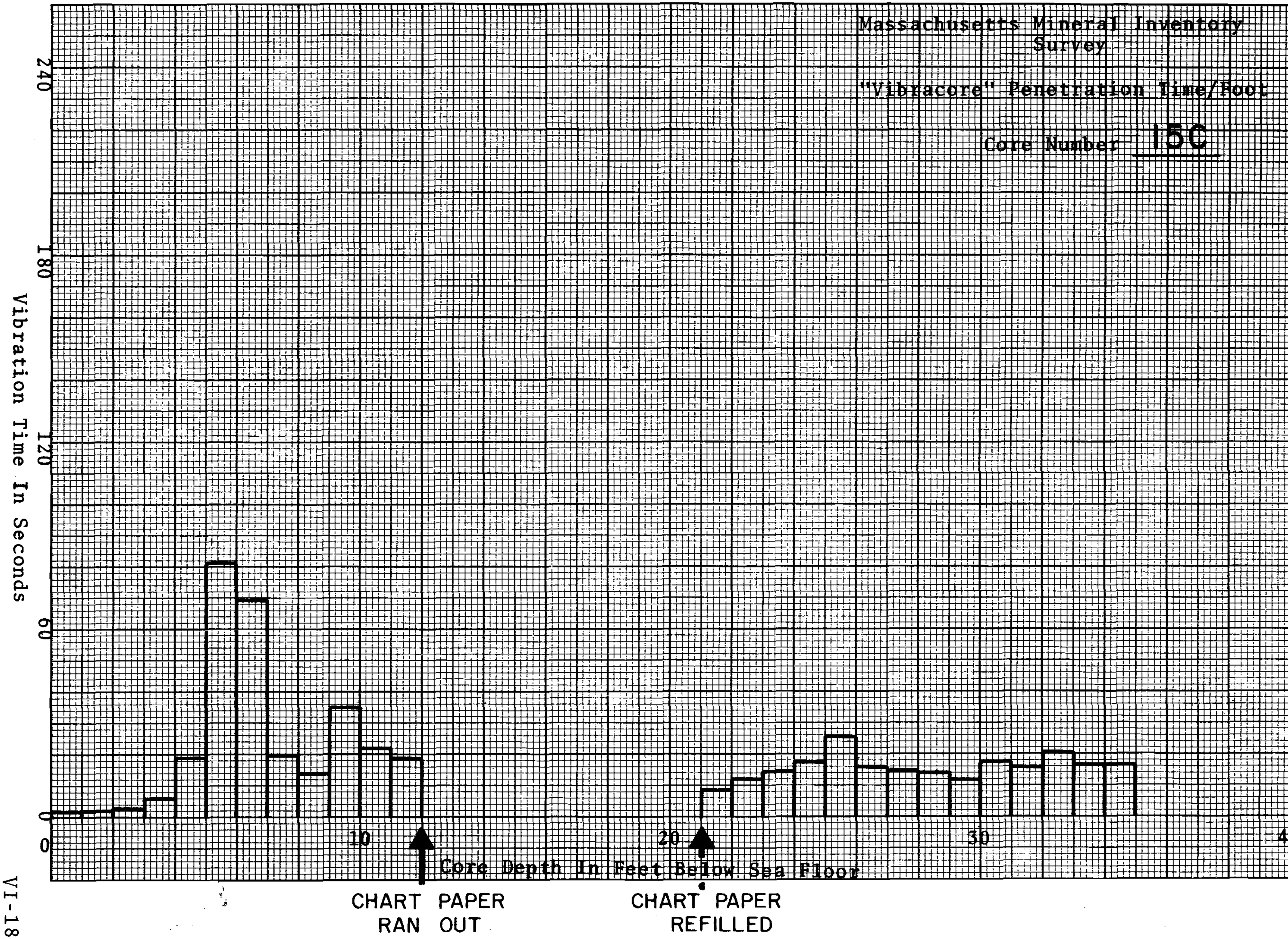
Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 14A
Vibration Time In Seconds
0
60
120
180
240
Core Depth In Feet Below Sea Floor
0
10
20
30
40

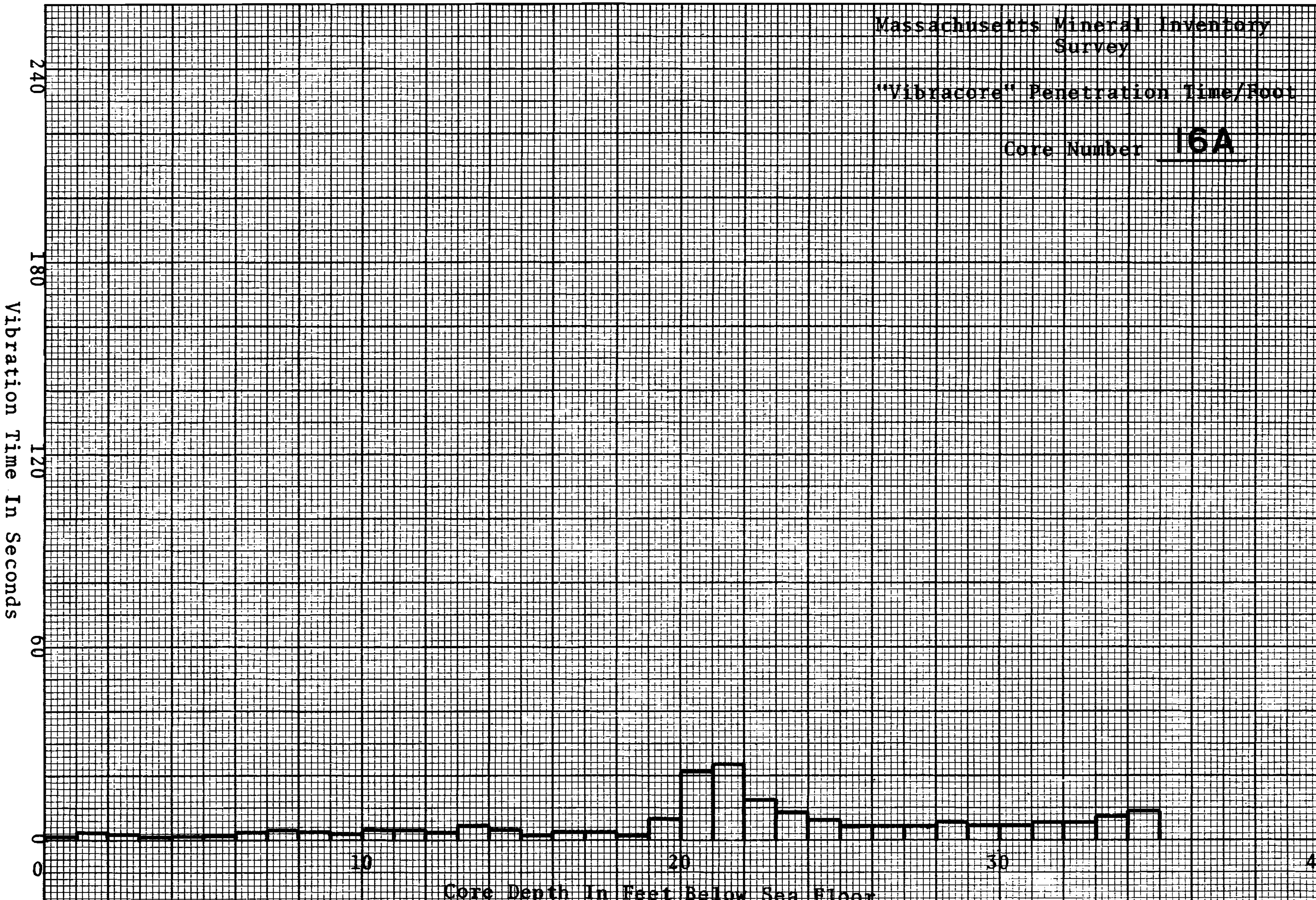


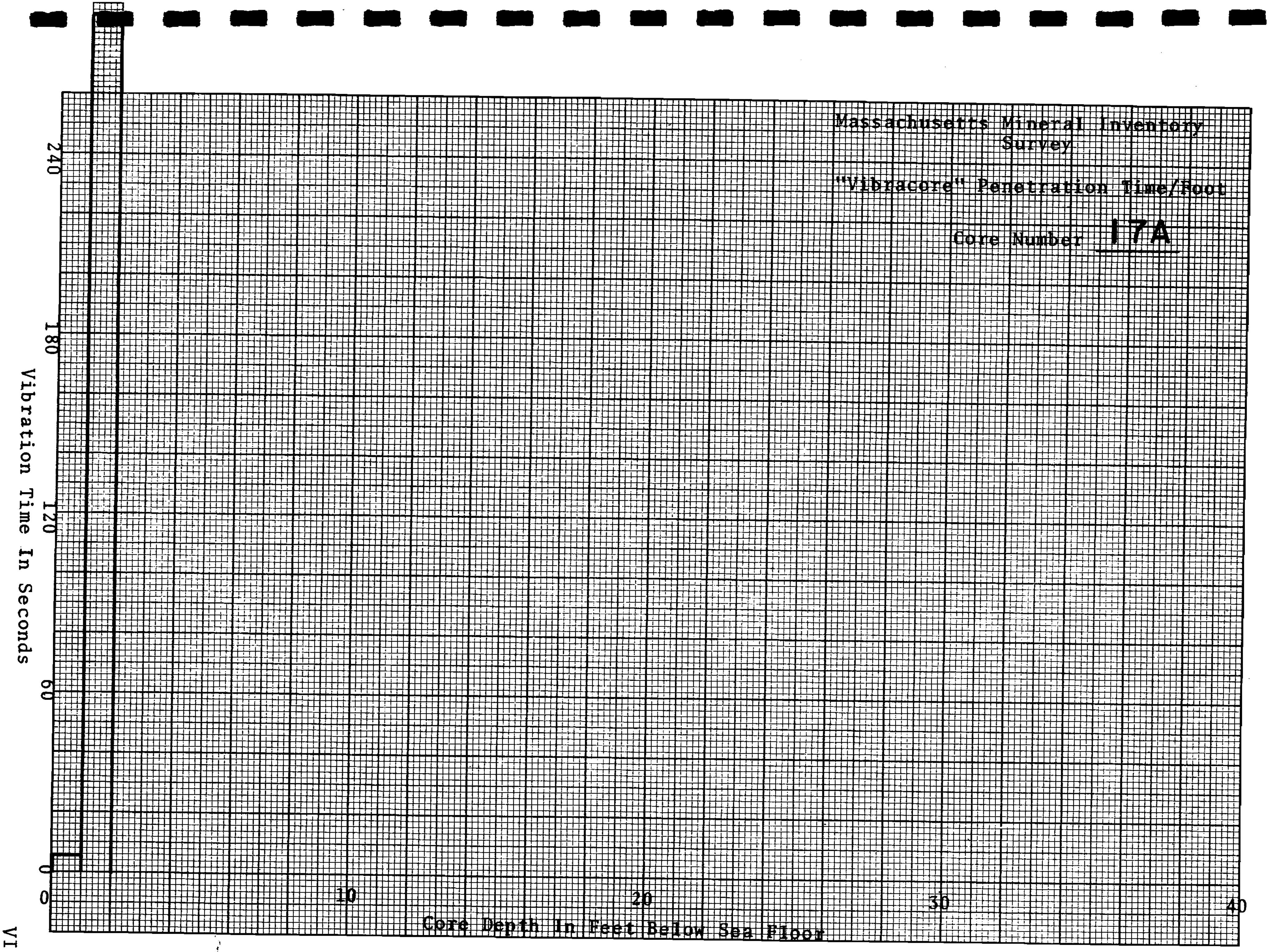
Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 15A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

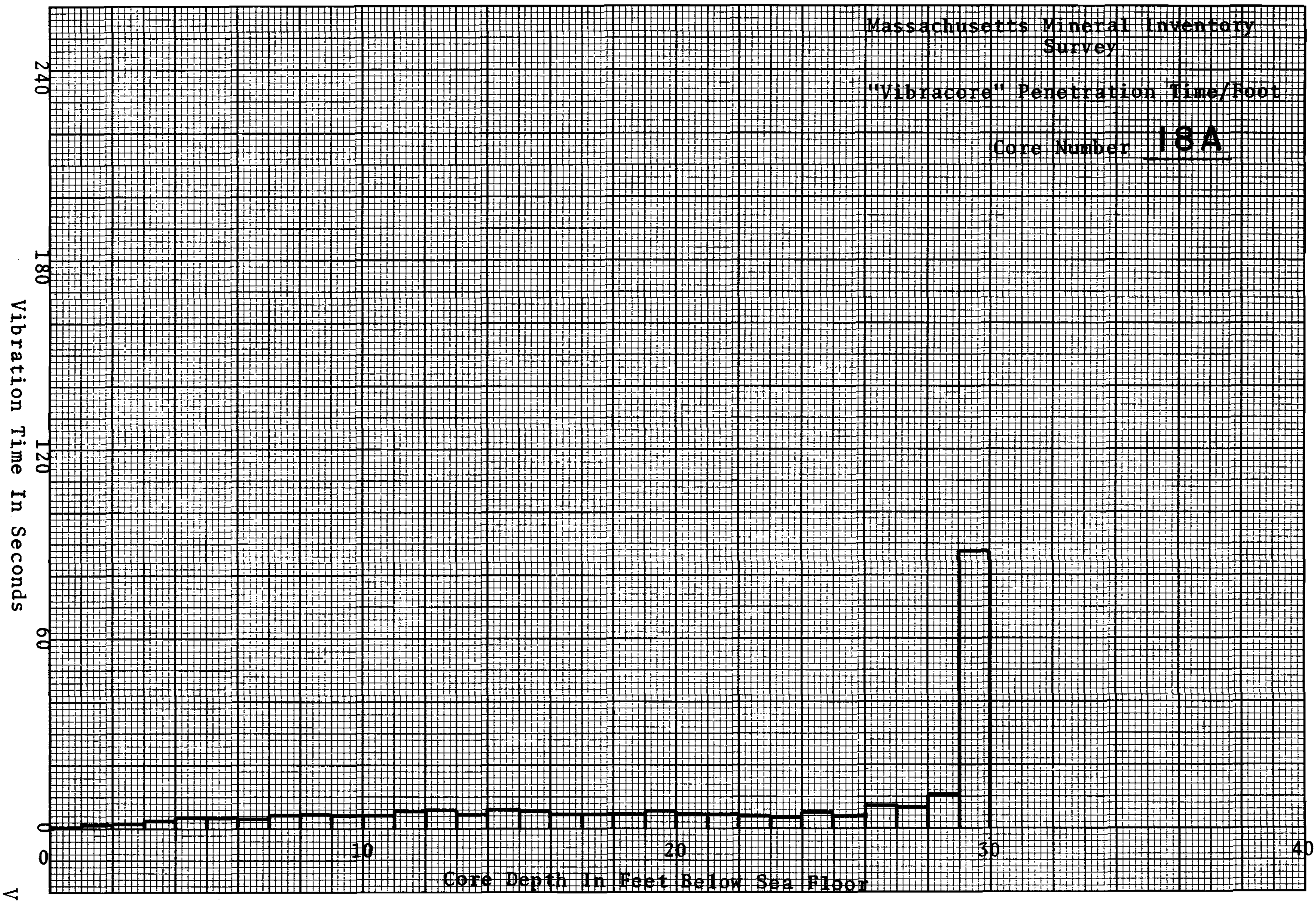


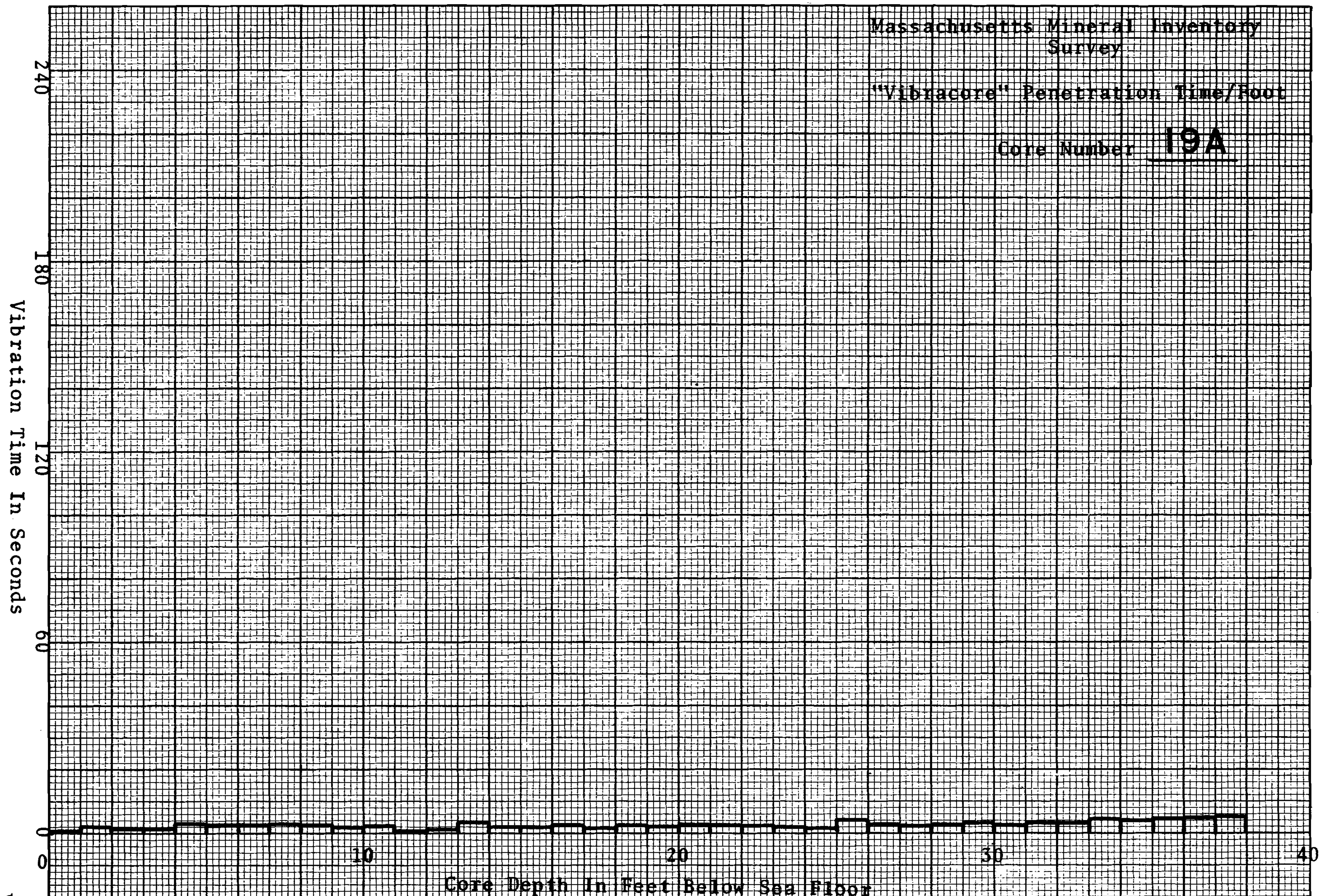
Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 15B
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

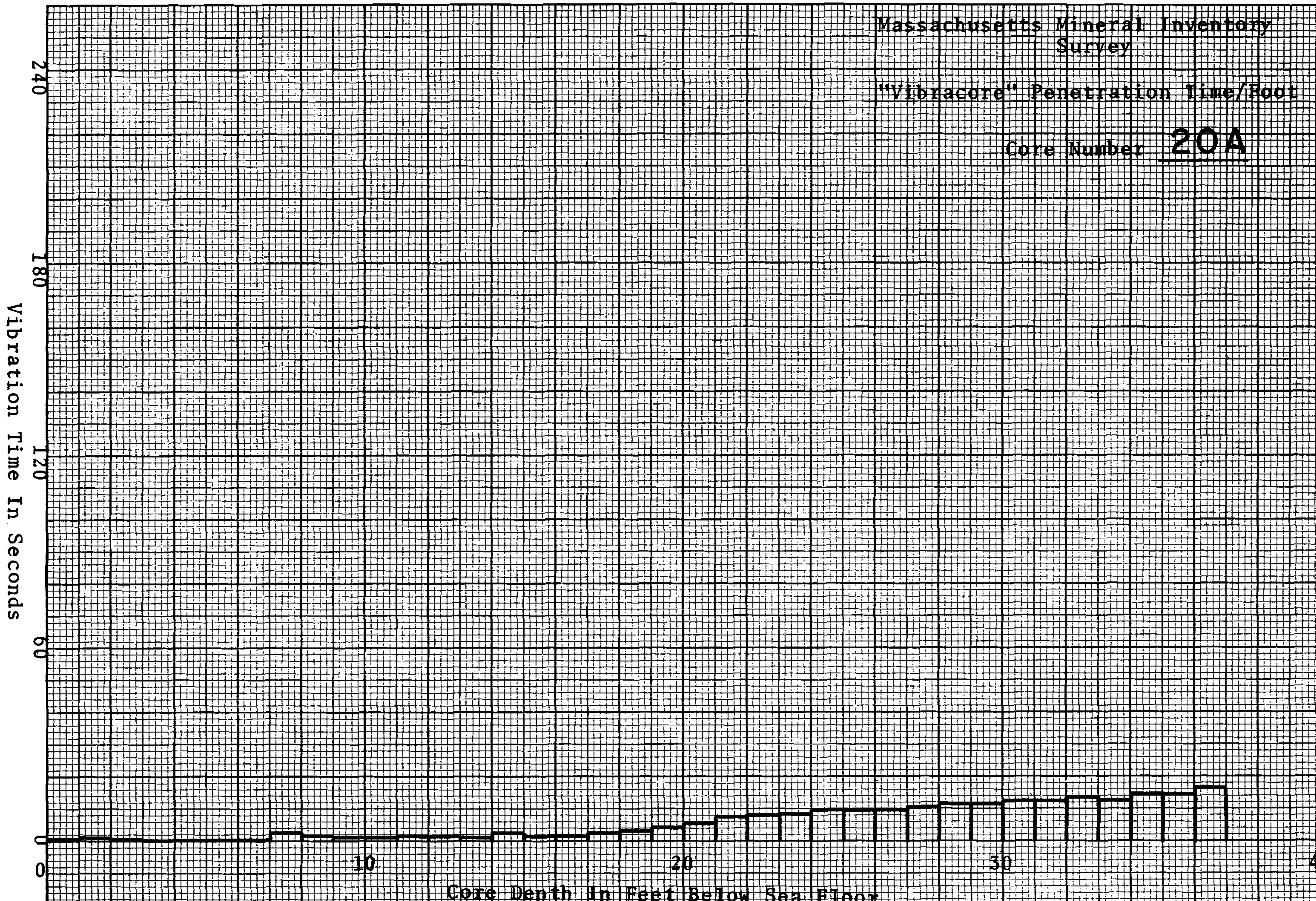

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 15C
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor
CHART PAPER RAN OUT
CHART PAPER REFILLED

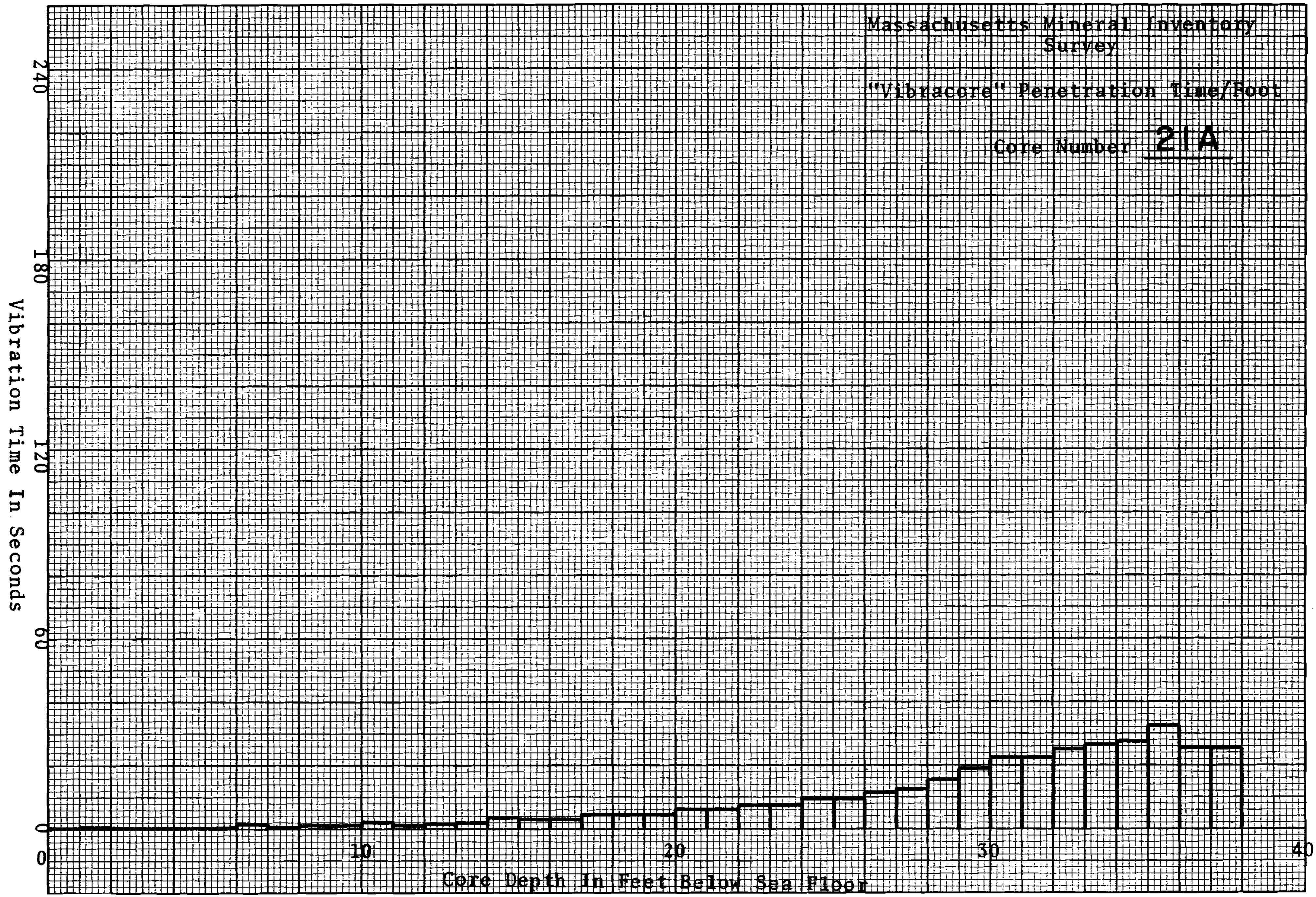

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 16A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

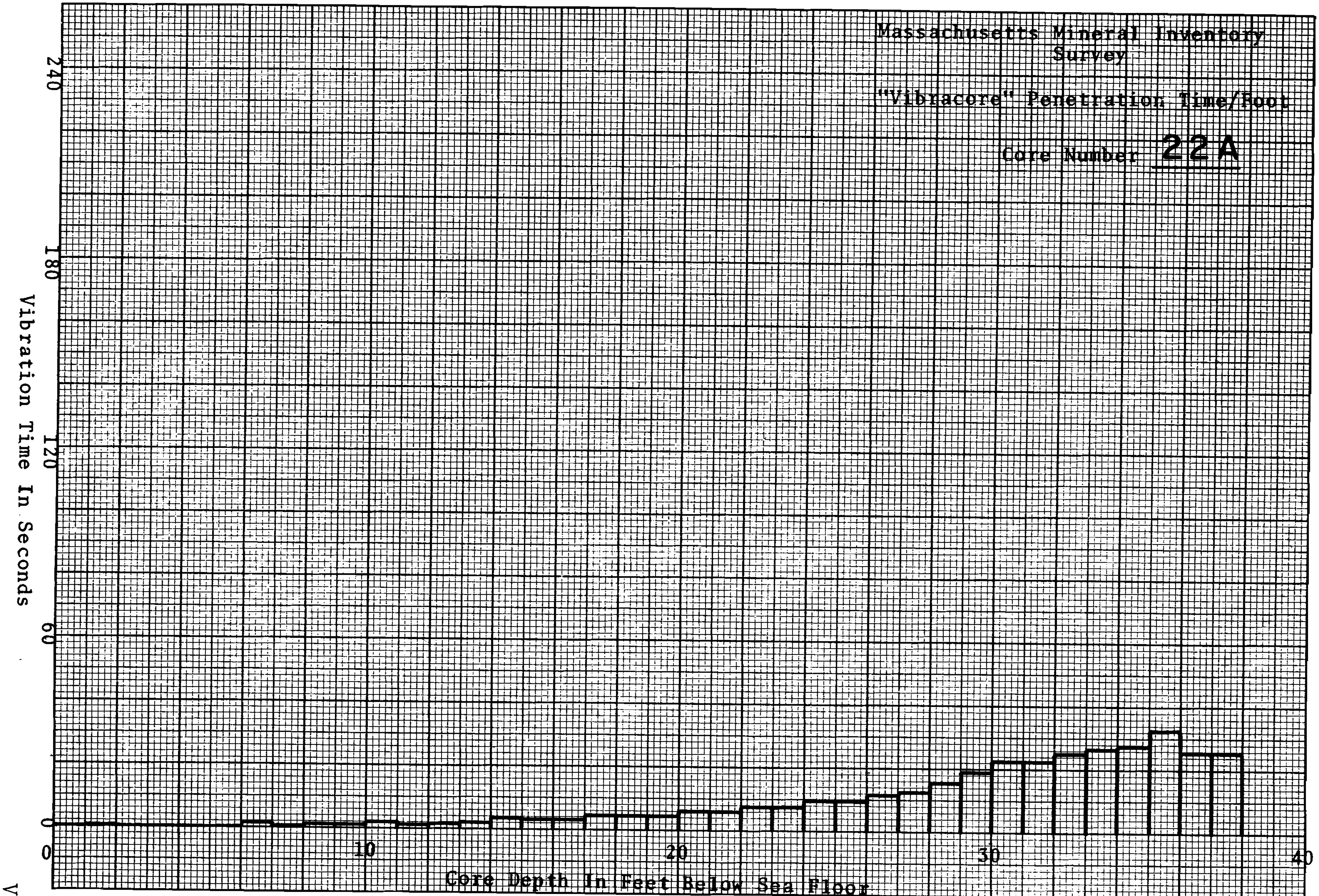

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 17A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor


Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 18A
Vibration Time In Seconds
0
60
120
180
240
0
10
20
30
40
Core Depth In Feet Below Sea Floor

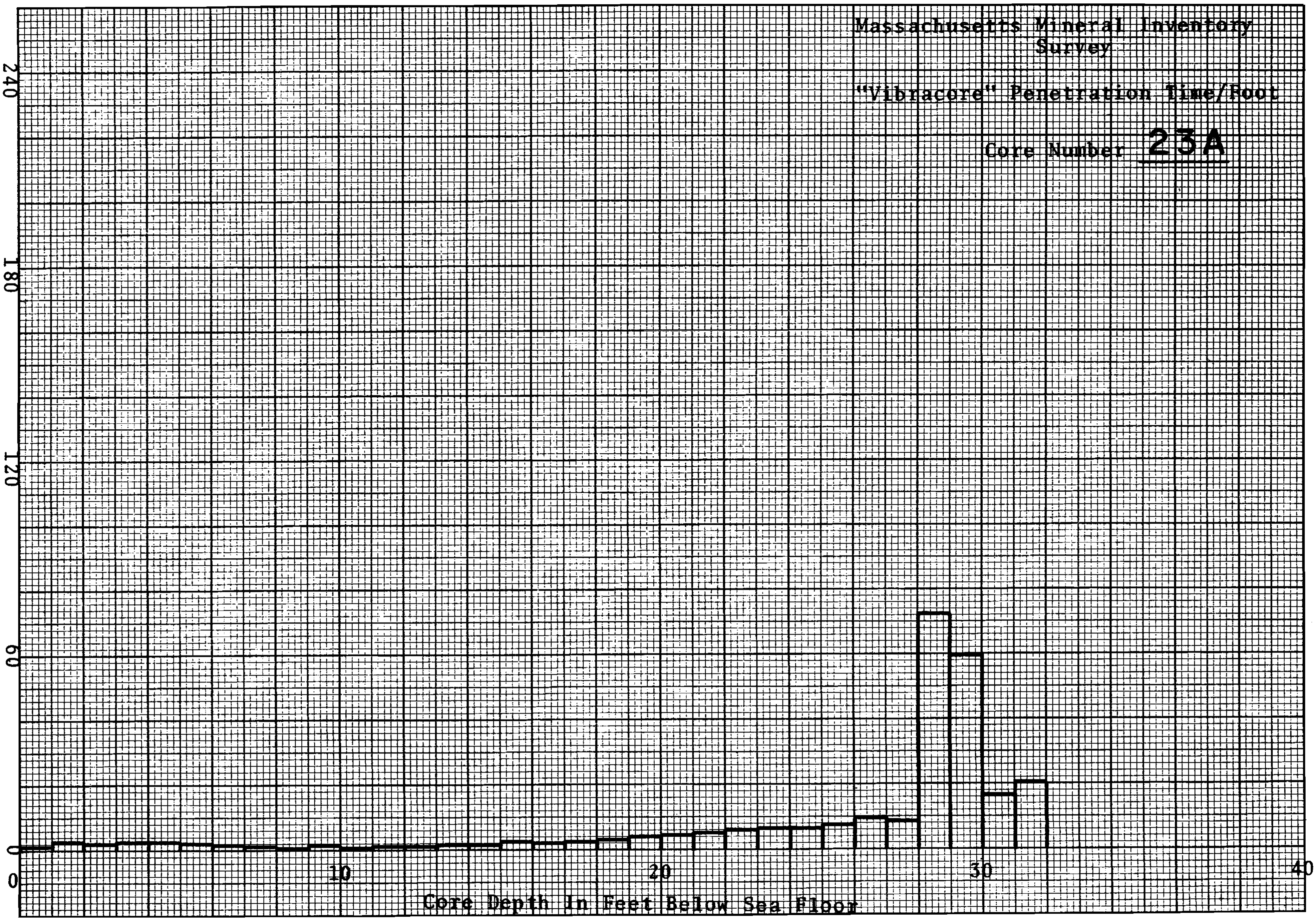

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 19A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

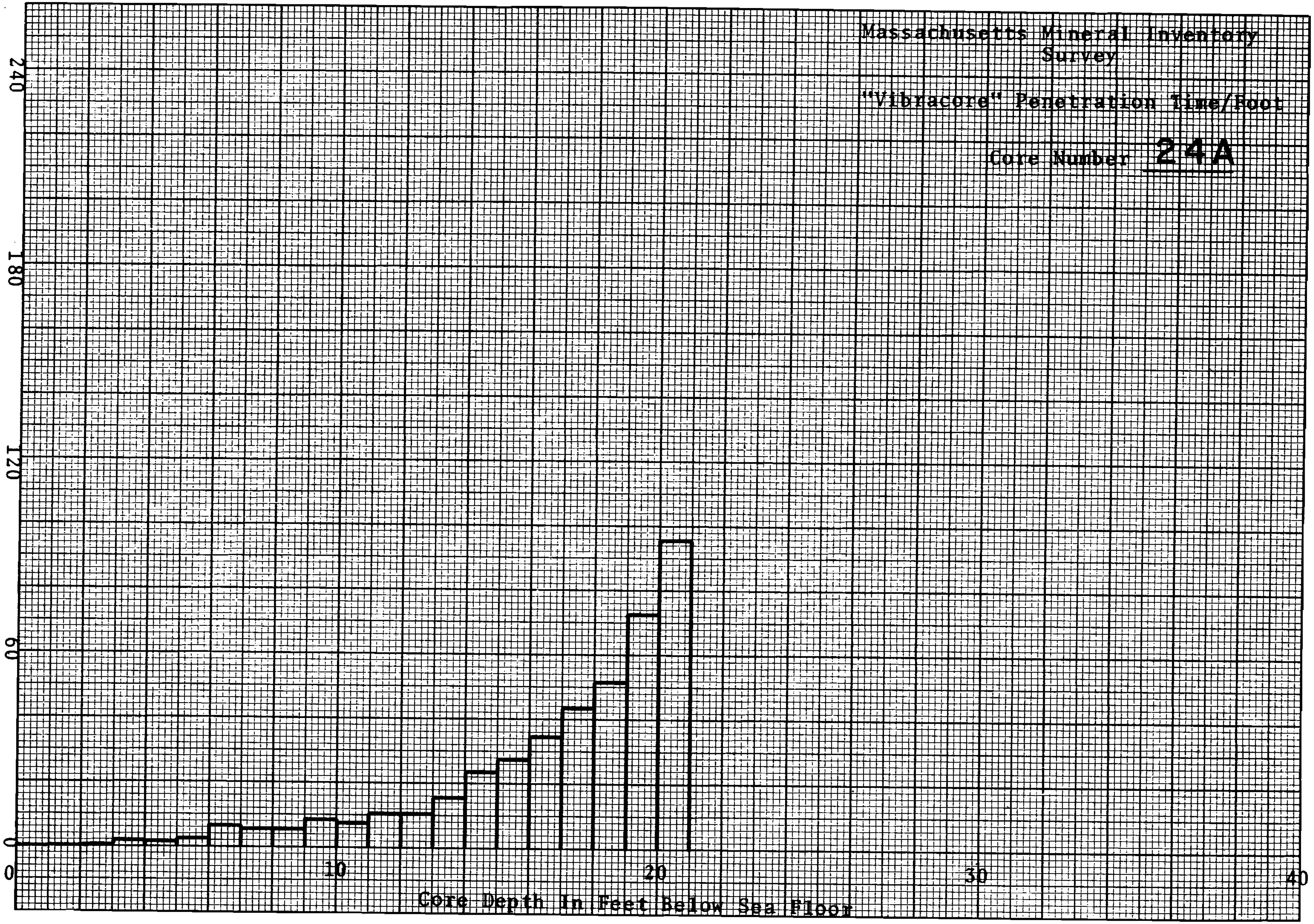

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 20A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

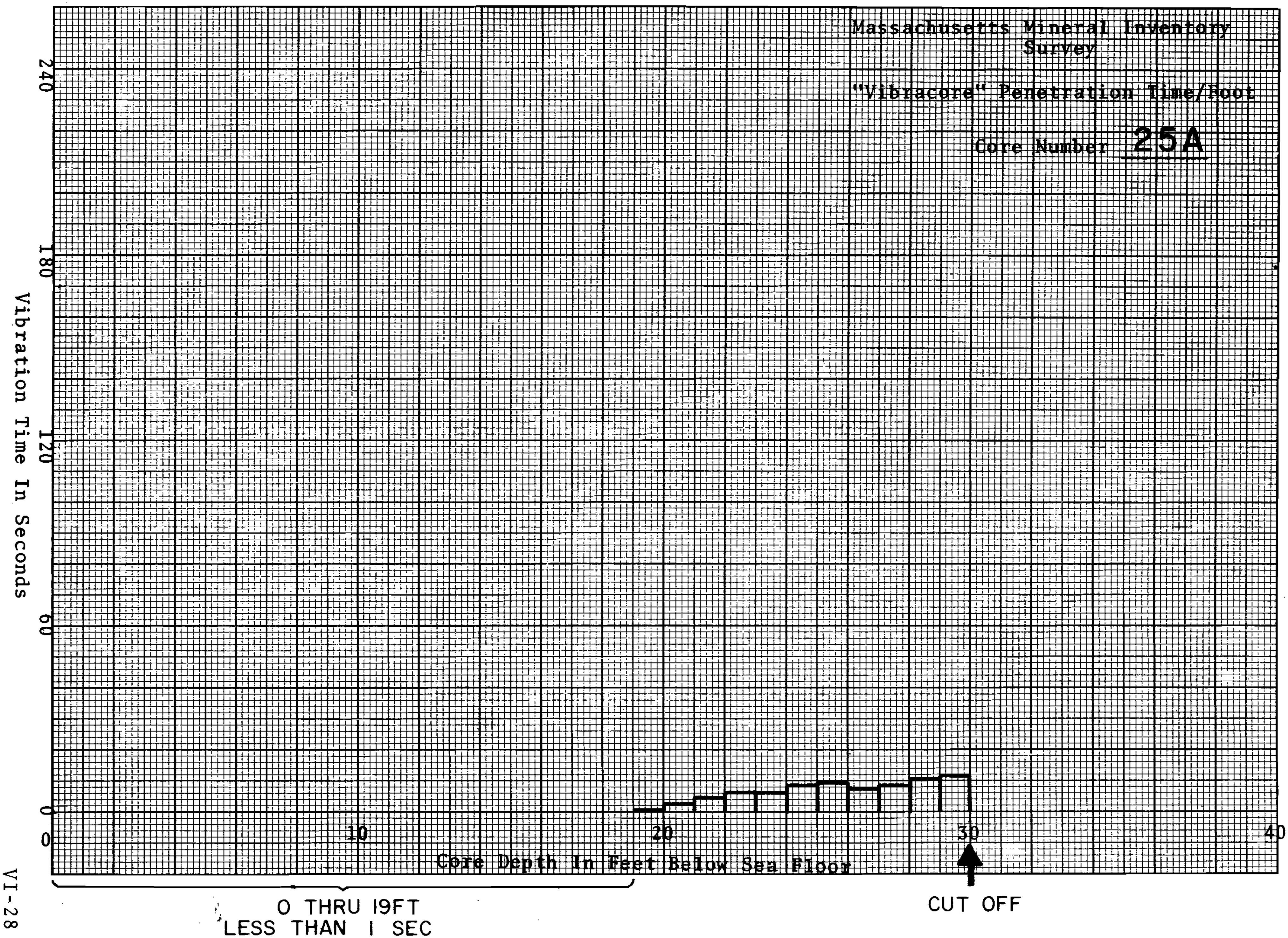

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 21A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

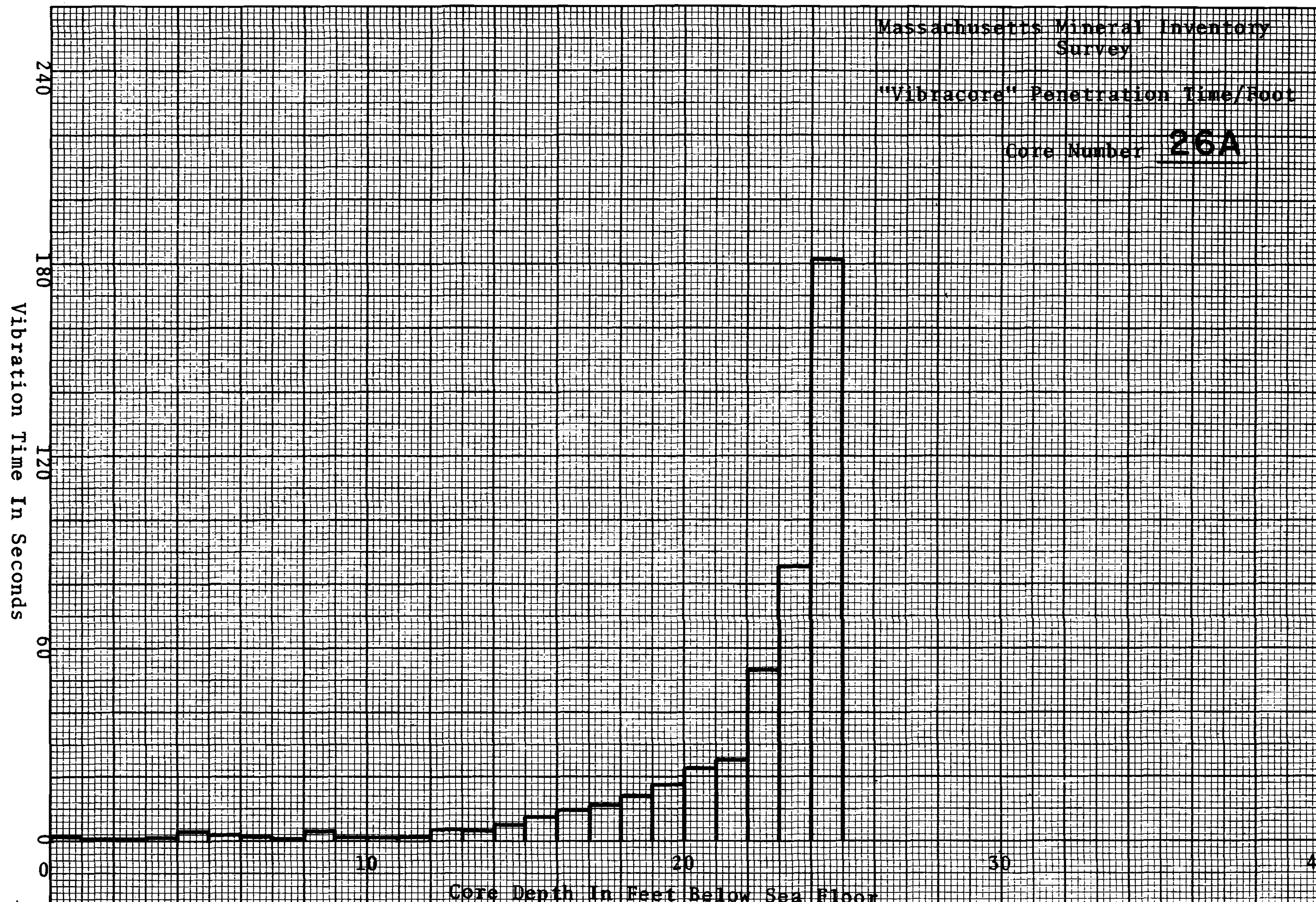


Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 22A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

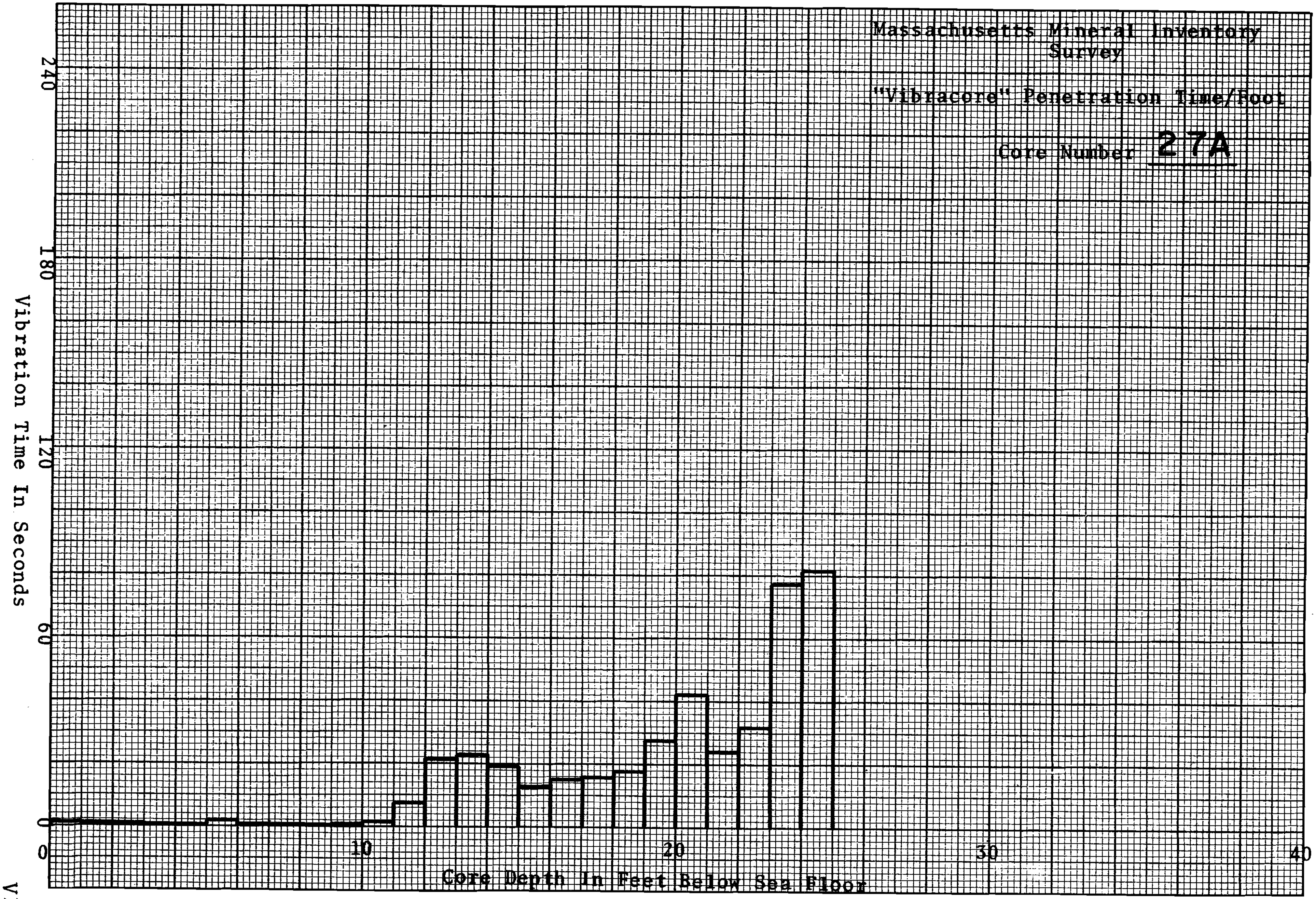

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 23A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

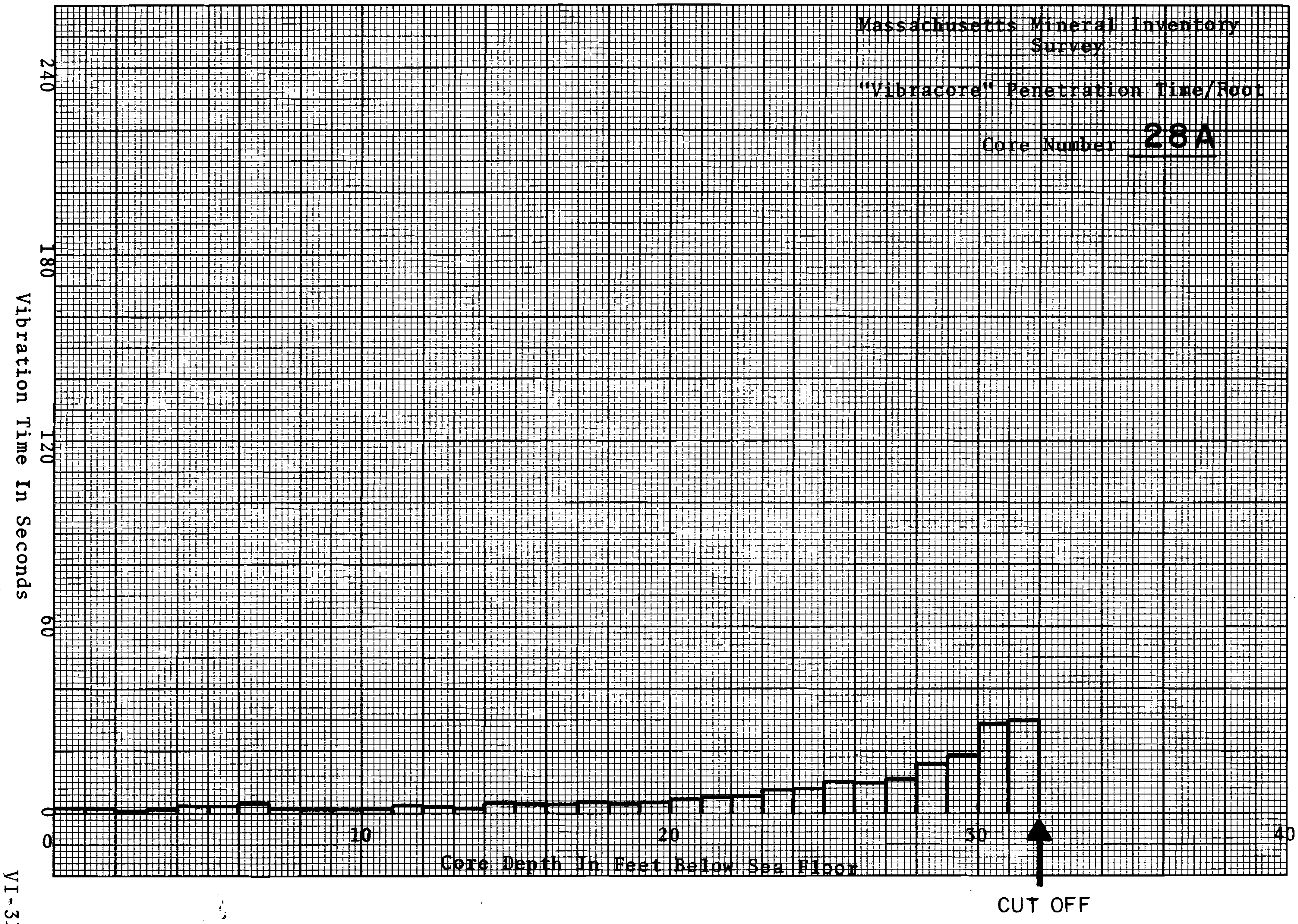

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 24A
Vibration Time In Seconds
0
60
120
180
240
Core Depth In Feet Below Sea Floor
0
10
20
30
40

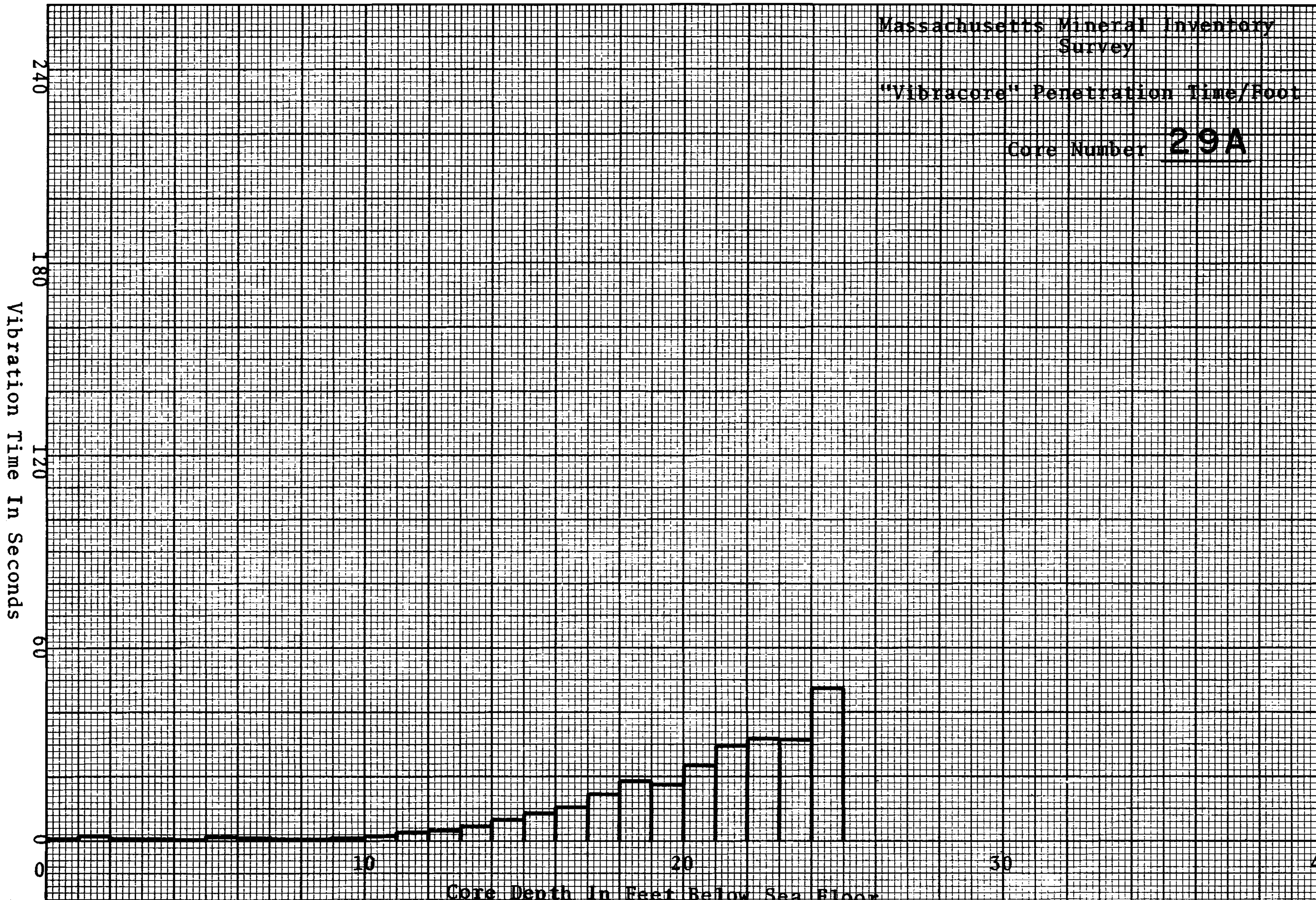

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 25A
Vibration Time In Seconds
0
60
120
180
240
0
10
20
30
40
Core Depth In Feet Below Sea Floor
O THRU 19FT
LESS THAN 1 SEC
CUT OFF



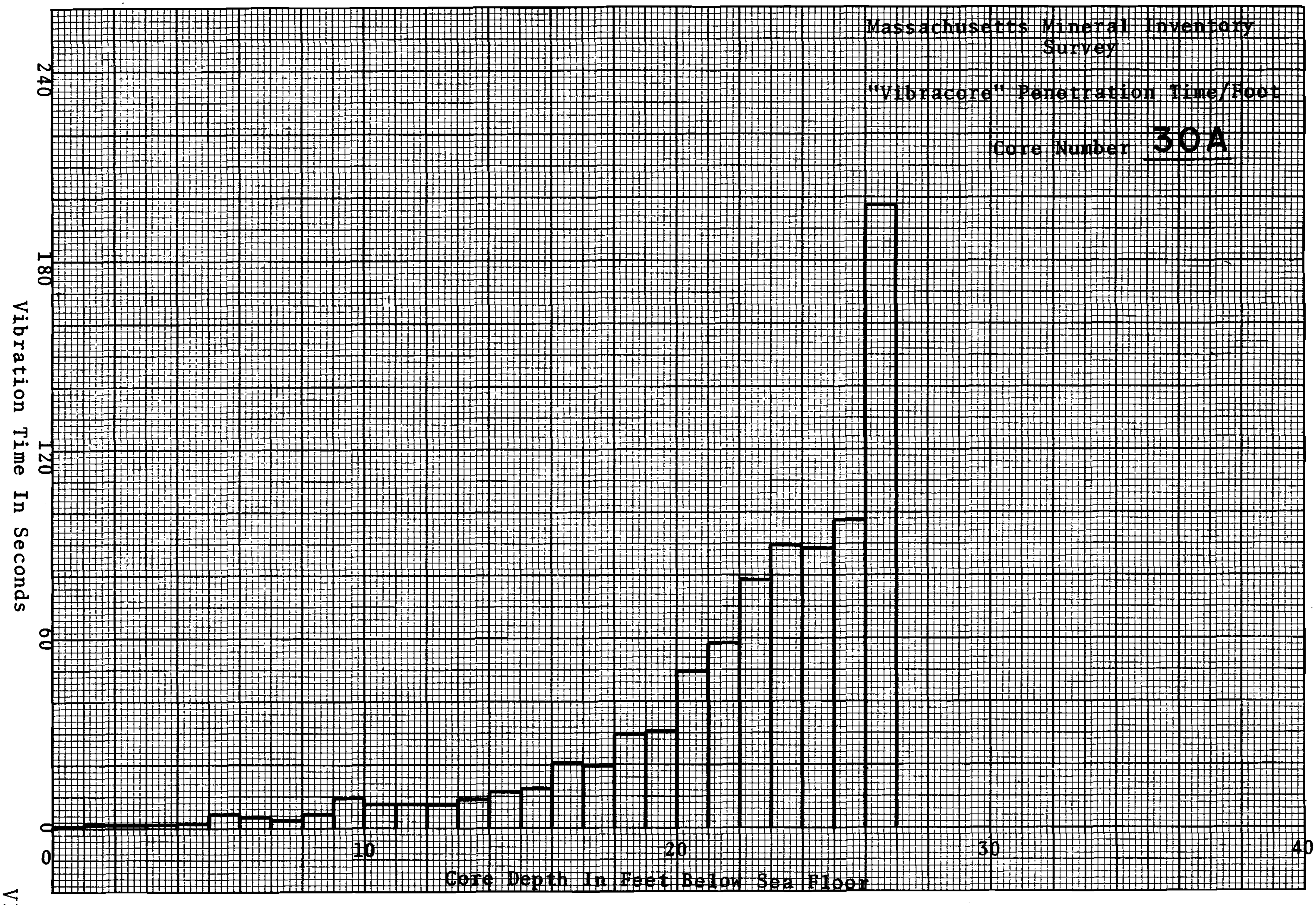
Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 26A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor


Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 27A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

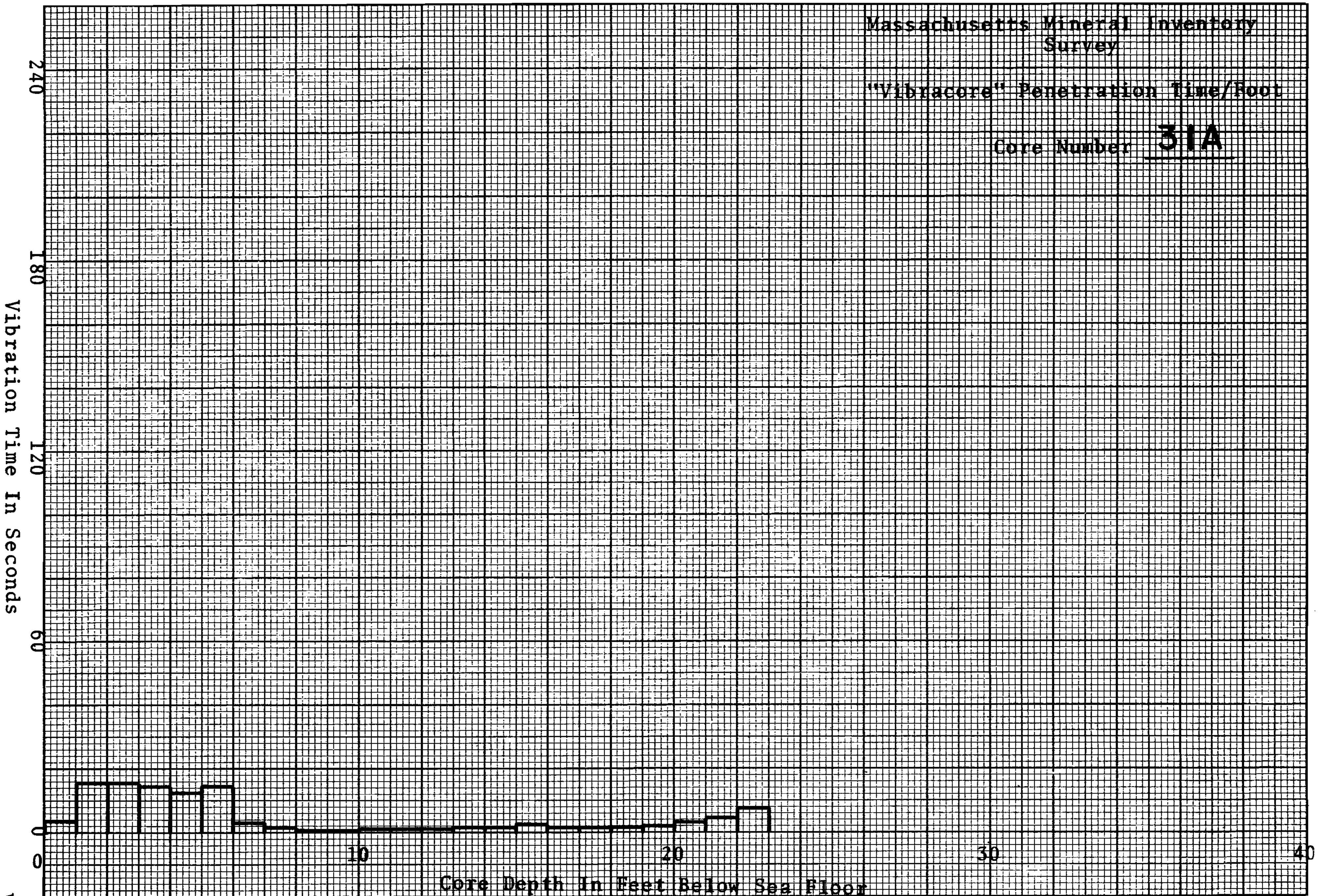

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 28A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor
CUT OFF



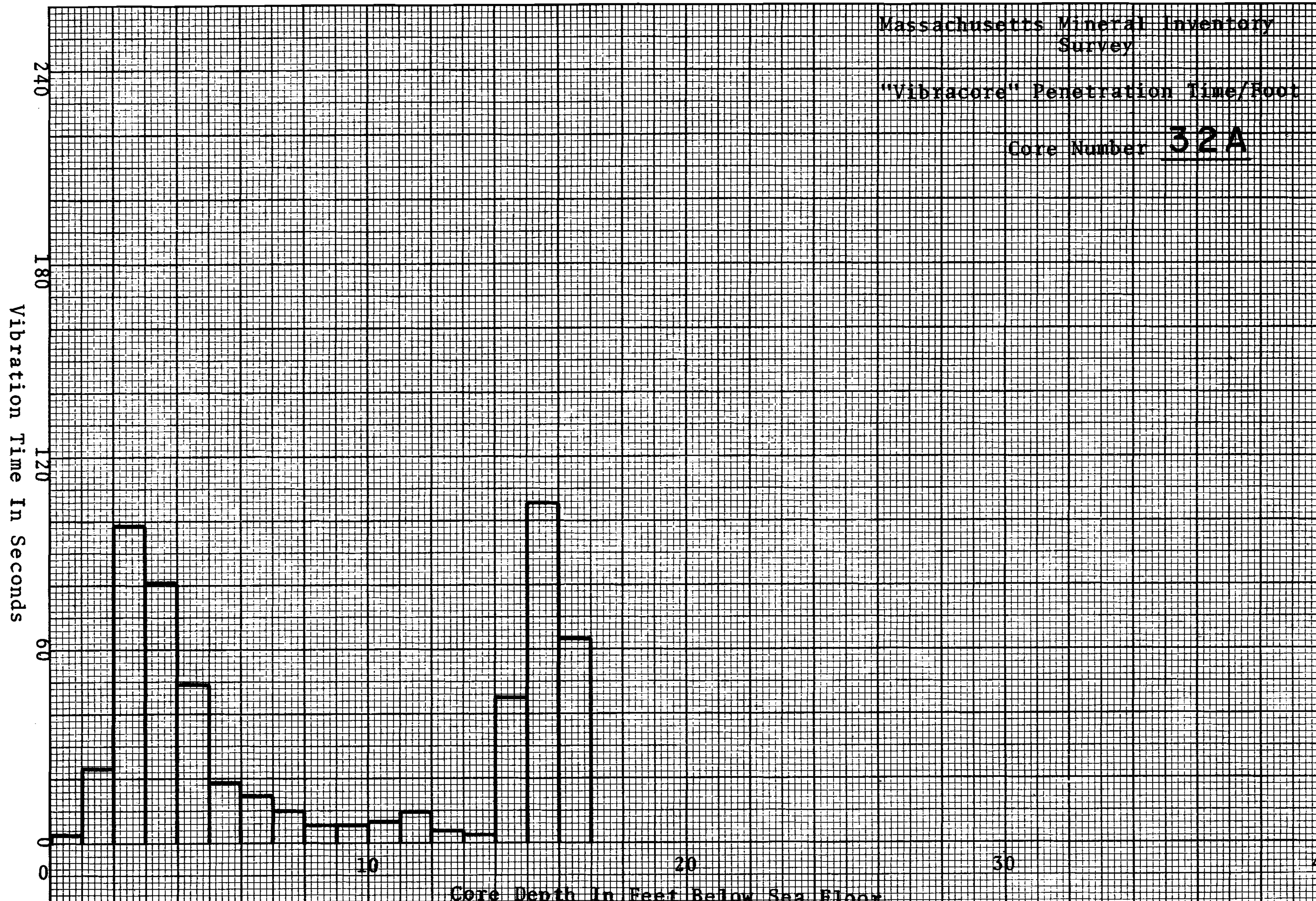
Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 29A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor



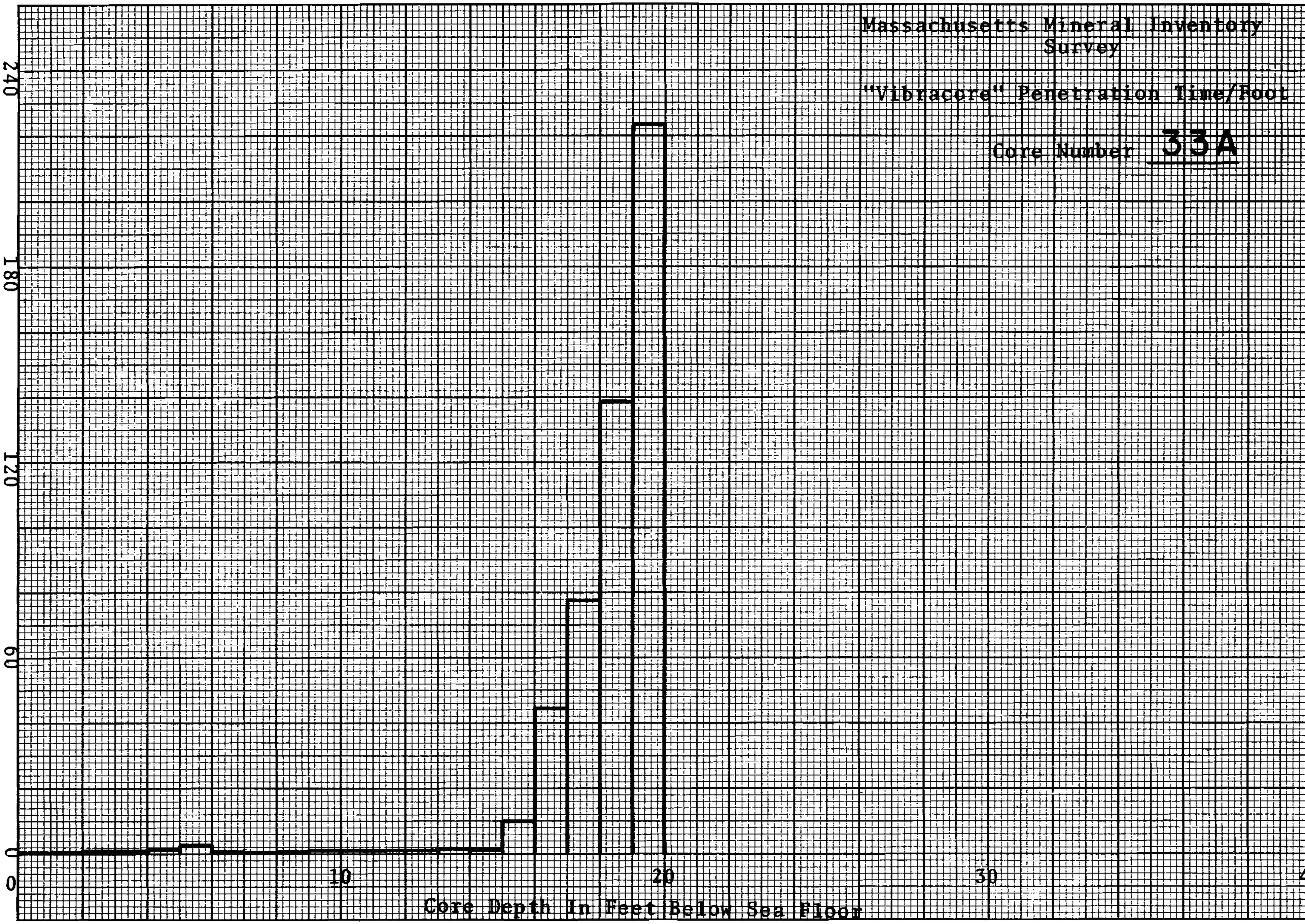
Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 30A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

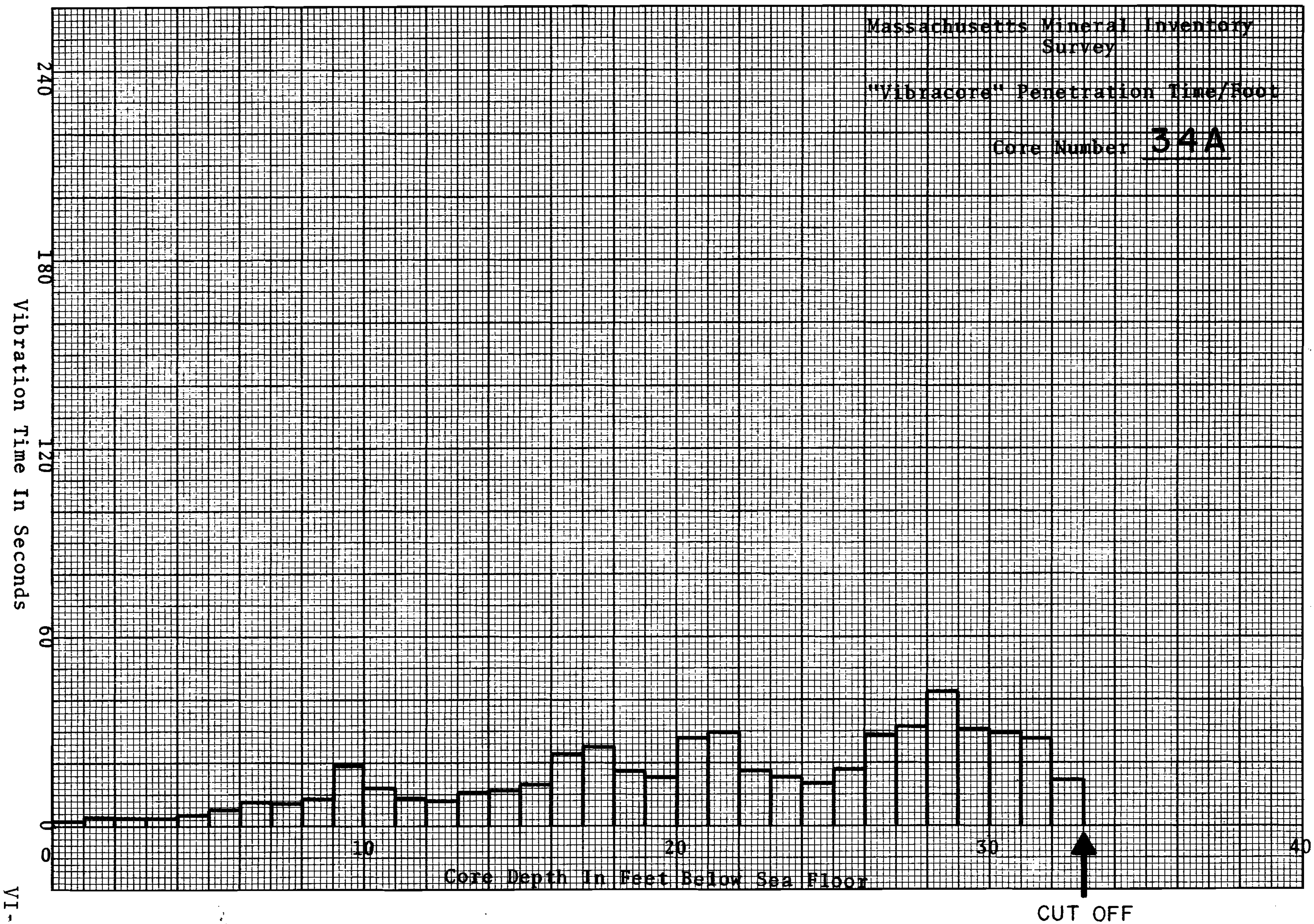


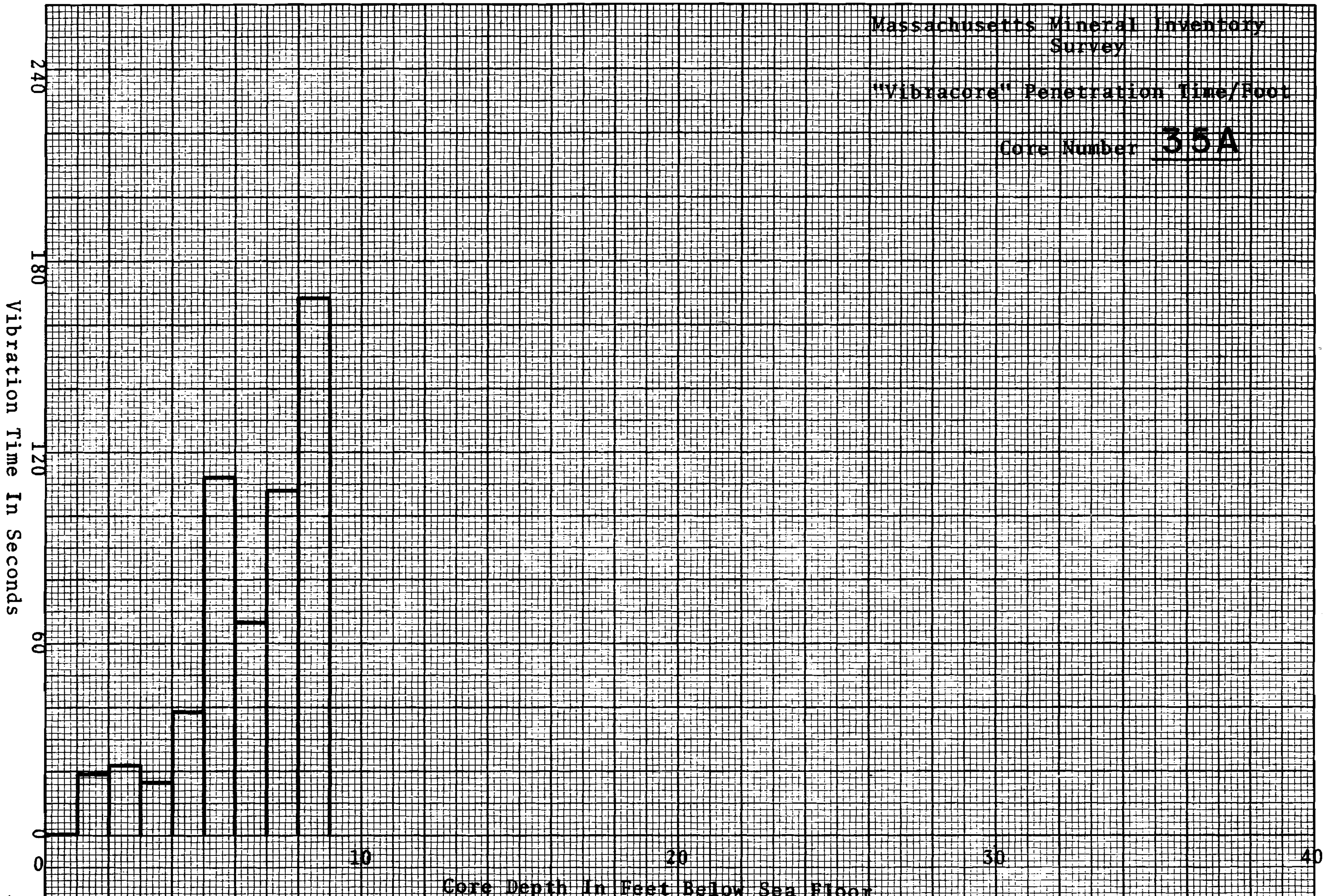
Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 31A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

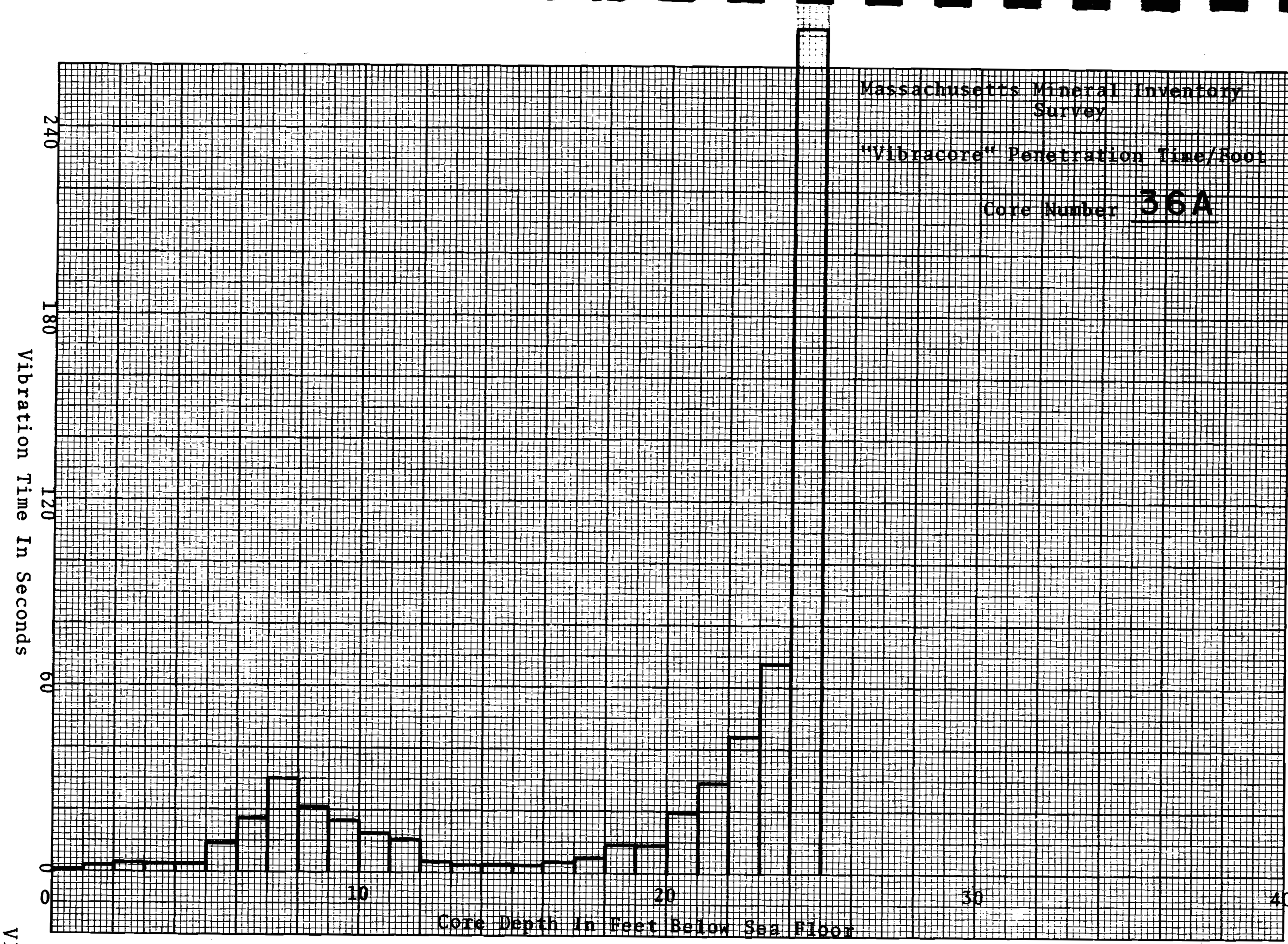


Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 32A
Vibration Time In Seconds
0
60
120
180
240
0
10
20
30
40
Core Depth In Feet Below Sea Floor

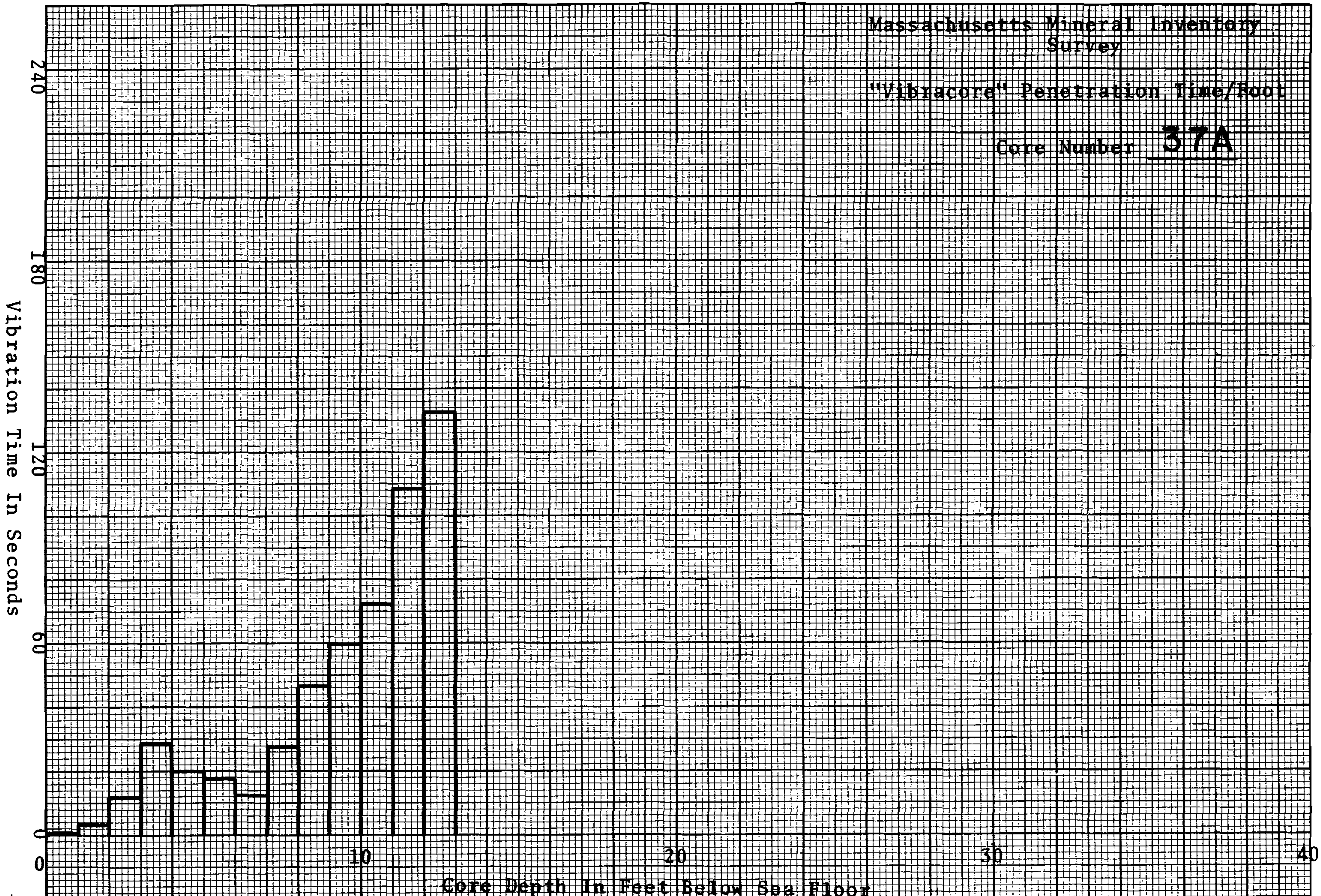

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 33A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

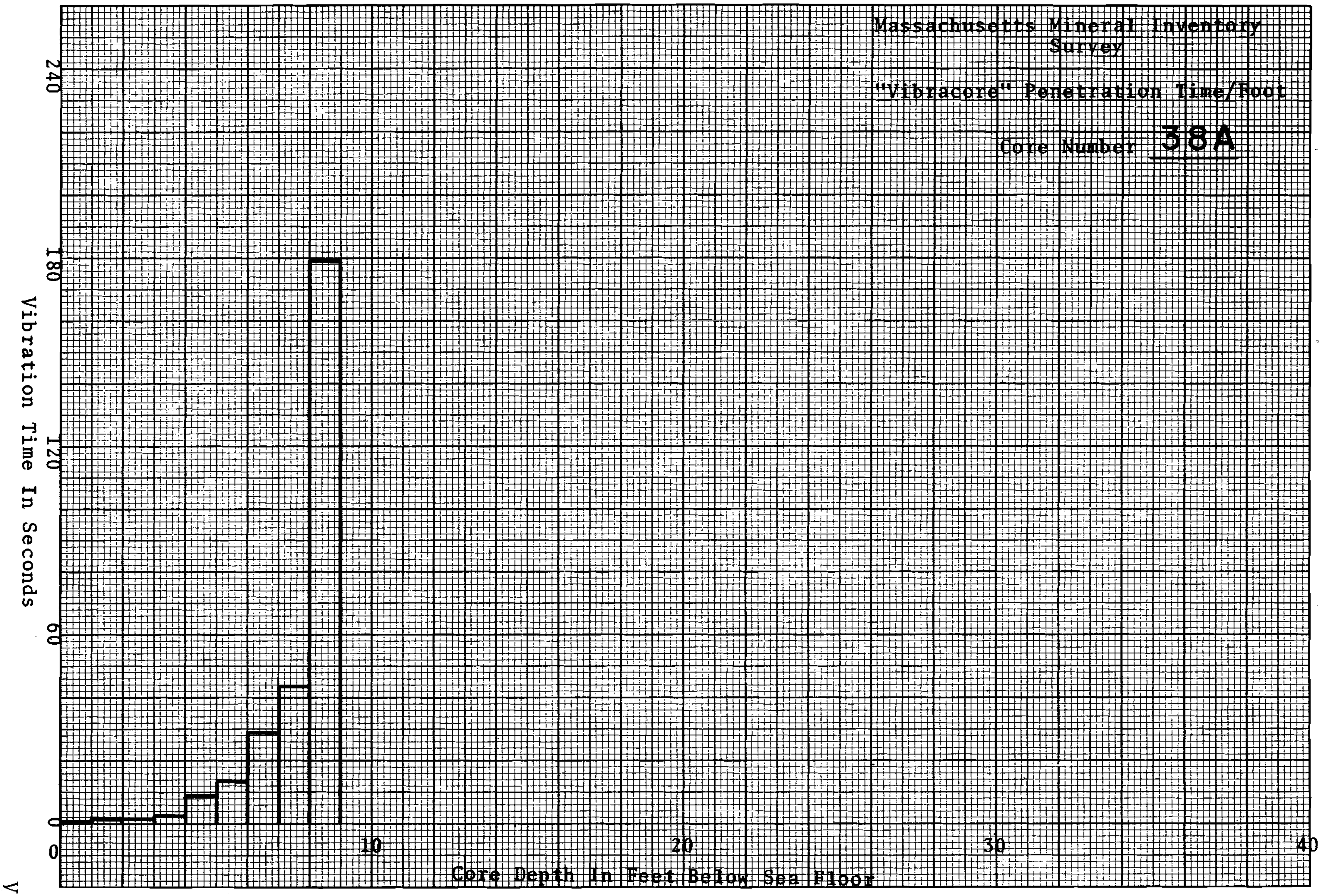

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 34A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor
CUT OFF

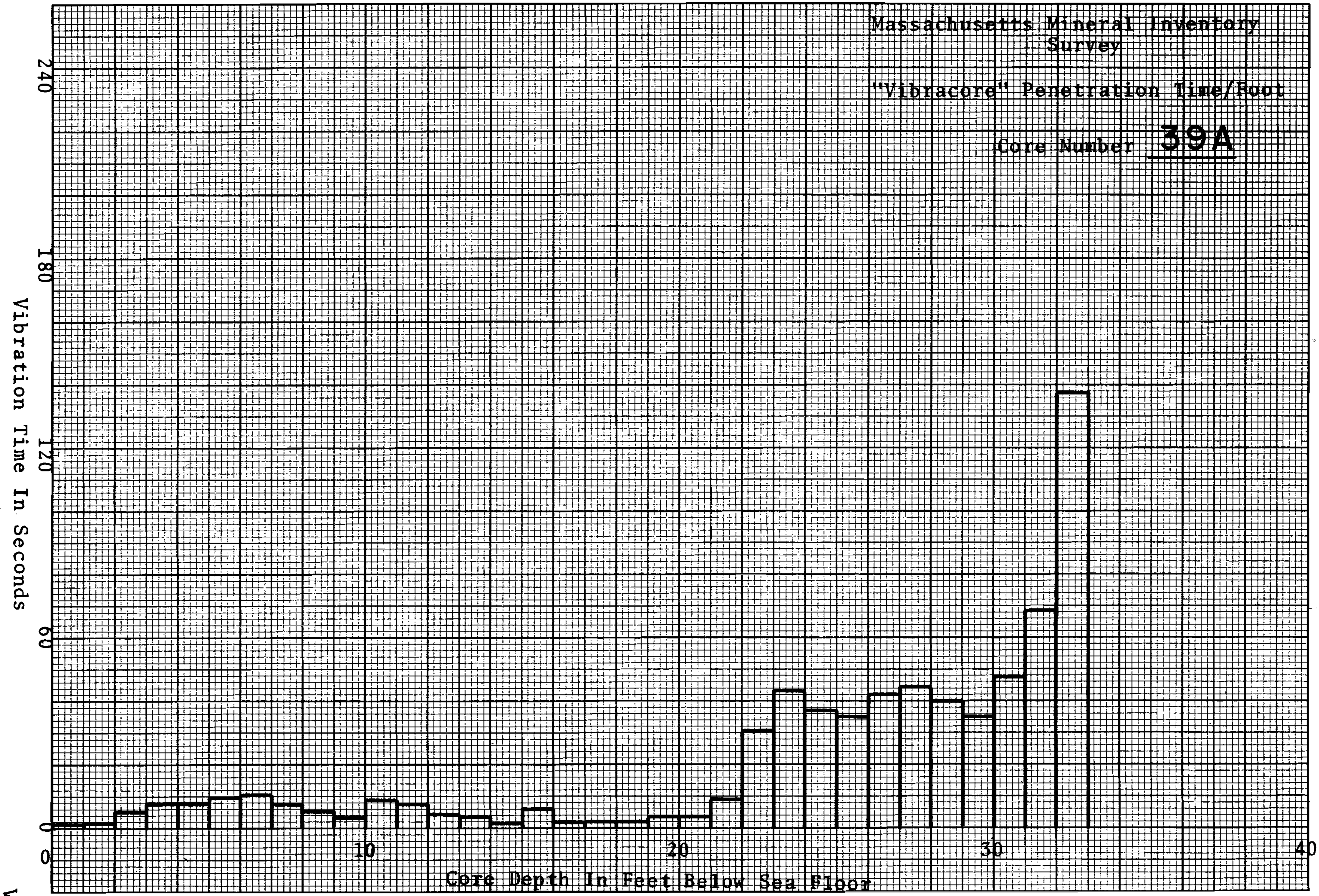

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 35A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor



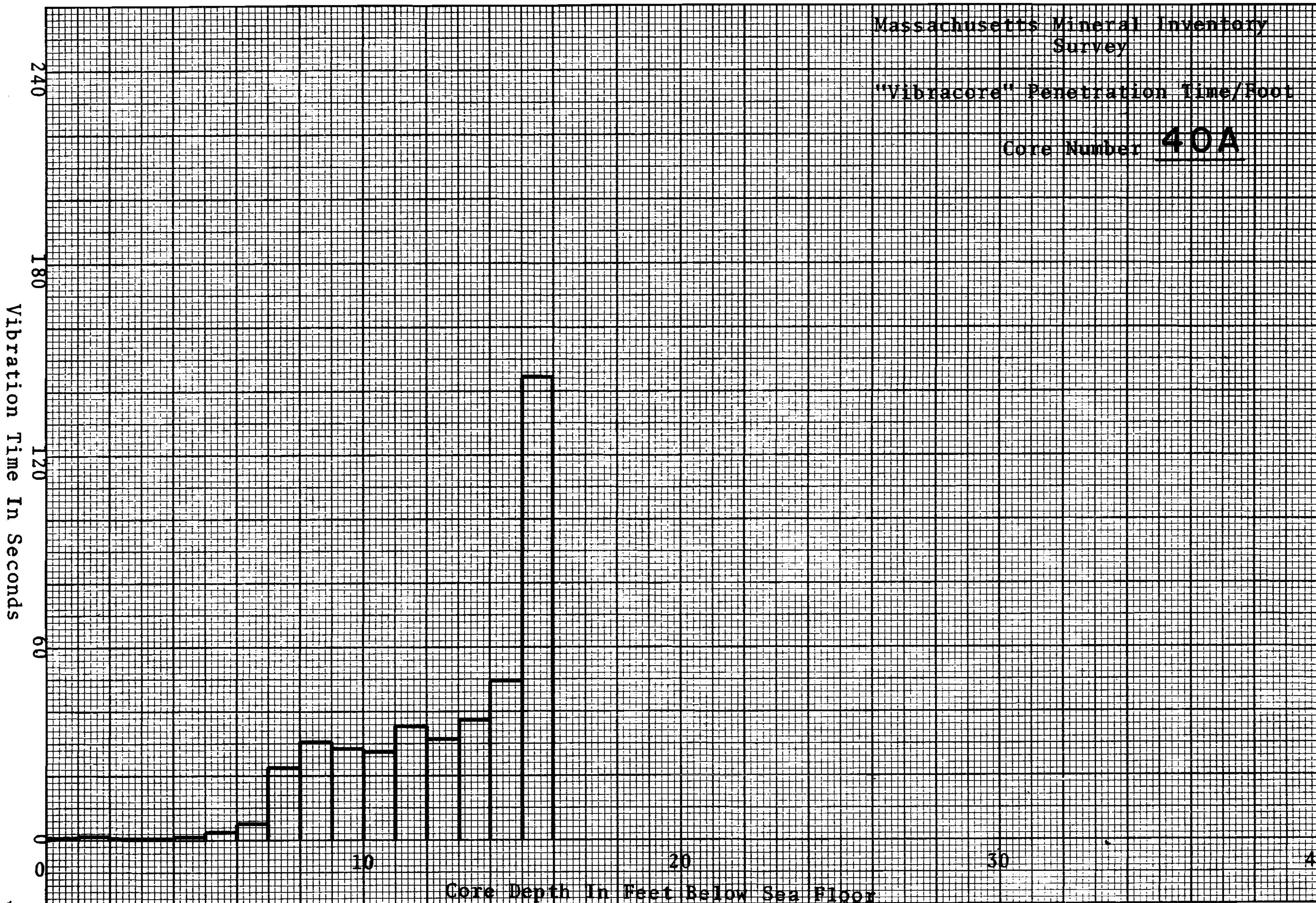
Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 36A
Vibration Time In Seconds
0
60
120
180
240
0
10
20
30
40
Core Depth In Feet Below Sea Floor

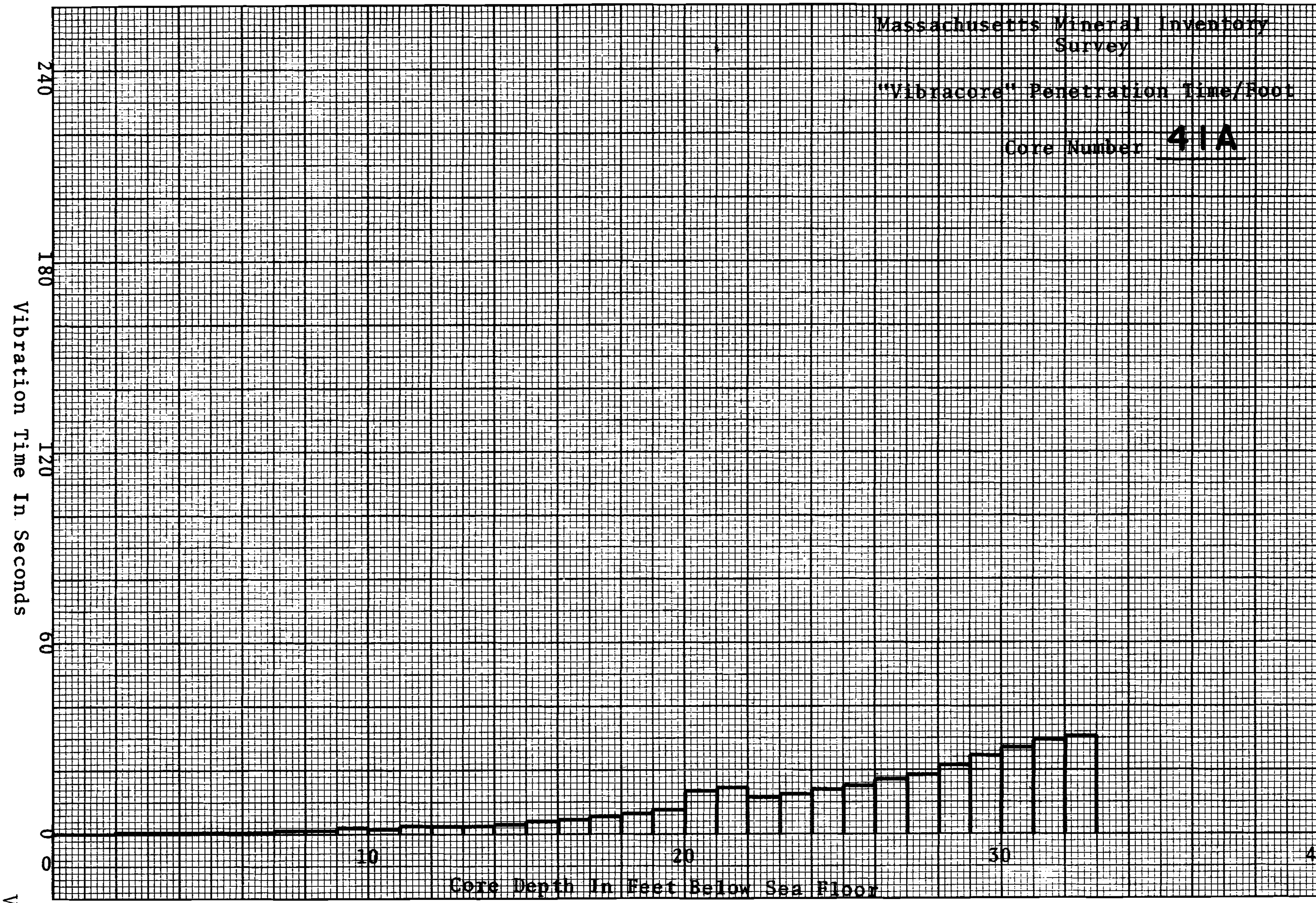

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 37A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

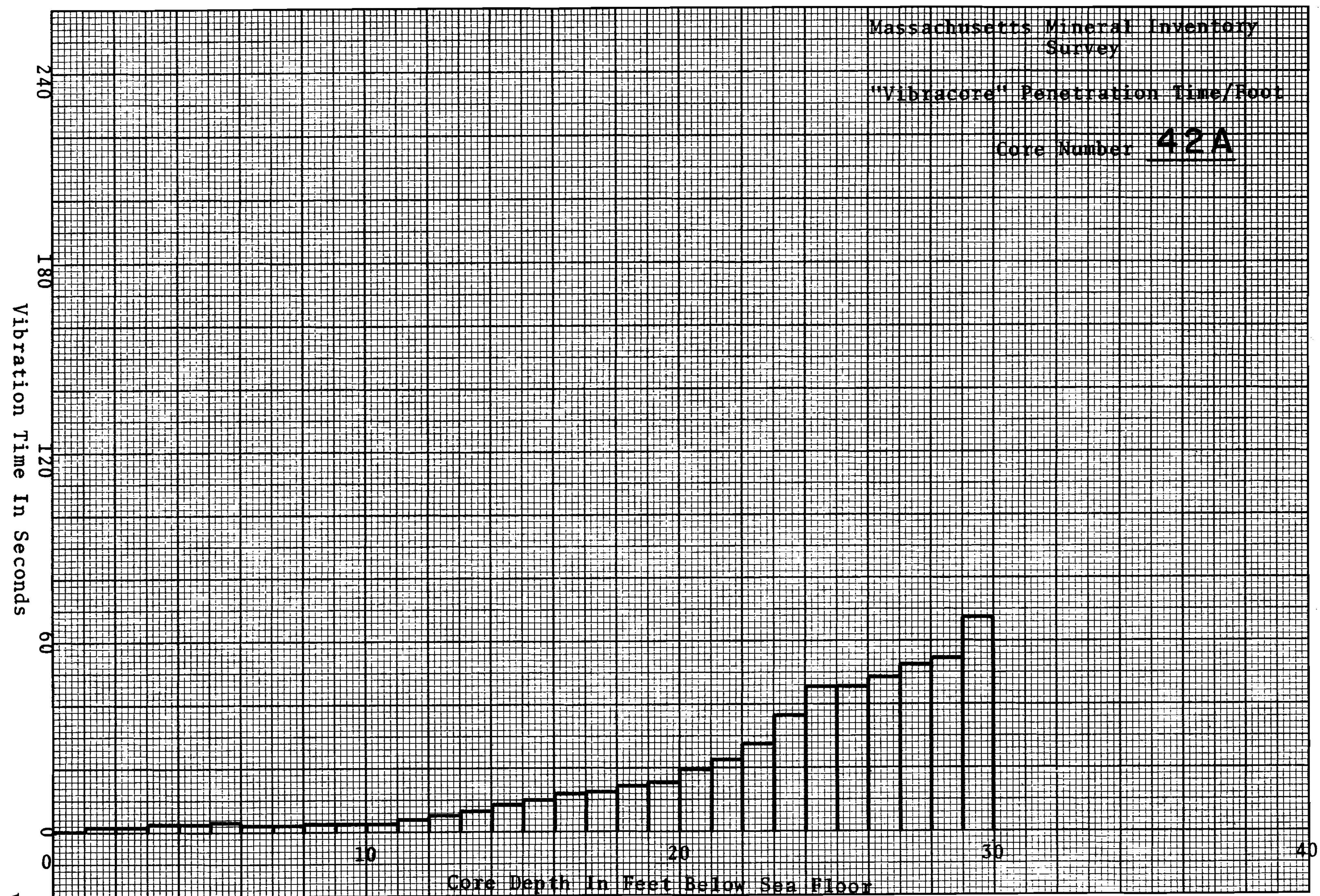

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 38A
Vibration Time In Seconds
0
60
120
180
240
0
10
20
30
40
Core Depth In Feet Below Sea Floor



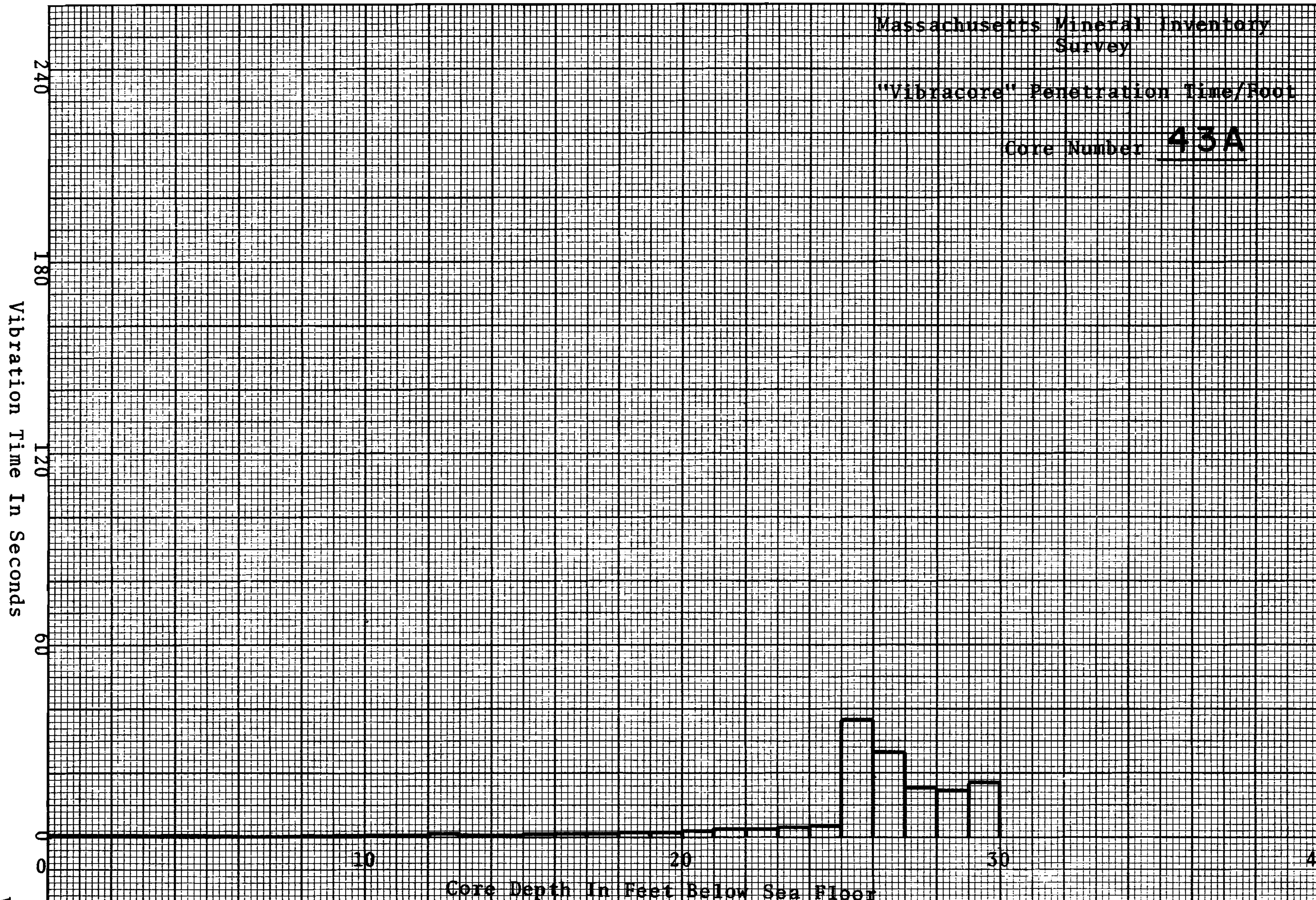
Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 39A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

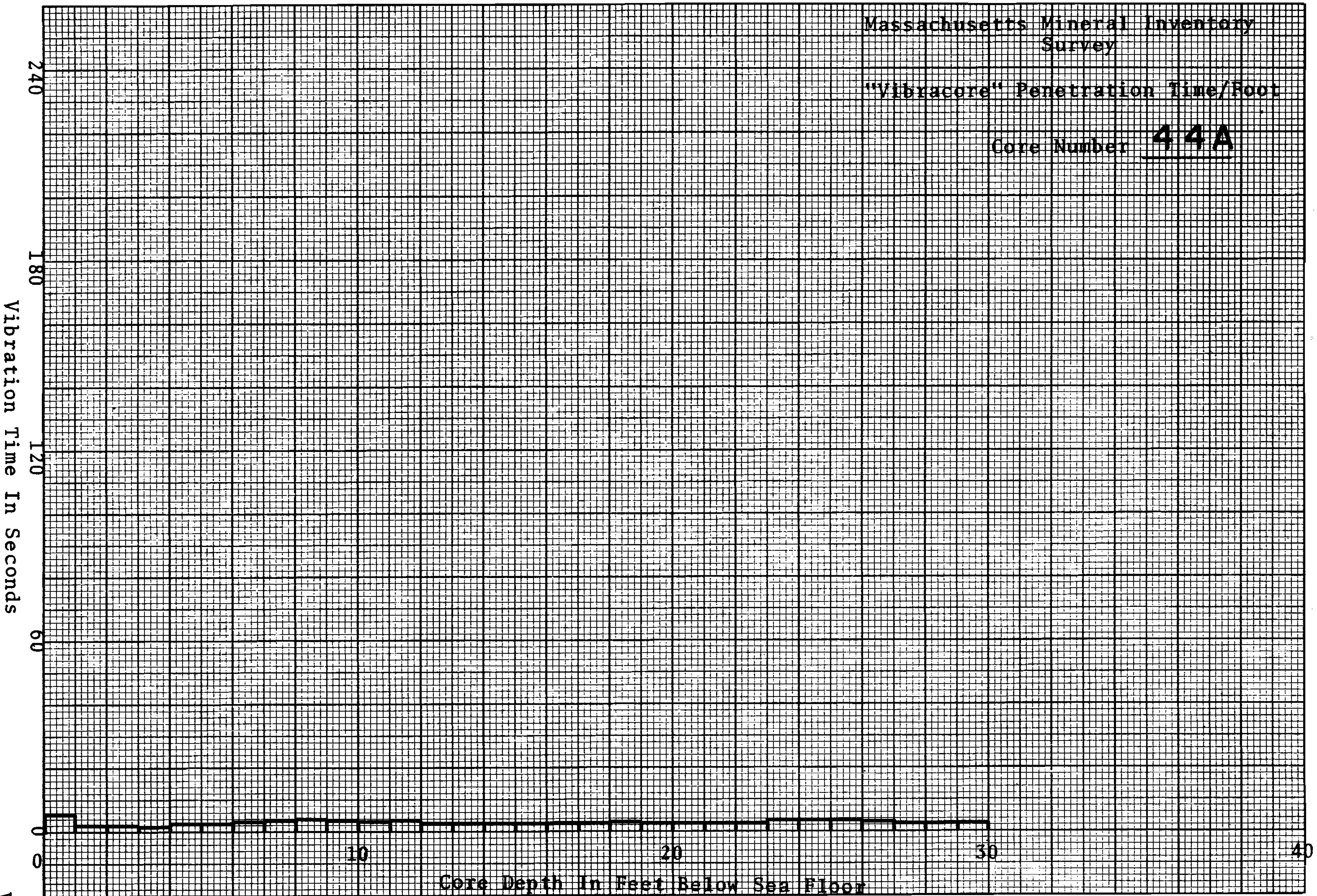

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 40A
Vibration Time In Seconds
0
60
120
180
240
0
10
20
30
40
Core Depth In Feet Below Sea Floor

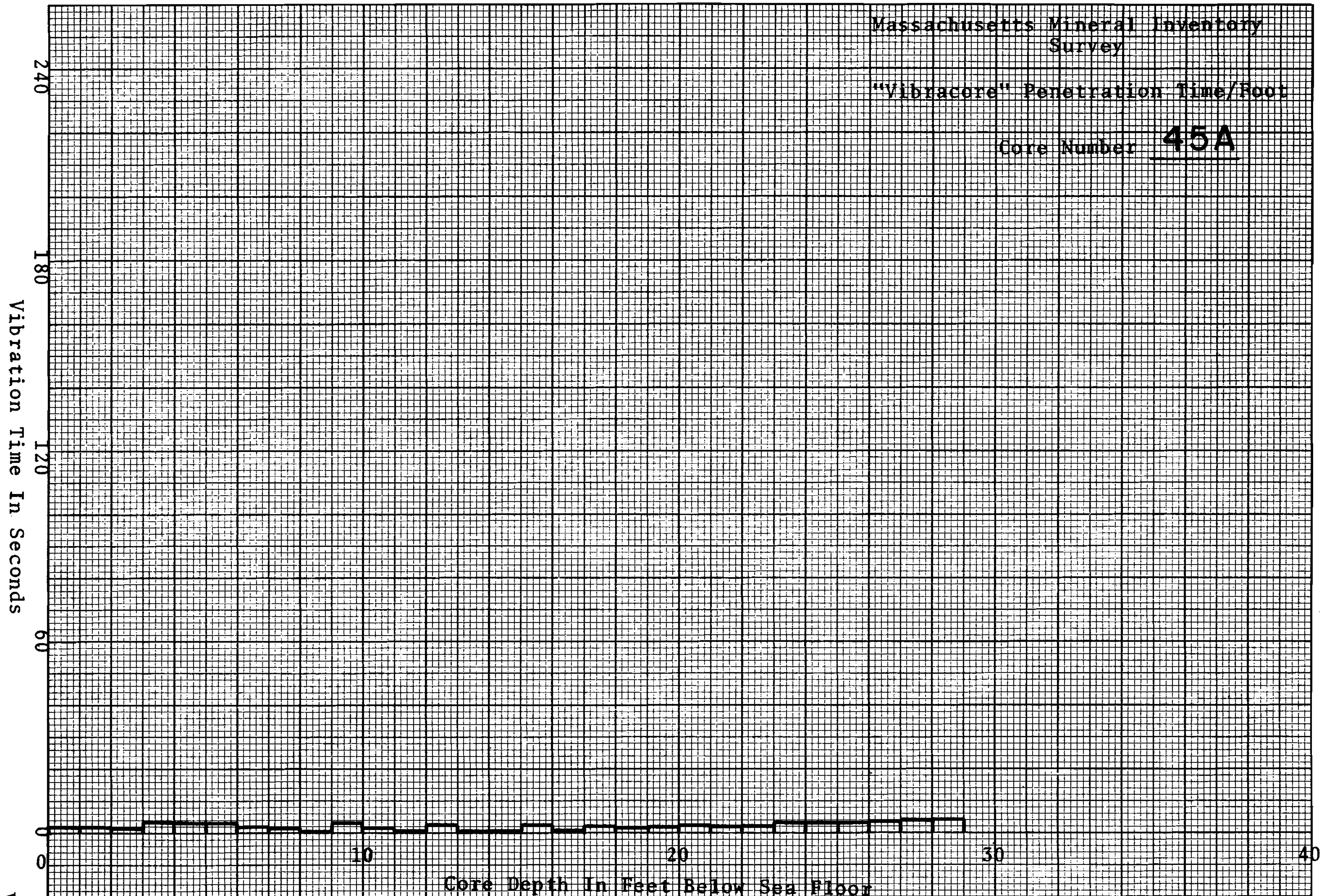

Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 41A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor



Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 42A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor


Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 43A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor


Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 44A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor


Massachusetts Mineral Inventory Survey
"Vibracore" Penetration Time/Foot
Core Number 45A
Vibration Time In Seconds
240
180
120
60
0
0
10
20
30
40
Core Depth In Feet Below Sea Floor

APPENDIX VII

SAMPLE AND PHOTO POSITIONS

Core Site Numbers	Readings		Lambert Zone #1 Coordinates		Geographic Positions	
	Lorac Green	Lorac Red	X	Y	Latitude	Longitude
0001A	11742	45830	851892.	407487.	42.11449	70.57161
0001B	11718	45878	851735.	407285.	42.11394	70.57220
0002	11270	45420	846317.	410245.	42.12222	70.59206
0003	10260	41063	832781.	423407.	42.15872	70.64145
0004	11140	44020	843191.	415626.	42.13708	70.60336
0005	10880	42464	839161.	420489.	42.15054	70.61804
0006	9770	41267	829093.	421376.	42.15324	70.65514
0007	9490	37040	823649.	432802.	42.18475	70.67480
0008	11723	46825	854110.	401196.	42.09717	70.56369
0009	11200	45355	845532.	410577.	42.12315	70.59492
0010	9326	34936	820870.	438423.	42.20026	70.68484
0011	9741	34856	823636.	440059.	42.20467	70.67459
0012	9314	32819	~~822960.~~	~~429887.~~	42.~~17677~~ 21722	70.~~67744~~ 69027
0013	9550	30738	818946.	451582.	42.23640	70.69150
0014	10330	24610	817351.	472227.	42.29311	70.69666
0015	9750	22350	812247.	477290.	42.30713	70.71536
0016	9114	18570	805617.	486944.	42.33379	70.73955
0017	29320	11023	831904.	568175.	42.55598	70.63930
0018	22970	9173	814636.	558113.	42.52884	70.70374
0019	20889	8505	809100.	554958.	42.52032	70.72438
0020	17020	8295	803418.	544300.	42.49121	70.74580
0021	10960	6170	788181.	534373.	42.46432	70.80260
0022	11865	7398	793378.	532271.	42.45845	70.78340
0023	6778	7080	783993.	517714.	42.41872	70.81860
0024	6970	8850	787308.	512050.	42.40309	70.80650
0025	4805	12485	782928.	493021.	42.35098	70.82327

SAMPLE AND PHOTO POSITIONS (Cont)

Core Site Numbers	Readings		Lambert Zone #1 Coordinates		Geographic Positions	
	Lorac Green	Lorac Red	X	Y	Latitude	Longitude
0026	7015	10782	789913.	505612.	42.38538	70.79706
0027	8790	10470	794401.	511999.	42.40280	70.78024
0028	8215	8330	789346.	517672.	42.41847	70.79878
0029	4420	3458	771770.	523877.	42.43588	70.86369
0030	4230	15828	780409.	479795.	42.31474	70.83298
0031	3350	12792	775190.	487060.	42.33479	70.85207
0032	10746	22547	816932.	479648.	42.31348	70.69795
0033	8877	20463	806452.	480384.	42.31577	70.73668
0034	6685	14280	791997.	493090.	42.35097	70.78972
0035	3968	3169	770365.	523509.	42.43491	70.86891
0036	10438	23687	816854.	475315.	42.30159	70.69839
0037	8223	20380	803383.	478602.	42.31094	70.74808
0038	6875	18190	795447.	481143.	42.31810	70.77734
0039	6687	13780	791622.	494721.	42.35545	70.79106
0040	10200	26580	818757.	465954.	42.27585	70.69168
0041	7850	5593	782404.	526711.	42.44344	70.82422
0042	12796	6910	792999.	537114.	42.47174	70.78465
0043	19004	8128	805213.	550979.	42.50949	70.73892
0044	22770	8473	811174.	560739.	42.53613	70.71649
0045	8375	8950	790836.	515977.	42.41379	70.79332

SAMPLE AND PHOTO POSITIONS (Cont)

Photo-Site Numbers	Readings		Lambert Zone #1 Coordinates		Geographic Positions	
	Lorac Green	Lorac Red	X	Y	Latitude	Longitude
0001	37426	11620	847243.	588900.	42.61241	70.58154
0002	35528	11386	842776.	583989.	42.59906	70.59833
0003	33545	11227	838986.	579040.	42.58560	70.61259
0004	31460	10668	832993.	575575.	42.57626	70.63498
0008	19066	8407	806455.	549946.	42.50664	70.73436
0011	13019	8282	797775.	532361.	42.45859	70.76711
0013	9497	9417	794185.	517720.	42.41850	70.78087
0014	7360	7605	786180.	517632.	42.41844	70.81052
0016	3289	5681	773508.	511691.	42.40240	70.85760
0017	5984	9766	785625.	505882.	42.38622	70.81291
0018	9600	15072	803344.	499342.	42.36786	70.74754
0019	4217	15794	780328.	479864.	42.31493	70.83327
0020	3787	13168	777787.	487296.	42.33537	70.84245
0021	5271	12911	785210.	493106.	42.35117	70.81483
0022	7516	16857	797421.	487416.	42.33527	70.76984
0024	8675	20428	805509.	479868.	42.31436	70.74017
0025	8220	22417	804946.	472309.	42.29364	70.74251
0029	9978	32776	823384.	446934.	42.22354	70.67528
0042	12350	46076	—	—	42.10388	70.54444

SAMPLE AND PHOTO POSITIONS (Cont)

Grab-Site Numbers	Readings		Lambert Zone #1 Coordinates		Geographic Positions	
	Lorac Green	Lorac Red	X	Y	Latitude	Longitude
0001	12246	46242	858606.	403211.	42.10255	70.54704
0002	11560	46155	850608.	406173.	42.11092	70.57640
0003	11790	45896	852549.	407001.	42.11314	70.56921
0004	12264	45277	856269.	409282.	42.11928	70.55540
0005	12890	44595	861314.	411731.	42.12585	70.53671
0006	10634	46330	841292.	407066.	42.11365	70.61069
0007	10663	44631	839605.	413185.	42.13048	70.61668
0008	10250	45012	836286.	411455.	42.12582	70.62898
0009	9538	45408	830365.	408511.	42.11792	70.65091
0010	10015	43148	832622.	416584.	42.14000	70.64229
0011	10260	43090	834611.	417360.	42.14207	70.63493
0012	10448	40748	833965.	424827.	42.16258	70.63704
0013	10039	41158	831125.	422516.	42.15633	70.64760
0014	9623	41380	828019.	420557.	42.15103	70.65912
0015	9110	39310	822503.	424715.	42.16260	70.67931
0016	9782	39104	827437.	427740.	42.17076	70.66101
0017	9966	39001	828728.	428624.	42.17316	70.65620
0018	10566	38706	832909.	431208.	42.18013	70.64070
0019	9763	36947	825528.	433994.	42.18797	70.66782
0020	10202	36860	828560.	435622.	42.19235	70.65657
0021	10216	34727	826705.	441930.	42.20972	70.66319
0022	9016	35009	818775.	437092.	42.19666	70.69263
0023	9037	32835	817343.	443626.	42.21461	70.69769
0024	9937	30754	821301.	452768.	42.23961	70.68275
0025	9093	30738	816129.	450061.	42.23232	70.70195
0026	7827	28796	806834.	451365.	42.23611	70.73622
0027	9198	26595	813420.	462790.	42.26730	70.71152

SAMPLE AND PHOTO POSITIONS (Cont)

Grab-Site Numbers	Readings		Lambert Zone #1 Coordinates		Graphic Positions	
	Lorac Green	Lorac Red	X	Y	Latitude	Longitude
0028	8869	22438	808180.	474314.	42.29906	70.73048
0029	10033	20652	811666.	483292.	42.32361	70.71730
0030	7666	18386	799264.	483061.	42.32327	70.76317
0031	7471	20266	799673.	476540.	42.30537	70.76186
0032	7126	22348	799098.	468852.	42.28429	70.76424
0033	5705	20142	790003.	470826.	42.28992	70.79778
0034	6043	18056	791194.	478800.	42.31177	70.79314
0035	5135	15981	785657.	482482.	42.32201	70.81349
0036	4350	13908	780995.	486721.	42.33374	70.83061
0037	6691	14282	792023.	493102.	42.35100	70.78963
0038	7692	13259	794813.	499491.	42.36847	70.77911
0039	8210	11849	794810.	505663.	42.38541	70.77893
0040	6961	10688	789640.	505763.	42.38579	70.79805
0041	4645	10599	781432.	498865.	42.36705	70.82864
0042	4010	8117	777644.	505370.	42.38498	70.84247
0043	2037	4469	768629.	512041.	42.40347	70.87566
0044	3481	4395	772455.	517045.	42.41713	70.86136
0045	6878	7075	784191.	518045.	42.41962	70.81787
0046	7159	8960	787950.	512247.	42.40363	70.80412
0047	7993	9757	791262.	512036.	42.40297	70.79185
0048	11181	10848	800741.	517754.	42.41844	70.75658
0049	11592	10125	800060.	521445.	42.42859	70.75899
0050	11061	9697	798026.	521382	42.42845	70.76653
0051	11914	8769	797359.	527236.	42.44453	70.76880
0052	9802	7219	789770.	526598.	42.44296	70.79694
0053	6418	4350	776833.	527002.	42.44435	70.84485
0054	9971	5973	786320.	532016.	42.45790	70.80956

SAMPLE AND PHOTO POSITIONS (Cont)

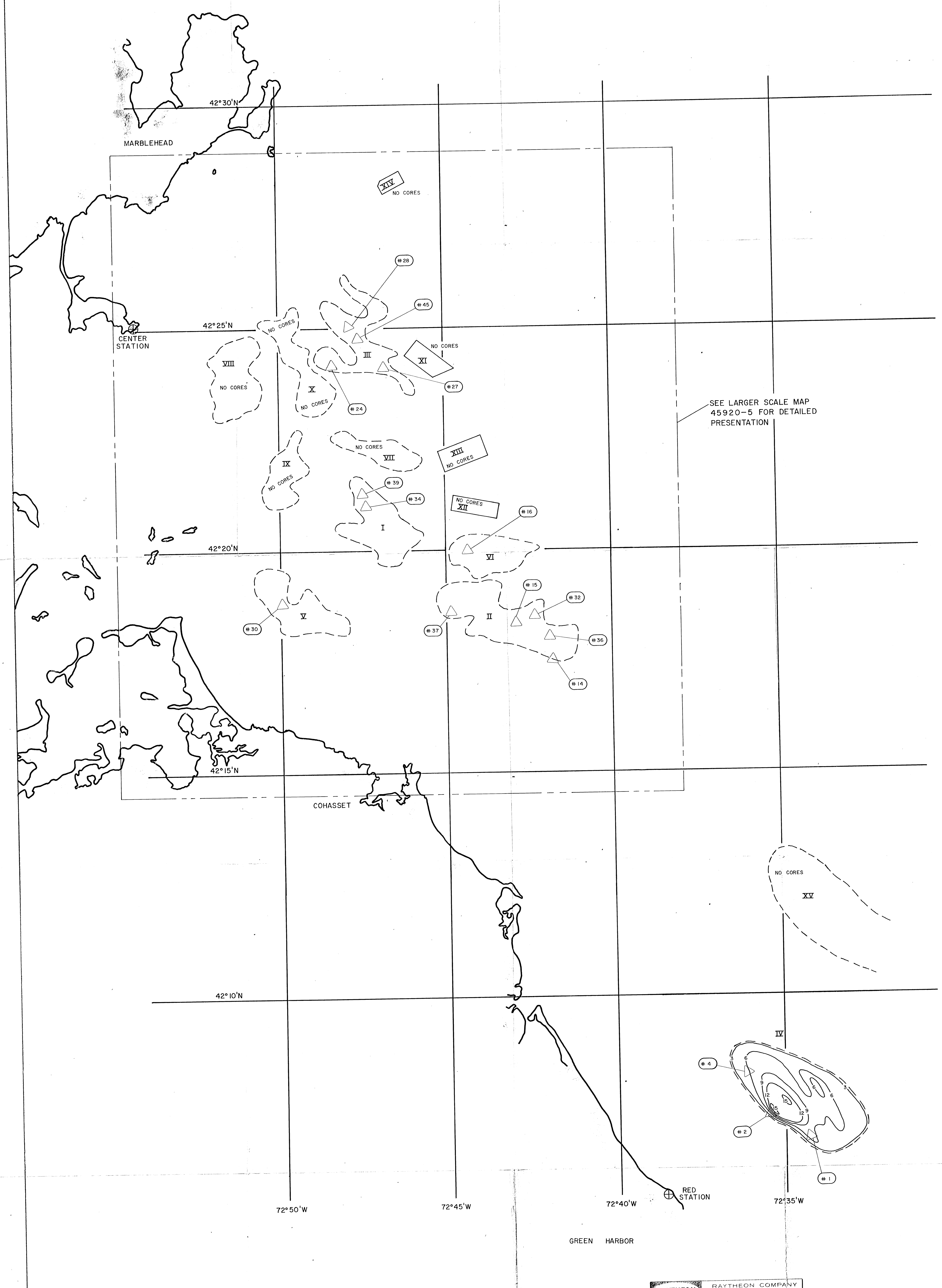
Grab-Site Numbers	Readings		Lambert Zone #1 Coordinates		Graphic Positions	
	Lorac Green	Lorac Red	X	Y	Latitude	Longitude
0055	12905	7094	793780.	536698.	42.47058	70.78177
0056	15080	7912	799473.	540031.	42.47960	70.76056
0057	21202	9935	815492.	549819.	42.50606	70.70085
0058	23150	9939	818238.	555352.	42.52116	70.69048
0059	22974	9351	815435.	557342.	42.52670	70.70079
0060	22765	8468	811144.	560748.	42.53615	70.71660
0061	25325	10552	823978.	558975.	42.53096	70.66905
0062	27354	10488	826512.	564912.	42.54718	70.65942
0063	29330	10674	830143.	569636.	42.56004	70.64578
0064	33436	11697	841576.	577026.	42.57999	70.60306
0065	37164	12135	850578.	587051.	42.60724	70.56923
0066	38540	12307	855238.	592791.	42.62285	70.55168

APPENDIX IX

ISOPACH MAP

(See drawing number 45920-5 & 6)


SWAMPSCOTT
NAHANT
CENTER STATION
42°30'N
42°25'N
42°20'N
70°50'W
70°45'W
70°40'W
HINGHAM
COHASSET
I
II
III
V
VI
VII
VIII
IX
X
XI
XII
XIII
XIV
SCALE IN NAUTICAL MILES
RAYTHEON
RAYTHEON COMPANY
LEXINGTON, MASS 02173
MASSACHUSETTS COASTAL MINERAL INVENTORY SURVEY
SAND AND GRAVEL ISOPACH MAP
CONTOUR INTERVAL — 3 FEET
— SURFACE EXPOSURE OF TILL AND/OR BEDROCK
45920-5



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MASSACHUSETTS COASTAL MINERAL INVENTORY SURVEY

SAND AND GRAVEL LOCATION MAP (INCLUDING AREA IV ISOPACHS)

45920-6

6-238

00768

APPENDIX X

SURFACE SEDIMENT MAP

(See drawing number 45920-4)

00770


GLOUCESTER
MARBLEHEAD
COHASSET
GREEN HARBOR
42°35'N
42°30'N
42°25'N
42°20'N
42°15'N
42°10'N
42°05'N
70°55'W
70°50'W
70°45'W
70°40'W
70°35'W
70°30'W
KEY
b = BOULDERS OR OUTCROPS WITH POCKETS OF COBBLES, GRAVEL, SAND, AND AN OCCASIONAL ADMIXTURE OF CLAY
c = COBBLES WITH SAND AND GRAVEL
sg = SAND AND GRAVEL, OCCASIONAL ADMIXTURE OF CLAY
s = SAND WITH OCCASIONAL SILT AND CLAY
ss = FINE SILTY SAND
sgm = MIXTURE OF SAND, GRAVEL, SILT, AND CLAY
o = OCCASIONAL BOULDERS OR OUTCROPS OCCURRING WITH OTHER SEDIMENT
z = OCCASIONAL COBBLE OR BOULDER ZONES INTERSPERSED WITH OTHER SEDIMENT
= CONTOURS AT 5 METER INTERVALS TAKEN FROM USC & GS CHART 0808N-50
= BOUNDARIES OF SEDIMENT TYPES
MASSACHUSETTS MINERAL INVENTORY SURVEY
SURFACE SEDIMENT TEXTURE MAP
450920-4
RAYTHEON
RAYTHEON COMPANY
LEXINGTON, MASS 02173
1 .5 0 1 2 3 4
SCALE IN NAUTICAL MILES

APPENDIX XI

ACOUSTIC PROFILES

(See drawing number 45920-2 & 3)

MASSACHUSETTS COASTAL MINERAL INVENTORY SURVEY

ACOUSTIC PROFILES

DWG. NO. 45920-2

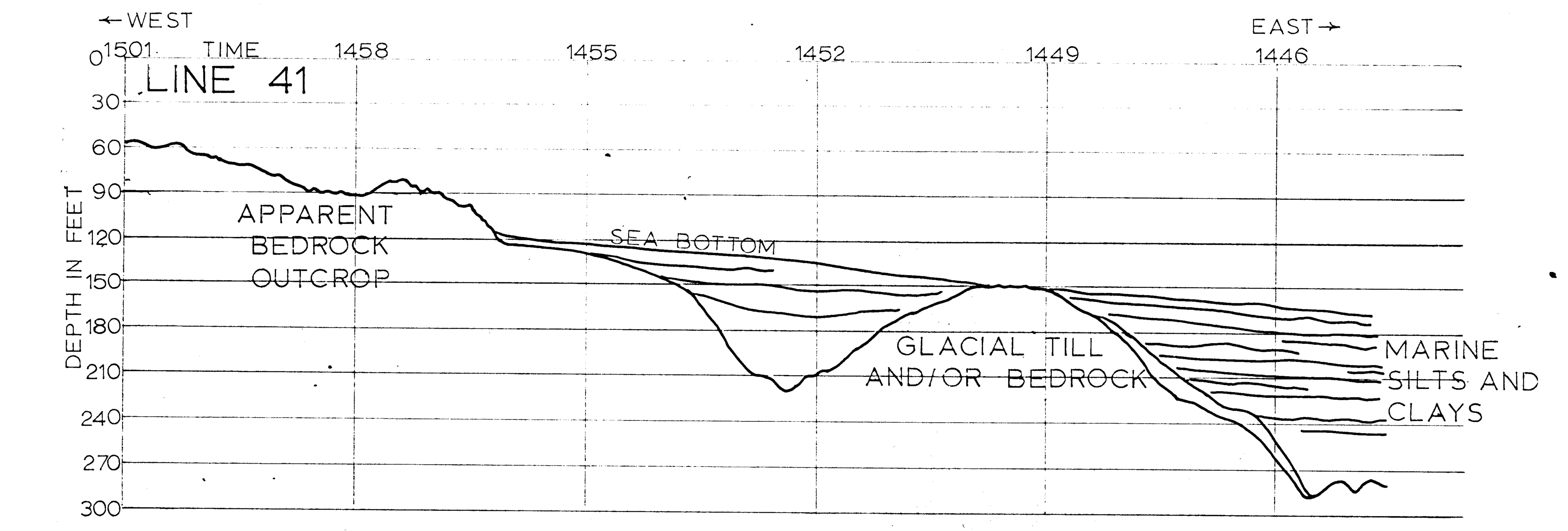
RAYTHEON

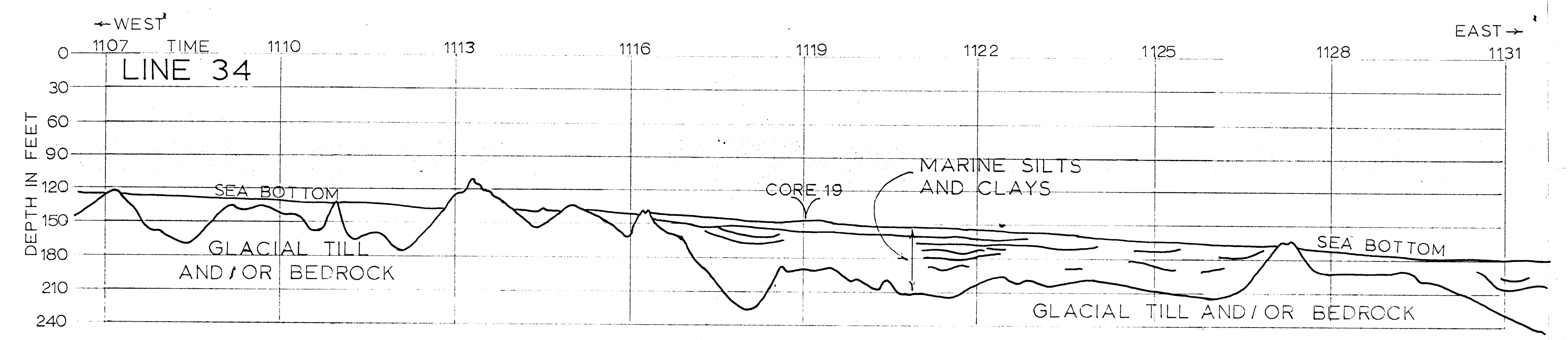
MASSACHUSETTS COASTAL MINERAL INVENTORY SURVEY

ACOUSTIC PROFILES

DWG NO. 45920-3

RAYTHEON





APPENDIX XII

KEY TO COLOR CODE

NUMBER	DESCRIPTION
5 Y 7/2	Yellowish Gray
5 Y 5/2	Light Olive Gray
5 Y 3/2	Olive Gray
5 Y 8/4	Grayish Yellow
5 Y 6/4	Dusky Yellow
5 Y 4/4	Moderate Olive Brown
5 Y 7/6	Moderate Yellow
5 Y 5/6	Light Olive Brown
10 Y 8/2	Pale Greenish Yellow
10 Y 6/2	Pale Olive
10 Y 4/2	Grayish Olive
10 Y 7/4	Moderate Greenish Yellow
10 Y 5/4	Light Olive
10 Y 6/6	Dark Greenish Yellow
5 GY 7/2	Grayish Yellow Green
5 GY 5/2	Dusky Yellow Green
5 GY 3/2	Grayish Olive Green
5 GY 7/4	Moderate Yellow Green
10 GY 7/2	Pale Yellowish Green
10 GY 5/2	Grayish Green
10 GY 3/2	Dusky Yellowish Green
10 GY 6/4	Moderate Yellowish Green
10 GY 4/4	Dark Yellowish Green
5 G 7/2	Pale Green
5 G 5/2	Grayish Green
5 G 3/2	Dusky Green
5 G 7/4	Light Green

KEY TO COLOR CODE (Cont)

NUMBER	DESCRIPTION
5 G 6/6	Brilliant Green
5 G 5/6	Moderate Green
10 G 8/2	Very Pale Green
10 G 6/2	Pale Green
10 G 4/2	Grayish Green
N 9	White
N 8	Very Light Gray
N 7	Light Gray
N 6	Medium Light Gray
N 5	Medium Gray
N 4	Medium Dark Gray
N 3	Dark Gray
N2	Grayish Black
N 1	Black
5 YR 8/1	Pinkish Gray
5 YR 6/1	Light Brownish Gray
5 YR 4/1	Brownish Gray
5 YR 2/1	Brownish Black
5 Y 8/1	Yellowish Gray
5 Y 6/1	Light Olive Gray
5 Y 4/1	Olive Gray
5 Y 2/1	Olive Black
5 GY 8/1	Light Greenish Gray
5 GY 6/1	Greenish Gray
5 GY 4/1	Dark Greenish Gray
5 GY 2/1	Greenish Black
5 G 8/1	Light Greenish Gray

KEY TO COLOR CODE (Cont)

NUMBER	DESCRIPTION
5 G 6/1	Greenish Gray
5 G 4/1	Dark Greenish Gray
5 G 2/1	Greenish Black
5 B 9/1	Bluish White
5 B 7/1	Light Bluish Gray
5 B 5/1	Medium Bluish Gray

APPENDIX XIII

SIEVING TECHNIQUES

Equipment

1 or 2 sets of nested sieves
1 vibrapad
supply of 250 ml beakers
brass and nylon brush
balance sensitive to .1 grams
data sheets
drying oven
distilled water

Sample Preparation

The sieving methods described below are useful only for dry sediment. Samples collected from the sea floor contain salt in the interstitial water, and when dry, small grains become cemented together. Therefore, the salt must be washed out of the sample before it is dried.

- Each sample is placed in a 250 ml beaker and appropriately labeled. Distilled water is added, the slurry mixed, and the sediment allowed to settle to the bottom. The supernatant water is then decanted. This process is repeated twice. The samples are then placed in a drying oven (105°C) and allowed to dry overnight.
- If the sample contains a significant quantity of silt and clay, it must be wet-sieved. The wet sample is placed in a .08mm screen positioned at the top of a beaker. Distilled water is poured into the screen, and the sample is gently agitated with a finger to wash silt and clay through the screen. When all the fines have been washed through, the coarse fraction is placed in another beaker. Both beakers are allowed to dry in an oven at 105°C overnight. A subsequent comparison of the fraction weights will reveal the percentage of silt and clay in the entire sample.

Sieving Procedure

- Aggregates of grains remaining in the dried samples (in the case of wet sieving, the coarse fraction) are gently broken up with a stirring rod.

- The sample is then split by the quartering method to an approximate weight if 50 grams or more than this amount is present. The quartering method involves placing the sediment in a pile on a sheet of cardboard. Another cardboard sheet is used to separate the pile into four quarters. Two opposite quarters are returned to the sample bag, and the other two are recombined to form a central pile. The process is then repeated until a 50 gram fraction is produced.
- The 50 gram fraction is then poured into the nest of sieves. The sieves are placed on the vibrapad and allowed to shake for 10 minutes.
- The sand remaining on each sieve and the pan is then weighed after placing it in a tared beaker. To insure complete analysis, sand grains adhering to the screens are cleaned off with brushes. The weight data is entered on a data sheet.
- The raw data is used to compute weight percentages of sediment in the different size grades.

Logistics

Assume that four samples, A, B, C, and D have been washed and dried.

- Disaggregate and split sample A, and shake in the sieves for 10 minutes.
- Disaggregate and split sample B while A is being sieved.
- When A is finished shaking, empty the sieves into beakers and replace with sample B, initiating the shaking.
- While B is being sieved, weigh the fractions of A retained on the different sieves and record. Then disaggregate and split sample C.
- When B is finished shaking, empty the sieves into beakers and replace with sample C, initiating the shaking.
- While C is being sieved, weight the fractions of B retained on the different sieves and record. Then disaggregated and split D.

This assembly line method is repeated until the set of samples is analyzed. Availability of a second set of sieves speeds up the procedure considerably. A short-cut in weighing the sieve fractions involves adding the increments of sand to the same beaker, and subtracting the previous weight to determine the weight added.