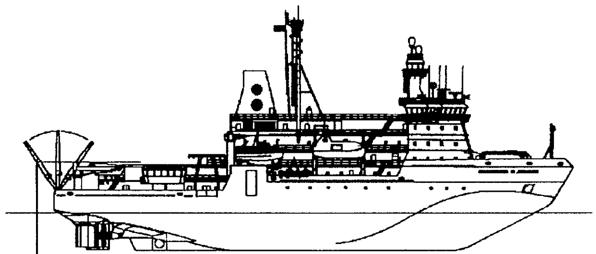
Nathaniel B. Palmer
Cruise 93-1

Report of Coring Operations



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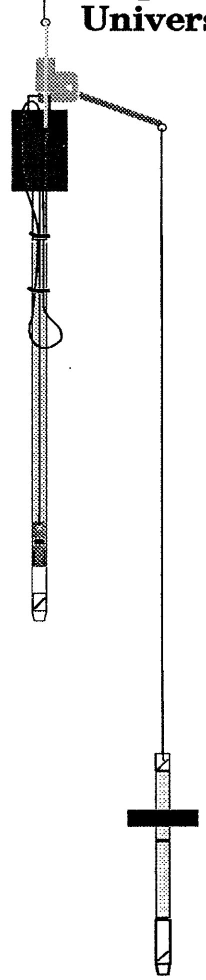

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Acknowledgements

The author wishes to thank Mark Wiederspahn and Benjamin Scott for insightful discussions on piston coring theory; the scientific staff aboard NBP93-1, many of whom acted as deck hands for the coring operations; assistance of workers from Antarctic Support Associates, particularly Marine Projects Coordinator Jim Holik and marine technician Benjamin Scott; terrific shipboard support from the Chouest officers and crew of the *Palmer,* a truly amazing scientific research platform; and, finally, Chief Scientist Larry Lawver for making the cruise possible and the Division of Polar Programs of the National Science Foundation for funding it.

Cruise NBP93-1, the maiden coring voyage for the *Palmer,* included thirteen coring stations, eleven on the Larsen Shelf and two in the Powell Basin, among which ten recovered mud-rich sediment columns ranging from 36 to 416 centimeters long. An ODP spec coring rig was used for both piston and gravity style coring, the former averaging far better recovery, particularly once trial-and-error led to technique refinements. Brittle liners were the only problem which should be addressed before future coring.

The areas sampled include the 300-meter deep Larsen Shelf, where a core was attempted 600 feet from the active ice sheet, the upper slope west of the shelf, and the Powell Basin center in 3400 meters of water. Sediments recovered were grey muds and clays ranging from soupy to dry and stiff with varying fractions of sand to cobble sized grains interpreted as debris derived from melting ice.

Apparatus

The coring apparatus is a relatively new piston coring rig that reportedly conforms to the specs of rigs successfully employed by the Ocean Drilling Program, ODP. While not in use, the bomb sits horizontally in a steel cradle on a sled sitting on rails which are bolted to the deck. Core barrels are lashed in a wooden cradle nearby and attached as needed. The core is deployed by sliding the sled down the rails to the stern where the bomb and barrel tilt on end into the water.

The steel parts of the coring apparatus are particularly susceptible to corrosion. Care should be taken to dry them as soon as possible after each use and apply a light coating of oil as necessary to prevent rust. Before packing this apparatus for the last time, the marine tech scoured it with a wire brush and oiled it thoroughly.

Components

Figure 1 depicts a single barrel piston core assembly as it would look upon deployment with the major elements labelled. Note should be made that the diagram is not to scale and, in particular, the trigger chain ought to be longer than shown.

Both barrels are lined and core catchers are threaded on them with flapper valves inserted. The flappers are one-way valves designed to allow sediment to travel up into the liner, but not slide back down and out the bottom during retrieval. The flapper valves sit inside a cylindrical holder which is dropped into the core catcher before it is attached to the barrel.

At the very end of the barrel a liner protector is inserted. The protector is a cylindrical sleeve with a small lip around the bottom designed to protect the bottom end of the liner from being abraded or chipped by any large rocks moving into it. This sleeve was not used in gravity coring, although it probably could be.

The piston is at the base of the core barrel, inside the liner, with the narrow basal section fitting inside the liner protector and the upper portion, including the sealing o-rings, fitting snugly inside the liner.

The scope line, a wire cable, is attached to the piston at base and to the cable on the trigger arm at the top. Extra scope line is taped to the upper part of the core barrel. The core barrel is a fifteen foot steel pipe that attaches to the bomb by means of an interlocking connector which is, in ~~term~~ turn attached to the bomb. The connector is designed for easy attachment and detachment of the barrel and works reasonably well in this regard.

The trigger core hangs from the trigger arm by a chain. With the trigger arm pulled down, the finger on the opposite end holds the main core barrel and bomb. A safety pin on the trigger which insures the arm doesn't swing up, is removed just before deployment.

Theory of Operation

Figure 3 is an attempt to depict how we think the piston coring rig operates. When the trigger core enters the sediment (3B), the trigger arm swings up and the main core is released and accelerates under the pull of gravity (3C), reduced by friction from water and, later, from the sediment. As the core catcher enters the sediment, the flapper is pushed open, and the piston should sit atop the sediment/water interface with the scope fully extended (3D). The core barrel and weight continue to fall. When the top of the barrel hits the piston, it drags the piston into the sediment (assuming it has the potential energy to continue to do so), takes up any slack in the winch line, and possibly even stretches it some (3E). The piston cores on NBP93-1 came back with mud up over the top of both bombs, suggesting superpenetration of the sediment, a situation which could upset the scope/chain geometry, probably resulting in a failure to sample the upper part of the sediment column in the main core.

A gravity core (Figure 2) is much simpler to operate than a piston core. The core barrel and bomb are lowered into the bottom at maximum winch speed (about 65 meters per minute on the *Palmer*). In hard sediments a gravity core won't penetrate as deeply as a piston core. Furthermore, without the piston, sediment neither enters the liner nor is kept in the liner as well in a gravity core.

Methods

This section explains the basic steps followed in rigging, deploying, retrieving, extracting, sealing, and storing the piston cores. Gravity core methods are very similar except without a trigger core, trigger arm, scope line, or piston. As a result, gravity core maneuvers tend to be a little faster. However, under optimal conditions, we were able to rig a piston core in about an hour, while in transit to the coring station, deploy it twenty minutes after arrival, and steam away about forty-five minutes after retrieval.

Rigging

The marine technician oversaw rigging of the cores. Before rigging, the cores and bombs should be clean of all mud from previous efforts, an important procedure following retrieval. The first step is to insert liners in the main and trigger core barrels, both of which require trimming with a hacksaw before the core catcher is attached. The trigger core takes a six foot long liner, which extends the length of the barrel up to the hinged cap at the top. Clearly, only in cases of maximum penetration, beyond the bomb, would the liner entirely fill with sediment. The main barrel should be lined before it is attached to the bomb, then attached, the piston fed through from the bomb, and seated at the bottom. Figure 1 shows the proper position of the piston: flush with the bottom of the liner and barrel, with the liner protector inserted around the base of it. Rumors from ODP suggest the piston should only be inserted to the first o-ring. While this has the advantage of occluding that much more air space from the core catcher, it doesn't allow proper seating of the liner protector inside the liner, so we chose to fully insert the piston in the barrel. Once the piston is seated, the core catcher, with the flapper properly situated, can be attached and hand-tightened (using wrenches makes the core catcher very difficult to remove). Extra scope line is looped once and taped to the upper core barrel, as depicted, with care taken that it won't tangle on the bomb cradle. The trigger arm is attached to the top of the bomb and the trigger pin inserted.

Deployment

The marine tech orchestrates deployment, including safe and careful travel of the sled down the rails and over the stern, lifting, lowering, and tieing off of the trigger core, extraction of the main bomb and barrel from the cradle, attachment of the trigger core chain to the trigger arm, and, lastly, removal of the safety pin. This maneuever typically requires the marine tech plus an assistant, a deck winch operator for the sled, and a main winch and A-frame operator in the aft control room.

An observer with a coring station form should be ready in the aft control room for deployment. In the forward dry lab, watchstanders should note times of critical elements of the operation by watching the winch and back deck monitors. The piston core can be lowered at full speed (65 m/min), but should be slowed and lowered at about half speed (30 m/min) the last hundred meters or so. The observer notes the time and speed of deployment and watches with the operator for a visible "hit", or jerking of the cable, near the depth indicated on the 3.5 or 12 kHz sonar. The winch tension on pullout is noted as an indicator of the depth of penetration and stickiness of the sediments. A pullout from full penetration in hemipelagic mud at 3,000 meters depth averaged about 5,000 pounds.

Retrieval

The marine tech executes the reverse of his deployment maneuver; ties off the trigger core, removes the trigger chain from the trigger arm, cradles the main bomb and barrel, and hoists the trigger core aboard. Once the sled is safely at the top of the rails, a swarm of handlers descends upon the core to unrig it and carry the barrel to the wooden cradle. One of these persons ought to be armed with electrical tape, a tape measure, liner end caps, a dry rag, and, if desired, ziploc bags and acetone. Before anything else, the length of mud outside the barrel is measured and noted as an indicator of penetration. Second, because we initially found ourselves getting poor recovery in the liner while a great deal of sticky clay adhered to the outer core barrel, we established a practice of scraping mud off the outer core barrel into ziploc bags. Such mud, although of unknown and almost certainly mixed provenance in the sediment column, was considered better than none at all. Once any desired sediment is collected, the core barrel and bomb should be thoroughly washed off. The top of the core barrel is detached and the core barrel carried by three people to the wooden cradle while a fourth guides the scope line, still attached to the piston, through the bomb.

Extraction

Once the core barrel is in the wooden cradle, the core catcher at the bottom and piston at the top are carefully removed so as to prevent mud from spilling. The core catcher is taken to the wet lab. Any mud extruding from the end of the liner is carefully pushed back in, and the liner slowly pushed from the top end of the barrel using the ramming pole. Once extruded several inches, the bottom of the liner should be wiped dry, capped with a clear endcap and sealed as described below. The remainder of the liner is extruded and taken to the Baltic Room. In cases of poor recovery, the outside of the empty liner is carefully hosed off so that a determination could be made as to whether sediment had entered the liner and later slide back out.

The core catchers for both the main and trigger cores were taken to the wet lab sink where they were examined and the contents extruded into ziploc bags using the small brass plunger. Examination consisted of trying to ascertain the attitude of the flapper valve and whether it closed or not, particularly in cases where recovery was poor. Our core #8B had a rock wedged in the tip of the catcher that acted as an excellent flapper, but certainly also prevented further sediment from entering the liner.

Sealing

Ends of cores were sealed using a three-part system of acetone, electrical tape, and bulldog tape. Acetone was applied to the inside the cap and on the *clean and dry* end of the liner before the cap was fitted on. Acetone melts the plastic on the liner and caps allowing them to bond tightly. Electrical tape was wound tightly, starting at the end cap and spiralling about three inches down the liner, to provide further insurance of an airtight seal. Finally, two strips of bulldog tape crossed over the cap, then taped down with a spiral from the end, prevent the cap from coming off should the first two parts of the system fail.

Labelling

All cores were labelled on the outside in magic marker with the cruise number, core number, and up direction. Some cores were also labelled on the end caps and on the bulldog tape (places not easily rubbed clean). In case the marker rubs off the liner, all cores were etched with the core number and an up arrow using a razor blade. Furthermore, red caps were used on the tops and clear caps on the bottoms of each length.

Storage

Cores were initially stored in the Baltic Room, lashed upright. Tops of long cores were tied to the balcony. Cores with a lot of water on top were drained by means of a hole pierced in the liner above the zone of unsettled mud in the water. Once said mud settled and all possible water was removed, a period of up to 24 hours, the tops were sawed off and they were capped. Once finally capped the cores were tightly enough sealed to store horizontally without disturbing the sediments inside, and were moved to the cooler and lashed together on the floor, as per ODP procedure.

Final Disposition

The cores were ultimately shipped to the core repository at University of Florida in Tallahassee. A crate was constructed of such dimensions as to halve the largest reasonable length core and to hold all the cores tightly. Cores that had to be cut to fit in the shipping crate were resealed as described above.

Results

Table 1 and Figures 4 and 5 summarize the results of the coring efforts on NBP93-1; other notes are posted below as was deemed necessary.

Site 1. Our first core was an unsuccessful piston-style operation in the Powell Basin centre which came back empty except for the trigger. Retrieval of the core onto the deck was an unmitigated disaster, lasting over two hours and including a fouling of winch lines under the a-frame. Unfortunately, during this entire time the core assembly was at the stern, out of the water. The chief scientist postulated that the scope (30 feet, same as the chain) was too short and that the piston pulled up prematurely, pulling water into the liner before the sediment. As this would require a scope at least fifteen feet too short, it is considered unlikely. However, the scope was increased (actually, the chain shortened) by three feet for the next piston core, at station number 10.

Site 2. Because of the unknown character of the bottom at the second coring site, in the middle of the Larsen shelf, a gravity core was attempted. Fair recovery (139 cm) was accepted considering the somewhat hard bottom. This core was lowered at 50 m/min, while succeeding cores were run down at full speed: about 65 m/min.

Site 3. This station probably ought to have been a piston core, instead of the first of eight gravity core stations comprising thirteen deployments which recovered a very modest total of 4.5 meters of sediment. However, the chief scientist was concerned about the amount of time piston cores would consume based on the fact that the first one proved so troublesome for the deck crew. Unfortunately, the gravity cores didn't achieve very good penetration (averaging about 200 cm) and seemed to have troubles with the flapper holding the sediment in.

Site 7. This site is notable because the ship was about 600 feet from the Larsen ice sheet, a most unique geologic, biologic, and oceanographic settting. Although nothing was recovered in the liner, mud was saved from the core barrel and the core catcher.

Sites 8 and 9. The marine technician discovered a "modified flapper" with a spring on both sides which we began using in hopes that the sediment would grab it and close the flapper. We had observed that the mud seemed to build a berm just above the flapper which allowed the sediment to flow past it and out. Core 8B had better recovery, but this was attributable to a dropstone lodged in the end of the core catcher. Cores 9A and 9B washed out at the surface to the great dismay of assembled witnesses. It was decided that it was time (finally!) to attempt piston coring, which turned out to be a good decision, even if rather late.

Site 12. The liner was splintered about one foot above the base and had a hole about the size of a grapefruit near the top. This was interpreted as the result of a bubble of overpressured air, trapped in the core catcher, travelling up the liner with the piston. Possible preventions for this type of catastrophe would be to swing the core about in the waves (this station was in very smooth seas) to get the air bubble out, to put a small perforation near the top of the core catcher (not recommended), or to use a less brittle liner.

Lithology

Determination of lithologies at the coring stations was performed by examination of the sediment from the outer core barrel and the core catcher, both of which were handled as they were put into plastic bags, and by examination of the sediment in the liner. Lithologically, the cores may be divided into groups from three physiographic locations: the Larsen shelf, the upper slope off the Larsen shelf, and the deep Powell Basin.

Cores two through ten and core twelve were from the Larsen shelf. On the gravity cores with any recovery in the liners, the core catchers typically contained a layer of soft light grey mud about six centimeters thick underlain by a much stiffer dark clay. Both zones had an abundance, perhaps 10% of the total volume, of sand grains, pebbles, and even cobbles. The gravity cores with some recovery had only the lower, stiff clay preserved in the core catcher. The same hard dark clay, with a veneer of light mud, was stuck to the outer core barrel, sometimes so well that it was difficult to break off a piece. One interpretation of these layers is that the lower dark, dry, stiff clay was compacted at some point by a grounded ice shelf while the upper soft mud has accumulated since the retreat of the ice. Such a scenario would produce a hiatal and possibly erosional unconformity between the two layers equal to the temporal existence of the grounded ice as a minimum. Such an unconformity would be expected to decrease in age in the direction of retreat of the ice, presumably east to west.

Coring station number eleven was on the upper slope about five miles east of the Larsen shelf edge. The core catcher contained soft to medium soft light to dark grey mud with very abundant (perhaps 20% of the total volume) sand, pebbles, and cobbles. The stiff, dry clay layer from the shelf stations was not observed. The outer core barrel was relatively free of sticky mud, instead coated lightly with light grey mud and abundant sand and pebbles. Abundant pack ice was located just east of the coring location and, if perennial, could explain the higher incidence of apparent dropstone debris. The lack of a compacted layer makes sense as one wouldn't expect a grounded ice shelf in such deep water off the shelf edge.

The first and last coring stations were in the Powell Basin. The core catchers preserved light grey medium soft mud with little or no larger clasts that could be interpreted as dropstone debris. This lithology makes sense in terms of the physiographic setting; we would expect pelagic and/or hemipelagic accumulations of fine-grained sediments compacted only by their own weight.

Recommendations

With due attention accorded the sensitive elements of piston style coring, including scope and trigger lengths, flapper and piston settings, and competent winch and deck handling, the rig used proved very well suited. Our final coring effort suggested it was relatively straightforward to take at least a fifteen foot sample of muddy sediment and entirely plausible to fill a second length of liner had one been attached. This rig does not appear particularly well adapted for gravity coring, which afforded shallower penetration and poor sediment retention probably attributable to inadequate support from the flapper valve. It is possible that in sediments other than those we gravity cored, especially softer muds, the rig would work better.

In the future, it would probably be a good idea to use some liners that are not quite as brittle as those we used. Temperatures at the coring stations average a little over 0°C, and probably didn't go below -5°C. These liners would probably behave more brittly under colder conditions.

Some problems with the logistics of using the several winches and blocks necessary for piston coring occurred early on and are best addressed by the marine technician, who may have recommendations regarding changes to the winch locations, a-frame blocks, or other apparatus.

Appendix I: Coring Equipment Inventory

The following is a partial list of the coring equipment on board for this cruise.

9	15' steel core barrels
2	trigger arm setups
1	trigger safety pin and line
1	short brass plunger
7	core catchers setups, including flapper, flapper holder, and liner protector sleeve
2	long steel plungers
3	pistons
2	scope lines
2	interlocking main barrel to bomb connectors
2	sleeve removal devices, steel
2	trigger core setups, including barrel, bomb weight, and top
	assorted extra pieces
	many 15' core liners
	a box of red and clear core end caps

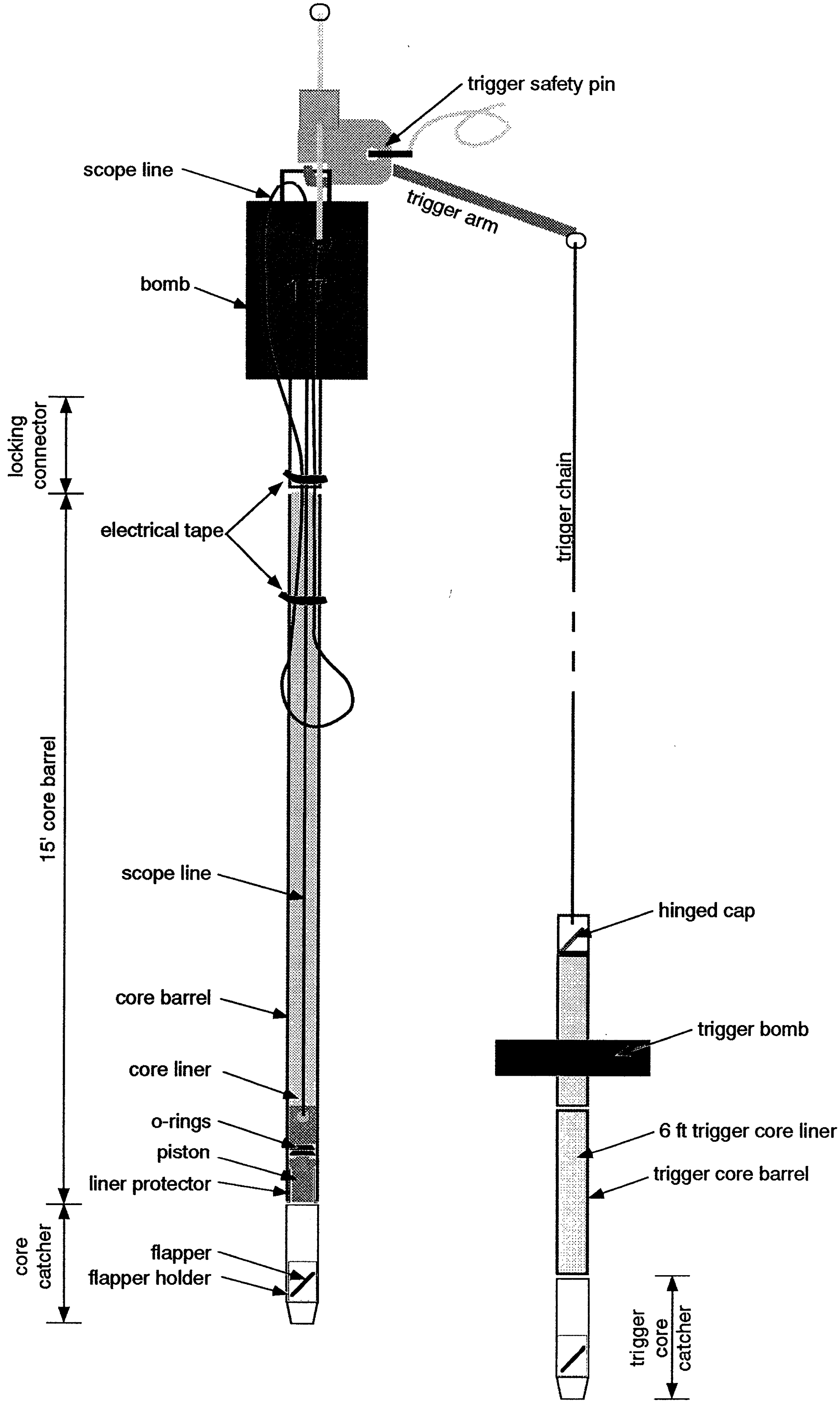


Figure 1. Piston coring rig used on NBP93-1. Not to scale. Trigger chain longer than shown.

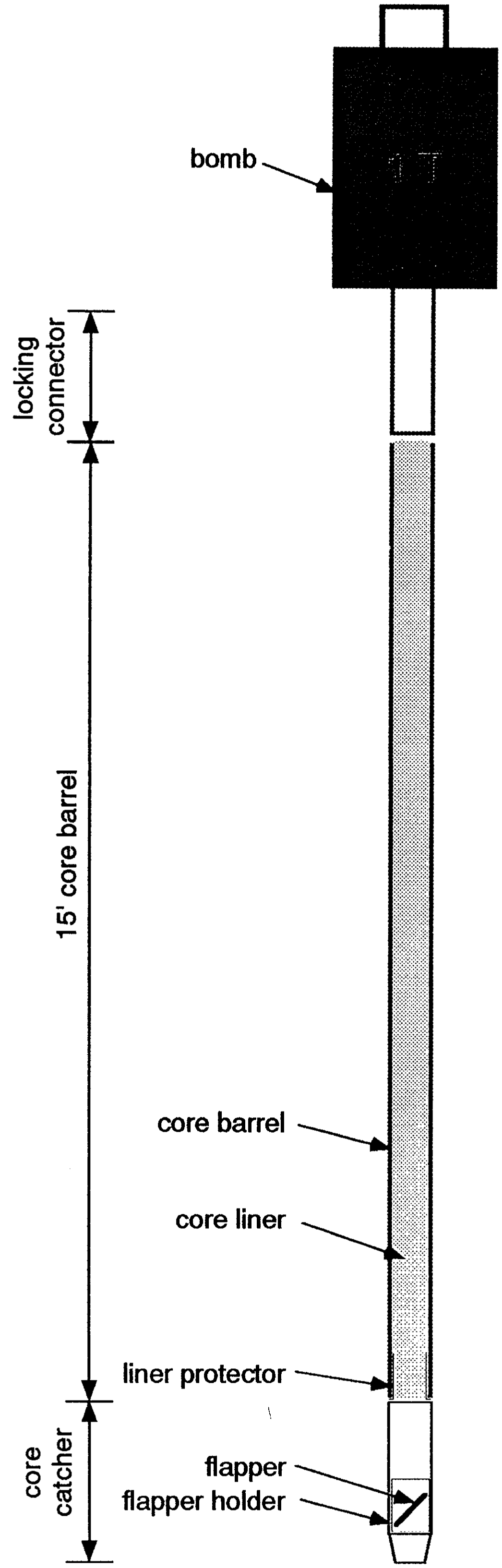


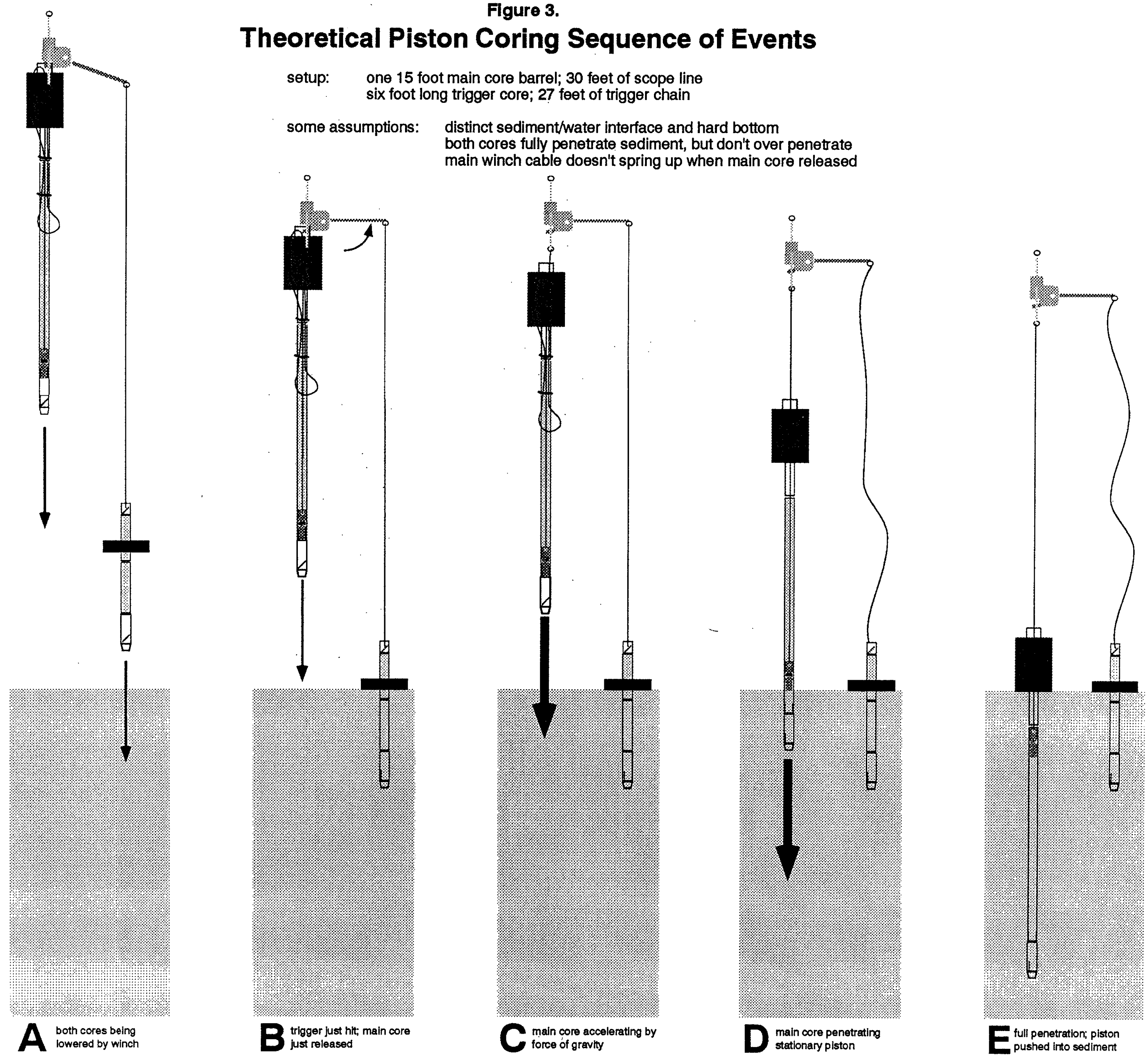
Figure 2. Gravity coring rig used on NBP93-1. Not to scale.

Figure 3.

Theoretical Piston Coring Sequence of Events

setup: one 15 foot main core barrel; 30 feet of scope line
six foot long trigger core; 27 feet of trigger chain

some assumptions: distinct sediment/water interface and hard bottom
both cores fully penetrate sediment, but don't over penetrate
main winch cable doesn't spring up when main core released



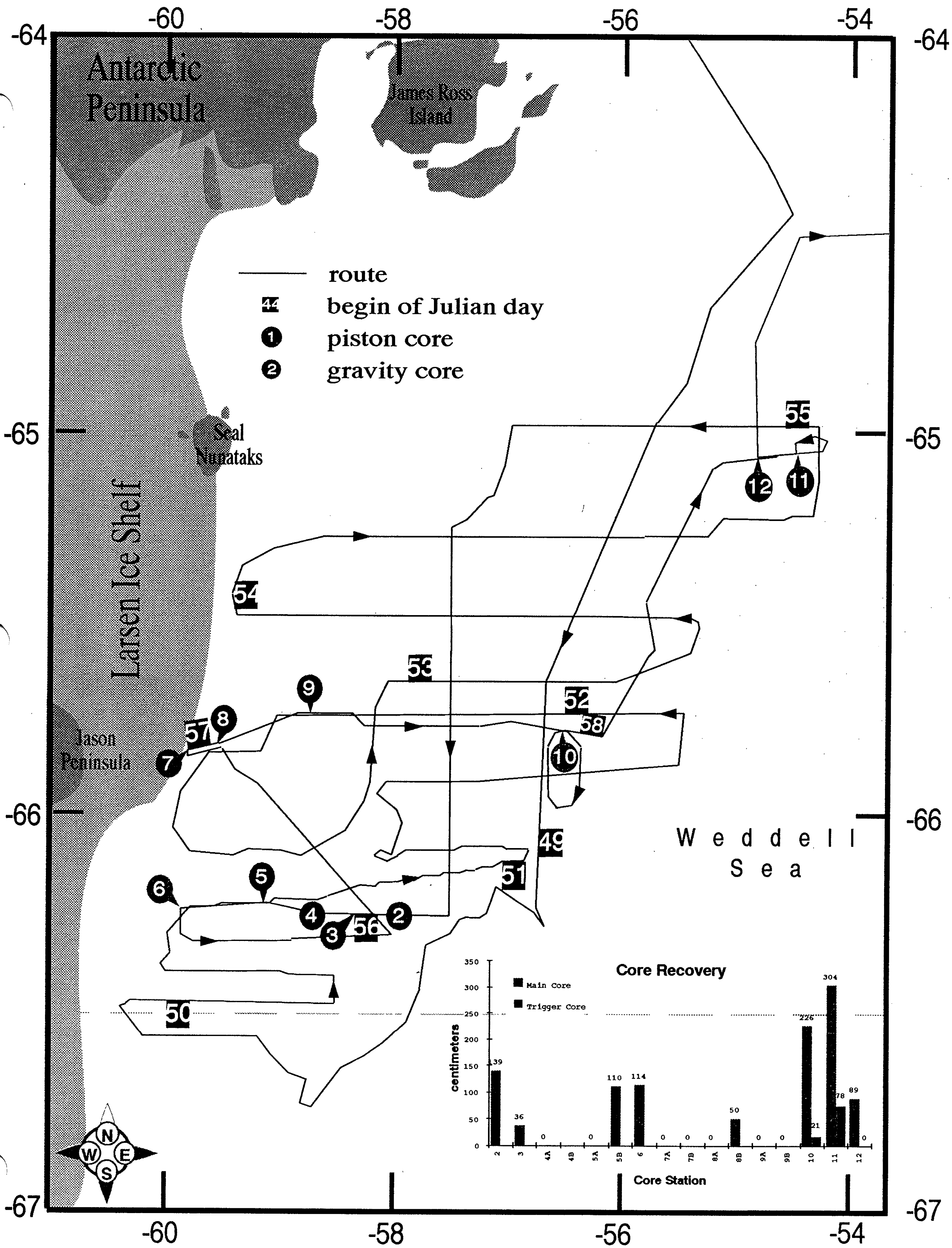


Figure 4. Location of Larsen Shelf cores and cruise route.

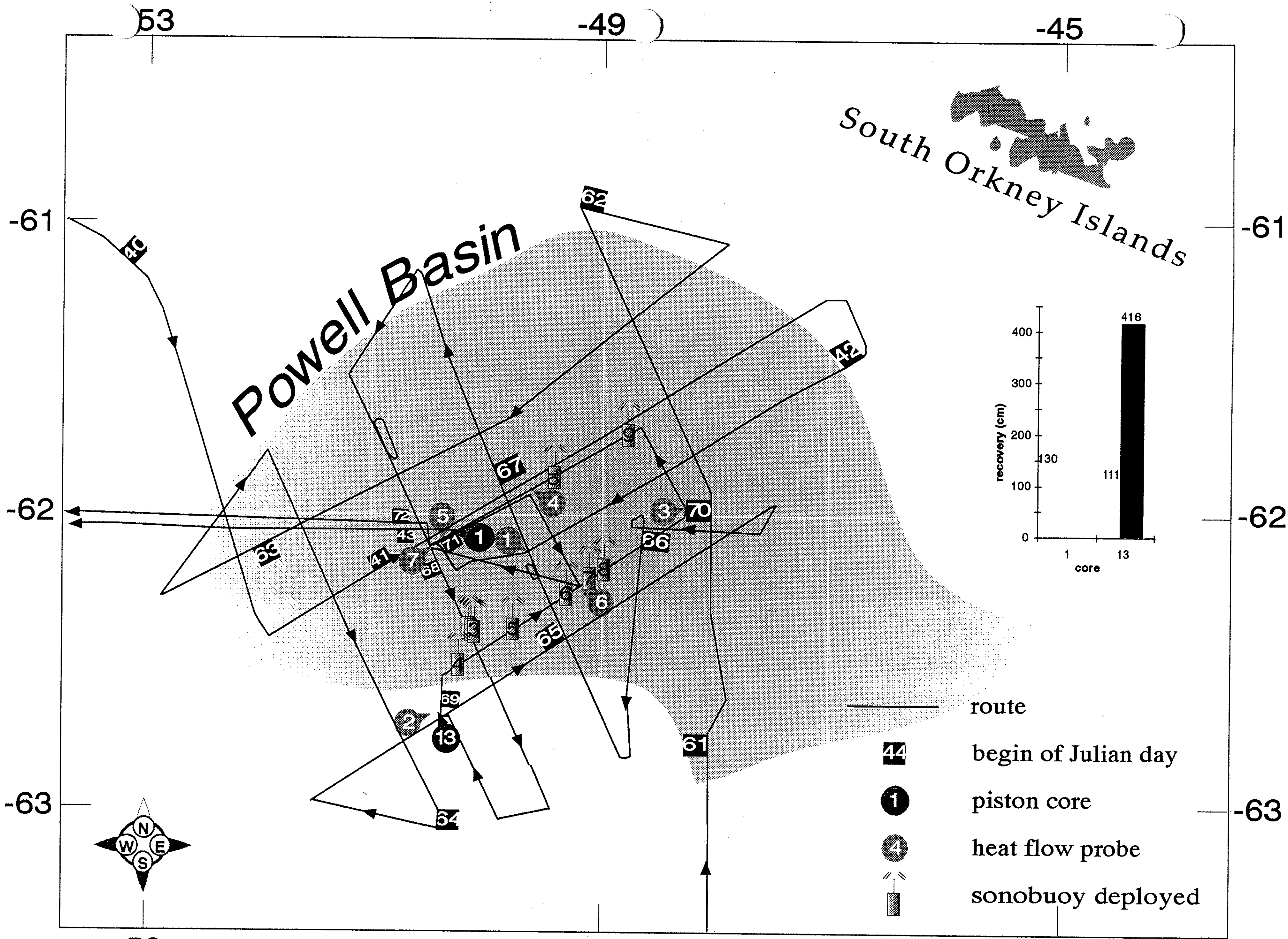


Figure 5. Position of cores 1 and 13 relative to Powell Basin seismic and heatflow.

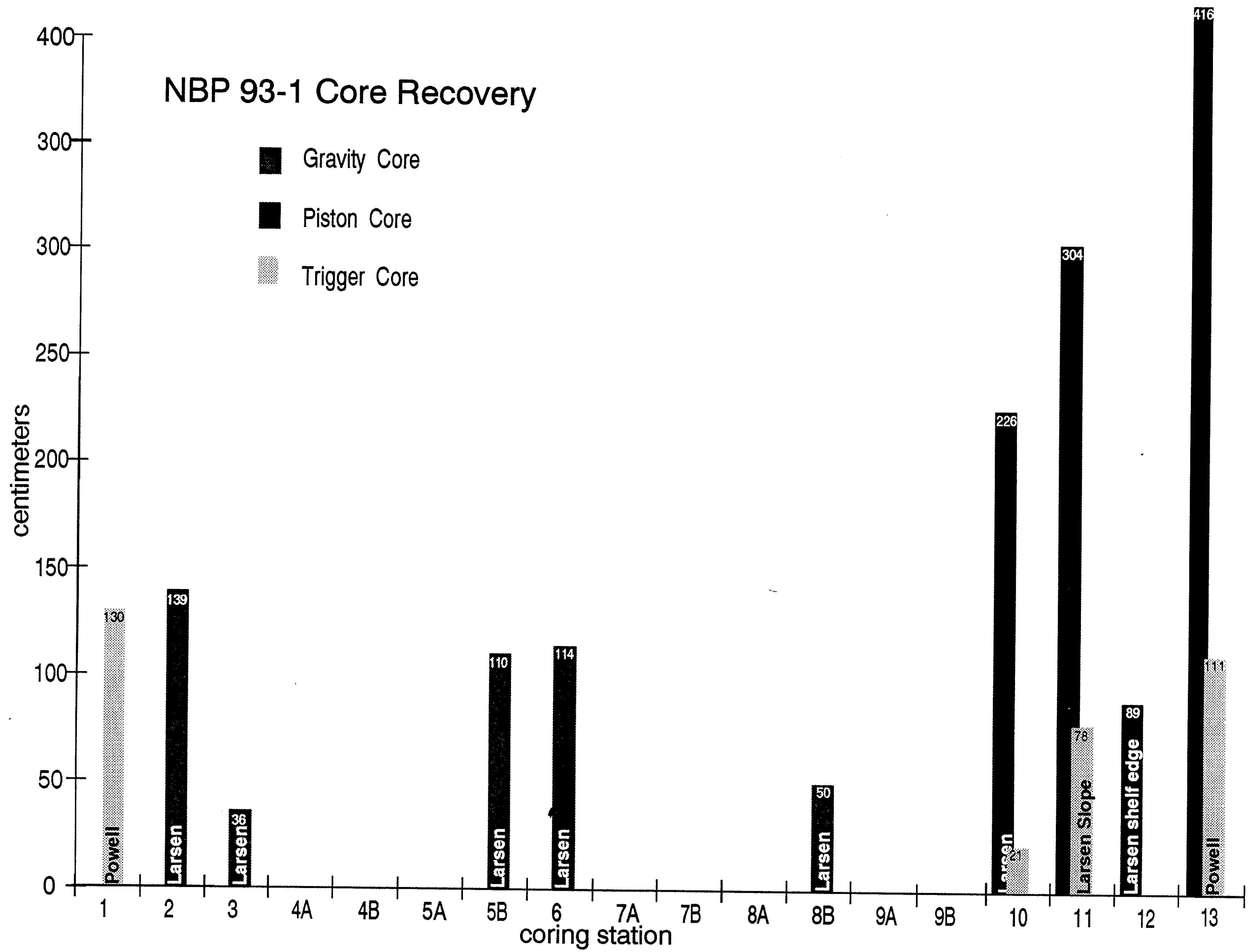


Figure 6. Core recovery chart.

Table 1. NBP 93-1 Coring Summary

No.	Type	Latitude	Longitude	Time of Previous Crossing*	Location	Water Depth	RECOVERY Main	RECOVERY Trigger	BAGS Main Core Barrel	BAGS Main Core Catcher	BAGS Trigger Core Catcher	Comments
1	piston	62°06.1082'S	50°19.8850'W	JD 41 00:15	Powell Basin-mid	3,420 m	0 cm	130 cm			TCC1-1,TCC1-2,TCC1-3	scope thought to be too short
2	gravity	66°14.18'S	57°57.44'W	JD 50 20:45	Larsen Shelf- mid	332 m	139 cm			CC2-1		
3	gravity	66°13.80'S	58°14.09'W	JD 50 19:45	Larsen Shelf- mid	330 m	36 cm		CB3-1			
4A	gravity	66°13.75'S	58°42.45'W	JD 50 18:00	Larsen Shelf- mid	330 m	0 cm			CC4A-1, CCA-2, CC4A-3		
4B	gravity	66°13.57'S	58°42.59'W	JD 50 17:58	Larsen Shelf- mid	319 m	0 cm		CB4B-1, CB4B-2, CB4B-3, CB4B-4	CC4B-1, CC4B-2, CC4B-3		
5A	gravity	66°12.16'S	59°9.58'W	JD 50 16:20	Larsen Shelf- mid	349 m	0 cm		CB5A-1, CB5A-2			flapper installed backwards
5B	gravity	66°12.21'S	59°9.58'W	JD 50 16:20	Larsen Shelf- mid	338 m	110 cm		CB5B-1, CB5B-2	CC5B-1		
6	gravity	66°13.2'S	59°51.87'W	JD 50 13:44	Larsen Shelf- west	341 m	114 cm		CB6-1	CC6-1		
7A	gravity	65°51.53'S	59°43.73'W	JD 52 11:20	Larsen Shelf- west, 600 ft from ice	428 m	0 cm		CB7A-1			
7B	gravity	65°51.57'S	59°43.79'W	JD 52 11:20	Larsen Shelf- west, 600 ft from ice	420 m	0 cm		CB7B-1, CB7B-2			
8A	gravity	65°44.06'S	58°47.78'W	JD 52 07:45	Larsen Shelf- west	352 m	0 cm		CB8A-1			
8B	gravity	65°44.043'S	58°47.8162'W	JD 52 07:45	Larsen Shelf- west	339 m	50 cm		CB8B-1, CC8B-1			Began using modified flapper
9A	gravity	65°44.01'S	58°28.67'W	JD 52 06:32	Larsen Shelf - mid	330 m	0 cm					washed out near surface
9B	gravity	65°44.1978'S	58°28.8684'W	JD 52 06:37	Larsen Shelf - mid	330 m	0 cm		CB9B-1			washed out near surface
10	piston	65°46.24'S	56°2.79'W	JD 57 15:55	Larsen Shelf - mid	330 m	226 cm	21 cm	CB10-1, CB10-2, CB10-3	CC10-1	TCC10-1	excellent penetration
11	piston	65°4.43'S	54°28.76'W	JD 58 12:45	Larsen Slope	643 m	304 cm	78 cm	CB11-1	CC11-1, CC11-2	TCC11-1	excellent penetration; no flapper in trigger core!
12	piston	65°5.08'S	54°48.83'W	JD 58 11:40	Larsen Shelf edge	443 m	89 cm	0 cm	CB12-1	CC12-1, CC12-2	TCC12-1, TCC12-2	excellent penetration, liner imploded
13	piston	62°43.69'S	50°25.12'W	JD 64 17:58	Powell Basin- mid	3406 m	416 cm	111 cm	CB13-1	CC13-1	TCC13-1, TCC13-2	excellent penetration

*Time of previous crossing refers to Julian Day and hour ship crossed core location collecting seismic and 3.5 kHz