CRUISE REPORT FOR NBP93-1

RVIB NATHANIEL B. PALMER

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NATHANIEL B. PALMER CRUISE NPB93-1

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We left Punta Arenas on the 4th of February 1993 at 0200 local. We were about 14 hours late departing because we were hoping that the McKissock blocks would arrive as airfreight and because the ship was still taking on oil out of drums. We had had to anchor off for at least two of the days the ship was in port which was why the oil had not been loaded earlier. Once underway, it was abundantly clear that this is the best platform that I have ever experienced for doing marine geology and geophysics in Antarctica. The anti-roll tanks are a dream. There seemed to be more room then we could possibly use. As far as interior space, that certainly turned out to be true. Deck space did get cramped with two sets of rails and two gun racks. Inside, it was a true luxury to have 20 foot counter spaces to put out seismic records for analysis.

Our track chart is shown as the first figure [NBP93-1 Route Map]. This cruise was originally funded to do heat flow and seismic work in Powell Basin and Bransfield Strait. As it developed, it turned out that Summer 1993, was the most spectacular ice-free year on the eastside of the Antarctic Peninsula on record. We decided that the opportunity to collect seismic, gravity and magnetics data along the shelf as far south as possible, was simply too good to pass up. Consequently, we modified our objectives, particularly since we found that weather conditions in Powell Basin proscribed working there at the beginning of the cruise. We left Powell Basin on JD 044 in order to be in Maxwell Bay early on JD 046 to collect the McKissock blocks when the SAAM flight came down from Punta Arenas. The blocks turned out to be critical to our cruise. We did a small amount of survey work in Bransfield Strait, as well as a half-day of very succesful dredging, prior to the visit to Maxwell Bay. After the stop at King George Island, we did some more dredging until the wire became jammed in the old block and we headed for the east side of the Peninsula in order to go where no one had gone before. We were able to collect seismic data that extends our knowledge of the geological history of the Peninsula far to the south of its previous limit. When we finally exhausted all the possible time that we could spare from the original cruise plans, we left the Peninsula, headed east along 64°30'S and made one of the significant new discoveries of this cruise. There was a large Geosat gravity anomaly [satellite derived gravity] which the track was planned to investigate. We actually ran down one of the largest landslides ever seen. It covers a distance of almost 120 km and coincides with the gravity anomaly. The deviation in track at JD 060 was a short survey along the footwall of the slide.

We then reluctantly headed north along 48° West to enter the Powell Basin. After 11 days of spectacular weather along the Larsen Ice Shelf, the wind picked up and seas got rough in Powell Basin. I was anxious to commence heat flow work but weather did not permit although we able to collect good to excellent seismic data in conditions that normally would have precluded seismic data collection. We finally got to heat flow work at the very last possible moment. Luckily the gear worked flawlessly after an initial leak problem. The heat flow values that we got were extremely uniform so our decision to spend less time on heat flow and to take the time down the Peninsula paid off. We got more than enough data to determine the age of the basin which was the main goal of the cruise. As we thought, there were no correlateable magnetic anomalies from the Powell Basin, so age can not be determined from the normal method. The heat flow with the depth to basement determined from the seismic data with four guns working will give an accurate determination of age. The weather at the end of our stay was adequate to good for station work. As it was, it appeared that during much of the time we spent south along the Peninsula, the weather was bad in Powell Basin because the eastward moving lows from the Bellinghausen Sea seem to get swept north along the west side of the Peninsula and straight across Powell Basin. We were caught in one bad storm in Powell Basin with the seismic and magnetics gear streamed. We had gotten complacent with the good weather that we had had along the eastside of the Peninsula so were less than vigilant about requesting weather reports or talking to Marambio for weather ops. The 1600-2000hr watch experienced 25 to 35 kt winds which we had had no real trouble operating in. By 2100, the winds had picked up to 60 kts sustained and the seas were confused with at least three separate wave sets. It was clearly too dangerous to bring the gear in, so Jamie Scott went out and secured the gear that had broken loose. We then congregated in the Aft Control Station and watched the show. The fantail would get buried in the waves and scoop up huge amounts of water that then washed everything on the fantail. We had a long night but all the gear survived, some slightly damaged but nothing was lost. We awoke the next day to beautiful skies, very confused seas and dead krill on the 03 deck with lots of krill scattered about the 02 deck.

We finished off the Powell Basin work and ran for Bransfield Strait to finish dredging. Dredging was so successful that we finished our six targets early and did some extra heat flow work. We finally had to head for home and got in one last seismic survey in the western Scotia Sea. The return crossing of the Drake was uneventful. We ran on four engines and made as much as 14.7 kts. The ship rode beautifully as before.

Report for week ending, JD 042, 11 February 1993

We left Punta Arenas, Chile on the 4th of February at 0200. We sailed out the Straits of Magellan, turned right, passed through the Straits of LeMaire and headed for Antarctica. After the first day out, the weather smiled on us and it was hot and sunny. We decided to take the opportunity to deploy the SSI gas-injector guns and the 24 channel MCS streamer. We had deployed the gradiometer previously. It took a while to get the guns deployed. The streamer was a major disappointment since it floated and the data was intolerably noisy. We tried numerous fixes, all of which seemed to make minor but only minor improvements. We are now in the process of adding a 400 foot, non-bouyant leader to the 72-phone, 24-channel streamer. We will then add chain links every meter to the streamer itself to overcome its bouyancy. Mark has been able to make the EG&G 2420 record 24 channel data with the proper headers. The Cypher tapedrive will read the tapes and write them to Exabyte.

We crossed the Scotia Sea on a track east of but parallel to the Shackleton fracture zone. We then did a minor survey of the Geosat anomaly that may be the new plate boundary between the Shackleton and Antarctic plates. We found one crossing of a 150 m, very prominent fault scarp that shows vertical offset of all the flat lying beds from the surface down. We hope that we will have an opportunity to further survey this feature at the end of the cruise. We then turned southward on our way into Powell Basin. We started our first long crossing of Powell Basin towing the gradiometer, a single-channel oil filled streamer, a 24 phone ITI streamer wired as a single-channel streamer and two SSI guns. We started to collect extremely nice high resolution single channel data on the ITI streamer. We had to weight this streamer with 72 pieces of two link chain in order to keep it from floating. I have gotten to be quite good at cutting up chain with a portable band saw. The effort worked. We then decided to deploy a second set of two SSI guns. Unfortunately one of the second set had an air leak and was misfiring. With the three guns on our return run across Powell Basin we collected beautiful data with over two seconds of penetration. We were able to see basement under the 0.8 seconds of flat lying high reflectivity, turbiditic sediments that seem to uniformly blanket Powell Basin.

Last night, the first set of guns had been operating flawlessly for almost five days so we decided to bring them in for preventive maintenance. We used the time to do a core, the first core ever taken on RVIB Palmer. While we did recover a good core and the Powell Basin looks to present an ideal place to core and take heat flow measurements, our operation needs a great deal of improvement. We are now on our way to Bransfield Strait in order to do some dredging and to be at Maxwell Bay when the SAAM flight arrives.

The ship is a true luxury liner. It has dynamic positioning which will be a great help on the heat flow stations. Mark [aka Dr. Wizard] and Keith have been an amazing pair in helping ASA sort out lots of the teething problems on the ship as far as computers and electronics. Keith may even get the 3.5 kHz system working. The chef was most recently the executive chef on Choest's yacht. Needless the say, the results are spectacular. I have already had trouble with the dryer shrinking all my pants. The scientific party is a good group, hard working, and should be commended.

Report for week ending, JD 049, 18 February 1993

The first week ended with the return crossing of Powell Basin with 3 of 4 SSI gas-injector guns firing. We were able to pick up the basement reflector which we had missed on the eastward crossing. We stopped to do the first piston core. Contrary to what was reported in the last cruise report, we did not get a good core. We cored 130 cm in the trigger core and retrieved a minor amount in the main core. We think that the seas were too rough and as the piston core hit the bottom the ship rolled pulling the piston through the liner, filling the liner with water and then just stabbing the bottom at the end. We have completely rethought the coring setup and hope that the next try will be far more successful.

Since the weather in Powell Basin had turned nasty, we pulled in the seismic gear and headed at 10+ kts to Bransfield Straits. By the time we got there the guns had been overhauled and we redeployed them. We then ran a series of lines suggested by Dan Barker across the eastern end of the King George Basin. We may have found another Great Wall or at least a very narrow 300+ m spire. We will dredge it when we return to the KGB. We also found another volcanic mound in the eastern KGB. On the seismic lines on the Antarctic Peninsula side of the basin, we found the same faulting that Dan had seen on the Ewing data but with our high resolution setup we were able to trace these faults to the surface or at least as close to the surface as is resolvable with any seismic set-up. We then crossed the central KGB to finally get some high resolution seismic lines that I can use to analyze the heat flow results. We then turned southwest and crossed the submarine volcano that rises from 1900 m to 600 m on the western end of KGB. The caldera is 2.8 km in diameter at the rim and 0.5 km diameter at the floor. We continued to the southwest and crossed the Great Wall along the same track as Ewing crossed it. It was 450 m high and about 0.5 km wide. We then pulled in the seismic gear. We recrossed the Great Wall and dredged it to the northwest. We got a number of good bites up to 8000 lbs. The bag was about half full with about 200 kg of fresh vesicular basalts. Many have glassy rinds with some palagonite. Since I have not done any dredging in over 15 years, it was a real thrill to bring up a bag full on the first try. We then ran over to the volcano and dredged the inner wall of the caldera. Again we got about 150 to 200 kg of fresh, glassy, vesicular basalt.

We then gave up work and the ship headed into Marsh Base with a rendevous with RV Polar Duke and a contingent of dignitaries. Amongst the DVs were Al Sutherland, Peninsula Ops, DPP, Ron Koger, president of ASA, Carol Roberts, Dep. Dir., DPP, various Embassy types, Senate Foreign Affairs Committee types, etc. They stayed through brunch and then headed for the beach and a SAAM flight back to Punta Arenas. They at least expressed an appreciation for the problems connected with this operation. With luck, some of the flaws may be rectified. Unfortunately, by the time the DVs headed for the beach, the weather was really starting to kick up. Consequently, the only person from the Scientific Party that got ashore at Marsh was Brad Wolaver.

After we left Marsh, we returned to dredging the volcano, and dredged the rubble pile at the base of the volcano. We collected a light load (50 kg) of mostly weathered basalts and some very large drop stones. We did get one very nice tubular basalt with large vesicles on the interior and some glassy rind on the exterior. We then dredged the steep outer slope of the volcano. We got another 200 kg bag of rocks and lots of biological type stuff. The rocks were more of the vesicular basalt with some palagonite. We then headed east and tried to dredge the small volcanic mound (~200 m high) on the western edge of KGB [NE of the volcano]. Unfortunately, the 3.5 kHz system was working so poorly, that even when we slowed to 2 knots, we still could not see the bottom. It is fairly hard to dredge something that you can not see. We have since discovered that the holding tank for the 3.5 kHz transducer was empty again which may explain part of the problem. An additional problem was that we were on a course of 183 with a strong eastwind producing a marked starboard list. The 3.5 is on the portside and was probably shooting what little energy it got beyond the 1.25 inch steel plate into the watery void. Someday that system may be sorted out. Needless to say, when the wire jumped the shieve we finally gave up dredging and got underway through Antarctic Sound to shoot down the east side of the Peninsula.

Report for week ending, JD 056, 25 February 1993

Our exciting story ended last week with our heading through Antarctic Sound to transit to the east side of the Peninsula. Our passage through Antarctic Sound was uneventful with only minor ice, some fog and generally low overcast. We then put out the 24 phone single channel streamer, four airguns and the magnetometer and headed on a course of 135 until we hit the ice edge at 64°30'S and 54°20'W. We then followed the ice edge on a southwest course and eventually got to 66°45'S, 58°45'W. We commenced an east-west grid with an intial 5 mile spacing to 66° where we switched to a 10 mile spacing. We got next to the iceshelf on three separate times. Twice at sunset and once in the early morning. The weather was clear, warm and there was little or no wind. I have never seen it so good for so long. The U1 reflector can be seen in almost all of our lines and we were easily able to trace John Anderson's S1, S2, and S3 subdivisions south from where he described them around Seymour Island. The high resolution seismic setup is perfect for this work. We then stopped the seismic work when we had completely run out of time and started coring. We collected 11 successful cores. We initially started with gravity cores. The bottom sampled by many of the cores close to the iceshelf and in

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Heat Flow Summary

Heat Flow Station #1 (Powell Basin)

HF Station #	Penetration #	Begin/End	Latitude	Longitude	Depth (m)	Tilt Angle
1	01	Begin	N/A	N/A	N/A	N/A
		End	N/A	N/A	N/A	N/A

Heat Flow Station #2 (Powell Basin)

HF Station #	Penetration #	Begin/End	Latitude	Longitude	Depth (m)	Tilt Angle
2	01	Begin	-62:43.510	-50:23.350	3406	8
		End	-62:43.497	-50:23.480	3507	8
2	02	Begin	-62:42.810	-50:23.450	3403	11
		End	-62:42.790	-50:23.320	3521	11
2	03	Begin	-62:42.100	-50:23.040	3403	12
		End	-62:42.010	-50:25.210	3528	12
2	04	Begin	-62:41.880	-50:23.090	3403	12
		End	-62:41.330	-50:23.140	3512	12

Heat Flow Station #3 (Powell Basin)

HF Station #	Penetration #	Begin/End	Latitude	Longitude	Depth (m)	Tilt Angle
3	01	Begin	-62:00.020	-48:16.050	3188	8
		End	-62:00.100	-48:16.18	3422	8
3	02	Begin	-61:59.493	-48:16.220	3188	8
		End	-61:59.561	-48:16.103	3432	8
3	03	Begin	-61:58.858	-48:16.226	3188	11
		End	-61:58.828	-48:16.289	3422	11
3	04	Begin	-61:58.229	-48:16.801	3188	17
		End	-61:58.244	-48:16.658	3405	17
3	05	Begin	-61:58.293	-48:16.703	3188	5
		End	-61:58.321	-48:16.724	3405	5

Heat Flow Station #4 (Powell Basin)

HF Station #	Penetration #	Begin/End	Latitude	Longitude	Depth (m)	Tilt Angle
4	01	Begin	-62:02.573	-50:10.210	3398	11
		End	-62:02.620	-50:10.060	3535	11
4	02	Begin	-62:02.019	-50:10.460	3399	8
		End	-62:01.955	-50:10.288	3508	8
4	03	Begin	-62:00.101	-50:00.983	3398	15
		End	-62:00.105	-50:00.922	3574	15

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Heat Flow Summary

Heat Flow Station #5 (Powell Basin)

HF Station #	Penetration #	Begin/End	Latitude	Longitude	Depth (m)	Tilt Angle
5	01	Begin	-61:55.279	-49:37.319	3368	11
		End	-61:55.350	-49:37.350	3506	11
5	02	Begin	-61:54.970	-49:38.990	3368	6
		End	-61:54.180	-49:39.280	3580	6
5	03	Begin	-61:54.770	-49:40.550	3375	5
		End	-61:54.870	-49:39.570	3542	5

Heat Flow Station #6 (Powell Basin)

HF Station #	Penetration #	Begin/End	Latitude	Longitude	Depth (m)	Tilt Angle
6	01	Begin	-62:14.520	-49:09.800	3392	8
		End	-62:14.530	-49:09.420	3510	8
6	02	Begin	-62:14.070	-49:10.390	3390	11
		End	-62:14.170	-49:10.810	3509	11
6	03	Begin	-62:13.817	-49:11.852	3390	19
		End	-62:13.820	-49:11.890	3520	19

Heat Flow Station #7 (Powell Basin)

HF Station #	Penetration #	Begin/End	Latitude	Longitude	Depth ((m)	Tilt Angle
7	01	Begin	-62:06.920	-50:28.850	3442	8
		End	-62:06.970	-50:28.880	3558	8
7	02	Begin	-62:06.440	-50:28.610	3442	11
		End	-62:06.410	-50:28.290	3572	11
7	03	Begin	-62:05.780	-50:27.490	3435	14
		End	-62:05.790	-50:27.460	3560	14

Heat Flow Station #8 (King George Basin)

HF Station #	Penetration #	Begin/End	Latitude	Longitude	Depth (m)	Tilt Angle
8	01	Begin	-62:17.980	-57:55.850	1972	8
		End	-62:17.990	-57:55.830	2016	8
8	02	Begin	-62:18.190	-57:57.040	1972	8
		End	-62:18.080	-57:57.140	2026	8
8	03	Begin	-62:18.240	-57:57.860	1965	8
		End	-62:18.300	-57:58.040	2023	8
8	04	Begin	-62:18.560	-57:58.980	1965	8
		End	-62:18.490	-57:59.040	2011	8

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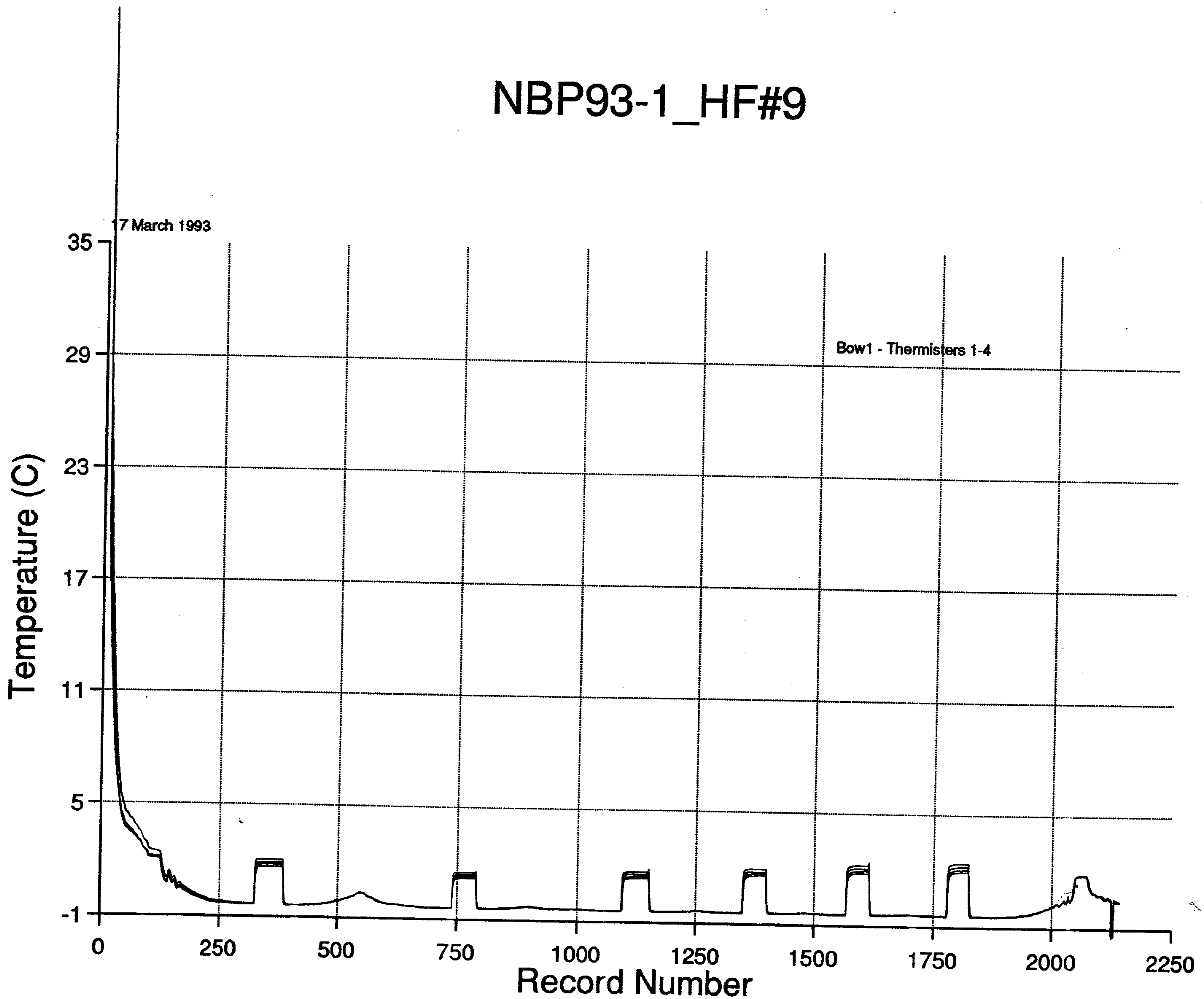
Heat Flow Summary

Heat Flow Station #9 (King George Basin)

HF Station #	Penetration #	Begin/End	Latitude	Longitude	Depth (m)	Tilt Angle
9	01	Begin	-62:17.490	-57:40.040	1989	13
		End	-62:17.490	-57:40.030	2031	13
9	02	Begin	-62:17.980	-57:40.780	1989	15
		End	-62:17.910	-57:40.980	2051	15
9	03	Begin	-62:18.150	-57:40.770	1989	14
		End	-62:18.180	-57:40.780	2032	14
9	04	Begin	-62:18.100	-57:40.670	1989	8
		End	-62:18.040	-57:40.660	2029	8
9	05	Begin	-62:18.140	-57:40.410	1989	13
		End	-62:17.950	-57:40.130	2042	13
9	06	Begin	-62:17.840	-57:40.020	1989	10
		End	-62:17.770	-57:40.040	2042	10

NBP93-1_HF#9



17 March 1993
Bow1 - Thermisters 1-4
Temperature (C)
35
29
23
17
11
5
-1
0
250
500
750
1000
1250
1500
1750
2000
2250
Record Number

the southern part of the area was very compact and almost dry. Some of the samples had to be dug out of the core catcher with a knife. When it became obvious that the core catchers on the ODP coring setup that we had, could not work with the stiff, gritty sediments that we were collecting, we switched to piston coring. We recovered two longer cores, one 2.5 m and one 3.5 m. On the third try, the core liner shattered, probably upon impact and we recovered less than a meter.

We spent eight days on seismic and two days coring. We are now underway on a course to the east along 64°30' S. We will turn north at 48° W and head into Powell Basin. I would say that with the dredging from last week and the seismic data from this past week, the cruise has been successful already. I hope that we can duplicate our success in Powell Basin and collect at least some heat flow data. I doubt that we will have weather nearly as perfect as we have had so far. The 3.5 kHz still gives lousy results and we have yet to try the 12 kHz system.

Report for week ending, JD 063, 4 March 1993

We finally tore ourselves away from the shelf off the east side of the Peninsula. We headed north to 64°30'S and turned east to cross the large negative Geosat gravity anomaly. We crossed the outer shelf and then crossed a steep continental slope. The upper part was steeper than the other part of the slope that we had crossed further to the south. As we went down the slope, we noticed a lot of beds being cut off at the surface. There was one particular set of wavy beds that started at about 0.4 seconds depth, eventually emerged at the surface, and then disappeared. As we headed east the slope gradually decreased until it ended at a 150-m scarp which I at first took to be an erosional feature or possibly some sort of fault scarp. Just after we had crossed the feature, the compressors had a problem so we circled around and crossed the feature a couple of miles north to get its orientation. After the compressor was fixed then the guns had a problem and we continued north in order to get another good crossing of the scarp. The second crossing of the scarp was west of the first but then the third crossing was quite a ways east of the first crossing. It finally dawned on me that what we were seeing was a huge landslide. In fact the size of the landslide coincides with the prominent negative gravity anomaly seen on the Geosat data. The seismic profile when viewed in that light looks exactly like one of the many landslides that I grew up with. The top of the slope was the headwall and the mysterious scarp at the bottom was the footwall. When viewed as a monstrous slide then all the disappearing beds make sense.

After we crossed the toe of the slide we continued east across what is called Trettin Bank on the DMA chart. We are happy to report that Trettin Bank does not exist, at least not where it is purported to be. We then continued on to Powell Basin. There are a series of ridges (?) that divide the westernmost part of Jane Basin from Powell Basin. In fact there are three which makes one wonder what we were crossing and where exactly Powell Basin starts. We got into Powell Basin and the weather was marginal to do station work so we continued with a seismic survey. The weather got progressively worse until we had 'the storm' on the 4th. We went from 20-30 kt winds to steady 60 kt winds within one hour. The fantail was completely buried in water on each set of waves. There was no question of trying to bring the guns or any other equipment in. All we could really do was stand in the aft control room and watch the water go by. I did not really expect to see all the equipment the next morning but lo and behold we got everything back. The storm really only lasted about four hours and then went back down to 25 to 30 knots. The next night the moon was out. Unfortunately the storm has left confused seas with at least three sets of waves. We finally tried our first heat flow station today. It was blowing about 5 to 12 kts when we started but had gusted to 25 to 30 knots when we aborted the station. The equipment appeared to be working well until it stopped transmitting. We are now changing out one of the endcaps since we found a connector with a chip out of it. We hope that that was the problem that produced a small leak and plan our next heat flow station tomorrow, if the weather cooperates. We are all thinking of wildflowers and spring. There are only two more weeks to go.

Report for week ending, JD 070, 11 March 1993

Well our weather luck has improved immensely. The Powell Basin is finally workable. We got the heat flow equipment working. It turns out that the problem was a leaking pressure sensor. We took a piston core and recovered 4.4m of hemipelagic muck. We have now been doing heat flow for the last three days. The equipment is working perfectly. Keith Najmulski has done a superb job getting the heat flow electronics to work and he understands the equipment better than anyone, including probably the people that built it. We are recording the data on an EPC 9800 which is a real dream machine, no odors. Beautiful separation of the data, the heater pulse has fired every time, and we can see the bottom bounce with the heat flow pinger. We did use an additional 12 kHz pinger on the wire for the first two and a half stations. Unfortunately it fell off the wire on the third station. The clamps, safety line, and frame returned to the ship minus the cylindrical pinger. There is no explanation for why or even how it was able to detach itself. Fortunately Powell Basin is flat, the winch works great and the ship's officiers are able to do heat flow station work without using the bow thrusters as long as the weather stays good. The last few days we have had 5 to 15 kt winds and 5 foot seas. We were able to get a beautiful 12 hour crossing of the extinct spreading center using four SSI guns and the 72 phone 24 channel streamer. We got excellent basement definition and could see layering in the sediments all the way to basement at about 2 sec or so. So far we have thrown 10 sonobouys. The first one we used on deck to test the homemade antenna. When we threw it overboard, it immediately sunk because all the CO2 had leaked out. Of the remaining ones, six have been successful for over two hours or more, and one worked for almost an hour. Our success rate is 80% or better. It looks like we may be getting some deep refractions.

We are now in the midst of a heat flow marathon. We only have 27 hours left in Powell Basin. So far we have gotten 11 successful penetrations without any problems. We just plotted out the pressure sensor results from the second station and they tracked the probe movement exactly. We plan three more stations tomorrow. We then leave for Bransfield Strait and a final two days of dredging. If there is any time left, we may try the camera or do some last heat flow work. We will then deploy the seismic gear again, do a quick survey in the southwest Scotia Sea and then on home.

Report for week ending, JD 077, 18 March 1993

The weather stayed good for our last week of work. We finally got six heat flow stations with a total of 21 penetrations. While I had originally planned more stations, the values are remarkably consistent so I doubt there was any need for more measurements. When we finally left Powell Basin we had planned to transit at full speed to Bransfield Strait to do the final two days of dredging. The weather only allowed 6 kts steaming so we took 12 more hours of 4-gun 24 channel seismic data. Great bottom definition and some peculiar wavy beds that Tom Williams calls contourites, whatever those are. The gravity map of Powell Basin looks remarkably similar if not exactly like the Geosat gravity map that Dave Sandwell produced. It kind of makes you wonder why people need aerogravity data at sea. We then pulled in the gear when the fog and weather lifted and headed for our first of six dredge targets in Bransfield Strait. Much to my amazement, we were able to come back with at least something from each site. A couple of times it was the wrong type of rocks, glacial erratics, but four of six returned the right stuff. The least successful dredge was one that I did. We watched three of the four rocks fall out of the bag as we were getting it aboard but they were all erratics anyway. One of my other dredges we got just the right amount of the right rocks (~50 kg). Randy Keller got another one of our mega-hauls, about 200 kg of the right stuff. It seems that the features closest to the South Shetland Islands are the older volcanics covered with more sediment and more erratics and the ones closer to the center are the freshest with glass and unaltered vesicular basalt. The large submarine volcano in between the two lines is about in between. We knocked off the dredge targets in about 30 hours so I was able to do two more heat flow stations. Keith got three penetrations on the first station while I slept and then I did six penetrations on the second station. The second station was done to verify the one very high heat flow value that we had gotten in 1989. The last three penetrations were done with the ship drifting back over the exact spot. The values are remarkable. They gradually increase from about 400 mW/m2 to 650 mW/m2. The total temperature variation from the top to the lower thermistor on the last site was 2.9 °C! When the heat flow probe came back on deck there was a fair quantity of mud in the heat flow weight. There are a lot of black particles in the mud. They are either ash or may be evidence of a black smoker in the vicinity.

We had hoped to take bottom photos of one of the dredge sites and of the high heat flow site. We tested out the camera but with the loss of the pinger from last week and a minor problem with the pinger in the heat flow instrument we had no way of knowing where the bottom was, so no way of taking pictures. We then got underway with all the engines going, ran to the north end of Bransfield Strait and did one seismic crossing of the North Bransfield Basin and exited the region between Clarence and Elephant Island with a good but overcast view of both islands as well as Cornwallis Island. We then went off the slope and out into the Scotia Sea with 4 guns banging, and the 24 channel streamer. We did a quick survey to look for the plate boundary and finally crossed an unusual feature at about 60S, 56W. We then hauled in the gear and headed at full speed across the Drake's Passage. We had a fairly uneventful but windy crossing until last night when we were reminded that we were in fact on a ship and we had a fair amount of rolling. We are now on the east side of Tierra del Fuego and headed north in almost balmy summer type weather. We should be in Punta Arenas by noon tomorrow.

JD68	Latitude		Longitude		Speed	CMG	TWT	Gravity	Magnetism
9 Mar 1993	°	'	°	'	(Knots)		(sec)		
0000	62	6.66	50	29.46			4.57	9674.1	35776.1
0005	62	7.13	50	28.84	6.6	148.3	4.57	9672.5	35725.6
0010	62	7.59	50	28.32	6.3	152.1	4.57	9673.9	35708.1
0015	62	8.01	50	27.67	6.2	144.1	4.57	9672.4	35691.1
0020	62	8.45	50	27.10	6.2	148.8	4.57	9673.9	35695.6
0025	62	8.89	50	26.55	6.1	149.7	4.57	9673.8	35705.8
0030	62	9.34	50	26.00	6.2	150.3	4.57	9674.3	35722.6
0035	62	9.77	50	25.48	5.9	150.5	4.57	9675.4	35738.3
0040	62	10.22	50	24.97	6.1	152.1	4.56	9675.5	35754.0
0045	62	10.65	50	24.48	5.9	152.0	4.56	9676.1	35754.2
0050	62	11.05	50	24.00	5.5	150.8	4.55	9676.9	35767.9
0055	62	11.49	50	23.49	6.0	151.6	4.55	9677.0	35779.0
0100	62	11.90	50	23.04	5.5	152.9	4.54	9677.0	35792.0
0105	62	12.31	50	22.51	5.8	148.9	4.54	9677.9	35820.1
0110	62	12.74	50	21.94	6.1	148.3	4.54	9677.6	35840.5
0115	62	13.16	50	21.41	5.9	149.5	4.54	9677.3	35860.5
0120	62	13.57	50	20.91	5.7	150.4	4.54	9678.8	35867.7
0125	62	13.97	50	20.33	5.8	146.0	4.54	9679.9	35876.9
0130	62	14.39	50	19.89	5.6	154.0	4.54	9680.7	35885.0
0135	62	14.79	50	19.43	5.5	151.8	4.55	9681.3	35890.5
0140	62	15.19	50	18.91	5.6	148.8	4.55	9682.0	35900.0
0145	62	15.58	50	18.39	5.5	148.2	4.57	9681.9	35907.6
0150	62	15.99	50	17.89	5.7	150.4	4.58	9681.8	35919.0
0155	62	16.38	50	17.41	5.4	150.2	4.58	9682.3	35925.9
0200	62	16.80	50	16.87	5.9	149.1	4.58	9683.6	35931.5
0205	62	17.22	50	16.40	5.7	152.5	4.58	9684.1	35931.4
0210	62	17.65	50	15.96	5.7	154.6	4.58	9685.5	35926.9
0215	62	18.07	50	15.51	5.6	153.5	4.58	9686.1	35922.6
0220	62	18.49	50	14.97	5.9	149.1	4.56	9686.9	35921.6
0225	62	18.92	50	14.49	5.8	152.6	4.56	9687.3	35921.4
0230	62	19.34	50	14.06	5.6	154.6	4.58	9689.0	35926.4
0235	62	19.74	50	13.42	6.0	143.4	4.58	9690.5	35925.1
0240	62	20.11	50	13.02	5.0	153.3	4.58	9692.4	35914.5
0245	62	20.53	50	12.54	5.7	152.1	4.58	9693.6	35902.2
0250	62	20.98	50	12.11	5.9	156.1	4.56	9695.6	35903.7
0255	62	21.35	50	11.55	5.4	144.9	4.56	9696.7	35896.7
0300	62	21.75	50	11.12	5.4	153.5	4.56	9697.9	35891.9
0305	62	22.15	50	10.58	5.7	147.9	4.56	9699.3	35888.0
0310	62	22.53	50	10.12	5.2	150.7	4.56	9701.0	35883.5
0315	62	22.97	50	9.71	5.8	156.6	4.56	9702.3	35888.0
0320	62	23.32	50	9.14	5.3	143.0	4.56	9703.5	35896.2
0325	62	23.72	50	8.58	5.7	147.0	4.56	9705.3	35906.0
0330	62	24.13	50	8.10	5.6	151.5	4.56	9706.2	35917.3
0335	62	24.58	50	7.72	5.8	158.6	4.56	9707.9	35930.7
0340	62	24.95	50	7.07	5.7	140.9	4.56	9709.7	35946.1
0345	62	25.28	50	6.59	4.8	146.0	4.56	9710.8	35952.5
0350	62	25.70	50	6.04	5.9	148.8	4.56	9712.8	35965.7
0355	62	26.07	50	5.53	5.3	147.5	4.56	9713.1	35970.5
0400	62	26.48	50	5.14	5.4	156.2	4.56	9715.6	35972.7
0405	62	26.91	50	4.60	6.0	149.8	4.56	9716.4	35983.1

JD68	Latitude		Longitude		Speed	CMG	TWT	Gravity	Magnetism
9 Mar 1993	°	'	°	'	(Knots)		(sec)		
0410	62	27.28	50	4.18	5.0	152.3	4.56	9718.5	35978.0
0415	62	27.70	50	3.78	5.5	156.2	4.56	9720.3	35975.4
0420	62	28.07	50	3.36	5.0	152.3	4.56	9722.9	35976.6
0425	62	28.45	50	2.95	5.1	153.5	4.56	9723.3	35970.5
0430	62	28.86	50	2.47	5.6	151.6	4.56	9723.7	35974.7
0435	62	29.17	50	2.08	4.3	149.8	4.56	9724.3	35974.0
0440	62	29.58	50	1.55	5.7	149.2	4.56	9725.5	35981.8
0445	62	29.95	50	1.18	4.9	155.2	4.56	9727.0	35993.5
0450	62	30.31	50	0.65	5.2	145.8	4.56	9728.0	36003.2
0455	62	30.69	50	0.32	4.9	158.2	4.56	9729.2	35987.2
0500	62	31.05	49	59.88	5.0	150.6	4.56	9731.6	36002.3
0505	62	31.45	49	59.43	5.4	152.6	4.56	9731.2	36011.4
0510	62	31.83	49	59.05	5.0	155.2	4.56	9732.4	36003.0
0515	62	32.17	49	58.56	4.9	146.4	4.56	9732.5	35992.7
0520	62	32.52	49	58.12	4.9	149.9	4.56	9733.6	35993.9
0525	62	32.91	49	57.63	5.4	149.9	4.56	9734.1	35990.2
0530	62	33.26	49	57.19	4.9	149.9	4.56	9733.8	35983.4
0535	62	33.61	49	56.71	5.0	147.7	4.56	9735.3	35969.0
0540	62	33.97	49	56.27	5.0	150.6	4.56	9735.7	35968.6
0545	62	34.34	49	55.77	5.2	148.1	4.56	9735.9	35960.2
0550	62	34.72	49	55.37	5.1	154.1	4.56	9736.7	35951.9
0555	62	35.10	49	54.91	5.2	150.9	4.57	9737.7	35932.2
0600	62	35.46	49	54.51	4.9	152.9	4.57	9738.0	35933.2
0605	62	35.83	49	54.11	5.0	153.5	4.57	9738.3	35920.8
0610	62	36.21	49	53.65	5.2	150.9	4.57	9738.2	35921.5
0615	62	36.59	49	53.31	4.9	157.6	4.57	9740.3	35929.5
0620	62	36.97	49	52.85	5.2	150.9	4.57	9739.9	35943.6
0625	62	37.33	49	52.36	5.1	148.0	4.57	9740.2	35959.1
0630	62	37.72	49	51.86	5.4	149.5	4.58	9739.7	35980.4
0635	62	38.10	49	51.39	5.3	150.4	4.58	9739.3	36006.1
0640	62	38.49	49	50.88	5.5	149.0	4.58	9739.8	36036.0
0645	62	38.89	49	50.37	5.6	149.6	4.58	9740.0	36056.6
0650	62	39.28	49	49.85	5.5	148.5	4.59	9739.9	36080.9
0655	62	39.67	49	49.35	5.4	149.5	4.59	9739.8	36092.1
0700	62	40.07	49	48.85	5.6	150.1	4.59	9740.8	36100.0
0705	62	40.47	49	48.32	5.6	148.7	4.59	9740.6	36106.1
0710	62	40.85	49	47.85	5.3	150.4	4.59	9741.3	36112.4
0715	62	41.29	49	47.35	6.0	152.5	4.59	9741.6	36121.3
0720	62	41.70	49	46.83	5.7	149.8	4.59	9741.8	36133.8
0725	62	42.12	49	46.36	5.7	152.8	4.6	9742.1	36143.1
0730	62	42.53	49	45.80	5.8	147.9	4.6	9742.6	36157.1
0735	62	42.91	49	45.16	5.8	142.3	4.6	9741.2	36165.2
0740	62	43.31	49	44.57	5.8	145.9	4.6	9740.5	36169.5
0745	62	43.73	49	44.02	5.9	149.0	4.6	9742.5	36177.0
0750	62	44.17	49	43.54	5.9	153.4	4.6	9744.3	36183.0
0755	62	44.60	49	43.01	5.9	150.6	4.6	9744.8	36190.5
0800	62	45.04	49	42.50	6.0	152.0	4.6	9744.9	36196.5
0805	62	45.45	49	41.92	5.9	147.1	4.6	9745.4	36204.9
0810	62	45.91	49	41.46	6.1	155.4	4.61	9746.0	36213.5
0815	62	46.33	49	40.95	5.8	150.9	4.61	9746.2	36210.6

JD68	Latitude		Longitude		Speed	CMG	TWT	Gravity	Magnetism
9 Mar 1993	°	'	°	'	(Knots)		(sec)		
0820	62	46.75	49	40.42	5.8	150.0	4.61	9745.7	36218.5
0825	62	47.17	49	39.89	5.8	150.0	4.61	9746.5	36219.0
0830	62	47.59	49	39.35	5.9	149.5	4.61	9745.6	36222.0
0835	62	48.03	49	38.86	5.9	153.0	4.62	9745.6	36224.0
0840	62	48.43	49	38.34	5.6	149.3	4.62	9745.0	36216.9
0845	62	48.85	49	37.82	5.8	150.5	4.62	9744.9	36210.3
0850	62	49.27	49	37.31	5.8	151.0	4.62	9742.4	36201.2
0855	62	49.70	49	36.82	5.8	152.5	4.62	9740.6	36188.6
0900	62	50.13	49	36.30	5.9	151.1	4.62	9739.9	36185.1
0905	62	50.56	49	35.83	5.8	153.5	4.63	9737.7	36183.9
0910	62	50.99	49	35.32	5.9	151.6	4.63	9736.5	36182.1
0915	62	51.42	49	34.82	5.9	152.1	4.63	9734.9	36187.1
0920	62	51.83	49	34.30	5.7	149.9	4.63	9732.7	36194.1
0925	62	52.23	49	33.78	5.6	149.3	4.63	9731.7	36200.9
0930	62	52.66	49	33.27	5.9	151.6	4.63	9730.7	36216.6
0935	62	53.10	49	32.76	6.0	152.2	4.63	9729.9	36228.2
0940	62	53.52	49	32.29	5.7	153.0	4.64	9730.3	36236.0
0945	62	53.93	49	31.79	5.6	150.9	4.64	9729.5	36245.9
0950	62	54.36	49	31.26	5.9	150.7	4.65	9729.9	36257.6
0955	62	54.79	49	30.76	5.9	152.1	4.66	9730.0	36262.3
1000	62	55.24	49	30.22	6.2	151.4	4.65	9732.0	36260.4
1005	62	55.65	49	29.79	5.5	154.5	4.5	9733.9	36266.7
1010	62	56.10	49	29.29	6.1	153.2	4	9736.2	36275.0
1015	62	56.53	49	28.80	5.8	152.6	3.74	9738.9	36277.2
1020	62	56.93	49	28.36	5.4	153.4	3.64	9740.8	36280.7
1025	62	57.34	49	27.76	5.9	146.4	3.61	9742.3	36286.9
1030	62	57.80	49	27.40	5.9	160.4	3.58	9743.6	36289.3
1035	62	58.20	49	26.87	5.6	148.9	3.62	9744.9	36294.7
1040	62	58.65	49	26.46	5.9	157.5	3.6	9743.5	36297.8
1045	62	59.09	49	26.06	5.7	157.6	3.6	9744.0	36299.9
1050	62	59.46	49	25.60	5.1	150.5	3.6	9743.9	36304.2
1055	62	59.91	49	25.22	5.8	159.0	3.59	9742.1	36309.1
1100	63	0.34	49	24.86	5.5	159.2	3.59	9741.5	36312.0
1105	63	0.83	49	25.10	6.0	347.5	3.56	9745.1	36319.7
1110	63	1.16	49	26.04	6.5	307.7	3.64	9760.3	36352.1
1115	63	1.21	49	27.17	6.2	275.6	3.6	9772.2	36382.3
1120	63	1.24	49	28.38	6.6	273.1	3.5	9775.8	36389.5
1125	63	1.23	49	29.05	3.7	268.1	3.43	9776.6	36393.2
1130	63	1.24	49	29.15	0.6	282.4	3.4	9777.4	36397.3
1135	63	1.29	49	32.39	17.7	271.9	3.43	9777.9	36401.2
1140	63	1.29	49	33.42	5.6	270.0	3.4	9778.5	36403.6
1145	63	1.36	49	34.85	7.9	276.2	3.41	9778.7	36403.9
1150	63	1.55	49	36.17	7.6	287.6	3.4	9779.5	36391.5
1155	63	1.76	49	37.01	5.2	298.9	3.36	9779.4	36399.1
1200	63	2.07	49	38.42	8.6	295.9	3.28	9779.4	36401.6
1205	63	2.31	49	39.55	6.8	295.1	3.18	9782.1	36413.5
1210	63	2.42	49	39.97	2.6	300.0	3.14	9782.9	36428.5
1215	63	2.74	49	42.02	11.8	289.0	3.2	9784.8	36449.9
1220	63	2.94	49	43.18	6.8	290.8	3.22	9785.6	36452.5
1225	63	3.00	49	44.36	6.5	276.4	3.21	9786.9	36464.8

JD68	Latitude		Longitude		Speed	CMG	TWT	Gravity	Magnetism
9 Mar 1993	°	'	°	'	(Knots)		(sec)		
1230	63	3.03	49	45.35	5.4	273.8	3.17	9786.0	36460.3
1235	63	3.04	49	46.76	7.7	270.9	3.14	9786.0	36468.8
1240	63	3.03	49	47.98	6.7	269.0	3.21	9787.1	36472.2
1245	63	3.10	49	49.09	6.1	277.9	3.28	9787.1	36474.0
1250	63	3.09	49	50.24	6.3	268.9	3.32	9787.3	36476.7
1255	63	3.14	49	51.33	6.0	275.8	3.33	9787.0	36478.3
1300	63	3.15	49	52.41	5.9	271.2	3.35	9787.4	36493.7
1305	63	3.05	49	53.43	5.7	257.8	3.33	9786.4	36510.7
1310	63	2.82	49	54.25	5.3	238.2	3.34	9785.2	36535.8
1315	63	2.49	49	54.94	5.5	223.5	3.37	9780.0	36543.6
1320	63	2.11	49	55.49	5.5	213.3	3.42	9777.4	36539.9
1325	63	1.73	49	56.02	5.4	212.3	3.46	9775.7	36537.9
1330	63	1.30	49	56.39	5.6	201.3	3.48	9773.2	36533.3
1335	63	0.90	49	56.80	5.3	204.9	3.52	9771.1	36530.6
1340	63	0.51	49	57.29	5.4	209.7	3.57	9769.6	36522.3
1345	63	0.12	49	57.78	5.4	209.7	3.75	9768.0	36511.0
1350	62	59.71	49	58.33	5.8	211.3	3.92	9765.4	36501.1
1355	62	59.28	49	58.80	5.8	206.4	4.15	9762.4	36497.9
1400	62	58.84	49	59.32	6.0	208.2	4.45	9759.6	36492.9
1405	62	58.39	49	59.78	6.0	204.9	4.51	9755.8	36481.2
1410	62	57.94	50	0.36	6.3	210.4	4.53	9754.1	36474.1
1415	62	57.54	50	0.96	5.8	214.3	4.56	9752.8	36468.3
1420	62	57.06	50	1.34	6.1	199.8	4.6	9751.3	36460.8
1425	62	56.63	50	1.94	6.1	212.4	4.61	9749.6	36452.2
1430	62	56.22	50	2.54	5.9	213.7	4.6	9749.5	36446.1
1435	62	55.93	50	2.90	4.0	209.5	4.6	9750.0	36437.1
1440	62	55.32	50	3.78	8.8	213.3	4.6	9749.0	36432.0
1445	62	54.87	50	4.14	5.8	200.0	4.59	9750.1	36414.1
1450	62	54.41	50	4.64	6.2	206.3	4.58	9751.2	36414.5
1455	62	53.97	50	5.25	6.3	212.3	4.58	9752.2	36400.4
1500	62	53.50	50	5.81	6.4	208.5	4.58	9755.0	36390.3
1505	62	53.05	50	6.38	6.3	210.0	4.58	9756.3	36387.8
1510	62	52.60	50	6.95	6.3	210.0	4.58	9757.7	36384.0
1515	62	52.13	50	7.55	6.5	210.2	4.58	9759.2	36388.4
1520	62	51.71	50	8.10	5.9	210.8	4.58	9759.5	36384.5
1525	62	51.29	50	8.69	6.0	212.7	4.58	9762.5	36377.8
1530	62	50.81	50	9.21	6.4	206.3	4.57	9762.8	36377.3
1535	62	50.36	50	9.76	6.2	209.2	4.57	9763.0	36377.5
1540	62	49.88	50	10.30	6.5	207.2	4.58	9764.4	36372.8
1545	62	49.48	50	11.06	6.4	220.9	4.58	9765.9	36374.4
1550	62	48.91	50	11.34	7.0	192.6	4.58	9765.9	36373.6
1555	62	48.80	50	12.50	6.5	258.3	4.58	9766.5	36370.6
1600	62	48.59	50	12.75	2.9	208.5	4.57	9766.7	36375.3
1605	62	47.80	50	13.22	9.9	195.2	4.57	9767.1	36376.6
1610	62	47.58	50	13.47	3.0	207.5	4.56	9766.9	36385.8
1615	62	47.37	50	13.74	2.9	210.5	4.56	9766.6	36388.8
1620	62	46.29	50	14.76	14.2	203.4	4.56	9766.9	36386.6
1625	62	45.86	50	15.38	6.2	213.4	4.56	9767.6	36390.4
1630	62	45.30	50	15.56	6.8	188.4	4.55	9766.5	36394.6
1635	62	44.96	50	16.37	6.1	227.5	4.55	9766.6	36393.2

JD68	Latitude		Longitude		Speed	CMG	TWT	Gravity	Magnetism
9 Mar 1993	°	'	°	'	(Knots)		(sec)		
1640	62	44.58	50	16.55	4.7	192.2	4.55	9766.9	36403.1
1645	62	44.36	50	16.82	3.0	209.3	4.55	9762.8	36403.7
1650	62	44.15	50	17.04	2.8	205.6	4.55	9762.3	36401.6
1655	62	43.95	50	17.31	2.8	211.7	4.55	9763.2	36397.6
1700	62	43.73	50	17.60	3.1	211.1	4.55	9762.9	0.0
1705	62	43.54	50	17.86	2.7	212.1	4.55	9763.4	0.0
1710	62	43.34	50	18.17	3.0	215.4	4.55	9762.8	0.0
1715	62	43.12	50	18.51	3.2	215.3	4.55	9763.6	0.0
1720	62	42.93	50	18.77	2.7	212.1	4.55	9763.0	0.0
1725	62	42.68	50	19.08	3.5	209.6	4.55	9763.5	0.0
1730	62	42.46	50	19.48	3.4	219.8	4.55	9764.3	0.0
1735	62	42.26	50	19.61	2.5	196.6	4.54	9763.3	0.0
1740	62	42.14	50	19.42	1.8	36.0	4.54	9754.7	0.0
1745	62	42.09	50	19.37	0.7	24.6	4.54	9754.1	0.0
1750	62	42.01	50	19.42	1.0	196.0	4.54	9754.7	0.0
1755	62	41.90	50	18.85	3.4	67.2	4.55	9754.9	0.0
1800	62	41.86	50	19.05	1.2	246.4	4.55	9756.4	0.0
1805	62	41.77	50	19.15	1.2	207.0	4.55	9756.6	0.0
1810	62	41.72	50	19.01	1.0	52.1	4.54	9756.9	0.0
1815	62	41.63	50	18.94	1.2	19.6	4.54	9757.6	0.0
1820	62	41.63	50	19.16	1.2	270.0	4.54	9756.6	0.0
1825	62	41.51	50	18.98	1.8	34.5	4.54	9756.5	0.0
1830	62	41.48	50	18.96	0.4	17.0	4.54	9756.4	0.0
1835	62	41.42	50	18.99	0.7	192.9	4.54	9756.9	0.0
1840	62	41.41	50	18.91	0.5	74.8	4.54	9756.5	0.0
1845	62	41.30	50	18.74	1.6	35.3	4.54	9755.6	0.0
1850	62	41.32	50	18.76	0.3	335.4	4.54	9757.4	0.0
1855	62	41.26	50	18.73	0.7	12.9	4.54	9756.8	0.0
1900	62	41.21	50	18.75	0.6	190.4	4.54	9756.8	0.0
1905	62	41.19	50	18.80	0.4	228.9	4.54	9757.8	0.0
1910	62	41.22	50	18.80	0.4	180.0	4.54	9757.4	0.0
1915	62	41.20	50	18.84	0.3	222.5	4.54	9757.5	0.0
1920	62	41.19	50	18.87	0.2	234.0	4.54	9757.4	0.0
1925	62	41.21	50	18.84	0.3	145.5	4.54	9756.8	0.0
1930	62	41.29	50	18.87	1.0	350.2	4.54	9756.4	0.0
1935	62	41.25	50	18.83	0.5	24.6	4.54	9757.1	0.0
1940	62	41.25	50	19.02	1.0	270.0	4.54	9759.5	0.0
1945	62	41.20	50	19.04	0.6	190.4	4.54	9758.6	0.0
1950	62	41.23	50	19.07	0.4	335.4	4.54	9757.3	0.0
1955	62	41.34	50	19.24	1.6	324.7	4.54	9758.2	0.0
2000	62	41.46	50	19.39	1.7	330.2	4.54	9759.4	0.0
2005	62	41.58	50	19.53	1.6	331.8	4.54	9759.2	0.0
2010	62	41.70	50	19.66	1.6	333.6	4.54	9758.5	0.0
2015	62	41.83	50	19.83	1.8	329.0	4.54	9759.6	0.0
2020	62	41.96	50	20.00	1.8	329.0	4.54	9760.6	0.0
2025	62	42.10	50	20.22	2.1	324.2	4.54	9761.2	0.0
2030	62	42.18	50	20.48	1.7	303.9	4.54	9762.2	0.0
2035	62	42.19	50	20.64	0.9	277.8	4.54	9760.7	0.0
2040	62	42.21	50	20.73	0.6	295.9	4.54	9758.2	0.0
2045	62	42.20	50	20.79	0.4	250.0	4.54	9758.3	0.0

JD68	Latitude		Longitude		Speed	CMG	TWT	Gravity	Magnetism
9 Mar 1993	°	'	°	'	(Knots)		(sec)		
2050	62	42.23	50	20.84	0.5	322.6	4.54	9757.0	0.0
2055	62	42.23	50	20.94	0.6	270.0	4.54	9757.7	0.0
2100	62	42.23	50	21.07	0.7	270.0	4.54	9758.3	0.0
2105	62	42.22	50	21.15	0.5	254.8	4.54	9757.7	0.0
2110	62	42.22	50	21.30	0.8	270.0	4.54	9757.9	0.0
2115	62	42.21	50	21.40	0.6	257.7	4.54	9758.4	0.0
2120	62	42.21	50	21.52	0.7	270.0	4.54	9758.1	0.0
2125	62	42.22	50	21.65	0.7	279.5	4.54	9758.5	0.0
2130	62	42.21	50	21.81	0.9	262.2	4.54	9758.3	0.0
2135	62	42.20	50	21.91	0.6	257.7	4.54	9758.2	0.0
2140	62	42.19	50	22.04	0.7	260.5	4.54	9757.8	0.0
2145	62	42.18	50	22.16	0.7	259.7	4.54	9758.2	0.0
2150	62	42.20	50	22.25	0.6	295.9	4.54	9758.5	0.0
2155	62	42.21	50	22.34	0.5	283.6	4.54	9757.4	0.0
2200	62	42.25	50	22.44	0.7	311.1	4.54	9757.3	0.0
2205	62	42.29	50	22.49	0.6	330.2	4.54	9757.8	0.0
2210	62	42.30	50	22.59	0.6	282.3	4.54	9756.4	0.0
2215	62	42.34	50	22.63	0.5	335.4	999	9756.7	0.0
2220	62	42.39	50	22.73	0.8	317.5	999	9756.2	0.0
2225	62	42.42	50	22.82	0.6	306.0	999	9756.6	0.0
2230	62	42.36	50	22.69	1.0	44.8	999	9756.2	0.0
2235	62	42.49	50	23.12	2.8	303.4	999	9758.3	0.0
2240	62	42.50	50	23.21	0.5	283.6	999	9758.1	0.0
2245	62	42.54	50	23.45	1.4	290.0	999	9758.2	0.0
2250	62	42.57	50	23.56	0.7	300.7	999	9758.3	0.0
2255	62	42.59	50	23.61	0.4	311.1	999	9757.9	0.0
2300	62	42.63	50	23.90	1.7	286.7	999	9757.8	0.0
2305	62	42.64	50	24.05	0.8	278.3	999	9758.4	0.0
2310	62	42.66	50	24.19	0.8	287.3	999	9758.1	0.0
2315	62	42.71	50	24.31	0.9	312.3	999	9758.1	0.0
2320	62	42.72	50	24.48	0.9	277.3	999	9756.6	0.0
2325	62	42.72	50	24.55	0.4	270.0	999	9756.8	0.0
2330	62	42.74	50	24.65	0.6	293.6	999	9756.1	0.0
2335	62	42.74	50	24.65	0.0	0.0	4.54	9756.2	0.0
2340	62	42.80	50	24.66	0.7	355.6	4.54	9754.6	0.0
2345	62	42.86	50	24.65	0.7	175.6	4.54	9755.2	0.0
2350	62	42.84	50	24.78	0.8	251.4	4.54	9755.0	0.0
2355	62	42.88	50	24.77	0.5	173.5	4.54	9756.5	0.0

NBP93-1

ON BOARD GRAVITY AND MAGNETICS DATA PROCESSING

Marta Ghidella and Jim Holik

with the help, support and good will of:

Phil Madison
Mark Weiderspahn
Bob Abbott
Jorge Strelin
Ben Sloan
Paul Olsgaard
Bruce Granger
Randy Keller

and everybody else in the ship

CHIEF SCIENTIST:

LARRY LAWVER

CONTENTS

Gravity link between two stations in Punta Arenas and the NB Palmer

Date: 01/30/93

Performed by Carol Raymond and Bruce Granger

Gravity meter: portable Lacoste & Romberg

station	rd	time	cr	dr	obs. mgals	et	f. mgals
PA-51230N	PAO1	13.16	48	96.484	4935.349	-0.016	4935.333
NB-PALMER	NBP1	13.36	48	95.752	4934.609	-0.019	4934.590
PA9814-72	PAA	15.60	48	73.550	4912.185	-0.061	4912.124
NB-PALMER	NBP2	16.57	48	95.859	4834.717	-0.069	4934.648
PA-51230N	PAO2	16.90	48	96.554	4935.419	-0.071	4935.348

cr: counter reading
dr: dial reading
obs. mgals: readings converted to relative mgals using the conversion table readings -> mgals provided by the gravimeter's manual.
et: earth tide correction
f. mgals: final relative value
rd: reading identification

The NBP measurements were made on the pier, 1 meter above main deck level.

Gravity value at PA-51230N: 981320.82 mgals
Gravity value at PA9814-72: 981297.64 mgals

Differences between readings

NBP1 - PAO1	= -0.743	dt = 0.20 hs	
PAO2 - NBP2	= 0.700	dt = 0.33 hs	
PAA - NBP1	= -22.250	dt = 2.27 hs	
NBP1 - PAA	= 22.524	dt = 0.97 hs	
NBP2 - PAO1	= -0.632	dt = 3.41 hs	
PAO2 - NBP1	= 0.758	dt = 3.54 hs	
PAO2 - PAO1	= 0.015	dt = 3.74 hs	drift = 0.004 mgal/hour
NBP2 - NBP1	= 0.058	dt = 3.21 hs	drift = 0.018 mgal/hour

Average differences:

<NBP - PAO> = -0.7215
<NBP - PAA> = 22.3870

Absolute values of gravity at PAO = 981320.82 mgal
at PAA = 981297.64 mgal

Gravity value at the pier, beside the ship:

Using the difference with PAO:

NBP(pier) = -0.7215 + 981320.82 = 981320.10

Using the difference with PAA:

NBP(pier) = 22.387 + 981297.64 = 981320.03

We could have averaged the differences, but we chose the PAO derived value, as at this site there were two readings made.

Up to now it is a link with the pier; we need a link with the ship's gravity meter.

Link with the ship

We plotted ship's gravity values versus time from julian days 30 to 43 using files of the kind grvddd93.d?. Plots show the following: ship's gravity value is almost a constant value for days 30, 31 and part of 32, when the ship left the pier; after that there are small oscilations while the ship is anchored at sea; after 5 in the morning of day 35 the ship leaves, and values start to change; there are some periods of malfuntioning of the gravimeter, which are noticed in the plot as the reading is 0 then.
As far as I remember, there were no more problems with the gravimeter after day 43.

We averaged the gravity values from day 30 to 35:

jd	Nr points	begin hour	end hour	average reading
30.	1551	23.99	4.29	8910.2
30.	1344	5.19	11.67	8910.0
30.	1239	12.21	16.00	8910.2
30.	498	16.01	17.39	8910.3
31.	16	18.40	18.44	8910.4
31.	1990	18.46	23.98	8910.1
32.	8640	23.99	23.98	8910.0
33.	4946	23.99	13.72	8907.0
33.	1154	20.78	23.98	8908.4
34.	2182	23.99	6.04	8908.2
34.	2609	10.88	8.17	8909.9
34.	30	18.18	18.26	8910.7
34.	208	20.45	21.03	8910.7
35.	6479	0.04	18.50	8864.7
35.	247	18.81	19.90	8929.6
35.	73	20.15	20.35	8940.6
35.	333	20.84	21.76	8953.8
35.	529	21.92	23.39	8962.2
35.	179	23.49	23.98	8969.7

Each line corresponds to a different file; we chose the average of the values for days 30 and 31 as the value to be representative of the ship's reeading at the pier. This value is:

$$gs = 8910.2$$

Latitude and longitude for the ship, taken from the Furuno files, was:

lat = 53.175 +/- 0.004
lon = 70.887 +/- 0.018

The error bound are taken from the calculated dispersion around the mean values.

The *gs* value corresponds to the absolute value already found for the pier beside the ship: gp=981320.1

Taking the difference between them, we find the constant offset value that has to be added to each ship's gravimeter output to obtain absolute gravity:

$$gof = gp - gs = 972409.9$$

Eotvos correction

The movement of the ship (and the gravimeter) with respect to the earth changes the acceleration that the g-meter measures, which is not pure gravity (Eotvos effect). It has to be taken into account, and the readings corrected. The equation that we used for the correction is:

$$dge = 7.503\ Ve \cos(lat) + 0.004154\ V^2$$

(from: "Applied Gephysics", WM Telford, LP Geldart, RE Sheriff, DA Kkeys, Cambridge University Press, pp. 49)

Ve is the eastward component of the ship's velocity; V is the total velocity; they have to be in knots for the numbers to hold. Note that the correction is negative when the ship moves to the West.

Therefore, for each reading (gr), the absolute value of gravity is:

$$g = gof + gr + dge$$

Free air anomaly

To obtain the free air anomaly, we calculate the "reference" gravity, which is the gravity acceleration produced by an ellipsoidal earth. We used an equation from the model IGSN71:

$$gt = 978031.85\ (1 + 0.0053024\ \sin^2(lat) - 0.0000059\ \sin^2(2lat)$$

("Gravity", by Chuji Tsuboi, eds.: George Allen & Unwin, London, 1983, ch. 3.3, pp. 65)

The free air anomaly is then:

$$gfa = g - gt = gof + gr + dge - gt$$

The earth tides caused by the moon and the sun also affect the gravity, and if we want it to be representative of what there is below the surface we should take this effect into account; we didn't do it. On one hand we know it is small (around 1 miligal as a maximum value); on the other hand we didn't have the equations to calculate it.

Drift

Regarding the gravity vs. time plots for days 30, 31 and 32 we gather that the ship's gravimeter doesn't have any significant drift. But we don't know about longer periods of time, like 40 days. We'll have to check that when the ship is back in Punta Arenas, at the pier, and then see if drift corrections have to be made.

Magnetics

To obtain magnetic anomalies, we calculated the reference field using the IGRF90 field coefficients and the suborutine *fieldg* developed by NASA ages ago. This reference field was substracted from the magnetometer readings. No corrections for external field were performed: for this we will have to wait until we get data from the closer permanently recording field station in Antarctica, which I think is San Martin base.

Data files and processing

We used the following files (*eve* files):

```
 Volume in drive H is DATAPORT
 Directory of H:\RT_DATA\ON_FLY\REPORT\EVERYTHI

EVE03993 P0     446154 02-08-93  11:30p
EVE03693 P0       1979 02-08-93   7:01p
EVE03693 P1       9556 02-05-93   2:58p
```

EVE03693	P2	4080	02-05-93	3:14p
EVE03693	P3	21248	02-05-93	4:25p
EVE03693	P4	117760	02-05-93	10:38p
EVE03693	P5	0	02-05-93	10:59p
EVE03693	P6	5784	02-05-93	11:29p
EVE03793	P0	178544	02-06-93	11:01a
EVE03793	P1	181272	02-06-93	9:35p
EVE03793	P2	2449	02-06-93	9:55p
EVE05193	P0	200621	02-20-93	4:31p
EVE05193	P1	63463	02-20-93	9:45p
EVE05293	P0	263847	02-21-93	9:45p
EVE05393	P0	263847	02-22-93	9:45p
EVE05493	P0	263847	02-23-93	9:45p
EVE05593	P0	42960	02-24-93	3:31a
EVE05593	P1	237	02-24-93	3:31a
EVE05093	P0	125679	02-19-93	10:21a
EVE06393	P0	291117	03-06-93	7:59p
EVE05093	P1	138304	02-19-93	9:44p
EVE04993	P4	2358	02-18-93	4:42a
EVE04993	P5	2661	02-18-93	4:56a
EVE04993	P0	18316	02-18-93	1:30a
EVE04993	P6	203348	02-18-93	9:45p
EVE05593	P2	220720	02-24-93	9:44p
EVE05693	P0	263847	02-25-93	9:44p
EVE04993	P1	18720	02-18-93	3:11a
EVE04993	P2	2964	02-18-93	3:29a
EVE04693	P2	180825	02-15-93	5:43p
EVE04693	P3	338	02-15-93	7:34p
EVE04693	P4	23972	02-15-93	9:45p
EVERC036	P1	56320	02-16-93	2:20a
EVE04793	P0	143152	02-16-93	11:47a
EVE04793	P1	116589	02-16-93	9:44p
EVE04893	P1	49626	02-17-93	4:27a
EVE04893	P2	1550	02-17-93	4:34a
EVE04893	P3	116084	02-17-93	2:08p
EVE04493	P0	380052	02-13-93	8:02p
EVE04493	P1	3671	02-13-93	8:19p
EVE04493	P2	641	02-13-93	8:22p
EVE04493	P3	742	02-13-93	8:25p
EVE04493	P4	237	02-13-93	8:25p
EVE04493	P5	16195	02-13-93	9:45p
EVE04993	P3	11448	02-18-93	4:27a
EVE04593	P0	263847	02-14-93	9:44p
EVE04693	P0	33163	02-15-93	2:42a
EVE04693	P1	338	02-15-93	2:44a
EVE03793	P3	869	02-06-93	9:59p
EVE03793	P4	1659	02-06-93	10:11p
EVE03793	P5	553	02-06-93	10:12p
EVE03793	P6	2133	02-06-93	10:19p
EVE03793	P7	553	02-06-93	10:20p
EVE03793	P8	22041	02-06-93	11:30p
EVE03893	P0	445503	02-07-93	11:30p
EVE03393	P0	1720997	02-02-93	1:53p
EVE04093	P0	313310	02-09-93	4:30p
EVE04893	P4	88208	02-17-93	9:45p

EVE04193	P0	413567	02-10-93	9:48p
EVE04293	P1	249095	02-11-93	6:15p
EVE04293	P0	85094	02-11-93	4:28a
EVE04293	P2	63877	02-11-93	9:45p
EVE04393	P0	1501	02-12-93	12:04a
EVE04393	P1	407895	02-12-93	9:44p
EVE06293	P0	291117	03-06-93	8:30p
EVE06493	P0	289602	03-06-93	7:59p
EVE06593	P0	215468	03-06-93	7:59p
EVE06593	P1	1752	03-06-93	7:59p
EVE06593	P2	11448	03-06-93	7:59p
EVE06693	P0	291117	03-10-93	12:25a
EVE06793	P0	291117	03-10-93	12:27a
EVE06893	P0	291117	03-10-93	12:27a
EVE06993	P0	1247	03-10-93	12:28a
EVE07393	P0	291117	03-18-93	12:57a
EVE07493	P0	291117	03-18-93	12:58a
EVE05394	P0	291117	02-23-93	12:00a
EVE05494	P0	291117	02-24-93	12:00a
EVE05594	P0	42960	02-24-93	3:31a
EVE05594	P1	237	02-24-93	3:31a
EVE05594	P2	247990	02-24-93	11:59p
EVE05694	P0	291117	02-25-93	11:59p
EVE05793	P0	291117	02-26-93	11:59p
EVE05893	P0	291117	02-27-93	11:59p
EVE05993	P0	291117	03-01-93	12:00a
EVE06093	P0	291117	03-01-93	11:59p
EVE06193	P0	291117	03-02-93	11:59p
EVE04194	P0	455121	02-10-93	11:59p
EVE03394	P0	1720997	02-02-93	1:53p
EVE03694	P0	2047	02-05-93	2:23p
EVE03694	P1	9556	02-05-93	2:58p
EVE03694	P2	4080	02-05-93	3:14p
EVE03694	P3	21248	02-05-93	4:25p
EVE03694	P4	117760	02-05-93	10:38p
EVE03694	P5	0	02-05-93	10:59p
EVE04994	P2	2964	02-18-93	3:29a
EVE04994	P3	11448	02-18-93	4:27a
EVE04994	P4	2358	02-18-93	4:42a
EVE04994	P5	2661	02-18-93	4:56a
EVE04994	P6	230618	02-19-93	12:00a
EVE05094	P0	125679	02-19-93	10:21a
EVE05094	P1	165574	02-19-93	11:59p
EVE05194	P0	200621	02-20-93	4:31p
EVE05194	P1	90733	02-21-93	12:00a
EVE05294	P0	291117	02-21-93	11:59p
EVE04794	P1	130628	02-16-93	10:54p
EVE04793	P2	1348	02-16-93	11:12p
EVE04793	P3	338	02-16-93	11:22p
EVE04793	P4	7812	02-17-93	12:00a
EVE04894	P0	0	02-17-93	12:00a
EVE04894	P1	49626	02-17-93	4:27a
EVE04894	P2	1550	02-17-93	4:34a
EVE04894	P3	116084	02-17-93	2:08p
EVE04894	P4	115478	02-18-93	12:00a

```
EVE04994 P0      18316 02-18-93   1:30a
EVE04994 P1      18720 02-18-93   3:11a
EVE04494 P3        742 02-13-93   8:25p
EVE04494 P4        237 02-13-93   8:25p
EVE04494 P5      43364 02-13-93  11:59p
EVE04594 P0     291117 02-14-93  11:59p
EVE04694 P0      33163 02-15-93   2:42a
EVE04694 P1        338 02-15-93   2:44a
EVE04694 P2     180825 02-15-93   5:43p
EVE04694 P3        338 02-15-93   7:34p
EVE04694 P4      33163 02-15-93  10:30p
EVE04693 P5      16498 02-15-93  11:59p
EVE04794 P0     143152 02-16-93  11:47a
EVE03994 P0     446154 02-08-93  11:30p
EVE04094 P0     445711 02-09-93  11:30p
EVE04294 P0      85094 02-11-93   4:28a
EVE04294 P1     249095 02-11-93   6:15p
EVE04294 P2      99006 02-12-93  12:00a
EVE04394 P0       1501 02-12-93  12:04a
EVE04394 P1     450555 02-12-93  11:59p
EVE04494 P0     380052 02-13-93   8:02p
EVE04494 P1       3671 02-13-93   8:19p
EVE04494 P2        641 02-13-93   8:22p
EVE03694 P6       5784 02-05-93  11:29p
EVE03794 P0     178544 02-06-93  11:01a
EVE03794 P1     181272 02-06-93   9:35p
EVE03794 P2       2449 02-06-93   9:55p
EVE03794 P3        869 02-06-93   9:59p
EVE03794 P4       1659 02-06-93  10:11p
EVE03794 P5        553 02-06-93  10:12p
EVE03794 P6       2133 02-06-93  10:19p
EVE03794 P7        553 02-06-93  10:20p
EVE03794 P8      22041 02-06-93  11:30p
EVE03894 P0     445503 02-07-93  11:30p
EVE07593 P0     291016 03-18-93  12:58a
EVE07693 P0     272937 03-18-93  12:59a
EVE07793 P0       1247 03-18-93  12:59a
EVE07693 P1      10135 03-18-93  12:59a
```

Here's a portion of one of those files:

```
DATASET EVERYTHI
VERSION 1
NUM_SERIES 16
STORAGE_MODE interlaced
SERIES sec_time,usec_time,lat,long,speed,cmg,DATE,HOUR,MIN,LAT_DEG,LAT_M
LNG_DEG,LNG_MIN,GRAVITY,GRTAVI_M,GYRO
DATE  2-28-93
TIME  0: 0:13.30
INTERVAL 30.0
DATA
730857535    58.00    23.00    58.00    64.00    44.79    54.00    46.87
9908.70 38573.00    36.37
730857565    58.00    23.00    59.00    64.00    44.73    54.00    46.78
```

9908.80 38574.60		36.0					
730857595	58.00	23.00	59.00	64.00	44.68	54.00	46.70
9908.90 38572.00		36.02					
730771225	59.00	0.00	0.00	64.00	44.63	54.00	46.62
9909.00 38570.90		36.44					
730771255	59.00	0.00	0.00	64.00	44.58	54.00	46.54
9909.10 38568.50		36.06					
730771285	59.00	0.00	1.00	64.00	44.54	54.00	46.45
9909.20 38567.80		36.70					

So these files have navigation (gps furuno) already merged with gravity and magnetics.

The program we used to calculate the anomalies is *leepal.for*. It reads the *eve* files and creates files of the kind *tbbff.dat*, where *bb* stands for begin day and *ff* stands for final day (e.g.: t3640.dat goes from day 36 to day 44).
The *eve files* used to have some data gaps up to about day 50.

leepal.for does the following:

- removes sectors of really bad navigation (there weren't many)
- flags malfuntioning or non functioning of either gravimeter or magnetometer.
- calculates gravity and magnetic anomalies in the way already described.

Here we show twosamples of the file t5051.dat:

jd	hr	min	sec	lat	lon	gfa	df	eot	dis
60.	0.	8.	53.0	-64.4471	-49.2760	-10.9	161.8	0.8	0.0336
60.	0.	9.	23.0	-64.4466	-49.2760	-10.9	161.9	0.8	0.0335
60.	0.	9.	53.0	-64.4461	-49.2759	-11.0	162.6	0.8	0.0334
60.	0.	10.	23.0	-64.4455	-49.2758	-11.1	163.6	0.7	0.0331
60.	0.	10.	53.0	-64.4450	-49.2757	-11.2	162.8	0.7	0.0328
60.	0.	11.	23.0	-64.4444	-49.2756	-11.3	163.4	0.7	0.0325
60.	0.	11.	53.0	-64.4440	-49.2754	-11.2	162.8	0.8	0.0313
60.	0.	12.	23.0	-64.4435	-49.2753	-11.3	165.3	0.8	0.0309
60.	0.	12.	53.0	-64.4430	-49.2751	-11.2	164.0	0.9	0.0297
60.	0.	13.	23.0	-64.4425	-49.2750	-11.1	164.0	1.0	0.0282
60.	0.	13.	53.0	-64.4420	-49.2749	-11.1	164.8	1.0	0.0280

gfa is the free air gravity anomaly; df is the magnetic anomaly; *eot* is the eotvos corection; *dis* is the distance in miles for 30 seconds of navigation; it is then proportional to the ship's velocity. In this example, speed is about 3.6 knots. Here's another sample:

60.	3.	3.	53.0	-64.4170	-48.9419	-8.5	31.9	20.2	0.0518
60.	3.	4.	23.0	-64.4173	-48.9398	-8.2	31.4	20.4	0.0526
60.	3.	4.	53.0	-64.4173	-48.9379	-8.3	30.1	20.4	0.0524
60.	3.	5.	23.0	-64.4173	-48.9359	-8.2	30.1	20.4	0.0526
60.	3.	5.	53.0	-64.4173	-48.9339	-8.1	27.7	20.5	0.0526

60.	3.	6.	23.0	-64.4174	-48.9318	-8.1	27.1	20.5	0.0526
60.	3.	6.	53.0	-64.4174	-48.9298	-8.0	27.6	20.4	0.0524
60.	3.	7.	23.0	-64.4174	-48.9277	-7.9	26.5	20.4	0.0523
60.	3.	7.	53.0	-64.4175	-48.9257	-7.9	26.4	20.4	0.0522
60.	3.	8.	23.0	-64.4175	-48.9237	-7.8	26.6	20.4	0.0523
60.	3.	8.	53.0	-64.4175	-48.9217	-7.7	25.4	20.5	0.0523
60.	3.	9.	23.0	-64.4175	-48.9197	-7.6	23.6	20.5	0.0524
60.	3.	9.	53.0	-64.4175	-48.9177	-7.6	23.2	20.5	0.0524
60.	3.	10.	23.0	-64.4175	-48.9157	-7.4	22.4	20.6	0.0525

Here the speed is about 6 knots; the eotvos correction is one order of magnitude greater than in the former example; besides the velocity being larger, it has an important eastward (not shown, although could have been) component that makes the eotvos term be as 20 mgals.

Calculating velocity

It is not as simple as it could be; we could think of difference in position over difference in time. But for 30 seconds difference in time (the time interval for the *eve* files) differences in position are not significant: they are obscured by navigation errors. It gets better if we take 1.5 minutes. So we did that. As we wanted the output file to be sampled each 30 seconds as the original files, we used a moving window that could read backwards and forward and the velocity values looked more reasonable. Inspection of the plots made with this method showed that the free air anomaly had some narrow local maxima and mminima distributed here and there. We considered that they could be due to noise and relatively small navigation errors. Checking the navigation files we realized that here and there there were "steps" or "offsets" in the navigation. At this point the options were: 1) leave gravity as it was for a time, and work hard on the navigation, plotting it at large scale, comparing ashtech with furuno and taking the best or each, interpolating when neccesary. 2) Smooth the furuno navigation to make the gravity anomalies look a little better and postpone the work of fixing to a later time. We chose the second. The smoothing was done as follows:

- take all the points of a window 1.5 min wide (or wider if neccesary). The window is centered at the point whose anomalies we are calculating.
- make linear least squares fits to latitude versus time *and* longitude versus time.
- use the *slopes* to find the velocity components.
- assign the latitude and longitude of the center of the window to the point in question.

This procedure is a smoothing filter. There has been one case (day 62, 02 hs 59 min) in which the furuno navigation had an offset 0.576 miles wide; to smooth that we needed a window 4.5 minutes wide.

Anomalies

We plotted the anomalies (grav and mag) as profiles along track on a large scale (-60,140 inches) polar stereographic projection. We used the Hewlett Packard Draftmaster plotter, using Fortran with a plotting library, plot88.lib

Inspection of those plots tells:

Gravity looks good, in spite of the difficulties with the Eotvos corrections. Crossovers are good, free air values agree with those from David Sandwell's map.

Magnetics has bad crossovers, which are mostly noticed where their amplitudes are relatively low, as in the Larsen basin. It has to be analysed in regard to the ship's heading. And, specially when their amplitudes are low, they have to be corrected for external field variations, as mentioned before. Improving the navigation will also change them, as the reference field will be different.

Coastlines and bathymetry

We managed to plot the GEBCO bathymetry which we took from a file which contained the result of digitizing sheet 16 (*sheet16.lls*). We converted it to a more easily readable file, *sh16.con*.

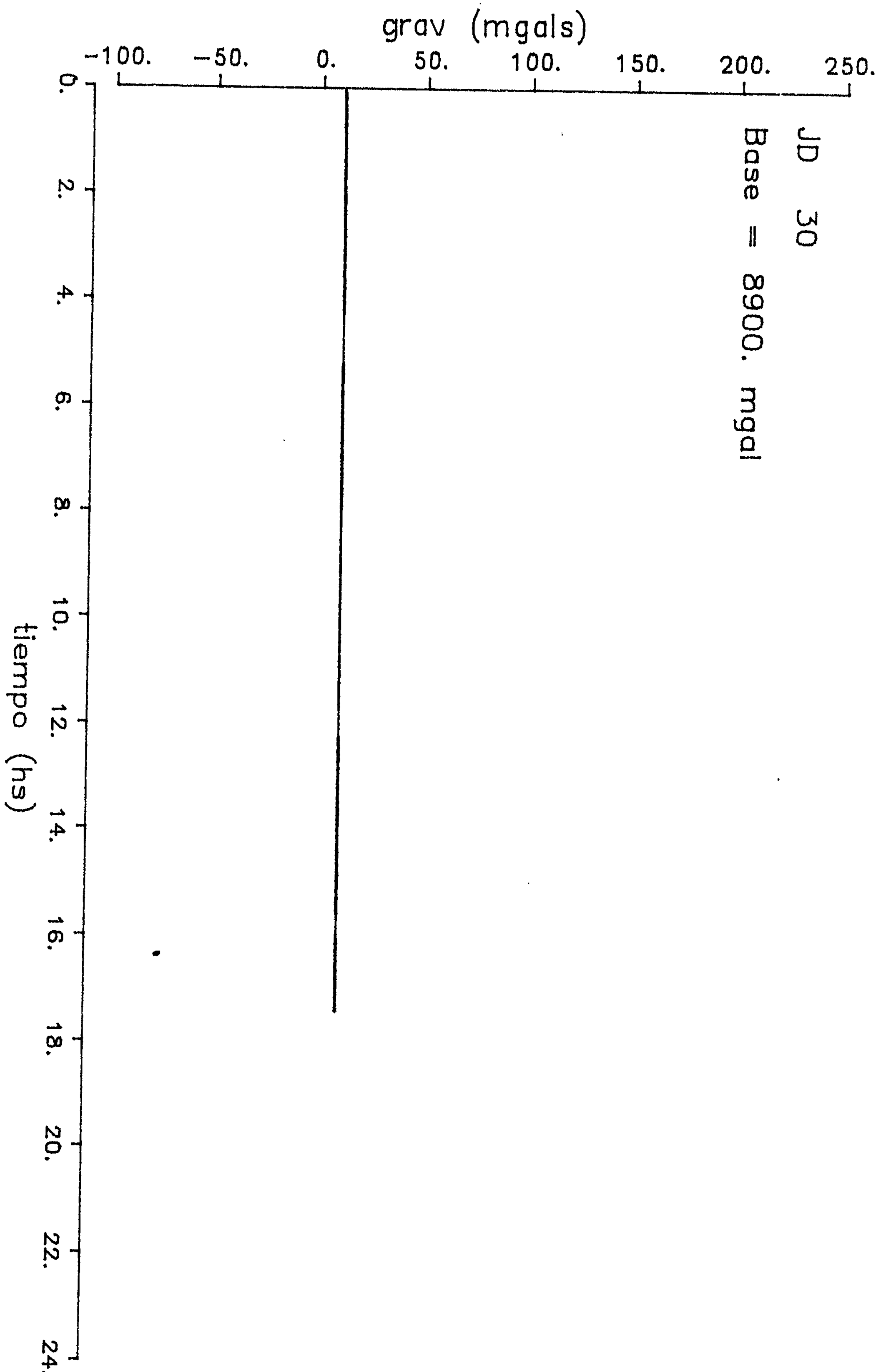
Gravity maps

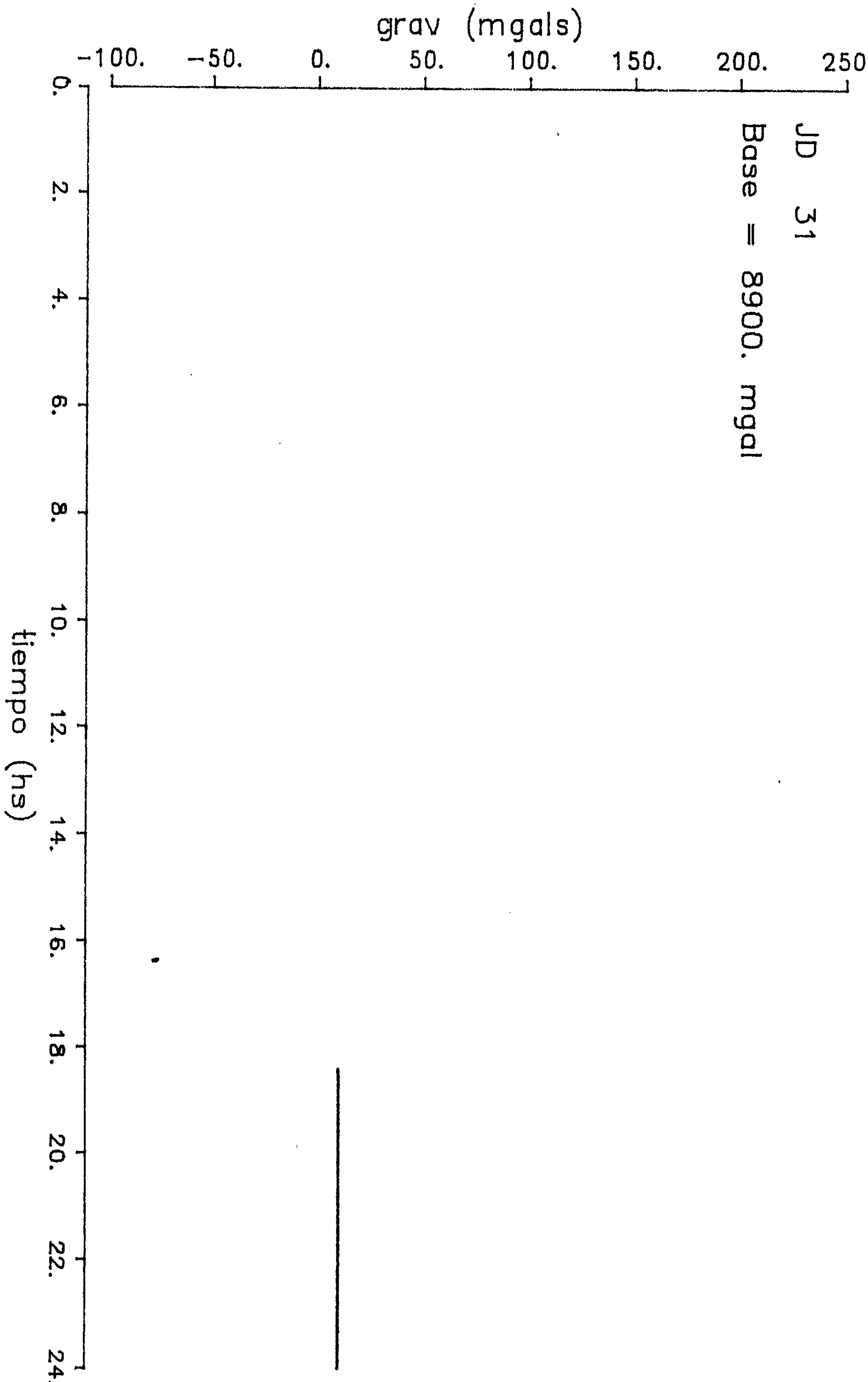
We could make gravity maps using the GMT programs that Mark installed on the Sun-3. We used the tbbff.dat files as input. *decipal.f* reads those files and decimates them using a decimating number which is proportional to the space density of data in the input files (at the coring stations, for instance, the ships was logging gravity at about the same place for two or more hours, and we want an approximately constant density of points to proceed with the gridding. The *surface* gmt program was used to grid with a tension factor of .5. *grdcontour* was used to draw contours and *grdimage* was used to create the color images. Psmask was used to mask the regions without data. We made two maps for the Larsen basin and two for the Powell basin. The difference between pairs is only presentation. We tried to reproduce D. Sanwell's colors in his Geosat map.

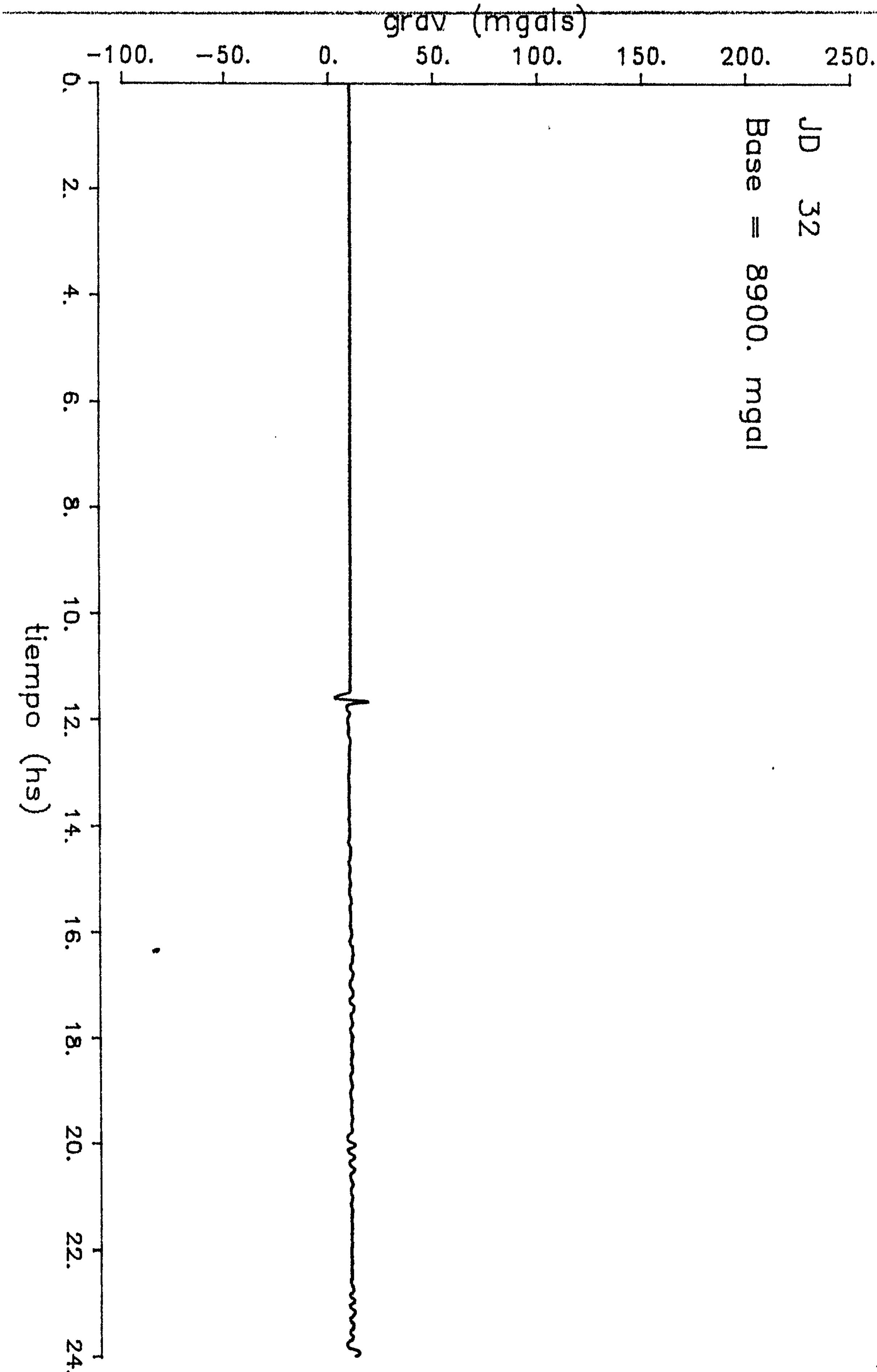
We are enclosing the script files that we used to make them.

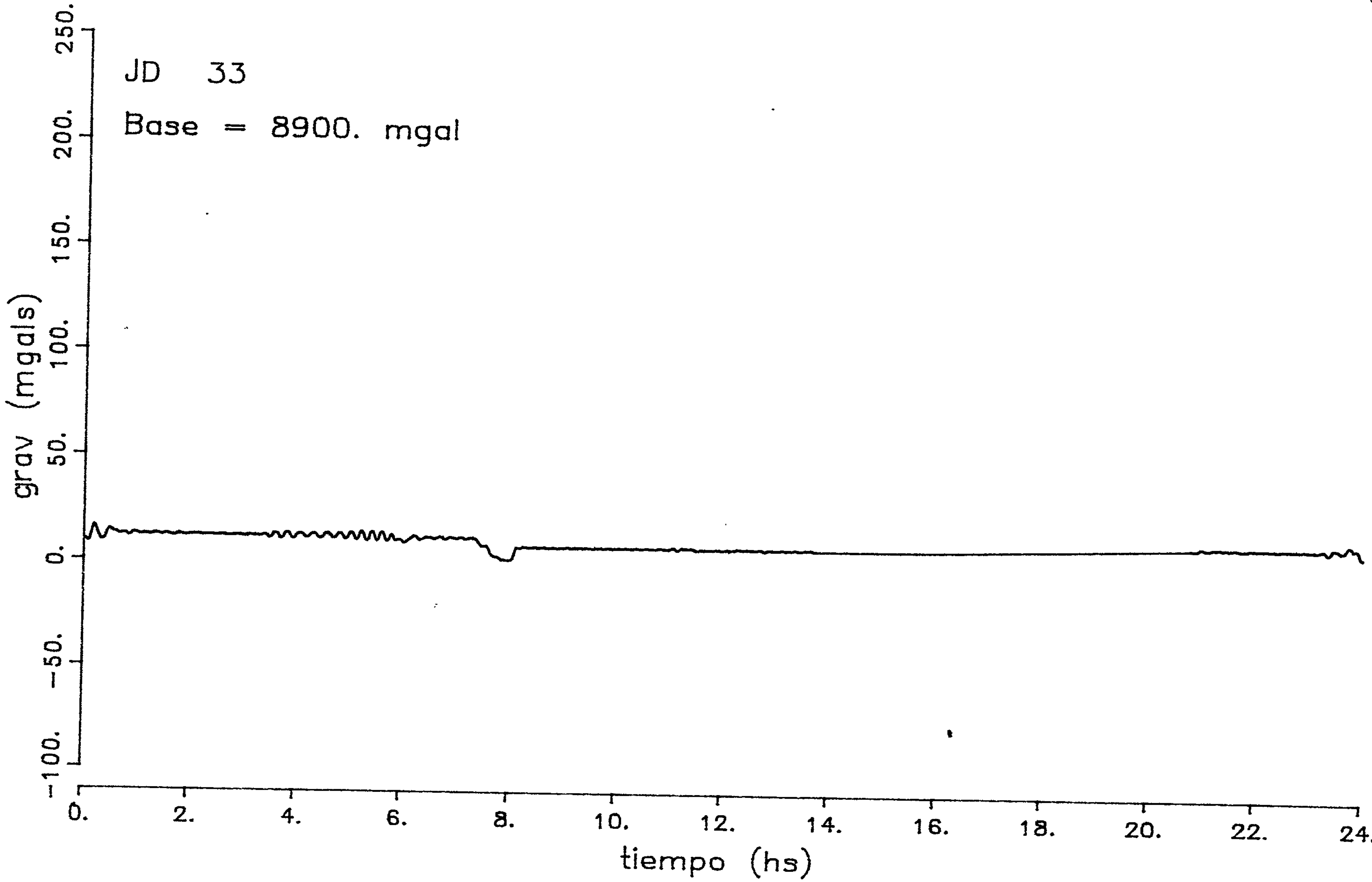
Magnetics on the Powell basin

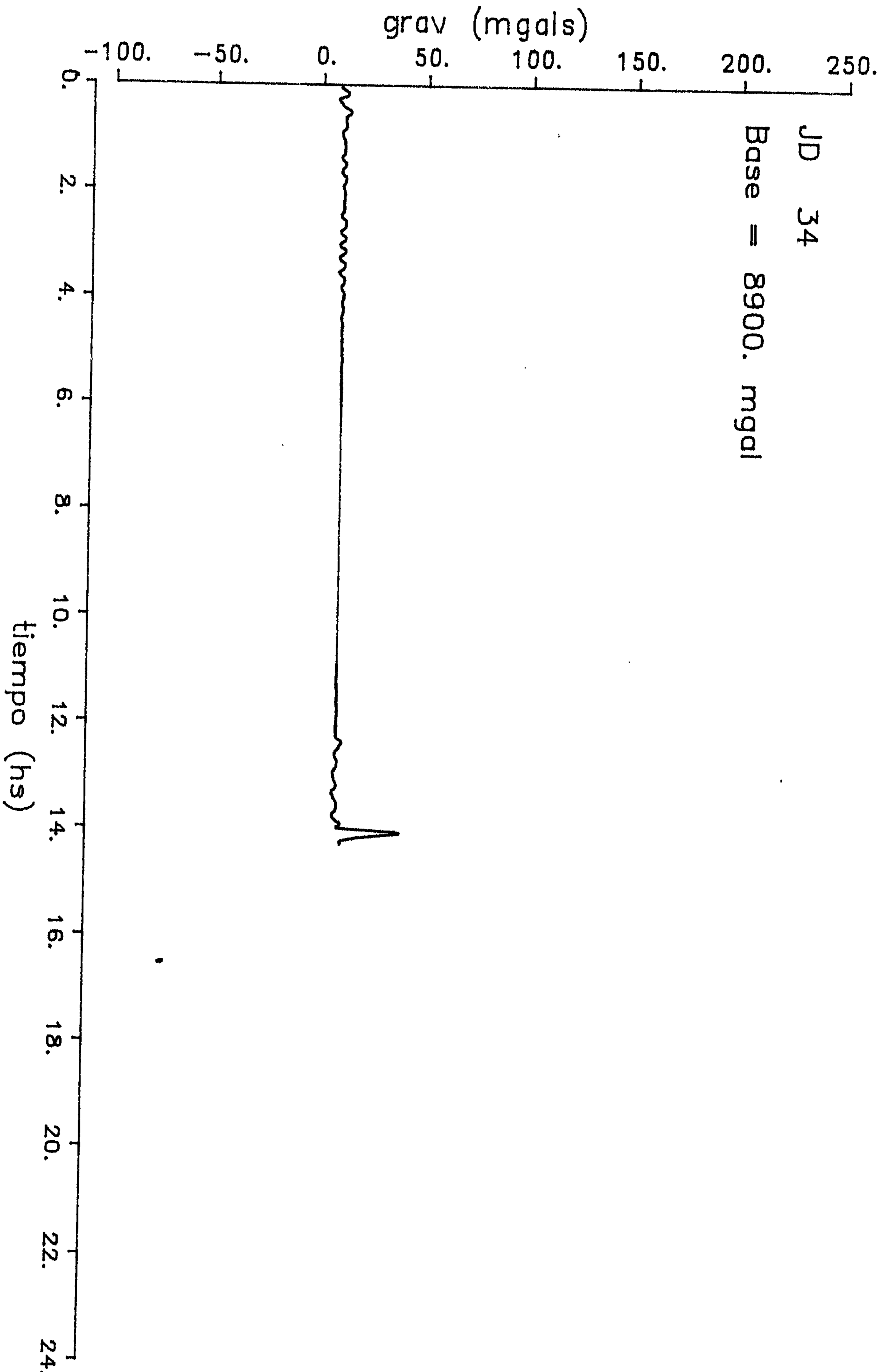
The Powell basin has a very low amplitude magnetic signature. We used sectors of the tbbff.dat files and four pow*.dat files extracted from the USAC aeromagnetics data. We projected the data along the straight line that best fitted them and we plotted them with *pswiggle*. The high amplitude magnetic anomalies at the basin's edge make the inside anomaly look meaningless. As we stated before, for low amplitude magnetic anomalies the crossovers need to be worked out more carefully. The map shown here is a test map. I still think that something may come up from those anomalies.

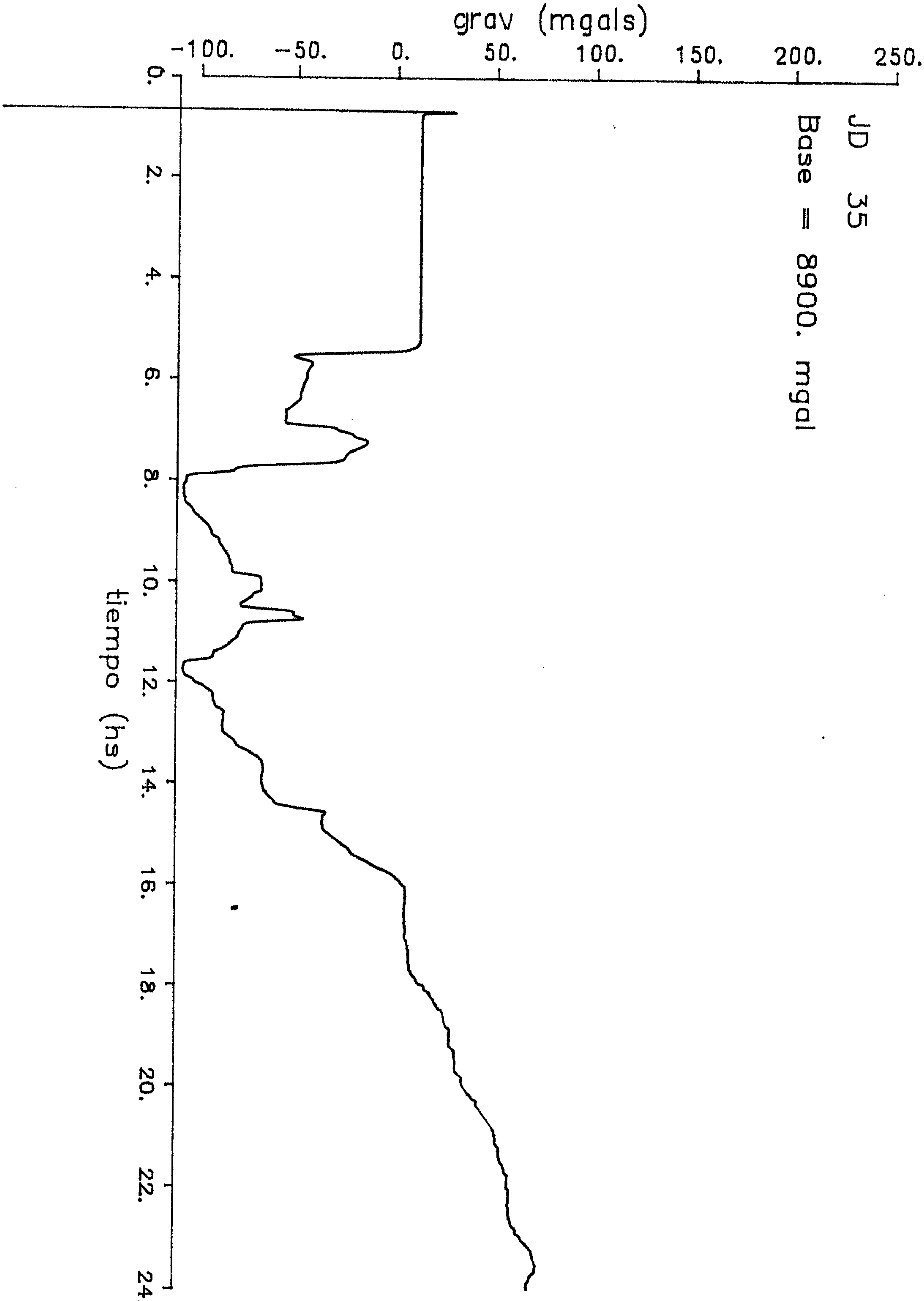

grav (mgals)
-100.
-50.
0.
50.
100.
150.
200.
250.
JD 30
Base = 8900. mgal
tiempo (hs)
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.
20.
22.
24.


grav (mgals)
-100.
-50.
0.
50.
100.
150.
200.
250.
JD 31
Base = 8900. mgal
tiempo (hs)
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.
20.
22.
24.

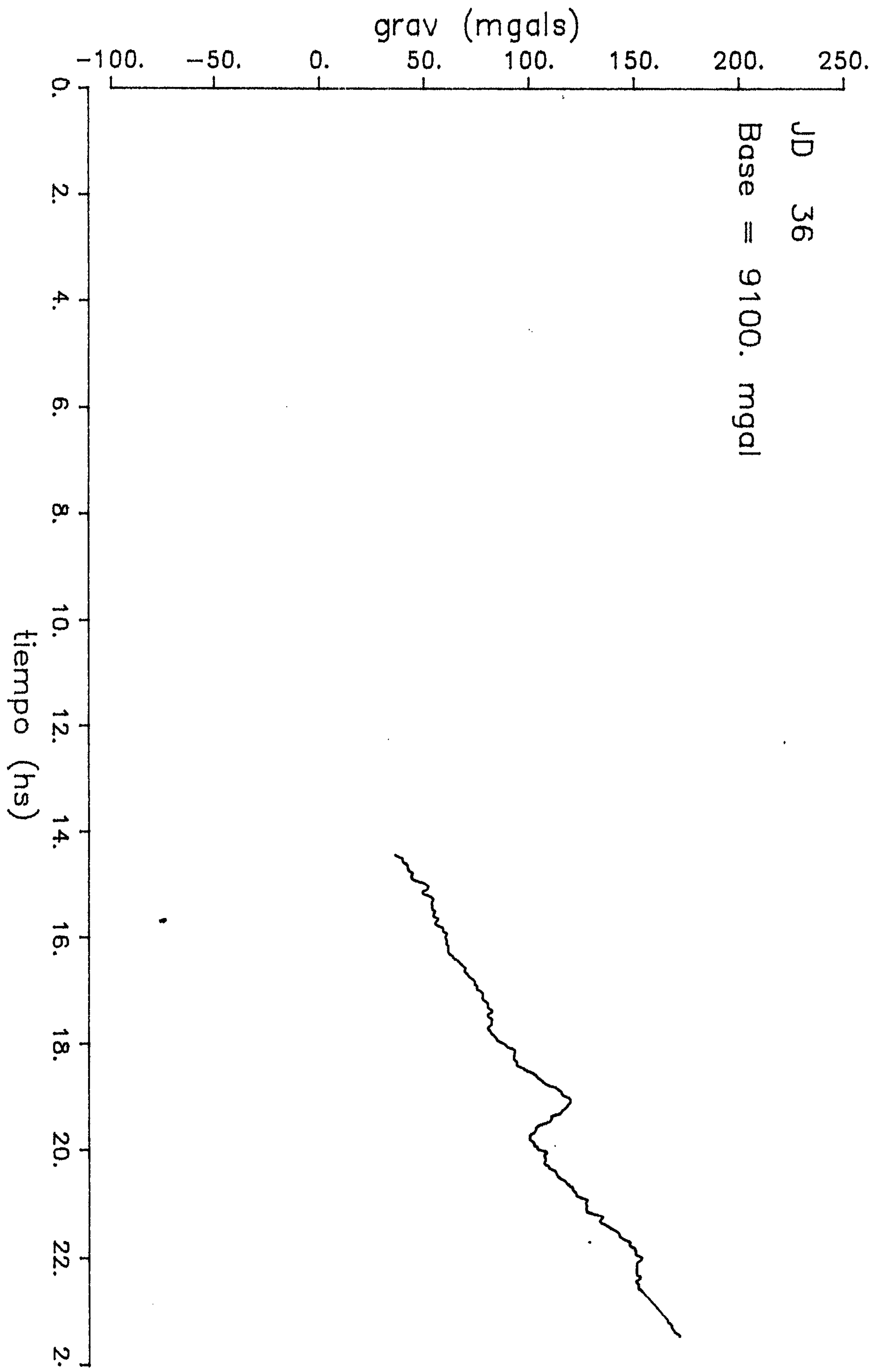

grav (mgals)
-100.
-50.
0.
50.
100.
150.
200.
250.
JD 32
Base = 8900. mgal
tiempo (hs)
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.
20.
22.
24.

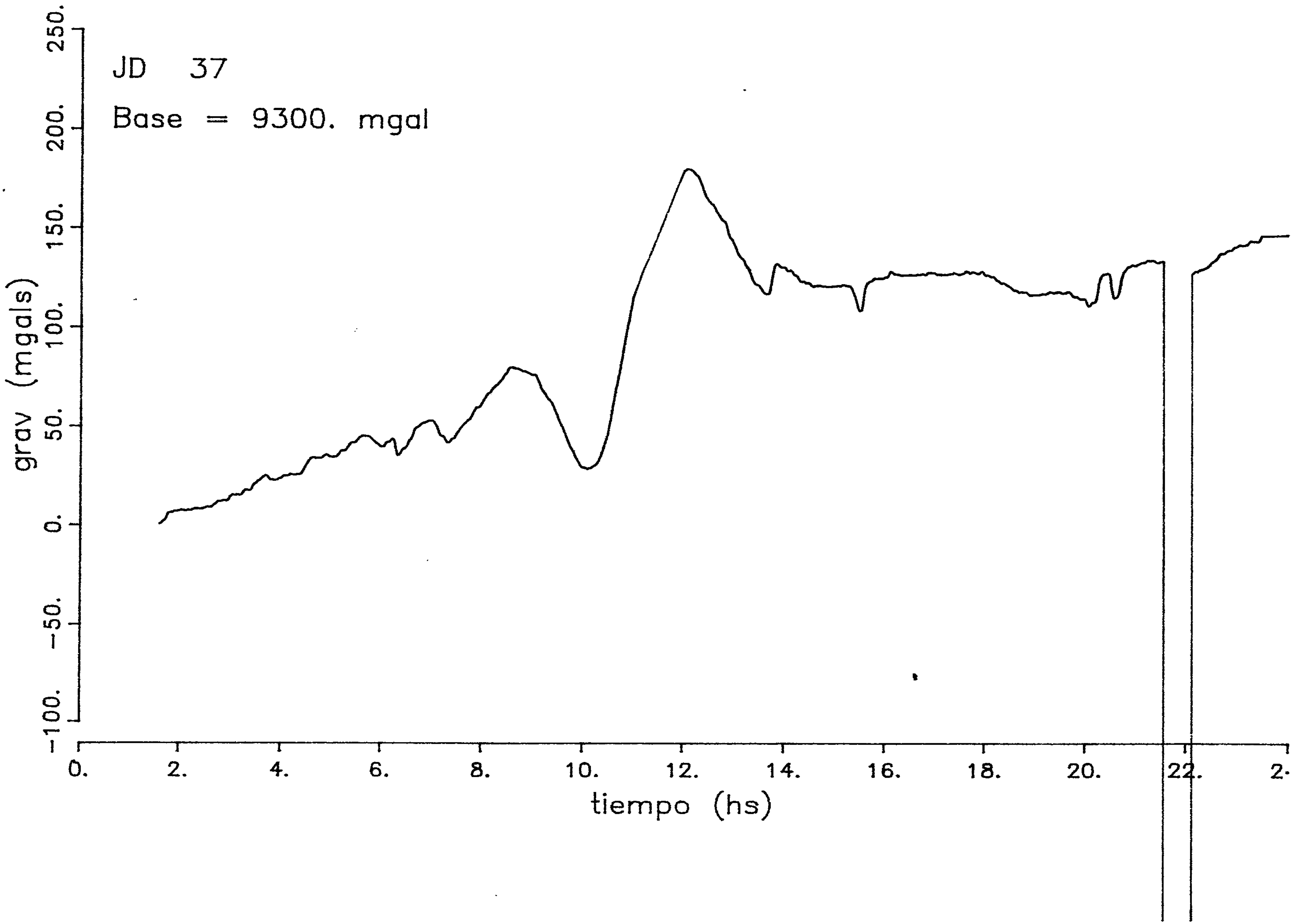

JD 33
Base = 8900. mgal
grav (mgals)
250.
200.
150.
100.
50.
0.
-50.
-100.
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.
20.
22.
24.
tiempo (hs)

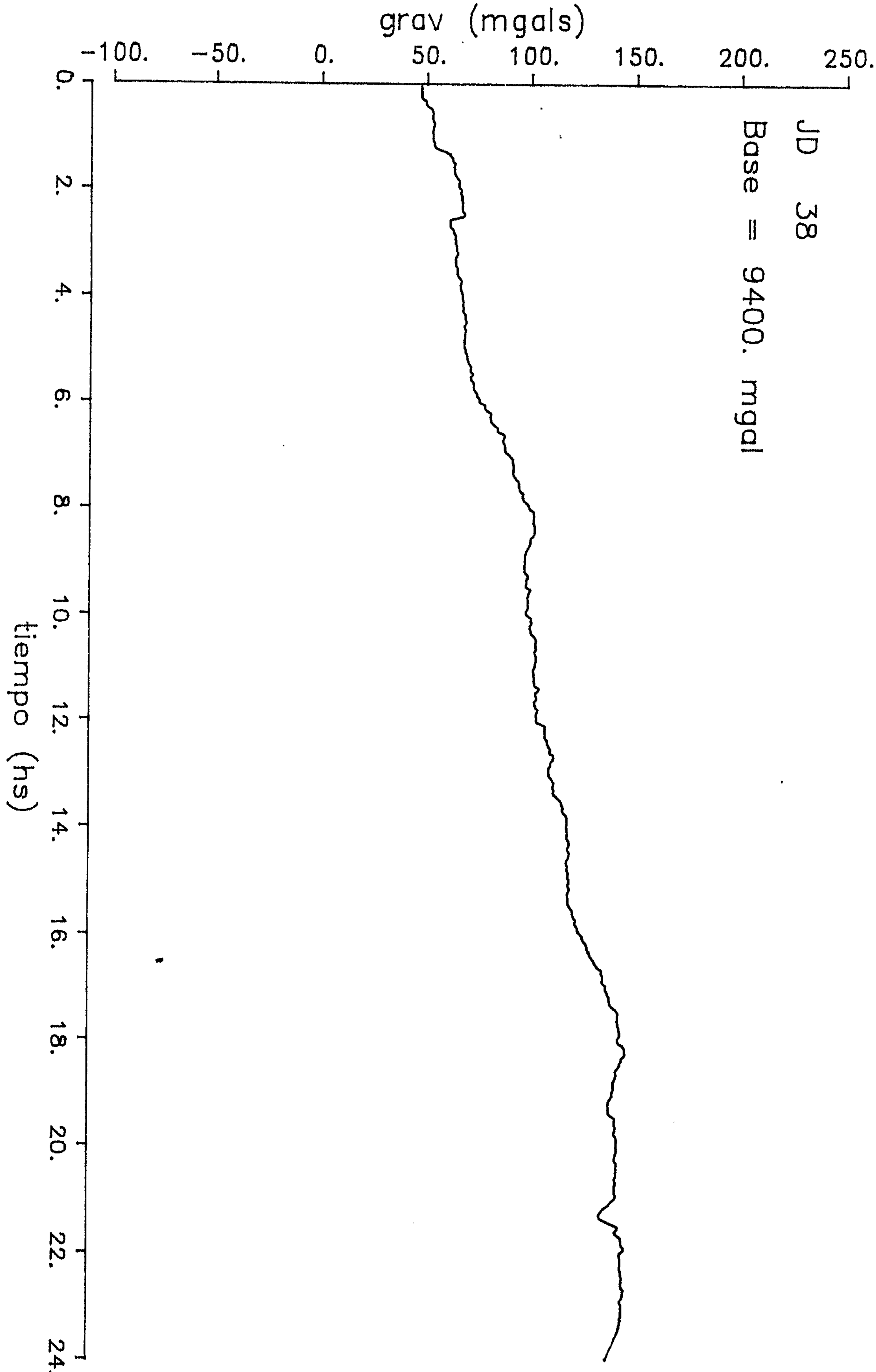

grav (mgals)
-100.
-50.
0.
50.
100.
150.
200.
250.
JD 34
Base = 8900. mgal
tiempo (hs)
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.
20.
22.
24.



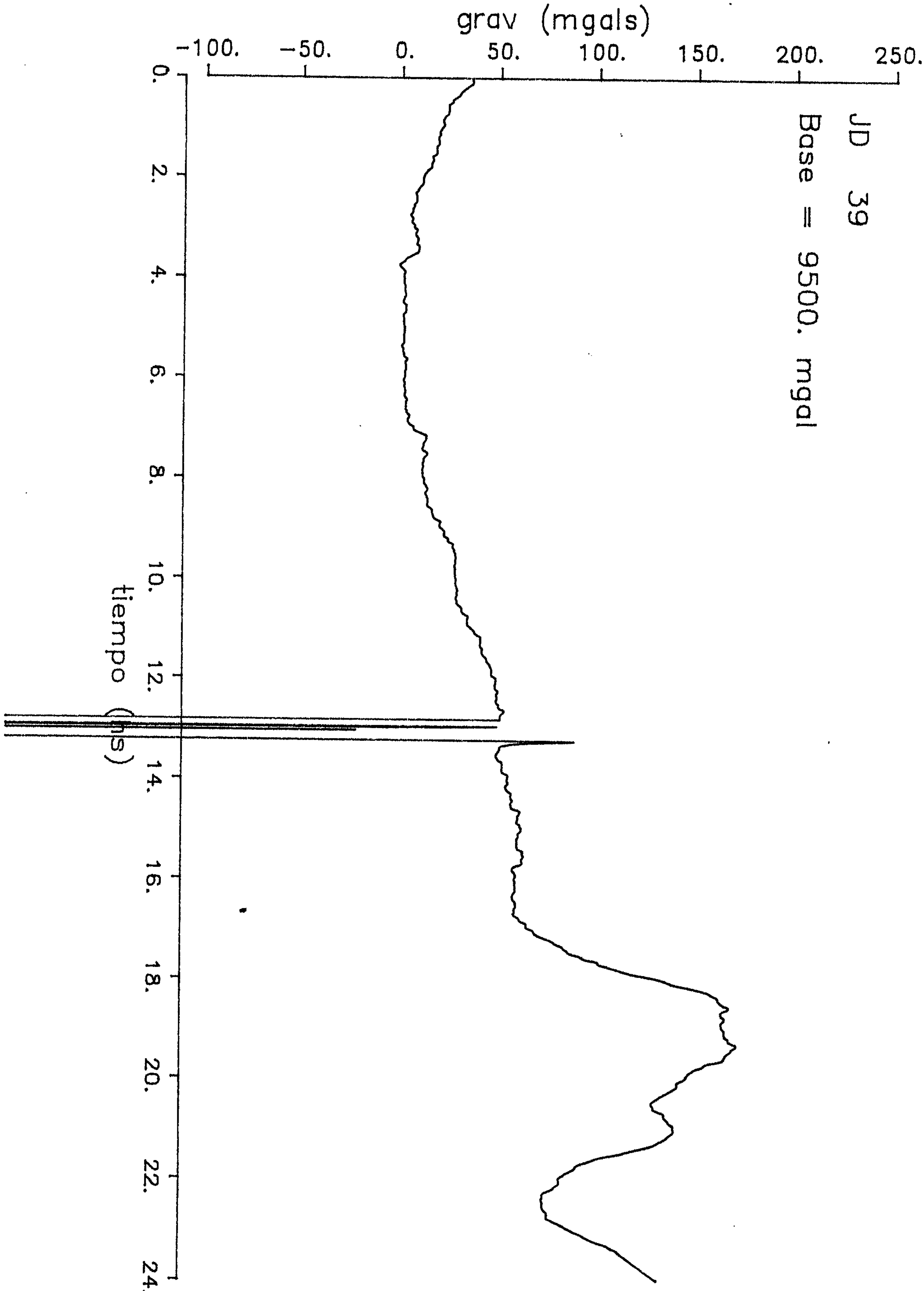
grav (mgals)
-100.
-50.
0.
50.
100.
150.
200.
250.
JD 35
Base = 8900. mgal
tiempo (hs)
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.
20.
22.
24.

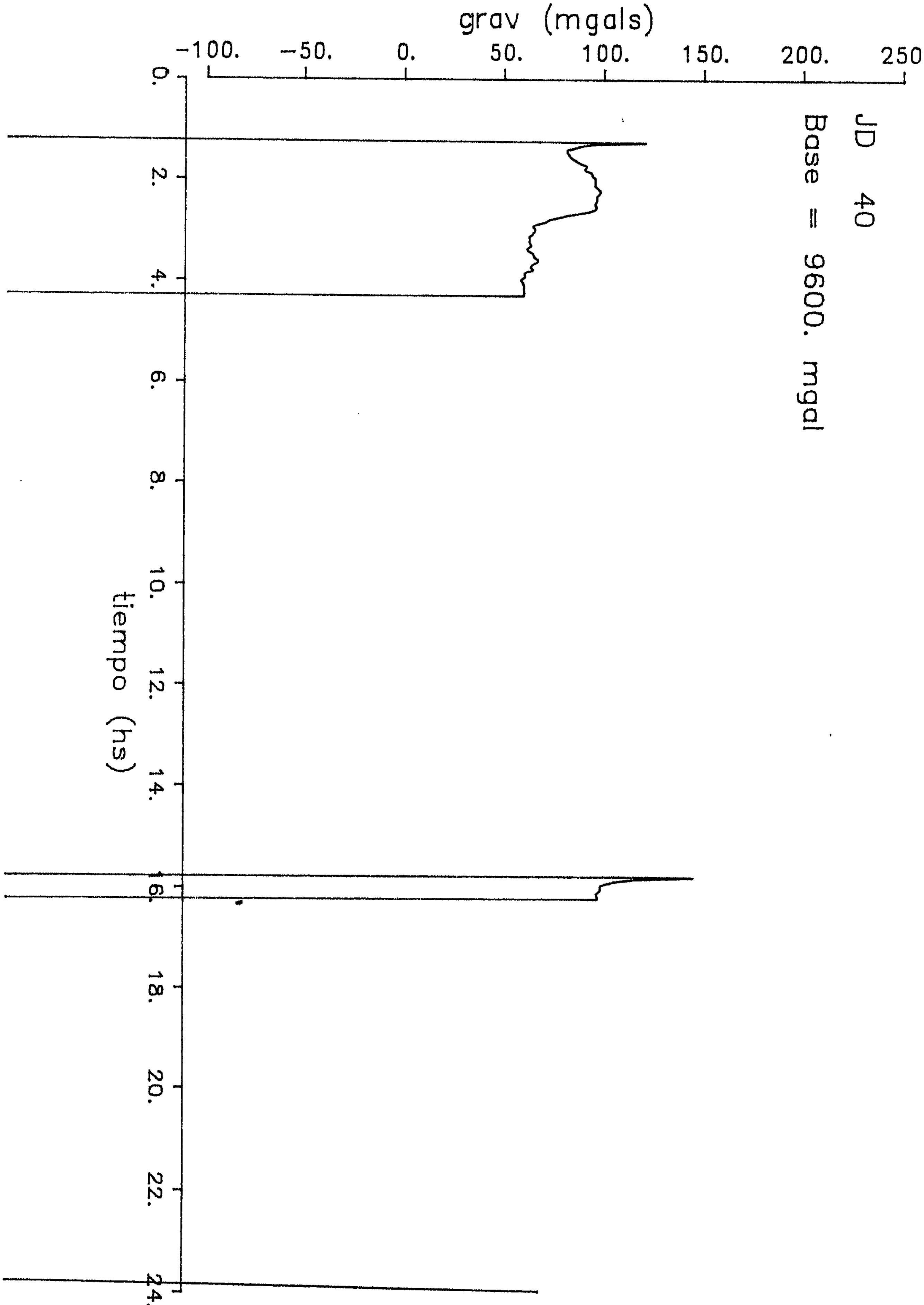

grav (mgals)
−100.
−50.
0.
50.
100.
150.
200.
250.
JD 36
Base = 9100. mgal
tiempo (hs)
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.
20.
22.
2.

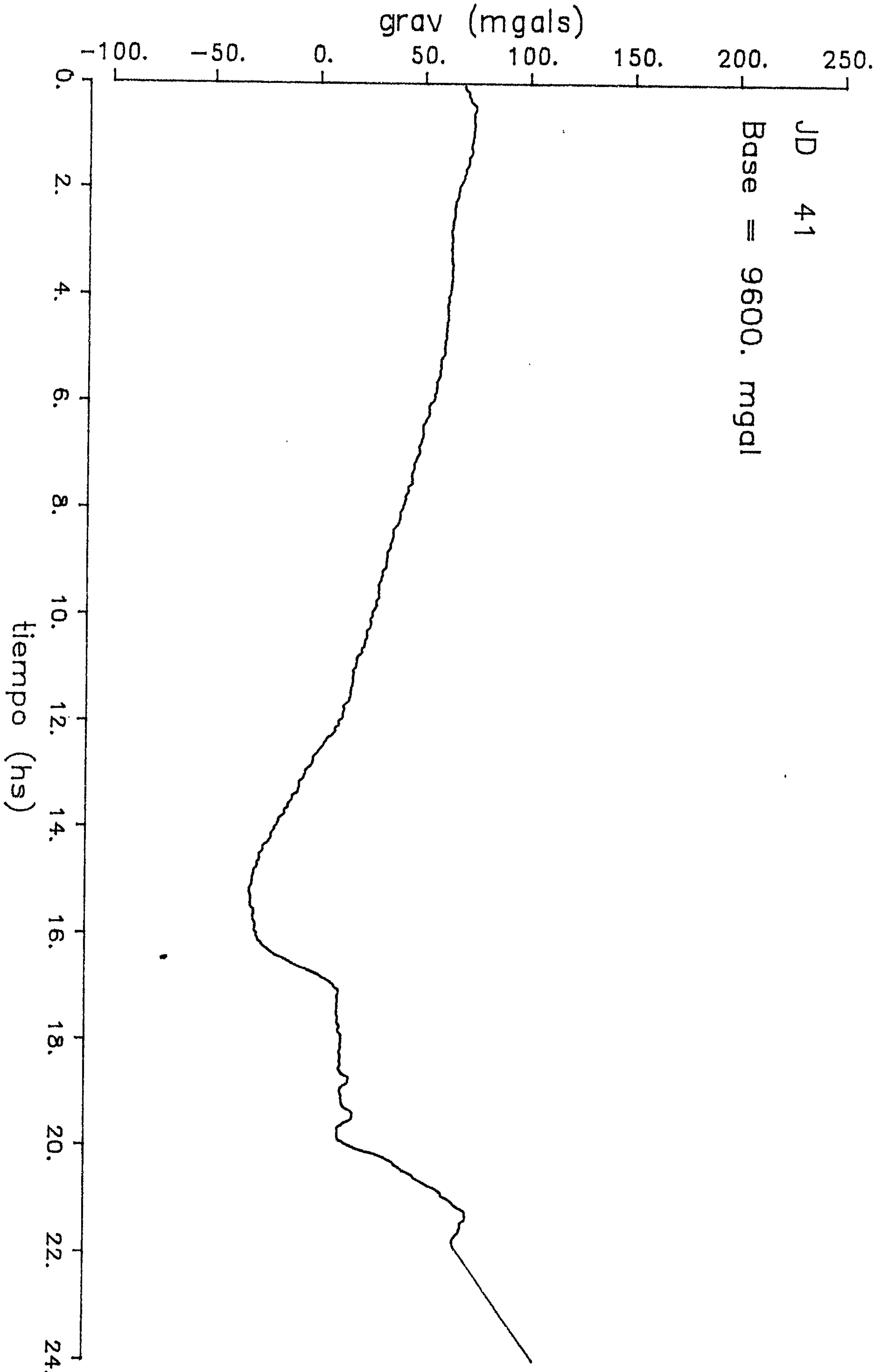

JD 37
Base = 9300. mgal
grav (mgals)
250.
200.
150.
100.
50.
0.
-50.
-100.
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.
20.
22.
2.
tiempo (hs)

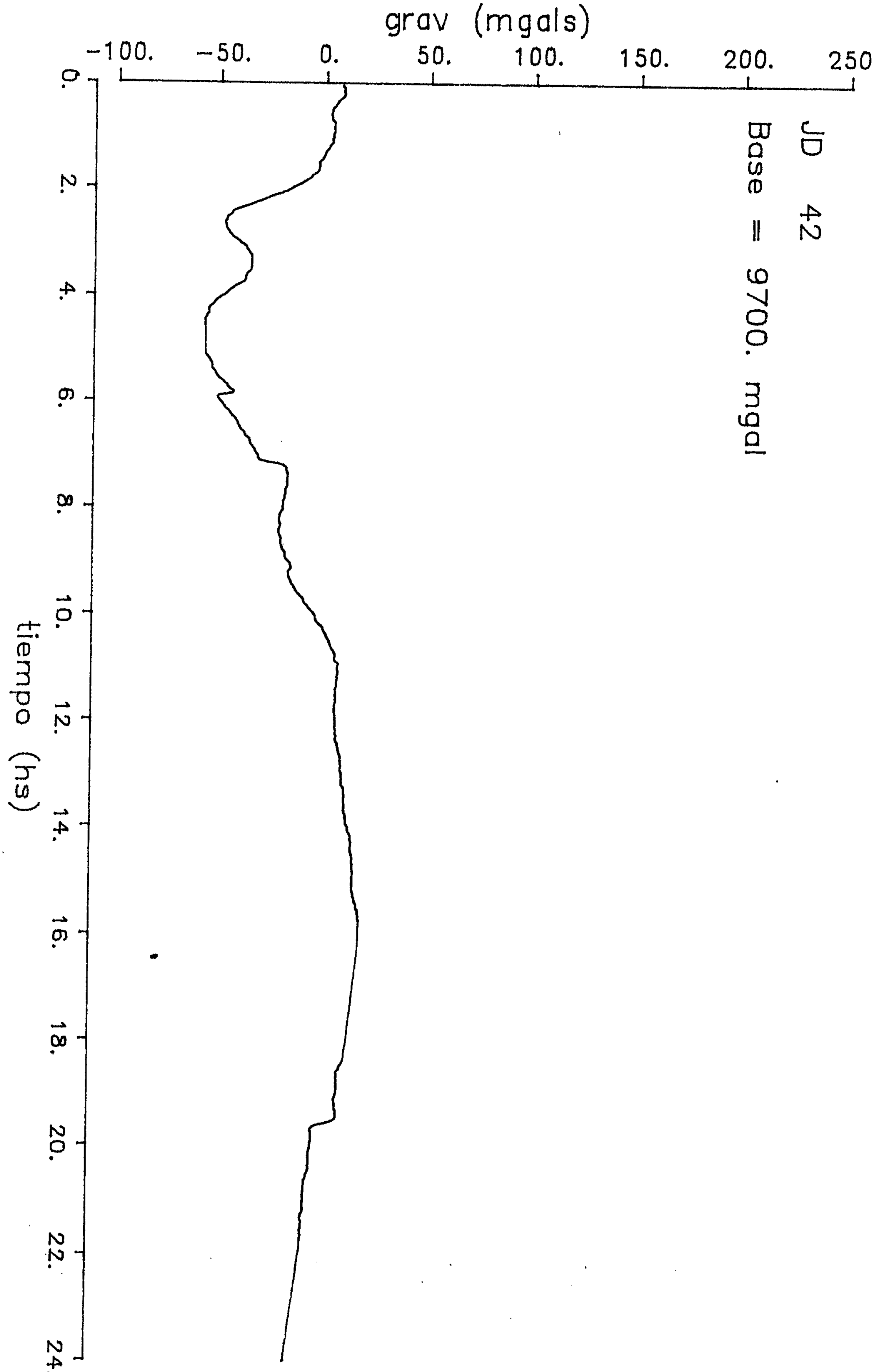


grav (mgals)
-100.
-50.
0.
50.
100.
150.
200.
250.
JD 38
Base = 9400. mgal
tiempo (hs)
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.
20.
22.
24.


grav (mgals)
-100.
-50.
0.
50.
100.
150.
200.
250.
JD 39
Base = 9500. mgal
tiempo (ms)
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.
20.
22.
24.


grav (mgals)
-100.
-50.
0.
50.
100.
150.
200.
250.
JD 40
Base = 9600. mgal
tiempo (hs)
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.
20.
22.
24.


grav (mgals)
-100.
-50.
0.
50.
100.
150.
200.
250.
JD 41
Base = 9600. mgal
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.
20.
22.
24.
tiempo (hs)


grav (mgals)
-100.
-50.
0.
50.
100.
150.
200.
250.
JD 42
Base = 9700. mgal
tiempo (hs)
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.
20.
22.
24.

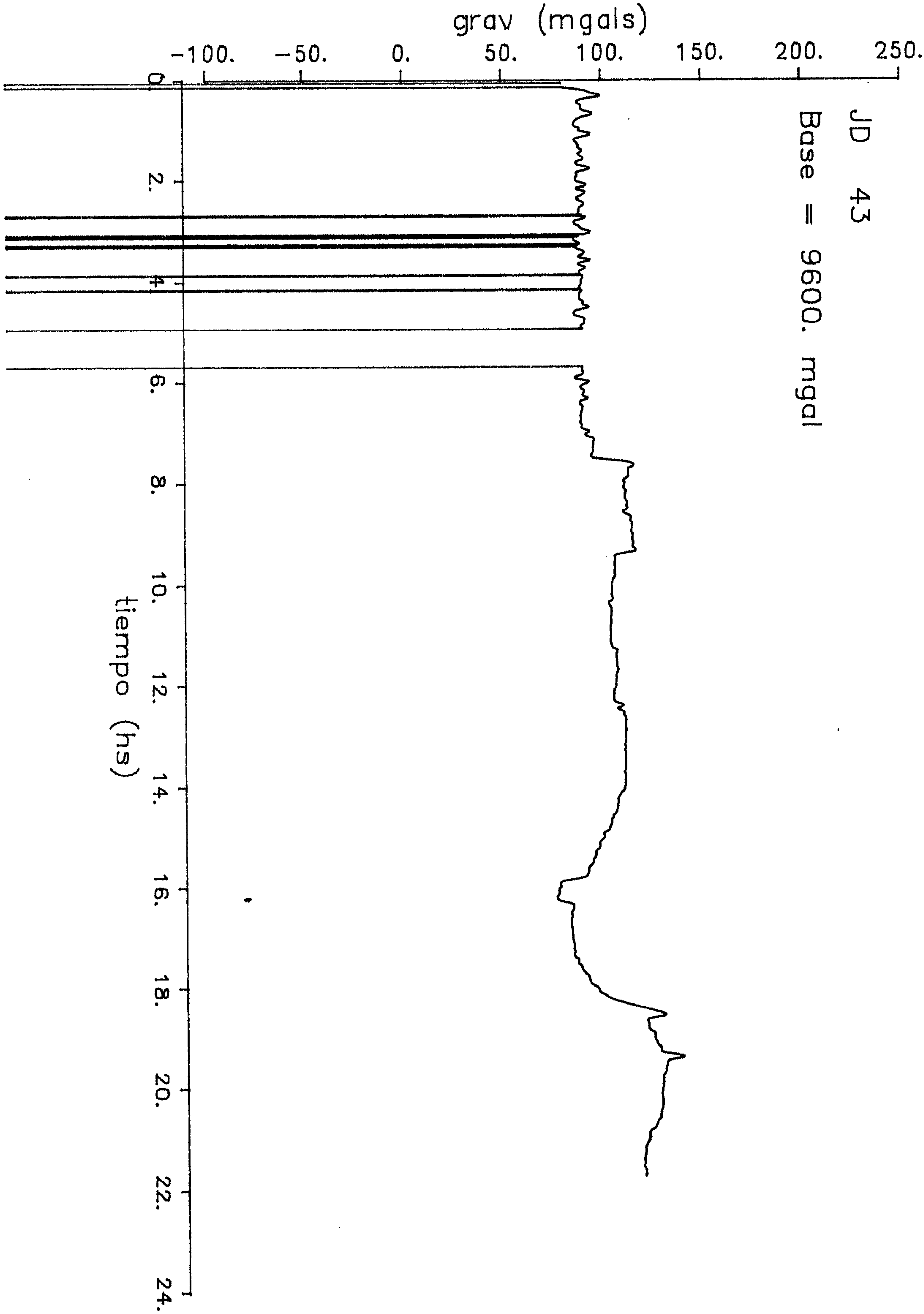

grav (mgals)
−100.
−50.
0.
50.
100.
150.
200.
250.
JD 43
Base = 9600. mgal
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.
20.
22.
24.
tiempo (hs)

TABLE 1

MILLIGAL VALUES FOR LACOSTE & ROMBERG, INC. MODEL G GRAVITY METER #G 807

COUNTER READING*	VALUE IN MILLIGALS	FACTOR FOR INTERVAL	COUNTER READING*	VALUE IN MILLIGALS	FACTOR FOR INTERVAL
000	000.00	1.00706			
100	100.71	1.00700	3600	3626.46	1.00899
200	201.41	1.00693	3700	3727.36	1.00910
300	302.10	1.00686	3800	3828.27	1.00921
400	402.79	1.00679	3900	3929.19	1.00932
500	503.47	1.00673	4000	4030.13	1.00943
600	604.14	1.00668	4100	4131.07	1.00953
700	704.81	1.00666	4200	4232.02	1.00960
800	805.47	1.00665	4300	4332.98	1.00969
900	906.14	1.00665	4400	4433.95	1.00976
1000	1006.80	1.00668	4500	4534.93	1.00982
1100	1107.47	1.00669	4600	4635.91	1.00990
1200	1208.14	1.00671	4700	4736.90	1.00996
1300	1308.81	1.00674	4800	4837.89	1.01001
1400	1409.49	1.00680	4900	4938.90	1.01007
1500	1510.17	1.00684	5000	5039.90	1.01010
1600	1610.85	1.00690	5100	5140.91	1.01014
1700	1711.54	1.00698	5200	5241.93	1.01018
1800	1812.24	1.00705	5300	5342.95	1.01021
1900	1912.94	1.00713	5400	5443.97	1.01022
2000	2013.66	1.00722	5500	5544.99	1.01020
2100	2114.38	1.00729	5600	5646.01	1.01019
2200	2215.11	1.00739	5700	5747.03	1.01016
2300	2315.85	1.00748	5800	5848.04	1.01009
2400	2416.59	1.00758	5900	5949.05	1.01003
2500	2517.35	1.00774	6000	6050.06	1.00994
2600	2618.13	1.00779	6100	6151.05	1.00983
2700	2718.90	1.00791	6200	6252.03	1.00971
2800	2819.70	1.00804	6300	6353.00	1.00958
2900	2920.50	1.00815	6400	6453.96	1.00943
3000	3021.31	1.00828	6500	6554.90	1.00928
3100	3122.14	1.00840	6600	6655.83	1.00913
3200	3222.98	1.00852	6700	6756.75	1.00898
3300	3323.83	1.00864	6800	6857.64	1.00882
3400	3424.70	1.00876	6900	6958.53	1.00865
3500	3525.58	1.00888	7000	7059.39	

*Note: Right-hand wheel on counter indicates approximately 0.1 milligal
09-19-1985

DLP

mpgr1col.x

```
#!/bin/csh

psbasemap -Bf5ma1g1 -Js-57.5/-90/65/-60  -R-61/-54/-67/-64 -X0.9 -K -V
-P>mpgr1col.ps


grdimage g3665.grd -Ccint101.cpt -Js-57.5/-90/65/-60 -R-61/-54/-67/-64
-K -O -P -V>> mpgr1col.ps

grdcontour g3665.grd -Js-57.5/-90/65/-60 -R-61/-54/-67/-64
-Wa2/250/250/0   -A5 -K -O -V -P>> mpgr1col.ps


psxy t4849.xy -Js-57.5/-90/65/-60 -R-61/-54/-67/-64 -A -W2/0/100/100 -K
-O -V -P >>mpgr1col.ps

psxy t5051.xy -Js-57.5/-90/65/-60 -R-61/-54/-67/-64 -A -W2/0/100/100 -K
-O -V -P >>mpgr1col.ps

psxy t5253.xy -Js-57.5/-90/65/-60 -R-61/-54/-67/-64 -A -W2/0/100/100 -K
-O -V -P >>mpgr1col.ps


psxy t5455.xy -Js-57.5/-90/65/-60 -R-61/-54/-67/-64 -A -W2/0/100/100 -K
-O -V -P >>mpgr1col.ps psxy t5657.xy -Js-57.5/-90/65/-60
-R-61/-54/-67/-64 -A -W2/0/100/100 -K -O -V -P >>mpgr1col.ps psxy
t5859.xy -Js-57.5/-90/65/-60 -R-61/-54/-67/-64 -A -W2/0/100/100 -K -O
-V -P >>mpgr1col.ps

psmask bm3665.xyg -Js-57.5/-90/65/-60 -C0.30 -N -G255/255/250 -K -O
-I2m/1m -R-61/-54/-67/-64 -V >> mpgr1col.ps

psmask  -Js-57.5/-90/65/-60      -S -I2m/1m -R-61/-54/-67/-64 -O -K  -V
-P >> mpgr1col.ps

psbasemap -Bf5ma1g1 -Js-57.5/-90/65/-60  -R-61/-54/-67/-64 -K -O -V -P
>> mpgr1col.ps

pstext -R0/11/0/8.5 -Jx1 -O -K -P -V<<END>>mpgr1col.ps 3.4 9. 36 0.0 1
2 Larsen Basin Gravity END

pstext -R0/8.5/0/11 -Jx1 -O -K -P -V<<END>>mpgr1col.ps 3.4 7.4 12 0.0 1
2 mgal END

psscale -Ccint103.cpt -D3.4/8.5/3.0/.5h -P -O -K -V>>mpgr1col.ps


psxy cont0.xyd  -Js-57.5/-90/65/-60 -R-61/-54/-67/-64  -A -M -L  -O -P
-V >>mpgr1col.ps
```

mpgr3sw.x

```
#!/bin/csh

psbasemap -Bf5ma1g1 -Js-57.5/-90/65/-60  -R-61/-54/-67/-64 -X0.9 -K -V
-P>sw.ps


grdimage g3665.grd -Cben.cpt -Js-57.5/-90/65/-60 -R-61/-54/-67/-64 -K
-O -P -V>> sw.ps



psxy t4849.xy -Js-57.5/-90/65/-60 -R-61/-54/-67/-64 -A -W2/0/100/100 -K
-O -V -P >>sw.ps

psxy t5051.xy -Js-57.5/-90/65/-60 -R-61/-54/-67/-64 -A -W2/0/100/100 -K
-O -V -P >>sw.ps

psxy t5253.xy -Js-57.5/-90/65/-60 -R-61/-54/-67/-64 -A -W2/0/100/100 -K
-O -V -P >>sw.ps


psxy t5455.xy -Js-57.5/-90/65/-60 -R-61/-54/-67/-64 -A -W2/0/100/100 -K
-O -V -P >>sw.ps psxy t5657.xy -Js-57.5/-90/65/-60 -R-61/-54/-67/-64 -A
-W2/0/100/100 -K -O -V -P >>sw.ps psxy t5859.xy -Js-57.5/-90/65/-60
-R-61/-54/-67/-64 -A -W2/0/100/100 -K -O -V -P >>sw.ps

psmask bm3665.xyg -Js-57.5/-90/65/-60 -C0.30 -N -G255/255/250 -K -O
-I2m/1m -R-61/-54/-67/-64 -V >> sw.ps

psmask  -Js-57.5/-90/65/-60      -S -I2m/1m -R-61/-54/-67/-64 -O -K  -V
-P >> sw.ps

psbasemap -Bf5ma1g1 -Js-57.5/-90/65/-60  -R-61/-54/-67/-64 -K -O -V -P
>> sw.ps

pstext -R0/11/0/8.5 -Jx1 -O -K -P -V<<END>>sw.ps 3.4 9. 36 0.0 1 2
Larsen Basin Gravity END

pstext -R0/8.5/0/11 -Jx1 -O -K -P -V<<END>>sw.ps 3.4 7.4 12 0.0 1 2
mgal END

psscale -Cben.cpt -D3.4/8.5/3.0/.5h -P -O -K -V>>sw.ps



psxy cont0.xyd  -Js-57.5/-90/65/-60 -R-61/-54/-67/-64  -A -M -L  -O -P
-V >>sw.ps
```

powgcol.x

```
#!/bin/csh

psbasemap -Bf5ma1g1 -Js-50/-90/40/-60   -R-55/-45/-64/-60 -X1.5 -K -V
>powcol.ps


grdimage gpow.grd -Ccint102.cpt -Js-50/-90/40/-60  -R-55/-45/-64/-60 -K
-O   -V>> powcol.ps

grdcontour gpow.grd -Js-50/-90/40/-60  -R-55/-45/-64/-60
-Wa2/250/250/0   -A10 -K -O -V  >> powcol.ps


psxy powgr.xyg -Js-50/-90/40/-60  -R-55/-45/-64/-60 -A -W2/0/100/100
-M -K -O -V   >>powcol.ps


psmask bmpow.xyg -Js-50/-90/40/-60  -C0.70 -N -G255/255/250 -K -O
-I4m/2m -R-55/-45/-64/-60 -V >> powcol.ps

psmask  -Js-50/-90/40/-60       -S -I4m/2m -R-55/-45/-64/-60 -O -K
-V   >> powcol.ps

psbasemap -Bf5ma1g1 -Js-50/-90/40/-60   -R-55/-45/-64/-60 -K -O -V   >>
powcol.ps

pstext -R0/11/0/8.5 -Jx1 -O -K<<END>>powcol.ps 3.5 6.6 36 0.0 1 2
Powell Basin Gravity END

pstext -R0/11/0/8.5 -Jx1 -O -K<<END>>powcol.ps 8.3 3.4 12 0.0 1 2 mgal
END


psscale -Ccint103.cpt -D7.5/1.5/3.0/.5 -K -O >>powcol.ps

psxy cont.xyd  -Js-50/-90/40/-60  -R-55/-45/-64/-60  -W2/0/100/250 -A
-M  -O   -V >>powcol.ps
```

pow sw. x

```
#!/bin/csh

psbasemap -Bf5ma1g1 -Js-50/-90/40/-60   -R-55/-45/-64/-60 -X1.5 -K -V
>ben.ps


grdimage gpow.grd -Cben.cpt -Js-50/-90/40/-60  -R-55/-45/-64/-60 -K
-O   -V>> ben.ps


psxy powgr.xyg -Js-50/-90/40/-60  -R-55/-45/-64/-60 -A -W2/0/100/100 -M
-K -O -V   >>ben.ps


psmask bmpow.xyg -Js-50/-90/40/-60  -C0.70 -N -G255/255/250 -K -O
-I4m/2m -R-55/-45/-64/-60 -V >> ben.ps

psmask  -Js-50/-90/40/-60       -S -I4m/2m -R-55/-45/-64/-60 -O -K
-V   >> ben.ps

psbasemap -Bf5ma1g1 -Js-50/-90/40/-60   -R-55/-45/-64/-60 -K -O -V   >>
ben.ps

pstext -R0/11/0/8.5 -Jx1 -O -K<<END>>ben.ps 3.5 6.6 36 0.0 1 2 Powell
Basin Gravity END

pstext -R0/11/0/8.5 -Jx1 -O -K<<END>>ben.ps 8.3 3.4 12 0.0 1 2 mgal END



psscale -Cben.cpt -D7.5/1.5/3.0/.5 -K -O >>ben.ps

psxy cont.xyd  -Js-50/-90/40/-60  -R-55/-45/-64/-60  -W2/0/100/250 -A
-M  -O   -V >>ben.ps
```

NBP 93-1 Seismic Acquisition

We recorded both single and multi-channel airgun seismic and sonobuoy data on the RVIB Palmer during NBP 93-1, Feb.-Mar. 1993. This note explains how these systems were set up and what results we achieved.

Mark Wiederspahn
Institute for Geophysics, University of Texas at Austin

Configuration

Airguns

We used two to four SSI GI airguns, fired in the medium power harmonic mode. Two guns were towed at fixed separation one behind the other from a single wire, one array on the port, one on the starboard side. The port tow point was about 5 feet inboard of the gate, while the starboard was essentially as outboard as it could be in the gate. We have no reliable way to gauge gun depth, but a guess of about 25-30 feet seems reasonable at 5-6 kts.

Streamers

We used three streamers in the course of our work. Two of unusual construction were provided by Innovative Transducers Inc. of Haltom City, Texas. The third was a Mark Products single channel 40 phone D8400 oil filled streamer of conventional design.

The ITI streamers use a small diameter (~1 inch) glass micro balloon filled urethane buoyant jacket around a Kevlar strength member and wire bundle. At periodic intervals, polyvinylidene fluoride (PVDF) hydrophones are embedded in larger diameter streamlined bulbous urethane outer moldings. The most complex streamer, the ST-5/24 (called the "24 channel" streamer), consisted of three PVDF phones per group with the groups being spaced 6.25 meters. The total active length was 144 meters. Each group has a preamplifier powered from the ship at nominally 24 volts by car batteries There were two 12 channel mil-spec type round connectors at the reel, connecting to a terminal strip inside a plastic jbox above the reel. Shielded and armored 6 pair wires ran forward to the wet lab to a terminal strip in a second jbox in the wet lab. Jumpers connected each pair to another terminal strip. This strip connected 5 6 pair cables to banana plugs and jacks at the back of the EG&G 2420 seismic recording system. We used this streamer as 24 channels and also as one long channel, by paralleling the channels.

The second ITI streamer was an older 24 channel design which has one PVDF phone per group at 3.5 meter spacing. We used this exclusively in single channel mode, with all preamp outputs paralleled. The total active length is 80 m., with a ~3/8 inch diameter leader of about 100 m length. The phone blobs differ in shape and diameter from the 24 channel streamer. It was connected into the same plastic jbox above the streamer reel, using an unused pair for the run forward to the recording room. An Ithaco preamp boosted the signal before recording by the 2420.

The third streamer is a Mark Products D8400 of 40 phones; total active length is about 10 meters. This was connected via a plastic jbox on the rear of the aquarium room via another plastic jbox in the wet lab to the recording room. The Ithaco preamp was used for this cable as well.

None of the cables had any depth sensing capability.

Signal Conditioning

In all cases, the output was fed directly into the 2420 via banana plugs, or also run through Ithaco model 451 differential preamps to obtain a higher gain. (The Ithacos were borrowed from the Polar Duke). The 2420 internal preamps were set at 30 dB. The Ithaco gain depended on conditions, but was nearly always 30 dB for the ITI single channel, or 60 dB for the oil filled streamer. An Ithacos were always used to buffer the signal sent to the graphic recorders. KronHite model 3700 filters with 20 dB of gain were usually set to pass from 20-30Hz to 6Khz. . We saw no evidence that connecting the Ithaco's in parallel to the 2420 inputs degraded the signal or contributed 60 Hz noise. We looked at the open circuit 60 Hz and higher harmonic noise from the deck cable to the lab; in all cases it was lower than -95dB, and usually was 105dB.

Sonobuoys

Paul Olsgaard, the ASA Electronics Tech constructed an antenna for the middle of the military sonobuoy frequency range (~167 MHz) which was then mounted on the after mast, about ??? meters high. The antenna run is a lengthy ~220 feet. The UT sonobuoy receiver, which feeds a frequency downconverted antenna signal into a commercial FM receiver chosen for its low frequency audio performance, was tuned to the proper frequency once the buoy began transmitting. Its output was fed to speakers and to one channel of the 2420 and a graphic recorder. Filtering was 0 to 150 Hz.

Timing

The Syntron gun synchronization system was used to fire up to 4 SSI GI guns, requiring 8 fire pulses. The trigger sent to the 2420 and to the recorders was the Syntron gun aim point. The Syntron also sent a character to the Trak GPS disciplined clock, which then output an rs232 time stamp, which a PC turned into a parallel byte stream to be included in the 2420 external header. This time stamp is the only way to associate individual records on the tapes with a particular shot, as neither 2420 record numbers nor Syntron shot numbers are at present logged.

Graphic Recorders

We had 5 EPC recorders available. Our favorite was the thermal EPC model 9800. It has high quality output, does not smell, and has flexible key/trigger capabilities.

We also brought two EPC model 3200/3212 recorders from the University of Texas. These have an option which we used for seismic and for sonobuoys which makes two sweeps per trigger. This reduces vertical exaggeration for slow cycle data like airguns. They both worked well until a power supply failed on one, late in the cruise. They too lack a flexible deep water delay, but do have led's which allow a quick estimate of proper gain.

We borrowed two EPC model 4600 recorders from the Polar Duke. These both were in poor condition, and one was never used for any data recording. The other had significant timebase problems, and was at times erratic in positioning each sweep. Because these mechanically stop the recorder belt each shot, they are much less suitable than the model 3200's for slow cycle data.

Recording System

The EG&G 2420 was used to record the streamer signals and the sonobuoys. It allows up to 24 channels to be recorded with individual floating point gain per sample. We usually recorded 8 second records. at 4 msec, with a 15-79 Hz band The 2420 records on 6250 bpi 1/2 inch tape; there is no provision to read these tapes on board while recording. (We brought our own Sun computer with 1/2 inch and Exabyte 8mm tape drives.) There is a read after write qc system which drives an OYO thermal paper "galvo" camera. This QC system does not function if the data sent to tape is demultiplexed, leading one to have to choose multiplexed recording with camera records or demultiplexed recording without. The 2420 has various limitations which seem to derive from its heritage as a land system. No parameter settings can be viewed or changed without stopping recording, including deep water delay. It writes two eofs at the end of each shot, then backs up one. This causes about twice the amount of tape to be used for 4 channel recording as might be expected. The manual does not document many of the settings which may be required to efficiently operate the 2420.

Streamer Launch and Towing

The 24 channel streamer was wound on a very slow large capacity reel mounted just to starboard of the centerline. It was towed from the starboard quarter bollard on an 10 ft length of 1 inch bungie cord. There was no leader per se, but about a 100 m phone-less length of the buoyant balloon material. We had available two Syntron non-programmable cable levellers, installed just ahead of the first active group. We don't know what the depth setting was for these. Initially, the streamer was very light and was visible on the surface for nearly its entire length, and about 1 pound of lead was added midway between groups. This too was not sufficient, and we began to add lengths of chain at the head end, our lead supplies having run out. A large amount of correlated noise at 0-15 Hz walked down the cable from the boat end, at slightly greater than 1/2 water velocity. This noise is lower in frequency than geological reflections , at or above water bottom reflection pressure levels. We were not able to eliminate this noise by changing boat speed and did not get a satisfactory towing arrangement with this cable at this time. The weather was not helping; we had 10-12 ft. quartering seas which tended to lift the cable into the upper parts of the waves.

We deployed the oil filled streamer by hand over the port quarter, and it was noticeably quieter than the 24 or single channel ITI streamers. We attributed this primarily to its reasonable balance and greater towing depth, not to any intrinsic advantage.

We turned our attentions to the ITI single channel streamer, it being similar in construction but shorter than the 24 channel streamer. It also was initially a floater. Based on recommendations of the manufacturer, we attempted to place 120 grams/meter on the cable. We taped two links of chain at 3 equal intervals between phones, which was approximately 130 grams per meter. Although the cross-section of the chain blobs was horrendously large, the weighting seemed about right and the cable towed moderately well. This cable was launched and retrieved by hand on the starboard quarter, and was towed on about 15 feet of 4x1/2 inch bungie cord. This cable was now qualitatively quieter than the oil filled cable, but still exhibited significant towing noise in the 0-20 Hz range.

This treatment was applied to the 24 channel streamer, and the levellers removed. Barbara of ITI also put a ~400 ft. leader onto the head of the existing cable, on the theory that the smaller cross section would tend to sink better, and to increase the offset to keep away from ship generated noise. This seemed to provide the best situation possible under the circumstances. We used this configuration in multi-channel mode when in shallower water, and in paralleled single channel mode when in deep water to obtain a better analog record (a single channel was nearly useless due to noise).

Results

Airguns

The guns worked well. Keeping four guns working takes two occasionally overloaded gun techs. One gun seemed to be sick every time it was put into service; this problem was never resolved.

The glycol/methanol injectors stopped working midway through the cruise, but this did not seem to affect the guns.

Towing in quartering or side seas can tangle the tow arrays. The port tow point needs to be as far outboard as possible.

There is a large quantity of compressor oil in the guns after they are fired for a time. It is unknown whether this affects them or not.

Streamers

The ITI streamers were extremely robust and durable. We towed the single channel streamer over ice several times with no ill effects. We also found them to be easy to handle both by hand, and if the winch speed were greater, off the seismic winch. The cause of the towing noise is still unresolved. We think that it derives from three sources: turbulence behind the ship, longitudinal tugs from the ship, and strumming in the leader. The bungie seemed to decouple much of the ship's motion from the cable, as determined by observing the motion of the outboard end of the bungie. If we had been better prepared with various bungie sizes and lengths, and much more weighting supplies, we might have been able to experiment more. As it was, we used up nearly all the bulldog tape on the ship in our limited tests. Our use of chain links for weights compromised the performance of the ITI streamers, but we can't say precisely to what degree. We can say that they were at worst slightly better than the oil filled streamer.

The inability to make the ITI cable more buoyant might be a disadvantage if varied operating conditions were encountered.

Signal Conditioning

There should be more of the special input connectors available for the Ithaco 451; they should travel with the unit. It would be better to reduce the number of connections in the signal path from the streamer to the 2420 although this did not matter much for the ITI's, since there is a low impedance preamp in the cable. Transformer coupled cables probably would not fare as well.

Sonobuoys

The system worked unexpectedly well. We tossed out 11 buoys; all turned on, and 9 ran for the expected duration. We obtained at least 2 hours of signal from each, at about 6 kts using 4 air guns. Switching the airguns from harmonic mode to airgun mode, which increases the energy in the low frequency, did not seem to increase the signal at larger range. We did not run any entire buoy in airgun mode.

Timing

The Syntron gun controller works very well. There were some software bugs which caused unexpected changes in the display when a gun was turned off. It had a power supply problem which caused it to crash. The supposed spare cpu board did not work when installed to try to diagnose the crashes. None of the Syntron output is available from the RTDAS logging system at present. The 2420 records endlessly if the Syntron is powered down or while it is booting.

The time stamping scheme, implemented by NBP-92-8 participants, worked most of the time, but quite often would get out of sync and insert garbage into the header.

Graphic Recorders

We had the usual pain and frustration with recorders, except for the EPC 9800. However, the 9800 has no easy way via blinking lights or other means of setting the proper gain/threshold settings, and lacks a flexible deep water delay. In our areas 1,2,4 second choices were not flexible enough. There is supposed to be a way to delay channel A by B to obtain 3 or 5 seconds of delay but this did not seem to work as expected..

We had at times 4 recorders connected to the Syntron trigger signal without ill effect.

Recording System

The 2420 worked well. It can be difficult to use; the menu system is ponderously slow and prone to error if you are in a hurry. The usage of tape is difficult to calculate beforehand. There were many error messages reporting errors at the ends of tapes; the algorithm for calculating tape used internally seems flaky. If auxiliary channels are selected, this breaks down entirely, and the EOT marker causes the tape to switch to another drive. This causes mangled tape format on the beginning of the next tape. Errors are not reported immediately, only after the system is stopped and the crt turned on, which might be hours after occurrence. There needs to be some alarm mechanism.

There needs to be some way to read back demultiplexed data on the ship. Perhaps the third spare tape drive could be used for this purpose.

We had trouble reading several out of 148 tapes; we're not sure if this problem is in our reading drive or the writing drive.

It would be nice to have the shot number from the Syntron in the external header as well as the time. If eventually shooting on distance becomes possible, it will be mandatory.

The OYO camera easily plots garbage. It took much experimentation to obtain consistent and predictable records.

Powell Basin Seismic Survey

Acquisition

During the periods of 12-14 February and 2-13 March 1490 nautical miles of seismic data were collected in the Powell Basin off the tip of the Antarctic Peninsula. Data was collected primarily using two experimental hydrophone arrays provided by Innovative Transducers Inc. (ITI) of Dallas. Generally because of the greatness of the water depth in the Powell Basin (3-3.5 km) relative to the maximum offset of the hydrophone array the multiple channels of the ITI streamers were paralleled and recorded as single channel or 3-channel data. The maximum moveout was calculated to be on the order of 5 ms. For part of the first day of collection a single channel streamer borrowed from John Anderson of Rice University was used in addition to an ITI streamer because the science crew was experimenting with various methods of towing the ITI streamers. Initially, problems were encountered in towing the ITI streamers because they were too buoyant. After adding sufficient weight to them to make them slightly heavier than water they appeared to tow deep enough to remove much of the towing noise and improve the signal-to-noise ratio to a workable level.

The seismic source was provided by ~~250~~ 150 in^3 GI (Generator-Injector) guns manufactured by Seismic Systems, Inc. of Houston and maintained and operated for the cruise by Antarctic Support Associates. Two to four of the guns were operated at 1800 psi. After initial problems with the ITI streamers were solved, the principal variable in seismic acquisition was the number of guns in the water at any given time. Various problems were encountered keeping the individual guns shooting. At various times anywhere from two to four guns were in use (see attached map). In general efforts were made to keep as many guns shooting as possible. Without at least 3 guns operating it was generally difficult to impossible to image the basement through the 1-2 sec of sedimentary cover. Two guns allowed imaging only of the top 1-1.5s of sedimentary strata. Since the principal scientific objectives of the Powell Basin survey related to the spreading history recorded in the underlying oceanic crust, the recurrent gun problems endangered these objectives. After all was said and done, 40% of the Powell Basin seismic data was shot using only 2 guns (see attached map). It remains to be seen how much the basement reflections can be improved during processing, but most of the seismic will be sufficient for providing control on morphology of the buried surface of the basaltic crust (see attached table).

In general, towing speeds of 5.5-6.3 knots were during seismic acquisition. Variations were often encountered during and after turning, due to wind and current conditions. Small variations over 6.5 knots decreased the signal-to-noise ratio of the data noticeably. When the ship was slowed to pull or launch guns, the guns which remained firing were generally not adjusted for the greater towing depth, and these brief portions of the record are quite apparent. The stratigraphy is imaged at a much lower frequency and the two-way-travel time of the water bottom decreases noticeably.

Weather provided another, less important variable in seismic acquisition. In rough seas considerable towing noise was encountered and constant ship speed and course were more difficult to maintain. In the open seas of the Powell Basin we encountered several days of 10-15 foot seas and one night of seas over 20 feet and winds of 50-65 knots. Fortunately, the worst weather was encountered while on transit leg which took us primarily over exposed basement beyond the southern margin of the Powell Basin, (waypoints G-H), and conditions improved considerably before we turned to pass across the basin floor again..

Finally, from time to time, sideband radio transmissions from the bridge were received through the seismic acquisition system and recorded with the data. This interference partially masked some of the seismic data for periods of a few minutes to an hour or more. It's appearance on the EPC records of the seismic data was distinctively different from that of other towing noise and is easily recognized, even where not annotated.

Geologic Aspects

Basement Structure

Morphologically, the upper surface of the basement seems to be relatively flat, with a few large seamounts or ridges of up to a second in relief. On at least one line, the morphology appeared to beautifully exemplify that of an extinct spreading center, exactly what we were looking for. It was difficult to identify the trend of this feature from cursory examination of the unprocessed data. Since, to a large degree, compaction has molded the sediments to mimic the structure of the underlying basement, one could learn something about the basement from the structural contours of the overlying sediments even on the lines where basement was not well-imaged. With the exception of one active syncline, no recent or active structural deformation of the sediments was observable.

Stratigraphy

Due to its remote location, the Powell Basin is largely removed from significant sources of terrigenous sediment input. The shelves of the surrounding continental blocks are also overdeepened, lying mostly below 400m, with a shelf break at about 500m.

These deep shelves make it even more difficult for terrigenous sediment to be transported to the basin. Deposition on the basin floor appears to be dominated by the monotonous rain of hemipelagic and pelagic sediments together occasionally interrupted by thin-bedded, mud-dominated turbidites. Additional terrigenous material is probably provided to the basin by melting icebergs. A number of point diffractors possibly representing large glacial erratics were noted. The presence of turbidites is mainly attested to by the wedgelike thickening of individual stratal packages toward the eastern and western basin margins. Toward the center of the basin the extremely constant thickness of most stratigraphic horizons, even over structures with moderate paleobathymetric relief, points to the dominance of the blanket-like deposition of pelagic sediments. At the northern and southern margins of the basin, the parallel strata which dominate the basin center continue right up to and abut the steep walls of the fault-bounded basin margin.

The seismic facies of the basin fill are dominated by extremely continuous parallel reflectors. These reflectors can even be correlated by character matching alone over very long distances. The amplitude of these reflectors consistently drops dramatically about 0.6-1.0 sec below the sediment surface. This apparent change in reflection coefficient may correspond to an increase in the supply of sand and silt to the basin as a result of the onset of Antarctic glaciation and associated changes in depositional regime. On a number of lines, particularly those close to the margin of the Orkney microcontinent, reflector-free or chaotic intervals up to 100 ms thick are present. These appear to be large debris flows.

The most fascinating depositional features were found in the northwestern corner of the basin. I've interpreted some of these features here as contourites, the depositional product of thermohaline-driven, bottom currents of the deep sea. On the seismic these deposits appear similar to large climbing ripples. They are migrating, nonerosional bedforms of about 2 kilometers in wavelength and tens of meters in amplitude. Presumably they consist primarily of pelagic muds. The examples imaged during our survey of the Powell Basin rival any textbook examples of contourites and provide an important, well-documented example of this type of deposit.

Straight Line Segments of Powell Basin Survey

Start			End			No.	Length				Tape
WP	Day	Hour	WP	Day	Hour	Guns	(Knots)	Rank	Geologic Comments	Acquisition Comments	#'s
Entry	40	0630	1	41	1515	2	52.9	12	Poor penetration; very little basement imaged; marginally-interesting stratigraphic section	Poor signal-to-noise; recorded with John Anderson's SC streamer	19-21
1	40	1545	2	41	1940	2	158.4	6	Basement imaged moderately well; low penetration; good stratigraphic section; Orkney margin well imaged	Splice in middle between 24 channel ITI array and John Anderson's SC streamer	21-26
2	41	2010	3	41	2240	4	11.6	21	Entirely on Orkney Shelf; one thin stratigraphic sequence on basement	None	26-26
3	41	2305	4	42	2035	3	112.2	8	Fair penetration and basement imaging; interesting basement high; monotonous strat.; good imaging of Orkney margin	Speed varied; 0545-0705Z poor acquisition due to slow speed	26-30
Entry	61	0500	B	61	1820	4	83.7	10	Poor basement imaging; interesting stratigraphy; some interesting basement highs	One small and one large data gap due to gun problems; poor S/N ratio; heavy seas	103-106
B	61	1845	C	62	0025	4	34.1	16	Half on exposed basement at basin margin; half strike line of moderately interesting basin edge strata	Varying number of guns	106-107
C	62	0045	E	63	0335	4	157.6	2	Poor penetration; modest basement imaging; v. good strat. section of upper 1s; interesting basement structure and	None	107-113
E	63	0425	F	63	0950	4	33	17	Strike line of more proximal basin floor facies; contorted strata	None	113-114
F	63	1010	G	63	2345	4	85.2	4	Good imaging; v. interesting stratigraphy and depositional features; some contourites; some basement imaging	Some speed variation; weather deteriorating	114-116
G	64	0005	H	64	1055	2,4	35	20	Mostly on basement beyond basin margin; some faulted sedimentary blocks	Horrid weather, perfectly horrid; low S/N; slow speed; non-linear navigation; loss of 2 guns	116-118
H	64	1235	I	65	1030	2	126.2	13	Little basement imaged; monotonous stratigraphic section well imaged	One data gap	119-123

Straight Line Segments of Powell Basin Survey

Start			End			No.	Length				Tape
WP	Day	Hour	WP	Day	Hour	Guns	(Knots)	Rank	Geologic Comments	Acquisition Comments	#'s
I	65	1110	HF1	65	1930	2	44.4	15	No basement imaged; perhaps some interesting debris flows	Major record degradation due to low battery; minor speed variations; one turn; one excellent section ties to another line	123-124
HF1	66	0135	J	66	0815	2	40.4	14	Poor penetration and basement imaging; monotonous stratigraphy	Low S/N going upseas	124-126
J	66	0850	K	67	0810	4,2,3	113.7	7	Interesting structure and stratigraphy at northern basin margin; poor basement imaging	Splice at Heat Flow Station 2; much better S/N going downseas	127-129
K	67	0820	L	67	1305	3	25.7	19	Contorted strata on top of basement at edge of basin	None	130-130
L	67	1325	M	68	1055	4,2,3	100.7	1	In north, excellent contourites; moderate basement imaging. In south excellent penetration and basement imaging; monotonous stratigraphy	Splice at backtrack loop to fill data gaps caused by gun maintenance	135-135
M	68	1115	N	68	1255	4	11.2	22	Entirely on faulted strata of continental block at basin margin; similar to Orkney margin	None	135-135
N	68	1315	O	68	1700	4	21.4	11	Excellent penetration and basement imaging	Short Line	135-136
P	69	1305	Q	69	2305	4	64.6	3	Excellent penetration and basement imaging; best of Powell Basin survey; monotonous stratigraphy	Excellent S/N; large ITI streamer made into SC; sonobuoys 4-8; some sideband radio noise	136-138
Q	70	0800	R	70	1055	2	13.8	18	No basement imaged; poor penetration; stratigraphy not especially interesting	One data gap; 2 periods of slow ship speed and consequent record degradation	138-139
R	70	1125	S	70	1910	3	46.8	9	Excellent penetration and basement imaging; monotonous stratigraphic section	Excellent S/N; Large ITI streamer recorded as 1 channel; 2 sonobuoys	139-140
T	72	0405	U	72	1655	2	74.6	5	Fantastic contourites; moderate basement imaging; some proximal fan facies; shot down possible axis of sediment delivery	Excellent S/N; Large ITI streamer recorded as 3 channels; one minor data gap toward end	140-142

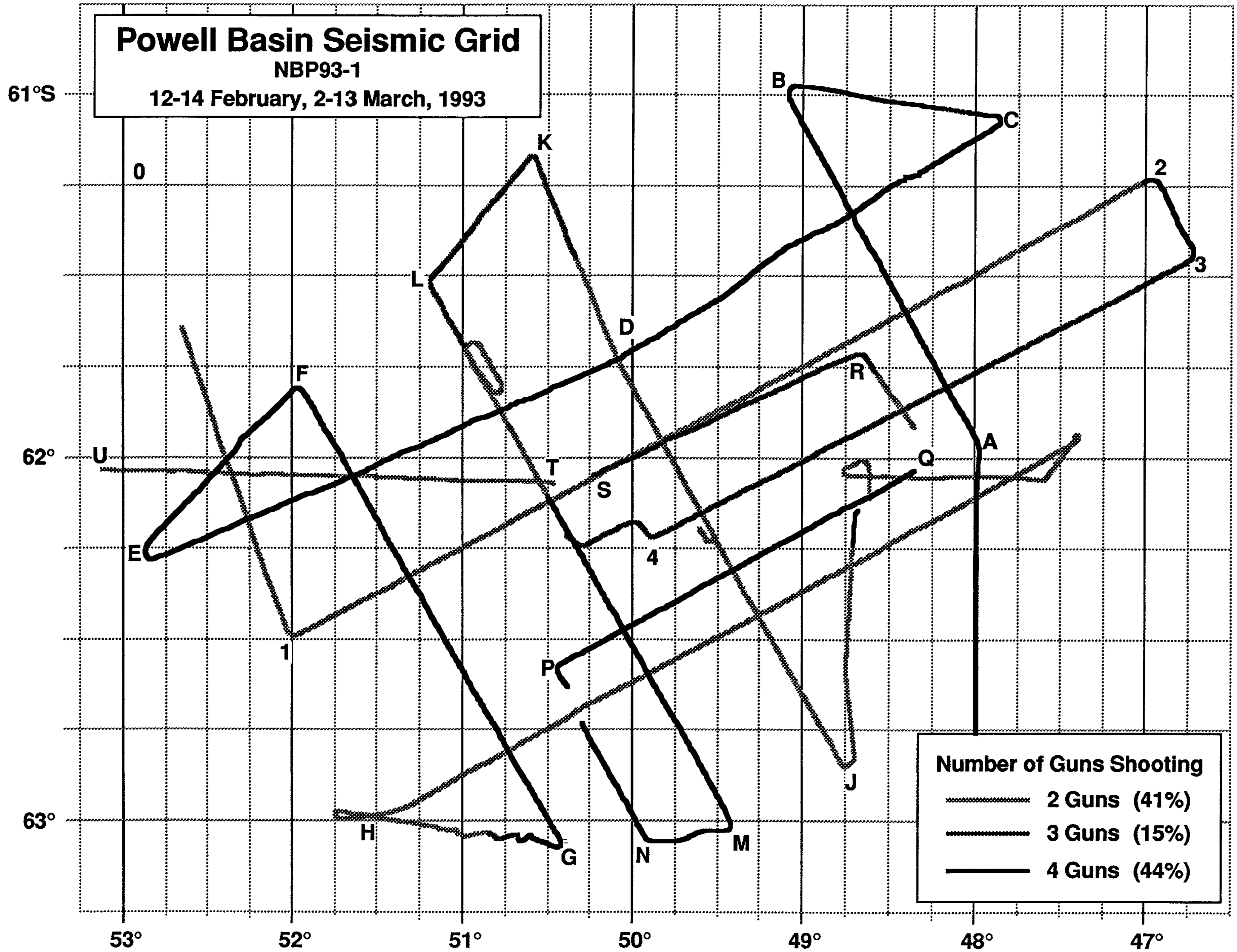
Powell Basin Survey

Way-point	Julian Day	Time	No. Guns	Tape No.	Event	Latitude		Longitude		Miles	Hours	Avg. Speed
						Degrees	Minutes	Degrees	Minutes			
0	40	0630	2	19	Entering Basin	61	38.93	52	37.96			
	40	1515	2	21	Turning NE	62	28.69	52	0.88	52.9	8.8	6.0
1	40	1545	2	21	Turn Complete	62	28.68	51	54.95	2.7	0.5	5.5
	41	0025	2	22	ITI Streamer Back in Water	62	4.58	50	17.82	51.4	8.7	5.9
	41	1920	2	26	Add 2 Guns	61	14.93	47	2.36	105.5	18.9	5.6
2	41	1940	4	26	Turning SE	61	14.33	46	59.43	1.5	0.3	4.6
	41	2010	4	26	Turn Complete	61	15.54	46	55.39	2.3	0.5	4.6
	41	2240	4	26	Turn SW	61	25.82	46	44.28	11.6	2.5	4.6
3	41	2305	4	26	Turn Complete	61	27.68	46	46.03	2.0	0.4	4.9
	41	2315	4	26	1 Gun Off	61	28.13	46	47.71	0.9	0.2	5.5
4	42	2035	3	30	Guns Off	62	12.79	50	22.92	111.3	21.3	5.2
	61	0500	4	103	Entering Basin	62	16.22	47	59.99			
A	61	0815	4	104	Turn NW	61	56.66	48	0.31	19.6	3.3	6.0
B	61	1820	4	106	Turn E	61	0.82	49	5.14	64.0	10.1	6.4
	61	1845	4	106	Turn Complete	60	59.00	49	2.52	2.2	0.4	5.3
	61	2235	4		Turn 1 Gun Off	61	2.58	48	13.05	24.3	3.8	6.3
	61	2335	3	107	1 Gun Back On	61	3.30	48	3.36	4.8	1.0	4.8
	62	0025	4	107	Turn SW	61	3.92	47	53.17	5.0	0.8	6.0
C	62	0045	4	107	Turn Complete	61	5.44	47	53.15	1.5	0.3	4.6
D	62	1245	4	109	Waypoint	61	44.14	50	5.79	74.6	12.0	6.2
E	63	0335	4	113	Turn NE	62	16.89	52	47.93	83.1	14.8	5.6
	63	0425	4	113	Turn Complete	62	12.98	52	47.64	3.9	0.8	4.7
	63	0950	4	114	Turn SE	61	49.17	51	59.19	33.0	5.4	6.1
F	63	1010	4	114	Turn Complete	61	49.22	51	55.48	1.8	0.3	5.3
G	63	2345	4	116	Turn W	63	3.05	50	24.81	85.2	13.6	6.3
	64	0005	4	116	Turn Complete	63	4.07	50	26.39	1.2	0.3	3.7
	64	0350	4	117	Turn 1 Gun Off	63	2.46	50	45.17	8.7	3.8	2.3
	64	0445	3	117	Turn 1 Gun Off	63	1.64	50	50.48	2.6	0.9	2.8
	64	1055	2	118	Turn NE	62	58.23	51	42.18	23.8	6.2	3.9
H	64	1235	2	119	Turn Complete	62	58.15	51	23.43	8.5	1.7	5.1
I	65	1030	2	123	Turn S	61	57.42	47	25.10	126.2	21.9	5.8

Way-point	Julian Day	Time	No. Guns	Tape No.	Event	Latitude Degrees	Latitude Minutes	Longitude Degrees	Longitude Minutes	Miles	Hours	Avg. Speed
	65	1110	2	123	Turn Complete	61	57.40	47	26.52	0.7	0.7	1.0
	65	1220	2	123	Turn W	62	2.89	47	34.75	6.7	1.2	5.8
	65	1235	2	124	Turn Complete	62	3.72	47	37.19	1.4	0.3	5.7
	65	1725	2	124	Turn NE, Lots of Turns	62	3.01	48	43.64	31.2	4.8	6.5
	65	1930	2	124	Guns Off	62	6.90	48	36.99	5.0	2.1	2.4
	66	0135	4	124	Guns On	62	8.88	48	41.46			
	66	0150	4	124	On Course	62	10.18	48	42.01	1.3	0.3	5.3
	66	0235	4	124	Turn 2 Guns Off	62	14.75	48	42.68	4.6	0.8	6.1
	66	0540	2	126	Slight Course Change	62	33.49	48	44.95	18.8	3.1	6.1
	66	0815	2	126	Turn Back NW	62	49.06	48	42.06	15.7	2.6	6.1
J	66	0850	2	127	Turn Complete	62	49.88	48	46.98	2.4	0.6	4.1
	66	1525	2	128	Guns Off	62	12.94	49	31.32	42.4	6.6	6.4
	66	2010	4	128	Guns On, Doubling Back	62	11.88	49	36.19			
	66	2105	4	128	On Course	62	12.67	49	31.26	2.4	0.9	2.7
D	67	0205	4	129	Waypoint	61	44.23	50	4.79	32.6	5.0	6.5
	67	0450	4	129	Turn 1 Gun Off	61	27.61	50	19.57	18.1	2.8	6.6
K	67	0810	3	129	Turn WSW	61	10.83	50	34.11	18.2	3.3	5.5
	67	0820	3	130	Turn Complete	61	10.73	50	35.72	0.8	0.2	4.7
L	67	1305	3	130	Turn SSE	61	30.37	51	9.94	25.7	4.8	5.4
	67	1325	3	135	Turn Complete	61	32.20	51	10.33	1.8	0.3	5.5
	67	1515	3	135	Turn 1 Gun Off	61	41.48	50	58.95	10.8	1.8	5.9
	68	0000	2	135	Turn 2 Guns On	62	6.66	50	29.46	28.8	8.8	3.3
M	68	1055	4	135	Turn W	62	59.91	49	25.22	61.1	10.9	5.6
	68	1115	4	135	Turn Complete	63	1.21	49	27.23	1.6	0.3	4.8
N	68	1255	4	135	Turn NW	63	3.14	49	51.44	11.2	1.7	6.7
	68	1315	4	135	Turn Complete	63	2.37	49	55.02	1.8	0.3	5.4
O	68	1700	4	136	Guns Off	62	43.73	50	17.60	21.4	3.8	5.7
	69	1200	4	136	Guns On	62	37.82	50	22.55			
	69	1220	4	136	Turn NE	62	36.02	50	25.40	2.2	0.3	6.7
P	69	1305	4	136	Turn Complete	62	33.10	50	22.09	3.3	0.8	4.4

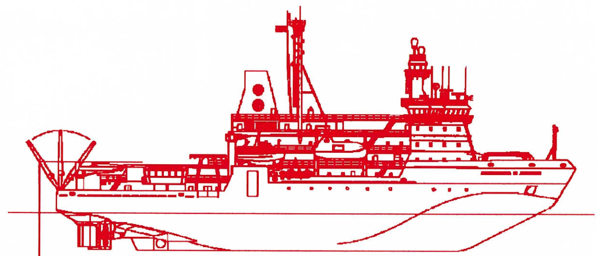
Way-point	Julian Day	Time	No. Guns	Tape No.	Event	Latitude Degrees	Latitude Minutes	Longitude Degrees	Longitude Minutes	Miles	Hours	Avg. Speed
Q	69	2305	4	138	Guns Off	62	1.99	48	20.89	64.6	10.0	6.5
	70	0800	4	138	Guns On	61	54.89	48	21.81			
	70	0820	4	138	Turn 2 Guns Off	61	53.67	48	23.26	1.4	0.3	4.2
	70	1020	2	138	Turn 1 Gun On	61	46.24	48	34.43	9.1	2.0	4.6
	70	1055	3	139	Turn W	61	43.49	48	38.25	3.3	0.6	5.7
R	70	1125	3	139	Turn Complete	61	43.25	48	43.36	2.4	0.5	4.9
S	70	1910	3	140	Guns Off	62	2.95	50	13.24	46.8	7.8	6.0
T	72	0405	2	140	Guns On	62	4.29	50	27.60			
U	72	1655	2	142	Guns Off	62	2.13	53	6.33	74.6	12.8	5.8
									Total:	1490.6	266.3	

Two Guns: 40.8%   Three Guns: 15.3%   Four Guns: 43.9%


Powell Basin Seismic Grid
NBP93-1
12-14 February, 2-13 March, 1993
61°S
62°
63°
53°
52°
51°
50°
49°
48°
47°
0
A
B
C
D
E
F
G
H
J
K
L
M
N
P
Q
R
S
T
U
1
2
3
4
Number of Guns Shooting
2 Guns (41%)
3 Guns (15%)
4 Guns (44%)

Nathaniel B. Palmer
Cruise 93-1

Report of Coring Operations



RVIB NATHANIEL B. PALMER

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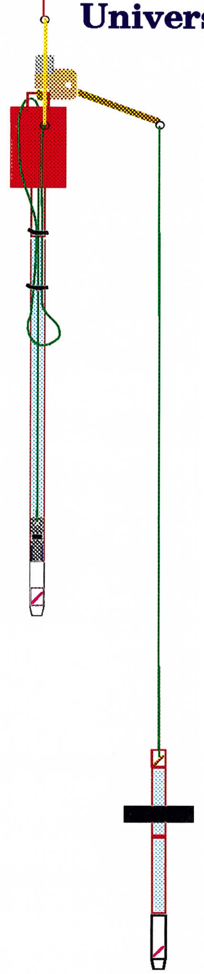

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Acknowledgements

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 turn ~~term~~ 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

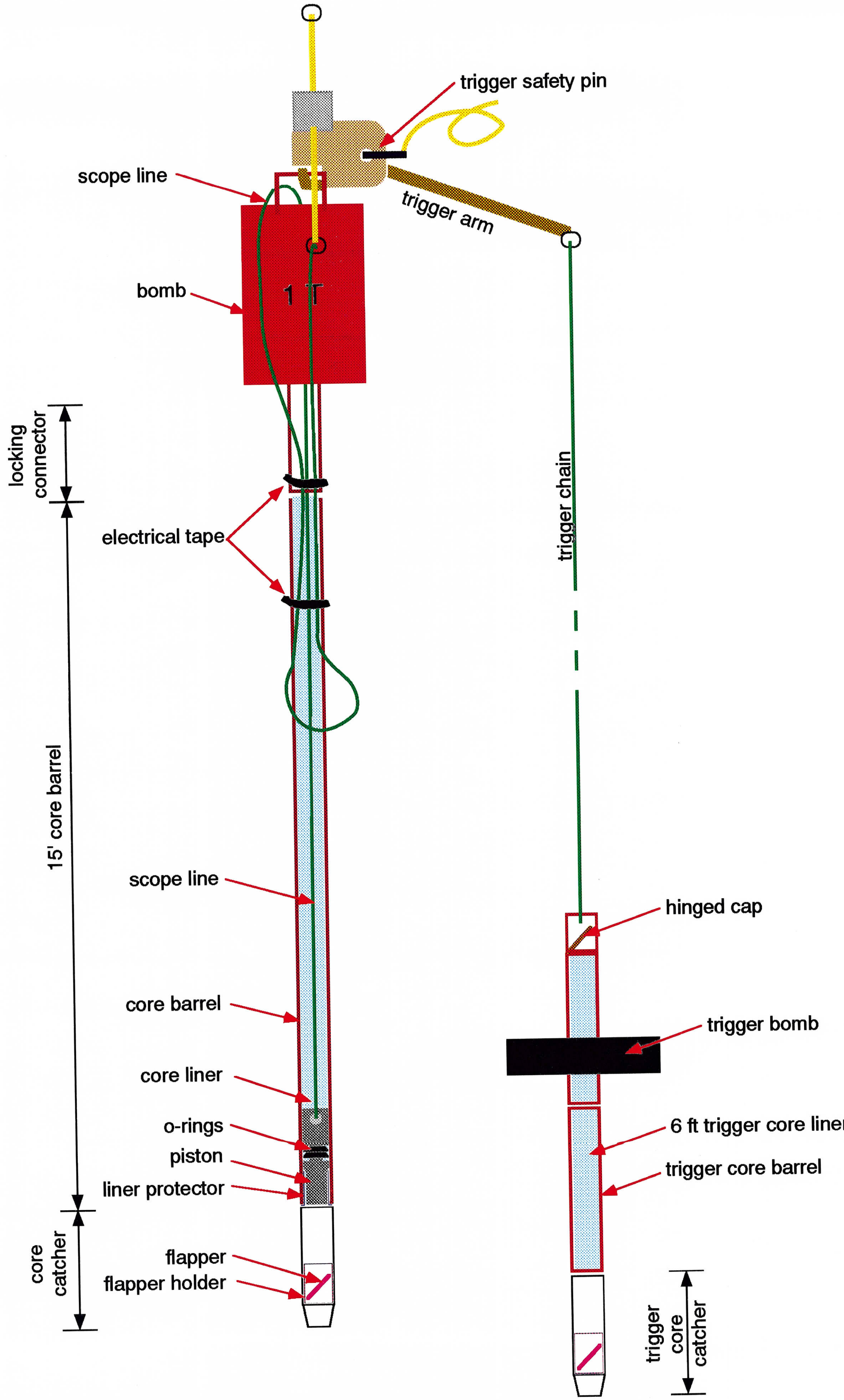


Figure 1. Piston coring rig used on NBP93-1. Not to scale. Trigger chain longer than shown.

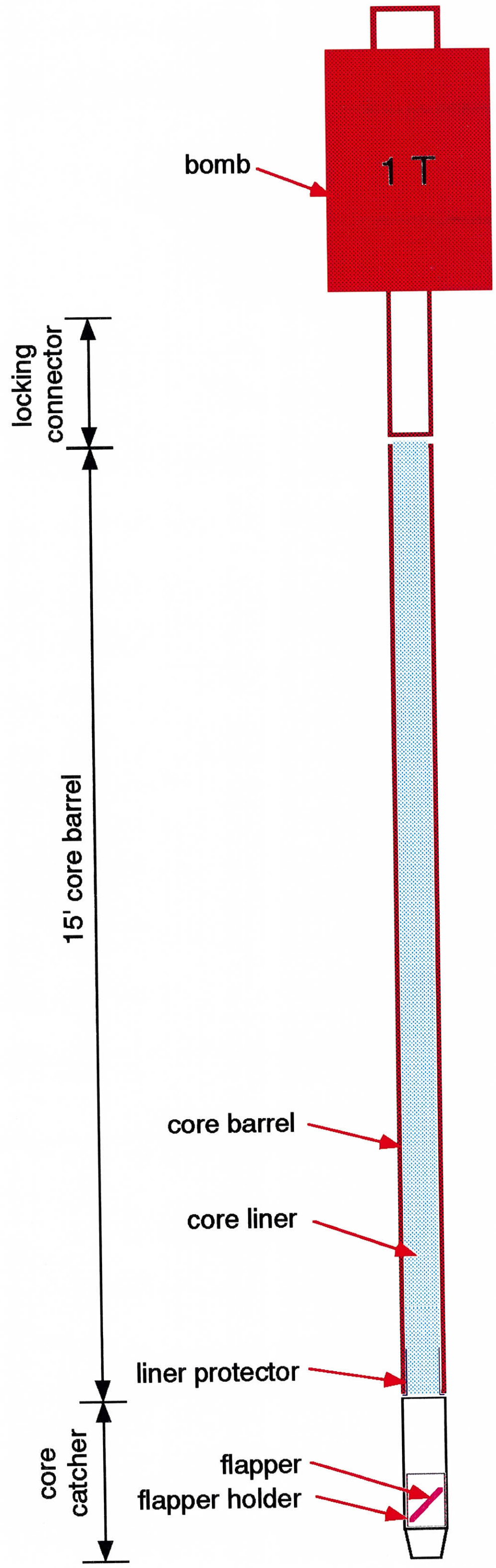
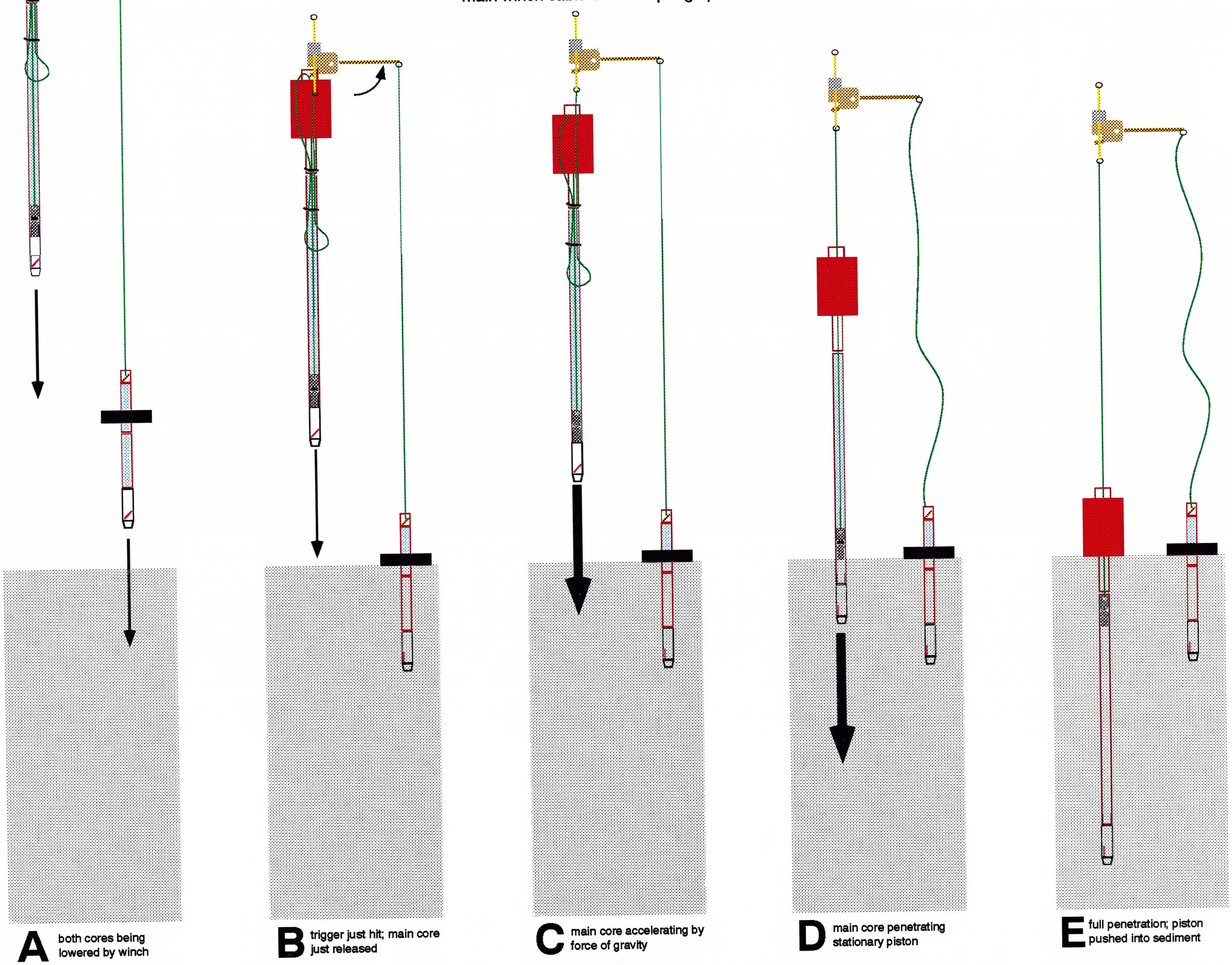


Figure 2. Gravity coring rig used on NBP93-1. Not to scale.

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



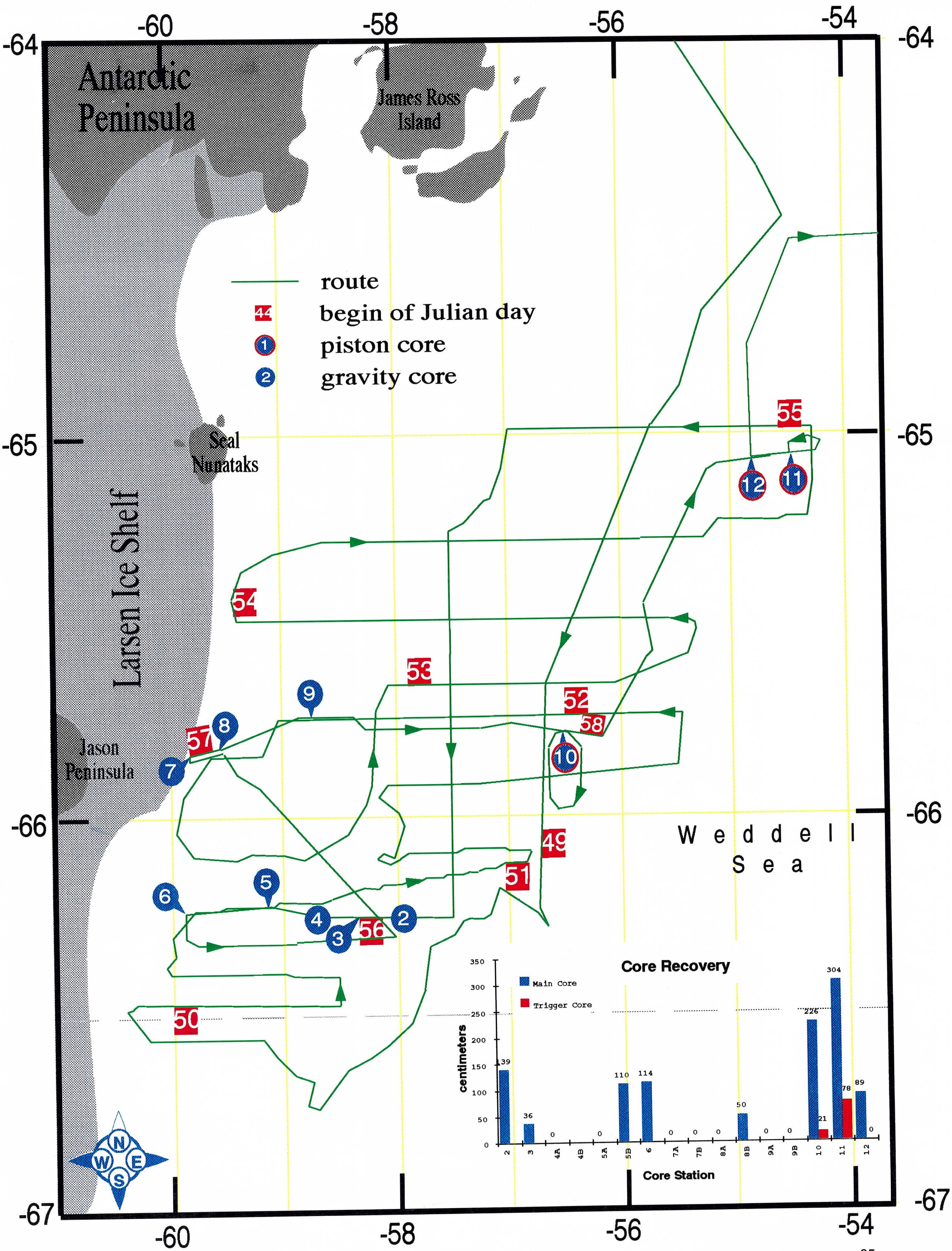


Figure 4. Location of Larsen Shelf cores and cruise route.

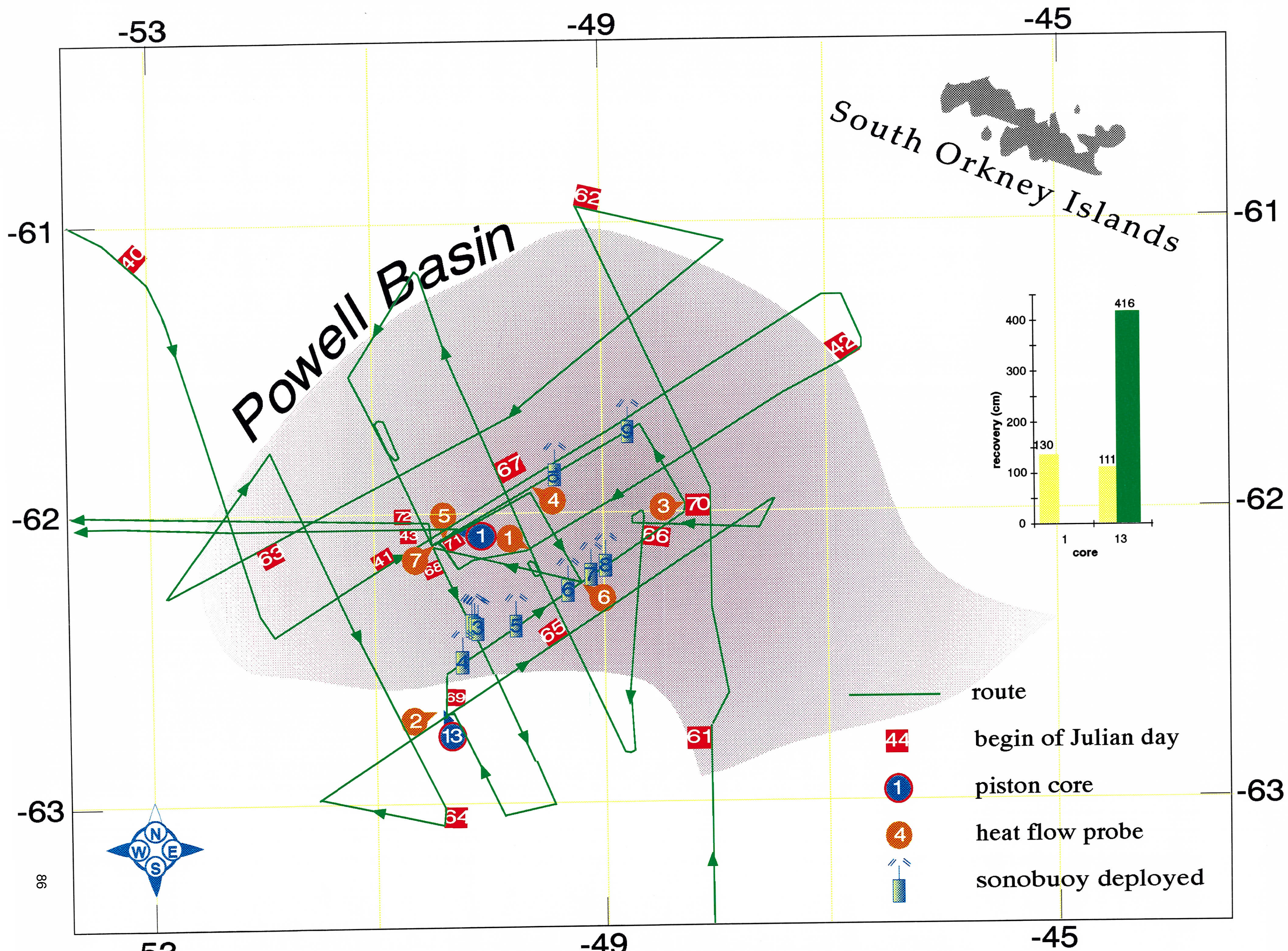


Figure 5. Position of cores 1 and 13 relative to Powell Basin seismic and heatflow.

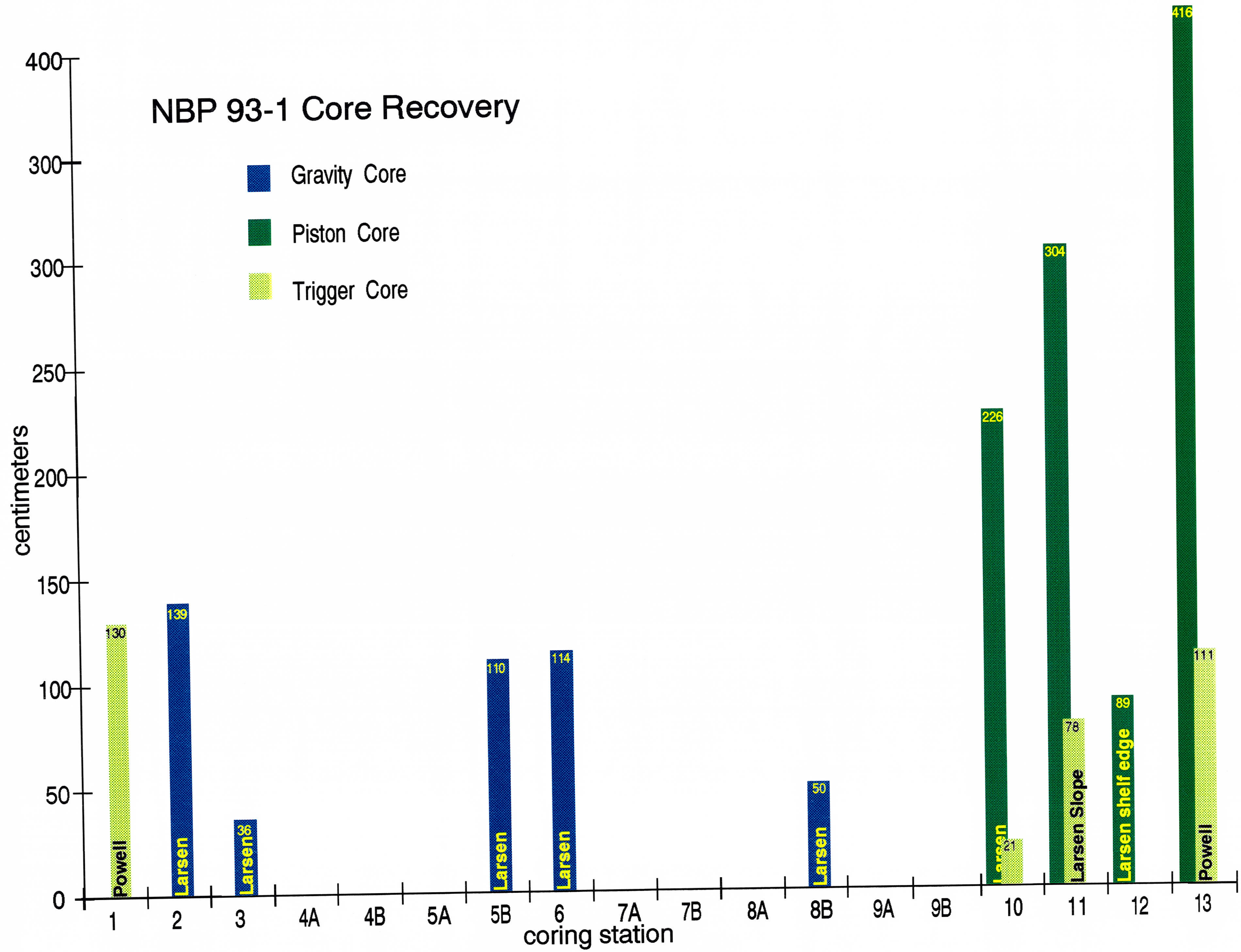


Figure 6. Core recovery chart.

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

Cruise NBP 93-1

Bags of sediment retrieved during coring and heat flow

No.	CODE	WEIGHT (g)	Latitude	Longitude
1	TCC1-1	305		
2	TCC1-2	590		
3	TCC1-3	770		
4	CC2-1	10		
5	CB3-1	405		
6	CC4A-1	215		
7	CC4A-2	875		
8	CC4A-3	550		
9	CB4B-1	1210		
10	CB4B-2	700		
11	CB4B-3	770		
12	CC4B-1	1100		
13	CC4B-2	820		
14	CC4B-3	605		
15	CB5A-1	1810		
16	CB5A-2	1830		
17	CB5B-1	785		
18	CB5B-2	1710		
19	CC5B-1	820		
20	CB6-1	1700		
21	CC6-1	1210		
22	CB7A-1	380		
23	CB7B-1	615		
24	CC7B-1	1130		
25	CB8A-1	130		
26	CB8B-1	115		
27	CC8B-1	1130		
28	CB9B-1	300		
29	CB10-1	1470		
30	CB10-2	1390		
31	CB10-3	1710		
32	CC10-1	860		
33	TCC10-1	1010		
34	CB11-1	1690		
35	CC11-1	955		
36	CC11-2	620		
37	CC11-2	470		
38	TCC11-1	310		
39	CB12-1	1085		
40	CC12-1	755		
41	CC12-2	856		
42	TCC12-1	730		
43	TCC12-2	260		
44	CB13-1	115		
45	CC13-1	325		
46	TCC13-1	710		
47	TCC13-2	445		
48	HF 3	90	-61°59.49'S	-49°16.24'W
49	HF 4	485	-62°2.07'S	-50°10.5'W
50	HF 5	115	-61°55.09'S	-49°37.03'W
51	HF 6	315	-62°14.79'S	-49°10.18'W
52	HF 8/9-1		-62°18'S	-58°S09'W
53	HF8/9-2		-62°18'S	-58°S09'W
54	HF8/9-3		-62°18'S	-58°S09'W

CODE	sediment source
TCC	trigger core catcher
CC	main core catcher
CB	outside main core barrel
HF	outside heat flow probe

NOTES

1. Codes are marked on bags; numbers (first column at left) are not.

2. Locations of cores on core summary sheet and on coring station forms; heat flow locations are listed below and represent multiple penetrations each.

Dredging Report for Nathaniel B. Palmer Cruise 93-01; 3Feb93-20Mar93

Equipment

Dredge

Two dredges were located in the AGUNSA warehouse in Punta Arenas and were taken aboard. Both have a chainbag attached to a rectangular mouth. One is approximately one meter wide, and the other is a little over half that size. The larger dredge was the only one used on this cruise.

The iron rings that make up the chainbag on the dredge were unusually large (4"), so at this scientist's request the ship's agent (AGUNSA) purchased approximately 30m^2 of 1/2" fishnet and some burlap sacks for lining the dredge. The fishnet was made into bags slightly larger than the chainbag, and was meant to increase the chances of recovering small samples (not necessarily a good thing as it turned out). A burlap sack in the bottom of the fishnet bag helped retain even smaller samples, which ended up being such an inconvenience that the burlap was used in the first two dredges only. After the first two dredges the fishnet was simply placed in a heap in the bottom of the chainbag.

The dredge was rigged with a weaklink system designed to break well before there was any danger of damage to the wire if the dredge became stuck on the bottom. Connected directly to the dredge handle was a 3/4" (4.75-ton) shackle. This shackle was the weakest link in the dredge rigging, and was meant to break first. Above this weaklink was a 7/8" (6.5-ton) shackle, a 5-ton swivel, and then a 1" (8.5-ton) shackle attached to the wire . Also connected to the 7/8" shackle was a length of 5/8" chain that ran down the handle of the dredge and looped around the side of the mouth of the dredge. This chain was doubled up and tied together with 3/8" nylon rope, and was attached to the dredge handle with hose clamps and light chain. The rope was intended to absorb some of the shock of the weaklink breaking, and then the chain would yank the dredge to the side, hopefully dislodging the dredge. The weaklink never broke, and at least three times sustained pulls reading up to 12000 pounds on the uncalibrated tensiometer.

Winch

All dredging was conducted using the aft A-frame and winch with two-strand 9/16" wire. The winch has a high (~20-70 m/min) and a low (~10-50 m/min) gear, but it is difficult or impossible to switch gears when there is any more than very light tension on the wire. In the case of dredging, the benefits of more control in low gear at low speeds while on the bottom outwayed the benefits of the higher speeds of high gear for the descent and return. Low gear was therefore used for all dredging. The winch controls are located in the aft control house, which is far from the area of the lab where we had the depth recorders. Therefore two persons in constant radio contact were required to monitor the tensiometer in the winch house and the bottom return on the depth recorder.

Rock Saw

A rock saw was discovered in the AGUNSA warehouse and was taken aboard. We found three different saws but took only the largest one.

Lab Area

The labs were so clean and new that I felt guilty hauling dirty rocks into them. I therefore used the Baltic Room for all initial stages of processing of the rocks. The Baltic Room is convenient to the aft deck, but has a Fibergrate floor that easily devoured small samples. We therefore layed burlap sacks on the floor and spread the samples on top of the burlap. A garden hose was available to rinse saltwater and biological miscellany off of the samples. Two large heaters kept the room warm and dry when necessary.

Dredging Rationale

Until this cruise the only substantial samples of volcanic rocks from the seamounts in Bransfield Strait were from several dredges near 62.2°S, 57.4°W. These rocks were compositionally transitional between island arc basalts and mid-ocean ridge basalts, and thus similar to some back-arc basin basalts. The fact that all of the available dredge samples were from two neighboring seamounts meant that the amount of compositional variation along the length of the Bransfield rift was unknown. Partial geochemical analysis of a small fragment of fresh basalt inadvertantly recovered by piston-core from 62.7°S, 58.0°W suggested that volcanism in that part of the rift was more similar to mid-ocean ridge basalt. It was clear that a thorough sampling of as many seamounts as possible in Bransfield Strait was necessary to properly determine the nature of the volcanic activity there. The Klepeis and Lawver compilation of bathymetric data in Bransfield Strait showed that there were at least a dozen eligible dredging targets. All that was needed was a few days of shiptime.

Dredging Results

Overall, dredging from the RVIB Nathaniel B. Palmer is fairly painless, and the dredging operations during NBP93-1 were very successful. Eight of the ten attempted dredges recovered volcanic rocks (Table 1). Fragments of basalt pillows and conduits were the most common form, followed by rubbly chunks. Most samples had at least one glassy surface and contained 20-40% vesicles.

It is difficult say which dredge target yielded the freshest basalt. Dredges D2 and D8 contained a higher proportion of fresh-looking basalt, but fresh to only slightly palagonitized glass could be found in every successful dredge except numbers D4 and D7. Glass on basalts in dredge D4 was moderately palagonitized throughout, while basalt glass in dredge D7 were almost completely altered to palagonite.

Dredge D8 contained an unusual sample that appeared to be a 2 cm thick sheet of palagonite breccia. One surface had a light green staining that oxidized within several hours to whitish green. The rest of the sample also oxidized within several hours from medium reddish-brown to a yellowish-orange.

Table 1. Dredge Target Descriptions and Results

Station number	Date	Time (GMT)	Latitude (S)	Longitude (W)	Heading	Depth to base of feature (m)	Depth to top of feature (m)	Results
D1	14 Feb 93	1930	62° 36.3'	58° 47.9'	247	1665	1325	basalt + erratics
D2	15 Feb 93	0105	62° 26.3'	58° 24.3'	060	1080	700	basalt
D3	15 Feb 93	2215	62° 28.2'	58° 28.8'	050	1688	1560	basalt + erratics
D4	16 Feb 93	0045	62° 27.3'	58° 27.0'	050	1560	675	basalt + erratics
D5	14 Mar 93	0135	61° 54.5'	56° 03.4'	180	1522	1132	erratics
D6	14 Mar 93	0700	62° 04.2'	56° 35.1'	250	1612	1065	basalt + erratics
D7	14 Mar 93	1425	62° 09.0'	57° 02.5'	150	1635	1455	basalt + erratics
D8	14 Mar 93	1835	62° 11.8'	57° 04.7'	350	1762	1395	basalt + erratics
D9	15 Mar 93	0040	62° 12.2'	57° 31.2'	240	1965	1665	erratics
D10	15 Mar 93	0645	62° 20.1'	58° 07.5'	270	1950	1590	basalt + erratics

RVIB N.B. Palmer NBP93-1 survey of the Antarctic Peninsula and Powell Basin

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Heat flow, magnetics, gravity, and seismic reflection data as well as piston and gravity cores in Powell Basin were part of the NBP93-1 cruise of *RVIB N.B. Palmer* to the Antarctic Peninsula. Because austral summer 1993 turned out to be an exceptionally ice-free year for the east side of the Antarctic Peninsula, we took the opportunity to collect seismic, gravity and magnetics data along the Larsen Shelf to 66°45'S, an area previously unexplored. In order to collect the shelf data, our planned work in Powell Basin was reduced and we gambled the weather during the cruise would be optimal. As it developed weather-wise, the twelve days spent along the Larsen Shelf were excellent, while at the same time, low pressure zones moved through Powell Basin and precluded successful work there.

During the crossing of Drake's Passage, a new 24-channel seismic streamer was deployed, and an attempt was made to weight it neutrally bouyant so it would tow at a depth between 20 and 30 meters. The streamer, designed by Innovative Transducer Inc. [ITI], had a floatation jacket that continued onto the reel. When it became apparent that the streamer required too much chain taped to it to reach the desired towing depth, a non-flotation leader was added. In the interim, a 24 phone single channel ITI streamer was used for the initial survey work in Powell Basin and on the Larsen Shelf.

With the single channel streamer, one crossing of Powell Basin was made but only two gas-injector SSI 150 cubic inch airguns were operational which did not give sufficient penetration to basement. On the return crossing, four guns were deployed and basement was observed. The weather deteriorated, the gear was retrieved, and we headed for Bransfield Strait where the seismic gear was redeployed. A new 'dike-like' intrusive feature was seen in the eastern end of the King George Basin as well as another heretofore unreported volcanic mound. Prior to a port call at Maxwell Bay, two dredges were made on previously identified targets (Keller et al., this volume). After the stop at King George Island, dredging continued until the main winch wire jammed in the block, and the ship headed for the east side of the Peninsula.

Upon exiting Antarctic Sound, the single channel ITI seismic streamer, four airguns, and the gradiometer were deployed on a course of 135° until Weddell Sea pack ice was encountered at 64°30'S, 54°20'W. The edge of the pack ice was followed to the southwest to 66°45'S, 58°45'W. Working northward, seismic data were collected along an east-west grid with a 10 km spacing, until 66°S where the line spacing changed to 20 km (Sloan and Lawver, this volume).

Enroute to Powell Basin, a large negative Geosat gravity anomaly was crossed with a single seismic line run due east to 64°30'S, 48°W. Figure 2 shows the profile of what may be a massive slump. A very obvious footwall was observed as a 150 meter drop at the eastern end of the slump. The headwall and footwall coincide with the edges of the major Geosat gravity anomaly. The east-west line crossed the slump at an angle, and no levees that might channel the slumped material were observed. Internal deformation is seen in the slump as well as truncation of beds at the sediment surface. An acoustically transparent layer reaches the surface about 20 km to the west of the footwall. If the Geosat anomaly defines the areal extent of the slump, it may be as large as 120 km by 200 km. The footwall appeared to be scalloped, based on three crossings of it.

Upon return to Powell Basin, rough weather made station work difficult. A total of 2700 km of seismic reflection data were collected in Powell Basin. Heat flow values indicate the general age of Powell Basin to be Oligocene. There are no correlatable magnetic anomalies from the basin, even though an extinct spreading center is identified from the seismic records. During one long night, the wind increased from 30 knots to 60 knots and the seismic gear could not be recovered. Fortunately all the gear survived, and though some were slightly damaged, none was lost. The cruise finished with more dredging in Bransfield Strait (Keller et al., this volume). The final hours were spent in King George Basin on three heat flow stations with a total of 14 penetrations. Enroute to Punta Arenas, a final seismic survey was made in the western Scotia Sea.

Participants in the NBP93-1 cruise included: Mark Wiederspahn and Keith Najmulski of the Institute for Geophysics; Benjamin Sloan and Brad Wolaver of the Department of Geology and the Institute for Geophysics, University of Texas at Austin; Randall Keller of Oregon State University; Tom Williams of Stanford University; Barbara Embry of Innovative Transducers Inc.; and Marta Ghidella and Jorge Strehlin of the Argentinian Antarctic Survey. This research was supported by National Science Foundation grant DPP90-19247.

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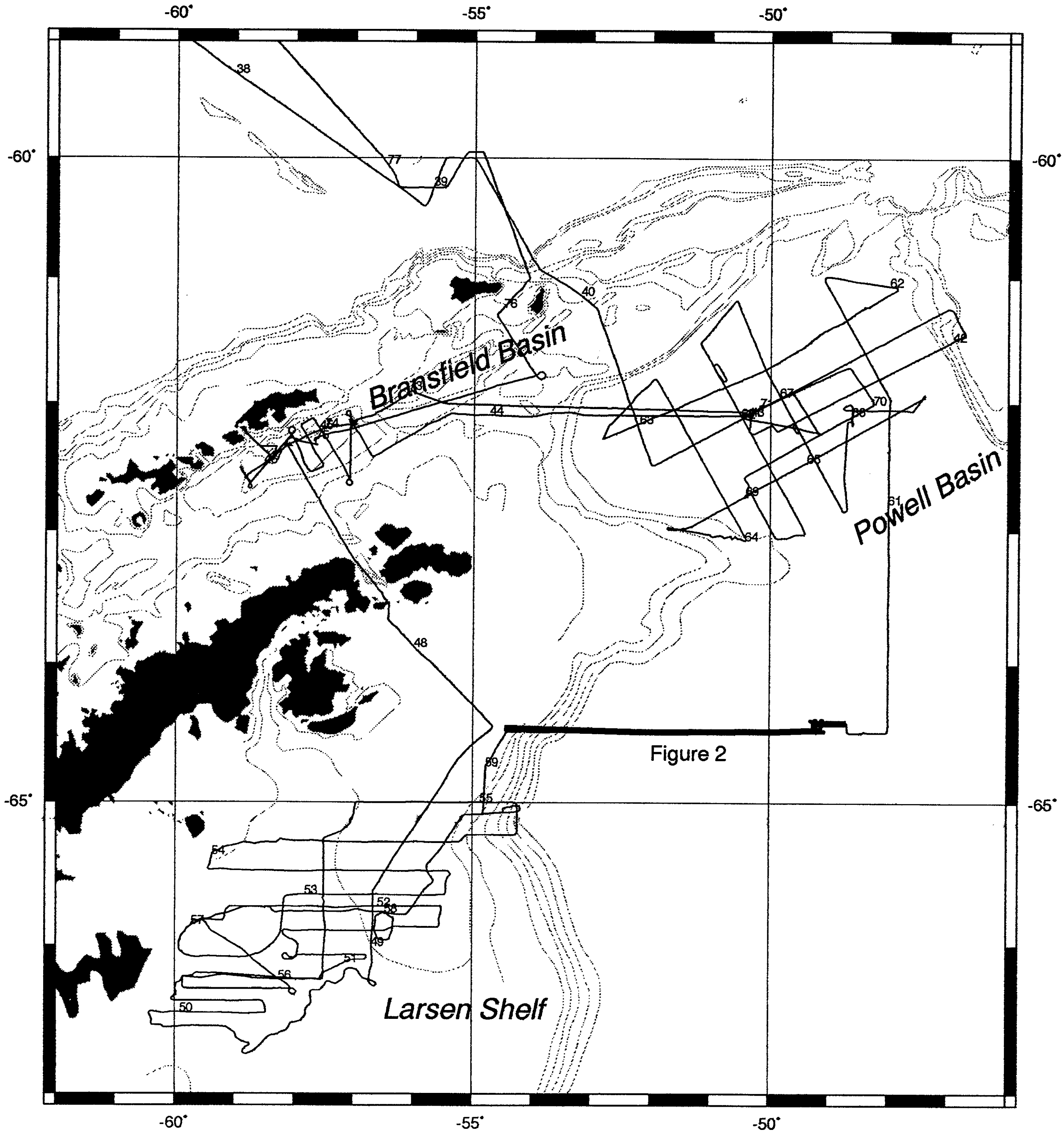
Figure Captions

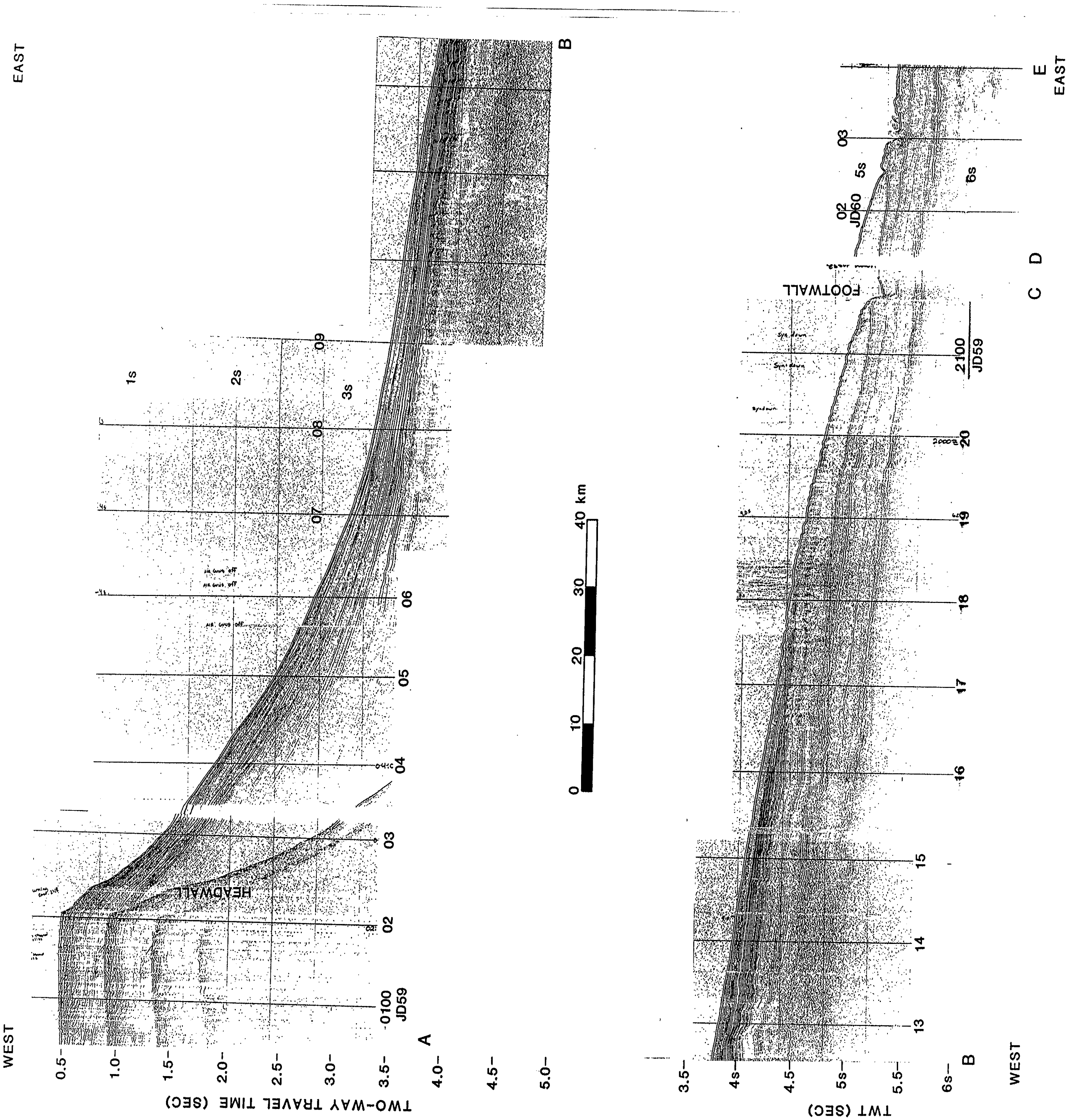
Figure 1. Track chart showing the route of *RVIB N.B. Palmer* during the NBP93-1 cruise to the Antarctic Peninsula. Mercator chart was produced using GMT-SYSTEM (Wessel and Smith, 1991). Bathymetric contours are in light weight lines and are taken from GEBCO Chart 5•16. Location of the seismic profile shown in Figure 2 is indicated by the heavy line. Numbers along the track refer to the Julian day for 1993.

Figure 2. Single channel monitor record across slump feature on east side of the Antarctic Peninsula. East-west location of seismic line shown in Figure 1. The time marks are every hour and indicate an approximate ship speed of 7 kts [12.5 km hr^{-1}]. Internal deformation can be seen between 0700 and 1800 on JD 59. Footwall is indicated on two separate crossings at the right end of the lower section.

Lawver, L.A.
Figure 1



Lawver, L.A.
Figure 2



NBP93-1 Route Map