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CRUISE REPORT

SHIP UTILIZATION DATA

SHIP NAME R/V Robert D. Conrad	OPERATING INST. Lamont-Doherty	PARTICIPATING PERSONNEL
CRUISE (LEG) NO. 29-02	DATES February 14-February 29	
AREA OF OPERATIONS: Tierra del Fuego — Argentina and Chile	PORT CALLS:	
DAYS AT SEA 15	DAYS IN PORT 4 5	

PORT CALLS: PLACE	DATES
Punta Arenas, Chile	February 10-14
Punta Arenas, Chile	February 29-March 3

CODE	NAME	TITLE	AFFILIATION
1.	DR. JOHN C. MUTTER	SENIOR	Lamont-Doherty
2.	DR. JAMES A. AUSTIN, JR.	RESEARCH SCIENTIST	U. Texas at Austin
3.	MR. EMILIO VERA	GRADUATE STUDENT	Lamont-Doherty
4.	MR. JOHN HOPPER	"	"

Use Reverse If Additional Space Required.

WAS RESEARCH CONDUCTED IN FOREIGN WATERS? Yes. COUNTRY: Argentina / Chile

PRIMARY PROJECTS (those which govern the principal operations, area and movements of the ship)

PROJECT TITLE AND PRINCIPAL INVESTIGATOR	SPONSORING ACTIVITY	GRANT OR CONTRACT NUMBER	PARTICIPATING PERSONNEL (AS CODED ABOVE)
DR. JOHN C. MUTTER DR. JAMES A. AUSTIN, JR. "MULTICHANNEL SEISMIC INVESTIGATION OF THE SOUTHERNMOST ANDES: DEEP STRUCTURE AND EVOLUTION OF A CORDILLERAN OROGEN" DISCIPLINE SUBMARINE GEOLOGY AND GEOPHYSICS	NSF-Division of Ocean Sciences		MUTTER AUSTIN DR. PAUL STOFFA — U. Texas at Austin DR. IAN DALZIEL — "

ANCILLARY PROJECTS (which are accomplished on a not-to-interfere basis and contribute to the overall effectiveness of the cruise)

PROJECT TITLE AND PRINCIPAL INVESTIGATOR	SPONSORING ACTIVITY	GRANT OR CONTRACT NUMBER	PARTICIPATING PERSONNEL (AS CODED ABOVE)
N/A			

2-0-0-2

SIGNATURE James A. Austin, Jr. DATE February 29 1988
CHIEF SCIENTIST

TOTAL SCIENTISTS 3 TOTAL TECHNICIANS 8
TOTAL GRAD STUDENTS 4 TOTAL STUDENTS/OBSERVERS 3

ATTACH PAGE SIZE CRUISE TRACK

COST ALLOCATION DATA

DAYS CHARGED	AGENCY OR ACTIVITY CHARGED	GRANT OR CONTRACT NO
20	National Science Foundation	OCE-86-16405

SIGNATURE [signature] DATE 12 April 88
Institution Official

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D. Hayes
Ocean.

June 8, 1988

TO:

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RESEARCH CRUISE REPORT

R/V ROBERT D. CONRAD 29-02

Attached is a copy of a cruise report for the above CONRAD cruise.

Ann Burns
Ann Burns
Marine Office

Enc.

CRUISE REPORT RC-2902

MULTICHANNEL SEISMIC STUDY OF THE DEEP STRUCTURE OF A CORDILLERAN OROGEN: THE SOUTHERNMOST ANDES

February, 1988

Co-Chief Scientists: John C.Mutter

James A. Austin

1. CRUISE OBJECTIVES

Although geologists have studied the structure of mountain belts in detail for over a century, knowledge of their deep structure is sparse, and our understanding of the processes by which these fundamental structures of the earth's crust originated is still in its infancy. One important reason for this is the tremendous logistic difficulty of obtaining geophysical data in rugged, (often tropical) mountainous terrains. Continuous seismic reflection profiling, which would provide direct images of the deep structure is particularly difficult to acquire in these areas. Nevertheless, the importance of obtaining an understanding of the deep structure of mountain belts has long been recognized, and debate on the nature of their substructure is at least as old as that which resulted for Airy (1855) and Pratt's (1855) contrasting interpretations of their isostatic compensation.

Attempts to determine the deep structure of the North American Cordillera are currently underway, notably the COCORP project that employs the "vibroseis" technique to obtain deep continuous seismic reflection profile (Phinney and Odom, 1983). The results from this project, especially those from the Southern Appalachians (Cook et al., 1979, 1980a & b) have had a profound effect on geologic thinking concerning orogenic belts. The data have confirmed Hatcher's (1978) proposal that the entire northwest half of the Southern Appalachians orogen, including the Blue Ridge and inner piedmont are allochthonous, having been thrust from the southeast on a flat-lying decollement occurring at a depth of 6 to 12 km.

Apart from the fundamental geologic insights that the COCORP project has revealed, it has also shown that it is possible to routinely image the deep structure of the continental crust, throughout its entire depth, in a variety of tectonic settings, and often record essentially continuous reflection events from the Moho (Phinney and Odom, 1983). Despite the impressive gains, however, progress has been quite slow. Multichannel seismic reflection profiling on land, especially in mountainous areas, is slow and laborious. Only about 650 km of profiling was obtained by COCORP in the Southern Appalachians along nine profile lines, not all of which are connected. A highly attractive alternative to land seismic work in orogenic belts is to use marine multichannel profiling on the adjacent continental shelves, and rivers and other waterways which run through the mountains. Marine multichannel seismic data is both an order of magnitude less expensive and more rapid to acquire, and provides data which is commonly superior to land data since it lacks, among other difficulties, problems associated with transmitting energy through a surface weathered layered, and static time corrections resulting therefrom.

Smythe et al. (1982) and Brewer and Smythe (1984) have reported on such a traverse across the shelf north of the Scottish Highlands and the Outer Hebrides (the Moine and Outer Isles Seismic Traverse, MOIST) that has provided spectacular images of the deep continental crust. Using conventional, commercially available acquisition and processing techniques they imaged low-angle thrust faults that penetrated the entire crust to Moho, apparently displace Moho, and in the case of the Flannan Thrust, continued into the mantle. While the geologic implications of these observations are, like much of the COCORP data, still being debated, they provide a clear demonstration that conventional marine multichannel seismic techniques are capable of imaging the entire thickness of the continental crust in an ancient orogenic belt.

The deep structure of the South American Andes is almost completely unknown. What is known from surface geologic mapping suggests that the style of orogenesis is quite different from that in the North American cordillera. If a Wilson Cycle has been involved in the mountain building phase it was a highly attenuated one. Furthermore Dalziel (1985 and in press) has argued that influence of collision with "exotic" terranes in the mountain-building is minor, despite current opinion that suggests that collisional events are a necessary prerequisite to such orogeny. In fact, it is only in southernmost Andes that significant tectonic shortening and attendant crustal thickening has taken place. Just how this tectonic shortening is accommodated at depth is simply not known at present; and the extent and nature of deformation in the surface exposure is such that extrapolation to depth outcrop is all but impossible.

During RC-2902 we made three crossings of the Andean orogen by exploiting the fjords of Tierra del Fuego and by shooting a line along the continental shelf immediately south of the southern tip of South America (Figure 1). Data acquisition was terminated prior to the intended time due to the loss of DSS-240 hydrophone array (see below). The data obtained prior to the loss, while representing approximately 60% of the data we originally anticipated collecting, is distributed such that it represents three unique transects of the orogen, plus one crossing of the modern margin. If processing yields a suite of clear images of the deep structure of the mountains we have every likelihood of achieving the overall scientific objective.

2. PERSONNEL

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Tim Nolan (LDGO, Deck Technician)

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John DeBernado (LDGO, Airgun Technician)

Ropate Maiwiriwiri (LDGO, Deck Technician)

Patrick Roberge, Captain

3. EXPERIMENTAL TECHNIQUES AND EQUIPMENT

CONRAD was equipped for this experiment with a 3 km-long, 240-channel digital streamer and a 10-gun, 4891 cu.in. airgun source array. This was the third leg on which the Digicon DSS-240 digital streamer and seismic acquisition system were used. The equipment had been tested on a short shakedown cruise (RC-2809) and used during legs 2810 (Blake Spur F.Z.), and 2901 (Chile Margin). Two new Price 275 scfm compressors had also been installed on the ship as part of this system upgrade.

The airgun source array employed in this experiment has been described by Diebold (1987) and is shown in Figure 2. It consists of 10 guns which are deployed in two subarrays. Eight of the guns are towed from two 25 ft truss-style booms that are swung out by two, 4 in. rams. The remaining two guns (#5 and #6) are towed from trolleys extending aft of the main boom stanchions. The airguns are Bolt Associated 1500-C's and are nominally fired at 1800-2000 psi at a depth of about 30 ft. (10 m).

The DSS-240 hydrophone array used on RC-2902 comprises a 3 km-long digital streamer with 240-channels and 12.5 m group lengths. The array configuration is shown in Figure 3. It consists of a 100 m armored lead-in cable, two 100 m inactive sections, a 50 m stretch section and sixty 50 m active sections each consisting of four, 12.5 m groups. Electronically controllable birds and depth indicators were located on every fourth section and seven, 4 m compass sections were positioned along the array. Three Syntron balloon-activated streamer recovery units were initially available (one was lost during operations), and floats were available at all birds to compensate for their negative buoyancy. The streamer was typically towed at a depth of about 40 ft in the open ocean and about 20-30 ft in the fjords. The seismic data were recorded on high-density (6250 bpi) tape with a 4 ms sampling interval in SEG-Y format. A record length of 15 sec was used and the firing rate varied from 20 to 24 sec. depending on the available air supply and the vessel's over ground speed.

4. CRUISE NARRATIVE (Feb. 14-22)

The cruise began around 1100 on Feb. 14 from Punta Arenas. The vessel steamed north to deploy the towed equipment in a region of the Magellan Straits which is sufficiently broad that maneuvering for deployment was easily possible. The streamer was trimmed to give a towing depth of around 20 ft. rather than the typical depth of 40 ft. This was done as a safety measure to ensure that the streamer could clear even the shallowest regions of the fjords. Compared with its configuration when first deployed on RC-2809/10, the streamer carried three Syntron depth-activated retrievers on this leg which are designed to bring the streamer to the surface by the action of floats which are inflated by a CO_2 canister when the depth exceds 150 ft. Their purpose to float the streamer if it becomes detached from the vessel. In addition, each of the depth control birds had a float attached to counteract its negative buoyancy.

After the initial deployment the streamer did not tow particualrly well; the central portions were shallow, the tail deep and variable, head somewhat deep; basically acting as if the towing speed were less than the actual speed. Shot interval is 22 sec at 4.4 knots for 50 m shot spacing for 4891 cu.in. at about 1800 psi. Sonobuoys were deployed almost continuously along the first lines.

After completing Line 2 (Figure 4) on Feb. 15 we broke off operations to rebalast the streamer which had continued to prove difficult to trim along the first two lines. Bird #5 was tangled with seaweed such that it was not operating, accounting for some trouble with trimming the tail end. Weight was removed from the tail and every second bird float removed from the central region, after which the streamer towed well at 20 ft. The tail section continued to give some problems, showing variable depths and lack of control, appearing as if in a long period turbulent flow.

Lines 3, 4, 5 and 6 through Canals Magdalena and Cockburn were run with no difficulty, largely during darkness on the evening of the 15th and the morning of the 16th. The passage out of Canal Cockburn into the Pacific was made in declining conditions, and after crossing about half way across the continental shelf, we encountered heavy seas and were unable to keep the streamer in good towing trim. We therefore retrieved the towed equipment, beginning at around 2100 and had it on board at around midnight. The retrieval was made under quite difficult conditions with considerable strain on the inner wraps. Two leaks were caused by retrieval operations - one at a joint where the streamer jacket meets a digitizing canister's bulkhead. This resulted from unusual lateral stresses caused by retrieval under the heavy weather conditions. The inner wraps were laid very tightly as a consequence.

Given the relatively short time available for the total leg, we decided not to wait on the weather at this location, but transited out to the start of Line 9, reasoning that one transect of the modern margin was probably suifficient for a comparative study. The weather moderated during the transit, and we began to redeploy the streamer around 1500, Feb. 17. The streamer towed badly again with most sections near the surface; only the tail at reasonable depths. The front sections were retrieved and 35 lbs of lead added to the outboard isolator. The streamer then towed reasonably well, although the head still appeared somewhat light. Line 9 was begun around 0010 on Feb. 18 and the entry into Bahia Cook made in the afternoon of that day.

During the 19th we traversed Bahia Cook and along the northern arm of the Beagle Channel to a location immediately west of Ushuaia (Figure 5). The passage was uneventful from an operational point of view. The only difficulty occurred when passing through the region where the two arms of the channel meet immediately at the western end of Isla Gordon. At this location a small island, Isla del Diablo, occurs at the end of the northern arm of the Beagle, making a narrow constriction with currents of 4 knots. The ships overground speed was as little as 1.0 knot in this area but the streamer towed through with no apparent problems.

The streamer was retrieved in the Beagle Channel near Ushuaia, beginning around 1500, heading west after making a turn to give maneuvering room. The Syntron retriever at section 12 was found to have blown and the balloon float missing. This may have occurred when the streamer passed through a pocket of glacial melt water earlier that day, although it did not sink to 150 ft. at any time.

The remainder of the Beagle Channel was transited without recording seimsic data between Feb. 19th, 2100 and 0700, Feb. 20th when the pilot disembarked near Isla Nueva. The streamer was redeployed southwest of Isla Nueva and 24 lbs. more lead added to the outboard isolator to keep the head down in the anticipated heavy conditions.

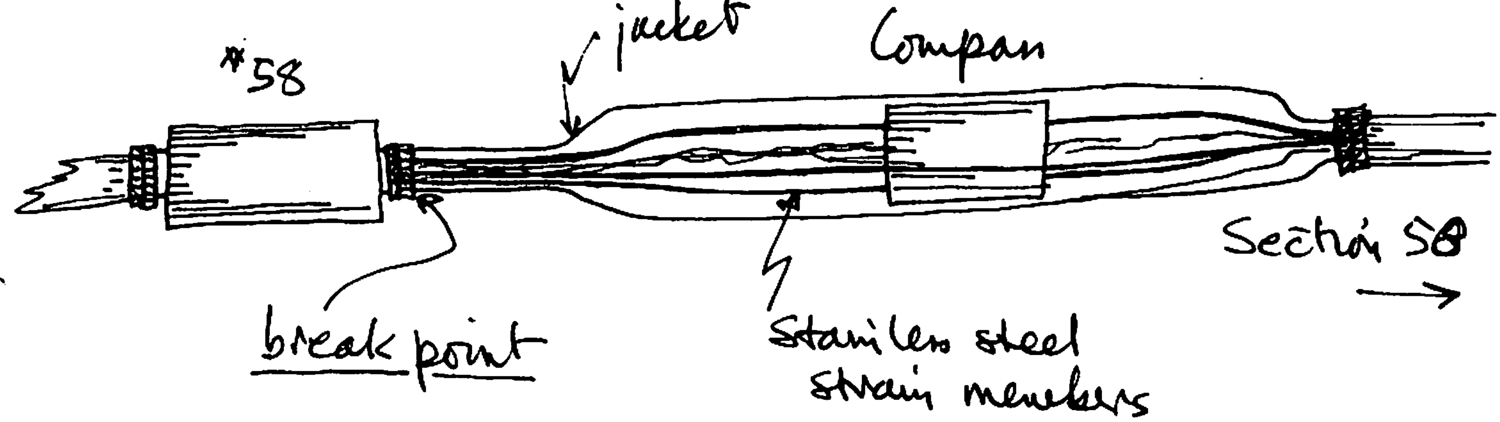
During the 20th we shot Line 21 to the S.S.E. of Isla Nueva and turned to the southwest to shoot Line 22 across the shelf, past Cape Horn, and to Diego Ramerez (Figure 6). The latter was obtained in declining sea conditions and strong winds (gusting to 50 knots near Diego Ramerez). Sea conditions continued to be heavy and increased further as we passed into open water west of Cape Horn on Feb. 21st. Because of the strong seas, winds and current, ship's speed was typically around 3 knots. The streamer towed extremely well, despite the heavy weather, remaining at a fairly constant 40 ft. without showing major excursions. This suggested to us that we had ballasted the streamer well for the conditions and that the reduced ship's speed also helped the streamer to stay deep, despite 4-6 m seas and near gail winds, averaging around 40 knots.

On 22nd we made the turn south onto Line 23 in heavy weather. This line was begun with a strong beam sea. The streamer continued to behave well and the weather conditions somewhat moderated.

5. LOSS OF THE HYDROPHONE ARRAY AND SEARCH (FEB. 22-28)

The hydrophone array parted from the vessel at around 0845 on Feb. 22 while steaming south in heavy weather on Line 23 (Figure 6 gives the location). The immediate indication in the main lab comprised a message on the MASSCOMP screen giving a "reset streamer" warning. When this was attempted the message returned indicating that there was no telemetering past canister 57, showing a "bad can" at location 57. Two interpretations of this message are possible. One is that there has been a physical break in the streamer at or around the "can" indicated. The second is that there has been an electrical failure of some sort at that location. From within the lab it is not possible to determine which is the appropriate interpretation. Exactly the same indications occurred during RC-2810 and led to the discovery of two broken strain members in section 56, which had led to the parting of electrical connections.

Given the above indications, we turned the vessel into the sea and wind (west) and commenced retrieving the array. With the armored leader on board it was immediately apparent from the lack of tension on the array that a major portion of the steamer must have been missing. The remaining sections were brought in rapidly and the break found immediately after "can" 58; at the head of the first compass section.



We then retrieved the gun array as rapidly as the heavy weather conditions would allow, and commenced searching for the array by returning to the position of the tailbuoy. At the time of the loss, and for the next several hours, GPS navigation was available so that there was little uncertainty in either ship's position or that of the array.

Upon returning to the previous location of the tailbuoy we were unable to locate any sign of the array, and therefore began a search pattern, commencing around 1100 (local). All personnel were brought to the bridge wings and flying bridge to assist; both seamen and science party. The search pattern begun at that time comprised N-S lines to the immediate east of the arrays last known location. Current, wind and sea direction were all from the west, so that the most likely direction of drift was to the east of the position at which it was lost. Two N-S lines were run within 2 miles of the streamer's last position, approximately along its length.

Having failed to locate the array by this procedure, and as the daylight was declining, we reset the search pattern further east. A sonobuoy had been launched about 2 hours prior to the loss of the array. Because the inflation device on the sonobuoy antenna provides a measure of windage, its drift represented the maximum likely drift that the array could have achieved. We therefore moved east to a location at the same longitude as the sonobuoy, and ran a pattern of N-S lines from east to west, spaced about 1 mile, across the drift path that the streamer would take. Our best indications were that the current ran at about 1.0 knot at around 93°. We searched in this way through the night of Feb. 22/23, the search aimed at locating the strobe light attached to a mast on the tailbuoy. The strobe light was normally visible more easily than was the tailbuoy mast during daylight hours. This search was also not successful. Prior to the evening search I contacted Lamont and advised Michael

Rawson via MARASAT of the situation.

The basic search procedure described above was continued until the evening of the 27th with no success. The search during the second night (23rd/24th) was conducted in very heavy seas, strong winds and frequently in intense rain squalls. The likelihood of locating the array in those conditions was trivially small as the visibility was only a few hundred meters. Although two Syntron retrievers had been attached on the streamer, and may have successfully brought it to the surface, it is most likely that the strong winds tore the floats from their mountings very quickly. It seems unlikely that the floats lasted more than a few hours. Our search concentrated on locating the tailbuoy. Given that it was also very likely that the tailbuoy overturned, causing the strobe light to be submerged, we determined that night time search patterns were not very valuable. The pattern was modified after the evening of the second day such that the daylight hours were spent conducting a grid of N-S lines, and the evening hours were spent steaming east, then holding station on the most likely drift path so that by first light the grid could be recommenced around the optimum projected drift position of the array. This was done to ensure that we conducted daylight searches in closest proximity to our best estimate of the array's position, and night hours used to relocate.

On the 25th-27th the search was aided by air support organized by Michael Rawson at Lamont and John LaBrecque in Punta Arenas. John LaBrecque has provided a separate report (Appendix I) describing their search procedure. The air search was not successful either but, in being able to cover a much greater area than CONRAD, gave us confidence that we had adequately covered the entire region of likely occurrence of the streamer. We determined the search area in the following way: it's north and south borders were defined by lines projected from the last tailbuoy position along azimuths of 90° and 110°, being the range of possible current/wind/sea drift direction; the east and west boundaries were obtained by assuming maximum drift rate of 1.5 knots, which assumed some component of wind drift, and 0.5 knots, which assumed some portion of the streamer had submerged and was acted upon by slower currents, or created a partial sea anchor. By the third day of the search this defined an area much larger than that which could be covered adequately by a surface vessel, and thus the air search was crucial to ensuring that the entire region was covered. To cover the unlikely possibility that the streamer had moved even slower than 0.5 knots, on the 27th the flight pattern began at the last position of the tailbuoy and flew east along 92° until reaching CONRAD's position thereby flying over the entire length of the streamers most likely drift path. This was done in fair weather and good visibility. Combined with the searches on the previous days, which had been conducted in generally much poorer conditions, we believed that the great majority of the region of likely occurrence of the array had been searched. The search was terminated at 1800 local time on 27th and the vessel steamed for Punta Arenas, entering from the Atlantic.

Cause of the Streamer Loss:

No extraordinary event occurred at the time of the loss that could adequately explain the mishap. We do not believe that the streamer was struck, and ship motion was not particularly severe at the time. The vessel was heading south in a beam sea, rolling heavily, but evenly. We therefore need to consider the entire history of use of the streamer to determine a cause.

1) The streamer parted at the head of the first compass section, located at the head of streamer section 58. As part of the rebuilding of the streamer to ready it for Lamont use, Digicon had been asked to reterminate the compass section's strain members because they had advised us that they have had a

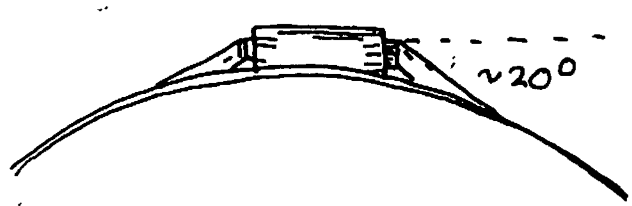
history of failure at these locations. Compass sections have stainless steel, rather than high tensile steel strain members in order to avoid magnetic interference. Stainless is inherently weaker. The streamer therefore parted at a known weak point. We have subsequently learned that the retermination job was, in fact, not done. Thus the compass sections represented unusually weak points.

The history of the particular compass section that failed is that on the Bermuda-Miami leg (RC-2810), we originally had a compass at can #61 which did not function. It was replaced and still did not function. It was later recognized that it was not correctly positioned, since it was adjacent to an isolator (inactive) section. It was then relocated to its final position, which is where it detached. That the strain member retermination was not done for this compass section, led to an unusually weak point near the head of the streamer where considerable strain is concentrated, and provides a plausible explanation for the location, and probable cause, of the breakage.

2) It is also likely that the streamer may have been overstressed at one of several earlier times, or that a cumulative prior history of use led to - or assisted - the final failure. These are:

a) heavy weather on Line 22 passing south and west of Cape Horn on 21st.

b) steamer retrieval under heavy weather conditions upon entering the Pacific, after exiting Cockburn Canal, Feb. 17. The streamer was brought in under difficult conditions as the sea state picked up very quickly after leaving the protection of the fjords. This caused considerable lateral and tensile strains to be placed on the streamer at the region where the bulkhead and strain member occurs at the base of the "can" on the inner wraps, such as at can #58. This lateral stressing may cause a weakening of the connection



into the bulkhead and/or crimp the strain members, eventually causing a failure.

c) as for (b) but at times when ship's speed had to be increased to avoid streamer sinking beneath the depth of activation of the retrievers. This may not be as important as situation (b) since we normally brought the head in at relatively low speed, then were required to increase the speed later on as the tail end dropped.

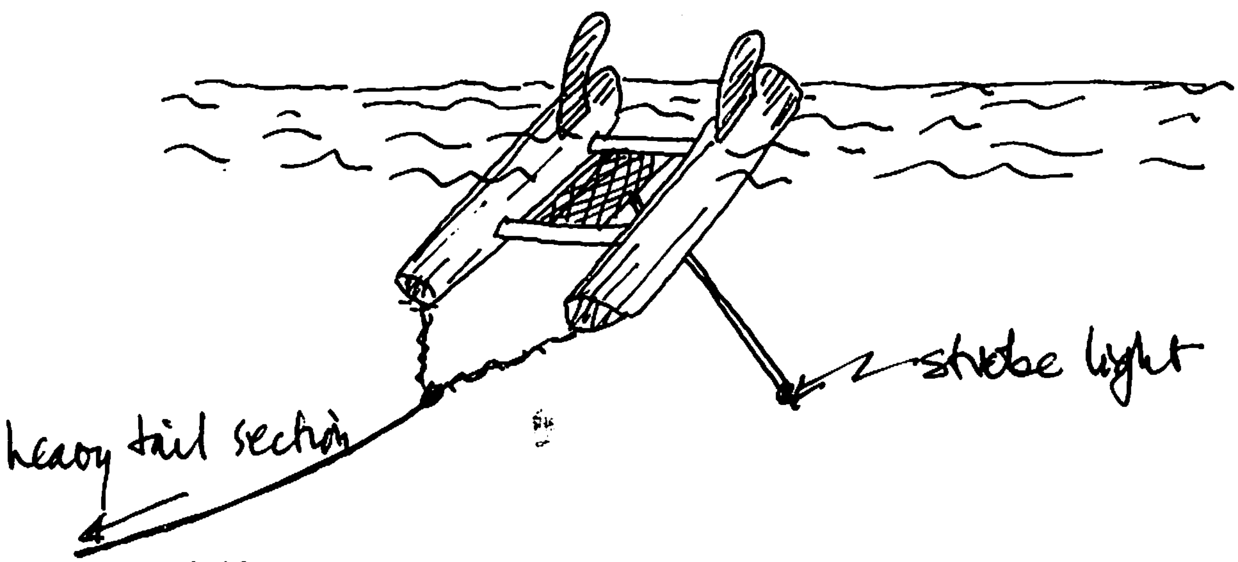
d) during the Blake Spur F.Z. cruise (RC-2810) an incident occurred which caused damage to several "cans" near the end of the streamer, imploded one "can", caused the tailbuoy to overturn and broke off one tailbuoy fin. The actual cause of the accident was never determined, but it certainly represented an extraordinary event. Soon after this, two strain members were found broken in section 56, rear-end (near can #55) giving further indication of unusual stress. Apparently one strain member was found broken in a section during 2901 under quite moderate sea conditions, and it seems likely that this could have been a problem inherited from the earlier incident. Clearly, sections such as #58 might also have been stressed by this event on RC-2810, and the continued use, particularly in heavy weather, eventually weakened it to the point of failure.

Failure to Retrieve the Streamer

Because the DSS-240 system provides no clear indication of a physical break in the streamer we adopted a retrieval procedure that assumed the streamer was still attached to the vessel. This is the correct action since a severe turn would have endangered the streamer had it still been attached. Given the available indications we were obliged to proceed as if the streamer were still attached. Had we a better indication of a break we could have altered course quickly and returned to the site of detachment, saving perhaps an hour. It is impossible to judge whether this would actually have made any difference.

The retriever floats are not designed to sustain heavy weather and although they probably brought the streamer to the surface, the balloons probably tore off in a few hours, or were attacked by albatross that could be seen pecking vigorously at garbage bags.

The tailbuoy design is poor in that it almost certainly inverted, probably floated front down and low in the water, making it extremely difficult to observe in the poor weather conditions.



Probably only the tops of the pontoons were out of the water. Thus the strobe light was of no use. There is no RDF, Pinger, etc.

Poor tailbuoy design is certainly the principal reason why the streamer was not sighted quickly and an early retrieval effected.

6. FUTURE CONSIDERATIONS

Given that we may always expect, or at least can anticipate, an accident that causes the loss of the streamer, we need to adopt practices that minimize the likelihood of a loss and maximize the likelihood of recovery. These should include:

a) Clearer indication of physical breakage such as a continuously reading tensiometer with chart recorder to monitor the history of stressing, and an associated alarm system. This would allow us to recognize a slack streamer, indicating breakage, and then effect a rapid return to the point of detachment. Similarly, it would give an indication of the stress level on the streamer so that the vessel could be turned down-sea to relax the stress in difficult conditions.

b) A larger number of more robust retrievers could be installed.

c) Routine maintenance should include systematic compass strain member retermination and the removal of compasses near the streamer's head when the array is deployed in areas where poor weather is anticipated.

d) The most effective means of improving likelihood of recovery is to replace the tailbuoy with a completely redesigned version that is self-righting and includes some active transmission device to assist in it's location. We believe that the search pattern was such that, if the streamer remained afloat, we must have come to within 0.3 miles of the tailbuoy; yet we were not able to see it, due to a combination of heavy weather and its low profile in the water.

e) If the heavy weather conditions experienced during the leg can be regarded as the most straightforward explanation for the equipment loss, then we must face the possibility that the Digicon hydrophone array may have a fairly small range of operating conditions. If this is the case, then it severely restricts the geographic range of our experiments, even in the summer months; high latitude investigations frequently involve work in high seas and strong winds. We cannot plan investigations in these areas assuming that we would work only when conditions are moderate, because moderate conditions occur less than 50% of the time. We must therefore either ruggedize the Digicon array, or provide a foul weather alternate system - perhaps a 96 trace analog streamer. In our three-leg history of operation of the array, two instances have occurred (RC-2810 and 2901) in which strain members in regular sections have been broken in moderate seas. This suggests a weather sensitivity that is considerably greater than the analog system, and must be of some concern for future operations.

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Punta Arenas, Chile
February 28,1988

HUNT FOR THE STREAMER

Feb 22,1988: Conrad array lost at 8:00 A.M. Local at 56° 57.3 S and 66° 4.4 W. Estimated current was 93-110° at .8 to 1.5 knots.

Feb 23,1988: I was contacted in Buenos Aires by telephone and Telemail. Arranged air tickets for Buenos Aires-Rio Grande and then remise to Punta Arenas through ITT/ DPP agent J.E.Turner. Later determined that it would be best to travel through Santiago in order to speak to Juan- Carlos Parra. Bought Pan Am ticket to Punta Arenas for Feb 24,1988 on my air travel card. Will refund Rio Grande ticket upon return to Buenos Aires. May be some service charges for J.E. Turner.

Feb 24,1988: Left Buenos Aires 12:30 noon, met Juan Carlos to check if first flight in search was successful. If array was found, I would abort trip. Report from Geodatos late afternoon was negative. Trip to Punta Arenas was continued. Arrived Punta Arenas evening 10:30 met by Mario Julio of Geodatos. Scheduled next flight following morning at 8:00 AM, contacted agent Peter Fussili, Conrad via Marisat and Rawson at home. Gave Juan Carlos Parra two bottles of Chivas Regal purchased in duty free shop as symbol of gratitude for arranging use of aircraft and logistics during critical first day.

Geodatos search info: Conrad requested search in 1 mile grid within (67° 20W, 67° 00W, 57° 10S, 57° 00S. Search flown at 500 feet. I was not aboard. Agent unable to obtain walkie talkie in marine band for ship to airplane communication in time for flight. Airplane under GPS navigation by Magnavox T-Set on loan from us to Sernageomin. Five personnel aboard aircraft, 4 from Geodatos, 1 pilot from German Antarctic group returning to Germany.

Feb 25,1988: Second day of search with negative results. Winds were 20-35 knots from west. Flew at 500 ft in east west lines at 1 mile line spacing. 5 personnel aboard aircraft. 2 pilots, 1 navigator, 2 observers. Off duty pilot also served as observer, navigator would watch sea about 50 % of the time. Estimate that we examined area at 120% coverage due to multiple observers and overlaping visual range at 1 mile spacing. Agent provided Walkie Talkie for ship to airplane communication for remainder of flights.

Search area defined in two grids:
57° 24S, 66° 28W, 57° 08S, 66° 28W, 57° 13S, 66° 00W, 57° 29S, 66° 00W
57° 08S, 66° 28W, 57° 29S, 66° 50W, 57° 24S, 66° 28W, 57° 24S, 66° 50W.
Both survey areas done at once in long E-W lines.

Upon return I was informed that ENAP was reluctant to continue its release of the aircraft because of its need to complete the aeromagnetic survey of Tierra del Fuego.

Intervention by Juan Carlos Parra in Santiago with Mladen Vrsalovic chief of Geophysics allowed us to continue flights for one more day and conditional 4th day if weather in Tierra del Fuego was unacceptable for flights. I wrote a letter to Vrsalovic to document release of the aircraft and to thank him for his help (included here).

Took Geodatos crew out to dinner to thank them for their efforts. Contacted Conrad, Rawson and agent to inform them of situation and to advise that search beyond 4th day was unlikely and probably futile because of the quick dispersion of the survey region due to the high current.

Feb 26,1988: Conrad telex to agent requested survey in grid (66° 40W, 65° 50W, 57° 11S, 56° 55S). Flew grid south to north at 1 mile spacing EW lines. Completed region up to 57° 02. Winds 265 at 27-32 knots. Clouds at 500 feet. Visibility good. Negative sightings.

Took Geodatos crew out to dinner as a second offering to the gods.

Feb 27,1988: Last day of search, I rode airplane to southern site of aeromagnetic survey in Cordillera Darwin in event that weather would be poor and that streamer search would be permitted. My offerings to the gods were successful and we traversed to Diego Ramirez at point of loss (56° 57.3S and 68° 4.4W and flew to requested search area along course of 93° in event that drift was slower than estimated. Observed swath about 5 miles wide. Seas were calm winds at 9 knots from west visibility was excellent. Searched region from 57° 25S to 57° 03S northward at 2 mile spacing between 65° 26W and 64° 58W . Flight time 6 hours 55 minutes. On the way to the survey we passed through terrific ice storm, thought I was dead as ice built up on the wings over the sea. Pilots looked worried. At that point the pilots told me that the wing deicers didn't work! I took this as an indication of how willing the Geodatos people were to help us and not as a attempt to get us all killed.

Search Info: All flights under GPS control. Average flight time was 6.75-7 hours. Search areas defined by morning telex from Conrad to the agent. 2.5 observers .5 navigators and 1 pilot on airplane. Track lines in region of the survey were about 350-400 miles or 3.5 hours.

Conclusion:

We did not find the array. I believe that the seismic array sank shortly after the cable break. We covered the region very well and the Conrads estimate of current speed and direction should have been very accurate. We also followed path of current flow from site of loss with no sightings of the array.

Geodatos pilots suggested that tail buoy should be equipped with aircraft LT transmitters which would allow us to locate bouy immediately both by satellite and by aircraft. These could be triggered by loss of power from ship. Also colors of both the Tail Buoy and the array itself should be choosen for maximum visibility. I suggest International Orange. Spare tail buoy on the Conrad did not have a distinctive color when viewed from the air at 500 feet. It appeared very similiar to the color of the ocean and was small. More flotation devices also appear to be necessary.

We were very fortunate to receive the kind of help which we got from Juan Carlos Parra, Geodatos and ENAP. It has resulted from our mutual efforts over the years such as the loan of equipment (e.g. Watts' land gravimeter, the USAC GPS, grad student education, joint programs etc.). Though we were not successful in locating the array I think that we were able to prove that it is not floating on the surface.

John LaBrecque

P.S. Thanks for sending last telex.

Dear John, Ian and Peter:

Enclosed is a brief report on my efforts. I very sorry that we were not successful. At times I wish that we had a devining rod in order to locate the beast. I really think that it sank because we really covered the region well unless the current flow was much less than .9 knots and in a direction north of east.

Anyway, if you can please be real nice to the people from Geodatos. They are:

Mario Julio (owner), Mauricio (chief Pilot), tel # 221942
Oswaldo (mechanic), Miguel (co-pilot)
Also in town and helpful were:
Gonzalo Yanez (hopefully future grad student at Lamont-works with Juan Carlos Parra and friend of Emilio Vera) tel # 224114
and
Rene Robertson from ENAP. tel # 226-898 x8579
or 221-910

If you travel through B.A. I have an apartment with a couch and an extra bed. I should be back in B.A. by Wednesday. I don't have a telephone so contact me at the Antarctic Institute tel # 44-1689 or 44-2039.

Please pass the report on to Mike Rawson and tell him that I also will send it via telemail.

Adios
John

Estimated expenses (will submit receipts in early April upon return):

Cab Buenos Aires to Ezeiza and Return:	$35
Call to Parra from B.A.	$10
Cab Santiago to Sernageomin and return	$25
2 bottles Chivas Regal	$45
Caps Punta Arenas	$25
Cabo de Hornos hotel	paid by agent
2 dinners for Geodatos personnel	$150
1 transformer (220-110V)	$30
cab to Santiago and return	$25
Hotel Santiago	$70
Communications (Marisat, New York)	paid by agent
Air ticket (on air travel card)	$638
J.E. Turner fees and telephone calls to Rio Grande	?

February 26,1988

Snr. Mladen Vrsalovic
Chief, Dept. of Geophysics
ENAP
Punta Arenas, Chile

Dear Snr. Vrsalovic:

I would like to express my thanks for allowing Lamont to hire the services of Geodatos in the search for our lost multichannel seismic streamer. The GPS capability and the range of the Geodatos airplane make it an ideal search craft in this effort. I understand that our use of the aircraft has delayed the completion of your aeromagnetic survey and you have been very kind in this regard. It is an example of the cooperative spirit which our two institutions have developed over the past years exemplified by the loan of equipment and personnel to help one another's programs. In this case the recovery of the multichannel seismic array is extremely important to Lamont. Because of its great cost, Lamont would have a very hard time to replace the array and several pending programs similiar to the experiments which were conducted on your margin will have to be put aside. It is for this reason that we are grateful for your cooperation and we hope that you will bear with us during the search which is expected to last from February 22 through and including February 27,1988.

Sincerely,

John L. LaBrecque
Senior Research Scientist
Lamont-Doherty Geological Observatory

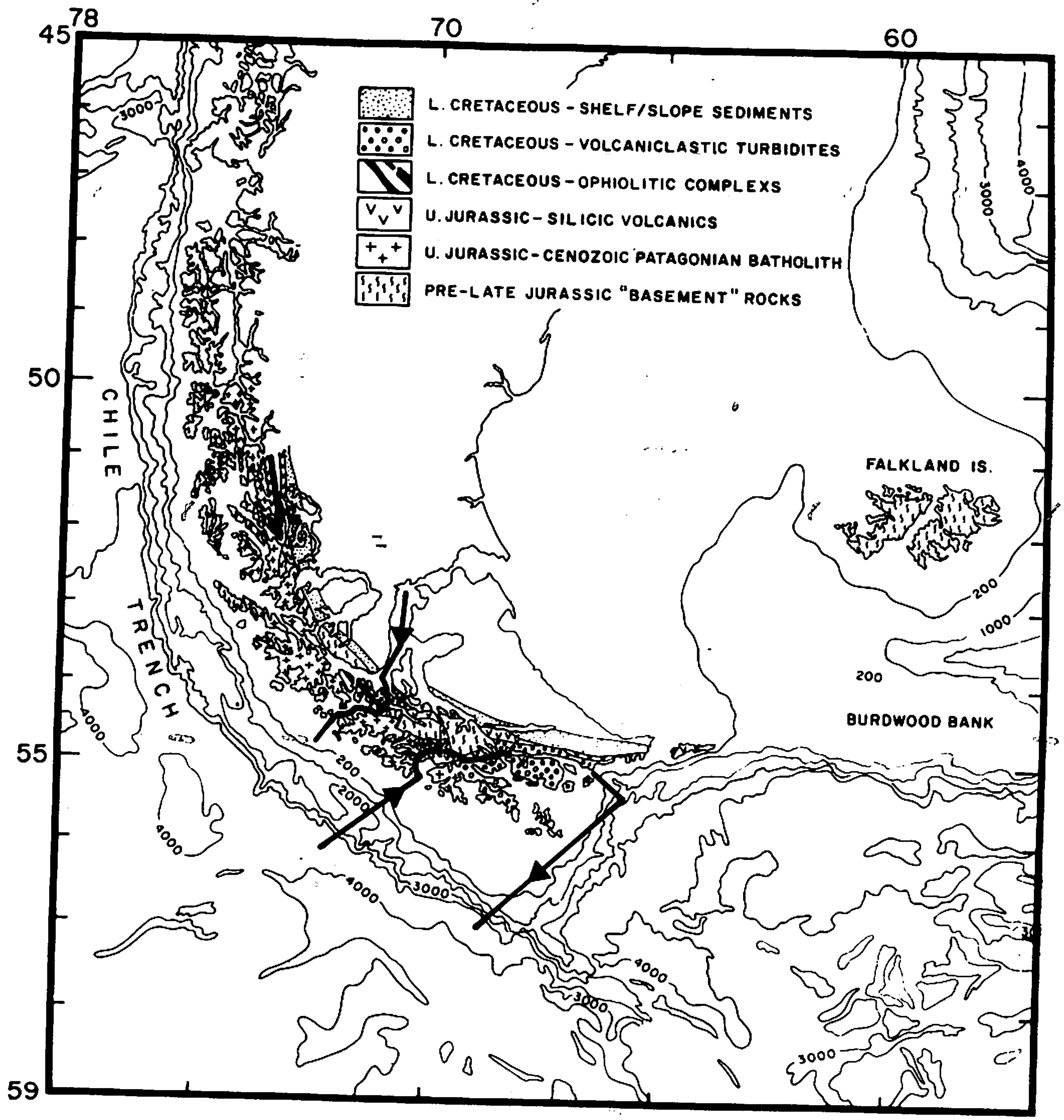

78
70
60
45
50
55
59
L. CRETACEOUS - SHELF/SLOPE SEDIMENTS
L. CRETACEOUS - VOLCANICLASTIC TURBIDITES
L. CRETACEOUS - OPHIOLITIC COMPLEXS
U. JURASSIC - SILICIC VOLCANICS
U. JURASSIC - CENOZOIC PATAGONIAN BATHOLITH
PRE-LATE JURASSIC "BASEMENT" ROCKS
CHILE
TRENCH
FALKLAND IS.
BURDWOOD BANK
3000
4000
2000
200
1000

Figure 1

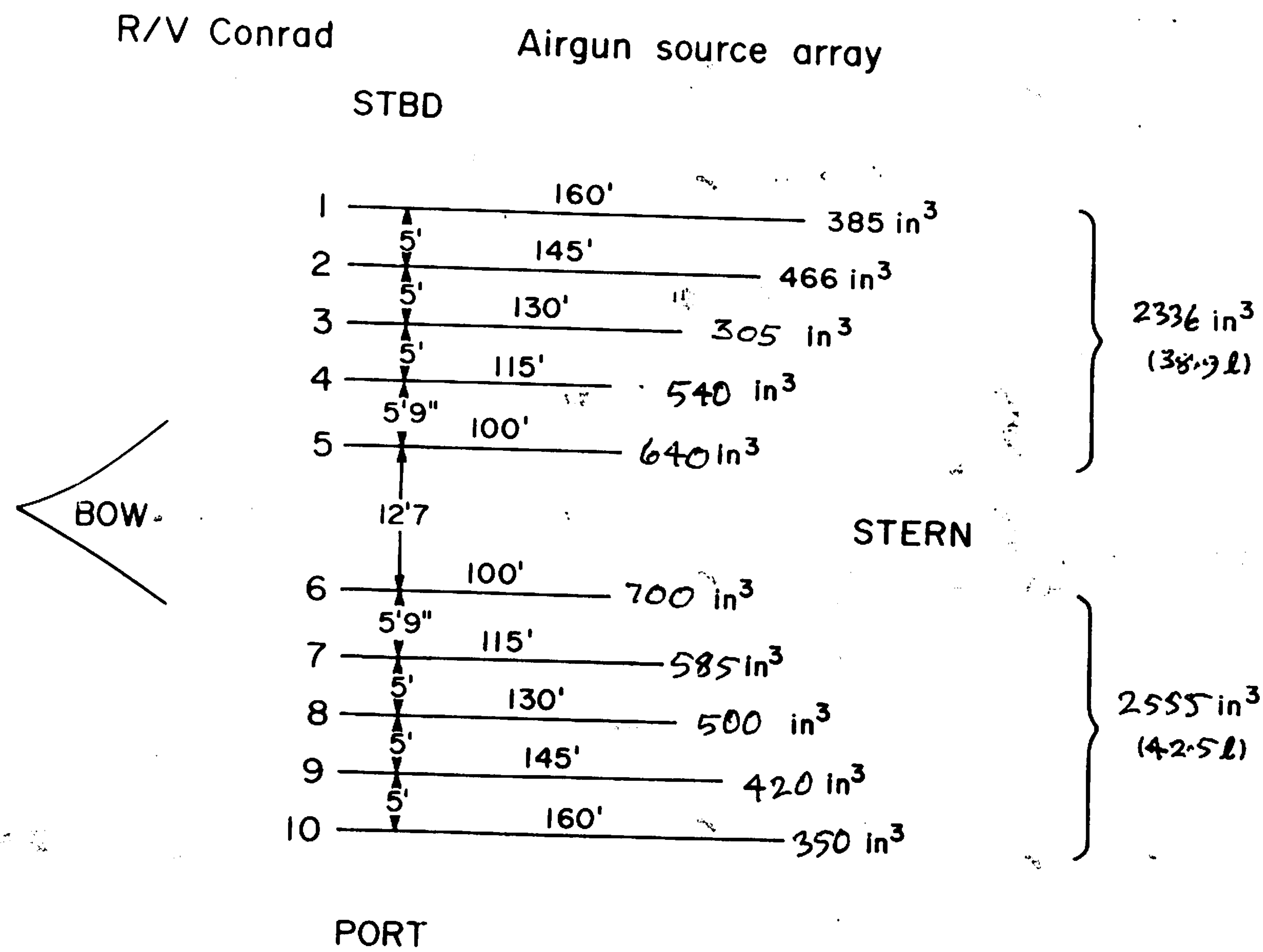

R/V Conrad
Airgun source array
STBD
1
2
3
4
5
6
7
8
9
10
160'
145'
130'
115'
100'
100'
115'
130'
145'
160'
5'
5'
5'
5'9"
12'7
5'9"
5'
5'
5'
385 in3
466 in3
305 in3
540 in3
640 in3
700 in3
585 in3
500 in3
420 in3
350 in3
2336 in3
(38.9 l)
2555 in3
(42.5 l)
BOW
STERN
PORT

Figure 2

R/V Conrad Streamer configuration and antenna geometry

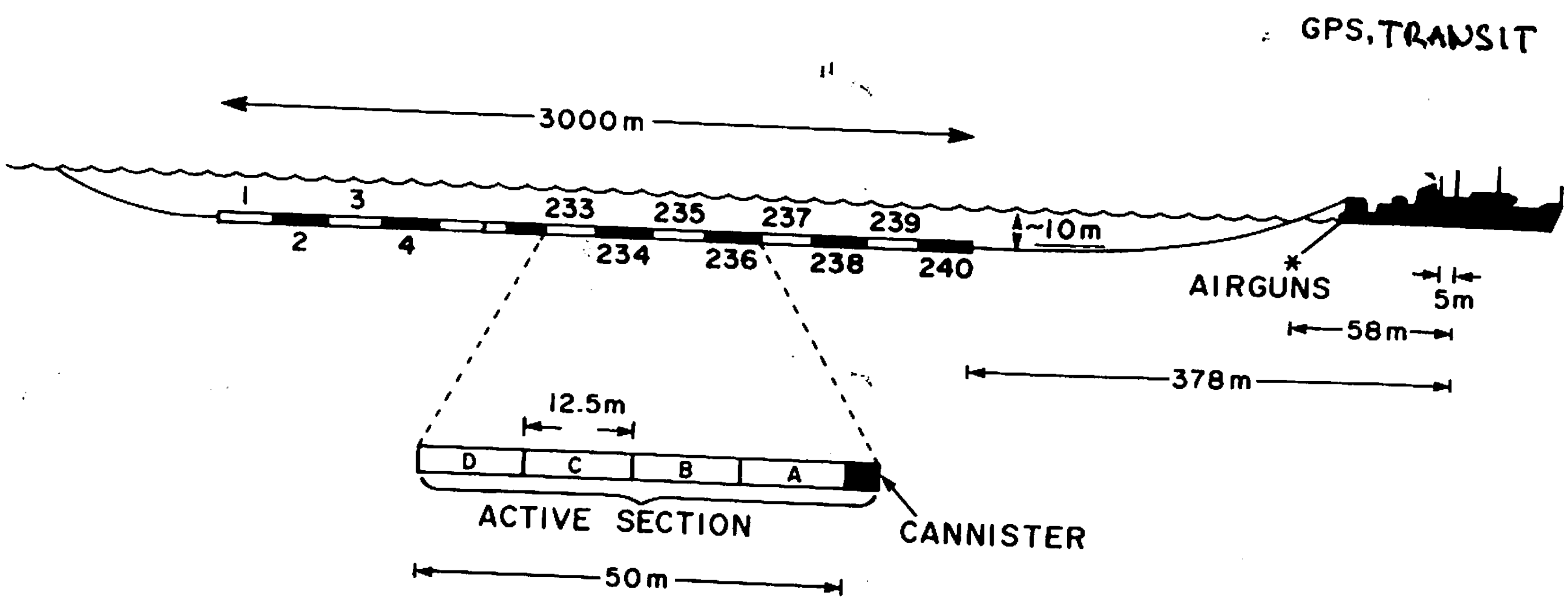
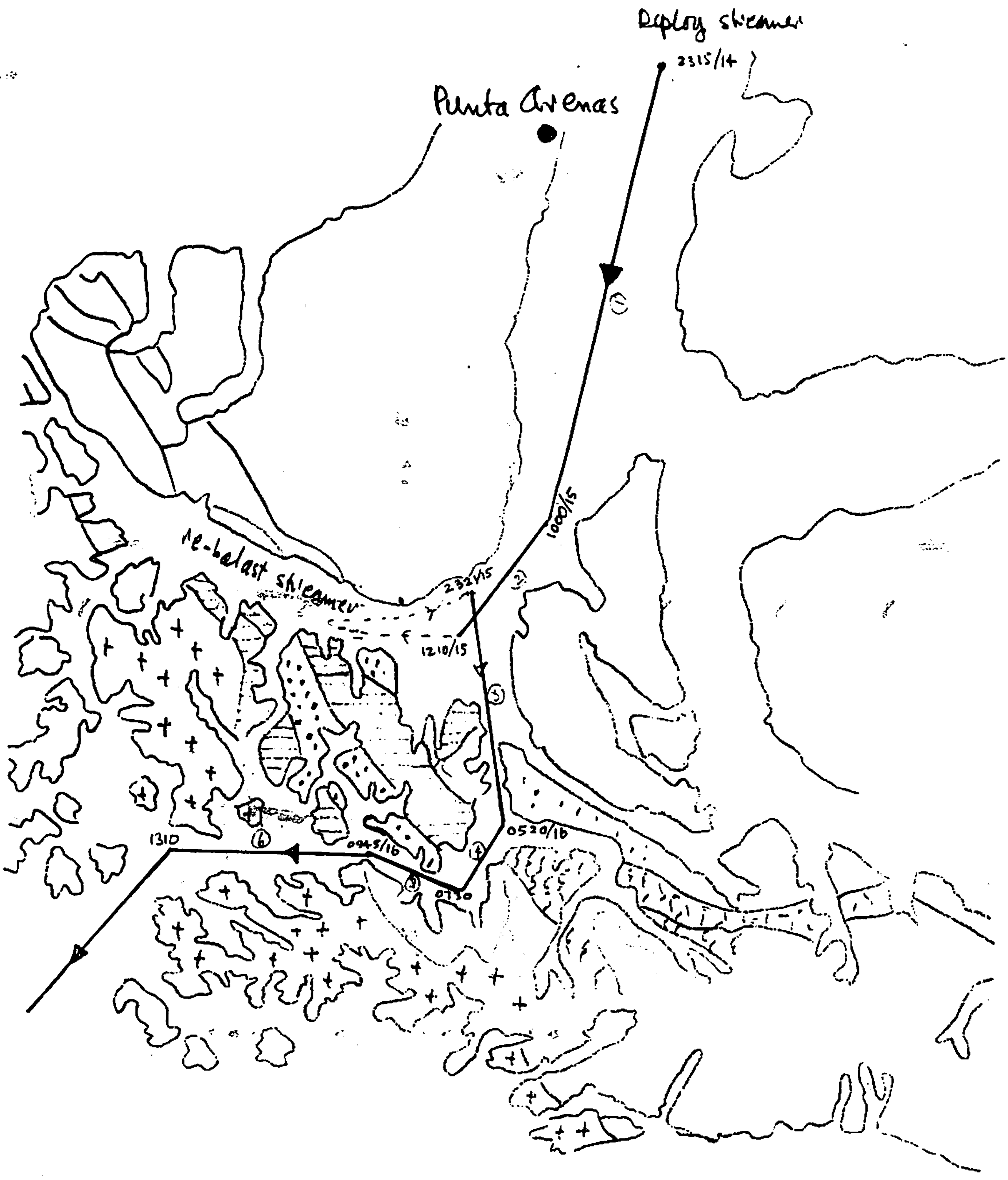


Figure 3



G.M.Time on map. = local + 3hrs.

Figure 4

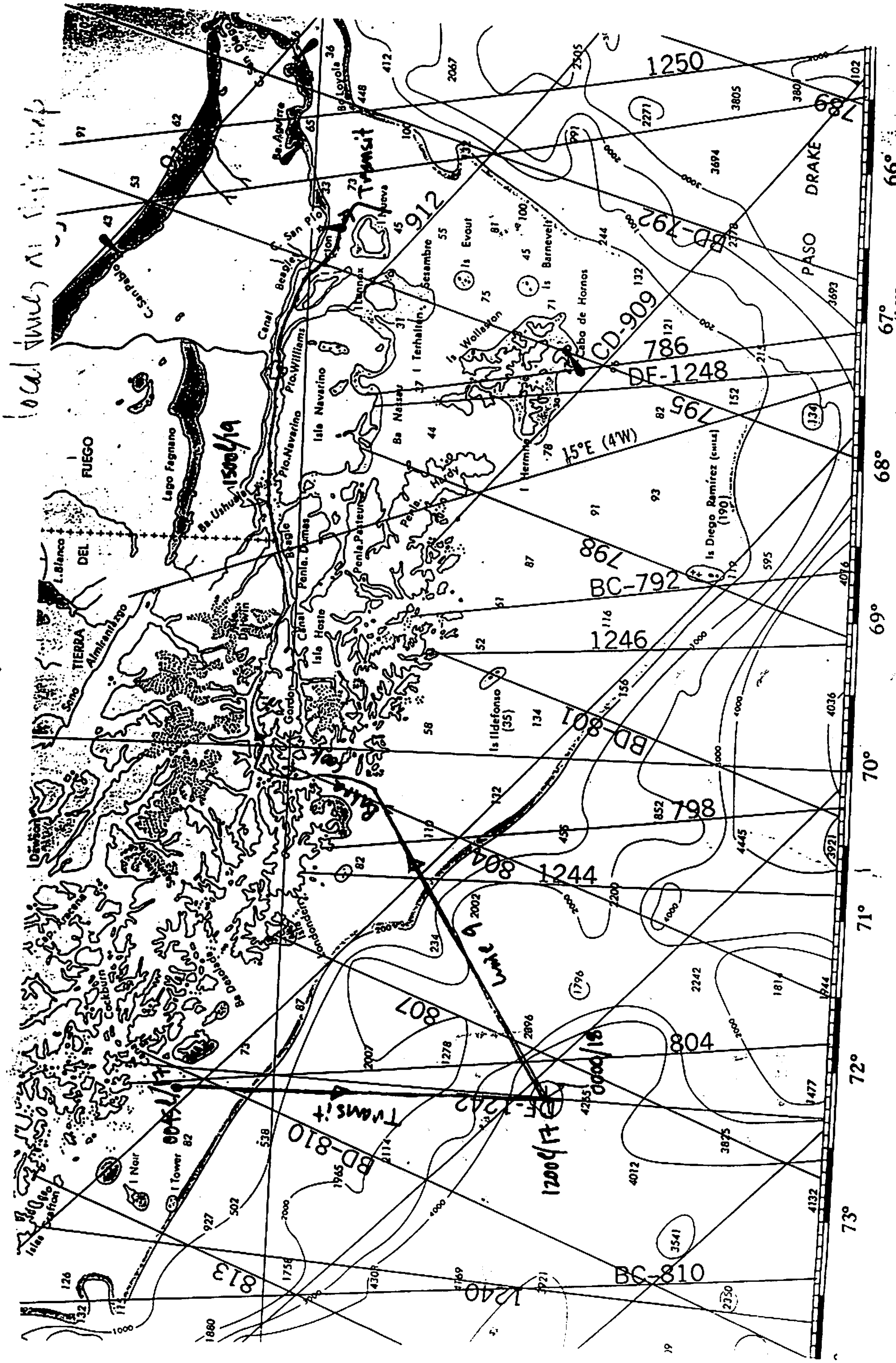
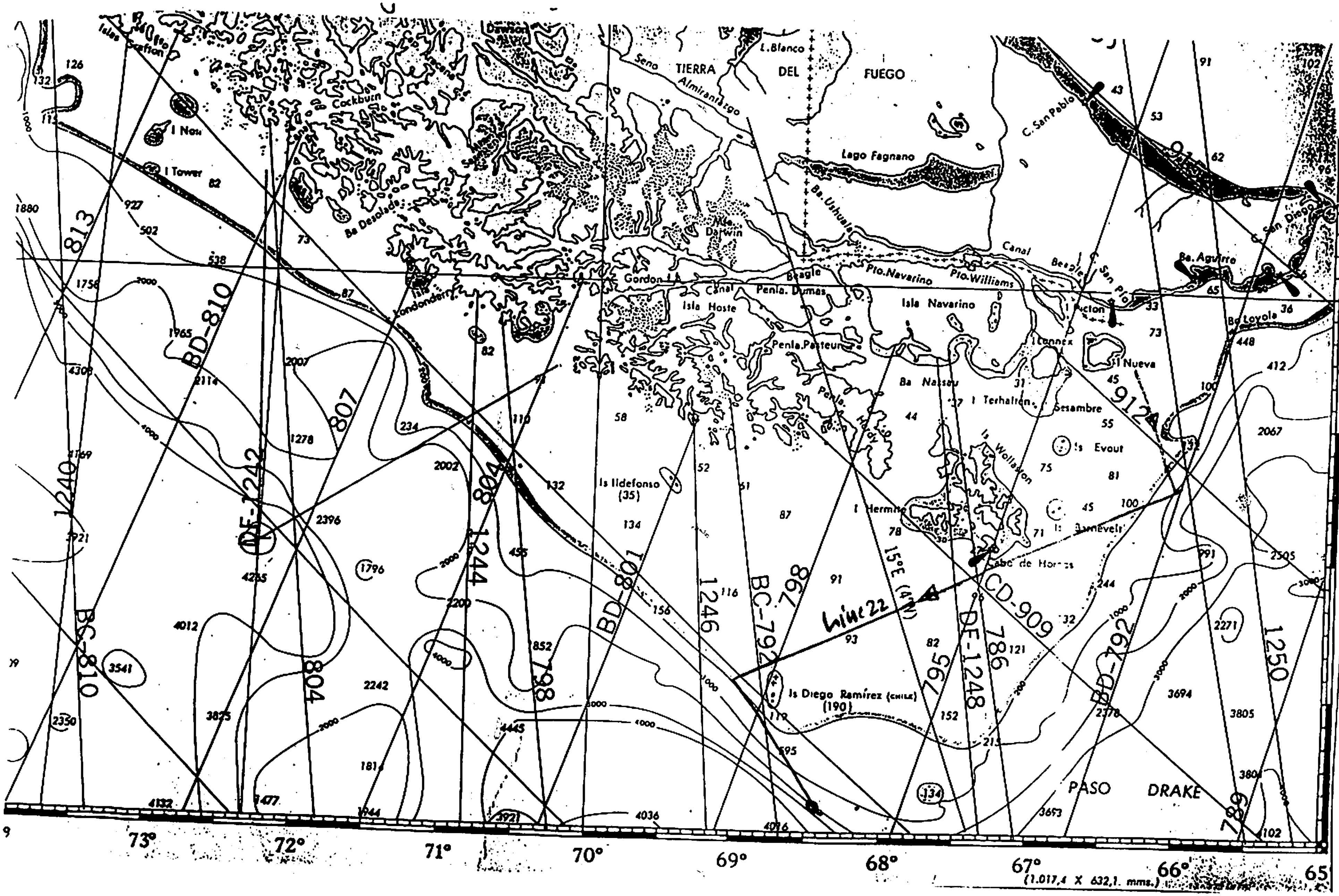

PASO
DRAKE
TIERRA
DEL
FUEGO
Lago Fagnano
Canal Beagle
Isla Navarino
Is Wollaston
Cabo de Hornos
Is Diego Ramírez
Is Ildefonso
1250
BD-792
912
CD-909
786
DF-1248
795
15°E (4'W)
798
BC-792
1246
BD-801
798
804
1244
807
804
BD-810
BC-810
813
1240
66°
67°
68°
69°
70°
71°
72°
73°
(1.017,4 X 632,1 mms.)
Transit
Line 9

Figure 5



TIERRA DEL FUEGO
Seno Almirantazgo
L. Blanco
Lago Fagnano
C. San Pablo
C. San Diego
Ba. Aguirre
Ba. Loyola
Canal Beagle
Pto. Navarino
Pto. Williams
San Pio
I. Picton
I. Lennox
I. Nueva
Isla Navarino
Isla Hoste
Penla. Dumas
Penla. Pasteur
Penla. Hardy
Ba. Nassau
I. Terhalten
I. Wollaston
Is Evout
I. Hermite
Is Barnevelt
Cabo de Hornos
Gordon
Ba. Ushuaia
Mte. Darwin
Ba Desolada
Cockburn
I. Londonderry
I. Noir
I. Tower
Islas Grafton
Dawson
Is Ildefonso
(35)
Is Diego Ramirez (CHILE)
(190)
PASO DRAKE
Line 22
15°E (4°W)
CD-909
DE-1248
BD-792
BC-792
BD-801
BD-810
BC-810
DE-1242
1250
1246
1244
1240
912
798
795
786
789
804
807
813
73°
72°
71°
70°
69°
68°
67°
66°
65
(1.017,4 X 632,1. mms.)

Figure 6