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UNIVERSITY of CAMBRIDGE

Department of Earth Sciences

Cruise Report

R. R. S. Charles Darwin 18/86

Geophysical investigations in the Gulf of Oman

R. S. White

CONTENTS

APPENDICES

1. INTRODUCTION

This cruise was intended to study the structure and sedimentology of the Makran accretionary prism in the Gulf of Oman, north west Indian Ocean. We planned a long land-sea wide angle seismic line using 15 digital seabed receivers and four land receivers, a grid of multichannel seismic reflection profiles and deep-tow seismic profiles, a number of piston cores, and underway magnetics, gravity and bathymetry mapping. None of this work except one multichannel seismic profile was possible on the Makran accretionary prism because diplomatic clearance was not received from the Pakistan authorities. This was despite long advance requests for clearance, first submitted via RVS and FCO ten months in advance of the cruise in January 1986, despite full notification of our precise firing schedule two months in advance in September 1986 to the various navies in the area (including Pakistani, Indian, UN, British), despite full support from the I.O.C. and the scientific agencies in Pakistan (National Institute of Oceanography in Karachi, M.I.O., and the Hydrocarbon Development Institute of Pakistan, H.D.I.P.), and despite having on board a Pakistani from N.I.O. involved in our work. The full circumstances of the diplomatic clearance saga are enumerated in section 7 in the Appendix.

Although we did not have clearance to work in Pakistani waters, the Oman authorities were extremely helpful and we were able to complete a full programme of excellent science in Oman waters instead. We completed 12 days of multichannel seismic profiling across the Murray Ridge, Owen Fracture Zone, Owen Basin and Oman continental margin, made three deep tow seismic profile deployments and shot a wide angle seismic line with 15 sea bed receivers across the continental margin of Oman just north of Masirah Island.

2. LAND WORK

The land party were to deploy four digital seismometers onshore Pakistan near Pasni so as to extend our offshore OBS profile. The seismometers were to be located using a satellite navigator with timing from an off-air signal. Security clearance for this was sought directly via the Hydrocarbon Development Institute of Pakistan (H.D.I.P.) by Dr. Jerry Leggett of Imperial College, London, for himself and two Cambridge people. Security clearance was received on 16th October 1986, some 3 weeks before we were due to leave to join the ship. A few days later, Dr. Leggett decided that he did not wish to go to Pakistan after all and he withdrew from the project. Dr. Simon Klemperer and Mr. Melvyn Mason from Cambridge took over organisation of the land seismometer work at short notice. It was clear that we were having problems with clearance for the offshore work before they few out to Karachi on 19th November, but the NERC urged them to go in order to assist the case for clearance. In the event, they spent nearly two weeks in Karachi, exerting a considerable amount of effort first to get the seismometer equipment cleared through customs, and later working on the N.I.O., the H.D.I.P., the Pakistan Navy headquarters in Karachi and the British Embassy, in an effort to obtain clearance for our work. When it became clear that it was too late to shoot the wide-angle seismic line, they packed up and returned home without ever getting into the field.

3. NARRATIVE

a) Preparation 9-14 November 1986

The Cambridge equipment was sent out in a jam-packed container in October, and was loaded on to the ship by the time we arrived. The Master complained that we had not used a soft-top container to facilitate unloading, but in view of all the electronics and computer equipment in the container, we think that this would be an unwise move in the future.

We were unable to board the ship on Monday, 10 November because it was moored offshore as a result of the visit to Muscat of the Britannia. This delayed our setting up and eventually resulted in being 12 hours late in sailing. On Tuesday and Wednesday, we were taken out by launch to the Charles Darwin and commenced setting up all our equipment on board. The Scientific Plot was used for most of the control and watch-standing, but the Deep Tow had to be driven from downstairs in the Main Lab., due partly to lack of space and partly to the removal of the remote control in the Plot for the winches. OBS electronics and computers were installed in the Controlled Temperature Lab., OBS and PUSS assembly in the Wet Lab., airguns in the starboard Main Lab. and general electronics repair and Deep Tow in the port Main Lab. The lab. spaces were all very full and it was fortunate that the good weather meant that most of the airgun maintenance and repair work could be done on deck.

The ship went alongside in Mina Qaboos on Thursday, 13 November and the airgun umbilicals were bound up on the quayside. Verbal permission for work in Pakistan waters was received on 14 November and we sailed at 1900 (local) on 14 November. Clocks were retarded to -5 hours to be on Pakistan local time. Watch-standing commenced in the evening.

b) Deep Tow and OBS, Dalrymple Trough, 15-19 November

Steamed direct to the Dalrymple Trough about 150 nm off Pakistan. On the evening of 15 November all power except emergency lighting was switched off to allow the main water cooling unit, which was becoming blocked by plankton, to be cleaned. Expected to take 24 hours, but was completed in about 12 hours, by $0500^{(-5)}$ 16 November. Seas fortunately flat calm, about Force 3, otherwise we would have had to return to port for this work. Unfortunately, a water cooling pipe to the air conditioning in the Plot burst when the power was switched back on. Since there was no-one on watch, the Plot was flooded in several inches of water, but no damage was done other than to a roll of charts which were soaked, and a dozen boxes of computer tapes which subsequently worked satisfactorily.

On 16-17 November we made a test deployment and airgun refraction line in the Dalrymple Trough using two new digital OBS, and recovered them by late afternoon. A single bar array of 2 x 700 cu. inch and 1 x 40 cu. inch airguns was deployed, but due to a severed air hose and sticking solenoid, only one 700 cu. inch gun worked, and this was towed very shallow because the buoy strop was rather short. The Refraction Technology airgun controller was set up in time for this deployment, and subsequently worked excellently and reliably.

We were about to start on a deep tow line at 2200(-5) on 17 November when we received a telex telling us to move out of Pakistani waters. So we moved southwestwards across the median line with Oman and deployed a buoyed airgun array (2 x 300 + 1 x 40) by 0100(-5) on 18 November.

The deeptow was deployed to 200 m depth but an intermittent fault on the conducting cable connector meant we had to pull it back in by 0400(-5)/18 November. Since the airguns were working well, we deployed the 30 m. surface hydrophone streamer and took a seismic profile across the Dalrymple Trough while the connectors were repaired. The streamer, however, was very noisy at anything above 2 knots.

Through 18 November we spent 12 hours trying to free the main block on the A-frame over which the conducting cable had to run. It was seized up at an angle which meant that the cable chafed on the cheeks, and was only jerked round more-or-less straight after considerable prodding with the HIAB cranes, pulling with blocks and tackle, and loading with more than 3 tonne of cable weight. There was no spare block on board, so if we had not fixed this, we could not have used the Deep Tow.

Deep Tow profile across the Dalrymple Trough was continued until 0600(-5)/19 November, when it was pulled in, being on board by 0900(-5)/19 November.

c) MCS Profiling 19 November-29 November, Owen Fracture Zone and Owen Basin

The mcs streamer was deployed in about 12 hours on 19 November, removing one bad section and adjusting the lead a little. Commenced profiling in the early hours of 20 November, staying near the median line because we were expecting Pakistani clearance imminently. Early part of profile was very noisy despite flat calm seas, because as we soon discovered, the E-M log was reading about 1/2 knot high so what we took to be a speed of 5 knots was actually 5.5-5.7 knots. When we slowed down, the array was much quieter. Firing on time at 20 sec. intervals, nominal 5 knot speed (nominal 50 m pop interval), 48 x 50 m groups in streamer, with streamer depth 30 ft. and airgun depth 9 m.

Throughout the early part of the mcs profiling we suffered many problems with airgun failure. These were occasionally due to the solenoids, but generally due to leakage of the high pressure air hose near the entry to the airgun. This was gradually cured as improvised hose clamps were machined and installed. But the airgun source varies between (and sometimes along) profiles.

From 20-25 November we continued profiling across the northern end of the Owen F.Z./Dalrymple Trough near the Pakistan/Oman median line. Seas almost flat calm, always less than Force 3, and mcs acquisition system working very reliably, apart from an average of one or two lost shots per tape (per 20 mins) due to parity errors. Another tape drive for the Sercel is essential. We found we could fly the streamer horizontally to within 1 foot, which is remarkably good, and better than ever before, using the 13 individually addressable depth levellers.

By 25 November, we had exhausted the region near the median line, so with diplomatic clearance looking increasingly unlikely, we moved southwards towards Masirah, continuing to profile across the Owen F.Z. on the way. We continued southwards, finishing with a long mcs line in across the Oman continental margin north of Masirah Island (line CAM 25) along the rapidly re-planned wide angle OBS line across the Oman margin. The weather had been almost flat calm throughout the 10 days of mcs profiling and the streamer had performed excellently. The mcs streamer and airguns were finally pulled in during the mid-afternoon on 29 November just off the Oman coast.

It had now become apparent that we could not shoot the OBS line across the Makran margin even if permission were received as there was insufficient time left so we transferred our profile to the Oman Masirah margin. It is unfortunate that we did not know earlier that clearance would not be received for the Makran line, because if we had so known, we would have done more mcs profiling in the vicinity of the Masirah line.

d) Deep Tow Profile across Owen F.Z. 30 November-1 December

Deep Tow and six airgun array were deployed on 30 November and two profiles made across the ?active trench of the Owen F.Z. Wind speed had increased to 20 knots during the night and we found it difficult to turn the ship on to a reciprocal course without tangling the gear. This was, in fact, done and two good profiles were recorded at about 1.5 knots, with 15 sec. firing interval. The Deep Tow profile had to be terminated in the early afternoon of 1 December in order to move back to the wide-angle line for OBS deployment.

e) Masirah wide-angle OBS Profile 1 December-6 December

Laid first OBS at $2200^{(-5)}$, 1 December, but then during a wire test of two gas pyro releases the hydrographic wire spooler would not scroll properly. It was not inboard until $0400^{(-5)}$/ 2 December, by which time we could only deploy one more OBS before moving on to the PUSS moored seismometers in shallow water.

PUSS laying commenced at $1000^{(-5)}$/2 December and all five were laid by $1600^{(-5)}$/2 December. Deployment over the stern was straightforward although a great deal of wire transferring off wooden storage reels onto the deck winch was necessary. The remaining four OBS were deployed from $1600^{(-5)}$ until midnight on 2 December. Then we hove-to until the morning since we could not risk the planned velocimeter dip in case the CTD wire again failed to spool properly. The explosive for the day's use was shifted commencing at $0530^{(-5)}$/3 December, into the ready-use locker and the empty container on deck.

The first half of the geophex line was fired from $0750^{(-5)}$/ 3 December, finishing soon after mid-day (schedule is in appendix). From 1900-$2359^{(-5)}$/3 December a single 700 cu. inch airgun was fired into conditional save windows on the OBS for high-resolution studies.

The remainder of the geophex was shifted on to deck starting at $0530^{(-5)}$/4 December, and fired during $0750^{(-5)}$/4 December to $1300^{(-5)}$/4 December with one shot every 5 mins. The first OBS (OBS 14) was recovered easily from the northwestern end of the line, but the next OBS, located at $0030^{(-5)}$/5 December, would not

release until we changed to the second (newer) onboard release command unit. Through daylight hours the five PUSS were successfully recovered over the stern on 5 December in flat-calm weather. By 2130(-5)/5 December, all but one OBS (OBS 9), were recovered. OBS 9 had apparently triggered the gas retractors, but was stuck on the bottom in over 2000 m of water. It was sitting on a 1:8 slope and it was suspected that it was snagged on one of the geophone wires. During 6 December, led by Tim Owen and Penny Barton, a detailed survey was made of OBS 9 with the aid of GPS navigation and the pinger on the OBS. A loop of mooring wire was then laid around the OBS and gradually pulled tight. The OBS left the bottom apparently as soon as the bottom wire nudged it. The OBS was recovered and on board by 1800(-5)/ 6 December.

f) Deep Tow Profile 7 December-8 December

A deep-tow profile was run for 24 hours in a region near the northern end of the Owen Basin where strike-slip faulting had been observed on an earlier mcs profile. This profile was quite noisy, and the deep-tow instrument and airgun array was recovered after breakfast on 8 December.

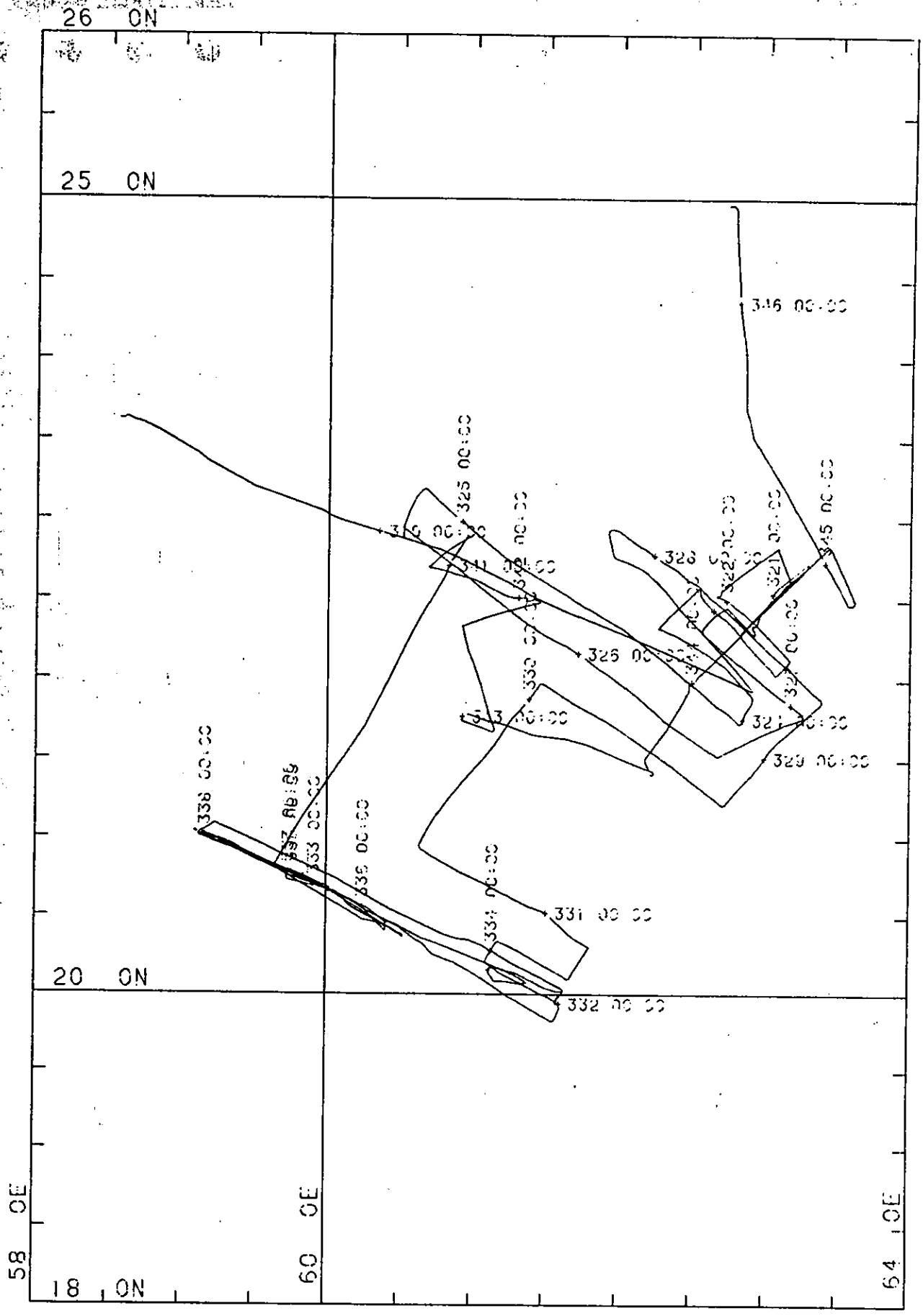
g) MCS Profiling 8 December-12 December

Started deploying mcs streamer at 1200(-5)/8 December, but were unable to deploy it steaming towards the Oman margin as planned because the sea had risen to about Force 5. MCS deployment took 12 hours from 1200(-5)-midnight/8 December. Some minor leading changes were made and damaged section 6 replaced. Unfortunately, it took 5 hours to trace and clear a dirty connector. Airguns were deployed in the early hours of 9 December, and mcs commenced. We had permission to enter Pakistani waters from 1200(-5)/10 December, so we adjusted our tracks to cross the median line at midday to maximise our time in Pakistani waters. The start of the monsoon was giving permanent Force 5 seas now, and was not to abate for the remainder of the cruise. During 11 December we commenced the long northward run across the Murray Ridge and Makran margin on to the ODP site. Mid-way to the Makran a shark attacked sections 8 and 9 of the streamer. We maintained the streamer for a while by switching out noisy 25 m groups, but eventually seawater reached the connector and we lost the signal from the rear two-thirds of the array.

During a 3-hour session from 1800(-5)-2100(-5)/11 December the array was pulled in and the two damaged sections were removed. There were no spares, so the streamer was reduced to 44 channels. The starboard airgun array was also repaired, and the profile recommenced at 2100(-5)/11 December. As we crossed the Makran margin the weather got worse, until by 0700(-5)/12 December it was gusting 30 knots, near gale. During the profile the 466, 300 and 160 guns progressively failed, the support buoy was lost from the starboard airgun array and the port support buoy was flooded. All the gear was pulled in commencing at midday, 12 December when we had reached the shallow-water shelf on the Makran. Watchstanding ceased at 1200(-5)/12 December and we steamed direct for Muscat, mooring by midday on 13 December.

ACKNOWLEDGEMENTS

We are extremely grateful for the superb support from the RVS technicians, who worked long hours and kept the equipment operational despite being short-handed by one person. The officers and crew cheerfully assisted throughout the cruise. Despite the difficulties with diplomatic clearance, the dedication and hard work of all aboard the ship contributed to the success of the scientific work.



MERCATOR PROJECTION

SCALE 1 TO 3500000 (NATURAL SCALE AT LAT. 35)

INTERNATIONAL SPHEROID PROJECTED AT LATITUDE 0

GRID NO 1

TRACK NO. 1

Ship....RRS CHARLES DARWIN..... Cruise No .P11/18/86.....

Cruise Dates (Inclusive, port to port) ...14 November - 13December 1986.....

It is requested that the following aspects of the cruise may be covered in this report of proceedings for dispatch or delivery to the Director, Research Vessel Base, immediately on return to port.

a) Main objectives of the cruise.
b) Geographical area. Reference stations or points in latitude and longitude.
c) Sea and weather conditions encountered.
d) Conduct of cruise, main problems encountered and success or otherwise of the program
e) Equipment performance.
f) Ship performance.
g) Any recommendations.
h) Signature and date.

Brief comments are preferred but if necessary please continue on another sheet.

a) MAIN OBJECTIVES. To work on the Makran continental margin of Pakistan, with multichannel seismic profiling, deep-tow seismic profiling, a land-sea seismic refraction line using 15 Cambridge Ocean Bottom Seismometers (OBS) and five land seismometers, underway gravity, bathymetry and magnetics measurements and sediment sampling by piston coring. Much of this data was to be used as a site survey for proposed Ocean Drilling Project (ODP) holes on the margin.

Less than one day's work was finally achieved on the Makran margin, due to difficulties in obtaining clearance for work in Pakistani waters. The full circumstances are discussed in a separate report. We transferred our work to Oman waters, with an OBS line across the Makran margin north of Masirah Island and profiling across the Owen Fracture Zone and Oman Basin. All this work was outstandingly successful.

b) Geographic Area

Gulf of Oman, 20°-25°N, 59°-63°E
Wide angle OBS line between $21^{\circ}02'$N, $59^{\circ}08'$E
and $20^{\circ}25$ N, $60^{\circ}30$ E

c) Sea and Weather

Perfect seismic profiling conditions, mostly flat calm or less than Force 3. The roughest weather, when it reached Force 7 near-gale, was in the last two days when we finally had permission to work in Pakistani waters.

d) Conduct of Cruise

Apart from the diplomatic mess, the science was outstandingly successful. The equipment worked well and the weather was near-perfect. The RVS technicians were outstanding and a pleasure to work with. We have some excellent data from Oman waters, and it is a tribute to the speed at which the Oman authorities granted us clearance that we achieved so much from an otherwise seemingly bad situation.

e) Equipment Performance

The RVS equipment worked well, and I am grateful for the efforts made to ensure that the new GPS navigation system, the Refraction Technology airgun controller and the deep-tow conducting swivel were

available for this cruise. The multichannel streamer was a pleasure to use and we were able to fly it level to within ± 1 foot, with the additional depth levellers and depth monitoring sections.The new airgun controller is excellent and the airgun array systems are improving dramatically, though details of the suspension systems and hose/cable attachments still need to be refined, and money spent to provide proper airgun handling facilities. The biggest cause of data loss while mcs profiling is still read and write errors on the Sercel tape decks, and I consider provisions of another tape deck essential for future work. The underway geophysical equipment, such as gravimeter, magnetometer, echo-sounders and data-logger all worked faultlessly.

We lost 12 hours due to the main block on the after A-frame being seized on one axis. This threatened to make all our deep-tow profiling impossible, but concerted efforts and brute force finally shifted the block.

f) Ship Performance

The ship performed well, except for the loss of 12 hours when the entire vessel had to be shut down (except for emergency supplies) in order to unblock the water cooler unit. In conditions other than flat calm, this would have necessitated a return to port with attendant large losses of time.

g) Recommendations

Detailed recommendations are in the main cruise report. In general, the equipment and ship performance were excellent, so the following refer only to items that could be improved. In brief:

(i) Diplomatic clearance procedures have to be improved. I submitted the cruise notification 10 months before the departure date. If it hadn't been for the fact that I had already thought about an alternative programme outside Pakistani waters, that this area is almost virgin territory with outstanding geological problems still unsolved, and that the Omani authorities were so quick to give clearance, then this cruise would have been a huge disaster. We actually did a lot of first-rate science. But it remains to be seen whether we shall lose the Ocean Drilling Project leg on the Makran as a result of our failure to complete the vast majority of our planned survey work on the Makran continental margin.

(ii) A small backup cooler ought to be installed on the ship so that scientific services and some propulsion could be maintained while the main cooler is serviced.

(iii) An extra tape drive for the Sercel mcs is essential.

(iv) The airgun firing control system is now excellent. Money needs to be spent on the airgun array handling system to provide robust and safe handling and deployment equipment.

(v) The GPS receiver needs looking at, and possibly the aerial mounting higher, to attempt to achieve more stable fixes.

(vi) The GPS and Doppler Log should be interfaced to the main navigation programs.

(vii) The main block on the A-frame needs freeing and checking regularly, particularly prior to cruises where it will be required.

R.S. White
22 December 1986

SECTION 7. DIPLOMATIC CLEARANCE FOR CHARLES DARWIN 18/86
14th November-13th December 1986

SUMMARY

Diplomatic clearance for our work on the Makran continental margin of Pakistan was requested by myself on 15th January 1986, via Research Vessel Services (NERC). Verbal clearance was given via the Foreign and Commonwealth Office (FCO) on the day we sailed, 14th November 1986, but was rescinded on 17th November 1986. Despite prolonged and intensive efforts to obtain clearance, we were finally only given permission to do our work in Pakistani waters for 1200 (local) on 10th December until 2330 (local) on 12th December. These were the last three days of our cruise, and permission was only given to work in restricted areas which did not include our site of prime interest for the Ocean Drilling Project. So we were able to achieve only a tiny fraction of our original objectives.

INTRODUCTION

This is an account of the steps taken to obtain clearance for marine geophysical work in Pakistani waters and of the consequences to our research of the failure to obtain full clearance. In accordance with normal instructions from the Natural Environment Research Council (NERC), I channelled all my communications regarding diplomatic clearance through Research Vessel Services, Barry.

SCIENTIFIC OBJECTIVES

Tha Makran continental margin of Pakistan is a classic example of a continental margin formed where two lithospheric plates collide. It was first described by myself and others following an exploratory cruise to the area on RRS SHACKLETON in April 1975. Since then, it has become a prime area of British marine research, and I have returned there aboard RV ATLANTIS II in 1977 and RRS SHACKLETON in 1980. Results from the work have been widely reported at international conferences and in scientific journals. As a result of my application in November 1983 to study the area with more sophisticated geophysical tools, I was funded for a cruise aboard RRS CHARLES DARWIN in November-December 1986. The Makran margin is sufficiently important that the International Ocean Drilling Project (ODP) has plans to drill there in September 1987. This would be a British interest leg, with a British Co-Chief Scientist, Dr. J.K. Leggett. The competition for drillsites is intense, with hundreds of proposals being filtered down to only a handful by numerous international committees. Whether the drilling plans come to fruition will depend largely on the results from my present work.

I have had considerable experience of organising marine geophysical cruises, but this particular one has been one of the most complex. Over the past three years we have done an enormous amount of preparatory work, including designing, testing and building a major set of new digital ocean bottom seismometers for use on the cruise, and organising a shore party to extend the seismic work from offshore on to the land.

CHRONOLOGY

1. In December 1985 I was contacted by Dr. S.M. Haq of the I.O.C. with a view to involving local scientists in our research. This apparently resulted from earlier contacts by Dr. Stuart White of NERC, Swindon, who had notified the IOC of our proposed programme in the Indian Ocean. I told him in our telephone conversation that I was reserving one space for an Omani and one for a Pakistani observer and that the observers should be nominated through our FCO.

2. 15 January 1986. I submitted my formal cruise notification to Research Vessel Services (RVS), requesting clearance for work in Omani and Pakistani waters. This notification was submitted 10 months in advance of our sailing date, well in excess of the 6 months requested by the NERC. RVS circulated this on 20th January 1986 to, inter alia, the FCO, the Marine Directorate of the DOT, the Hydrographer of the Navy, the Submarine Flag officer and the MOD.

3. 23 January 1986. I received a letter from Dr. Quraishee of the National Institute of Oceanography (NIO), Karachi, to say that Dr. Haq of the IOC had informed him of our proposed cruise and that NIO scientists would like to be involved.

4. 28 January 1986. I wrote to Dr. Quraishee, and copied the letter to Dr. Haq, to say that I would be glad to take one NIO scientist as an observer, and to offer him post-cruise facilities for one or two scientists in Cambridge, including office space and use of all our facilities, including computers, libraries and secretaries. I also enclosed the cruise notification and discussed in some depth our scientific programme.

5. 11 February 1986. Dr. Haq wrote thanking me for my letter. He wrote that he "discussed this matter with Dr. Quraishee, and jointly with the Adviser and Secretary, Ministry of Science and Technology in Islamabad, during my visit to Pakistan from 24 December 1985 to 13 January 1986. They have expressed keen interest and are taking the necessary steps to nominate two scientists from NIO to join the cruise".

6. 21 February 1986. Mr. C.M.G. Adams of RVS sent me a copy of a letter received by the FCO asking for the provision of two scientists' berths in the cruise. He had responded to the FCO that we could only commit one observer berth to Pakistan at present.

7. 5 March 1986. I replied to Mr. Adams' letter, enclosing copies of all my correspondence with Dr. Quraishee. I confirmed that I would only be able to guarantee one place for a Pakistani observer, and that I would like him to be nominated as the official observer via FCO. My reasons for this that we were extremely short of space and I had already had to drop Cambridge technicians and scientists I wished to take. I was already taking one other NIO scientist from Pakistan, Mr. Athar Ali Khan, who was spending the year working with Dr. J. Leggett of Imperial College. So to reserve one more place for a Pakistani observer and one for an Omani was as much as was available. I wanted the observer to be nominated via FCO because, as I wrote, "One problem I foresee is that the Pakistani navy may wish to send an observer - they did so on my last cruise on SHACKLETON 1/80 ... I don't know what internal Pakistani politics are like, but we should be wary of offering places to one organisation and then

finding insistent demands from another, too. In general, I would prefer to take a scientist than a navy person, since they are likely to gain more from the experience". I did not want to find a naval observer and a Pakistani scientist fighting on the quayside to get on to the ship.

I also enclosed a slightly revised cruise notification, extending the area we required to work westwards by 34 miles to 62°11'E so as to include the region of our earlier detailed seismic survey on SHACKLETON 1/80, and the region proposed as possible drillsites for the ODP.

8. 4 March 1986. (letter date). Dr. Quraishee replied to my letter of 28 January to say that he thought that our work was well thought out and that he was glad we would train NIO scientists. He wrote that "The case of participation of NIO scientists in Charles Darwin cruise is being processed by the Government of Pakistan".

9. 9th May 1986. At a pre-cruise planning meeting at RVS, we discussed cruise clearance. We talked about berths for observers and items 1-8 above.

10. June-August 1986. At a number of NERC and ODP committee meetings, I reported that we had not yet received clearance for work off Pakistan, and I also notified the Site Survey Panel of the ODP of the same.

11. 17 September 1986. I compiled a detailed list of the exact detonation times, charge sizes and locations of the explosives charges we planned to detonate across the Makran margin on two of four specified dates. This was sent to RVS with a request that in view of "all the naval activity in our area of operations ... it is vital that this information is circulated to all possible parties (inc. NATO, U.S., British, Pakistan, Iranian, Indian, Omani forces). Can you please circulate it to all the necessary authorities, and also put it in the relevant Notices to Mariners if this is appropriate ... In view of the sensitivity of this area, we shall adhere rigidly to the times and locations for charges listed".

On 1 October 1986, Mr. Adams of RVS sent this firing schedule on to Miss Abbott-Watt of the FCO, with a request that it should be copied to the Defence Attaches in Islamabad and Oman, to the MOD and USN UK, and to the Area 9 Co-ordinator in Karachi Naval HQ.

12. 23 September 1986. I received a telex from Dr. Quraishee to confirm his interest in NIO participation. I telexed back with the dates of the cruise and (para. 2):

"We have reserved one space aboard for a Pakistani Observer, which has been offered to the Pakistani Government via our Foreign and Commonwealth Office. I have not yet been notified of the Pakistani nominee, but would be very glad to have a participant from NIO as the official Pakistani observer provided he is nominated through the Government authorities and FCO".

These telexes and my reply were sent to RVS on the same day, with a request that they be forwarded to the FCO.

13. 4 October 1986. Dr. Quraishee telexed back to request that we retained Mr. Athar Ali Khan on the cruise, and that "NIO has nominated Mohd. Tahir as observer for Charles Darwin cruise(.) His nomination being sent via FCO(.)".

14. 16 October 1986. Dr. J.K. Leggett of Imperial College, London, received a telex informing him that as a result of our earlier request he, together with Dr. Simon Klemperer and Mr. Melvyn Mason from Cambridge, had security clearance to work onshore near Pasni on the Makran coast. They were to install seismometers near Pasni to extend the seismic profile from our offshore work. Security clearance for this was sought independently by Dr. Leggett, in continuance of his previous geological mapping work with the Hydrocarbon Institute of Pakistan (HDIP) in that region. HDIP arranged the security clearance and logistics support in the field.

Dr. Leggett decided a few days after receiving the security clearance to withdraw from the project and not to go into the field. The two Cambridge people, Dr. Simon Klemperer and Mr. Melvyn Mason took over at short notice all the arrangements for shipping and installing the land seismometers. They left for Karachi on 19 November.

As the problems with clearance grew, the two Cambridge people did a great deal of work in Karachi, shuttling information and requests between NIO, HDIP, RVS, the British Embassy in Islamabad, the Pakistan Navy (via Dr. Quraishee of NIO), and ourselves on the Charles Darwin. Much of our information, and all the details of the Pakistan Navy exercise areas and dates, came from Karachi a long time before the British Embassy informed us. It was unfortunate that Dr. Leggett was not with them as planned, because, as Co-Chief Scientist of the putative ODP Makran leg, he could probably have exerted additional pressure by lobbying on behalf of the ODP site survey: he would have been fully aware of all the implications and possibilities of our ODP survey work.

15. 20 October-7 November 1986, I was becoming increasingly concerned with the lack of clearance and contacted both RVS and Miss Abbott-Watt at FCO directly to stress the urgency of the situation. The FCO told me that they were cabling the British Embassy in Islamabad (hereafter Britemb), but had no reply. The situation was unchanged when I flew out to Muscat on 9th November 1986.

16. 12 November 1986. I received a telex from Dr. Quraishee of NIO to say that "Govt. permission for Mr. Muhammed Tahir of NIO has been obtained through Foreign Office(.) He will be reaching Muscat on 12 morning". He asked for our agent to arrange a Certificate of No Objection (NCO) for him. Although it was the local weekend, the agents did in fact get one. But Mr. Tahir did not board the PIA flight in Pakistan and never arrived.

17. 13 November 1986. Telex from RVS to say that Ministry of Foreign Affairs (MFA) had given verbal clearance for Cruise 18/86, and that Britemb going back for written note. Telex from Dr. Quraishee to say "formal cruise programme and offer of one Pakistani observer did not receive by the Pakistan Foreign Ministry". But since this was at variance with his previous day's telex, and with the MFA verbal clearance, RVS telexed back to Quraishee to explain the situation.

18. 14 November 1986. FCO telephoned 2nd Secretary, Britemb,

who confirmed that all clearances were OK. RVS advised us to sail as planned. Eventually sailed from Muscat at 1900 (local).

19. 17 November 1986.

a) 1828 (Local). We had just completed an OBS test in the Dalrymple Trough when we received a telex to say that MFA had not got written approval from the Ministry of Science and Technology (MST), and advising us not to enter Pakistani waters until matter clarified.

b) 2134 (Local). FCO told us to pull out to the SW and clear Pakistani waters. This we did, and were ultimately not to return to Pakistani waters until midday on 10 December, just two days before the end of our work.

20. 18 November 1986. I sent telexes to RVS and Mr. E. Nickless at NERC (for ODP) stressing the danger of losing the ODP site survey on the Makran and my concern about whether the land party should fly to Karachi the next day. Mr. Nickless contacted Cambridge to urge the land party to go anyway. In case the difficulties with cruise clearance were due to our proposed work on the Makran continental margin, I also proposed a more restricted seismic reflection survey across the Murray Ridge, south of 23°23'N as a backup programme. This area is well away from the continental shelf, near the 200 mile limit.

21. 19 November 1986. Telex received from Mr. R. Beetham, Head of Maritime, Aviation and Environment Department, to say, amongst other things, that "delay in obtaining clearance for this cruise is in no part due to FCO: clearance was sought in March and the post instructed to chase this at end October".

22. From 19 November 1986 onwards the messages we were receiving from RVS and FCO suggested that the difficulties should shortly be resolved and clearance formally agreed. Although I had a viable alternative programme outside Pakistani waters, I remained near the border so as to be able to enter Pakistan as soon as clearance was received.

23. 1932 (local) 27 November 1986. Received telex from Simon Klemperer in Karachi to say that Prime Minister Junejo and MFA had approved all work before 2359 (local) on 27 November 1986. Permission for 4 hours' work was as good as no permission.

24. 27 November 1986. Information from JOIDES office in USA to tell us that Pakistan navy is conducting exercises and will not allow a research vessel into the area until after 17 December 1986. FCO concurred with this view. Our cruise was scheduled to end on 13 December in Muscat.

25. 1 December 1986. Informed by FCO that permission granted by Pakistan for us to work from midnight, 1 December, in the area south of 24°N (that is not on the Makran continental margin, but to the south in deep water), provided the work was non-seismic. Since everything we were able to do was seismic (i.e. multichannel seismic profiling, deep-tow profiling, OBS wide-angle profiles), this was effectively another refusal of permission for us to work, even in the area off the continental margin.

26. 5 December 1986. FCO sent a rather ambiguous 'clarification' by the MFA of the conditions under which we could operate in Pakistani waters. It repeated that we could only do

oceanographic research until 10 December, and that thereafter we should resort to Pakistan for details of work the Pakistan Navy would accept. This was said to be the last word from the Pakistan authorities.

The clearance conditions were taken to be those in the warning 427 issued by Pakistan Navarea 9 as follows:

"Seismic survey with a tow of 2.5 kilometres in length with end marked by a light buoy from 101200E to 122330E Dec. 1986 in area enclosed by

A. 25 10 N , 62 45 E

B. 24 00 N , 62 45 E

C. 24 00 N , 65 30 E

D. 25 10 N , 65 30 E"

This was the final information we received. We therefore repaired and deployed the multichannel array outside Pakistan waters, crossing the median line with Oman shortly before 1200E on 10 December 1986. In the remaining time until 12 December we were able to record just one multichannel seismic profile across the Makran continental margin, through the proposed ODP drill sites.

EFFECT ON SCIENCE

Of the planned 26 days' work on the Makran continental margin, we were able eventually to do less than one day's work. The one multichannel seismic profile we were able to record was not in the prime location for the ODP survey because that was outside the area for which clearance was given by the Pakistan navy. We were unable to do the proposed grid of multichannel seismic profiles, the deep-towed seismic profiles, the bottom sampling by piston coring or the seismic refraction work which were to have contributed to the site survey. As fate would have it, although it had been almost continuously flat calm during the whole of the cruise thus providing perfect conditions for seismic profiling, on the one day we were able to work on the Makran continental margin it blew a Force 7 near-gale. This caused us to lose several of the airguns through damage. We also lost four channels of the hydrophone streamer and the data is generally very noisy and not therefore of optimal quality. It remains to be seen whether the limited new data we have acquired is sufficient for the ODP to proceed with drilling.

The failure to obtain clearance for this cruise has ended ten years of very fruitful work on the Makran margin on a very sad note. We shall not return. We have lost the opportunity of using a ship which was better equipped geophysically than any other cruise I have been on: an enormous amount of new and sophisticated equipment had been gathered together for this particular cruise, including an enhanced multichannel profiling system, satelite navigation systems, deep-tow profiler, micro-processor controlled seismometers and much more. The weather was near-perfect, which is especially important for allowing the acquisition of high-quality data and the equipment was all working well.

In financial terms, the full economic cost of this one cruise was about 0.5 Million, and about 20 man-years have been expended in preparation and work at sea. If the Ocean Drilling Project does not drill here as a result of our failure to obtain the planned site survey data, we shall lose about £3 Million worth of drilling.

The alternative programme we pursued in Oman waters was made possible by the rapid response of the Oman authorities to our request to work there at just a few days' notice. For that we are most grateful. The contrast with Pakistan is marked.

RECOMMENDATIONS

From the time I submitted my cruise notification in January 1986, I did not hear anything from the British Embassy in Pakistan until the day we sailed in mid-November. It is my impression, bolstered by Mr. Beetham's comments (para. 21 above) that the clearance was not chased hard until the end of October, by which time it was too late. Even if this is not the case, it would have been much better if I could have been alerted much earlier to possible difficulties. Then I would have had time either to arrange alternative work elsewhere or else to try to rearrange the timing of the work or of the cruise dates, so as to avoid any particular dates when work was not permitted. The uncertainty as to whether or when we would receive clearance for work in Pakistan waters and the high priority of doing the ODP site survey work meant that much of our time was spent near the median line: had we known from the outset that permission would be denied until the last few days, our surveys in Oman waters would have been much better located.

This is not the first time in my experience that clearance has not been obtained until the last minute. In December 1983, aboard RRS DISCOVERY, the British Embassy in Senegal did not obtain clearance for us to work around the Cape Verde Islands until the day we sailed. Again, I was faced with a ship full of equipment and people ready to go on a long-planned project with, in that case, no viable alternative work at all if clearance had not been forthcoming. In that case the Embassy told me they had been busy with more important things, but that clearance could quickly be sorted out. Fortunately it was.

I recommend that in future, particularly with coastal states becoming much more wary of research within 200 miles of their coast, the FCO keep the Principal Scientist informed of progress with clearance by regular reports prior to the cruise, and that a final cut-off date, say one month ahead of the start of the work, be agreed. If clearance has not been agreed by this date then at least there would be time for viable alternative programmes to be arranged.

SECTION 8.

MARINE GEOPHYSICAL WORK ON THE MAKRAN CONTINENTAL MARGIN DURING CHARLES DARWIN 18/86

SUMMARY

This report summarises the geophysical work we achieved on the Makran Continental Margin which is relevant to proposed ODP drilling there. Although we had planned to spend 26 days working on the Makran margin, with multichannel seismic profiling, deep-tow seismic profiles, bottom sampling by piston coring and a land-sea seismic refraction line using 15 digital ocean bottom seismometers and 4 land seismometers, we were eventually able to record only one long multichannel seismic reflection profile across the margin due to lack of diplomatic clearance.

DIPLOMATIC CLEARANCE

I first sought clearance from Pakistan for the marine work via Research Vessel Services and the Foreign and Commonwealth Office (FCO) in January 1986, some 10 months before the start of the cruise. Clearance for the land work was given on 16 October 1986, but the long saga of the efforts to obtain clearance for the offshore work resulted eventually in permission for only 2½ days' work, and that right at the end of the cruise. The full saga is documented in a separate report. If the delay in obtaining clearance was in no part due to the FCO, as Mr. Beetham, the Head of the Maritime, Aviation and Environment Department, told me in a telex on 19 November 1986, then I am deeply pessimistic that permission could be obtained for drilling on the Makran. We had done everything possible to get permission and were fully supported by scientists in Pakistan at the National Institute of Oceanography. If, however, the FCO and the British Embassy in Pakistan were not as diligent in this case as they might have been in pressing our request for clearance and in meeting possible objections, then I suspect that permission for future work could indeed be obtained satisfactorily.

LOCATION OF PROFILES

Permission was eventually given to profile within Pakistani waters from midday on 10 December 1986. We remained outside the 200 mile limit until then, and repaired the hydrophone streamer and gun arrays. When we entered Pakistani waters we had a 48 x 50 metre streamer and six-gun array fully operational. We recorded 425 km of mcs profiles within Pakistani waters.

We made one crossing of the Makran margin just east of 62°45'E. This was not in the ideal location illustrated for the proposed drill sites on the ODP proposal, which lies some 30 km to the west, because we only had clearance to work east of 62°45'E.

TECHNICAL DETAILS OF PROFILE

The profile commenced with a 48 group streamer flown at 10m. depth and a six-gun array (700 + 466 + 300 + 160 + 40 + 20 cu. inch) of airguns also at 10m. depth, and operating at 1950 psi.

The profile was recorded to 15 sec. with 50 metre (nominal) pop interval. However, on the run in to the margin a shark damaged the eighth and ninth sections of the streamer and two of the airguns failed. We were able to maintain the streamer in good condition for a while by switching out some of the damaged 25 metre groups, but eventually seawater reached the connectors and we lost the signal from the rear two-thirds of the streamer. In a gallant three hour rescue at night, the damaged sections of the streamer were removed and the signal from the rear sections restored. One of the airguns was repaired. The mcs profile (CAM30) was continued with a 44-channel streamer (22 fold stack), five-gun array.

Towards the end of the profile the weather deteriorated to Force 7 near-gale. This inevitably made the streamer noisier, and battered the airgun arrays: we lost two airguns, one from a broken high pressure hose and the other from a severed support chain, the support buoy from one airgun subarray was lost and the other flooded. Normally I would have aborted the profile at this stage, but in view of the importance to the ODP program, I continued until we crossed on to the shallow continental shelf. The NERC kindly allowed us to over-run our agreed finishing time in order to complete the profile.

DESCRIPTION OF PROFILE

Numerous sedimentary reflectors and a strong basement reflector can be traced into the Makran margin from their outcrop (or subcrop) on the Murray Ridge. There is abundant gas along the entire profile 550-700 msec (about 500-650 metres) below the seabed, with evidence of gas hydrate in the shallower sections.

Seaward of the frontal fold there is sub-bottom folding, but the uppermost sediment section exhibits more confused deformation, with evidence of slumping. This slumped section is a maximum of 350m. thick, but may be much less: it will only be possible to tell from the processed mcs profile.

The deformation in the slope basins immediately landward of the frontal fold is complex, with evidence of recent disturbance by slumping and/or strong currents. The more landward section exhibits more regular deformation and back-tilting in the slope basins similar to that seen further west, in the existing single-channel grid survey.

PROCESSING

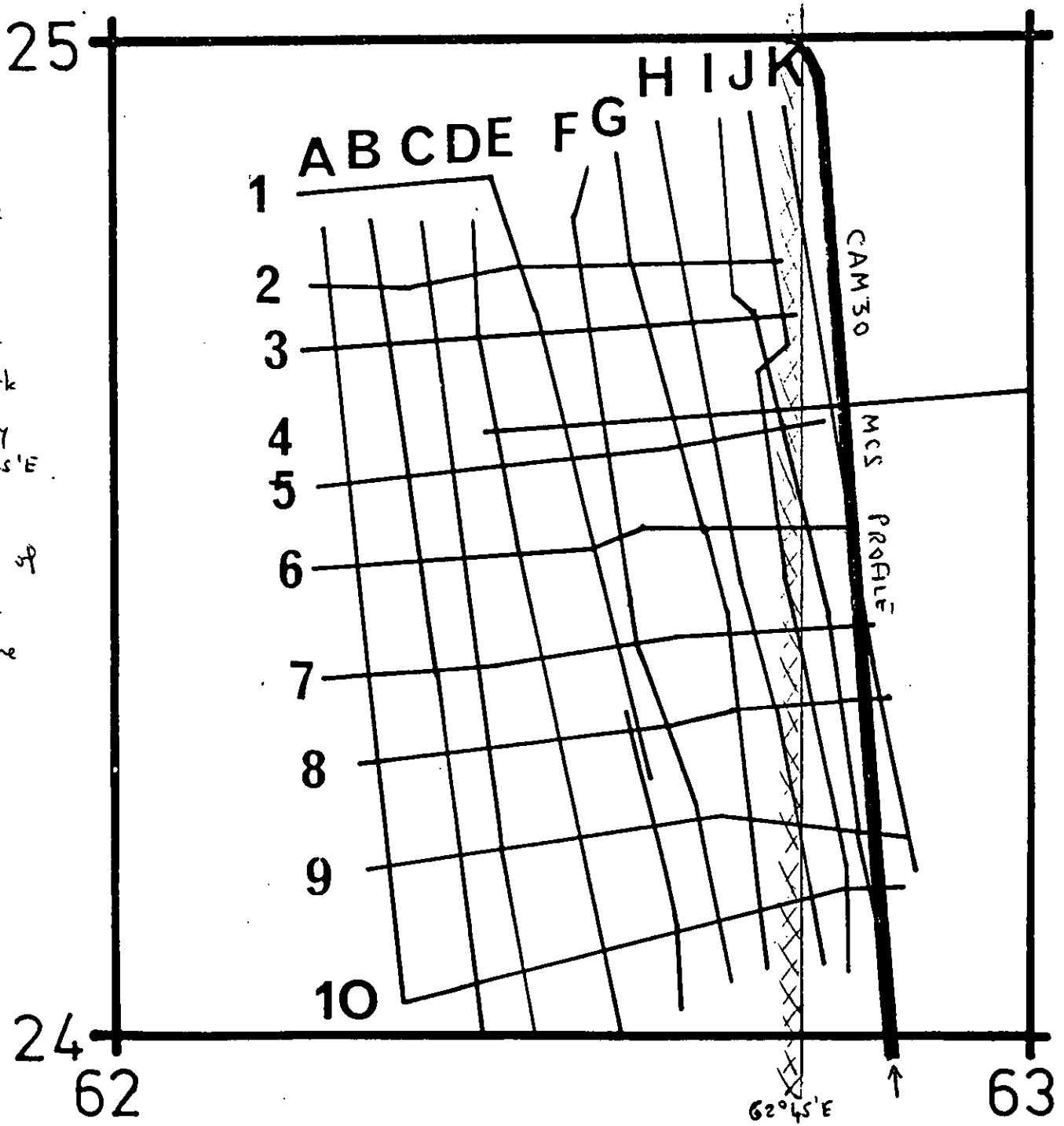
The data tapes are expected to be in Cambridge by the end of January 1987. Depending on the level of NERC funding we shall process to stacked time sections or to migrated time sections, starting as soon as we have the data tapes.

Robert S. White
5th January 1987

Fig. 1.

Heavy line shows CAM30 mcs profile and its relation to the existing Cambridge single-channel seismic survey. Seismic work was only permitted by Pakistan east of 62°45'E (shaded line)

Single channel monitors of the CAM30 are shown in accompanying figures. One is read before write, the other is read after write.



SECTION 9

CHARLES DARWIN 18/86

Digital OBS Preliminary Report

Six DOBS instruments and 5 PUSSes were taken. All had newly built electronics.

Instrument list:

		Recorders	Batt.	C-PROM	Housing
PUSS	1	1	Module		Old Puss
	2	1	"		"
	3	1	"		"
	4	1	C Cells		"
	5	1	C Cells		
DOBS	9	3	Module		DOBS 9 (Silver)
	10	4	"	C-Save	" 10 Old
	11	3	"		" 11 Old
	12	3	"		" 12 New
	13	3	"		" 13 New
	14	3	"		" 14 New

Geophones:- All DOBS geophone packages, except one, were large gimballed old type. Exception was smaller experimental non-gimballed unit used on #13 on main MASIRAH line. Deployment arm was that used previously with 2 x 4 inch x 4 inch x 13 inch weights and tube arm.

Geophone Connections:- new system was used to replace old junction boxes. Four separate wires from geophones via cable cutter were joined to 4 separate wires in an encapsulated block attached to the DOBS frame. The four wires from this block were encapsulated into a field installable 4-pin Brantner connector. The object of the arrangement is to re-use the 4-pin Brantner and its wires by cutting off the encapsulated block after use and joining on new wires. The assembly was encapsulated in the lab and the wires threaded through the cutters and soldered to the geophone packages at sea.

Hydrophones:- The old, yellow PUSS shallow water (air-backed) hydrophones were used on 3 pusses and the old oil filled DOBS hydrophones on ?4 DOBS. New black urethane encapsulated hydrophones (solid encapsulation) were used on two PUSSES and two DOBS.

Releases:- Gas retractors and RVS supplied pinger units were used on all DOBS deployments. Retractors were re-charged at sea as necessary by Steve Jones.

Floats:- DOBS float frames (3 old and 3 new) with 3 large balls and 12" balls on strayline were used.

Rigging:- We used about 2 m of rope for the geophone and 2.5 m for the bottom weight to cutter connections, which thus finished up rather short and may have been a factor in the failure of #9 to free itself. The cutter weight was threaded onto the rope

with a stopper knot to stop it sliding downwards and the rope fixed to the bottom of the cutter assembly with a bowline in order to leave a flexible coupling between cutter and cutter weight.

PUSS moorings:- As previous experiments except slight modification to surface float arrangement so that it was recovered inverted. Wire strop on PUSS replaced with rope strop.

Deployments:- There were two deployments, a short air-gun line into 2 DOBS in the Dalrymple trough as a test, and a full scale line off MASIRAH with all instruments using explosives. A short air-gun profile was shot into one DOBS (#9) during main deployment to test the conditional save program.

Test deployment results:- DOBS #10 was deployed with hydrophone only and DOBS #13 with old style geophone package. Both worked well, although the signals seemed quite weak. DOBS 9 had a little water in it on recover, no sign of any seal damage could be found.

Main deployment results:- There were a number of problems in both PUSS and DOBS instruments which need further investigations when the data is replayed fully.

1) Low signal amplitudes on one or more channels, sometimes without much noise.

2) Spikes sometimes associated with 1). These appear to affect both hydrophones and geophones, thus suggesting that it is not the sensors, but the signals seem to be doing logical autoranging so it does not look like the CPU.

3) 2 clocks stopped or slow on recovery, thought to be due to insufficient pressure on battery contacts allowing power break.

4) Instrument 9 failed to release although pinger indicated that it had worked. It was deployed on a 1:8 slope. We dredged and released it and could see no signs of anything wrong. The geophone wires were very cleanly cut. There was a slight kink in the cutter blade wire suggesting it may have snagged but it is not clear how it could have occurred.

5) Instrument 9 had water in it on recovery, thus suggesting that water is leaking past the sealing faces at low pressure even when perfect rings are present. The surface anodising finish is very poor and this tube should be stripped before re-use.

6) One PUSS appeared to stop recording any sensible data altogether after a close shot and never recovered, although some noise was recorded throughout.

Dredging operation:- DOBS 9 failed to release when commanded although the pinger appeared to operate normally. I thought that it was possible that the cutter assembly had failed to release and that dredging might free it, although it did not seem likely that dredging with wire and weights would recover the instrument from any other failure. The instrument was located carefully using G.P.S. (which was available for the first part of dredging only) and travel time variations for the pinger to better than

0.1n.m. A dredge of 1/4 ton chain clump, and 900 m of wire (ex PUSS moorings) was laid on the bottom with a 1/2 ton chain clump at the bottom of the main warp. The weights were laid in a S-N line, 500 m apart, slightly to the E. of the position and a sweep clockwise on a 1/2 mile radius was steamed. The P.E.S. trace showed that the DOBS released on first contact with the wire.

Software:- The instruments shipped to Oman had different eproms for PUSS and DOBS, the PUSSes had "orange label" eproms dated 27.9.86 which did not have correct sequential reporting and did not turn off the tape decks on wake-up. The DOBS had 10DSR4 dated 3.10.86 which had semi-correct sequential reporting and did turn off the tape decks on wake-up. When we tested the instruments on board (Mike McCormack came out to help set them up) we found the cause of the short initial block and of the peculiar interaction between record and replay boards to have been a bug in the hardware of the mode select in the record board whereby sending the stop command 0 put it into a mode which always truncated the next block. As a kluge we overwrote the sequence which turned off the tapes in the DOBS eproms with a harmless operation. The correct change is to use F to turn off instead of 0. These DOBS still produce short blocks after any operation which involves switching off the tape, i.e. replay or load, but this does not affect normal deployments.

A conditional save window modification was made on board and at the same time the tape stop character was changed to F and the output to L.C.D. and screen during recorded changed to show the current gain value of channel 1 at each gain change (not sure what I did to the buffer number indication).

Land instruments for MAKRAN had a different program, modified from the earlier programs to put the display of time in wake-sleep mode onto the third line of the L.C.D. so that it could be seen through the window.

Data Format:- All instruments used the same data format and header constructions, except that conditional save inserts its parameters into the start of the alarm message. Windows begin at some time during the second following the window start time, the delay being due to the variable time needed to run through the table.

Conditional save:- The conditional save version of the program takes a window length of FE to indicate a single block conditional window. The number of gain changes occurring in the block is totalled (each channel-change is counted separately) and the total compared with the value stored in the alarm table next to the status byte. If greater than the stored value, the block is saved before returning to sleep mode.

Replay programs:- The old single block display programs were used in slightly modified form, the version used for 4 channel data was D4.EXE and for single channel data D1.EXE. These programs, plus Penny Barton's table compiling programs, were run on the M28, communications with the DOBS used PROCOMM.EXE.

Replay system:- The standard DOBS CPU and record and replay board were used in a SCHROFF rack built by Richard Smith. It had a switched mode power supply and multiple sockets to power and communicate with the DOBS. On the test deployment the clock jumped and the CPU and crystal were transferred to battery power

using a bank of D cells wired into the rack. The PUSSes were linked to the separate switchboard mode supply and comms box and initially programmed via the M24 separately from the DOBS. For time checking of all instruments together the supply/comms box was used as a passive interface. Problems were occasionally experienced as follows:-

1) At times the PUSSes got hung up and could not communicate.

2) Some operation or other occasionally caused time jumps and corruption of some bits of memory, so all instruments were disconnected from the comms lines when not in use. The jumps occurred even when all instruments were running on batteries.

Provisional conclusions:-
(Subject to full analysis of the data)

1) The instruments (electronics and programs) work satisfactorily although minor changes would be beneficial and all instruments should ideally run identical programs.

2) The new battery packs need better contacts and more even fixing of the end disks to avoid intermittent supplies if the instrument is subjected to shock.

3) Anodising which appears to have a poor surface finish as DOBS 9 can leak and should not be used.

4) The new hydrophones seem to work in deep and shallow water.

5) The new geophone package works well on flat sediments and has a higher resonant frequency, particularly noticeable on the horizontal response.

6) The encapsulated wires are a more convenient system than the junction boxes. (They do not seem to be linked with the attenuated signals problem.)

7) The new DOBS frames are much easier to handle, store, transport and deploy. It would be worth having simple frames to fit on the exposed ends to enable a sheet of ply to be put on top of the frames to take boxes.

8) The old float frames need modifying to provide a vertical fixing for the flashing light - we broke one again this cruise because the slip rope caught round the light as it pulled through the ring.

9) The rigging system has no obvious faults but I think the rope between the cutter and bottom weight should be lengthened to 3.5 m minimum especially on sloping terrain.

10) The gas retractors work very well and are much easier to use as they can be partially rigged in the wet lab.

11) The old (coloured front panel) release electronics box only just worked and gave us a severe scare before we started to use the newer one. The old one is barely adequate even as a back-up and needs fixing.

12) The racks in the lab are fine, and the time compare mode is useful except that, even with batteries, the clock in the replay system jumped. We need a separate clock with a much better crystal and possibly software to decode the IRIG signal from the RVS clock. Some means of setting the DOBS and PUSSes on an external clock would be useful - bit of software needed.

13) The multiple comms arrangements need sorting out to make sure that all instruments in use can communicate with one system without getting hung-up.

14) DOBS full battery packs should last for a complete cruise if needed and the small PUSS packs for 10-12 days.

15) We need an on-board replay program to handle multi block windows for display and plotting.

16) The conditional save windows are fine and seemed to record wanted blocks and ignore unwanted ones. The alarm table does not hold enough entries for an explosive line and a reasonable airgun line with significant redundancy in the conditional save windows, so a loop entry in the alarm table is needed.

ACTION LIST
(Not including new work for next cruise)

Electronics:-

1) Check all sensor wiring and signal channels.

2) Re-make battery packs as necessary.

3) Make additional comms link box.

4) Replay precision clock etc.

5) Permanent battery holders for replay.

6) Sort out external sync signals etc.

Software:-

1) All DOBS/PUSS/SCRAPS to run same program, update to include correct tape stop and correct sequential reporting.

2) Check method of synchronising clocks etc.

3) Replay software development - continue!

1) DOBS#9 to be stripped, re-machined and hard anodised.

2) Float frames of DOBS 9, 10 11 to be modified to be same as 12+.

3) Battery packs to be modified.

4) End cap of deep tow was stripped and re-anodised without re-machining the connector 'O' ring face. This is bad practice as it leaves a finish which is too rough for the 'O' ring to seal on. The encap need to be stripped again and all seal surfaces re-machined before re-anodising.

T.R.E. Owen
1.1.87

SECTION 10.

CHARLES DARWIN 18/86

SHOT FIRING SCHEDULE

DAY 1

SHOT NO.	TIME GMT	CHARGE SIZE, KG	FUSE LENGTH, M	FLIGHT TIME, S	COMMENTS
A1	0250	2.1	-	98	
A2	0300	25	1.84	170	Floated
A3	0305	25	1.40	150	Floated
A4	0310	-	-	-	Charge postponed
A5	0315	100	1.30	83	
A6	0320	25	1.20	86	
A7	0325	100	1.28	86	
A8	0330	25	1.18	78	
A9	0335	25	1.25	88	
A10	0340	100	1.32	89.7	
A11	0345	25	1.27	92.5	
A12	0350	25	1.26	88.6	
A13	0355	100	1.47	95	
A14	0400	25	1.26	90.7	
A15	0405	25	1.26	84	
A16	0410	100	1.60	106.5	
A17	0415	25	1.27	88.1	
A18	0420	25	1.27	93.5	
A19	0425	100	1.80	111.9	
A20	0430	25	1.27	90.1	
A21	0435	25	1.27	79.3	
A22	0440	100	1.85	106.7	
A23	0445	25	1.27	80.1	
A24	0450	25	1.27	89.7	
A25	0455	100	1.95	122.2	
A26	0500	25	1.27	91.3	
A27	0505	25	1.27	85.4	
A28	0510	100	1.95	123.3	
A29	0515	25	1.27	91.9	
A30	0520	25	1.27	85.0	
A31	0525	100	1.95	122.4	
A32	0530	25	1.27	91.6	
A33	0535	25	1.27	90.4	
A34	0540	100	1.95	124.4	
A35	0545	25	1.27	90.2	
A36	0550	25	1.27	88.5	
A37	0555	100	1.95	123.5	
A38	0600	25	1.27	84.6	
A39	0605	25	1.27	87.2	
A40	0610	100	1.95	121.6	
A41	0615	25	1.30	85.5	
A42	0620	25	1.35	87.3	
A43	0625	100	1.95	120.3	
A44	0630	25	1.40	90.45	
A45	0635	25	1.40	90.0	
A46	0640	100	1.95	122.4	
A47	0645	25	1.40	92.8	

SHOT NO.	TIME GMT	CHARGE SIZE, KG	FUSE LENGTH M	FLIGHT TIME, S	COMMENTS
A48	0650	-	-	-	Charge cancelled
A49	0655	200	2.20	119.0	
A50	0700	25	1.40	92.3	
A51	0705	25	1.40	89.6	
A52	0710	25	1.40	92.5	
A53	0715	25	1.40	93.0	
A54	0720	25	1.40	92.9	
A55	0725	200	2.20	117.2	

DAY 2

SHOT NO.	TIME GMT	CHARGE SIZE, KG	FUSE LENGTH M	FLIGHT TIME, S	COMMENTS
B1	0250	2.1	1.20	93.1	
B2	0300	25	1.40	98.1	
B3	0305	25	1.40	93.8	
B4	0310	200	1.90	124	
B5	0315	25	1.40	96.9	
B6	0320	25	1.40	91.2	
B7	0325	25	1.40	93.8	
B8	0330	25	1.40	98.0	
B9	0335	25	1.40	97.0	
B10	0340	200	1.90	122	
B11	0345	25	1.40	97.3	
B12	0350	25	1.40	96.6	
B13	0355	100	1.90	125.8	
B14	0400	25	1.40	93.1	
B15	0405	25	1.40	87.9	
B16	0410	100	1.90	123.3	
B17	0415	25	1.40	91.6	
B18	0420	25	1.40	93.4	
B19	0425	100	1.90	122.7	
B20	0430	25	1.40	92.6	
B21	0435	25	1.40	93.1	
B22	0440	100	1.90	122.6	
B23	0445	25	1.40	91.7	
B24	0450	25	1.40	96.9	
B25	0455	100	1.95	122.0	
B26	0500	25	1.40	92.1	
B27	0505	25	1.40	91.3	
B28	0510	100	1.95	123.1	
B29	0515	25	1.40	91.2	
B30	0520	25	1.40	93.1	
B31	0525	100	1.95	111.2	Flight time unreliable
B32	0530	25	1.40	92.1	
B33	0535	25	1.40	92.1	
B34	0540	100	1.95	119.6	
B35	0545	25	1.40	87.7	Flight time unreliable
B36	0550	25	1.40	86.5	
B37	0555	100	1.95	123.8	

SHOT NO.	TIME GMT	CHARGE SIZE, KG	FUSE LENGTH M	FLIGHT TIME, S	COMMENTS
B38	0600	25	1.40	90.4	
B39	0605	25	1.40	92.9	
B40	0610	100	1.95	125.5	
B41	0615	25	1.40	91.5	
B42	0620	25	1.40	92.4	
B43	0625	100	1.95	125	Partial fire only
B44	0630	25	1.40	95.4	
B45	0635	25	1.40	93.8	
B46	0640	100	1.95	121.3	
B47	0645	25	1.40	91.5	
B48	0650	25	1.40	90.6	
B49	0655	100	1.95	123.3	
B50	0700	25	1.40	93.4	
B51	0705	25	1.40	91.4	
B52	0710	100	1.95	117.4	
B53	0715	25	1.40	92.5	
B54	0720	25	1.40	89.0	
B55	0725	100	1.95	116.9	
B56	0730	25	1.40	91.6	
B57	0735	25	1.40	91.6	
B58	0740	25	1.40	91.9	
B59	0745	25	1.40	93.5	
B60	0750	25	1.50	96.4	12 x 2.1 kg
B61	0755	25	1.45	98.5	12 x 2.1 kg
B62	0805	21	1.05	135.1	10 x 2.1 kg + spare dets. floated

11. GRAVITY BASE STATION

Pending a post cruise base station reading, a drift rate of +0.014 mg per day is recommended. A positive drift rate means that if you return to the same location at a later date, the ship's meter will read a higher number. Drift rate from S. Jones pers. comm. January 1987. This may be improved once subsequent base values are obtained. No drift rate has been applied to the values recorded on the data-logger tapes.

Value of g at ship in Muscat on 8 November 1986

(Day 312) = 978973.49 mg nl

Corresponding ship's gravity meter reading = 07299.0

Ship's meter calibration constant = 0.9917

RESEARCH VESSEL SERVICES

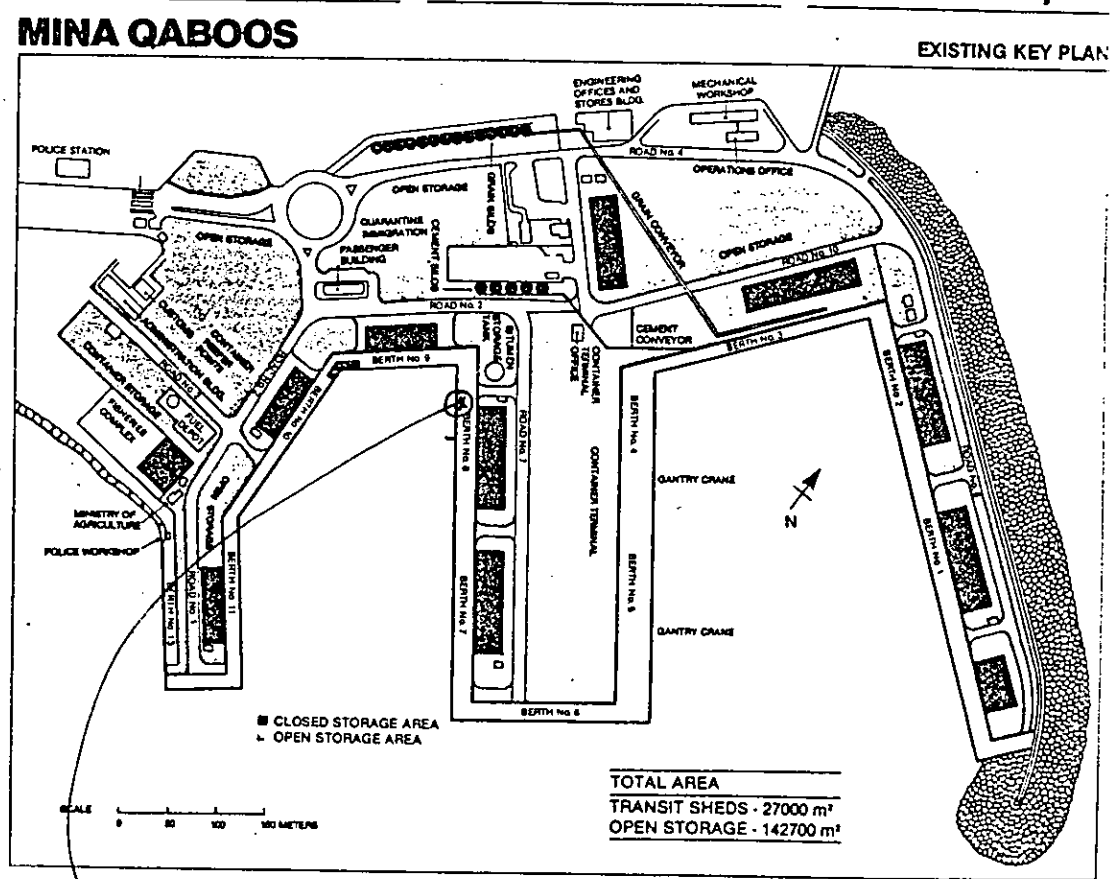
GRAVITY AND MAGNETIC SECTION

GRAVITY BASE STATION

SITE DESCRIPTION:-

LATITUDE
LONGITUDE
METER NO WORDEN 676
METER READING
5.40 L/R SEAMETER
CORRECTION FACTOR
FOR WORDEN 676 0.08822
DATE/TIME
9th NOV 1986
SEEB - 0423z, 0530z
SHIP - 0331z, 0900z
OBS: S. JONES
PORT MINA QABOOS MUSCAT SULTANATE of OMAN

SKETCH PLAN:



4" BOLLARD FROM N.W. CORNER OF PIER.

VALUE : 978973.0 mgal

Based on 195N71

N.B.

SEEB AIRPORT USED AS REFERENCE. VALUE @ SEEB IS 978923.5 mgal (EVANS & SHELTON 195 & 0.U.)

SURVEY JUNE 1978

12. EQUIPMENT PERFORMANCE AND RECOMMENDATIONS

1. Multichannel Streamer

This performed excellently. The addition of two depth sensors and more depth levellers has now provided very tight control on the depth. We were able to keep the entire streamer level to within one foot, even in Force 5 conditions, which is far better than when I last used it in Summer 1985. It is a pleasure to use.

a. I recommend that RVS purchase one or two extra depth levellers, to be kept strictly as replacement back-ups.

b. I recommend that some means be found to extend the battery life of the tail buoy light. Possibilities include a propellor driven generator, a solar panel, or simply more batteries.

2. Sercel Acquisition System

This also performed well, with no major breakdowns during the cruise. Read errors on the tape drives cause the system to close down, and hence lose data, typically once an hour. Most of these errors occurred on the same tape drive, A. The tape drives are certainly the part of the system that is most liable to faults and the partial or complete loss of one tape drive is catastrophic to an mcs profile. It gives me nightmares. Almost all the loss of data we suffered was caused by faults on the tape drives.

c. I recommend that a third tape drive be purchased for the Sercel, to provide immediate stand-by replacement of either of the decks in use.

3. Refraction Technology Airgun Synchroniser

This was perhaps the most important improvement to the mcs system. It worked extremely well. The software is versatile but robust and it provided very good control over the six airguns we were firing. An excellent system.

4. Airgun Deployment System

The new system of binding the umbilicals together around a central strain member and suspending the airgun chambers from a bar towed below a buoy worked very efficiently. Obviously, airgun deployment systems still need improvement, as in rougher seas and colder weather than we became accustomed to, the airgun bar would be much more difficult to handle over the stern. Also the guns are much too close together, so they interact and severely degrade the signature. But this type of system is the best that I have seen to date on any NERC ship. The biggest problems experienced with the airguns were fatigue of the couplings, suspensions and hydrophone mounts. These problems were gradually reduced during the course of the cruise as Stan, Huw and Rob devised and machined various brackets and mounts to clamp the hoses and hydrophones. Presumably these improvements will be incorporated in future versions of the airgun systems.

5. Conducting Cable and Swivel

The new conducting swivel worked well. Unfortunately, the main block in the centre of the stern "A" frame was partially seized and would not swivel properly. The cable was chafing on the side cheeks of the block, and it looked for a while as if it would not be possible to use the block at all. There were no other blocks of sufficiently large radius on the ship to take the conducting cable. After 12 hours of lubricating the block, pushing and prodding it with the Hiab crane jibs, and pulling it with winches and blocks and tackle, the block was finally pulled to a more nearly vertical position and was used subsequently without difficulty. I recommend that the block be thoroughly overhauled at the next refit, and tested prior to any cruises requiring the conducting cable.

I recommend that the suspension bracket of the conducting swivel be redesigned so that there is less chance of damaging the electrical cable which links the conducting wire to the socket on the top of the swivel. At the moment this cable trails loose and could easily get pinched.

6. GPS Navigator

Fixes from GPS were available typically for six hours per day. They were extremely useful when available to calibrate the dead-reckoning navigation. However, successive fixes proved to be surprisingly variable in position. Possibly this is due to jumps to different constellations of satellites, or from 3 to 4 satellite fixes. We tried various smoothing parameters, without enormous improvement. This problem of jumping fixes needs looking into systematically, as the data seems much less good than the system is capable of providing. The GPS aerial could also be mounted much higher on the Darwin in a less shielded position than at present, which might improve matters. The computer software for merging GPS navigation into normal Transit-based navigation ought to be improved.

7. The Data Logger

This worked reliably. As mentioned above, the GPS fixes and also the Doppler Log ought to be interfaced into the system and used for producing navigation files wherever they are superior to the Transit-E/M log combination. A niggling nuisance is that the charts produced on the computer still have different aspect ratios to standard Admiralty plotting sheets, and so cannot be overlaid accurately on previously compiled data.

8. On this cruise we made very full use of the Scientific Plot behind the bridge as our main scientific control centre. It is, however, extremely inconvenient. It is vital to have good communication and access between firstly, the scientific plot and the working deck, and, secondly, between the bridge and the working dock. In practice, there is rather little need for frequent access between the bridge and the plot, which, as now configured, is the only route which does not entail three flights of steps and most of the length of the ship. I estimate that I went either up or down these three flights of steps over one thousand times during the cruise. I have heard various ideas to

move the Scientific Plot down to an expanded area of laboratory spaces near the main lab. I think that would be an excellent idea. In practice, I understand that many people without the heavy underway equipment and watchstanding requirements of our geophysical cruises already ignore the Scientific Plot and keep watches from the Main Lab.

9. The entire ship's propulsion and main power is dependent on a cooling unit which in these waters is prone to get bunged up by plankton. We had to stop once for 12 hours without power to clear the cooler and throughout the remainder of the cruise another such stop was threatened (although eventually not required). In worse weather than a flat calm we should have had to return to port, which would have lost a lot of time. I recommend that a small backup cooler be installed to maintain a reduced level of propulsion and services while the main cooler is cleared. I understand that the Chief Engineer first proposed this some time ago, but it has not been implemented.

13. SCIENTIFIC PARTY

Cambridge University

Dr. R.S. White
Dr. P.J. Barton
Dr. C.P. Peddy
Mr. T.R.E. Owen
Mr. M. Joppen
Mr. J.R. Leonard
Mr. T.A. Minshull
Mr. P.D. Patel
Ms. C. Peirce

Research Vessel Services

Mr. A.R. Cumming
Mr. D.R. Davies
Mr. G.H. Evans
Mr. S. Jones
Mr. G.C. Knight
Mr. S.J. Smith

National Institute of Oceanography, Karachi, Pakistan

Mr. A.A. Khan

R.R.S. "CHARLES DARWIN" CREW LIST November 15th. 1986

No.	Surname	Given Name & Initials	Rank/ Rating
1	WARNE	Philip H.	Master
2	JACKSON	Simon	Ch.Officer
3	CHAMBERLAIN	Roger J.	2nd.Off'r
4	BEAL	Shaun B.	3rd.Off'r
5	WARE	Richard J.	Radio Off.
6	BATTEN	George M.	Ch.Eng'r
7	ROBERTSON	Gordon A.	2nd.Eng'r
8	ANDERSON	James E.	3rd.Eng'r
9	THORPE	Kenneth J.	Elect.Eng.
10	POOK	Glenn A.	CPO(Deck)
11	BEVAN	David W.	Seaman 1A
12	PRIDDLE	Nicholas J.	Seaman 1A
13	ROACH	Arthur E.	Seaman 1A
14	BUFFERY	David G.	Seaman 1B
15	OLDS	Arthur E.	Seaman 1B
16	GIBBS	Ivan W.	Motorman
17	PETERS	Kevin	Cook/Stwd.
18	HUBBARD	Colin	Ships Cook
19	ACTON	Peter C.H.	2nd.Stwd.
20	CROSS	Michael J.	Steward
21	SWENSON	Julian J.E.	Steward
22	WHITE	Robert S.	Pr.Sc'tist
23	BARTON	Penelope J.	Scientist
24	CUMMING	Anthony R.	Scientist
25	DAVIES	David R.	Scientist
26	EVANS	Geraint H.	Scientist
27	JONES	Stephen	Scientist
28	JOPPEN	Mathias	Scientist
29	KHAN	Athar A.	Scientist
30	KNIGHT	Gareth C.	Scientist
31	LEONARD	John R.	Scientist
32	MINSHULL	Timothy A.	Scientist
33	OWEN	Timothy R.E.	Scientist
34	PATEL	Pravinkumar D.	Scientist
35	PEDDY	Carolyn P.	Scientist
36	PEIRCE	Christine	Scientist
37	SMITH	Stanley J.	Scientist

Master

14. TABLE OF JULIAN DAY NUBERS VERSUS DATE

Fri.	14	November	1986	=	318
Sat.	15	"	"	=	319
Sun.	16	"	"	=	320
Mon.	17	"	"	=	321
Tues.	18	"	"	=	322
Wed.	19	"	"	=	323
Thur.	20	"	"	=	324
Fri.	21	"	"	=	325
Sat.	22	"	"	=	326
Sun.	23	"	"	=	327
Mon.	24	"	"	=	328
Tues.	25	"	"	=	329
Wed.	26	"	"	=	330
Thur.	27	"	"	=	331
Fri.	28	"	"	=	332
Sat.	29	"	"	=	333
Sun.	30	"	"	=	334
Mon.	1	December	"	=	335
Tues.	2	"	"	=	336
Wed.	3	"	"	=	337
Thur.	4	"	"	=	338
Fri.	5	"	"	=	339
Sat.	6	"	"	=	340
Sun.	7	"	"	=	341
Mon.	8	"	"	=	342
Tues.	9	"	"	=	343
Wed.	10	"	"	=	344
Thur.	11	"	"	=	345
Fri.	12	"	"	=	346
Sat.	13	"	"	=	347

SECTION 15

DEEP TOW REPORT OF CD 18/86

1. Equipment list

2 x electronics package
2 x pressure vessel & endplates
2 x acoustic transducer Datasonics DSS-350
1 x long streamer of 30m length
1 x short streamer of 20m length
2 x weight stand & aluminium wrap-around
32 x steel bar weight (25kg and 30kg)
various leads, shackles, strops

2. Deployments

2.1. Dalrymple Trough 322/1120Z - 323/0400Z

When the Deep Tow package reached 200m below the sea surface, the carrier signal disappeared and we had to recover the instrument. A careful inspection on the aft deck and in the main lab only proved that the instrument was working perfectly. We then noticed that the plug to the connector on the conducting swivel had slightly slipped out, which most likely had caused the loss of the signal. We taped all the connectors together and redeployed the package.
At a depth of 500m the sea surface reflection of the 3.5kHz pinger started to fade away which we thought was due to the low voltage of the Nicad battery pack. By then the instrument had been running for more than 24 hours. The poor signal of the sea bottom reflection made me to decide to keep it at a level of 800m instead of 400m above the seafloor.
The two 300cui airguns equipped with a wave shape kit and an additional 40cui gun turned out to be too weak a source array and only produced signal penetration of 1s. At the end of the line noise tests with varying haul in/pay out rates were carried out, which confirmed that the streamer was perfectly balanced.

2.2. Owen Fracture Zone 334/1000Z - 335/1043Z

For this deployment we decided to use a more powerful array of guns (20,40,2x160,300,466cui). We fired every 15s and slowed the towing speed down to 1.5knots. All these measures led to a much better quality of recording with signal penetration of 3s.
The 3.5kz receive signal however had not improved and only showed the sea bottom reflection which makes it somewhat more difficult to process the seismic data.
A broken solder joint at the termination of the single conductor cable had caused another delay and by the time the instrument was running smoothly and we had not finished the line yet, the OBS team pressed to finish the survey.
When we finally pulled in the instrument package, the transducer stopped pinging. As it turned out a cupful of water had leaked through and shorted out the pinger circuit, when the instrument was lowered onto the deck horizontally. The boards were washed in fresh water to remove the corrosive salt water and two component faults were fixed the following day.

2.3. Owen Basin 341/0420Z - 342/0010Z

On the last deployment of the Deep Tow we used electronics package No.2, which had been build by T.R.E. Owen. It was not equipped with a 20Hz highpass filter

as package No.1 is. The high amplitude low frequency towing noise limited the amount of gain that could be applied to the seismic signal before modulation. This severely limited the signal to noise ratio.

3. Improvements & repairs

3.1. electronics package

In order to improve the signal to noise ratio a 20Hz low pass filter should be installed before the first preamp stage in the small pressure vessel.
The leak during the second deployment only caused minor damage to electronics package No.2. One power transistor and the high power chip on the logic board got damaged and were replaced the following day. The Nicad battery pack should be replaced since it shows corrosion from the salt water.

3.2. pressure vessels

The threads on both pressure vessels are damaged. Only pressure vessel No.1 seals so that metal face sits on metal face and there is no gap visible. On the other vessel there is a gap of 15 thou, which cannot cause any leakage according to T.R.E. Owen. (One of the endplates fits on one particular thread only after having been forced over the last turn before it locks.)
One of the endplates had been remachined and reanodised. The bulkhead connector sealing face had been left slightly rough which caused water to leak through on the second deployment.
The coax bulkhead connector leaked on the second deployment which caused spark corrosion between the contacts. The plug of the coax lead got damaged and needs replacement.

3.3. transducers

Transducer No.1 only provided a strong enough receive signal from less than 500m off the seafloor. The cause of the weak signal reception was never found and is most likely related to the transducer rather than to the amplification stages in the electronics package itself which were carefully tested out.
Transducer No.2 leaked oil through the sealing of the rubber shoe at the bottom face and needs refilling.

3.4. streamers

Only the long streamer was used for the deployments. It seems to be well balanced, but the polyurethene tubing has suffered from the various deployments throughout its life and has hardened so that is prone to scratches and kinks.
The short streamer served as a backup and was never in use.

3.5. weight stands

The weight stands were used with more steel weight bars than they were designed for which made it impossible to mount the aluminium fairing. Allen bolts should be used to clamp the pressure vessel.
The strops were tested in January 1986 and the certificate is valid for one year only.

3.6. RVS conducting swivel

The conducting swivel was equipped with underwater mateable Electro connectors, which cannot be locked. On the first deployment the plug slipped out of the connector and caused an intermittent signal. By taping the connectors together

we cured this problem. One of the three slip ring assemblies within the conducting swivel was not connected up, which is now being fixed according to M.C. Sinha.

3.7. single conductor cable

The termination at the bottom end of the cable has to be redesigned. The solder joint with the pigtail of the conducting swivel had caused an intermittent signal on the second deployment.
The maximal load with 900kg weight in the water and 6000m wire out never exceeded 3.5tons.

Mathias Joppen
05/02/87