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CanRidge III to southern Explorer Ridge
and West Valley, Juan de Fuca Ridge.

1994

CRUISE REPORT

CanRidge III

to

Southern Explorer Ridge
and
West Valley, Juan de Fuca Ridge

CSS John P. Tully
John Anderson, Captain
with
ROPOS ROV
Keith Shepherd, Chief Pilot

Steve Scott, Chief Scientist
Nigel Edwards, Co-chief Scientist

July 18 - 29, 1994

Compiled and edited by S.D. Scott from reports written by
participating scientists

1941
1942
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2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025

TABLE OF CONTENTS

Scientific Participants	3
ROPOS Pilots/Engineers	3
Objectives	4
Abbreviations	4
Summary	5
Acknowledgements	7
Distribution	7
DATA SUMMARY	
Daily Narrative	8
Navigation	19
Station Listing	19
ROPOS Operations	24
Electromagnetic Measurements	29
Hydrothermal Deposits	32
Petrology	34
Description of Rock Samples	35
Macrobiology	40
Microbial Geochemistry	42
CSS John P. Tully	46
Appendix: Dive Narratives	48
Dive 281	49
Dive 282	66
Dive 283	68
Dive 284	77



SCIENTIFIC PARTICIPANTS

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ROPOS PILOTS/ENGINEERS

Keith Shepherd, Chief Pilot, IOS Pat Bay
Dan Conway, DTEC Ltd.
Bob Holland, IOS Pat Bay
Kevin Kelly, HURL, University of Hawaii
Keith Tamburri, DTEC Ltd.

OBJECTIVES

We proposed to deploy ROPOS with seafloor transponder navigation at the "Magic Mountain" and neighbouring vent sites of Southern Explorer Ridge, NE Pacific Ocean for geological, geophysical and biological investigations. The geological activities included locating, mapping and sampling sites of hydrothermal activity (rocks, sulfides and vent fluids), concentrating mainly on "Magic Mountain" while holding the nearby AGOR 171 site as a secondary target. The geophysical experiments were designed to obtain electrical images of the crust. They included the deployment of highly sensitive ocean bottom magnetometers from TULLY, part of an experiment to search for magma chambers beneath the ridge. A second project used instruments carried to the seafloor on ROPOS to create a three dimensional view of a sulfide tomographically. Biological studies focussed on bacteria in and around the vent sites and the collection of a variety of faunal specimens.

ABBREVIATIONS

- CSTEM Controlled source transient electromagnetic system (see TEM).
- E/S Echo sounding survey. Numbering starts at E/S-1. The Simrad 12 kHz echo sounder had not been calibrated and reads 40m too shallow according to Kim Juniper, Chief Scientist of the preceding leg.
- OBM Ocean bottom magnetometer within orange pressure casings, deployed from surface.
- ROPOS "Remotely Operated Platform for Ocean Science" - a tethered ROV.
- SER Southern segment of Explorer Ridge
- TEM Ocean bottom electric dipole-dipole transient electromagnetic system. The computer controlled electronic systems are installed in two pressure cases. The electrodes are attached to flexible PVC pipes. The array may be deployed from the ship or carried by ROPOS in two separate units to the sea floor.

SUMMARY

CanRidge III was the third leg of an ongoing Canadian investigation, based at the University of Toronto, concerned with the geology, geophysics and biology of ocean ridges as a contribution to the international InterRIDGE program. CanRidge III deployed the Canadian ROPOS remotely operated vehicle (ROV) four times at southern Explorer Ridge (SER) in the northeast Pacific Ocean where previous cruises since 1984 had discovered many, large and small, active and inactive, hydrothermal vents and metallic sulfide-sulfate-oxide deposits. Additionally, echo sounding survey work navigated by differential GPS was done at a hydrothermal site discovered during the CUROSS II expedition in 1987 along the spreading axis of West Valley at the far northern end of the Juan de Fuca Ridge. ROPOS operations at SER included mapping, sampling geological and biological materials, and conducting a transient electromagnetic (TEM) experiment for determining the thicknesses of different geological units from their electrical resistivities. Additionally, two ocean bottom magnetometers, dropped from surface, recorded data for three days each using natural ionospheric radiation as a source. The cruise was successful despite having only 8.5 days on station of which 4.5 days were lost to weather and 1 day to mechanical-electrical problems with the ROV system. Some mapping, critical systematic sampling of geological materials and a second planned TEM experiment could not be done because of the shortage of time.

The main part of the Magic Mountain hydrothermal deposit and the adjacent areas to the west and southwest were located, mapped and randomly sampled. With both transponder systems (Benthos and Oceano) not fully operational for different reasons, navigation was by range and bearing on the cage using ROPOS' sonar and making the assumption, which was usually but not always correct, that the cage was directly below the stern of the ship, itself located within a few metres by differential GPS. Some transponder ranges displayed by the receiver were hand calculated to give accurate fixes but this was done infrequently because of the time used up in doing this and the necessity of shutting down ROPOS' systems for about 30 seconds at a time when ranges were being measured. While this map will be suitable for some purposes, it needs to be checked and extended further afield using good transponder navigation for detailed and systematic studies of geology, geophysics and biology.

For the TEM experiment ROPOS placed an EM dipole receiver on the southwest edge of Magic Mountain. The transmitter was carried by ROPOS to different directions and distances from the receiver, the electrodes contacted on or near the seafloor and a signal was transmitted in two orthogonal orientations of the ROV. Lack of continuous computer linked transponder navigation was a definite problem because positions must be known within a few metres for proper interpretation of the data. The experiment was conducted

before the main sulfide deposit was located at Magic Mountain but appears to have obtained good data in the low temperature hydrothermal southwest margin. The experiment should be repeated on the main sulfide mound as a means of determining its thickness.

ROPOS is a marvelous tool when it is working properly and has many advantages over a heavy occupied submersible, the most important being endurance. Altogether ROPOS achieved in 4 dives (one of which was aborted after 25 minutes of bottom time) 56h59m of total dive time, 42h55m of bottom time, took 37 geological samples, numerous and diverse biological samples, 375 still photos, recorded 42 hours of black and white wide angle SIT video and 44 hours of colour close range video. CanRidge III dives lasted for as long as almost 17 hours of bottom time and this was terminated by choice. However, the system has to be used more extensively if it is to become reliable, as commercial and paying scientific users will demand. Breakdowns are inevitable if a complex machine like ROPOS spends long periods of time in the Pat Bay hanger. As a minimum, its obsolete telemetry system for which spares are no longer available must be replaced, the transponder navigation system must become absolutely reliable, and a heave compensator needs to be added to the cable termination on the cage to dampen the snap loads that are inevitable in the normal good-weather sea states of 3-4 (15 kt wind, 1-2 m seas with >7 sec. period) that are encountered in the offshore.

CSS John P. Tully ran flawlessly during the ROPOS and other operations. In most cases, the ship was able to hold station within better than 25 m for hours on end using only its main engine and bow thruster in all sea states (dead calm to 3-4), thanks to differential GPS, an excellent computer graphics navigation display and the dedication and skill of a very talented bridge crew. The deck crew launched and recovered a multitude of equipment including the 6700 kg ROV and cage, once under difficult conditions, with great skill.

CanRidge IV will return to SER with ROPOS and reliable transponder navigation to conduct the detailed geological mapping and sampling, TEM experiments on the main sulfide mass of Magic Mountain and biological sampling of a variety of well located sites that could not be done properly on CanRidge III for lack of time and good positioning. A minimum of three weeks of ship time is essential if cruise objectives are to be met in the face of anticipated down time for reason of weather and normal mechanical repair and maintenance.

ACKNOWLEDGEMENTS

CanRidge III achieved most of its objectives thanks to the excellent and good humoured ship handling by Captain John Anderson and his officers and crew of R/V John P. Tully. As always, people at the Pacific Geoscience Centre, particularly Bill Hill and Bob Macdonald, and at the Institute of Ocean Sciences were most helpful in providing equipment, logistics support and advice.

Steve Scott and Nigel Edwards are funded for their continuing work on the Juan de Fuca and Explorer Ridges by Research, Equipment, Ship Time and Special Project grants from the Natural Sciences and Engineering Research Council of Canada. Additional support from the Bank of Nova Scotia and the University of Toronto is gratefully acknowledged. Graeme Cairns holds an NSERC studentship. Marion Jegen has a Government of Canada award. Liming Yu is supported by the Government of Ontario. Ganpat Roonwal is a Commonwealth Fellow. IFREMER and UBO paid Marc Constantin's expenses within Canada. Andrew McArthur holds an NSERC student scholarship. Steve Scott thanks the Hawaii Undersea Research Laboratory at the University of Hawaii for providing facilities and support while on research leave and for allowing Kevin Kelly to participate on CanRidge III as a ROPOS engineer.

Distribution of full report (91 pages)

CanRidge III shipboard scientists (12)
Keith Shepherd, ROPOS
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Distribution of summary only (7 pages)

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Trevor Lewis, Acting Director of PGC
Capt. John Anderson, IOS
Marie Edmond, NSERC
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DAILY NARRATIVE

Pre-cruise

Scientific and one ROPOS personnel arrived in Sidney, B.C. during the week of July 11 from Toronto, Brest (France), Delhi (India), Honolulu and Victoria. Four of the ROPOS crew were on board from the previous leg (BioROPOS: Juniper/Tunncliffe). Geophysics and some geology equipment and supplies were air freighted from Toronto. Roonwal and Scott hand carried last minute items from Toronto and Honolulu, respectively. Small items of hardware, film, more blank video tapes, etc. were purchased in Sidney and Victoria. Thin walled titanium tubing to make snorkels for the vent fluid samplers arrived too late in Toronto.

TULLY arrived at the Pat Bay docks at about 0930h Friday July 15 and unloaded small equipment from the BioROPOS leg. Most of our gear was loaded that afternoon and on Saturday. A trip was made in a rented car to Vancouver on Saturday by Grant Ferris and Larry Petrie to pick up 2 S-VHS high resolution video monitors and 2 S-VHS VCR's which Verena Tunncliffe advised we would need in order that a group of scientists can observe the seafloor video feed without encroaching on ROPOS pilots' space during a dive. This equipment could not be shipped to us by bus because the retailer lacked packing cases.

Day 1 Monday, July 18

Departed from Pat Bay dock at 1245h, launched and returned ashore one of the motorized life boats and then at 1300h proceeded via the Inside Passage to southern Explorer Ridge.

Science meeting held for 1 1/2 hours to explain the cruise objectives and ROPOS' capabilities. Decided transponder positions.

Met by R/V VECTOR in the evening and transferred to them some hydraulic oil. Social gathering on the afterdeck during a glorious sunset.

Day 2 Tuesday, July 19

Fire and boat drill as we rounded Cape Scott on the north end of Vancouver Island. Watches started at 2000h:

8-12 Watch: Constantin (captain), Nangini, Yu

12-4 Watch: Petrie (captain), Cairns
4-8 Watch: Roonwal (captain), Ferris, Jegen
0000- 1200 (biology): McArthur
1200-2400 (biology): Franklin

Co-chief Scientist on call:

0000-1200: Edwards
1200-2400: Scott

Arrived in vicinity of "The Pimple" on southern Explorer Ridge (SER) at 2312h.
Total transit time 34h12m.

E/S-1 echo sounding run from east to west across "The Pimple" to check its location in differential GPS (DGPS). The Pimple is a high standing edifice on SER shoaling to 1760m that previous CASM, CUROSS and CanRidge cruises have used to coordinate. The Pimple was located at 49°47.02' 130°14.83' (interpolated) at a measured depth of 1725m which is corrected to 1765m. (The 12 kHz echo sounder has not been calibrated and was reported by the BioROPOS group to be reading 40m too shallow). This position found on E/S-1 is in excellent agreement with the SeaBeam map that had been reprocessed by Larry Petrie.

Cleaned the heads on the two ROPOS VCRs which participants on the previous leg said were too dirty to be useful.

Day 3 Wednesday, July 20

Sea conditions (wind NNW 20-25 kt, sea 2-3 m, wave period 3-5 sec.) are outside specifications for safe launching of ROPOS.

E/S-2 echo sounding run on a south to north track located "The Pimple" at 49°47.01' 130°14.40'. Average position from E/S-1 and E/S-2 is 49°47.015' 130°14.815'. This compares favourably with the position obtained by careful traverses with normal GPS during CanRidge II at 49°46.97' 130°14.81'. The estimated insonified area of the 12kHz transducer having a 33° cone is ~525m at 1766m water depth. Therefore, a shift in the navigation relative to the reprocessed SeaBeam is not required.

Transponders were deployed with 100m tethers in a more or less square pattern near Magic Mountain at the following locations (see July 21 for calibrated bottom positions):

#1	10.5kHz	49°46.35'	130°16.23'	1793m (uncorrected)
#2	12.5 kHz	49°45.75'	130°16.88'	1830m (uncorrected)
#3	13.5 kHz	49°45.31'	130°15.59'	1811m (uncorrected)
#4	14.5 kHz	49°46.01'	130°15.30'	1775m (uncorrected)

Attempt to calibrate the transponders (i.e., determine precise locations on bottom) with the Oceano receiver failed because the computer could not read the range data. The problem is apparently Jim Ilman's software but this could not be fixed because the password to enter the source program was not available. Oceano software also malfunctioned so calibration attempts were abandoned temporarily.

OBM's dropped on SER as follows:

"L8R"	0714h	49°45.59'	130°16.00'	(near magic Mountain)
"CU2"	0900	49°44.85'	130°19.98'	(off ridge to the west)

E/S-3 was a 3.5 and 12 kHz echo sounding run across SER in the vicinity of Magic Mountain. Ok on 12 kHz. Very poor records on 3.5 kHz; 12 kHz sounder puts bundles of diagonal lines across 3.5 kHz records.

Calibrated transponders using the Benthos receiver. Obtained 37 good readings out of 94 tries. Locations of transponders are as follows (x,y,z values are UTM coordinates - m from Greenwich - which uses a central meridian of 130°00' so there will be minor distortion; x is latitudinal, y is longitudinal, z is vertical):

#1	49°46.34'	130°16.25'	x=480500.6	y=5513350.4	z=1682.7
#2	49°45.74'	130°16.84'	x=479782.6	y=5512245.2	z=1719.1
#3	49°45.275'	130°15.63'	x=481241.2	y=5511376.3	z=1714.5
#4	49°46.13'	130°15.30'	x=481638.8	y=5512952.0	z=1685.8

For plotting and calculation purposes, the 4 was omitted from all x values and 551 from all x values. The z value was ignored.

Day 4 Thursday, July 21

Sea conditions (wind NW 20 kt, sea 2 m) are still outside specifications for safe launching of ROPOS. The weather pattern seems to be stable and, in reality, is normal sea and wind for the NE Pacific in summer. This particular wind is being caused by abnormal heating of the BC interior (temperatures 35-42°C) creating a thermal low into which air from the NE Pacific high is spilling parallel to the coast. The weather pattern will continue until the heating on land dissipates. Inability to launch ROPOS in such wind and sea conditions because the ship's A frame or ROPOS' cage lacks a heave compensator is a definite shortcoming.

E/S-4 & 5 were attempted 3.5 kHz echo sounding traverse across the failed rifts to the west of SER. E/S-4 was aborted part way through because of bad records. The EPC recorder was tweaked and the traverse continued as E/S-5. The records were so poor as to be virtually useless and certainly of no value for subbottom profiling. This is the

same deck box borrowed from PGC that we have not been able to get to work in deep water on several of our previous cruises.

A fax was received from the Superintendent of IOS Ships Division, Ray Mackenzie, saying that Tully was to **return a day earlier than scheduled** to Esquimalt so a crane there could be used to offload ROPOS and its winch. This cannot be done at Pat Bay because of load restrictions on the dock. Crane operators are taking Friday off work for some unknown (to us) reason so the job has to be done on Thursday. Chief Scientist Scott telephoned Mackenzie and objected strenuously to losing a day on an already short cruise. NSERC had paid \$106,000 for the ship time and a significant sum towards ROPOS (\$93k in 1993 and \$60k so far in 1994). According to Mackenzie, the NSERC ship time money would buy only 10 days, not 12, and we would get the 10 days. Nevertheless, the cruise plan had been approved and reconfirmed with Captain Anderson just the preceding Friday. It was unfair to bump us in favour of an in-house cruise (Tom Juhasz) coming up next and for whom the afterdeck had to be cleared. During a second call with several other people at IOS listening in on a speaker phone, a compromise was reached whereby we would come in to Esquimalt on Friday but at 0800h instead of 1000h and the cruise would pay the approximately \$700 for the crane. This money will come from the NSERC ROPOS grant.

The **Benthos does not work in relay mode** (malfunction) so we will use the Oceano during dives and calculate positions from ranges. Edwards, with the help of information faxed to the ship from Toronto, wrote a DOS program which converts ranges from 2, 3 or 4 transponders to UTM coordinates.

Chief Scientist discussed with the Captain and First Mate the likelihood of the weather being more conducive to ROPOS operations 94 miles further south at West Valley on the Juan de Fuca Ridge. A fax was sent to R/V New Horizon enquiring their whereabouts and weather. Response was that they were at 44° (central Juan de Fuca Ridge) with wind 15-20 kt, seas 6 feet, wave period 6 sec (ROPOS minimum is 7 sec.). This is too far away to be meaningful for us. Decided to proceed south anyway. There is a hydrothermal site on the ridge axis of West Valley at 48°28.8' 129°03' that was photographed during CUROSS I & II and an EMR cruise, and described by Scott et al. (1988, EOS, v. 69, no. 44, p. 1497) and Leybourne and Van Wagoner (1992, Can. Jour. Earth Sci., v. 29, p. 2346-2352).

Transit to West Valley at 1900h.

Day 5 Friday, July 22

Arrived at West Valley at 0540h. Transit time 10h40m.

Sea conditions (wind NW 20 kt, sea 2-3 m) are outside those in which it is safe to launch ROPOS. This was the third dive day in a row lost to weather.

E/S 6 - 11 echo sounding surveys were conducted to locate a small prominent mound just north of the hydrothermal site in West Valley to tie DGPS navigation in with the SeaBeam map and CUROSS I & II camera/video tows. Some crossings of the mound were indistinct and some records were poor. The top of the mound, in the two navigation systems, is at:

SeaBeam chart	48°28.95'	129°02.20'
DGPS	48°28.85'	129°02.30'

The SeaBeam grid must be shifted 0.1'N and 0.1'E although these are within the error of measurement by a 33° cone of insonification.

Transit back to SER at 1130h. Bouncy ride directly into moderate seas. Slowed for easier ride and arrival at SER in time to recover the first OBM due on surface at 0655h. Assembling EM apparatus ("Pipe Dream") to be deployed from the ship if ROPOS cannot be launched tomorrow.

Day 6 Saturday, July 23

Arrived at the vicinity of Magic Mountain on SER at 0500h.

Recovered CU2 OBM at 0726h. It came to surface (beacon first heard) on time at 0655h as detected by its radio beacon and was sighted at 0700h. Position of recovery was not recorded. There was a smear of khaki coloured sediment on one of the weight holders so this OBM was deployed on sediment as planned.

Recovered L8R OBM at 0810h at 49°45.88' 130°15.73'. This one seemingly came to surface at 0747h and sighted at 0810h. The recovery location was about 0.4 n mi. from the deployment. Good data were recorded by both OBM's.

Weather is moderating and it is anticipated that we may be able to launch ROPOS later in the day. Wave height is about 1m but with a few bigger waves that could cause snap loads on the fibre optic cable.

Decided to commit 6 hours to deploying the "Pipe Dream" in order to fill in time usefully waiting for appropriate conditions to launch ROPOS. Pipe Dream is an EM unit with a control box in a cylindrical pressure housing in the centre, a transmitting electrode at the end of one 30m long PVC tube (ordinary electrical conduit obtained from ship's stores) and the receiving electrode at the end of another colinear 30m long PVC tube. The design by Nigel Edwards and software by Graeme Cairns were done in haste aboard ship. A transponder set to 12 kHz was to be used in place of a pinger but it was subsequently decided to do only a shallow water test to see how the instrument behaved so the

transponder was not used. Considerable discussion on how to launch and, particularly, recover the apparatus.

Deployed Pipe Dream EM to 350m to test launch and recovery procedures, how the apparatus behaves in water and whether a signal could be measured. Launch and recovery went smoothly. Some data were recovered but the sampling rate was too fast and the data were corrupted.

DGPS was not receiving a signal just prior to ROPOS launch. Keith Shepherd inspected all connections including the one at the antenna up the stern mast. All were fine. On closer inspection, it was found that the GPS was searching for satellites in a completely different part of the world and had to be reinitialized. A "dial twiddler" was suspected.

Dive 281 was to the north end of East Valley in search of Magic Mountain or any other active hydrothermal vents. ROPOS carried its sample tray, suction sampler, 35 mm Photo Sea camera in mono mode with a 250 shot film magazine, colour and SIT video and the standard claw on its 7 function arm. The suction sampler became disabled during the dive when the hose became separated from the nozzle and the sample tray would not rotate when deployed making it difficult to store samples. With the transponder net essentially nonfunctional, the search was conducted by ranging outwards from the cage along N, NE, E, SE ... tracks for about 100m, returning to the cage at the end of each run. The slant range and bearing from the cage was determined by sonar. These ranges have to be converted to true distance by knowing the depth below the cage and the height of the cage off bottom. The ship held station usually within about 25m of the waypoint and was then moved slowly to the next position such that the ends of the search lines overlapped slightly. This worked very well because the cage hung straight down from the stern and the ship was able to keep station usually within about a 25m radius of the waypoint through good seamanship and the Ilman navigation software. The software displays at different scales the outline of a ship with its GPS antenna indicated by a small circle, the waypoint and a circle of arbitrarily chosen radius around the waypoint. The best estimate of the location of Magic Mountain was at $49^{\circ}45.50'$ $130^{\circ}16.20'$ which is on the west side of East Valley on the ridge separating East and West Valleys. Two stations were occupied and this area was found to be devoid of any indication of hydrothermal activity. Indeed, the water was so clear that the light on the cage could be seen with ROPOS' SIT camera at a distance of 100m. The search then moved to the east side of East Valley where 5 stations were occupied. Metalliferous sediment, jarosite?, mounds and dead chimneys were found on several traverses indicating a concentration of former hydrothermal activity centered around $49^{\circ}45.45'$ $130^{\circ}15.69'$. The three types of chimneys sampled were Fe-Si oxyhydroxides with probable nontronite, barite and pyrite. Some very large spires were encountered that were too strong for a sample to be broken off. On the easternmost traverse a dense "snowstorm" which was thought to be a hydrothermal plume (subsequently proven upon

examination of a suction sample) was encountered and followed. This brought ROPOS to a mound of pillow lava at 49°45.55' 130°15.62' which sprouted dense clusters of small (30 cm long) tube worms. A temperature reading in a cluster gave 4.22°C. The site was named "ROPOS Garden". No obvious venting and no sulfides were observed. Altogether, the dive returned many hours of video (8 2-hour tapes each of both SIT and colour), 132 still photos, 7 samples of hydrothermal material, 5 basalt samples, 4 suction samples consisting of solids and water and numerous biological specimens including a putative new species of shrimp. The dive lasted 21h36m from launch (1655h Saturday) to recovery (1431h Sunday) with 16h49m of bottom time. This was the longest dive that ROPOS has ever had.

Day 7 Sunday, July 24

Rich Lutz, Chief Scientist of an Alvin/Atlantis II cruise presently at Middle Valley, spoke with Scott by radio about the possibility of their doing a dive at Explorer Ridge. From lengthy communication between Scott and Lutz prior to the cruise, it was recognized that the ROPOS/Tully cruise had priority at the site and this was so stated by the Canadian Department of External Affairs in the clearance papers issued to Atlantis II. Scott had given Lutz the coordinates of the hydrothermal site in West Valley of the Juan de Fuca Ridge as an alternative. The radio communication reconfirmed the arrangement that Scott would give Lutz advanced notice if ROPOS was unable to dive the following day as Alvin could reach the site overnight.

Sea conditions are flat calm with only a slight swell, ideal for diving.

Deployed OBM'S for the second time. Each carries a sediment corer designed by the Chief Engineer and consisting of a 1" nipple to hold the sediment and a check valve to stop the back flow of water on ascent attached to a piece of pipe that was hose clamped onto one of the uprights of the OBM's cradle.

CU2	1659h	49°45.00'	130°09.50'	East of SER
L8R	1755h	49°45.59'	130°16.09'	N end of East Valley

Both are set to return to surface on Wednesday, July 27 at 1815h (L8R) and 1900h (CU2).

Dive 282 with the TEM experiment aboard was aborted due to a short in the cage 25 minutes after it reached the bottom in the vicinity of ROPOS Garden. An inactive sulfide chimney was encountered. When ROPOS was examined on surface at 0200h (Sunday), the short was found to have been caused by water in the tether termination can. Also, a gauge was torn off the tether compensator in the tether spooling drum by some unknown means causing flooding of the slip ring assembly. Faults in the nav computer and the cage's video camera also cropped up. The repairs took longer than expected and

eventually consumed about 24 hours. This was the biggest repair job ever done on ROPOS at sea.

Day 8 Monday, July 25

Sea conditions dead calm with very slight swell.

Repairs to ROPOS continued through most of the day. The results of Dive 281 were plotted at 1:10,000 scale to give a clearer indication of where the hydrothermal deposits are. Magic Mountain is expected to be on the hill to the NNE of the Dive 281 stations.

Lutz and Scott spoke again by radio. Alvin dive at West Valley on Juan de Fuca Ridge found abundant stalked sponges at coordinates Scott gave him but no hydrothermal vents or products. Was not able to sample basalt because it was very tight pillows. Will send Scott a video of the dive so he can check it against CUROSS I and II photos and video. Alvin will dive at SER on Thursday after we depart.

Dive 283 with the TEM experiment aboard was launched in the vicinity of abundant sulfides on Dive 281. The receiver was carried to the seafloor in ROPOS' two claws and placed on a mound of metalliferous sediment and pillow lava at the foot of a hill at 49°45.45' 130°15.60' which was later determined to have a large sulfide deposit on it. ROPOS' claw was able to sink 8 cm into the sediment before encountering resistance. One of the electrodes on the whisker poles (flexible electrical conduit) was touching the seafloor and the other was about 1 m off the seafloor. The third electrode was dragged away from the receiver pressure housing by ROPOS. A fourth electrode was attached to the housing. The orientation of the electrode array was determined and the ship was then moved so that the cage was positioned over the receiver in order to facilitate the running of short transits and be a beacon for retrieving the receiver at the end of the experiment. Navigation was by means of the transponder net which was not fully operational and provided about 10m accuracy. The sub's propulsion system had to be shut down for transponder readings and positions calculated with a computer program. When the receiver was deployed, ROPOS became very light and had to be ballasted with two lumps of basalt which were retained as samples. ROPOS was driven away from the cage and from time to time sat on the bottom in two orientations at right angles while EM transmissions which were programmed automatically for every 5 minutes took place. The first line with a NE heading encountered an inactive 10m spire and a large sulfide mound. Two small samples were taken of this mound. Transponder fixes showed that the line initially went NE but by the end of the tether (about 150m) the sub was due east of the cage. A southwest heading to regain the cage put ROPOS due south of the cage. Therefore, there must have been a

current from the north. Several reasonably well navigated measurements were made during the 9h53m of bottom time. The northeast line was the only one to encounter sulfides. The others were over pillow lava. The SIT video for the entire dive was not recorded because of a malfunction in the VCR. On recovery, the transmitter was found to have a broken wire and a malfunctioning amplifier. However, good data appear to have been obtained.

Day 9 Tuesday, July 26

Sea conditions 1 to 1.5 m waves, slight swell, wind variable but light.

ROPOS' tether could not be wound back into the cage at the end of Dive 283 so the cage was recovered with the A-frame as normal, the tether was pulled in by hand and ROPOS was recovered with the ships crane. The recovery was difficult but went well. The repair of the tether winder was not difficult.

E/S-12 was an east to west echo sounding run across the top of the hill where the NE line in Dive 283 encountered extensive sulfides (inactive) and Magic Mountain is suspected to be lurking. The pinnacle at 1814m plots off center on the western side of the 1820m contour on the reprocessed SeaBeam map.

Launch held up for several hours by repair to cage video camera. Also, the video port in the rented VCR for the SIT camera was found to be faulty and was repaired.

Dive 284 continued the geological search for active hydrothermal venting at Magic Mountain. Three colinear stations about 75 m apart were occupied on the flank of a prominent hill on the east side of East Valley and search patterns were conducted as for Dive 281. The temperature probe was not working because of a problem in the electronics can and would have required about 6 hours of down time to fix. The suction sampler was fitted with 60 and 120 micron filters but these were too fine and clogged quickly when samples were taken. The suction sampler was slightly damaged and two bottles were lost, probably from a collision with a rock during the dive. All other equipment functioned normally. Extensive areas of sulfide mounds, spires to about 10 m tall, talus and metalliferous sediment were encountered and mapped using range and bearing on the cage as a reference. Only 2 transponders could be received and fixes from these were ambiguous. There was a strong set to the south such that lines run with a heading, for example, of NE actually went due E. Also, some lines ended far from their intended position when a good range and bearing on the cage were obtained. The area should be remapped systematically with good transponder navigation. The sulfide area investigated in Dive 284 appears to be about 100 x 75 m and occupies the south and southwest side of the hill whose peak was located by E/S-12 near and within the 1820 m SeaBeam contour (SeaBeam depths determined for a constant velocity of sound through water are greater

than ROPOS depths determined by pressure gauge by about 50 m). Station 3 (49°45.530' 130°15.504' x = 81389 y = 1849) was right over a vent field. One vent which we sampled consisted of a single vigorously active chimney sitting on a 1-metre high mound of soft white material (probably anhydrite). The best area of large spires and both active and inactive chimneys is at the top of a N-S scarp to the west of Station 3 at a ROPOS depth of 1768 to 1773 m. Here there is a cluster of 20 or more spires up to about 10 m tall over an area about 30 x 10+ m. The spires are broad at their base and taper upwards with flanges growing out of their sides. From the distance in the SIT camera, they look something like Christmas trees with snow on them. At their tops are small chimneys which look like organ pipes. Some of these are venting hot water as black smokers, some are lower temperature white smokers and many are inactive. Small spires, both active and inactive, are scattered about. The spires, big and small, are surprisingly devoid of animals although some do have clusters here and there and some are totally covered by fauna. Four vertical sections were measured up the N-S scarp on top of which this field of spires sits. Thicknesses of massive sulfides range from 8 to 23 m (average 18 m). The mound is covered on its lower slopes by a talus of pillow basalt and sulfide blocks. This is probably the area of the sketch in the 1986 Tunnicliffe et al. paper in Deep-Sea Research. The entire area of this hill (and we did not explore all of it) appears to be quite a lot more complicated than the sketch in that paper with fields of pillow lava interspersed with sulfide mounds and spires, and high scarps striking both N-S and E-W. The detailed plotting of the traverses should make the picture more clear. A colony of large crabs which look something like Dungeness crabs were seen and may be a new species. An attempt to capture one with the claw failed.

Day 10 Wednesday, July 27

Dive 284 concluded at 1825h with ROPOS on deck. Length of dive 19h15m, bottom time 15h48m, 251 photos taken, 8 2-hour tapes each of b&w SIT camera and colour camera, 18 samples collected.

Totals for ROPOS: 4 dives, length 56h59m hours (includes Dive 282 which was aborted after only 25 minutes of bottom time), bottom time 42h55m, 37 geological and numerous biological samples collected.

Recovered OBM L8R at 1810h and **CU2** at 1945h. Their timers had been set erroneously but this will not have affected the data. Both returned a complete data set. There was no evidence that the OBMs landed on sediment and the corers were returned empty.

Recovered all four transponders, the last one just as darkness was setting in.

Sea conditions deteriorated to 20 kt wind and 2-3 m waves. Decision made at 2015h not to dive again. The next dive would have carried Verena Tunnicliffe's "chimney catcher" and would have done systematic sampling from the base to the top of active and inactive mounds.

Rich Lutz on the Atlantis II radioed by Scott and given detailed information about where to launch Alvin and what bottom traverses to run in order to find the vent fields located on Dives 281 and 284.

Departed at 2030 for Esquimalt via Cape Scott and the Inside Passage. Suitable celebrations in the officers' lounge and main lab.

Day 11 Thursday, July 28

Dense fog on the B.C. coast necessitated continuous blowing of the fog horn to the concern of all those trying to sleep. The fog cleared around noon. Many killer whales seen.

Rich Lutz called by radio to Scott to thank him for the good advice that resulted in their having a very good Alvin dive at Magic Mountain. Sending one piece of basalt and one of sulfide to Toronto and also a videotape so locations can be identified. Measured a vent temperature of 285°C. Sampled vent waters.

Day 12 Friday, July 29

Arrived Esquimalt at 0800 and cleared Customs at 0900. Travelling dock crane worked about 3 hours taking off ROPOS, the cage, the Hepburn winch, the telemetry transducer and its winch, and loaded on the heavy equipment for the next leg. Jack Bradbury took back to Pat Bay the equipment borrowed by Scott from PGC and Ocean Chemistry. Edwards left the ship to arrange a truck and car to meet us at Pat Bay. Franklin left the ship to go home in Victoria. She took with her the rented monitors and VCRs and arranged their return to Vancouver.

Departed Esquimalt at 1130 for run to Pat Bay. Guests of Jegen remained on board.

Arrived Pat Bay at 1530. Unloaded. Most of the equipment was stacked on palettes in the Pat Bay hanger for shipping by truck to Toronto. Some of the geophysics equipment was air freighted.

End of CanRidge III.

NAVIGATION

CanRidge III was navigated exclusively by Global Positioning System (GPS). Satellite signals were logged by a Trimble Navigation Model 4000DL GPS receiver which provided continuous fixes every 10 seconds in differential mode by a satellite link to the base at Everett, Washington. The satellite link cost \$200 (US) per day.

The Trimble receiver is a GPS recorder that continuously monitors eight satellites and is capable of computing positions every one or two seconds. The unit can operate with either 2-D or 3-D position information. The unit provided by the ROPOS crew was mounted in the dry lab and its antenna fixed approximately 9m above the funnel deck on the aft mast termination post. This unit's sole obstruction was the funnel and bridge deck limiting the forward view to approximately 10 degrees from the horizon. Continuous logging was available through the data link with the ROPOS console. Back-up recordings were manually recorded every 5 minutes in the cruise log book.

All fixes used the World Geodetic System (WGS-84) geoid to correspond to the Sea Beam bathymetry maps. Positioning was available in either lat./long or UTM coordinates depending of the survey.

During operations, there were two GPS fixes on the summit of the "Pimple", a prominent pinnacle at the bathymetric minimum on SER. The fixes were obtained from two 12 kHz echo sounding runs and had a closure of less than 50 m. The results correspond well with the coordinates obtained during the CanRidge II operations (49°46.97'N 130°14.81'W).

STATION LISTING

Times and dates are UT (= PDT + 7 hours)

The following information was extracted from the log book. Any missing details were taken from the accompanying computer records. Times are Universal Time (UT) unless otherwise indicated as being Pacific Daylight Time (PDT).

Time of arrival at SER: Tuesday July 19, 1994 2312h (PDT) or Wednesday, July 20, 0612 (UT).

ECHO SOUNDER SURVEYS

<u>E/S-1</u>	<u>12 kHz</u>	<u>Time</u>	<u>Latitude</u>	<u>Longitude</u>
(July 20)		0614:00	49°46.99'	130°12.91'

	06:38:00	49°47.01'	130°16.22'
E/S-2..12 kHz	07:14:00	49°46.34'	130°14.82'
(July 20)	07:27:30	49°47.41'	130°14.78'

Purpose of E/S-1 and E/S-2: Check position of "The Pimple" in DGPS co-ordinates with an East-West transverse at 5 knots, and compare results with those obtained from CanRidge II.

E/S-3 12 kHz	21:28	49°45.96'	130°15.49'
(July 20)	23:49	49°45.75'	130°09.92'

Purpose of E/S-3: SE to NW crossing of the hill on which Magic Mountain is located with 3.5 and 12 kHz sounders. Only the 12 kHz recorded useful data.

E/S-4 12 kHz	18:03	49°43.86'	130°17.77'
(July 21)	19:50	49°47.83'	130°29.42'

E/S-5 3.5kHz	00:00	49°43.77'	130°16.19'
(July 22)	02:50	49°47.99'	130°30.25'

Purpose of E/S-4 and E/S-5: E to W crossing with 3.5 kHz sounder as a subbottom profiler of the failed rifts (abandoned spreading ridges?) west of SER. Obtained unusable records.

E/S-6 12 kHz	12:55	48°28.55'	129°02.80'
(July 22)	13:18	48°28.91'	129°01.08'

E/S-7 12 kHz	13:34	49°29.01'	129°01.13'
(July 22)	14:26	49°28.88'	129°04.09'

E/S-8 12 kHz	14:28	48°28.88'	129°03.87'
(July 22)	15:02	48°28.86'	129°01.10'

E/S-9 12 kHz	15:34	48°29.13'	129°02.19'
(July 22)	15:53	48°28.01'	129°02.19'

E/S-10 12 kHz	16:05:30	48°27.64'	129°02.50'
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(July 22)	16:35:40	48°29.15'	129°02.47'
E/S-11 12 kHz	17:55	48°28.91'	129°03.95'
(July 22)	18:24	48°28.94'	129°01.18'

Purpose of E/S-6 to E/S-11: Survey to locate a small prominent mound just north of the hydrothermal site on the spreading axis of West Valley, Juan de Fuca Ridge to tie DGPS navigation in with the SeaBeam map and CUROSS I and II camera/video tows. DGPS located the top of the mound at 48°28.85' 129°02.30' which agrees well with the SeaBeam position of 48°28.95' 129°02.20'.

E/S-12 12 kHz	20:53	49°45.56'	130°15.44'
(July 26)	20:59	49°45.69'	130°15.85'

Purpose of E/S-12: An east to west echo sounding run across the top of the hill were the NE line in Dive 283 encountered extensive sulfides (inactive) and Magic Mountain is suspected to be lurking. The pinnacle at 1814m plots off center on the western side of the 1820m contour on the reprocessed SeaBeam map.

TRANSPONDER DEPLOYMENTS AND CALIBRATED LOCATIONS (July 20)

The tether length on all transponders is 100m.

Transponder Drops	Freq(kHz)	Time	Latitude	Longitude	Depth (m)
1	10.5	0808	49°46.35'	130°16.23'	1793
2	12.5	0823	49°45.75'	130°16.88'	1830
3	13.5	0849	49°45.31'	130°15.59'	1811
4	14.5	0907	49°46.01'	130°15.30'	1775

Transponder Locations	Latitude	Longitude	x (UTM)	y (UTM)	z (UTM)	Depth (m)
1	49°46.34'	130°16.25'	480500.6	5513350.4	1682.7	1793
2	49°45.74'	130°16.84'	479782.6	5512245.2	1719.1	1830
3	49°45.275'	130°15.63'	481241.2	5511376.3	1714.5	1811
4	49°46.13'	130°15.30'	481638.8	5512952.0	1685.8	1775

OCEAN BOTTOM MAGNETOMETER DEPLOYMENT & RECOVERY

DROP #1

OBM Name	Drop Time UT	Drop Latitude	Drop Longitude	Drop Depth (m)	Recover Time
L8R	20/07 1414h	49°45.59'	130°16.00'	---	23/07 1510h
CU2	20/07 1600h	49°44.85'	130°19.98'	2190	23/07 1426h

DROP #2

OBM Name	Drop Time UT	Drop Latitude	Drop Longitude	Drop Depth (m)	Recover Time
CU2	24/07 2359h	49°45.00'	130°09.50'	---	28/07 0245h
L8R	25/07 0055h	49°45.59'	130°16.09'	---	28/07 0110h

ROPOS DIVES

DIVE 281 (July 24)

The purpose of this dive was to locate, map and sample Magic Mountain.

Station	Start Time	End Time	Latitude	Longitude	Depth (m)
1	02:49	04:34	49°45.51'	130°16.21'	1809
2	04:50	06:53	49°45.57'	130°16.29'	1801
3	08:12	10:54	49°45.50'	130°15.84'	1840
4	11:34	14:00	49°45.48'	130°15.68'	1825
5	14:35	16:53	49°45.41'	130°15.67'	1794
6	17:17	18:11	49°45.48'	130°15.61'	1789
7	18:18	19:38	49°45.48'	130°15.61'	1785

DIVE 282 (July 25)

The purpose of this dive was to obtain controlled-source transient electromagnetic (CSTEM) measurements from various transmitter locations relative to a fixed receiver.

Station	Start time	End time	Latitude	Longitude	Depth (m)
1	06:19	06:44	49°45.48'	130°15.61'	1765

Dive aborted due to ground fault in the cage.

DIVE 283 (July 26)

Dive repeated the CSTEM experiment aborted in Dive 282.

Receiver Position

Time	x	y	Depth (m)
02:44	481196.3	5511714.0	1840

Transmitter

Position	Time	x	y	Depth
1	03:42	481221.5	5511759.5	--
2	04:20	481383.6	5511768.8	1842
3	--	No fix	No fix	--
4	04:53	481190.3	5511644.5	1800
5	06:14	481160.4	5511774.0	1838
6	06:49	481163.0	5511801.3	1845

DIVE 284 (July 27)

The purpose of this dive was to continue the locating, mapping and sampling of Magic Mountain started on Dive 281.

Station	Start Time	End Time	Latitude	Longitude	Depth (m)
1	08:10	12:59	49°45.55'	130°15.55'	1766
2	13:42	15:41	49°45.50'	130°15.47'	1790
3	15:47	23:48	49°45.53'	130°15.50'	---

ROPOS OPERATIONS

Description

The ROPOS submersible is a highly versatile remotely operated vehicle (ROV) for both shallow and deep sea operations. Originally designed to operate at a depth of 5000 m, it is presently deployable to 3500 m due to limitations of its fiber optic cable. ROPOS has proven capable of operating with up to 70 kg of payload. ROPOS is housed in a cage for deployment and recovery. The cage remains about 100 m above bottom acting as "home base" for the ROPOS while it is working. The tether for the ROV is managed by a winch on the cage. Experience has shown that, for good ship station keeping, the cage hangs immediately beneath the stern of the ship but will pendulum out of position if the ship moves.

The extensive functional capability of ROPOS allows for a variety of underwater investigations. Its operational features include a five- and a seven-function manipulator, a multi-compartment sample tray, and a suction sampler. In addition, the ROV is equipped with three cameras that provide good field coverage. One high-resolution colour camera is mounted on a pan and tilt. A tilt-only supports a low light level black and white SIT camera. The third camera takes still photographs. A fourth black and white camera is mounted on the cage.

Communications from the surface to both the sub and the cage, and its tether management system, are possible at all times during a dive. The telemetry system consists of both electrical and fibre optical networks. A 4 km armoured cable carrying power conductors and eight optical fibres links the cage to the surface. Control signals are multiplexed down one of the fibres, while the returning control is transmitted back along a second fibre. Four video channels are multiplexed onto a third fibre. The five remaining fibres are reserved for spares. Currently the middle spare fibre is non-operational. The ROV in turn is linked to the cage via co-axial cables and shielded, twisted pairs. This tether is neutrally buoyant and spans a distance of approximately 300 m but is usually deployed only to 100 - 150 m.

Dive History

In 1987, ROPOS was acquired by the Institute of Oceanic Sciences in Sidney, B.C. from International Submarine Engineering (ISE), but deep water operations were not begun until 1992. At present, ROPOS is employed for one-month to six-week deep water operations per year. Several shallow-water operations are carried out throughout the rest of the year. To date, all ROPOS missions have been for scientific purposes.

In 1992, ROPOS was employed for its first deep water off-shore scientific operation by the U.S. National Oceanic and Atmospheric Administration (NOAA).

Participants included scientists from NOAA, University of Victoria, University of Quebec, and the Geological Survey of Canada. The four week cruise on the NOAA ship *Discoverer* took place at the Cleft Segment and Middle Valley sites. Surveys of the area were recorded on video, and samples of ridge organisms and associated geological structure were brought to the surface.

On a similar trip in 1993, again on *Discoverer*, the same scientific team with the addition of scientists from the University of Toronto was taken to the Cleft Segment and Co-Axial Seamount sites three days after an underwater eruption had produced a megaplume cloud in the water column. This gave the scientists an excellent opportunity to examine and survey fresh lava flows. Biological and geological samples were collected, and video footage from the newly formed hydrothermal areas were obtained.

Earlier this year, ROPOS was used to set up the "Ridge Biological Observatory" at the Endeavor Segment of Juan de Fuca Ridge in a joint experiment with Pennsylvania State University, University of Quebec, University of Victoria and Texas A&M. The three week cruise aboard the *J.P. Tully* involved the deployment of two time-lapse cameras with thermistor arrays as part of the Observatory, which will remain on site for one year.

The aim of the scientific experiments was both geological and biological. Hydrothermal vent organisms, as well as several samples of basalt and sulfides, were collected from the ridge site. A chemical stainer was applied to resident tube worms to differentiate new growth from existing growth over a one year period. The frame-grabbing cameras enabled video mosaics of the area to be compiled on board ship to document the evolution of the ridge environment.

ROPOS' latest mission followed days after the Endeavor explorations. Once again aboard the *J.P. Tully*, the sub was taken out to Explorer Ridge for ten days in search of Magic Mountain, an active hydrothermal vent site. Vent creatures, basalts, iron oxyhydroxides, sulfides and sediments were sampled from the ridge. In addition to sampling, ROPOS was used to carry out an experiment in seafloor electromagnetics. This involved the deployment of a receiver at a site on the seafloor and the transport of an electrical transmitter to various locations along the ridge.

Recommendations

The scientific and commercial potential for the ROPOS is vast. Unfortunately, the ill-designed electric and electronic systems of the cage severely limits the capacity of this submersible. In addition to proper cage electronics, the success of any ROPOS dive lies in the stability of the umbilical cable to which the cage is attached. Even mildly rough seas can apply enough strain on the cable to cause it to experience high snap loads. Ideal weather conditions do not often coincide with scheduled dive days; without a means of securing the umbilical cable the sub is forced to remain on deck wasting expensive ship

time. The acquisition of a heave compensator for ROPOS will reduce this problem and increase the operating window from Sea State 3 to Sea State 5.

High quality navigation is also an important requirement. Without precise ship positioning, operations are difficult. ROPOS needs to operate and maintain its own acoustic system to ensure compatibility and reliability. Good navigation enables ROPOS to exploit more of its great potential as a mapping tool.

To ensure that ROPOS can continue to produce significant scientific results, the present lack of resources must be resolved. Improved design, reliability and navigation are essential to allow this submersible to produce quality results at a reasonable cost which is a fraction of that of a heavy manned submersible.

CanRidge III Dives

N.B. Detailed dive narratives are appended to the end of the cruise report. A summary only, copied from the Daily Narrative, is given here.

Dive 281 was to the north end of East Valley in search of Magic Mountain or any other active hydrothermal vents. ROPOS carried its sample tray, suction sampler, 35 mm Photo Sea camera in mono mode with a 250 shot film magazine, colour and SIT video and the standard claw on its 7 function arm. The suction sampler became disabled during the dive when the hose became separated from the nozzle and the sample tray would not rotate when deployed making it difficult to store samples. With the transponder net essentially nonfunctional, the search was conducted by ranging outwards from the cage along N, NE, E, SE ... tracks for about 100m, returning to the cage at the end of each run. The slant range and bearing from the cage was determined by sonar. These ranges have to be converted to true distance by knowing the depth below the cage and the height of the cage off bottom. The ship held station usually within about 25m of the waypoint and was then moved slowly to the next position such that the ends of the search lines overlapped slightly. This worked very well because the cage hung straight down from the stern and the ship was able to keep station usually within about a 25m radius of the waypoint through good seamanship and the Ilman navigation software. The software displays at different scales the outline of a ship with its GPS antenna indicated by a small circle, the waypoint and a circle of arbitrarily chosen radius around the waypoint. The best estimate of the location of Magic Mountain was at 49°45.50' 130°16.20' which is on the west side of East Valley on the ridge separating East and West Valleys. Two stations were occupied and this area was found to be devoid of any indication of hydrothermal activity. Indeed, the water was so clear that the light on the cage could be seen with ROPOS' SIT camera at a distance of 100m. The search then moved to the east side of East Valley where 5 stations were occupied. Metalliferous sediment, jarosite?, mounds and dead chimneys were found on

several traverses indicating a concentration of former hydrothermal activity centered around 49°45.45' 130°15.69'. The three types of chimneys sampled were Fe-Si oxyhydroxides with probable nontronite, barite and pyrite. Some very large spires were encountered that were too strong for a sample to be broken off. On the easternmost traverse a dense "snowstorm" which was thought to be a hydrothermal plume (subsequently proven upon examination of a suction sample) was encountered and followed. This brought ROPOS to a mound of pillow lava at 49°45.55' 130°15.62' which sprouted dense clusters of small (30 cm long) tube worms. A temperature reading in a cluster gave 4.22°C. The site was named "ROPOS Garden". No obvious venting and no sulfides were observed.

Altogether, the dive returned many hours of video (8 2-hour tapes each of both SIT and colour), 132 still photos, 7 samples of hydrothermal material, 5 basalt samples, 4 suction samples consisting of solids and water and numerous biological specimens including a putative new species of shrimp. The dive lasted 21h36m from launch (1655h Saturday) to recovery (1431h Sunday) with 16h49m of bottom time. This was the longest dive that ROPOS has ever had.

Dive 282 with the TEM experiment aboard was aborted due to a short in the cage 25 minutes after it reached the bottom in the vicinity of ROPOS Garden. An inactive sulfide chimney was encountered. When ROPOS was examined on surface at 0200h (Sunday), the short was found to have been caused by water in the tether termination can. Also, a gauge was torn off the tether compensator in the tether spooling drum by some unknown means causing flooding of the slip ring assembly. Faults in the nav computer and the cage's video camera also cropped up. The repairs took longer than expected and eventually consumed about 24 hours. This was the biggest repair job ever done on ROPOS at sea.

Dive 283 with the CSTEM experiment aboard was launched in the vicinity of abundant sulfides on Dive 281. The receiver was carried to the seafloor in ROPOS' two claws and placed on a mound of metalliferous sediment and pillow lava at the foot of a hill at 49°45.45' 130°15.60' which was later determined to have a large sulfide deposit on it. ROPOS' claw was able to sink 8 cm into the sediment before encountering resistance. One of the electrodes on the whisker poles (flexible electrical conduit) was touching the seafloor and the other was about 1 m off the seafloor. The third electrode was dragged away from the receiver pressure housing by ROPOS. A fourth electrode was attached to the housing. The orientation of the electrode array was determined and the ship was then moved so that the cage was positioned over the receiver in order to facilitate the running of short transits and be a beacon for retrieving the receiver at the end of the experiment. Navigation was by means of the transponder net which was not fully operational and provided about 10m accuracy. The sub's propulsion system had to be shut down for

transponder readings and positions calculated with a computer program. When the receiver was deployed, ROPOS became very light and had to be ballasted with two lumps of basalt which were retained as samples. ROPOS was driven away from the cage and from time to time sat on the bottom in two orientations at right angles while EM transmissions which were programmed automatically for every 5 minutes took place. The first line with a NE heading encountered an inactive 10m spire and a large sulfide mound. Two small samples were taken of this mound. Transponder fixes showed that the line initially went NE but by the end of the tether (about 150m) the sub was due east of the cage. A southwest heading to regain the cage put ROPOS due south of the cage. Therefore, there must have been a current from the north. Several reasonably well navigated measurements were made during the 9h53m of bottom time. The northeast line was the only one to encounter sulfides. The others were over pillow lava. The SIT video for the entire dive was not recorded because of a malfunction in the VCR. On recovery, the transmitter was found to have a broken wire and a malfunctioning amplifier. However, good data appear to have been obtained.

Dive 284 continued the geological search for active hydrothermal venting at Magic Mountain. Three colinear stations about 75 m apart were occupied on the flank of a prominent hill on the east side of East Valley and search patterns were conducted as for Dive 281. The temperature probe was not working because of a problem in the electronics can and would have required about 6 hours of down time to fix. The suction sampler was fitted with 60 and 120 micron filters but these were too fine and clogged quickly when samples were taken. The suction sampler was slightly damaged and two bottles were lost, probably from a collision with a rock during the dive. All other equipment functioned normally. Extensive areas of sulfide mounds, spires to about 10 m tall, talus and metalliferous sediment were encountered and mapped using range and bearing on the cage as a reference. Only 2 transponders could be received and fixes from these were ambiguous. There was a strong set to the south such that lines run with a heading, for example, of NE actually went due E. Also, some lines ended far from their intended position when a good range and bearing on the cage were obtained. The area should be remapped systematically with good transponder navigation. The sulfide area investigated in Dive 284 appears to be about 100 x 75 m and occupies the south and southwest side of the hill whose peak was located by E/S-12 near and within the 1820 m SeaBeam contour (SeaBeam depths determined for a constant velocity of sound through water are greater than ROPOS depths determined by pressure gauge by about 50 m). Station 3 (49°45.530' 130°15.504' x = 81389 y = 1849) was right over a vent field. One vent which we sampled consisted of a single vigorously active chimney sitting on a 1-metre high mound of soft white material (probably anhydrite). The best area of large spires and both active and inactive chimneys is at the top of a N-S scarp to the west of Station 3 at a ROPOS depth of

1768 to 1773 m. Here there is a cluster of 20 or more spires up to about 10 m tall over an area about 30 x 10+ m. The spires are broad at their base and taper upwards with flanges growing out of their sides. From the distance in the SIT camera, they look something like Christmas trees with snow on them. At their tops are small chimneys which look like organ pipes. Some of these are venting hot water as black smokers, some are lower temperature white smokers and many are inactive. Small spires, both active and inactive, are scattered about. The spires, big and small, are surprisingly devoid of animals although some do have clusters here and there and some are totally covered by fauna. Four vertical sections were measured up the N-S scarp on top of which this field of spires sits. Thicknesses of massive sulfides range from 8 to 23 m (average 18 m). The mound is covered on its lower slopes by a talus of pillow basalt and sulfide blocks. This is probably the area of the sketch in the 1986 Tunncliffe et al. paper in Deep-Sea Research. The entire area of this hill (and we did not explore all of it) appears to be quite a lot more complicated than the sketch in that paper with fields of pillow lava interspersed with sulfide mounds and spires, and high scarps striking both N-S and E-W. The detailed plotting of the traverses should make the picture more clear. A colony of large crabs which look something like Dungeness crabs were seen and may be a new species. An attempt to capture one with the claw failed.

Summary of ROPOS Dives

Dive	Length	Bottom Time	No. Rock & Sed. Samples	No. 35 mm Photos*	No. 2 hr b&w SIT Videotapes	No. 2 hr Colour Videotapes
281	21h36m	16h49m	16	132	8	7
282	2h45m	0h25m	0	0	1	1
283	13h23m	9h53m	3	0	0	5
284	19h15m	15h48m	15	243	8	8
TOTALS	56h59m	42h55m	34	375	17	21

* Photo Sea camera borrowed from Verena Tunncliffe. Some photos at the beginning of each 250-frame roll are test shots done on deck.

ELECTROMAGNETIC MEASUREMENTS

We conducted electromagnetic experiments to resolve the electrical structure of the subsurface. The measured parameter is electrical conductivity, a rock property which

depends on porosity, composition, pore fluid conductivity and degree of partial melt. Nowhere are these parameters more variable than on ocean ridges. Conductivity profiles with depth may constrain the possible existence of a axial magma chamber while tomographic measurements may reveal the depth and composition of active hydrothermal sulfide mounds and their associated plumbing.

Electrical experiments require a time varying primary electromagnetic fields to induce telluric currents into the subsurface. The strength and distribution of the induced currents depend on the conductivity of the subsurface material. The currents in turn generate a secondary field diagnostic of the conductivity.

Depending on the mechanism producing the primary field variations, the electromagnetic experiment falls into 2 basic categories. If the primary fields are generated by an artificial source, then the techniques are known as controlled source EM. Alternatively, the natural variations of the earth's magnetic field as primary fields can be used in a passive, natural source electromagnetic experiment. In the marine environment the controlled source experiments are best used to investigate shallow conductivity features in the crust, whereas natural source experiments are able to resolve lower crustal and upper mantle features.

During the cruise, both type of experiments were completed successfully. Cairns conducted a transient electromagnetic tomographic study of a sulfide mound using an electric dipole dipole array while Jegen continued her studies of the deep structure of the ridge environment experiment using the natural source vertical gradient sounding method (VGS) transient developed controlled source equipment.

The Vertical Gradient Sounding Method

The sources of the time varying magnetic field signals used in the VGS measurements are charged particles in the ionosphere and magnetosphere. The particles are excited by the interaction of the solar wind with the Earth's magnetic field. The EM fields propagate down through the electrically resistive atmosphere to the Earth's surface. As the signals penetrate into the Earth they are attenuated. High frequency oscillations are attenuated more quickly than low frequency oscillations and signals are most strongly attenuated in more conductive materials such as sea water. The magnetic field signals measured on the ocean floor are thus much smaller than those measured on land, especially for higher frequencies. For a 2500 m water depth, signals with periods less than 30 s are completely attenuated within the ocean layer and only longer period signals are observed at the sea floor.

If the conductivity beneath the sea floor is relatively uniform, the apparent resistivity will be an accurate measure of the true resistivity. If the electrical resistivity varies with depth, then the apparent resistivity is a measure of the weighted bulk resistivity

of the subsurface to a certain depth. This depth of penetration depends, as mentioned earlier, on the resistivity and the frequency of the signal. Knowing the apparent resistivity as a function of depth therefore allows us to extract information about the conductivity profile with depth.

With the experiment conducted on the Endeavour Segment, apparent resistivity data as a function of frequency from 0.01 up to 0.00001 Hz (1.5 min to 11 hrs) could be derived yielding an approximated depth of investigation of 10 km to 200 km.

As the magnitude of the magnetic field variations in general are very small (they constitute about 0.02% of the Earth's magnetic field), it is impossible to measure the magnetic field variations on board the ship using the VGS method. However, with minor modifications of the theory, it is possible to substitute data measured on the ship with nearby land observatory data. In this experiment, data from the Magnetic Observatory on Vancouver Island will be used.

Instrumentation

The Ocean Bottom Magnetometer (OBM) used in the experiment were constructed in the University of Toronto Physics Electronic Resource Centre. The instrument is based on a 7 MHz Faraday XT Computer. It is presently configured with a 4 Mb of solid state ("hard-disk") memory, 16 analog input channels as well as several digital input and output channels.

The instrument can be programmed to record and process data in a variety of configurations. In this experiment the instrument was programmed to collect data for a specific time period, and then enter a sleep state in order to conserve battery life. It was also programmed to average and collect data of 320 Hz into longer sample times (1 sec.). The recording time was divided into a number of blocks with a length of 60 min each. Within each block the magnetometer sensors are sampled at 1 sec. (58 min per block). At the start of each block the magnetometers are bucked (cancelling the static part of the Earth's magnetic field using a set of coils) and the temperature inside the magnetometer is recorded (2 min per block).

The instrument is powered by several packs of alkali dry cells. In order to minimize the chances of losing an instrument, separate battery packs power the computer, the magnetometer and the release.

The magnetometer sensors used in this experiment are high-sensitivity, high-frequency fluxgate sensors constructed by Scintrex. The magnetometer sensors contain bucking coils controlled by the digital to analog circuitry of the computer. Each seafloor instrument also includes a temperature sensor.

The magnetometers are deployed inside 14" diameter anodized aluminium spheres. The spheres, constructed at the University of Washington, are 1" thick and capable of being deployed at depths up to 6000 m.

The spheres are attached to a bottom assembly constructed for us by the Scripps Institution of Oceanography. The instruments are allowed to free fall from the ship and are subsequently released from the seafloor by the dropping cylindrical ballast weights. They take about 1 hour to ascend from 2 km. Strokes and 27 Mhz radios aid location.

HYDROTHERMAL DEPOSITS

Dive 281

Systematic surveys radially outward from each station in search of hydrothermal vents and deposits. Details are in the dive narratives appended to the end of the cruise report.

Station 2 N49°45.570'
W130°16.290'

Sheet lava, broken sheet talus, increased biological activity. Minor stains of yellow sediment. Collapsed lava and lobate flows, wrinkled and scrambled lava. Partly sedimented. Fissures 2m wide and 20m deep.

SE Traverse shows mainly pillows and lobated flows turning to ropy sheet flows. Crab and other animal activity - finally getting into alternating pillow and sheet lava.

Due West - lobated flows.

Due East - Scrambled sheet to lobated flows and pillows.

Station 3 N49°45.504'
W130°15.8384'

South Traverse - Pillows and talus and fault scrap mainly. Reddish brown sediment. Hydrothermal field. Chimney at 0930 UT.

Southeast Traverse - Yellow metalliferous sediments over pillow lavas.

Station 4 N49°45.48'
W130°15.68'

South Traverse - Chimney area. Metalliferous sediments in pillows - Broken pillows and old chimney at 1152 UT and 1155 UT. Sulfide sample collected. Chimney with fauna (49°45.48', W130°15.69). Pillows and lobate lava. Small chimney (1216 UT). Metalliferous sediments and talus. 1250 UT Large old chimney about 10m high, spaghetti worms and yellow "snow". Appears to be a silicate chimney.

Talus and pillows with jarosite?.

Station 5 N49°45.41'

W130°15.67'

West Traverse - Sulfide chimney (1520 UT), pillows and talus.

South Traverse - Bulbous pillows and lobated flows. Scarps and fissures, sediment dust and hydrothermal activity - nontronite?

Station 6 N49°45.48'

W130°15.61'

Yellow "snow" and tube worms (1802 UT). Pillow lavas.

Station 7 N49°45.4759'

W130°15.6088'

Pillow lavas, extensive fauna and black tube worms.

Dive 282

A sulfide mound was seen at 0638 UT on this aborted dive to the southwest of the main Magic Mountain field.

Dive 283

Numerous sulfide mounds and occurrences of metalliferous sediment were encountered on this dive. See the detailed dive narrative appended to the end of the cruise report.

Dive 284

Hydrothermal deposits of Magic Mountain were surveyed and sampled during this dive. The hill top, slopes and valleys were mapped for lava types, and to delineate the hydrothermal chimneys area by making several radial traverses of about 100 m from the fixed points.

During this dive 18 samples were collected which included two water samples and one tube worm sample. The fifteen geological samples comprised parts of active and inactive spires or chimneys, anhydrite, jarosite and hydrothermally altered basalts.

The Magic Mountain area contains pillow lava, lobated pillow lava, broken pillow and talus of pillow lava. Several minor and relative major faults were observed which confirms the tectonically active nature of the region. Approaching the chimneys, yellow hydrothermal sediment and fauna were observed, and finally inactive and actively venting chimneys were seen. Large chimneys had ancillary spires. Over the active

chimneys/spires a white cap of anhydrite was seen and samples of this were collected. The surrounding lavas appeared to be hydrothermal altered. An unusual feature of the Magic Mountain hydrothermal deposits is a lesser abundance of fauna compared to some other known areas.

In one area of large active and inactive 10-m high spires aligned along the top of a fault scarp on the east side of East Valley, apparent thicknesses of sulfides of 8 to 23 m were measured. Smaller chimneys were found on ledges down the scarp.

Details of samples and their basic mineralogy are given in the Sample log book.

PETROLOGY

Geological mapping of the seafloor with the ROPOS submersible offered the opportunity of obtaining valuable visual observations about the structure, lithological distribution and morphology of the studied area. In addition, precise in situ locations of the samples were obtained.

The first two stations on Dive 281 explored the western side of East Valley and they revealed abundant sheet flow and lobated flows with minor pillows. The next stations and dives were around the Magic Mountain hydrothermal field, along the east side of East Valley. The field consists mostly of pillow basalts with minor lobated flows and with no sheet flows. Seven out of eight basalt samples are aphyric with one plagioclase-porphyritic basalt. From submersible observations, most outcrops appeared to be made of aphyric basalt, although it is very difficult to distinguish between porphyritic and aphyric lavas because of the thin Mn-coating (1mm thick) and the dusty sediment cover. Submersible observations at Magic Mountain allowed us to confirm abundant NE-SW trending fault scarps. These fault scarps showed vertical section of both truncated pillows or fissures partially filled by massive pillow and pillow talus. These features denoted concurrent tectonic-volcanic activity followed by the present tectonic-hydrothermal phase.

Crystal-rich basalts have been recovered along the length of the SER whereas aphyric basalt have been recovered only at the culmination of the ridge (Magic Mountain) and slightly farther south (Michael et al., 1989). In the specific context of the Magic Mountain area, precise locations of submersible samples may allow us to constrain small scale regional spatial distribution of basalt (aphyric and porphyritic) concurrent with chemical type (enriched vs depleted basalt). Moreover, the relationship between the mineralogy and chemistry of hydrothermal fluids and sulfide mounds with basalt chemistry is critical to our understanding of the overall hydrothermal chemical budget. Scott (1989) noted such a relationship with the high Ba content of both sulfides and basalt at Magic

Mountain in comparison to the EPR. During this cruise, the precise sampling of spatially associated basalt and sulfide mounds, will allow further testing of this hypotheses.

DESCRIPTION OF ROCK SAMPLES

CanRidge III Rock Sample Descriptions

Note: Unless otherwise noted, samples are not from active hydrothermal areas.

Sample No.	Time	Depth	Description
D281-01	0313	1817	Aphyric basalt from in situ outcrop of sheet flow. Glassy margins (3-8mm thick) on both sides of platy sample (size: 17x15x4 cm). Minor amount of vesicles (<5%, and <2mm). Broken surface is fresh: black to dark brown. Top surface coated with ferromanganese oxide (1-2mm thick). Station 1, line 2 towards South. lat.: 49°45.51'N long.: 130°16.21'W Glass chips taken by M.C.
D281-02	0349	1798	Sediment taken from small pockets between pillows with the suction sampler into bottle #8 with a 125 micron filter. Not an active hydrothermal area.
D281-03	0500	1803	Aphyric basalt from in situ outcrop of sheet flow. Thin glassy margin (2mm thick). Glassy basalt very irregular bulbous shape with several quenched surfaces. 5% vesicles (1-3mm wide). Ferromanganese coating about 1-2 mm thick. Broken surface is dark black and fresh. Flecks of yellow sediment in between glassy crust. Sample size 15x13x13 cm. Station 2 line 1 towards NW. lat.: 49°45.576'N long.: 130°16.284'W Glass chips taken by M.C.

D281-05	0858	1803	<p>Plagioclase porphyritic basalt. In situ broken fragment. Small surface with thin glassy margin (2mm thick). Matrix of 20% phenocrysts and microphenocrysts of plagioclase (2-3mm long), trace olivine. Completely covered by manganese coating (1mm thick). Broken surface is dark grey with <5% vesicles (<1mm). Triangular shaped with one flat surface (size 17x13x11 cm). Station 3 line 3 towards E lat.: 49°45.511'N long.: 130°15.813'W Glass and rock chip taken by M.C.</p>
D281-08	1153	1853	<p>Sulfide/silica, anhydrite chimney. Large friable piece 6x4x4 cm. Greyish white and stains of ferromanganese coating. Pieces of dead chimney or hydrothermally altered basalt? Ship at 49°45.48'N 130° 15.72'W. Marker =15. Sub ca. 100 m due south of ship position.</p>
D281-10	1325	1840	<p>Sulfide/ barite sample? Black grey and brown patches. Red brown stains of Fe oxides. Fine disseminations of sulfides pyrite, gas cavities. Hydrothermally altered basalt? pillow talus, rising up a cliff, metalliferous sediment, sulfides, jarosite. Size 13x7x7 cm.</p>
D281-11	1518	1788	<p>Large piece of sulfide from a dead chimney? Dark grey, light grey. Brownish due to alteration. Subsequent coating of Fe-Mn- oxides. Lower part shows structure of amorphous silica. Hydrothermally altered basalt? size: 28x18x10cm</p>
D281-12	1549	1795	<p>Hydrated iron oxyhydroxide. Rock very soft, friable, light with Mn oxide coating in lower part. Brown and black. 9x4x1cm.</p>
D281-13	1636	1794	<p>Fe-oxyhydroxides. Chemical precipitate. Mound; soft orange nontronite sample w/ copper green interior collected. 17x10x7cm.</p>

D281-15	1745	1808	<p>Aphyric to microcrystalline basalt Glassy margin (2-5mm thick) with botryoidal surface. In situ fragment of pillow (radiating shape caused by jointing) covered with bacteria. Aphyric near quenched zone and grades progressively to microcrystalline (<1mm) matrix towards core of pillow. Mn coating 1-2mm thick. Fresh broken surface is dark grey with less than 5 % vesicle (5mm) containing small pyrite cubes (<<1mm) along cavity. Rectangular, size: 14 x 8 x 6 cm. Station 6 line 1 towards W. lat.: 49°45.45'N long.: 130°15.62'W Glass chips taken by M.C.</p>
D281-17	1918	1804	<p>Aphyric to microcrystalline basalt Piece of broken pillow with radiating joints. Thin glassy margin (5mm). Aphyric with 5-10% vesicles (1-3mm) mainly concentrated near glassy margin which grades to microcrystalline (<1mm) basalt 4 cm away from quenched margin. Fresh broken surface is dark grey. Mn-coating (1mm thick). Some vesicles have very small pyrite cubes. Size: 24cm long columnar shape. Station 7: ROPOS located 40m west of cage. lat.:49°45.47'N long.:130°15.63'N Glass chips taken by M.C.</p>

D283-01A	0900	1844	<p>Aphyric basalt Glassy rims (3mm thick) partly palagonitized. Piece of small pillow 1/4 buried in sediment and 3/4 covered by 1mm thick Mn-coating. Radiating triangular shape (size 12x11x11cm). Fresh broken surface is grey to dark grey with 5-10% vesicles (5-10mm). Altered surfaces orange to green along radiating joint and preferentially on the 2/3 outer rim of the pillow. Area is relatively flat and covered with 70% pillows and 30% interstitial pockets of sediment. Sediment roughly 8 cm depth over these pillows (50-100cm large). Two in situ fragments (samples -01A and -01B) of pillow basalt probably from the same flow, taken 50cm apart at the CSTEM location. Fix on ROPOS (directly over the CSTEM receiver) in UTM coordinates X=481196.3, Y=5511714.0 and lat.: 49°45.45'N long.: 130°15.69'W Glass chips taken by M.C.</p>
D283-01B	0900	1844	<p>Aphyric basalt No glass. Vesicular: 30% round vesicles 1-5mm. Long curved exterior piece (size 27x8x7cm) of pillow completely covered by Mn (2mm). Broken surface is grey to dark grey. Outer 1cm corona altered by seawater. UTM coordinates: X=481196.3, Y=5511714.0 and lat.: 49°45.45'N long.: 130°15.69'W</p>
D283-02			<p>Highly weathered part a chimney. Fragile variable colors: brown, black, green. No sulfides seen. Two pieces recovered: 9x4x3cm, 6x3x2cm.</p>
D284-01	0923	1789	Small piece of anhydrite from top of the active spire
D284-02	0926	1789	Suction sample of emission at the top of the active spire.

D284-05	1036	1771	<p>Aphyric basalt In situ pillow lava fragment. Glassy rim (5mm thick). 1-2% small vesicles (<1mm wide). Broken surface dark grey to black. One radiating shaped piece (25x15x12cm) with columnar joint completely coated with Mn (1-5mm thick). Station 1 line 2 to E. X=481489, Y=5511881 lat.: 49°45.53'N + long.: 130°15.42'W Glass chips taken by M.C.</p>
D284-06	1103		<p>Sulfide weathered cap. Part of a chimney. Whitish (anhydrite), gray and black Mn-oxides. Black part may contain ZnS.</p>
D284-09	1149	1765	<p>Sample of "beehive structure" at active vent. Upper part of a chimney with mainly white anhydrite. Flat shape 20x12x2cm.</p>
D284-10	1157	1768	<p>Small bits of active vent and also a large part of chimney with anhydrite (30x18x12cm).</p>
D284-11	1206		<p>Sample of sulfide?</p>
D284-12	1516	1771	<p>Adjacent white small chimney (barite?). "Beehive shape and oyster looking" piece (25x14x16cm).</p>
D284-13	1531	1771	<p>Pieces of anhydrite of an active chimney. Located 120m NW of the cage. Size: 8x7x5cm. Ship's position: 49°45.4988'N 130°15.4594'W.</p>
D284-15	2034	1790	<p>Beehive structure and anhydrite. Sample from the base of cliff. Not known if it is in situ or talus. Reddish oxide on one side. Flat shaped rock about 15x10cm.</p>

D284-16	2126	1781	<p>Hydrothermally altered aphyric basalt Glassy rim quite altered (3mm thick). Piece of pillow with radiating shape (size: 20x14x14cm) taken along fault scarp below hydrothermal mounds (near the rooting of activity, with shimmering waters). Coated by Mn (1mm thick) on one side and by iron oxyhydroxide (orange rust) on the other. Broken surface is dark grey to black with some more rusty surfaces along radial joints. lat.: 49°45.529'N long.: 130°15.503'W Glass chip taken by M.C.</p>
D284-17	2342	1757	<p>Sample of top of active black smoker chimney.</p>
D284-18	2346	1757	<p>Large chunk of top of inactive chimney, one piece. Size: 30x18x15cm</p>

MACROBIOLOGY

Unlike hydrothermal vent communities found at the Juan de Fuca Ridge to the south, the composition of the hydrothermal vent communities on Explorer Ridge is relatively unknown. Explorer hydrothermal vent communities are important because of Explorer's age and geographic position. The collecting of biological samples from Explorer would be helpful for our study of the geological and historical controls of hydrothermal vent communities. ROPOS and the CSS. J.P. Tully proved more than adequate for the task. Numerous grabs and suction samples of the megafauna were obtained. These samples included vestimentiferan tubeworms (*Ridgeia sp.*), polychaete worms (*Paralvinella sp.* and *Hesiodeira glabra*), limpets (*Lepetodrilus sp.*), and spiders (*Copidognathus papillatus*). These samples will increase our knowledge of hydrothermal vent community composition and biogeography. The extensive video coverage of diverse environments ranging from diffuse, low temperature hydrothermal flow occurring in cracks in the sea floor to large sulfide hydrothermal vent chimneys will aid our understanding of hydrothermal vent community organization in relation to geochemical environments.

As an added bonus, the many geological samples collected away from active hydrothermal vent areas provided us with biological samples from the normal, ambient deep-sea of which we know less than the hydrothermal vents. A large thick-legged crab was seen and may be a new species.

CanRidge III Macrobiological Samples

This is a list of all biology samples taken by Andrew McArthur and Laurel Franklin for Verena Tunnicliffe. It does not include microbiology samples taken by Grant Ferris, which are listed separately in the next section.

Code	Container	Fix	Creatures
D281-01	vial	7% BSWF	animals from rock sample D281-01
D281-10	vial	7% BSWF	animals from rock sample D281-10
D281-13	vial	7% BSWF	animals from rock sample D281-13
D281-17	vial	7% BSWF	animals from rock sample D281-17
D281-05	vial	7% BSWF	animals from rock sample D281-05
D281-16a	jar 500ml	7% BSWF	tube worms
D281-16b	jar 500ml	7% BSWF	unsorted tube worm grab
D281-16c	bucket	7% BSWF	unsorted tube worm grab
D281-16d	vial	7% BSWF	scale worms
D281-17	vial	95% EtOH	brittle (?) star (in 7% BSWF first 24 hrs)
D281-09	jar 250ml	7% BSWF	anemone
D281-02a	vial	7% BSWF	sediment sample, may include animals
D281-02b	vial	7% BSWF	shrimp
D281-02c	vial	7% BSWF	copepod
D281-02d	vial	7% BSWF	misc.
D281-04	vial	7% BSWF	sediment sample, may include animals
D281-06	vial	7% BSWF	sediment sample, may include animals
D281-14	vial	7% BSWF	water column sample, possibly plume
D283-01a	vial	7% BSWF	animals from rock sample D283-01a
D283-01b	vial	7% BSWF	animals from rock sample D283-01b
D283-02	vial	7% BSWF	animals from sulfide mound D283-02 & 03
D284-02	vial	7% BSWF	125 μ suction sample
D284-07	vial	7% BSWF	125 μ suction sample
D284-08	jar 50ml	7% BSWF	64 μ suction sample
D284-03	vial	7% BSWF	64 μ suction sample
D284-16	vial	7% BSWF	animals from rock
D284-15	vial	7% BSWF	animals from rock
D284-06	vial	7% BSWF	animals from rock
D284-10	vial	7% BSWF	animals from rock
D284-14a	bucket	7% BSWF	tube worms
D284-14b	jar 500ml	7% BSWF	tube worms

D284-14c	vial	7%BSWF	tube worms from rock
D284-09	vial	7%BSWF	animals from rock
D284-18	vial	7%BSWF	animals from top of inactive chimney
D284-12	vial	7%BSWF	animals from chimney piece

MICROBIAL GEOCHEMISTRY

Scientific Objectives

A systematic investigation is planned to evaluate the geochemistry of epilithic microbial biofilms that occur on rocks near hydrothermal vents on the SER. Specific objectives include (i) characterization of neogenic minerals that develop in association with bacteria cells, (ii) appraisal of chemical environments and mineralogical assemblages that occur in association with planktonic (free floating) and epilithic bacteria, and (iii) integration of these observations to develop an understanding of dynamic biogeochemical processes that contribute to mineral precipitation at deep ocean hydrothermal sites.

Background

The precipitation of minerals by living organisms is a widespread phenomenon that is generally referred to as biomineralization. Familiar products of biomineralization in eukaryotic plants and animals include various types of shells, bones and teeth; however, biological mineral precipitation is not carried out by higher organisms alone. Many prokaryotic microorganisms (i.e., bacteria) are potent catalysts of biomineralization, and contribute to the formation of a tremendous range of minerals.

The significance of microbial biomineralization is emphasized by the fact that microorganisms are the most abundant life form on Earth, and live in an unparalleled variety of environments. Microorganisms exist wherever there is liquid water up to temperatures of at least 110°C, and thrive in the harshest of environments, from the high Arctic to the depths of the oceans. Moreover, microbial life is as old as the geologic record, stretching back at least 3.8 billion years. The implication is that microbial biomineralization is important on a global scale, and has helped shape the Earth throughout geological time.

Minerals that develop in association with microorganisms can be treated as being authigenic in origin. This essentially involves the precipitation of ions from an oversaturated solution. Basically, the process can be divided into two stages, nucleation and crystal growth. Distinctions between the two can be made based on the energy

changes associated with crystallization and causative physicochemical conditions that contribute to authigenic processes.

In general terms, nucleation represents an activation energy barrier that inhibits or blocks the spontaneous formation of a solid phase from a supersaturated solution. The activation energy barrier to nucleation can be reduced by lowering the interfacial energy of the solid phase, and/or increasing the degree of solution supersaturation. Supersaturation levels may be regulated, to a certain extent, by the metabolic activity of microorganisms. For example, growth of denitrifying or sulfate-reducing bacteria may promote an increase in solution pH which is more supportive towards the precipitation of carbonate minerals. Conversely, interfacial free energies can be lowered by the presence of organic surfaces (e.g., bacterial cells) that promote chemical bonding at the nucleation site.

Nucleation may occur either homogeneously or heterogeneously. In homogeneous reactions, critical nuclei are formed simply by random collisions of ions or atoms in solution. On the other hand, heterogeneous nucleation involves development of critical nuclei on surface of foreign solids which catalyze nucleation by reducing the activation energy barrier. The surface of the heteronucleus may be viewed as a template of similar atomic spacing that promotes mineral precipitation. Favorable heterogeneous nucleation templates typically possess sites where strong surface chemical interactions occur (i.e., adsorption or bonding).

Crystal growth involves transport of ions or atoms to the surface of a crystal and various surface reactions, such as adsorption, dehydration, ion exchange, etc., that result in the incorporation of the ions into a crystal lattice. The rate of crystal growth may be limited by either transport, surface chemical reactions, or by a combination of both processes. The implications of transport and surface chemical reactions for crystal growth in microbial biomineralization are not particularly well understood; however, bacteria are so small that a low Reynolds number of about 10^{-5} applies to them. This means that microorganisms cannot outswim their local aqueous environment, no matter how fast they move. Consequently, microorganisms rely entirely on diffusion for their subsistence and live in a microenvironment that is apt to be quite different than the bulk aqueous phase. Thus, mineral phases may be precipitated by microorganisms in an environment where otherwise unfavorable geochemical conditions seem to prevail.

Microbial biomineralization is obviously a very complex phenomenon that can proceed in a number of different ways. For example, metal cations can be precipitated directly from solution as a result of microbial metabolic activity. This happens on the inside, outside, or even at some distance away from cells. Indirect bacterial mineral precipitation as a consequence of regional geochemical conditions is also possible and involves passive epitaxial crystal nucleation and growth on the outside of bacterial cells.

This later process can be attributed to the inherent metal cation binding capacity of anionic structural polymers in the cell walls and external sheaths of bacteria.

The complex biological communities associated with deep ocean hydrothermal sites are unparalleled on Earth in that they owe their vitality to a food chain that is based exclusively on bacterial primary production (i.e., prolific growth of chemoautotrophic bacteria instead of photosynthetic plants). Most microbiological work that has been done on these bacteria has been focused on ecophysiological aspects of microbial growth under extreme conditions of high temperature and pressure. In this regard, the CanRidge III microbial geochemistry program is unique as relatively few investigations have considered the biogeochemical contributions of bacteria to mineral precipitation at hydrothermal sites along mid-ocean ridges.

Methodology

Rock, sediment, and water samples collected at the Magic Mountain site on the SER using ROPOS were processed on board CSS. John P. Tully as follows. Surface films and mineral crusts were recovered from rock samples by scrapping ca. 2.0 cm² areas with sterile scalpels. The material removed from each rock was subsequently transferred to 10 mL plastic tubes containing 5.0 mL of 2.5 % glutaraldehyde (a fixative for electron microscopy) in seawater. Sediment samples from the suction bottles on ROPOS were chemically fixed in the same way, whereas water samples were processes as follows; a Corning Checkmate meter was used to measure pH and total dissolved solids for each water sample. Then syringes were used to transfer 10 mL of water to vacutainers for alkalinity measurements, 100 mL aliquots of 0.45 µm filtered water were measured into 125 mL polypropylene bottles for chemical analysis of dissolved constituents, and 400 mL samples were dispensed into 500 mL polypropylene bottles for chemical analysis of total (dissolved and particulate) solids.

CanRidge III Samples of Microbial Materials

No.	Sample Code	Description
<i>Surface coatings off rocks</i>		
1	281-1A black	black mineral coating
2	281-1B black	black mineral coating
3	281-1A rust	rust colour Fe-oxide material
4	281-1B rust	rust colour Fe-oxide material
5	281-1 scale	hard black scale
6	281-3 black	black mineral coating
7	281-3 mud	light brown mud under black coating

8	281-5 rust	rust colour Fe-oxide material
9	281-5 rust	rust colour Fe-oxide material
10	281-5 Mn	black colour mineral coating (Mn-oxide?)
11	281-5 green	green material from centre of rust spot
12	281-8 black	black surface coating
13	281-8 light	soft light brown-red colour material
14	281-12	surface scrape from rock
15	281-12	surface scrape from rock
16	281-13 yellow	yellow material from oxide deposit
17	281-13 orange	orange material from oxide deposit
18	281-13 outside red	surface of oxide deposit
19	281-13 green	green mineralization from oxide deposit
20	281-15 rust	rusty spots from rock surface
21	281-15 mud	mud from under scale
22	281-15 dark	dark surface coating
23	281-15 yellow	yellow-brown mass on surface (bacteria?)
24	281-17 rust	rust Fe-oxide material
25	281-17 black	black surface coating
26	281-17 brown	mud tracks (fecal pellet trace?)
27	281-8 fragment	fragment of rock in glutaraldehyde
28	281-3	fragment of rock in glutaraldehyde
29	281-15	fragment of rock in glutaraldehyde
30	283-1A rust	Fe-oxide material
31	283-1A green/brown	soft green/brown material under rust spot
32	283-1A green mud	from underside of rock
33	283-1A green/black-rust	layered deposit green bottom, black top
34	283-1A rust spot 2	second rust spot removed from rock
35	283-1A green-white	green/white coloured material under rock
<i>Sediment Samples</i>		
1	281-06	
2	281-04	
3	281-14	snow in (hydrothermal?) plume
4	281-08	
<i>Water Samples</i>		
1	281-06	100 mL filtered
2	281-04	100 mL filtered

3	281-14	100 mL filtered
4	281-08	100 mL filtered
5	281-06	10 mL vacutainer
6	281-04	10 mL vacutainer
7	281-14	10 mL vacutainer
8	281-08	10 mL vacutainer
9	281-06	400 mL unfiltered
10	281-04	400 mL unfiltered
11	281-14	400 mL unfiltered
12	281-08	400 mL unfiltered
13	284-03	10 mL vacutainer
14	284-03	10 mL vacutainer with SAOB
15	284-03	400 mL unfiltered
16	284-08	10 mL vacutainer
17	284-08	10 mL vacutainer with SAOB
18	284-08	400 mL unfiltered
19	284-07	10 mL vacutainer
20	284-07	10 mL vacutainer with SAOB
21	284-07	400 mL unfiltered
22	284-02	10 mL vacutainer
23	284-02	10 mL vacutainer with SAOB
24	284-02	400 mL unfiltered

Note: SAOB, sulfide antioxidant buffer for potentiometric titration with sulfide ion specific electrodes.

CSS JOHN P. TULLY

The John P. Tully is a 69m ice class research ship operated by the Canadian Department of Fisheries and Oceans. Propulsion is supplied by two Deutz engines totalling 2300 kW (3080 HP) geared to a single shaft driving a CP propellor in a fixed nozzle. There are three rudders. For normal operation only one engine is on line. Additionally, the ship is fitted with a Brunvoll CP bow thruster of 600 kW (800 HP) and an Omnithruster stern thruster of 240 kW (350 HP), the latter usually only being used for berthing. These features provide exceptionally fast response to helm and engine, which gives the ship the ability to keep station to within about 30 m, and frequently about 15 m in the open sea, in at

least Beaufort force 5/6 winds; thus, in 2000 m of water, excursion is kept under 5% of water depth.

APPENDIX

Dive Narratives

For each dive, a geologist or geophysicist occupied the observers seat beside the pilot, a geologist watching another monitor kept a hand written account in the Cruise Logbook and someone with good typing skills, usually a biologist, typed information from the observer and others into the following tables. An open microphone recorded all comments onto both the b&w SIT and colour videotapes that were running throughout the entire dive.

Orientations of various linear features (fault scarps, fissures, etc.) are stated as if the top of the video screen was at 000 or N. Corrected orientations will be determined later from actual ROPOS tracks.

Abbreviations

P	Pillow lava
PL	Lobated pillows
Snow	Hydrothermal plume particulates
SS	Scrambled sheet flow

CanRidge III ROPOS Dive Report

Dive No. 281

Location Magic Mountain area

Objectives: Locate, map and sample Magic Mountain hydrothermal site. Locate vents suitable for later deployment of vent fluid sampler and "chimney catcher". Drop markers at appropriate locations.

Camera: Mounted high on the bumper, angled downward to focus 7 feet in front of the sub. 400 ASA film, Fujichrome 400 color reversible (slide) film, 28 mm lens, FStop 4.5, distance set to 4.5-7 feet, film code is L7 - Total exp. 151.

Time & Date at Start 2355h, Sat. July 23, 1994 (PDT)

End 1431h, Sun. July 24, 1994 (PDT)

Lat & Long at Start 49°45.52'N, 130°16.21'W (ship)

Time	Depth	Photo	Comments
1655 PDT	0		ROPOS launched. Time is PDT for this dive only.
1818	499		ROPOS going down
1830	660		"
1835	737		"
1845	891		"
1900	1108		"
1910			changed sit cam time display to GPS time (UT) from local time
0210	1257		Sunday UT = local PDT + 7 hours
0230	1556		Oceano system has died; can't navigate
0245	1783		stopped approx. 40m above bottom.
0247	1812		Station 1. Ships position N49°45.510' W130°16.210' Line 1 to N from cage.
0249	1805		P no sediment
0252	1797		PL and one crab. Very light sediment in striations on the pillows.
0306	1807		abundant pillows intermingled with lobate tubular flows. Sediment cover is scarce

0309			End of Line 1. ROPOS 90 m along track and returning to cage. <i>Confusion in this log as to when Line 2 started and in what direction. Sample at 0313 was taken on Line 2 to the south (SDS).</i>
0312	1816		Line 2? to S. encountered rat tail fish. sheet flows
0313	1817		sampled piece of sheet flow. Placed in front of bin 6. The rock is about 20cm dia.. Feather duster coral close vicinity. Sample #D281-01.
0317	1816		spider crab Mostly pillow lavas with some lobated and partly sheet small talus made of pillows.
0322	1764		End of Line 2? ROPOS 90 m from cage and headed back. Still no navigation.
0324	1805		Line 3? to E. pillow and sheet lava mixed - broken. Pillows and lobated flows. Large fissure.
0326	1797		crossed fissure to vertical cliff. striations in the pillows. PL
0328	1787		fish. Now we're turning around and going to cage.
0331	1779		End of Line 3? at 80 m from cage. back to the cage to reorientate, so no bottom contact.
0333	1809		Line 4 to W ..bottom contact. broken pillows, quite dusty sediment. crab. striated pillows and fissure.
0335	1813		P and PL. broken pillows and talus
0337	1806	1	more broken pillows and talus. photo taken.
0338	1809	2	Large pillows and talus photo of fish
0339	1807	3	Large pillows with striations - photo. no sediment present
0341	1776		End of Line 4 at 90 m. back to cage.
0342	1767		heading on a SW course 220° no bottom contact.
0345	1806		Line 5 to SW. Contact with bottom P and talus. sediment dust. Broken pillows some fracture and dislocation.
0346	1798	4	fissure to the left pillows and lobates. - photo
0346	1895	5	pillows fresh flows little sediment present.
0347	1795	6	sediment dust to the left. picture of hydrothermal sediment
0348	1798		pillows with striations. sampled the sediment in interstices between 1m size pillows with suction hose into bottle #8 with 125 micron filter. Sample D281-02
0350	1798	7	attempted to take photo but missed
0356	1797		observing bottle #8. mostly rock chips collected.

0357	1790		End of Line 5 at 80 m. headed back to the cage. reorientating.
0358			ships position changed to N49°45.52' W130°16.19'
0401	1809		Line 6 to SE. Heading back to the bottom. Pillow lava, striated fresh lava. very little sediment present. Ship at 49°45.51' 130°16.187'
0403	1806		encountered a fissure oriented N relative to monitor.
0404	1807		going down in to the fissure. ground contact. Talus of broken pillows.
0405	1805	8	broken pillows talus. photo.
0407	1817	9	more pillows and crab - photo
0409	1819		End of Line 6 at 100 m. going back to the cage, observing more pillows and talus. Drained and crushed pillows. Heading 328°
0411			Ship's position 49°45.504' 130°16.193'
0412	1774		Line 7 to NE
0415	1819		bottom contact. pillow lava - large pillows - lobated pillows. only sediment dust. Striated lobate flow.
0416	1814		crushed pillows and a small dislocation. talus. little biology.
0417	1810		encountering a fissure.
0417	1814	10	photo of crab. fissure direction NE/SW crushed pillows with stains of yellow sediment.
0418	1809		more talus - spider crab
0419	1810		more talus and pillows.
0420	1804	11	white mystery worms - photo
0420	1801	12	photo - white mystery worms
0421	1802	13	photo of orange sea stars.
0421	1796		End of Line 7 at 100 m from cage. headed back to the cage.
0425			water depth 1803m from echo sounder - ships position N49°45.51' W130°16.19'
0428	1814		Line 8 to NW. Pillows (large) and broken. small amounts of sediment dust (yellow)
0428	1811		talus of broken pillows.
0429	1804		encountering a fissure. Heading NW 314° no bottom contact
0430	1813	14	bottom contact. broken pillows and truncated pillows - photo
0431	1793		Ship's position 49°45.509' 130°16.191' going uphill approx. 20 m. no bottom contact.

0432	1795		bottom contact. Large pillows fresh and striated. Still more pillows. - small amounts of sediment dust. Again assume fresh flow.
0433	1786	15	small yellow starfish and black fish - photo -more spongy things...
0434	1774		medusa - jelly fish. more stuff on the rocks.
0434	1768		End of Line 8. returning to the cage on a heading 135° . no bottom contact. Moving the ship NW about 150m in search of Magic Mountain. Station 2 Ships position N49°45.57 ' W130°16.29' - water depth 1801m (Simrad echo sounder)
0450	1802	16	Line 1 to NW. bottom contact. photo of large and small pillow lavas. very little sediment dust. just a sprinkle.
0451	1803	17	photo of large unknown animal.
0452	1803	18	photo - pillows with lobates and sediment cover. striated.
0454	1803	19	photo - of black fish at pillows and sheet boundary.
0455	1801		more talus and some specks of yellow hydrothermal sediment.
0456	1801		sheet lava, big talus and scrambled sheet lava. some small animal
0457	1802	20	sheet lava, crushed and yellow hydrothermal sediment - photo
0500	1803		sheet lava sample - Sample #D281-03 placed in bin #7 sitting anti clockwise from the first rock. Much rounder in shape than the first rock. Flecks of yellow sediment.
0509			Ship's position 49°45.576' 130°16.284'
0511	1803	21	photo of sample site.
0514	1801		Beautiful sheet lava and lobate flow following.
0514	1803		sheet lava, lobated lava and talus.
0515	1802		lobated lava flows with a dusting of sediment , followed by pillows
0516	1804		sheet flow SS small old chimneys. pillow lava.
0517	1801		End of Line 1. headed back to the cage more than 100m away.. heading 139° no bottom contact. <i>First 2 hrs (tape 1) of color video blank due to technical difficulties. Second 2 hours (second video tape) has a 20-30 min blank lead in and then color restored with annotation.</i> ships position N49°45.57' W130°16.29'

0523	1774		Line 2 to NE. going back down after reorientating. heading 58°. Ship's position 49°45.580' 130°16.301'
0524	1801	22	pillow lava heading of 61° NE - photo
0525	1801	23	collapsed lobe with sediment - photo
0526	1800	24	photo - rat fish
0526	1801	25	photo - spider and sediment over lobate flow.
0527	1801		suction Sample D281-04: yellow sediment into cylinder #2 - 63 micron mesh.
0532	1800	26	moving on - photo of large pillow.
0533	1794	27	lava tubes
0533	1790		lobated flow and a crab. dusting of yellow sediment in striations.
0536	1789	28/29	encountered a small fissure - 2 photos
0537	1790	30	large lobate pillows and a crab - photo
0538	1787		pillow lavas
0538	1784		very deep fissure about 2m wide and very deep. heading 51°. Large pillows and lobated flows along each side.
0540	1774		End of Line 2. turning around headed for cage. Foray over 100m.
0543	1767		Line 3 to SE. Ship's position 49°45.575' 130°16.285'
0543	1793	31	bottom contact. Pillow lava with another big fissure. Lobated flows and pillows - photo
0545	1794		scarp with 60° slope to the right approx orientation about 45° to us. ROV heading 140°
0548	1808		lobated flows with some pillows. light cover of yellow sediment in striations.
0549	1810		sheet flow - curtain drape sheet flow. 100m out from cage. course 114°
0550	1804		End of Line 3 at 100m. returning to cage course 323° Ships position N49°45.57' W130°16.29'
0552			Line 4 to SW. 226° no bottom contact..
0555	1802		bottom contact - broken lobes, light yellow sediment cover. Followed by pillows and a few orange starfish.
0556	1805		SS flow
0557	1806		SS flow
0558	1807	32	photo- SS lava flows
0559	1808	33	very flat sheet flows photo

0559	1808	34	Gjar in sheet flows photo ropey sheet flows.(flows with small linear parallel ridges.)
0601	1809		more lobate pillows - heading 215°
0603	1792		End of Line 4. headed back to cage foray 115m - no bottom contact
0606			Line 5 to S. heading 173°
0610	1797		bottom contact - bulbous pillow lava - light sprinkling of yellow sediment.
0612	1804		Large pillow lavas approx. 1m!
0612	1807		nice fissure (scarp) - SS lavas
0613	1809		very flat sheet flow with a very small fissure running through it.
0614	1808		back into broken lobate flows.
0614	1808	35	broken lobate flows
0615	1807		SS
0615	1806		Flat sheet flow with broken sheet flows over it
0616	1805	36	photo of crab on SS
0617	1805		more SS
0618	1805		lots of yellow sediment stirred up
0619	1806		hyaloclastite
0620	1806		End of Line 5. turning around and headed back to cage. foray 130m
0624			Ship's position 49°45.573' 130°16.283'
0626			Line 6 to N. Ships position N49°45.57' W130°16.29'
0629	1802		bottom contact - fissure, filled with tubular lobated flows
0630	1801		some glass sponges and a fish.
0631	1798		SS
0632	1796	37	photo-tubular lobate lava flows.
0633	1785		End of Line 6. headed back to cage - foray approx 100m no bottom contact.
0639	1798		Line 7 to W. bottom contact - lobate lava flows
0643	1803		series of scarps. Heading 271° out 100m.
0644	1810		fissure approx 1m wide.
0645			End of Line 7 at 100 m from cage. headed back to cage on heading 107°
0648			Ship's position 49°45.575' 130°16.283'
0649			Line 8 to E. Heading 88°. No bottom contact.

0651	1802		bottom contact. Scrambled sheet flows SS and ropy sheet flows
0652	1800		lobated flows and pillows. Light dusting of sediment aka LDOS.
0653	1784		crab and more pillows
0655	1784		still pillows ; out 100m.
0656			End of Line 8. headed back to cage. Planning for the next station. <i>Video taping stopped while we plan.</i>
0734			ROPOS at the cage, moving the ship to a new position: N49°45.50', W130°15.80' (Station 3)
0744			<i>Oceano acoustic set now working - we have bottom navigation by reading the Oceano box but a computer program Edwards wrote to do the trigonometry for sub position based on previous fixes on the transponders from the Benthos acoustic gear does not provide a solution for the configuration of the navigation..</i>
0734			Ship at station 3, lowering the cage to depth of 1794m
0807			<i>videotaping resumed</i> , sub returning to bottom heading due North
0812	1841		Line 1 to N. at bottom, talus (PT), continuing due north
0813			lowering the cage more. Note: sounder reading 37m shallow
0819	1834		End of Line 1 120m due north of the cage - pillow talus the entire way, returning to cage. Ship's position 49°45.5044' 130°15.8384'
0823			back at the cage, ship's position is N49°45.53', W130°15.80' , leaving the cage heading due south.
0824	1844		Line 2 to S. at bottom, pillow talus
0825	1840		fine talus, vertical wall, sub heading 183°
0827	1848	38	pillow talus and some pillows, still at the vertical walls (fault scarp, cliff face - westward dipping)
0828	1849	39	just pillow talus, cliff face
0831	1845		top of the scarp, pillow talus
0833	1852		End of Line 2 110m due south of the cage, mainly pillows with some talus, returning to the cage. Ship's position 49°45.4981' 130°15.8024'
0836	1795		back at the cage, next run heads due east
0841	1844		Line 3 to E. at bottom, heading due east, pillow talus, at bottom of a scarp and ascending

0843	1824		at top, descending on the other side of scarp
0844	1836		bottom of other side, pillow talus, ascending next scarp
0844	1826		at a flat point, pillow talus, ascending more, still heading due east
0845	1800		at the top, pillow talus, descending other side
0848	1847		at the bottom, pillow talus
0849	1828	40	site where a sampling attempt was aborted, ascending to easier site
0858	1803	41	stopping for a manganese coated basalt Sample D281-05 placed into bin #4 (triangular shaped with one flat surface)
0907	1805		continuing on and we find hydrothermal sediment (HP) which we suction sample into jar #1 (Sample D281-06)
0916			hose came off the suction sampler during sampling
0919	1810		resuming due east course
0923	1812	42-44	solitary dead chimney which we knocked southward off the cliff
0927			Ship's position 49°45.5108' 130°15.8130'
0931	1812	45	remains of broken chimney: iron oxide interior surrounded by a layer of yellowish silica (?)
0937			End of Line 3. tether possibly caught somewhere, heading back to check
0940			tether found to be wrapped around an outcrop, manoeuvring to untangle it.
0945			ship's position is N49°45.51', W130°15.80'
0948	1783		back at the cage, beginning next run heading due west
0953	1833		Line 4 to W. at bottom, pillow talus
0956		46	photo of large cnidarian or ctenophore (went by fast)
0957	1840		pillow talus
1000			Ship's position 49°45.4963' 130°15.8290'
1001	1824		End of Line 4 120m due west of cage, all we found was pillow lava, returning to cage.
1005	1772		At the cage but ship had slipped out of position slightly during last run.
1013			ship still repositioning, sub being dragged
1022			sub back at cage, ship in position
1025	1833		Line 5 to SE. at the bottom beside a cliff (east of the sub), note that depth reading is only part way down the cliff as we want the top of the cliff

1026	1828		ascending cliff, pillows and pillow talus, maintaining heading of 136°
1027	1830		moving 136° parallel along the cliff. pillow talus, anemones, ophiuroids
1029	1824		metalliferous sediment, pillow talus
1030	1820		passing over the top and down the other side, heading 136°
1032	1822		lost (?), cannot see bottom, attempting to return to last cliff passed. Ship's position 49°45.5216' 130°15.8153'
1036	1857		at bottom of metalliferous sediment and pillow, position unsure but not far off course, possibly in hydrothermal plume, resuming heading of 136°
1038	1861		sulfide deposit, metalliferous sediment, black small hyaloclastite
1040			End of Line 5 at 110m from cage, bearing 136° (cage to sub), returning to cage
1046			back at the cage
1048	1841		Line 6 to NE. at bottom, pillow talus, flying 43° along scarp
1052	1825		scarp rising
1052	1824	47	metalliferous sediment amongst pillows
1053	1821		over the scarp, just pillows without metalliferous sediment
1055	1829		on bottom, pillow talus
1058	1827		End of Line 6 at 115m from cage, returning to cage
1100			<i>Stopped video taping</i> , moving ship 150m east, 50m south to begin new traverses
1113			Station 4. Ship's position 49°45.4853' 130°15.6989'
1114			<i>Video recording resumed</i> , sub leaving cage heading due South.
1116	1825		Line 1 to S. at the bottom, pillow, but ship off station, returning to the cage while ship repositions
1130			sub and cage lined up, sub returning to the bottom heading due south.
1131	1833		on bottom, pillow lava
1133	1837	48	hyaloclastite, lobate flows, pillow
1134	1845		pillow talus, metalliferous sediment
1136		49	ship a bit north off position, sub got tugged back over the metalliferous sediment, lots of particulates in water ("snow"), maintaining due south heading

1355	1828		Line 6 to SW. on bottom heading south west; pillow talus
1356	1835		fault scarp on left
1357	1836		pillow talus; going down
1358	1849		pillows; lots of sediment (100%); sheet flow; lots of popcorn
1359	1861		combination of pillows and sheet flows with metalliferous sediment
1400	1862	78	patchy sulfide; crab attacking small skate
1401	1862	79/80	drained pillow; sedimented sheet flows and pillows; End of line 6 at ? m from cage.
1405	1794		Station 5 chosen to be N49°45.41' W 130°15.67'; <i>videos stopped</i> and tapes changed
1436	1809		Line 1 to N. bottom contact - pillow lavas, normal pelagic sediment. Videos started. LDOS (light dusting of sediment)
1444	1788		pillow talus
1446	1769		End of Line 1 at 110 m from cage. headed back to the cage. Heading 212°. no bottom contact.
1452	1779		Line 2 to W. headed west @ 271°
1453	1790		bottom contact - more pillows - going up slope. Ship's position 49°45.3977' 130°15.6763'
1454	1789		some sediment
1455	1788		dead chimney and some sulfide deposit.
1456	1789	81	photo of chimney.
1457	1788		anemone
1457	1789	82	photo- chimney and sulfide mound.
1457	1789	83	photo - same as above.
1501	1787		anemone, same as one collected earlier
1502	1788	84	dead sulfide chimney
1503	1789	85	photo attempted of sample area, but probably missed.
1504	1789		sample of dead chimney - sample attempted
1510	1789		still trying to sample. iron oxyhydroxides , silica and small fish. Sampling attempt aborted.
1514	1789		TP and LDOS. metalliferous sediment.
1514	1788		another dead chimney site. Sample attempted.
1517	1788	86	photo - dead chimney and metalliferous sediment
1518	1788		Sample D281-11 placed in bin 7. Small piece of dead chimney
1522	1790		lobate flows.

1522	1789		pillows with LDOS Metaliferous sediment and sulfide pillows. 50 m from the cage on heading 279°.
1524	1788		striations on pillows. LDOS.
1524	1787		back to pillows, starfish.
1524	1787		talus and some more sulfide. Large pillows
1525	1788		edge of big valley
1527	1798		still heading 275° - lost bottom contact.
1528	1807		dropped down 10m
1528	1822		bottom contact. - still sloping down.
1530	1833		lots of metalliferous sediment and broken pillows. 30-50% sediment. enough to be stirred up by the sub
1531	1831		ROPOS at ~100 m from cage. Headed back to the cage along bottom on a bearing of 80°.
1534	1805	87	headed uphill - photo of slope with talus.
1537	1793		sulfide deposits. heading 082° still on the way back to the cage. attempting to sample.
1539	1794	88	photo of pillow and hopefully sulfide mass.
1548			Ship's position 49°45.4146' 130°15.6851'
1549	1795		Sample #D281-12 - sulfide deposits. sampled nice chunk of sulfide and placed it into bin #3.
1550	1795		metalliferous sediment at ~50? m from cage
1557	1764		End of Line 2. Back to cage
1558	1795		Line 3 to E. On bottom, pillow lavas
1559	1800		Gap between pillows, fissure?
1600	1801		Fissure
1601	1803		Cardboard on bottom
1604	1813		Large pillows w/ sed pockets between; lightly sedimented
1604	1813	89	Sea cucumber
1605	1804		End of Line 3 at 100 m from cage. Heading back towards cage at 270°
1612	1799		Line 4 to S. on bottom heading initially 000; pillows and lobate flows; light sed cover; Ship at 49°45.39, 130°15.68
1614	1800		Turning direction to 180, heading south past launcher along bottom
1615	1801	90	Photo: Pillows
1616	1803		Fissure 000, metalliferous sediment and jarosite north of fissure.
1616	1803		Scarp, lightly sedimented

1617	1800		small starfish
1620	1800		metalliferous seds
1621	1798		End of Line 4 at 100m from cage, return to cage in mid-water
1625			<i>Change video tapes on both decks</i>
1628	1793		Line 5 to SW. on bottom; heading 225; pillow lavas lightly sedimented
1631	1794		Ship at 49°45.39 130°15.68
1631	1795		sulfide mound, about 50m out from cage
1634	1795		pillows and metalliferous sed; jarosite
1636	1794	91	photo of sulfide mound; soft orange sample of iron oxyhydroxides w/ copper green (nontronite?) interior collected, Sample D281-13 deposited into bin 4
1640	1794	92	photo of oxyhydroxide mound & nontronite deposit
1641	1794	93	photo; same as 92
1643	1794	94	photo; sampling site of mound, same as above
1647	1794	95	photo; same as 93
1648	1793	96	photo; same as 94
1650	1792		transition from oxyhydroxide mound to lightly sedimented pillows
1650	1787		fissure trending 000
1652	1790		Ship at 49°45.48' 130°15.67'
1653	1802	97	photo; pillows exposed in scarp
1654	1801		End of Line 5; returning to cage in mid-water
1707	8749		STATION 6 @ 49° 45.48'N, 130°.15.61'W. Moving to a new site in search of the "snow cloud" on Line 3 of Station 4.
1717	1789		bottom contact--P. Initially went to E for ~25 m but saw only P so reversed track to west.
1720	1795		Line 1 to W; heading west 285°
1721	1788		contact with snow cloud -
1723	1789		
1724	1788		Sample of sediment : D281-14 in jar #3 - floating particles (snow) sucked into vacuum as ROPOS moves
1725	1796	98	photo: crab on P
1729	1797	97	photo: P
1730	1799	100	photo: wire in pillows
1733	1795	101	photo: crab on pillow
1736	1810		Pillow lava field

1739	1808	102	translucent white bacteria on pillow; photo: small patch (~50cm)
1741	1808	103	photo: bacteria (same as 102)
1742	1808	104	photo: same as 102
1745	1808		Nice pillow lava field. Sample D281-15 in bin #2: small in situ broken fragment of basalt covered with bacteria. Rectangular shape with thin Mn coating : size 10x10x5 cm.
1748	1804	105	photo: crossed over big fish
1749	1804		Fault scarp several meters deep and 2-3m wide trending towards 27°N ROPOS following along fissure walls covered with P. Crossing over because too narrow to get in.
1755	1808		ship position: 49° 45.45N, 130° 15.62W
1759	1800		water temp up to 2.23 °C
1800	1790		water temp down to 2.16°C (= normal)
1801	1787	106	photo: tube worms!!!!; temp=2.21°C
1801	1787	107-	photos:dense patches of tube worms covering pillows;
		111	interstitial pockets of sediment.Temp=2.24°C
1803	1785	112	photo: tube worms
1804	1785		dropped marker (=2); ship @ 49 45.45, 130 15.61. ROPOS 100m S-SE of cage.Temp=2.34°C
1807	1785		conducting temp probes: 2.27°C
1808	1785		temp= 2.29°C
1811	1785	113	photo: brilliant orange shrimp swimming by; Temp=2.27°C
1813	1785		pillow scarp
1814	1785		ship moving while ROPOS stationary. New ship coordinates: STATION 7: 49° 45.4759N, 130° 15.6088W
1817	1785		sea anemone
1818	1782	114	photo: small octopus
1819	1782	115	photo: small clump of black & white tube worms
1819	1782	116	photo: tube worms (Ridgia)
1820	1782		dropped marker (=3) ROPOS is 80m N of cage
1823	1784	117	clumps of tube worms Photos 117-118
1825	1786		changed video cassette
1826	1786		temp read with probe =2.29C
1828	1786	119	photo:tube worms/lavas

1829	1787		Sample D281-16: large clump of tube worms; blood in water Put into bin #1; sample completed at 1839. Located 80m N-NE of cage.
1831	1787		probe put in tubeworm patch. Max temp reading = 4.22°C
1834	1787	120	photo: vent field
1840	1787		marker dropped (=4) at tube worm sample site
1840	1787	121	photo: marker (=4) on tube worm site
1841	1786	122-	photos tube worm site
		123	
1842	1784	124	photo: tube worm site
1844	1784		ship's position: 49°45.4983N, 130°15.6122W
1845	1784		ROPOS moved further N-NE and sideways towards the west. No more tube worms. ROPOS backing up to previous tube worm site
1847	1784		marker (=2) spotted; small, sparse patches of tube worms seen
1850	1787	125	photo: tube worm patches
1850	1790		large crab feeding near tube worm patches
1851	1790	126	photo: tube worm site; pillow lavas
1852	1791	127	photo: large crab; tube worms; pillows
1852	1791		dropped marker (-5) @ tube worm site
1854	1787		marker field approximately 50m long N-S. No evidence of hydrothermal precipitates outside field.
1855	1787	128 -	photos: crab eating tube worms
		129	
1856			marker (=4) spotted
1857		130	photo: fish in lobated flow. (but missed the fish)
1859	1785		galatheid crab spotted
1900	1785	131	photo: pillow lavas, tube worms
1913	1780		ROPOS stationary; waiting for lubricating oil for main winch.
1918	1804		Sample D281-17: broken pillow talus; has flattened star-like organism. Put into bin #3 together with the tube worms
1921	1804		ship's position: 49° 45.47, 130° 15.63; 40m W of cage
1926	1804	132	photo: pillow talus
1928			cage brought up a few meters
1932			cable being lubricated; Steve did not make log for station 7
1936			departure from bottom

2018	1100	ROPOS being raised in the cage
2033	802	temp = 3.68°C
2052		temp = 4.55 C @ 400m
2058		temp = 5.1 C @ 300m
2102		video on @ 200m
2131		ROPOS on Deck
 <u>DIVE 281 SUMMARY</u>		
total bottom time = 16h49m hours		
dive length = 21h36m (longest on record for ROPOS)		
total # of photos = 132		
total # of samples = 17		
total # of SIT tapes (2 hr. length) = 8		
total # of COLOUR tapes (2 hr. length)= 7		

CanRidge III ROPOS Dive Report

Dive No. 282

Location: N49°47.59', W130°15.61'

Objectives: Deploying Nigel's CSTEM experiment to above location on the southwest side of Magic Mountain using ROPOS

ROPOS Configuration: Both arms being used to carry down the CSTEM experiment so suction sampler has been removed. Marker dropper, still camera, and still camera strobe removed to reduce ROPOS weight. SIT camera, colour camera, and sample tray deployed although sampling facilities cannot be used because of weight limitation.

Time & Date at Start 2100h, July 24, 1994 (PDT)

End 0120h, July 25, 1994 (PDT)

Lat & Long at Start: Ship at N49°45.54', W130°15.57 (ship)

Time	Depth	Hdg	Comments
0359 UT			ROPOS launched but ship is not in correct position - waiting on the ship. Time is UT (= PDT + 7 hours).
0403			ROPOS descending as ship moves to specified coordinates (given in Location above)
0407			ship's position: 49°45.598'N, 130°15.61'W
0411			ship's position: 49°45.5625'N, 130°15.6326'W
0414			ship's position: 49°45.5314'N, 130°15.9536'W
0420			ship's position: 49°45.5183'N, 130°15.5924'W
0425			ship's position: 49°45.5078'N, 130°15.6262'W
0430			ship's position: 49°45.4807'N, 130°15.6136'W
0441	274		ship's position: 49°45.4976'N, 130°15.5816'W
0445	334		ship's position: 49°45.4798'N, 130°15.6042'W
0501	596		ROPOS descending
0540	1264		cage lost, cage stopped; searching for it begins
0548	1268		cage relocated and descent continues
0554	1367		
0604	1552		
0609	1597		hydraulics briefly turned off to test Nigel's nav program. This is needed to obtain accurate ROPOS-transponder distances.

0619	1762	
0619	1765	REACHED BOTTOM Ship's location: 49°45.4814'N, 130°15.6131'W ROPOS at X=81316 Y=1733.
0620	1791	video recorders turned on. Moving to NW.
0622	1787	patch of coral; P
0629	1787	taking a fix on transponders. Attempt abandoned.
0633	1789	Fissure (several meters wide) in pillow lava trending NE-SW ~205°
0635	1790	more coral patches
0636	1799	broken pillows
0638	1800	sulfide mounds and a sponge.
0642		lost video image - now 75m NW of start position.
0644		DIVE ABORTED DUE TO GROUND FAULT IN THE CAGE. Videos off.
0820		ROPOS back on deck
<u>DIVE 282 SUMMARY</u>		
Total Bottom Time = 25 minutes		
Total Dive Length = 2 hours, 45 minutes		
Total # of SIT video tapes (2 hrs each) = 1		
Total # of Colour video tapes (2 hrs each) = 1		
No samples = 0		
No photos = 0		

CanRidge III ROPOS Dive Report

Dive No. 283

Location: Magic Mountain area

Objectives: To create an electrical image of an active sulfide deposit using Transient Electromagnetics (TEM). The method includes the deployment of a receiver unit on the sea floor. A second transmitter unit attached to ROPOS is conveyed to remote locations and signals passed between the units are recorded.

Note: Camera and marker droppers are not on ROPOS for this dive due to weight restrictions. No heavy samples will be taken. Suction sampler removed.

Time & Date at Start (off deck): 2300h, Mon. July 25, 1994 (PDT)

End (on deck): 1235h, Tues. July 26, 1994

Lat & Long at Start 49°45.4505'N 130°15.6902'W (ship)

End 49°45.4411'N 130°15.7160'W (ship)

Time	Depth	Heading	Comments
0612 UT	0		ROPOS launched from afterdeck Time is UT (= PDT + 7 hours)
0709	1361		
0727	1718		ROPOS position (in cage): X=481202, Y=5511714
0737	1832		at bottom, pillow lava, beside scarp 20° up to NW relative to image
0739	1831		heading due west in search of vent field, <i>videos started</i>
0740	1836		metalliferous sediment, pillow, hyaloclastite, working way up scarp
0743	1833		dead chimney, sulfides
0744	1833		pillow
0746	1835		circling about looking for a vent field, more dead chimneys
0749	1833		pillows, ROPOS position (out of cage): X=481184, Y=5511646
0751	1837		sulfide mound
0754	1839		single, lobate flow, plagiophyric, looking for a spot to deploy TEM, heading west
0757	1836	280	lobate flow

0800	1833	090	searching due east (back-tracking towards the cage)
0802	1838	091	pillow, metalliferous sediment, sulfide deposit
0805	1840	089	ROPOS set down on the bottom near sulfide mound with intent to deploy TEM. ROPOS position: X=481354, Y=5511677
0813			same location, deploying TEM experiment
0832			TEM (including receiver) deployed
0833	1839		mound appears to be made of iron oxyhydroxide, unable to sample
0834			ROPOS is directly above the TEM receiver position: X=481334.3, Y=5511709.3 (only three transponders so we will repeat)
		072	flying over the TEM to measure the orientation: 080° looking from the sensor south receptor towards the sensor north receptor
0839	1834	155	TEM orientation: 155° looking from the sensor west receptor towards the sensor east receptor
0842			second fix on ROPOS (directly over the TEM receiver): X=481240.4, Y=5511650.98
0900	1844		ROPOS is too buoyant so taking two rock samples to gain weight. We will keep both Samples D283-01A and 01B basalts in bin #1. Note these samples taken 50 cm apart at the TEM location. Note: Two in situ fragments of pillow basalt probably from the same flow. Sediment roughly 8 cm depth over these pillows (50-100 cm large). Area is relatively flat and covered with 70% pillows and 30% interstitial pockets of sediment.
0906	1840	67	sitting on the bottom, discussing what to do while the ship moves to a position directly over top of the ROPOS and TEM experiment.
0940			ROPOS fix directly over the TEM receiver: X=481227.1, Y=5511674.98
0941			ROPOS fix directly over the TEM receiver: X=481202.2, Y=5511711.18
0944			ROPOS fix directly over the TEM receiver: X=481196.3, Y=5511714.00

0956	1840		on bottom at the TEM. Attempt to move cage directly over the TEM failing because, despite ship movements, we cannot find the cage on the sonar.
0958	1800		ascended to 40m above the TEM in hopes of finding the cage on the sonar.
1002	1781		cage found on sonar, planning where to move the ship
1010	1841	71	back at the bottom, trying to locate the TEM, heading east, pillow talus
1014			found the TEM. We believe that the cage is directly above the TEM
1016			ROPOS fix directly over the TEM: X=481178.3, Y=5511723.4 (received only three transponders)
1017			ROPOS fix directly over the TEM: X=481237.7, Y=5511660.91
1019			ROPOS fix directly over the TEM: X=481175.8, Y=5511719.95 (received only three transponders)
1020			TEM is northwest of a dead chimney
1021			ROPOS fix directly over the TEM: (received only three transponders)
1023			ROPOS fix directly over the TEM: X=481184.2, Y=5511696.82
1024	1840	57	Line 1 to NE: leaving TEM, heading north-east in hopes of finding Magic Mountain, rising up a hill of pillow lava with metalliferous sediment
1027	1838	47	slight heading change, sulfides, metalliferous sediment, on a sulfide mound, jarosite
1030	1839	50	Beginning transmitter station #1 for the TEM work
1038			ROPOS fix at transmit station #1: X=481331.8, Y=5111737.73 (three transponders only)
1040			ROPOS fix at transmit station #1: X=481350.9, Y=5111732.28 (three transponders only)
1041			ROPOS fix at transmit station #1: X=481221.5, Y=5111759.46 (three transponders only - one probably not good). Cage is 95m southwest of ROPOS by sonar.

1043			ROPOS fix at transmit station #1: X=481243.1, Y=5511740.43
1045		46	moving towards another station (again towards Magic Mountain), sulfide mounds, 10m high dead chimney
1049	1842	50	Beginning transmitter station #2 for the TEM work, cage is roughly 124m NE (bearing 51°) from the cage
1052			Two sulfide mound samples (Samples D283-02 and D283-03) into bin #2
1054	1842	48	Maintained this heading while sampling at station #2, barite fragments, sulfide
1057	1842	322	New heading at station #2 for TEM work
1107	1842	54	New heading at station #2
1114	1842	46	ROPOS moved slightly
1119	1842	324	New heading at station #2
1123			ROPOS fix at transmit station #2: X=481383.6, Y=5511768.79 (three transponders only)
1124			ROPOS fix at transmit station #2: X=481350.5, Y=5511720.77
1126			ROPOS fix at transmit station #2: X=481341.2, Y=5511730.42
1129		225	Line 2 to SW: Heading southwest towards a new station, pillow lava
1135	1838	229	Beginning transmitter station #3 for the TEM work, cage is 90m away bearing 229°.
1138	1837	228	moving onwards, sulfide mound
1140		225	broken pillow, ascending to get a sonar fix on the cage
1148	1805	225	found the cage on sonar. This will be transmitter station #4, cage is 75m away bearing 226°
1149	1805	222	ROPOS fix at transmit station #4: X=481185.0, Y=5511660.03 (three transponders only)
1151	1806		ROPOS fix at transmit station #4: X=481192.9, Y=5511653.97 (three transponders only)
1152	1820		ROPOS fix at transmit station #4: X=481190.3, Y=5111644.52 (three transponders only)

1154	1808		ROPOS fix at transmit station #4: X=481190.3, Y=5111644.52 (three transponders only)
1156	1809	228	ROPOS fix at transmit station #4: X=481192.2, Y=5111637.46 (three transponders only)
1158	1831	228	on bottom at transmit station #4, pillow lava, fixes for station #4 were taken at the top of a large fault scarp
1207	1830	139	new heading for TEM work, pillow talus
1218		226	done station #4, going back to the TEM receiver
1221	1852	229	pillow talus
1222	1849	225	metalliferous sediment, dead chimneys
1225			tether possibly caught somewhere, have to go back and look
1231			back at the cage, large fish
1234	1764	102	ROPOS fix at the cage: X=481138.9, Y=5511695.36
1235	1765	135	ROPOS fix at the cage: X=481143.6, Y=5511722.69
1236	1763	105	ROPOS fix at the cage: X=481142.0, Y=5511710.58
1241			descending to the bottom directly below the cage (if all is correct, the TEM should be there according to the above fixes)
1244	1840		at bottom, looking for the TEM
1247			went east a little and we found the TEM
1247	1840	000	Line 2 (3?) to N: for a new TEM station
1249	1832	000	heading north, pillow lava, ascending a slope
1250	1833	000	at the top of the hill, pillow lava
1250	1838	000	at top of the hill for transmit station #5, 75m north of the TEM site, maintaining this heading for first reading
1304	1837	272	new heading for TEM readings
1312			ROPOS fix at transmit station #5: X=481157.1, Y=5511777.15
1313			ROPOS fix at transmit station #5: X=481205.5, Y=5511717.60
1314			ROPOS fix at transmit station #5: X=481160.4, Y=5511774.01
1315		003	continuing north in search of a new site, pillow lava
1319	1834	002	pillow lava, ascending a ridge of pillow lava

1322	1809	003	120+m of tether played out, at the top of the ridge which heads north-south, but not a good spot for transmitting. Heading down the east side of the ridge (where we came from) in hopes of a good spot.
1326	1844	002	a bottom of ridge (east side), pillow lava
1329	1846	005	beginning transmit station #6
1337	1846	275	new heading for TEM readings
1343	1846	271	slight change in ROPOS position
1348	1813		ROPOS fix at transmit station #6: X=481130.2, Y=5511701.2
1349	1807		ROPOS fix at transmit station #6: X=481132.2, Y=5511704.7
1350	1802		ROPOS fix at transmit station #6: X=481124.7, Y=5511705.5
1351			returning to the cage
1400			at cage, descending to the TEM
1411			unable to find the TEM, back to the cage
1413	1820	153	cage is located on sonar, taking a ROPOS fix: X=481150.2, Y=5511641.36. Cage is 30m north of the ROPOS
1414	1820	180	ROPOS fix: X= 481165.1, Y= 5511642.97
1425	1815		Headed back to the cage
1427	1787		Back at cage. Plan to go more N and E.
1429	1793	030	Trying to find the receiver.
1433	1838	030	Bottom contact.
1435	1840	031	Talus. Scarp below talus oriented 300° slopes down to 075.
1437	1836	030	Rat tail fish.
1441	1836	033	Crab. Pillow lava, talus and scarp still @ approx. 300°, down to 070
1442	1834	010	More crabs. Distance from cage on sonar about 80m.
1445	1838	093	More talus.
1446	1831	217	Headed back toward the cage.
1448	1837	242	Pillow lava and talus.. Small scarp @ about 350° sloping down to about 060°.
1449	1836	234	popcorn. Found receiver!!
1451	1836	072	Looking at receiver from the other side. Circling over it.
1453	1836	138	Starting Line #3 - going about 75m from the cage.

1456	1835	139	Crab and small spider crab.
1457	1838	138	Small scarp @000 sloping down to 090.
1459	1829	135	Still seeing same scarp, position relatively constant.
1503	1788	139	Gained about 50m elevation.
1504	1785	117	Reached the top!! About 80m from the cage.Small pinnacle at the end made of pillow lavas..
1507	1789	359	Backtracking. Going back down to get a reading at the bottom.
1508	1789	003	Scarp @000, sloping down to approx. 090.
1510	1793	003	Still going down....
1511	1796	148	pillow lavas, scarp at 000 sloping down to 090.
1512	1795	141	lost sight of bottom.
1514	1812	142	Still going down...
1518	1815	142	60m from the cage.
1519	1826	146	Pillows and talus of broken pillows
1520	1829	144	Ship has moved 37.5m to the east and 15 m south.
1523	1842		Talus. Still going down.
1524	1835	144	Some "snow", probably kickback from the thruster. Ascending back to the cage.
1529	1781	294	Cage in sight.
1530	1782	105	For the last 30 min we have been having problems...Tether appears to be caught. Heading towards neck of the wire.
1532	1784	311	Tether caught on pillows at the top of the cliff.
1533	1773	275	Tether is free.
1534	1758		Aborted line due to being unable to go far enough and getting caught on the top.
1535	1765	293	Going back to the cage.
1538	1778	250	Back at the cage.
1540	1780		Tether is all tangled up around the drum on the cage. Have to reel it out to untangle it. Traveller that runs across the drum has come off. So we only have about 80m free.
1550			Videotapes changed - put in tape #5
1551	1779	269	Cage moved up 20m to keep tether from getting more tangled.
1554	1762		No tether control, so moving the ship back to original position above the receiver.
1557	1828	015	Encountered bottom (pillow lava) in efforts to untangle tether.

1600-1604	1830		ROPOS fix: X= 481168 Y= 5511636 Fix indicates we are approx 80m south of the receiver. Trying to find the receiver
1613	1814	123	Possible chimney encountered along the way.
1618	1793	020	ROPOS fix: X= 481236 Y= 5511673.7. Need to go NW about 70m.
1623	1815	311	Cage about 80m away in a NW direction.
1625	1831	318	Back on bottom. Large rat tail fish. Pillows and talus. Crab.
1626	1834	318	"Snow"
1628	1836	314	Pillows and broken pillows. Unable to get sonar distance from cage.
1630	1841	283	pillows. Distance to cage 70m.
1633-1638	1833	275	ROPOS Fix: X= 481282.9 Y= 5511707.68. Appear to be too far to the east. Need to go 105m to the west.
1642	1836	296	Back to the bottom Crab and an anemone. Pillow lavas and talus.
1645	1832	289	Navigating by biology. Back over crab and anemone.
1647	1823	283	Distance from cage about 90m.
1649	1835	280	Round pillow lava field
1650	1830	280	Talus of broken pillows
1651	1833	083	Going East to try to come back on the receiver.
1652	1834	086	pillow lava field. Crab. Still not on station.
1653	1827	083	going up..Cage 80m to the south of ROPOS.
1657	1805	083	lost sight of bottom. Need to head 60m south. .Going back to the bottom. Up in water column to get a good sonar scan.
1659	1832	173	Back to the bottom. Pillows.
1700	1835	132	Found the receiver!! Going up to have a look at it. Receiver is bent at an angle of about 30° - resting against a boulder. In a site with pillows, metalliferous sediment and iron oxyhydroxide.
1704	1836		Picking up the electrode and putting it in the sample tray in bin 2/3.
1706	1836		Brittle (?) star. Quite a bit of sediment cover on the pillows.
1708	1836		Picking up the receiver.
1713	1836		Receiver secured in arms, getting ready to take off.

1714			Ships position 49°45.4351'N 130°15.7131'W Cage is 70m SSW
1717	1836	190	Going back to the cage.
1721		183	Cage in sight. Checking tether for ascent.
1730			On our way back up. ROPOS not in cage because of tether problem Will do a two part recovery.
1923			Cage on Deck, manoeuvring ROPOS to bring on deck
1935			ROPOS on deck End of Dive 283
			<u>DIVE 283 SUMMARY</u>
			total bottom time = 09h53m hours dive length = 13h23m
			total # of photos = 0 total # of samples = 3
			total # of SIT tapes (2 hr. length) = 0 (malfunction, recorded only sound) total # of COLOUR tapes (2 hr. length) = 5

CanRidge III ROPOS Dive Report

Dive No. 284

Location Magic Mountain area

Objectives: Locate, map and sample Magic Mountain hydrothermal site. Locate vents suitable for later deployment of vent fluid sampler and "chimney catcher". Drop markers at appropriate locations. This dive is located within reach of tubes worms on Dive 281, sulfides on Dive 283 and peak of hill of E/S-12.

Camera: Mounted high on the bumper, angled downward to focus 7 feet in front of the sub. 400 ASA film, Fujichrome 400 color reversible (slide) film, 28 mm lens, FStop 4.5, distance set to 4.5-7 feet, film code is L2 - Total exp.: 250

On board equipment: normal claw on 7 function arm, suction sampler and temperature probe on 5 function arm, marker dropper.

Time & Date at Start (off deck) 2315h, Tues. July 26, 1994 (PDT)

End (on deck) 1815h, Wed. July 27, 1994 (PDT)

Lat & Long at Start 49°45.55'N 130°15.55'W

Time	Depth	Photo	Comments
0615 UT	0		Two-part ROPOS and cage launch completed. Time is UT (= PDT + 7 hours)
0624	10		ROPOS back in cage for faster descent.
0745	1594		Temperature probe is not working.
0753	1724		ready to take ROPOS out of its cage, waiting for the ship to get on position
0807			ROPOS leaving the cage, heading downward
0810	1766		directly below the cage, on the bottom, facing a pillow mound
0813			two attempts at an acoustic fix, both failed (only receiving two transponders)
0815	1785		Station 1 Line 1 to S. ROPOS on the west side of a scarp, scarp slopes down NW to SE (relative to screen) Ship's position 49°45.55' 130°15.55'
0816	1791		not all the way down, pillow talus, jarosite
0819	1792		metalliferous sediment, pillow talus, plume (?) snow, sulfide

0822	1799	1	sulfides, metalliferous sediment
0823	1799	2	white bacteria amongst the sulfides
0825	1802	3	sulfide mound
0825	1802		as far south as ROPOS can go, 120m due south of the cage
0827			heading due east, ascending the scarp
0828	1796	4	ascending the scarp, pillow talus, possible sulfides
0829	1793		ship having navigation problems (Gyro), so ROPOS must ascend
0831	1790		aborting ascent, approaching a large active spire, low-temperature vent based on pillow lava
0833	1790	5	photo of the active spire
0834	1791	6	again
0835	1791	7	again
0835	1792	8	again
0835	1791	9	again
0836	1793	10	again
0836	1793	11	again
0836	1794	12	again
0841	1792	13	near base of spire, photo of collapsed chimney beside it
0843	1792		small venting near the base surrounded by Paralvinella sp., tube worms, Beggetoa, limpets.. Several locations on the spire harbour dead tube worms.
0844	1792	14	base of spire
0850	1792		dropped marker "=12"
0856	1801	15	photo of strange crab
0900			attempting to sample a sulfide chunk (many are too soft)
0910	1789	16	photo of top of spire
0923			small piece of anhydrite in bin #7 (sample D284-01) from top of the active spire
0926			suction sample (D284-02) into jar #6 of emission at the top of the spire
0932			suction sample (D284-03) into jar clockwise to jar #6 (if looking down on from the roof of the sub) of animals from top of spire and at the active spot at the bottom - not successful as the filter is plugged - trying again into jar #4 (D284-04) however the suction sampler not working well.
0955	1791		diffuse flow venting just south of spire, Buccinum snails, drop marker "=13"

1006	1793		at the spire, ROPOS fix failed (no transponders)
1008	1793		at the spire, ROPOS fix failed
1010	1769		above the spire, hopefully high enough, cage 90m north-west of ROPOS, ROPOS fix: X=481465.4, Y=5511838.72
1011	1757		as above, ROPOS fix: X=481455.5, Y=5511852.33
1013	1744		as above, ROPOS fix: X=481368.8, Y=5511813.52
1015			returning to the cage
1024			Line 2 to E
1028	1801		at the bottom, pillow lava, continuing due east
1030	1785		heading east, ascending a vertical cliff, pillow lava
1033	1766		at the top, pillow lava, continuing east
1035	1770		60m due east of the cage
1036	1771		sample of pillow lava fragments (Sample D284-05) into bin #8
1050	1766		continuing due east
1053	1780		fallen over chimney (not active), plume in the water, metalliferous sediment, cage 60m due east (we moved south a bit while sampling), lots of non-active chimneys
1055			ROPOS fix at above location: X=481489.3, Y=5511882.3
1057			ROPOS fix at above location: X=481485.5, Y=5511881.42
1058			ROPOS fix at above location: X=481490.8, Y=5511879.8
1100	1770		looking for rock samples
1101	1766	17	sulfide chimney, not active
1101			many large non-active chimneys (exceeding 10m in height) visible
1102	1767	18	photo while leaning on a chimney, possibly a fish in frame
1103			taking a sulfide sample (Sample D284-06) placed into bin #1; part in 7 and little bits in 8
1118	1773	19	ca. 60 m from cage heading eastwards
1119	1770		sulfide talus
1120	1767	20	spire; inactive; photo top of chimney
1122	1764	21	active vent ; shimmering water; drop marker = 14; using suction sampler, seems to be working, into bottle 8; Sample D284-07 . Took another suction sample, into bottle 3; Sample D284-08
1135	1762	22/23/ 24	big tube worms at active shimmering vent site
1144	1767	25	photo of tube worms on active vent

1149	1765	26	photo of active vent, managed to sample "beehive structure" at the vent into bin # 8; D284-09
1151	1769		attempt at recovery of oxide spire unsuccessful
1157	1768		managed to get some small bits of active vent into bin 6&7; then managed to get a very good sample into same bin Sample D284-10
1206			sample of sulfide? into bin 6/5 Sample D284-11
1208	1761	27	extremely large clump of tube worms
1215	1772	28	photo of a small spire. try to hack it off into sample bin 4 unsuccessful. as it proved to be too hard.
1219	1773	29	photo of bacteria? mat on sulfide mound fix x = 81459.1 y = 1866.78
1227	1731		40 m south of cage (bad fix); return to cage; want to go north
1233	1746		Line 3 to N. fading towards east
1234	1771		pillows, vertical wall, going up east wall of valley
1236	1753	30	2m wide ridge that we're following; like a spine; photo
1240	1752	31	skate egg sacs on pillows; north about 80 m from cage
1241	1755	32	brittle coral on pillows of east fault scarp
1243			fix was unsuccessful as there were responses from only 2 transponders.
1244	1748		returning to the cage as no interesting structures were found.
1247	1719		Line 4 to NE reasoning being that in lines before we always got pushed to the south when trying to go east. Our goal is to head east
1253	1789		pillow talus at the side of the line. metalliferous sediments on bottom
1254	1775		broken off, sheared off talus
1255	1766		fault scarp 000, 10m high
1255	1764		fissure at 340
1256	1764		pillow lava
1258	1764		80 m northeast of cage
1259	1761		heading back to the cage as no vent sites were discovered. x = 8151 y = 1962.4
1300			midwater 90 m WSW of the cage taking fix x = 81489 y = 1942.695
1318			Moving ship 100 m to SE
1342			Station 2 Ships position 49°45.4974' 130°15.4666' x = 81434 y = 1788

1342	1722		Line 1 to S
1346	1790		on bottom, pillows; deep fissure oriented 000
1348	1799	33	photo of pillows
1349	1802		metalliferous sediments
1350	1808	34	picture of a small fissure
1359	1719		back at cage
1403			staying at cage to change video (Dive 284, tape 3)
1404	1785		hit bottom underneath the cage
1405	1785	35	Line 2 to E , heading off east, pillow lavas, photo of pillows
1407	1785		heavy to medium snow
1408	1786		pillows
1411	1800		heading back to the cage, misses vent field
1414	1755		
1417	1720		back to cage
			Line 3 to NE,
1423	1798	36	photo of pillows!! and a crab
1426	1789		medium snow, metalliferous sediments
1428	1773		returning towards cage after venturing 120 m towards northeast
1430			arrived at cage,
1433			Line 4 to N
1435	1788		bottom contact, pillow lavas
1439	1766		arrived at the top of the hill
1440	1765		sulfides, 80m NE away from cage
1442	1764		fissures
1442	1764		cage is 95 m SW from us now
1443	1764	37	pillows and metalliferous sediments
1444	1763		fissure 045, 1m wide
1446	1762		cage due south 100 m
1446	1762	38	photo of fissure
1448	1763	39	photo of talus, fissure
1449	1759		we are due north of cage 118m
1451			heading back towards the cage. Will head WNW from there. Currents are pushing us towards the east
1453	1724		Line 5 to NW . Pillow lavas and metalliferous sediments. ROPOS is 20 m WNW from cage. Hit edge of sulfide mound
1458	1771	40	pillows

1840	1785	118	bottom contact ; chimney knocked over, smoke billowing out horizontally. Photos 118-125 of this site
1844	1780		dead spire; another dead spire at least 10m high
1845	1772	126	photos 126-127: other chimney; 15m from cage, still in field of spires, mounds, black smokers. Continuing on with Line 6.
1846	1772		still in lava field, pillows, spires, smokers @ 30m from cage
1847			fragments of massive sulfides on pillows
1848	1771		on a small mound a few meters across. Back to pillows again.
1849	1771		metalliferous sediment & pillow lavas. Ship position: 49°45.53'N, 130°15.510'W
1850	1767		ROPOS 70m E of cage and on pillow lavas
1851			80m E of cage still on pillows with occasional patches of metalliferous sediment
1852			fault scarp 000 relative down to SE
1853	1769		ROPOS 90m E of cage
1854	1768	128	photo: octopus
1855	1758		100m E of cage. End of Line 6. Going back to cage.
1857	1724		appears to be a current from the N that pushes NE lines eastward and northwest lines westward.
1900	1770		Line 7 to SE. Bottom contact; sulfides and isolated tube worms
1901	1772		pillows with metalliferous sediment
1902	1777		pillows going downhill stepwise
1904	1798		dropped 20m; moderately sedimented pillows
1906	1780		going back to the cage.
1912	1726		Back at cage. Repositioning ship back on site, and getting Captain on the helm to hold course. Sailboat on horizon.
1920	1723	129-31	3 photos of the cage from ROPOS.
1921			Line 8 to SW. Going down.
1923	1774		on the bottom - getting reorientated.
1925	1777	132	Photo of smoker. Dropping marker #-8. We've sampled here before.
1928	1776		Continuing SW. Pillow lavas with some metalliferous sediment.
1930	1775		Scarp 135° relative to the monitor screen, sloping down to 000.

1931	1779		Sulfide chimney covered with bacteria and sulfide worms (palm worms) Bacteria on spires, but dead chimney.
1932	1775	133-4	2 photos of dead chimney. est. 50m from cage.
1933	1778		back to pillows.
1934	1777		ROPOS 90m S from cage
1934	1776	135	photo of dead spire.
1935	1778		scarp N/S down to the W relative to the screen.
1936	1788	136	photo of 3-4m high active chimney.
1937	1791	137	photo of live part of spire.
1938	1791	138	photo of live spire, lots of spires. Still moving SW.
1938	1794		going down.
1939	1802		bottom contact, still have spires. Heading 234.
1940	1808		metalliferous sediment. On another mound!
1941			End of Line 8. Out 150m SW from cage. Headed back to cage.
1947	1724		Back at the cage. <i>Plan to go down to the bottom and go NW to a scarp with activity and try to measure the thickness of the sulfide deposit.- try to find the spires of line 5A.</i>
1950	1767		Bottom contact. Scarp at 330 sloping down to 030, relative to screen
1951	1766		Right under cage, and going down. Pillow talus.
1952	1770	139	photo of rusty tin can. Starting to go up the slope.
1953	1769		going up - pillow lavas with brittle coral.
1954	1768		sulfide starting. heading 169°. Spires. Not happy with site, so going NW to a better area. heading 324°.
2009	1744		didn't find it - back at the cage.
2009			continue searching for cliff where tube worm sample was taken on Line 5A.
2012	1771		at the bottom. heading south @173°. Scarp 335 sloping down to 075 relative to the monitor screen.
2014	1772		heading west; very large chimneys encountered. some live and some dead. We've found the field with the big spires line 5A.
2018	1776		big blocks of sulfides with some brittle coral. Moving up to find out where the cliff top is.
2021	1767	140	photo of fault scarp with sulfides

2022	1767		at the top of the scarp. Over the 8m we saw: At 1776m sulfides, 1771 sulfide blocks and metalliferous sediments. 1769 photo of the fault scarp and 1769 reached the top of the scarp.
2024			chimney
2024	1769		moving down now...top of scarp active chimneys and sulfide blocks.
2025	1770	141-2	photo of crabs and spires
2026	1774		sulfides continue.
2027	1778	143-6	photos of scarp. Still appears to be mostly sulfides. Slumped down and fractured with little chimneys on it.
2030	1783		part of a mound. Striking white stripe - poss bacteria?
2031	1785	147-9	photos of bacteria and sulfides.
2032	1789	150	photo down slope
2032	1790	151	jarosite
2033	1790	152	photo of general rubble.
2033	1792		at the bottom - pillow lava with talus. Cross section of sulfides 22m thick.
2033	1790	153	photo of spire - anhydrite and old dead chimney (?).
2034	1790		Sample D284-15. sampling above structure. - rock about 15x10cm put into bin 4. Sample from the base of cliff; not known if it is in situ or talus. Pilots disagree. Reddish oxide on one side; flat.
2035			Changed video tapes - on tape #7. <i>moved 10 m to the east and now we're going back up for a rising cross section.</i>
2043	1785		at 1790 we have metalliferous sediment, 1788 pillow talus, 1783 pillow talus
2045	1781	154	photo sediment and talus
2046	1779	155-6	photos of tube worms, sediment and talus
2047	1777		tube worms and same
2047	1774	157	photo massive sulfides.
2048	1773		still climbing. Chimneys.
2049	1770		at the top. A brief synopsis 1790 metalliferous sediment. 1788m pillow talus. 1783 metalliferous sediment and talus blocks. 1780 old tubes and metalliferous sediment. 1776 pillows coated with sulfides. 1774m massive sulfides. 1770 chimney on top of the scarp

2052	1771		heading changed from east to north east. going down a cliff
2053	1772	158	photo of chimney on beginning of descent down cliff heading 046°.
2052	1777		white deposits, bacteria(?)
2053	1784		pillow talus with sulfide coating
2054	1786	159	photo of sulfide talus
2056	1789		predominantly pillow talus with occasional sulfide coatings.
2058	1795		pillow talus with metalliferous sediment.
2059	1791		going back up to find a sample of pillow with sulfide coating..
2059	1788	160	photo of talus and sediment.
2101	1785		excellent example of radial fracture and pillows.
2104	1790	161	photo of large block of sulfide.
2107	1784		pillow talus and outcrop. polarity visible.
2109	1777	162	photo of loose looking rock with white deposit on it and a pillow with good covering of orange sediment.
2111	1777	163	photo of bacteria on cliff face.
2114	1776		looking for a sample of small basalt.
2125	1779	164-7	photos radial joint pillows.
2126	1781		sampling above area Sample D284-16 : hydrothermally altered basalt rock Into bin #4 with tube worms.
2127	1781	168	photo of sample being taken.
2131			moving up to get a fix at the spires.
2133	1790	169	lobated flows and pillows
2134	1788		Pisces IV drop weight observed - probably a dive start marker thinks Keith.
2136	1792	170	photo of sulfates and pillows.
2137	1782		headed back to the cage on a heading of 300° to get our bearings. We plan to go back to the cliff top with the spires in order to get a fix.
2144			ships position 49°45.529'N 130°15,503'W
2146	1780	171-2	photo of pillow talus
2151	1764	173-4	photos of pillow talus and brittle coral and "ginger like" pillow lava.
2155	1756	175-7	photos of pillows.
2200	1768	178	photo - pillows with metalliferous sediment.
2206	1759	179	photo of pillows.
2209	1756	180	photo pillows on scarp. Intersection of two fault scarps at approx. 45° angle.

2220	1768	181-2	whip corals on pillows
2221	1766		still searching for chimney field to obtain sample
2223	1763	183-5	pillows
2225	1755	186-8	pillows and small talus
2229	1772	189-90	pillows
2230	1767	191	active chimney, 70m east of cage, white smooth mound at base
2234	1768	192	pillows and metalliferous sediment
2235	1766	193-4	white mound, with active hydrothermal vent
2238	1769	195	pillows Steve recognizes
2239	1759	196-03	metalliferous sediment and sulfide spires sub is 80m northeast of the cage on mound marker dropped # -9
2242	1758	204-9	sulfides
2245	1761	210-17	photos of sulfide chimneys.
2247	1759	218-28	photo of chimney we're trying to sample.
2255	1755	229-40	photo - chimney or what's left of them
2324	1761	241-43	photo of active chimney and chopping it down
2342	1757		Sample D284-17 sample of top of chimney in bin #6.Active.
2346	1757		Sample D284-18 Large chunk.. top of chimney, one piece.Inactive. Coming up in the arm as the sampling bin is full.
2356	1716		Back at the cage, trying to get a fix...Tried to get a fix at the sampling site, but were unable to do so. Fix: X= 481519.9 Y= 5511883.04
2358			ROPOS is on its way back up to the surface.
2359			Videos stopped.

1815 (PDT)			ROPOS on deck <u>DIVE 284 SUMMARY</u> total bottom time = 15h48m hours dive length = 19h15m total # of photos = 243 total # of samples = 18 total # of SIT tapes (2 hr. length) = 8 total # of COLOUR tapes (2 hr. length)= 8
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