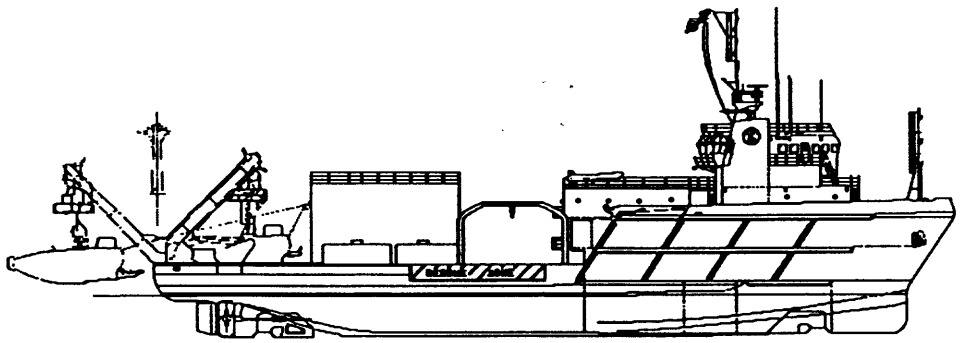
U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY



PRELIMINARY REPORT OF THE 1988 DSV-4 *SEA CLIFF* DIVE PROGRAM, ESCANABA TROUGH, GORDA RIDGE

by

Carol A. Reiss[1]
Robert A. Zierenberg[1]
Mark L. Holmes[2]

Open-File Report 92-286

[1]U.S. Geological Survey, Menlo Park, California
[2]U.S. Geological Survey, Seattle, Washington

1992

TABLE OF CONTENTS

INTRODUCTION

Preliminary data collected during field operations along the Escanaba Trough, southern Gorda Ridge, aboard the DSVSS *Laney Chouest*, and U.S. Navy submersible DSV *Sea Cliff* in September 1988 (C1-88-NC) are presented in this report. Figure 1 shows the extent of sediment cover, uplifted terraces along either side of the axial valley, a series of volcanic edifices which pierce the sediment fill, and the location of the northern Escanaba Trough (NESCA) study area. Hydrothermal mineral deposits are associated with at least three of these edifices. The hydrothermal deposits at NESCA were the target area of this dive operation. A bathymetric map of NESCA locating the Central Hill and Southwest Hill, and the four dive tracks is shown in figure 2. The primary objectives were to map, as well as sample volcanic rocks, active vent locations, and associated sulfide mineralized areas. Figures 3-6 show detailed bathymetry, dive tracklines, previously marked vents, sample locations, and interpreted geology, based on submersible observations, dive transcripts, samples, photographs, and videotape. Appendix 1 contains the pre-dive profiles, voice transcriptions including port and starboard observer's comments, depth and heading information (when available), and descriptions of the external camera photographs, and lastly, diver's summaries, when available. Hand-held photo descriptions appear in appendix 2. Videotape transcriptions are in Appendix 3. Sample and marker locations and depths are included in appendix 4, and sample descriptions are included in appendix 4a. A brief summary of biota collected from dive 764 is listed in appendix 5.

Personnel

The Gorda Ridge Technical Task Force coordinated the 1988 DSV *Sea Cliff* dive program, which included participants from many federal and state agencies, as well as state and private institutions (see table 1).

REGIONAL SETTING

Gorda Ridge, located 200 to 300 km west of northern California and southern Oregon (fig. 1) is bounded by the Blanco Fracture Zone to the north and the Mendocino Fracture Zone to the south. Escanaba Trough, situated on the southernmost end of Gorda Ridge, is characterized as a slow-spreading axis with a total opening rate of about 2.3 cm/yr (Atwater and Mudie, 1973; Riddihough, 1980). Turbiditic and hemipelagic sediment (Moore, 1970; Vallier and others, 1973; Karlin and Lyle, 1986) covers much of the southern axis of Escanaba Trough to latitude 41° 17' (fig. 2; Morton and others, in press). Sediment thickness is generally about 500

m; however, in places it reaches 1000 m or more. Volcanic edifices have disrupted the overlying sediment, and basalt is exposed in localized areas on the sea floor. Large massive sulfide deposits are associated with these edifices.

Previous studies

Atwater and Mudie (1973) and Riddihough (1980) characterized the spreading rate along the ridge; Moore (1970) and Vallier and others (1973) characterized the hemipelagic sediment covering the Escanaba Trough. The morphology of the Gorda Ridge is summarized in Clague and Holmes (1987). Detailed studies of the geology and sulfide deposits in northern and southern Escanaba Trough (NESCA and SESCA) are presented in Morton and others (1987, 1990), and Holmes and Zierenberg (1990). Previous submersible operations in this area were carried out in 1986 using DSV *Sea Cliff* (Zierenberg and others, 1991), and DSV *Alvin* in June of 1988. High temperature (220° C) hydrothermal venting was discovered in the Central Hill area of NESCA on the 1988 *DSV* Alvin dives in this area (R. Zierenberg, unpub. data, 1988), and were marked using weighted syntactic foam blocks ('markers' or 'benchmarks') with distinctive and highly visible symbols. A comprehensive volume on the geologic, hydrothermal and biologic studies of the Escanaba Trough is being edited by Morton and others, and will soon be available as a U.S.G.S. Bulletin.

Navigation

An acoustic transponder net, set up by the U.S.G.S., has been continuously maintained in the NESCA area since 1985. The acoustic transponder system provided by Unmanned Vehicles Detachment (UMV) utilized the U.S.G.S.' transponder net and the hull-mounted transducer of the DSVSS *Laney Chouest*. Positioning accuracy is generally within several meters when three or more transponders respond, allowing specific vents to be reoccupied (markers could be located from previous dive operations); however, transponder replies were often obscured or totally obliterated on this cruise due to acoustic noise created by DSV *Sea Cliff* hydraulic systems (see end of dive 764 transcript in appendix 1). Whenever a position was required, the submersible was requested to remain 'quiet' on the bottom and refrain from using hydraulic systems until a position could be determined ('secured propulsion' notes in transcripts). Therefore, all tracklines in figures 3-6 are estimated (dashed lines) between fixes based on bathymetry, and depth and heading information recorded by the divers. Note that depths recorded in the submersible are consistently deeper than acoustically calculated depths from which basemaps were generated. Coordinates along the bottom and

right sides of the figures (meters), correspond to the XY acoustic transponder net deployed by the U.S.G.S. Way Points, referred to in the pre-dive profiles, were assigned to area's of geologic significance, thus allowing the submarine to be navigated toward specific areas, or their position relayed to them in relation to these points. Benchmarks, or markers, referred to in transcripts, designate a specific site physically marked by deployment of identifiable flags on the sea floor.

SULFIDE DEPOSITS

Reconnaissance dive 763 (app. 1; pre-dive profile 763) was deployed at the hill to the southeast (affectionately called 'Larry') of the South West Hill (affectionately called 'Moe') to map the sediment-hosted sulfide deposits photographed in 1986 (Morton and others, 1990). Much of the dive encountered sediment and outcropping mudstone (fig. 3). Midway through the reconnaissance, sediment- covered massive sulfide deposits, talus, and fresh blocky fractured outcrops, with crystal faces of coarse-grained sulfide minerals, were visible to observers. Sediment was sampled at the top of the South West Hill (app. 1, pre-dive profile 763-C1), where the dive was terminated. The dive summary follows transcription log in appendix 1.

The primary objective of dive 764 was to reacquire locations of known sulfide deposits and active hydrothermal vents mapped during DSV *Alvin* dive 2036 (R. Zierenberg, unpub. data 1988) near the Central Hill (affectionately called 'Curly') to ascertain the extent of these fields (app. 1, pre-dive profile 764). Dive 764 successfully navigated to markers 6X and O (deployed near active vents on DSV *Alvin* dive 2036), and recorded temperature measurements of 222°C near marker O (fig. 4).

Dive 765 was deployed over the summit of 'Zeppo' (east of the Central Hill) to determine the extent of volcanic outcrop (fig. 5; app. 1, pre-dive profile 765) and is discussed in the following section.

Dive 766 began at the eastern flank of the Central Hill, at the approximate location where dive 765 was terminated. The objectives for this dive were to determine the extent of the sulfide deposits and to collect biologic and geologic samples .when feasible (app. 1, pre-dive profile 766). This dive touched down on a sediment-covered area, and transited southwest, where mudstone talus, channels, hummocky terrain, and scattered bivalve shells were observed. A large deposit of 'old' massive sulfide composed of ledges, chimneys, mounds, and some bacterial mat was observed on the southeast side of the Central Hill (fig. 6). Clam shells were also observed at the base of this deposit. Although no active venting or live clams were observed, live clams and (or) bacterial mat are indirect evidence for low temperature or diffuse venting. After considerable maneuvering, the sulfide deposit was again

observed and a chimney sampled. A dive summary and description of the observed sulfide deposit follows the transcription log in appendix 1. The location and a complete description of the chimney sample appears in appendices 3, 3a and 4.

VOLCANIC FLOWS

Volcanic rocks are known to outcrop along the topographic high to the east of the Central Hill (fig. 5) in the NESCA area (Morton and others, 1990). The objectives of dive 765 were to locate the exposed volcanic rocks, map the extent of the volcanic outcrop, and sample any vents, sulfide deposits, and biota observed (app. 1, pre-dive profile 765). Pillow lava with local sediment cover was immediately encountered on the starboard side of the submersible upon bottom contact, and throughout much of the dive. Sheetflow basalt was also observed later in the dive. The basalt flows were generally sediment dusted with sediment pockets dividing many pillows. Basalt morphology and contacts were successfully mapped around the eastern nob and northern side of the Central Hill (Ross and Zierenberg, in press).

FILM AND VIDEO

An externally mounted 35 mm camera took approximately 700 exposures on dive 764; 435 frames on dive 765; and approximately 460 frames on dive 766. (The camera was inoperative on dive 763). Two external videocameras (forward and side viewing), and one internal camera alternately recorded on 3/4 inch video to document the dives. Appendix 2 documents camera and viewing angle recorded on tape. Approximately four hours of videocamera coverage were taken on both dive 763 and 764, two and a half hours on dive 765 and three hours on dive 766. Video transcripts for dives 764, 765, and 766 appear in appendix 2. Due to low light level on dive 763, the video from this dive is too dark to identify geologic features, so no transcript is available.

Photographs from a hand-held camera taken from inside the submersible document the observations of the port scientist, and photo logs are included in appendix 2.

VENT FAUNA

One major biology sample was collected on dive 764 (app. 3), where vent fauna, predominantly live tubeworms, were encountered near actively venting mounds. Encompassed within this large biosample were a variety of biota informally described by Michel Boudrias (app. 4). Soft-sediment vent communities of the Escanaba Trough are described in VanDover and

others (1990), and will be presented by Grassle and Petrecca (in press) in the U.S.G.S. Bulletin on Escanaba Trough.

ARCHIVAL

The chimney sample collected on dive 766 has been described, analyzed, and archived at the U.S. Geological Survey in Menlo Park, California. Push cores taken on dive 763 and 766 are currently at the Mackay School of Mines, Reno, Nevada. The biota sample collected on dive 764 is archived at Scripps Institute of Oceanography, La Jolla, California. Film and videotape are archived at the U.S. Geological Survey in Menlo Park, California.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the dedicated professional crew of the DSV *Sea Cliff* submersible group (U.S. Navy), the captain, and crew of the DSVSS *Laney Chouest* (support ship). We would like to thank the scientific staff and personnel listed in table 1 for an enjoyable, successful cruise. We are espesially grateful to Jane Reid for her detailed and thorough review of this manuscript.

NOTES

Editorial explanatory notes have been added during transcription [] for clarity to the following appendicies, and diver's explanatory notes remain in parentheses ().

GORDA RIDGE 1988 SAILING LIST
C1-88-NC

UNMANNED VEHICLES DETACHMENT
ICC Joe E. Jones
STS1 Miguel Dominguez
ET1 Jerry A. Schmidt
STS2 Tod J. Zellers
ET2 Jay A. Henson

DSV *SEA CLIFF* DETACHMENT
LCDR M. Reid Popovich
LT Joe W. Craver
LT Pat J. Scanlon
LT Steve W. Poirier
ICC Jack R. Elliott
MMC Tim A. Pelnarsch
IC1 Jim K. Branham
IC1 Dwight D. Pollock
MM1 Joel C. Howard
SK1 Dave P. Brown
ET2 Jim Gore
ET2 Steve M. Gault
EM2 Rich C. Guffey
MM2 Mike L. Breecher
MM3 Kevin P. Wilcox

DSVSS *LANEY CHOUEST*
Victor P. Gisclair, Master
Steven Laster, Mate
Eugene Thomassie, Mate
David Nelams, Engineer
Manson Billiot, Oiler
Greg Verdin, Oiler
Lloyd Kanipe, Cook
Jimmy Calanton, Cook
Roy Guidry, Galley Hand
Tim Calver, Able Seaman (Bos'n)
Ricky Dardar, Able Seaman
Donal Landry, Able Seaman
Doyle Van Deman, Electronics Technician

U.S. GEOLOGICAL SURVEY
Mark Holmes
Rob Zierenberg
Randy Koski
Pat Okita
Carol Reiss
Lisa Bader

SCRIPPS INST. OF OCEANOGRAPHY
Michel Boudrias
Jeff Stein

MINERALS MANAGEMENT SERVICE
John Smith

U.S. BUREAU OF MINES
Jim Allen

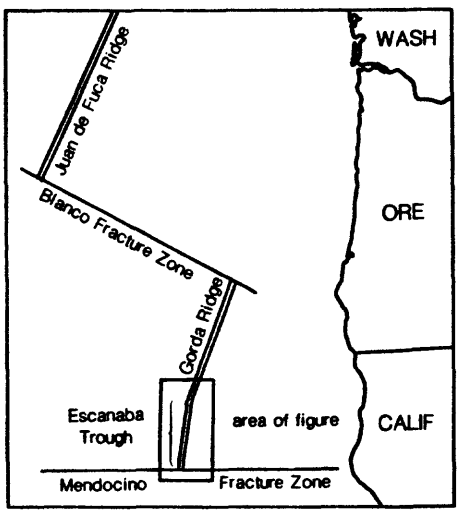
DOGAMI/GRTF
Greg McMurray

UNIVERSITY OF HAWAII
John Wiltshire

MACKAY SCHOOL OF MINES
Bob Karlin

COMSUBDEVGRU-1
HMCS "Doc" Dalzell

Table 1. Gorda Ridge cruise (C1-88-NC) participant list and affiliation.



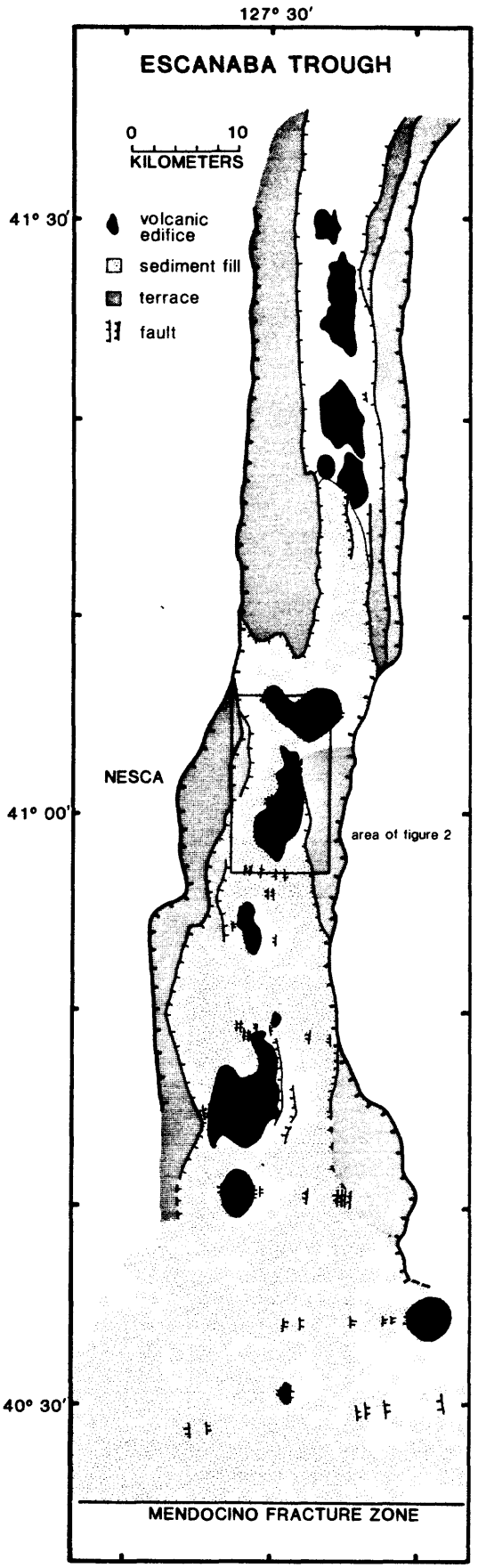


Fig. 1. Location map and general geology of the Gorda Ridge, showing volcanic edifices, terraces, sediment cover, faults and the NESCA study area of figure 2.

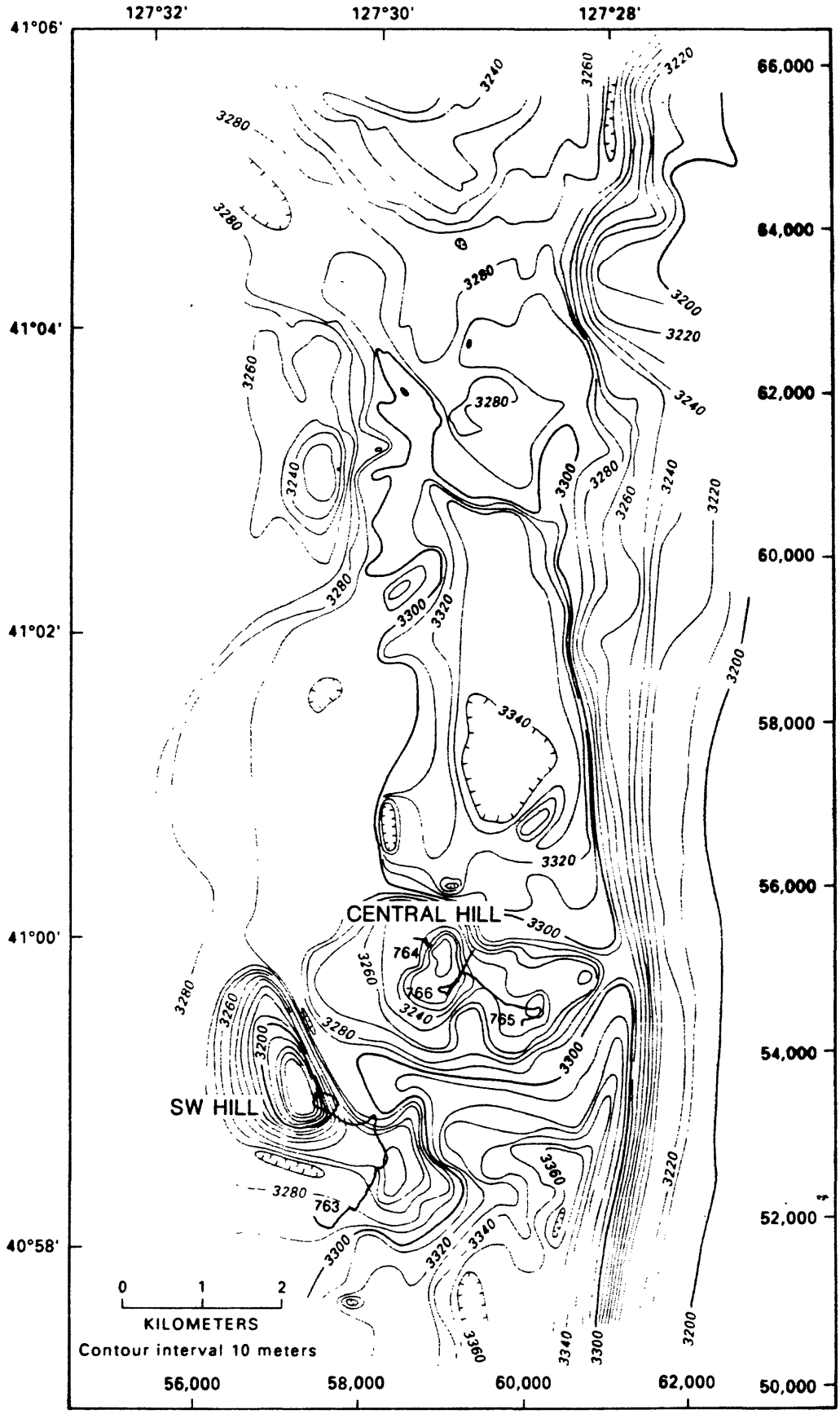


Fig. 2. Bathymetric map of NESCA showing the four dive tracks, South West and Central Hill.

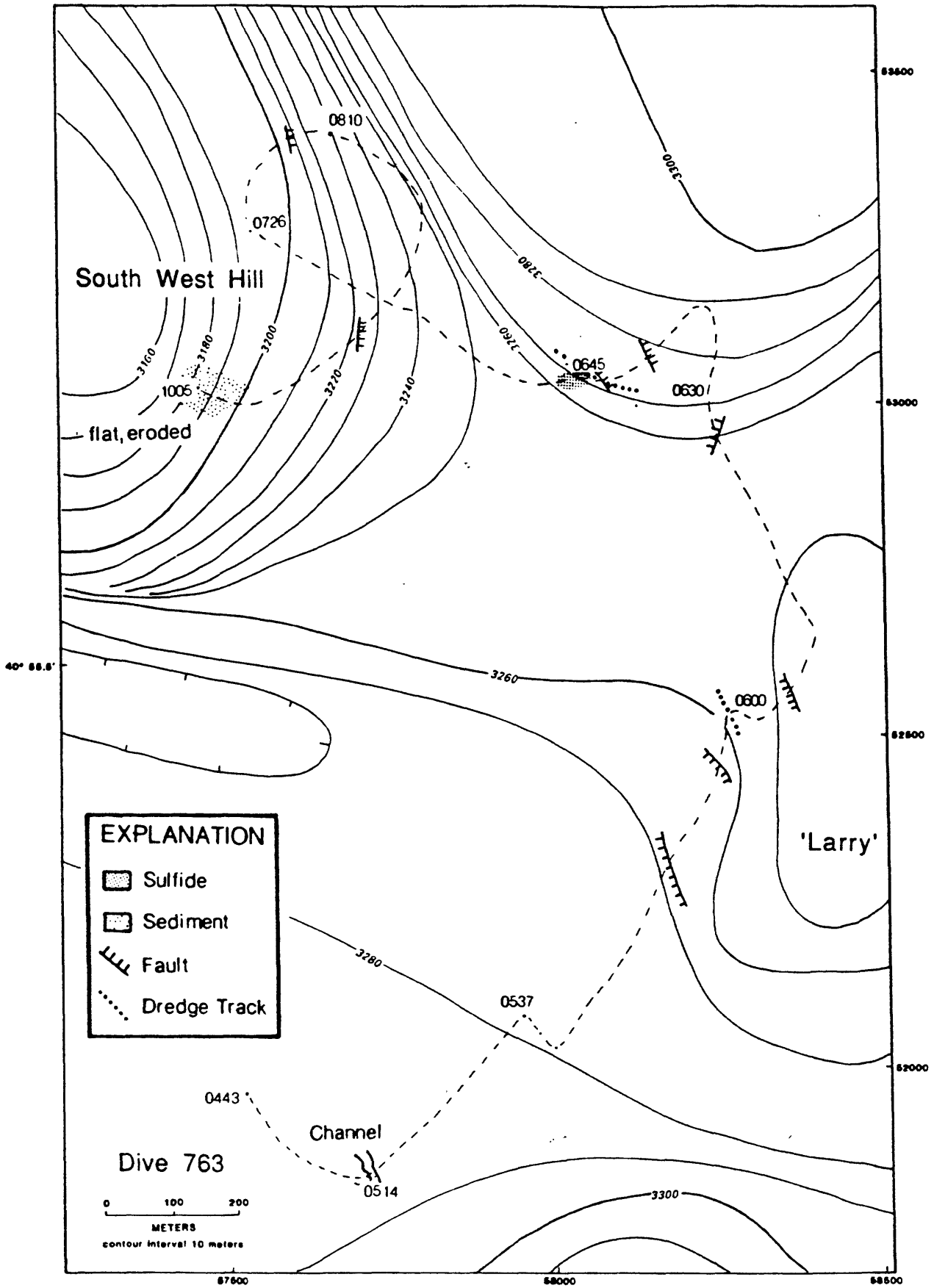


Fig. 3. Detailed bathymetry of southeastern end of the South West Hill, showing dive track and interpreted geology for dive 763. Dots represent good positions obtained during dive.

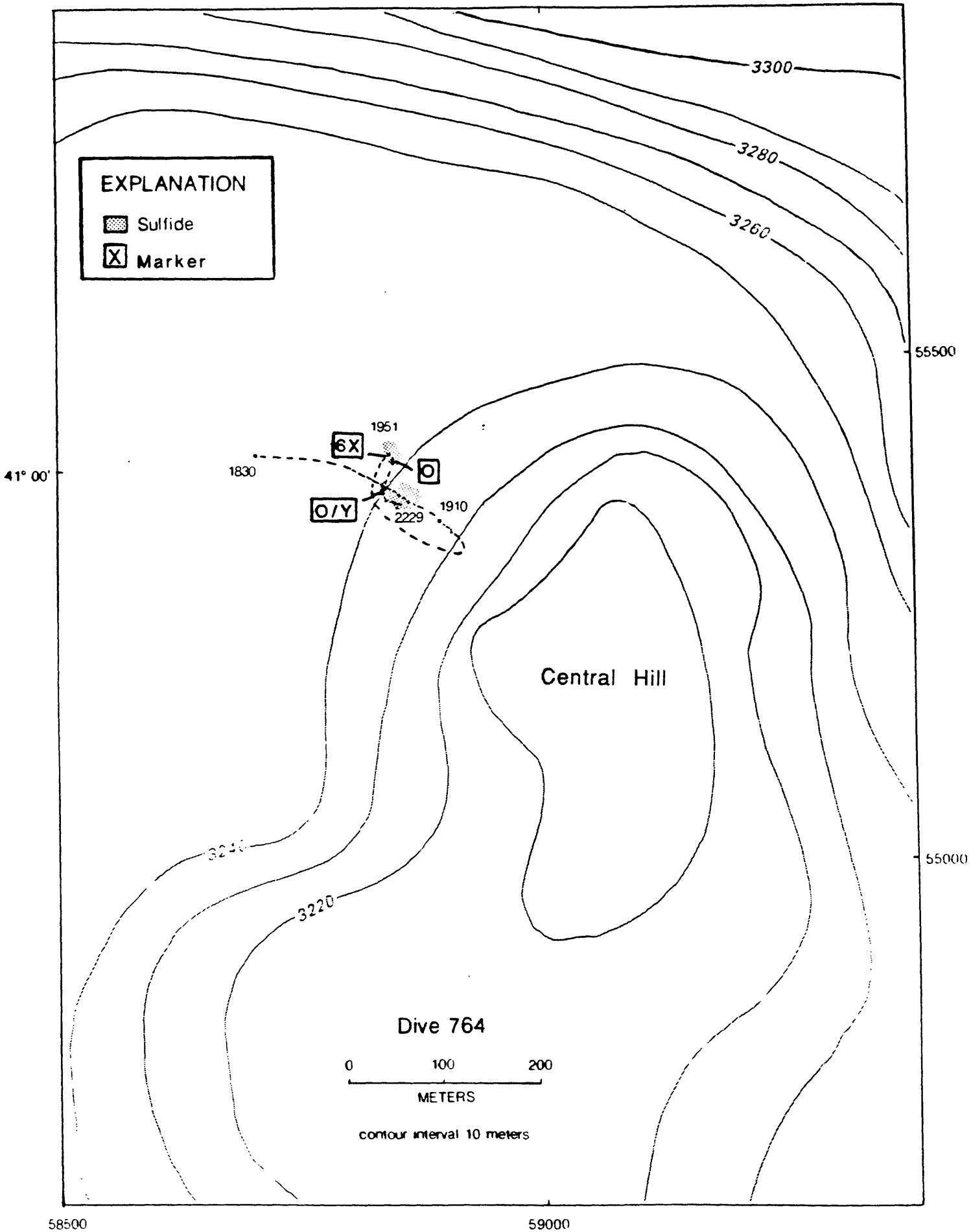


Fig. 4. Detailed bathymetry of the Central Hill, showing dive track, benchmarks and interpreted geology for dive 764.

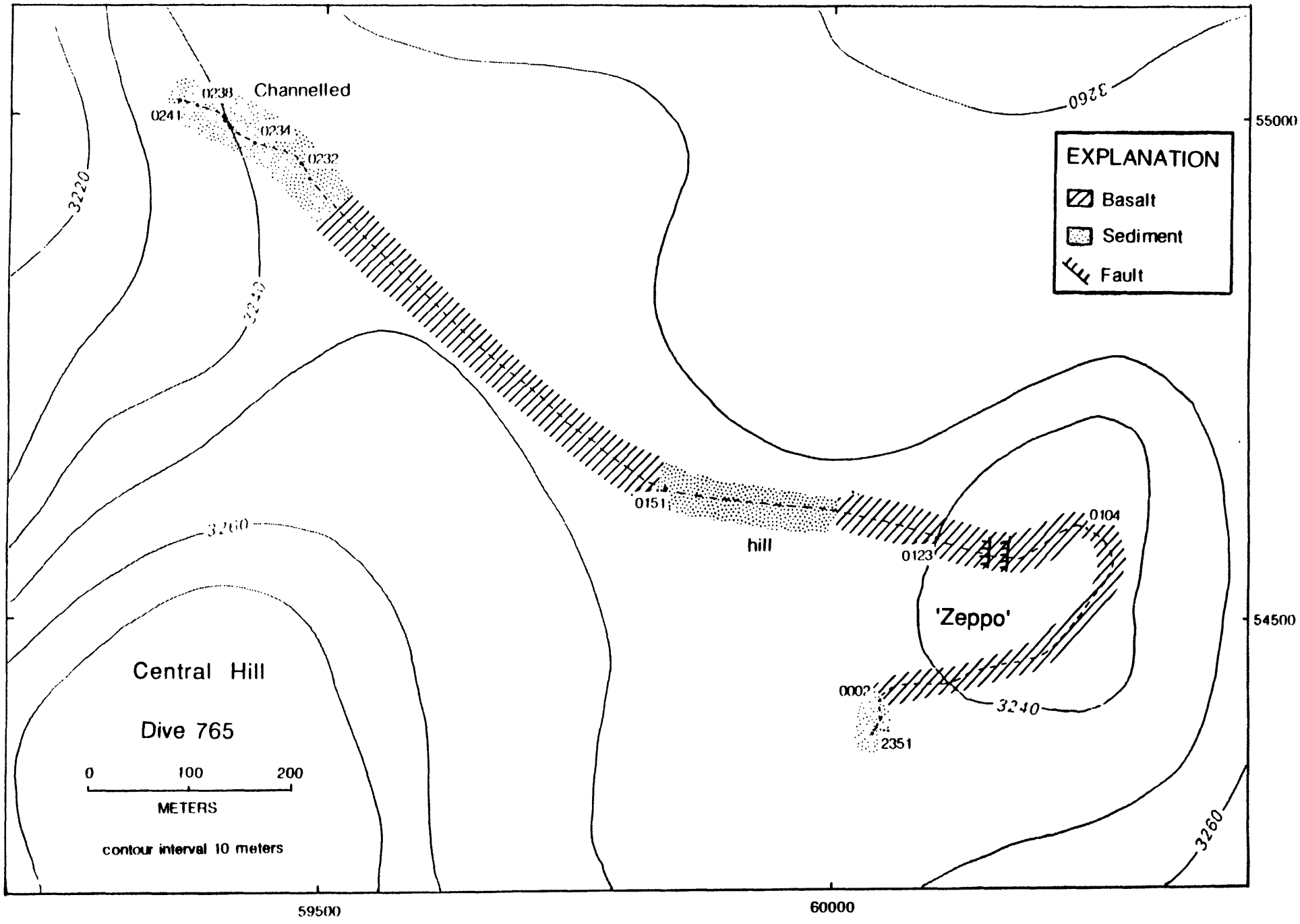


Fig. 5. North and eastern bathymetry of the Central Hill, showing dive track and interpreted geology for dive 765.

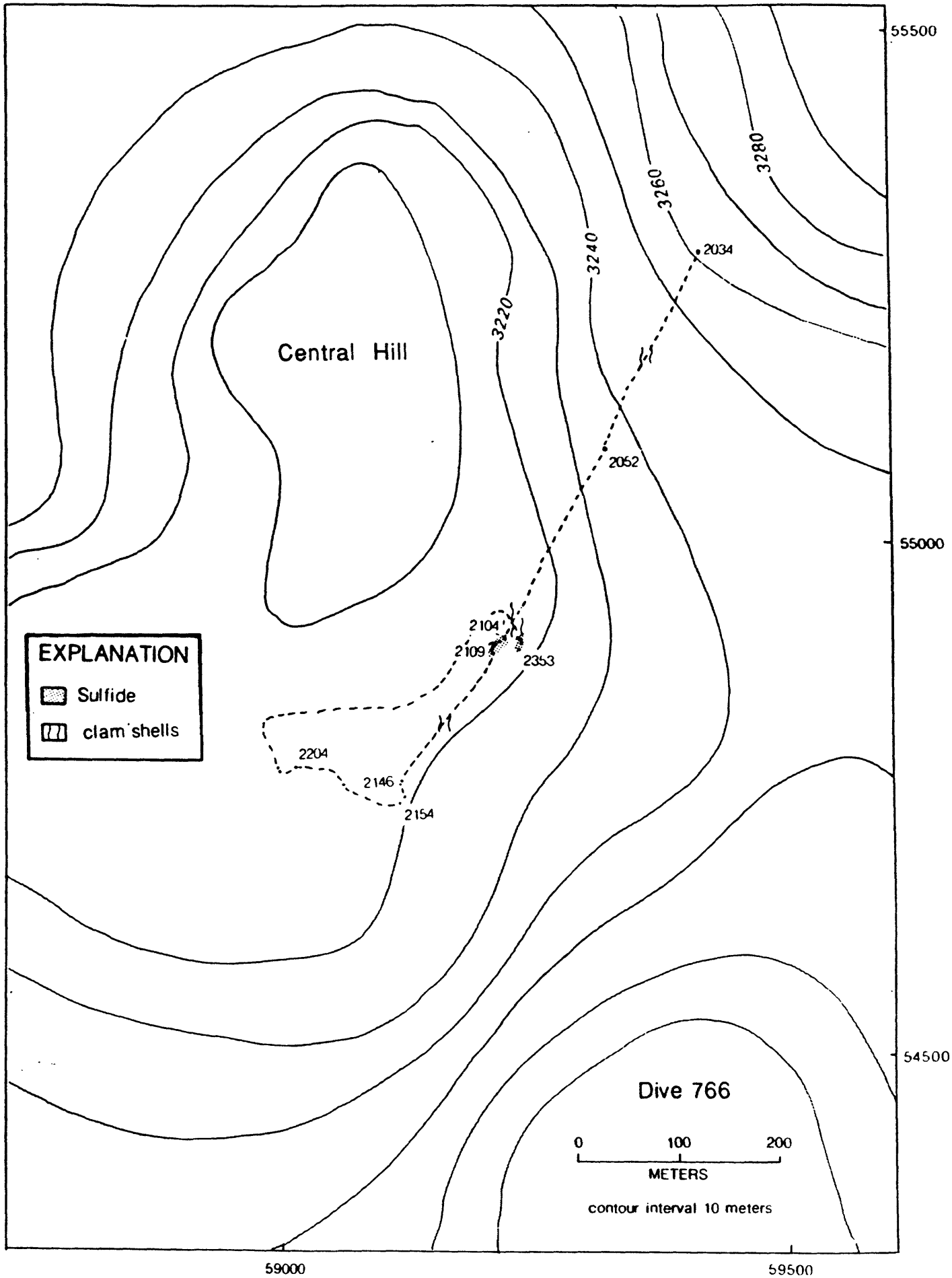


Fig. 6. Detailed bathymetry of the Central Hill showing dive track and interpreted geology for dive 766.

REFERENCES CITED

Atwater, T. and Mudie, J.D., 1973, Detailed near-bottom geophysical study of the Gorda Rise: Journal of Geophysical Research, v. 78, p. 8665-8686.

Clague, D.A. and Holmes, M.L., 1987, Geology, petrology and mineral potential of the Gorda Ridge, *in* Scholl D.W., Grantz A., and Vedder, J.G., eds., Geology and Resource Potential of the Continental Margin of Western North America and adjacent Ocean Basins-- Beaufort Sea to Baja California: Circum Pacific Council for Energy and Mineral Resources, Houston, Texas, vol. 6, p. 563-580.

Grassle, F.J. and Petrecca, R., (in press), Soft-sediment benthic communities of the Escanaba Trough, *in* Morton, J.L., Zierenberg, C.A., and Reiss, C.A., eds., Geologic, Hydrothermal and Biologic Studies at Escanaba Trough, Gorda Ridge, Offshore Northern California: U.S. Geological Survey Bulletin, chap. 18.

Holmes, M.L. and Zierenberg, R.A., 1990, Submersible observations in Escanaba Trough, Southern Gorda Ridge, *in* McMurray, G.R., ed., Gorda Ridge: A Seafloor Spreading Center in the United States' Exclusive Economic Zone: New York, Springer-Verlag, p. 93-116.

Karlin, R. and Lyle, M., 1986, Sediment studies on the Gorda Ridge: State of Oregon, Department of Geology and Mineral Industries, Open-File Report O-86-19, 76p.

Moore, G.W., 1970, Sea-floor spreading at the junction between Gorda Rise and Mendocino Ridge: Geological Society of America Bulletin, v. 81, p. 2817-2824.

Morton, J.L., Normark, W.R., Ross, S.L., Koski, R.A., Holmes, M.L., Shanks, W.C., III, Zierenberg, R.A., Lyle, M., and Benninger, L.M., 1987, Preliminary Report, Cruises L1-86-NC and L2-86-NC, Escanaba Trough, Gorda Ridge: U.S. Geological Survey Open-File Report 87-375-A, 20p.

Morton, J.L., Koski, R.A., Normark, W.R., and Ross, S.L., 1990, Distribution and composition of massive sulfide deposits at Escanaba Trough, Southern Gorda Ridge, *in* McMurray, G.R., ed., Gorda Ridge: A Seafloor Spreading Center in the United States' Exclusive Economic Zone: New York, Springer-Verlag, p.77-92.

Morton, J.L., Zierenberg, R.A., and Reiss, C.A., (in press), Geologic, hydrothermal and biologic studies at Escanaba Trough, an introduction, *in* Morton, J.L., Zierenberg, R.A., and Reiss, C.A., eds., Geologic, Hydrothermal and Biologic Studies at Escanaba Trough, Gorda Ridge, Offshore Northern California: U.S. Geological Survey Bulletin, chap. 1.

Riddihough, R.P., 1980, Gorda Plate motions from magnetic anomaly analysis: Earth and Planetary Science Letters, v. 51, p. 163-170.

Ross, S.L. and Zierenberg, R.A., (in press), Volcanic Geomorphology of the SESCA and NESCA sites, Escanaba Trough, *in* Morton, J.L, Zierenberg, R.A., and Reiss, C.A., eds., Geologic, Hydrothermal and Biologic Studies at Escanaba Trough, Gorda Ridge, Offshore Northern California: U.S. Geological Survey Bulletin, chap. 8.

Vallier, T.L., Harold, P.J. and Girdley, W.A., 1973, Provenances and dispersal patterns of turbidite sand in Escanaba Trough, northeastern Pacific Ocean: Marine Geology, v. 15, p. 67-87.

VanDover, C.L., Grassle, J.F., and Boudrias, M., 1990, Hydrothermal vent fauna of Escanaba Trough (Gorda Ridge), *in* McMurray G.R., ed., Gorda Ridge: A Seafloor Spreading Center in the United States' Exclusive Economic Zone: New York, Springer-Verlag, p. 285-290.

Zierenberg, R.A., Morton, J.L., Reiss, C.A., and Holmes, M.L., 1991, Preliminary Results of the 1986 *Sea Cliff* Dive Program, Escanaba Trough: U.S. Geological Survey Open-File Report 91-137, 176p.

DSV *SEA CLIFF* PRE-DIVE PROFILE
C1-88-NC

Dive # 763 JD/Date 245 / SEPT 1

Port Observer : Zierenberg
Equip. Operator : Boudrias

Pilot: Popovich
USGS SC: Holmes
(Surface controller)

Dive Objective(s):

This dive will be launched on the saddle between 'Larry' and 'Moe' [South West Hill]. A camera tow during a 1985 R/V *S.P. Lee* cruise photographed sulfide at WP [Way Point] 1, and a much larger deposit at WP 2. The planned dive transect is to the northwest up to the top of 'Moe', and then southward across the southern flank of this steep, uplifted sediment dome. Objectives are reconnaissance mapping and the collection of sulfide, sediment, and biological samples. The steepness [of the slope] suggests that there will be signs of significant mass wastage. Some of the slopes appear to be fault controlled, although that could be the result of the low-resolution surface bathymetry. Comparison of the AII/Alvin positions and the USGS bathymetry map indicates that there may be a ~250 m offset in the X-Y positions derived from the transponder net. One objective of this dive will be to determine what, if any, offset there is.

Launch Point: X= 58200 Latitude 40°58.59
(WP L) Y= 52750 Longitude 127°30.12

Way Points:
1) X= 58000 Y= 52750
2) X= 57675 Y= 53000
3) X= 57400 Y= 53300
4) X= 57100 Y= 52500

DIVE TRANSCRIPT

Location: NESCA South West Hill
Port observer: Zierenberg
Starboard observer: Boudrias

Julian Day: 245
Date: 09/01/88
Pilot: Popovich

KEY: P = Port observer, S = Starboard observer, E = External photograph, Photo # = Hand-held photograph number, description in appendix 2.

Time (GMT)	Depth (m)	Hdg.	Photo. #	Obs	Comments
01:07				P	Started descent at 01:07. We are diving on the South West Hill at NESCA. We have secured the bow 35 mm external camera due to a ground leak. That means we have also secured the data frame readout which reads out time, depth, and heading. I will be reading time from my travel alarm clock set to GMT, depth reading will be taken as often as possible in feet from the DDIS, and heading will be read from one of two compasses, either the subs gyro which is set to the DSVSS *Chouest's* compass or a magnetic compass, with a correction applied as possible to the magnetic compass. Most of the data will be very sketchy, and there will be no external photos on this dive.
02:35				P	Dropping descent weights, approximately 800 ft off the bottom, range and bearing to launch target 1500 m at 050°.
04:08				P	Making very cautious bottom approach. Range 1500 m to target at a heading of north. We are still about 300 ft off the bottom, making very slow bottom approach.
05:01				P	Just made bottom contact. Smooth sediment-covered bottom, we're about 2 m off the bottom, I can just barely make the bottom, the only thing I see alive on it is one purple anemone.
05:02	3300			P	Bottom contact, about 1.5 m off, flat sediment-covered bottom with a few purple urchins, a couple of purple holothurians, very smooth, flat, sediment-covered.

05:09	3300		P	We are sitting about .5 m off a flat sediment-covered bottom. There is a channel or drop off about 1-2 m deep, I can't see it too well. There is a little bit of outcropping mudstone here. Across the other channel wall, which I can just barely see, it looks like there is some outcrop, but I can't see it well enough. There are a couple of small fish, a xeno, and a couple of holothurians.
05:10		133	P	Bottom is dropping off very steeply to the front, still smooth sediment-covered, a bit hummocky, it looks like we might be going down a channel wall.
05:11	3304		P	Still coming down to the bottom.
05:12			P	Some subcropping whiter mudstone exposed on the steeper slopes underneath the normal sediment, flat bottom now.
05:13	3309	042	P	Sediment-covered bottom, sloping up to the port.
05:14	3310		P	Very steep slope to the port, it looks like a channel wall. There is some outcropping mudstone and some definite slides of mudstone down the wall. There are some crinoids on it. It looks like a big scarp. I just saw an interesting white creature on the bottom, the kind of thing that shows up on some of the photographs. It was very white and reflective, a flat white disk, really light colored, you can only see the structure to it if you are very close. It was about 5-8 cm across, a few mm thick. It would show up as a white dot in any photograph, sort of like a jellyfish laying flat on the bottom.
05:16			P	Hummocky bottom, stalked sea pen, several holothurians, brittle star. Flat and sediment-covered, a couple of anemones, fairly sparsely colonized. Several xenos, small ones, there is one of the spiky white holothurians.
05:19	3302		P	Still transiting smooth sediment-covered bottom, a little hummocky, there is a large purple urchin out there, fairly normal bottom fauna, not to densely colonized, several small

				fish, some rat-tails, may be all rat-tails, some feeding traces here in the bottom, a stalked sea pen and a crinoid.
05:21	3298		P	Still over hummocky sediment-covered bottom, normal fauna.
05:22	3299		P	Moving over a sediment mound, it has a little bit lighter sediment on the surface.
05:26	3300		P	Hummocky sediment-covered bottom. 1-2 m relief on these sediment hills, normal bottom fauna including some stalked organisms, several holothurians.
05:28	3304	009	P	Still over a hummocky sediment-covered bottom, normal fauna, some anemones right now.
05:31	3309			
05:33	3305	020	P	Small Venus flytrap out here, colonizing a stalked animal. Heading for some sonar targets just about dead ahead at 020°, about 250 m.
05:36	3305		P	Still over sediment-covered bottom, coming uphill slightly, hill moves up to port, normal bottom fauna.
05:38	3303		P	Over very smooth sediment-covered bottom, less fauna.
05:41	3303	050	P	Sediment-covered bottom, the relief is increasing, hummocky terrain. We just put tape 2 in the video. Normal bottom fauna, fairly sparse still, some of the purple anemones, purple holothurians, brittle star, xeno. Still heading towards the target on the CTFM [in sub. foward looking horizontal scanning sonar system].
05:44			P	Hummocky sediment-covered bottom, there is a steep scarp ahead of us, only a 1-2 m drop. Normal looking bottom with a few stalked animals, the one below me has a lot of small Venus flytraps colonizing it.
05:48	3294	040	P	There is a very steep wall right in front of us. Wall is also out to starboard, a smooth slope out to port. Some very white mud, it looks like it came from a dredge track.
05:51	3292		P	We've come up a very steep wall, now we are now coming back up the other side of the

					wall, it is a ridge of sediment which runs roughly 030°. We are going to head uphill and head for the south east end of the South West sediment Hill.
				P	We just passed an octopus, about 20-30 cm, whitish-grey octopus.
05:54	3281			P	Climbing up a very steep wall. Steep enough that we could be at the South West Hill. Lost bottom at the moment, but still coming up the scarp.
05:57	3278			P	There are more piles of white sediment sitting on the surface here, now I do see a dredge track. This dredge track is going to head right up to the South West (sediment) Hill. We will try to follow it. It is heading off to port, it is about 40° off to port.
06:01	3282	130	9	P	Just took the first bottom photo of xenos, they are fairly small ones. We are still trying to head in the direction of the dredge track.
06:03	3282	040		P	Moving over a fairly flat bottom right now. Some disturbed white sediment, presumably from the dredge track on it. Coming up a steep slope.
06:07	3267	040		P	Coming up a very steep slope. There is a holothurian swimming in the water here. The slope is about 40°, from what I can see, I can't get a good look at it here.
06:08	3263	030		P	On a fairly flat sediment-covered bottom, after coming up a steep sediment-covered scarp.
				P	Coming up another steep slope with sediment, some barely outcropping mudstone, but mostly sediment-covered, slope of about 60° here. A couple of stalked animals here.
				P	That scarp is about 4 m high, and we're back on another flat terrace at the top, rather hummocky, not much colonization here, a few little stalked sea pens and a few brittle stars, not much on starboard side either.
6:13	3260			P	We're coming up a stepped scarp, there is some whitish subcropping mudstone at the top at the steepest part here, clearly exposed.

					Normal bottom, no signs of hydrothermal activity. A nice shrimp just swam by the window. At the top of the scarp there are several brittle stars, a brisingid and a holothurian.
06:24	3272		11-12	P	Just took two pictures of a branched stick on the bottom with some white biota on it. There is a galatheid swimming in the water and a Venus flytrap colonizing a sea pen.
06:26	3277	305		P	Our heading 305° coming up to 300°, there is a scarp dropping off to port very steeply, I can't see the bottom. The scarp is parallel to our heading right here, it is a near vertical scarp. I can't see the bottom.
06:30	3291		13	P	Picture of a Venus flytrap, face on, which was colonizing a sea pen. I see a few more Venus flytraps right here.
06:31			14-15	P	Two more pictures taken, one was of another Venus flytrap on a sea pen, and another of two different types of stalked crinoids next to each other. Several holothurians, some xenos, fairly large ones here, a couple cms. across.
06:33	3289	325		P	Real outcropping mudstone on that last scarp, very soft and somewhat sediment-covered. There are more stalked animals here.
06:35				P	Just passed some more outcropping mudstone, big blocks of mudstone, fairly indurated stuff. I have a feeling that there may be some sulfide in the cliff off to port, which is just out of view. Coming over another scarp now with outcropping mudstone, no sulfide, just outcropping mudstone. Too far away to take a picture here. A lot of mass wasting here, big blocks have moved down the slope.
06:39	3303	316	19	P	Last picture of a large starfish. Still climbing up a hill. We've come up several steps on the hill, the steps go from 20° to near vertical, they are not all heading the sample direction, a rather irregular topography. Some fairly flat slopes in between with sediment-cover. There is some outcrop now on the starboard side.

06:42			P	Still climbing up a slope of 30°-40°, there is some recent mudstone talus sitting on it, and a definite dredge track. We are coming right up a dredge track, very definite. Right over it now. It did some funny things on this steep slope, it rolled down the hill, scraped and then came back up.
06:43	3284	20-21	P	Just took two pictures of one of the octopus-like animals with webbing between the arms. And then a picture after that of a mudstone block. We're moving up a sediment-covered slope, along a dredge track. Should be moving towards the South West (sediment) Hill.
06:45		23	P	Just passed some outcropping mudstone, but the last picture was mudstone dropped out of the dredge. We're sitting over some mudstone that was dropped out of the dredge, we're on a fairly flat bottom right now, some xenos and sea pens. There is some outcropping rock uphill from me here, it looks like it is probably outcropping mudstone, but I can't see too well yet. There is subcropping mudstone below me.
06:46	3272		P	We are on massive sulfide. It is blocky, fairly sediment-covered. It is rather old, there are no chimney projections, fairly well colonized and sediment-covered, but there are some rather coarse crystals in it. There is a very big deposit here, there are some crinoids and some stalked sea pens, a couple of galatheids. We are going to continue to explore here, if we start to run out of it we will stop and sample.
06:55	3252		P	On a flat sediment-covered bottom here. Should be sitting just uphill from the massive sulfide deposit we crossed. Medium-aged deposit, a lot of talus and blocky outcrop, but not much weathering to it, it was very fresh looking, lots of crystal faces, but no real chimneys were seen, it was fairly fractured. We are going to go explore that deposit a bit and probably take a few samples.

06:59	3257	250		P	We've re-established bottom contact, where heading back towards the sulfide deposits based on sonar targets. Slope is coming up to port away from me, still fairly smooth and sediment-covered at this point, there are very large reflectors on the CTFM.
07:02			26	P	Coming up a fairly steep slope, there is mudstone talus below me, a bit of mudstone talus laying on the steep sediment slope, may be some subcropping mudstone. There is a stalked wine glass sponge, I'll try to take a picture of it.
				P	We've been hanging in the water column, taking some readings, checking a few things out, so there will be a gap in the times. I'll record the time when we re-occupy bottom.
			28	P	Picture of something in the water column, about 55 ft off bottom, it could have been a holothurian.
07:39	3246			P	We've just been given a range and bearing to Way Point 3 at the top of the hill, 300 m at 165°. That does not agree with what we think our location is. Way Point 3 should be at a heading of between 270°-300°.
07:46				P	Video tape 5 put in.
07:54	3251			P	We are about 2 m off bottom over a scarp to port which drops away vertically below us from port to starboard so that just below the sub is about 6 m off bottom, I can't see that far, the scarp is trending parallel to our heading which is 278°. It is a vertical scarp below this step with outcropping mudstone along it. Very little colonizing this scarp, it is too steep for most organisms.
08:18	3264			P	Re-occupied bottom.
08:20	3265			P	Re-occupied bottom. We are going to head E to SE, move down hill, try to re-occupy the sulfide site. The bottom at this point is fairly flat, sediment-covered, not too well colonized.
08:53	3202			P	We are on about a 30-40° slope with whitish mudstone talus exposed on it.

08:56	3195	222		P	We are climbing up a sediment slope heading 222°, the slope is perpendicular our heading, sloping about 40° to the aft, smooth and sediment-covered.
	3186	229		P	I see some very large, what look like sediment ripples, they could be erosional features. There is some mudstone shingling now, coming up this slope. The slope has flattened to about 30°. Moving up this slope, there is almost nothing on it, there is one asteroid a couple of cm across.
08:58	3179		29	P	The slope has flattened out. There is a hummocky slope of 10°-12° now, probably right at the top of the hill, a fairly large rat-tail fish, which I will get a picture of.
09:00	3176		30	P	We're moving up a gentle slope, it is very flat here, it has what look like very large scale ripple marks. They are about 1.5-2 m in wave length and about 5-10 cm high. I am going to try to take a picture, but I don't think they will show. They are demarcated by whiter sediment at the top, no obvious grain size difference, I can see them mostly by the shadows. We are getting some more biota now that we are on a flatter slope, there are quite a few holothurians, an occasional anemone, not much in the way of stalked organisms.
09:06	3169	270		P	I think we are really at the top of the hill now. It is table-top flat up here. There were some ripples which were really more like small subcropping mudstone layers, which gave the slope a rippled effect. It is very flat now. There is not much up here, just a couple of holothurians. We have a current coming from about 270° or so, our heading is 293°.
09:09	3170			P	We are sitting on the bottom in a very flat area covered with sediment. We are going to take a push core, and go home. To summarize the dive as best I understand it at this point, which is not to well, we apparently landed to the south of saddle between the South West (sediment) Hill and the knob to the east. We

		headed about 020°, intersected the slope and came up several scarps, steep sediment scarps, some of them vertical, some of them might have been channels, a few of them looked like faults. We turned more to the west, continued up the slope. At a depth of about 3275 m we encountered a very large massive sulfide deposit. Just prior to reaching the massive sulfide deposit, we crossed several very steep, what were almost certainly fault scarps with outcropping mudstone, some of which looked rather indurated and blocky. Scarps with throws of 2-4 m. We came to the top of that and found very rubbly and blocky massive sulfide, very irregular talus blocks 0.5 m on a side. Very few chimney-like projections, almost none. However, there was very little weathering of the sulfide and only minimal sediment-cover, and a lot of broken fragments with shinney large crystal faces on them. We continued up above that deposit heading about 330°. Crossed sediment on a steep hill. We turned around and tried to fly back on a heading 090° trying to move a little north and east of there. We kept getting shallower depths. We finally re-occupied the bottom and came up a steep sediment scarp to the top of the hill, and will terminate the dive at 10,400 ft.
	32-35 P	I'm shooting off the end of the roll on the port camera. The first shot was #32, *f* stop 5.6, #33 *f* 3.5, #34 *f* 8, #35 *f* 4.5. One roll of film taken on the port camera. The last four shots were exposure tests. They were taken of bare sediment with almost no distinguishing features on it. Six video tapes were used on the dive, the only sampling was one push core taken at the end of the dive.
09:43	P	Ascent weights away, leaving the bottom, best location for push core X-57440, Y-53077.
11:49	P	On the surface.

DIVE SUMMARY 763-Port Observer

Dive 763 submerged at 01:07 GMT and reach bottom 05:01 after a very protracted bottom approach. The intended launch target was the saddle between the South West (sediment) Hill and the smaller knob to the south east. The dive actually started south of the South West (sediment) Hill (X-57750, Y-51900). We headed about 020°, intersected the slope and came up several steep sediment scarps, some of them vertical. Some of them might have been channels, a few of them looked like faults. We encountered recently disturbed mudstone, interpreted as debris from a dredge track, at 05:48, and encountered a dredge track (probably a separate track from the first seen) at 05:57. We apparently reached the top of the ridge between the South West (sediment) Hill and the knob to the south east at 06:13 and changed heading to 300° and began climbing the steep flank of the South West Hill. At 06:35 we crossed several steep to vertical sediment scarps interpreted as faults. The scarps exposed semi-indurated sediment and were covered with large angular blocks of talus up to 75 cm on a side. Another dredge track was encountered at 06:42, and after crossing another steep scarp with siltstone talus blocks, we encountered a large massive sulfide deposit at 3272 m. The sulfide outcrop was generally irregular blocky talus 0.5 m on a side, with very few chimney-like projections. However, there was very little weathering of the sulfide and only minimal sediment cover, and a lot of broken fragments with shinny large crystal faces on them. After a long traverse across massive sulfide we re-encountered the steep sediment slope at 3252 m placing an upper limit of 20 m on the vertical extent of the sulfide deposit. We spent a long time in the water column attending to the needs of the submarine and apparently drifted away from the deposit due to the strong bottom current and were not able to relocate the deposit. We then continued up the steep slope and reach the top of the South West Hill at a depth of 3170 m. The current across the top of the hill was quite strong, and the hill top had sedimentary structures which were either ripple marks with 2-4 cm amplitudes and 20 cm wave lengths, or the leading edges of subhorizontal bedding planes exposed by erosion. The top of the current-swept hill had noticeably fewer fauna than areas of comparable slope. The bottom also appeared to be more bioturbated with a lot of mound structures. The observation that areas with high bottom currents are poorly colonized and have a mounded bioturbated appearance has been repeated at other sites, and it is now clear that these areas have the lowest rates of bioturbation by miofauna and therefore better preserve the larger bioturbation structures from macrofauna. The dive was terminated at 09:43 and surfaced at 11:49.

DIVE SUMMARY 763-Starboard Observer

Because of heavy seas, launch time for Dive 763 was delayed until 17:00 on September 1, 1988. After a well-executed launch in rolling seas, our surface check showed a ground on the DDIS-35 mm camera connection. We had to disable the camera, thus losing photo potential, and digital readouts in the sphere displaying time, heading, and depth in meters. Descent was uneventful until about 9000 feet. At this point we found out that we were 1500 yards away from our target. We started driving as we were sinking but then we lost radio communications for nearly an hour. We came close to aborting the dive, but we were pretty sure the loss in communication was due to engine noise from the DSVSS *Laney Chouest* trying to track us on the surface. We continued our very slow descent, at about 20 feet per minute, while we waited for the surface to find us.

Once we were given a range and bearing for our target, we discovered during an hourly log reading that we had a 30 volt hard ground on both the forward TI light and the pan-and-tilt lights. This means we have very little light to drive by and we will not be able to get video footage with the pan-and-tilt camera. We only have enough light for hand-held video on the starboard side because even the still mounted video on starboard side is in low light. Also because of the lighting problems, I was busy with the sonar and the fathometer (more than usual because we could not see well where we were going) and was not able to take hand-held photos or tape descriptions from the starboard side.

Once we reached bottom we were on soft substrate with typical soft bottom benthos. This means the animals we saw during the dive were not vent related and were the type one expects for sediment fauna in the deep sea. We saw many holothurians, mainly large purple ones (probably Abyssocuccumis abyssorum), some white ones with dorsal lobes (probably Scotoplanes), and some orange swimming forms. We should have good video footage of an orange swimming cucumber on the last videotape (#6). There were also many xenophyophorians, sometimes up to about 10 per m^2. I also saw a few rat-tails, again one should show up quite well on video. There were also many pennatulids (sea pens) and some anemones, including small white, burrowing forms, and Venus flytrap anemones. Rob (Zierenberg) also has 2 good pictures of a large, cuttlefish-like animal. I did not see it from the sub but from its shape and the number of arms that can be counted, I would say it is a cuttlefish rather than an octopus or a squid. There were also a couple of galatheids (white squat lobsters) on the sediments but not in any concentration that might indicate a vent.

Geologically, all I can say is that we saw some white mudstones overturned during one of the USGS dredges in the area, and some sulfides on the top of 'Moe' (?). The deposit, according to Rob (Zierenberg), was

older than the vent-related sulfides, but still quite young. We only saw a small portion of the entire deposit and could not return to it later in the dive. We collected a sediment core at the top of 'Moe' (South West Hill).

In summary, our long (almost 12 hours total dive time) dive was spent exploring the soft bottom benthos around Moe. We spent a great deal of time in the water column trying to get to specific sites so most of our 6 videotapes will not show much of the bottom. We did not see any vents, but did document a patch of sulfides near 'Moe' (South West Hill). No unusual bottom fauna were observed and no biological samples were collected.

DSV *SEA CLIFF* PRE-DIVE PROFILE
C1-88-NC

Dive # 764 JD/Date 247 / SEPT 3

Port Observer Holmes
Equip. Operator : Okita

Pilot: Craver
USGS SC: Koski
(Surface controller)

Dive Objective(s):

The primary objective of this dive is to re-acquire the active vents mapped during DSV *Alvin* dive 2042 earlier this summer on the northwest flank of 'Curly' (affectionate term for Central Hill). Markers 6X and 0 were deployed at/near the 220°C vent (WP L). Launch will be at the location of these markers (58819, 55401), and DSV *Sea Cliff* will be vectored to this site during descent. The divers will ascertain the extent of the active vent field, approximate number of active vents, and the trend of vents/structures. Vents will be marked and temperature measurements conducted where possible. Samples will be collected from the active chimneys, and biological specimens will be obtained of vent-associated fauna. Push cores will be used in sedimented areas. If time permits, a transect will be made south east to top of 'CURLY' (Central Hill; WP A) and thence downslope to the north to WP B to tie in the sulfide deposits mapped on DSV *Sea Cliff* dive 658 in 1986. These WP's are based on questionable tracking of the 1986 dive, and may be changed at the discretion of the divers or the USGS surface controller.

Launch Point: X= 58819
(WP L) Y= 55401

Latitude 41°00.03
Longitude 127°29.61

Way Points: A) X= 58935
Y= 55250

B) X= 58780
Y= 55750

DIVE TRANSCRIPT

Location: NESCA Central Hill
Port observer: Holmes
Starboard observer: Okita

Julian Day: 247-248
Date: 09/03/88
Pilot: Craver

KEY: P = Port observer, S = Starboard observer, E = External photograph, Photo # = Hand-held photograph number, description in appendix 2.

Time (GMT)	Depth (m)	Hdg.	Photo #	Obs.	Comments
15:14	0			S	In the ball; 1.2 mile off dive position.
15:24	0			S	1200 yds off dive posit[ion].
15:27	0			S	800 yds off dive posit[ion].
15:41				P	Vents are open.
15:41	0	046		S	Vents open; 830 m from dive position Gyro reads 046°.
15:47				P	Submerged.
15:49				P	Vents are shut.
16:10				P	We just got a couple of TIPE signals and upon reporting Delta 3 [depth 3000 ft]. We were told that they've lost Sonatrack tracking about 5 minutes ago.
16:10		345		S	Sonatrack lost at 16:05. Gyro at 345°.
16:15				P	Just received a message that target A bears 275°, 1000 m. That range and bearing was to target A, not target L, but they're both going to be in the same direction.
				P	First frame on the Benthos camera is numbered 42.
16:15		275		S	Corpin [course] 275°, range 1000 yds to Alpha. Propulsion engaged.
16:26				P	Delta 5. We've calculated a course of approximately 305° to get to Way Point L [Note: Way Point L is location of benchmarks 6X and O deployed on DSV *Alvin* dive 2042]; probably about 1200-1300 yds away.
16:30	1646			S	Lost tracking; 5400 ft, descent rate 105 ft per minute, secured propulsion.
16:35				S	Regained tracking.
16:37				S	Lost communications.
16:48				P	Delta 8.
17:02				P	Descent weights away.

17:05			P	We've been having a lot of problems with communications during the last 15 minutes. Appear to be going through noisy zones; lots of background noise on the UQC [underwater communication system]. We can't get through to the surface and I assume they can't get through to us.
17:12			P	One selective weight [dropped].
17:24			P	Just got a message from the surface: Way Point L 275° 800 yds.
17:27			S	Comm[unication]s re-established; Fly 275°, 800 yds.
17:35	3015		P	We're attempting to drive over to Way Point L. We're off to the east-southeast of it, still probably by some 700 yds or so. Altitude approximately 130 fathoms.
17:43			P	Lima [WP L] bears 270° 300 m.
17:45	3028		S	Event marker placed on fathometer to mark plateau. Sub at 9935 ft, 110 fathoms under the keel, speed 1 knot.
17:54			S	Event marker placed on fathometer to mark edge of plateau, stepping down into a trough.
17:56			P	From surface: have not had good track for last 15 minutes.
17:56			S	Secured propulsion.
18:00			P	Message from surface: Target Lima [WP L] bears 110° 140 m.
18:00		110	S	Drive 110°, 140 m to Lima, approximately 5 minutes.
18:02	3025		P	We're coming around onto course 110°. We're going to fly along at this altitude, depth 3025 m, for about 5 minutes and then make a bottom approach. We should be definitely in the vicinity of the vent field.
18:05	3026		P	Commencing bottom approach. Pumping VBS. Present depth 3026 m.
18:05			S	Trim sat[isfactory]., commence bottom approach.
18:07			S	Secure hydraulics.
18:09		085	S	Heading 085°, 50 m to Lima.
18:10			P	085°, 50 m to Lima.

18:23	3177	097		P	We're continuing a bottom approach. We have a very strong CTFM sonar contact, 400 m dead ahead. Altitude 175 ft.
18:27				P	We're about 75 yds now from a very strong CTFM [in sub. foward-looking horizontal scanning sonar system] sonar contact ahead and off to the starboard side. We're descending.
18:29	3233			P	The bottom is in sight - barely. I've got one of those white fish just off the port bow.
18:31	3239	057		P	We are on the bottom. A sediment-covered slope. Sediment is grayish color; there's quite a bit of topography to the slope. I can see some white anemones, not too much particulate matter in the water. The bottom also is covered by small bumps, small-scale topography a few centimeters high, 10-20 cm in diameter - not rippled - slightly bumpy. Bottom is falling away to port and aft of us at, I'd say, 25 degrees. We're on a heading of 062°.
18:34	3236	070		P	We have started video tape 1 [Video was recorded onto 3/4 inch tapes of 20 minute duration, and subsequently transfered onto VHS tapes].
18:35		090		S	Heading 090°, 25 m to Lima.
18:36				P	Range and bearing to Target Lima is at 090°, either 125 m or 25 m. Transmission from surface was a bit garbled (note: it was 25 m).
18:40	3237		2	P	First bottom picture, I'm not even sure the strobe went off.
18:41				P	We're proceeding 090° toward the line of sonar contacts that we have. Joe says he sees a rock wall. I can't see anything out my port at the present time. It's very steep and must be dropping away from me.
18:42	3227	115	3	P	Picture number 2, mainly as a strobe test which did successfully fire.
				P	Considerably below me now, maybe 10 or 15 ft, some rocky outcrops, slight covering of sediment, a little bit too far away for me to make out the details. Very distinctive blocky outcrops sticking up through the sediment.

18:43	3220			P	We're maybe 15-20 ft above the bottom.
18:44	3234	119	4	P	Another picture, inadvertently taken. Having trouble triggering my camera.
18:45:53	3234	120		E	Lobate mound of massive sulfide.
18:46	3234		5	P	Another shot of some broken sulfide chimneys, small ones. We appear to be at the edge of a deposit of sulfides. I do have a chimney, a sediment-covered chimney, about 1 m high, possibly, sitting on some slabby, horizontal slabby outcrops of sulfide. Appear to have a centimeter or two of very fluffy tan sediment on top of them. No real colonization that I can see, no distinctive animals. Some yellow encrustation. I took a picture of that with the previous frame, but the camera appears to be triggering on it's own. I can't get the shutter button to control things.
18:47	3234	123	6	P	Picture of the sulfide chimney. The shutter button on the camera is still not working. I'm not sure whether these pictures are going to come out.
18:48	3233		7	P	Camera went off in the ball.
				P	We have a large mound of sulfide composed of blocks. It's about 1.5 m high, 20 ft off the port side now. A rubbly-looking outcrop. Bottom is still sediment-covered for the most part, with these rounded knobby blocks of sulfide sticking through them. Fairly heavily sedimented at this location. Everything looks pretty old.
18:49	3227		8	P	Shot of a sulfide pavement, lightly sedimented.
18:50	3222	085	9	P	The camera went off again on it's own as I was holding it about a foot from the viewport.
18:52	3212	110	10	P	At the base of a fairly steep slope. It's a rocky slope, some covering of sediment, very indistinct out my side. We're pointed right at it and it's trending at right angles to our course.
18:53				P	On the steep slope off the port side now, a long accumulation of tube worms. They're too far away to see exactly what state of life

					they're in. It's a patch that was about 6 m long, 25-30 cm wide that was draped over the edge of one of these outcrops, a steep face, sort of like a tube worm waterfall.
18:54	3204	105		P	We've got tube worms out the starboard side on the hand-held TV now.
18:54	3204	117	11	P	Shot of the sulfide pavement, blocky solid outcrops. These outcrops are colonized by small star fish and some white puffy animals, possibly sponges. We're going up right now, I'm losing the bottom. There's a large mound ahead of us that Joe is climbing over.
18:55	3200	138		P	Very bright sonar contact ahead of us about 75 yds, slightly off the port bow.
19:00			12	P	Shot of the sediment-covered bottom on this part of the slope. It's fairly flat. Still grayish-brown sediment. Difficult to tell whether it's a veneer or not. Very fluffy, We stirred up a lot of mud back there on just a close bottom approach. We didn't impact.
19:01	3196	095	13	P	Another shot of the sediment-covered domes. That shot showed some of the small bumpy features on the bottom - it's not completely smooth. There are some anemones, some sponge-like animals.
19:01	3196	070	14	P	Another shot of the sediment-covered bottom.
19:01	3193		15	P	Another shot of a white crab on the sediment. That was mainly to index my picture-taking.
19:02	3194	087		P	The slope falls away from me about 25-30 ft off the port side of the vehicle.
19:03	3194	107	16	P	A shot over and across the drop-off that's about 25 ft off the port side.
19:05	3194	124		P	We're hovering over the bottom while we take a Drager tube sample to check some high oxygen readings. Our sonar contact is still very strong (125 m, relative bearing 045°). A large arcuate contact that actually extends from relative bearing 350° down around about to 110°. Stays about the same distance around that arc from the vehicle.
19:06				P	Just got a range and bearing to Lima: 307° 91 m.

19:09	3195	099		P	Drager tube indicates that the forward oxygen monitor may be in error. We're going to use the aft one for the monitoring of the life support system. We're hovering in place meanwhile at a depth of 3195 m. We're above the bottom some distance, I can't see it out the porthole. The surface ship is attempting to vector us to Way Point Lima. They have been unable to get a good posit[ion] for the last few minutes.
19:09				S	Drager tube test, forward meter in error.
19:12	3195			P	Range and bearing 306° 106 m. This doesn't jibe very well with our sonar picture at all, but we'll drive over there and see if that vectoring information is correct to get us into the vent field.
19:13				P	Because of the discrepancy between the sonar contact that we have and the location of Way Point Lima from the DSVSS *Laney Chouest*, we've elected to keep going on a course of about 060°-090° and investigate the nature of the sonar contact.
19:15				P	The bottom is in sight again. Large mounds, sediment-covered mounds, 1-2 m high colonized in some cases by white crabs. The overall topography is heavily dissected but rounded terrain, with these sediment-covered mounds scattered around.
19:17	3208	142		P	We're going up a very steep slope now, I'd say about 45-50 degrees. Again mostly sediment-covered, there's even some vertical faces on which I can't see any distinct outcropping or stratification, but it's a little too far away for me to see if that is actually covered by this same mantling of soft sediment.
19:18	3204		17	P	Picture of part of the slope.
19:18	3200	175	18	P	This shot of the sediment-covered bottom. We've reached the top of the strong sonar contact. We may be on top of 'Curly' [Central Hill] at this time.
19:20	3200	280	19	P	Slope out the port side falling steeply away. Just took a picture of that.

					Still sediment-covered bottom. Small mounds tens of cm in diameter, about 10 cm high. The bottom here is colonized by some type of critter, maybe an anemone. It's appeared in the pictures and on the TV, looks like a small sponge, about golf ball size, scattered over the bottom. Fairly dense, they're spaced apart a few tens of cms.
19:22			20	P	Another picture of the sediment-covered bottom with one of the white (Spectrunculid?) fish swimming into our lights.
19:23	3195	297		P	The generally flat sediment-covered sea floor is dropping off steeply ahead of us and slightly off the port side into one of these swales between ridges. Very rounded bottom, and ahead of us I can see the other side of it. It's a valley, a U-shaped channel, that is trending across our track at about 270° relative. We're on a heading of 312°.
				P	Now we're across it, up on the other side. There are holothurians. We're dipping down into another swale much smaller than this one, again U-shaped in cross-section, this one trending about 300° relative. And now back on the flat sea floor, the flat part of the dome flank. Still all sediment-covered, no sign of rock outcrops that I can see out the port side.
19:24	3199	317	21	P	Shot of a white, semi-transparent anemone off the port side.
19:25	3195	287	22-23	P	Two pictures in quick succession of some sort of gouge mark off the port side, .possibly a camera bump. It didn't look heavy enough to be a dredge.
19:26	3195			P	Off the port side now, still sediment-covered bottom. Counted about 4-5 large purple holothurians in the last 5 minutes. A couple of long stalked anemone-like animals on very thin stems maybe 10-15 cm long.
19:29				P	Bow camera turned back on. It had been turned to manual from 16 seconds. I don't know what time that was done.

19:29	3207	291		P	Just ended video tape 1, I believe. We're headed downslope, a dissected slope cut by these U-shaped swales. It's not really extreme topography; sediment-covered for the most part. I can barely make out some darker patches that must be rock outcrops but they're too far away from me to really say what they are.
19:31	3213	298		P	We're probably 7-10 m off the bottom, slope dropping away from us about 20 degrees. There are rock outcrops now, sediment-covered for the most part. It's hard to make them out.
19:31	3216	288	24	P	I've got some tube worms off the port side.
19:33:42	3222	330		E	Sulfide mound with tube worms and bacterial mat.
19:37	3221	345		P	We're hovering over a large outcrop of sulfides, visible really only out the starboard side and the forward port, falling away too steeply to port for me to see. It's colonized by tube worms, we've just collected video of the tube worms. The last fix that the Sonatrack system had on us was approximately 20 minutes ago. At that time Point L was 300° 100 m from our position. So we're essentially without positioning now. We will continue to investigate this sulfide field and try to locate the active venting.
19:46	3222			P	We just received a position from the surface that indicates we're very close, within 20 or 30 m from Point L. We're on the bottom in this sulfide field so we'll start to move around slowly and look for active chimneys at this point.
19:46:28	3223	085		E	Orange iron oxide crust on brecciated massive sulfide mound.
19:50	3220	067		P	We're up off the bottom about 7-10 m. Joe [Craver, pilot] just spotted one of the benchmarks so we're going to go see which one that is.
19:51	3219	105		P	We are at Benchmark 6X.
19:52	3221		25	P	Picture of some dead (?) tubeworms.

19:52:11	3221	125		E	Anhydrite and tube worms next to orange weathered massive sulfide.
19:53	3220	150	26	P	Another picture of some pretty tired-looking tube worms off the port side. Most of the deposits are out the bow. Even on the ahead-looking TV camera we can see the shimmering water. We will attempt to get some temperature readings on these vents to calibrate our temperature probe and to refine the temperature-measuring techniques that we'll be using on subsequent dives.
19:56	3219			P	The mounded ridge ahead of us appears to be leaking hot water along about a 10-12 inch zone. Sort of a linear leaking patch. It's not confined to a chimney here. We're going to try to lay the temperature probe right in there and see what the fluid temperatures are.
19:58	3220			P	We've gotten temperatures to kick up to about 12°, but have seen no higher.
20:01	3220			P	There's a good video of the leaking patch that we've been measuring, very good shots of it, and we've got temperatures that went up to about 36°C out along this linear patch of venting.
20:02				P	Currently recording, or were recording, a shot on the pan and tilt of Benchmark 6X just ahead of us and to the right.
20:02				P	We've repositioned the temperature probe, temperatures being measured now close to 150°C.
20:08	3220		27	P	A picture of the bottom off the port side in this sulfide field in the vicinity of 6X and 0. We're essentially resting on the bottom.
20:10:07	3219	180		E	Marker 6X.
20:11	3217			P	We're coming around for another pass on Benchmark 0. We got some good video of it. It's right on a chimney that appears to be venting. We're going to get some temperature measurements there. Also some additional shots of the Benchmark float itself which appears to have accumulated a covering of

					some sort of material during the time it has been deployed.
20:15	3222	062	28	P	During maneuvering. Shot of sulfide out the port side as we come back for a pass.
20:15			29-30	P	And another shot showing the encrustation of white sponges or anemones on the blocky sulfides.
20:15:33	3223	053		E	Sediment-covered base of sulfide mound.
20:16			31-32	P	Two shots of the sulfides, very close to the port side, colonized by the venus flytrap anemones or something that looked like them. Tube worms now, I'll take a picture of those.
20:17	3217		33	P	Lots of tube worms now. Just took a shot.
20:20	3217			P	We're looking at the main chimney structure associated with Benchmark 0. There's hydrothermal fluids coming out of the top of it as well as from around the base. Diffuse flow around the base coming out of the blocky structure on which the summit chimney mound has been built.
20:21	3216		34	P	A shot out the port side of sulfide with an anemone on it. Some tube worms off to the right. The video out the bow is showing the hydrothermal fluids leaking out of the chimney structure associated with Benchmark 0.
20:23:32	3216	315		E	Tube worm cluster near marker 0.
20:24	3217			P	Some of the sulfides, what few I can see out the port side (all the action is kind of ahead and to starboard) have a sort of crenulated appearance, crenulated vertically, hard for me to put into words, obviously. More like the kind of structures you see on stalagmites in caves.
20:28	3217			P	We're still on the Benchmark 0 site. Joe [Craver] says that from his point of observation he can see venting really taking place all over this hill. Appears to be quite active but not completely channelized into the chimneys. Some diffuse flow areas scattered all over.
20:28:52	3216	247		E	Active chimney at top of mound.

20:29:24	3216	245		E	Close-up of tube worms and palm worms on active chimney.
20:32:07		207		E	Marker 0, heavily encrusted with hydrothermal products.
20:34	3266	181		P	We've got Benchmark 0 right ahead of us. We're going to attempt to get a temperature measurement on a jet that's coming out just downslope from Benchmark 0. (note: this depth could have been 3216, but I'm pretty sure I read it correctly. Possible glitch in the system).
20:35:56	3220	180		E	Temperature probe in active vent.
20:36	3219	179		P	We're stopped on site. Taking temperature measurements. The probe will go right into this area (bottom) where the venting is, even where it's confined and jet-like, it's partially sediment-covered but apparently the sulfides are pretty rotten. We're currently taking video of the temperature measurement operation.
20:37	3220		35	P	A shot of one of the sulfide outcrops off to the port side with associated tube worms. This one is fairly angular, a little bit weathered looking. In the background (of the picture) you can probably see the large sulfide boulders that have spalled off from uphill. It doesn't look like an in place deposit.
20:38	3220		36	P	Picture off the port side of the sulfides colonized by crabs, tube worms, anemones of various kinds. It's hard to tell whether the tube worms are alive. Some of them look pretty tired. I can't see any red heads, but there does appear to be a flowering at the heads.
20:39	3221			P	We've just gotten a reading of 222°C on that vent. Interesting, at least to me, because it's not associated with a chimney, it's well below the chimney at Benchmark 0.
20:42	3266			P	Just started video tape 4. We're in the Benchmark 0 area, having just completed temperature measurement of 222°C off one vent down below the Benchmark 0 chimney.

					(note: here's another of those 3266 m depths.).
20:43	3267		36a	P	Picture out the port side of one of the Benchmarks. I believe that's 6X but I couldn't see it. (note: another erroneous depth off the camera display).
20:48	3219		0a	P	First frame on roll 2 was of the sulfides and tube worms about 1 m from Benchmark 6X I believe. (note: depths are now back to the 3220 m range).
20:53:19	3220	156		E	Crack in barite(?) crust on surface of sulfide mound, near active vent.
20:54:41	3218	164		E	Active vent, shimmering water.
20:55	3219			P	We got up to about 8° measuring temperature almost 1 m above this small chimney that's being recorded on video right now.
20:59:02	3218	142		E	Vitreous black globs of hydrocarbon(?) next to active vent.
21:08	3215			P	We've abandoned efforts to sample around the vent that we were studying. With no discrete chimney to sample, the sulfide and sediment deposits were very soft, possibly anhydrite, a patch of white material around those active vents. When we backed away from the slope, in fact we backed over Benchmark 6X, you could look back at the slope and see other patches of venting associated with these whitish deposits, discrete circular patches of white material through which the venting was occurring
21:09	3217		1a	P	Picture of Benchmark 6X out the port side as we're going up into sampling position near Benchmark 0.
21:10:43	3218	161		E	Small chimney near top of mound.
21:11	3217		2a	P	Picture of Benchmark 0 out the port side. It's shielded partly by possibly turbulence but I believe also some venting that is taking place very close to the Benchmark. There are tube worms, which I hope were included in the picture, with nice red heads and also the benchmark itself has become partially covered on the sides and underside from what I can see by gelatinous growth.

21:14	3263		3a	P	A shot off the port side of some tube worms, definitely alive, nice red heads. (note: another bad depth reading).
21:14:14		136		E	Active chimney at top of mound showing shimmering water.
21:14:47		129		E	Active chimney at top of mound, marker 0 visible below.
21:15	3239			P	Just started video tape number 5.
21:16	3239		4-5a	P	A shot of the sulfides out the port side. I don't have the lights turned on right now but the last (next) picture showed some dark patches that may be due to a difference in sulfide type, possibly due also to a difference in sediment cover. Without the lights on it's a little difficult for me to see. We're steaming back to the chimney, going past Benchmark 6X at the present time.
21:18	3232		6-7a	P	Two pictures in quick succession, one of Benchmark 6X and the other of the vents near where we made the last temperature measurements. Benchmark 0 coming into view now off the port side. Very visible venting right beneath it as I have described previously.
21:20			8a	P	Accidental shot inside the ball.
21:21	3233		9-11a	P	At the 6X and 0 site. Three pictures in quick succession of the vents beneath Benchmark 0 with the white encrustations surrounding them.
21:29			12-13a	P	Attempting to maneuver back to the sampling site at Benchmark 0. Two shots in succession of the slope that we're going up, partially sediment covered, some outcrops of blocky sulfide colonized by white starfish and the smaller puffballs (sponges?).
21:33	3233		14a	P	Still maneuvering to regain the site of Benchmark 0. Just took a shot of the sulfides out the port side again.
21:35	3230		15-16a	P	Two shots in quick succession. Shots of tube worms associated with active venting. The submersible has just kissed the bottom. We've got very diffuse active venting off the

					port side. Nothing real concentrated. A gentle flow but you can see the turbulence.
21:35:59	3227	066		E	Sulfide mound.
21:39	3266			P	We're deploying benchmark at another site with live tubeworms and diffuse venting. This site is deeper than the Benchmarks 6X and 0 which had depths of about 3230 m. (note: this depth is probably incorrect. See previous comments. This new site is probably very close to the same depth as 6X and 0).
21:40	3266	.	17-21a	P	Two shots (actually it was 5) successively of the live tube worms off the port side as we're deploying this benchmark.
21:40:36		067		E	Marker O/Y in arm.
21:41	3266			P	We'll be deploying Benchmark "Orange/Yellow".
21:46:01		304		E	Marker O/Y deployed in tube worm clump.
21:48	3266			P	We've just collected a piece of the tube worm colony at recently deployed benchmark site Orange/Yellow.
21:50	3259			P	We just started video tape 6. We're going to obtain some pictures of the tube worm sample that we've just collected out the front viewport with the hand held camera.
21:51:28		304		E	Close-up of O/Y in tube worms.
22:00	3220			P	We've been at this same - there we go, there's a depth 3262, that 3220 was an aberration. We've just collected a huge sample of tube worms. In fact what probably amounts to an entire colony. Trying to put in the bio-box. It's probably bigger than the bio-box.
22:00:10		303		E	Tube worm sample in arm.
22:21	3210			P	I don't believe that depth is right. We've been sampling at this tube worm site at Orange/Yellow. The depth in the past was reading 3260 m., it's now reading 3211 for some reason [Editor's comment: this is the correct depth]. We're going to attempt to fly up to another chimney that Joe has seen and terminate the dive at that point. We were just notified by DSVSS *Laney Chouest* that they have a good position on us.

22:27	3176	P	We have received permission to terminate the dive.
22:30		P	Dropped descent weights; commenced surfacing. The last frame on the Benthos camera is showing 708; starting frame was 42.
22:30		S	Dive terminated.
23:19		P	We're in mid-water on the way up. We've been conducting tests to see which combinations of hydraulic systems could be interfering with the Sonatrack navigation. We've determined that the main hydraulic pump and stern propulsion combination wrecks the navigation; the Aux hydraulic pump all by itself wrecks the navigation, but the main hydraulic pump all by itself seems to have no effect on the tracking. Side pods had no effect.
00:30		P	We didn't make it back before the 4th of May after all. Pat [Okita]'s taking one more shot with the bow camera attempting to photograph some sort of vent-specific arachnid.
00:32		P	Another shot of some sort of spider-like animal that appears to have colonized the tube worm colony. These last few frames are going to have the incorrect time stamp on the data frame. Depth, heading, seconds, and so on are OK, but the time is about 25 minutes off. Benthos camera reads 720 at the end of the picture-taking session.
00:38		P	On the surface. Quite a bit of material is washing loose from the basket, possibly just the pieces that were loose anyway.
00:42		P	We've commenced taking additional pictures with the bow camera of the swimmers in their attempts to stabilize the worm bundle.
00:53		P	Blowing tanks.
01:01		P	We're lifting out right now.

DSV *SEA CLIFF* PRE-DIVE PROFILE
C1-88-NC

Dive # 765 JD/Date 248 / SEPT 4

Port observer : Wiltshire
Equip. operator : Koski

Pilot: Poirier
USGS SC: Zierenberg
(Surface controller)

Dive Objective(s):

DSV *Sea Cliff* will be launched over the best-known position of the summit of the 'volcano' ('Zeppo') east of 'Curly' [Central Hill]. The first objective is to locate the summit and map/sample any vents/sulfides/biota found there. The divers will then conduct a transect to the northwest across the boundary between the volcanic ('Zeppo') and sedimented ('Curly') terrains. This track will take DSV *Sea Cliff* over a narrow graben-like feature that seems to be a structural boundary between the two features. The nature of the basalt/sediment contact will be mapped and sampled. The bottom along this transect is expected to be fairly rugged, with large pillows and broken sheet-flows. It might be pretty slow going. From there, time permitting, DSV *Sea Cliff* will proceed to the active vent field on the northwest flank of 'Curly' (Alvin targets 4 and 5) where sulfides, bacterial mats, and tube worms have been seen. Temperature measurements will be conducted on active vents. Rock and faunal samples will be obtained as opportunities are presented. Tests conducted during Dive 764 indicate that transponder navigation is seriously degraded whenever the aux. hydraulic pump or stern prop./shroud are activated. During transects requiring the use of the stern prop., periodic stops should be made in order for the nav. team to maintain an accurate plot.

Launch Point: X= 59890
(WP L) Y= 54375

Latitude 40°59.47
Longitude 127°28.87

Way Points: A) X= 59255
Y= 54875

B) X= 59261
Y= 54964

DIVE TRANSCRIPT

Location: NESCA Central Hill
Port observer: Wiltshire
Starboard observer: Koski

Julian Day: 248
Date: 09/04/88
Pilot: Poirier

KEY: P = Port observer, S = Starboard observer, E = External photograph, Photo # = Hand-held photograph number, description in appendix 2.

Time (GMT)	Depth (m)	Hdg.	Photo #	Obs.	Comments
21:35				S	Off the deck.
21:42				S	In the ocean, 4-6 ft seas.
21:54				P	Leaving surface to commence dive 765.
22:00				S	Ballast tanks vented, submerging.
23:24				S	Drop descent weights, slowing descent.
23:35	3000			S	
23:43				P	Commencing bottom approach.
23:52	3231			P	Bottom contact. The bottom is sediment covered. The sub is on the edge of a small ravine which drops down about 10 feet on the port side.
23:53	3242			S	On the bottom, pillow lava with local sediment cover; location 100 m east of target L.
00:01		090	4,5	P	First pictures taken with the port hand-held camera, pictures taken at *f* 4.5 and 1/60 sec., sub stirs up cloud of sediment.
00:05	3247		6,7	P	Shot pictures 6 and 7 on port hand-held camera of holothurians and tracks on light-brown colored sediment, bottom topography drops off to the port side.
00:06		000		P	Sub is 20 ft off a sediment-covered bottom. We just crossed a sharp contact entering an area of large pillows. The pillows have a slight dusting of sediment. We are proceeding slightly uphill, the sediment is in a lower topographic position than the pillows. Many of the pillows show toothpaste-like structures and are about 6 ft in diameter.
00:08				P	Taking hand-held video out the port side. Some of the pillows show fresh faces. There are numerous broken pillows, with pillow

					debris around. The largest of the pillows are 8 ft in diameter. There are pockets of sediment a few feet in size interspaced between the pillows. A few bamboo corals are present but few other organisms. We are entering an area of slightly larger pillows. There are pockets about 10 ft deep between the pillows.
00:13:00	3258	009		E	On bottom, apparently sediment covered, but pictures very dark.
00:15			18,19	P	Secured hand-held video. Took pictures of a large mound of coalesced pillows. Changed the camera settings to 1/30 sec at *f* 4.5 and focus at 10-30 ft. Photographs of a star fish on a pillow and a large sea cucumber. Sediment dusting on the pillows is 1/4 in. or less. Some of the visible structures are agglomerations of several pillows.
00:19			20-24	P	Still in pillow field. Picture 22 of fresh-looking pillows. There is a 10 ft gully off the port side filled with pillows. Picture 23 is of a large sea cucumber sitting on the pillows. Pillows have a light dusting of sediment which is very fine grained and light brown in color. The pillows are up to 8 ft in diameter and show evidence of striated flow structures. There is considerable exfoliation of exterior layers on the pillows. Irregular masses of pillows are piled one on another with drops of 10 ft between the masses of pillows. These pockets are sediment filled.
00:24	3261	052	25-27	P	Heading toward target position 200 yds to the north. Took picture of a large rat-tail fish about 3 ft long. Area contains a higher percentage of broken pillows at this point.
00:26			28	P	Transect is continuing in the pillow field. The distance between pillows is decreasing. The largest of the pillows are still about 8 ft but there are now many more smaller pillows. A few solitary corals and starfish are present.
00:27	3266		29-32	P	Pillows have a breadcrust texture. We appear to be going slightly downhill. Picture 29 is

					of a bamboo coral on a pillow. The pillows are of decreasing size, tend to be more elongate in shape and have more toothpaste like textures than those seen earlier. The distance between adjacent pillows has also decreased. Picture 32 is of a group of secondary pillows built one on top of the next.
00:29			33,34	P	Changed camera settings from 1/30 to 1/60 of a second. We are moving slightly down slope. The pillows continue to be sediment dusted as before. The bottom is getting somewhat flatter, the pillows are not as dominant as earlier. There are more pillow fragments and debris. The pillows are not piled one on top of another.
00:30				P	Changing course from 072° to 040°. The bottom is less irregular. The average pillow is about 5 ft in diameter.
00:33			36	P	Picture 36 in the pillow field as above.
00:43	3275	320		P	Finished roll 1, loaded roll 2 in the port hand-held camera. Glass sponges are now much more common on pillows, particularly along the edges of the pillows.
00:48	3280	320	1-5	P	Continuing in the pillow field, sponges and anemones are common. Pictures 1-5 are of this pillow area. The topography is smoother than before but pillows continue to be sediment dusted.
00:51	3280		6-9	P	Stopped on the top of a hill in a group of pillows waiting for a position fix. Glass sponges, light purple in color and about 8 in. in height are well developed and abundant along the sides of pillows. Pictures taken of the sponges as well as of broken pillows at the bottom of a group of intact pillows.
00:53	3280			S	Stopped on the bottom waiting for XY information. We are on a mound or hill of pillow lavas. Individual pillows are very large, up to 2 m in longest dimension, quite bulbous and humpbacked. There is a moderate amount of sediment in the interstices between pillows. Tops of pillows are

					"dusted" with sediment. There are a large number of white sponges on pillow surfaces, also brittle stars and starfish. No signs of hydrothermal activity at this location.
00:57	3280	345		P	Still in pillow lava field on the edge of an escarpment 10-20 ft in height. As before the pillows have a light dusting of sediment, range from 5-8 ft in diameter and are covered with purple sponges.
01:01				P	We are waiting near the edge of the pillow lava field for a surface position.
01:02			10,11	P	Took pictures 10 to 11 on roll 2 of the areas of sediment between the pillows including sponges and brittle stars. After getting a position we sail out of the pillow field heading to [Way] Point Lima, cruising over an area of rough and broken pillows.
01:11	3281			P	Small gullies between areas of pillows and sediment pockets. Many pillows are exfoliating and broken. The average pillow diameter is about 5 ft. The pillows are both round and oblong in shape. Several scarps are present about 10 ft in height. These are probably fault scarps. As before there are small sediment ponds between the pillows and abundant sponges.
01:11	3281			S	We are proceeding on course 240° toward Point L, range 400 m.
01:12	3283			S	On course toward Point L.
01:16		240	12-16	P	Coming into an area of larger pillows. Tongues of lava are present. The bottom has apparent flow structures. The pillows are not as well defined, the bottom is less irregular. The pillows may be overlaying sheet flows. Picture 12 on roll 2 was taken at 1/60 sec. and *f* 4.5.
01:18			17-23	P	Bottom is now covered in sheet flows. This is a transition from a predominantly pillow basalt bottom. The sheet flows appear to have flow structures running in two directions, the first approximately the same direction as the sub's track (west), the other

					running off to the port side (south). Broken pillows are scattered over the flows.
01:18:54	3275	252		E	Lobate flow, dark.
01:20:31	3273	269		E	Pillows.
01:23:31	3270	257		E	Striated pillows 0.5 to 1 m.
01:25			24-25	P	Pictures 24 and 25 (roll 2) are of basaltic outcrops and pillows which are quite irregular and appear to be very fresh.
01:28		304		P	Pillow-covered bottom.
01:30				P	Large pillows, broken pillows, hollowed pillows, exfoliation of pillows, generally irregular terrain, pillows up to 8 ft in diameter.
01:32			26-33	P	Transition to a flatter area, well-formed pillows are much less common, topographic relief is limited to several feet. Basaltic debris is scattered about. A number of solitary corals are present. Proceeding to Point Lima.
01:35	3267		34-36	P	Contact with sediment. The contact is quite sharp. Sub is travelling upslope. There are no pillows visible. A number of bivalves are visible. Picture 34 is the sediment with a bivalve. Topograghy drops off to the port side with a number of different holothurians present.
01:35:28	3261	281		E	Sediment-covered bottom, dark.
01:43:53	3264	226		E	Sediment-covered slope.
01:47	3264	298	1-3	P	Changing film to roll 3. Have reached Point Lima, pictures 1-3 of sediment-covered area.
01:50			4-10	P	Flat bioturbated bottom, holothurian marks and mounds. Proceeding to Point Alpha. Headed downslope. There are small pieces of basalt on the slope. Roll 3, picture 4 is of the general sediment cover. Topography drops down to the port side. Pictures 7-10 were shot going down the slope. The slope is strewn with small pieces of rubble and basaltic fragments.
01:50	3264			S	We have moved west from the pillow lavas onto sediment. The transition or "contact" was very abrupt and intersects the basalt at a steep angle. The basaltic pillows near the

					contact may have been more broken than previously seen. We have moved onto the top of the sediment hill which should be near Point Lima, waiting for XY coordinates. When we leave here our course will be NW toward Way Point A on the east side of Curly [ed. note: affectionate term for Central Hill]. The sediment here is soft ooze. We passed over blocks of broken sediment poking up through the loose sediment blanket. I see holothurians as well as pebbles and small chips of more indurated sediment on the crest and upper slope of this hill.
01:52				P	Transition from sediment-covered basalt to pillows overlaying basaltic flows. These pillows appear even fresher than the earlier ones, they also have less sediment dusting. There are lobate sheet flows as well as broad pillows.
01:55:50	3272	310		E	Large pillow.
01:57		313	11-14	P	Pillow-covered area. Pillows vary from small well-defined pillows to lobate flows. Many pillows have broken and exfoliated surfaces. Picture 14 is a rat-tail fish which has come into view on the port side.
02:00				P	Bottom is 10 ft below sub. The bottom is a mixture of pillows, sheet flows, and debris.
02:03:11	3284	280		E	Sediment-covered sheet flow.
02:04	3284	289	15-20	P	Contact with sheet flows. The sheet flows show relatively fresh surfaces with light sediment dusting and abundant fracturing. Picture 17 (roll 3) shot of the sheet flows in a gully.
02:04:57	3285	309		E	Folded sheet flow, partially sediment covered.
02:05:45	3344	319		E	Glassy folded sheet flow with sediment cover.
02:10			21,22	P	Proceeding to Point Alpha [nautical term for 'A'] over a hard bottom.
02:14				P	Transition back into a predominantly pillow covered bottom. Fresh faces are visible on many of the pillows. Sediment is ponded in the areas between the pillows.

02:14:47	3286	298		E	Pillows.
02:21:19	3283	307		E	Sediment-covered slope.
02:22		295		P	Proceeding toward the target slightly off the bottom.
02:23		326	23-26	P	Bottom is sediment covered with a few fragments of basaltic debris. Coming up the side of a hill. Abundant holothurian tracks.
02:25	3278	326	27,28	P	Coming up on sediment-covered ridge running parallel to the sub's heading. Area is uniformly sediment-covered with abundant tracks and burrows visible in the sediment. Sub is proceeding up slope to Point Alpha.
02:26			29,30	P	Sediment-covered terrain, several large gullies. Took picture 29 of gully. Sediment is light brown in color and very fine grained. Holothurians and brittle stars are present on the bottom. Sub is proceeding up hill toward the target.
02:28			31,32	P	Series of gullies (on the order of 10-20 ft deep) in a sediment covered terrain.
02:29				P	Bioturbated bottom sediment. Bottom drops off 30 degrees to the port side in a gully.
02:31	3260	328	33,34	P	Proceeding toward Alpha in sediment-covered terrain. Small outcrops of whitish-gray rock (indurated sediment?) cropping out into the sediment on the edge of the sediment hill.
02:31:05	3260	332		E	Brasingid on steep sediment slope.
02:34			35,36	P	Cross skid marks in sediment (probably previous sub track). Took picture 35 on roll 3 of this general sediment area. Proceeding up slope. The general bottom topography is getting hillier, more relief, more mounds in the sediment and gullies. In places the sediment is clearly indurated and outcrops.
02:34:58	3255	301		E	Sub? Dredge? Track in sediment.
02:38				S	We received instructions to terminate the dive owing to rapidly worsening weather conditions.
02:40				S	Ascent weights dropped, dive terminated. Ascending at 100 ft/min. Our total time on the bottom was 2:47.
02:41				P	Terminating dive because of rapidly worsening weather on the surface.

04:30	S	On the surface, 10 ft seas as we go a bob-bob-bobbin' along.
05:00	S	Swing lo, sweet chariot. We land on deck several times, and just in time for midrats.

DIVE 765-Observations of a Starboard Observer

The sky was a gunmetal gray and a bone-chilling autumnal wind whipped port to starboard across the FADOSS deck. The MV [DSVSS] *Laney Chouest* lurched through a heavy sea that reminded some crewmembers of a bad laundromat. The DSV *Sea Cliff* looking proud and poised like a great white narwhal, waited in the unusually quiet hangar for the inevitable return to the sea. Finally, the predive preparations complete, the youthful yet dynamic lieutenant commander issued his thoughtful proclamation: "It is time to dive." So began DSV *Sea Cliff* dive 765.

Once inside the titanium ball, the occupants joined hands for a short chant, selected a recent tape by the Miami Sound Machine for the proper ambience, and settled back for the 90 minute journey to the bottom. Few words were spoken by the pensive crew; well prepped by agonizing hours of study and a lengthy written exam, the location of each toggle switch and LED was forever etched in remote but accessible recesses of their minds. The pilot, also youthful but with considerable experience aboard the nuclear-driven (and much larger) cousins of DSV *Sea Cliff*, expertly maneuvered the proud and poised vehicle into position, guided by occasional static-laden communiques from the surface.

Now at the sea floor, where no man had ever gone (so to speak) before, the intrepid crew gazed in awe at the dramatic seascape. It was immediately obvious that the rocks were of volcanic origin, spewed onto the ocean floor from a subjacent magma chamber where swift reaction with the icy cold seawater (1.47° C) caused the lava to billow up into large pillowlike forms, reminding one of the passengers of the blubbery sea lions lying on the beach at Ano Nuevo State Park. They gazed at a plain of bulbous pillows, many the size of bathtubs; some of these lava flows were drawn out to resemble large recumbent Polish sausages. The larger pillows bore a peculiar striping across their tops resembling the welt patterns on the backs of Roman slaves documented in the movie Ben Hur. Sediment, much of it derived from the ubiquitous mucous settling down through the water column, seemed to fill the voids between pillows and sausages. Bits and pieces of the unconsolidated ooze swirled in a murky yellow maelstrom around the proud and poised craft.

After a rather sharp reminder from the surface to secure (Navy talk for "shut the [redacted] thing off") the powerful stern propulsion unit, the craft began a course toward the southwest in search of the legendary Point Lima. The craft paused for a surface communication above a low hill covered by a tortured maze of bloated pillows and sausages. Only a few permanent residents seemed to accept the creature comforts of this alien world. Attached to rocky surfaces were a sparse assemblage of brittle stars, starfish, sea pens, and sponges, the latter looking like errant golf

balls sliced into the rocky rough by some Neptunian hacker. At one point, a sluggish and, frankly, quite ugly rat-tail, seemingly more eel than fish, moved across the starboard viewport, apparently totally anesthetized by the extreme cold and pressure of its environment.

After the location of the vehicle was determined by the youthful navigation team working in harmony more than two miles above, the pilot continued a course toward Point Lima. Suddenly, the vehicle passed above a much steeper slope covered by a blanket of unconsolidated sediment. The somewhat rubbly apron of sediment appeared to be deposited onto the underlying lavas in much the same way that the waste rock from large open-pit mines in Arizona and Nevada is dumped onto the surrounding countryside. The sediment slope was perhaps steeper near the top, but no solid rocks that might reveal the origin of this feature were seen by the eager observers. At a height above the volcanic sea floor of perhaps 8 to 10 fathoms, the craft came to rest on the relatively flat top of a sediment hill. Clusters of small rock fragments, probably composed of indurated sediment, appeared on the otherwise smooth surface like a bad case of acne. Large brown holothurians or sea slugs, about which little positive can be said, seemed to be marching in some random pattern on the sediment-covered plain so clearly visible through the starboard viewport.

Buoyed by news from the surface that the submarine was a mere 80 meters from Point Lima and deducing that the launch target also occupies a point atop the sediment hill, the crew pushed on toward Way Point A, a previously discovered hydrothermal wonderland on the eastern slope of the hill known as Curly [Central Hill] no Babylon, but still the cause of considerable anticipation. Gliding with great grace and side pod power toward Curly, the vehicle descended down the western slope of the sediment hill, crossed another abrupt contact, and started out across a low field of pillow and sausage lava. These lavas appeared much the same as those encountered east of the sediment hill, but at one point an open fissure large enough to conceal a mermaid was observed. The gash had a generally north-south trend and appeared at first glance to be the handywork of some giant submarine surgeon who, in a fit of jealous rage (over the mermaid?), had sliced through the flow tops with his scalpel. Perhaps more significant was the observation through the forward port of deformed sheet flows with glassy surfaces, highly reflective in the greenish glow of the sponson lights. The crew fell silent during the video taping of this significant feature.

Following a rather lengthy traverse through the lavas, the vehicle became slightly elevated and then descended again onto a steep sediment-covered slope-the eastern slope of the formidable Curly. Alas, the actual contact between lava and sediment had slipped by unobserved, but the drive upslope toward Alpha and the coveted sulfide had begun. Now the

terrain induced a bit of deja vu for the starboard observer, that is, it seemed to unfold in a series of steps similar to that experienced during DSV *Alvin* Dive 2033 on the north side of Curly. In this configuration, a steep slope would lead to a terrace or backtilted surface that would abut against another steep slope and so on. On Dive 2033, sulfide was encountered on the steps near a depth of 3240 meters. Sulfide had already been reported at Way Point A just a few tens of meters above the current location of the vehicle. Tension and carbon dioxide levels began to rise in the sphere in anticipation of sulfides, tube worms, and hot vents.

But wait now. What was that crackling communique on the UQC? Then again, a short minute later, but clearer the second time, "Bad weather topside. The dive must be terminated immediately." The reality of the situation spread through the titanium ball like a cold-wave in Manitoba as ascent weights and selective weights were jettisoned and side pods were enabled to speed the ascent to the surface. The yellow-green vista of the sea floor disappeared in seconds, replaced by the inky darkness of the water column. "So close but yet so far" was one of several trite but still appropriate expressions muttered in despair by the crestfallen trio. Another phrase, though, seemed to echo softly again and again through the ball like the hoot of an owl in a narrow canyon: "[redacted] happens." Silently, the proud and poised DSV *Sea Cliff* continued its ascent to the surface and another day.

DSV *SEA CLIFF* PRE-DIVE PROFILE
C1-88-NC

Dive # 766 JD/Date 250 / SEPT 6

Port Observer : Zierenberg
Equip. Operator : Karlin

Pilot: Popovich
USGS SC: Holmes
(Surface controller)

Dive Objective(s):

Study area for this dive is the southeastern flank of 'Curly' [Central Hill], beginning at the vent field which was the planned termination point for Dive 765. This is the location where sulfides and bacterial mats were observed during DVS *Alvin* Dive 2042. Way Point A is the general area of extensive tube worm communities; the actual extent of this sulfide/vent field has not yet been determined. Way Point B is a point on the southwestern flank of 'Curly'; that is near the suspected location of a topographic irregularity that may be the site of additional hydrothermal activity. The primary objective of the dive is to begin mapping the extent of the sulfide deposit between [WP] L and A, and will include collection of geological and biological samples. Tube worms and clams were encountered here during the DSV *Alvin* dives, but there was only limited sampling of the clams. A secondary objective is to conduct a survey transect to the west toward Way Point B across the southern flank of 'Curly', mapping the major geologic and topographic features and collecting samples of sediment and mudstone as opportunities arise. Tracking (and communications) has continued to be a problem. A possible contributing factor is colder than normal bottom water that, in effect, would create a deep pyncnocline that could influence sound travel paths. During descent, water temperatures will be logged (at intervals to be decided) in order to identify any anomalous thermal structure.

Launch Point: X= 59261
(WP L) Y= 54964

Latitude 40°59.77
Longitude 127°29.32

Way Points: A) X= 59255
Y= 54875

B) X= 58750
Y= 54875

DIVE TRANSCRIPT

Location: NESCA Central Hill
Port observer: Zierenberg
Starboard observer: Karlin

Julian Day: 250
Date: 09/06/88
Pilot: Popovich

KEY: P = Port observer, S = Starboard observer, E = External photograph,
Photo # = Hand-held photograph number, description in appendix 2.

Time (GMT)	Depth (m)	Hdg.	Photo #	Obs.	Comments
17:19:11	0000	121		E	Typical task force activity.
20:33	3251			S	Bottom in view; landing on crest of sediment hill.
20:36	3247	200		S	Underway to Launch [Way] Point 'Lima' [nautical term for 'L'] using side pods to allow surface tracking; range 400 m; bearing 200°.
20:37	3251	200		S	Lost bottom while transiting to [Way Point] 'Lima'.
20:38		200		S	Commence using stern shrouds.
20:40		200		S	Sighted bottom.
20:41		200		S	Lost bottom; fathometer shows that we are suddenly ~10 m over the deck (possibly a graben?).
20:45		200		S	Mudstone talus covered by a thin veneer of loose tan sediment; steep slope on starboard side sloping starboard to port.
20:46	3257	189		S	Clam shell on port side; bottom is hummocky relief 3-5 m.
20:47				S	Turned on Benthos camera with 16 sec repeat.
20:47:31	3254	221		E	Sediment-covered slope.
20:48	3249			P	Coming up to the top of a small hill, hummocky terrain, there is some outcropping mudstone, some mudstone talus, one dead bivalve shell on the surface, not much colonization here, very little biota here actually, one or two holothurians, and one or two sea pens.
20:48	3249			S	On crest of hill; mudstone dusted with sediment; numerous mounds ~10-20 cm high by 20-40 cm diameter; little obvious colonization on rocks; numerous holothurians, crinoids, and brittle stars.

20:49	3250	200	P	Transiting a hummocky bottom with irregular changes in slope, very little colonization, one crinoid, one holothurian, a stalked tunicate or a stalked animal with a tunicate on it, and one brittle star.
20:50	3246	200	S	Hilly bottom - wavelength ~20-30 m, height 5-10 m.
20:51	3240	210	P	I'm having trouble with my tape recorder. I put the tape in backwards and it has reversed several times, probably recording over everything previously said. Trying to recap what we've done so far. We landed in about 3250 m of water, went over a small channel and dropped down to about 3258 m. We have come up again out of that and are transiting to target L, the launch point. We are over a very hummocky sediment-covered bottom. Very few organisms, rather sparse colonization, just the normal bottom fauna with the exception of one dead bivalve shell. We have continued to transit basically to the south, to intersect a sulfide deposit. At the bottom of some of the channels there was some mudstone talus, talus blocks 10-15 cm on a side, and there was some subcropping mudstone.
20:53	3241	204		
20:55		255	P	Off bottom by several meters.
20:55	3245	200	S	Steep slope; lost bottom, seems to be strong current; sub. pushed off course to 255°; pilot turned back to 200°
20:57	3245	211	P	Coming to 200°, over a very irregular bottom with channels that drop down 4-5 m and then come back up to roughly the same elevation. This one has a side channel cut into it. No clear signs of mass wasting, but it looks like an erosional channel cut into the side of it. It runs nearly perpendicular to the main channel. The main channel is nearly north-south, the side channel is nearly east-west. Very sparse colonization here, an anomalously sparse amount of fauna.

20:58	3243	200	P	Over a fairly smooth portion of the bottom right now. Flat and sediment covered, anomalous sparse biota.
20:58	3239	200	S	Regained bottom; hummocky topography; hills 3-5 m high; relatively little biota; clam shell seen on port side; Galatheids & orange shrimp also noted.
20:59	3244		P	Coming up another sediment mound, coming up a slight slope, sloping up a bit to port, there are a couple of galatheids. There is a field of clam shells out here, on mudstone talus, it looks like they have slumped down, the field is actually only a couple of them.
21:00	3239	200	P	Still coming up a slight slope, but over a sediment-covered bottom. I saw a very nice slump that had a couple of clam shells on top of it, I think they were slumped down the hill.
21:01	3239	200	P	Just passed over a rat-tail fish, I saw another small dead bivalve shell. I am seeing random shell[s] here and there. Still very sparse colonization. There are some bioturbation mounds, but there is not much on the bottom itself.
21:01	3239	200	S	Rat-tail swimming over bivalve shell; bottom is hilly and sediment covered.
21:02	3241	200	P	There are several more clam shells now, a galatheid crab, I can see maybe half a dozen dead clam shells. Even more coming up, there is a furrowed track in the sediment, a recent track, there must be some live clams in the area.
21:02	3241	200	S	Several clam shells & crabs.
21:02:44	3240	209	E	Isolated dead clam shell.
21:03:43	3233		P	We are over massive sulfide, it is shingled, there is some bacterial mat, clams all over the place in the sediment. You're going to touch down here, Reid [Popovich]. We are on a pretty decent sulfide mound. The bottom is quite nicely shingled with sulfide. It is fairly old, but it still has some bacterial mat on it. There are a lot of white sponges on it. There are clams living towards the base of it. It is fairly weathered, I can see iron oxides

				on it. The bacterial mat part is pretty minimal, it is fairly old right here. There is a galatheid crab.
21:03:57	3234	174	E	Weathered massive sulfide.
21:04	3233	200	S	Large sulfide deposit observed; composed of ledges, chimneys, and mounds; no active venting seen; Outer rim of mounds appears to be barite; shingled sulfides at base of chimneys; possible bacterial mats; clam shells common.
21:04:59	3235	156	E	Altered sediment or hydrothermal crust next to sulfide deposit. Areas of bacteria and globs of black waxy hydrocarbon.
21:06			S	VCR tape #1 done [videotape]; replaced with tape 2.
21:07	3239		S	Drifted off mound and temporarily lost bottom; sub. backed off site by a few meters and descended to sediment-covered bottom. For next 5 minutes, we took ground/leak checks.
21:09	3238		P	We are sitting on bottom on a massive sulfide, we have just been given a range and bearing to [Way] Point L, which is also massive sulfide, of 047°, 93 m.
21:15	3239	142	P	We are going to move up to the base of this massive sulfide deposit and take some samples. We are right at the base here, I don't know what the extent is uphill. There were some clams at the base, we will try to take a sediment core around one of the clams. One picture taken.
21:15	3239		S	Lifted off bottom & started search for sulfide deposit.
21:17			S	Dusted bottom; from 21:17 to 21:21, pumped into SWVB [sea-water variable balast] and waited for dust to settle.
21:21			S	Sub has been turned by currents (Heading 111°). Sub returning to course 200° CCW [counter-clockwise]
21:22			S	Bottom dusted; still returning to course.
21:25	3238	095	P	We are going to come around to try to get out of our wake, and move down to try to sample the massive sulfide.

21:25			S	Off bottom, still turning; top of dust cloud visible.
21:30			S	Lost at sea; maneuvering in water column; CTFM [in sub. foward-looking hirpzintal scanning sonar system] put in operational mode.
21:32	3225		S	On course 210°; about 13 m off bottom; still trying to find the sulfide deposit.
21:34	3225	210	S	About 10 m off bottom driving forward - rat-tail visible.
21:38	3233		P	We have reacquired the bottom, there are several galatheid crabs. That's a good sign we might have some active venting, some dead clam shells in the sediment-covered bottom. We are moving back up towards the massive sulfide. There is a holothurian here, I don't see any live clams at the moment.
21:38	3233		S	On sediment-covered bottom; Galatheids; holothurians; dead clams seen.
	3234	213	P	
21:40	3231	103	P	We are still moving over a sediment-covered bottom with some clams and fairly abundant galatheids. Still trying to come back to the sulfide site.
21:40			S	On relatively flat bottom with small mounds–video put sideways for special effects.
21:41	3234		S	End of tape #2; tape #3 starts at 21:50.
21:42:12	3234	202	E	Sediment-covered bottom.
21:43	3233	200	P	Turning a bit to starboard from our heading of 200°. Starting to lose the clam shells, there are fewer galatheids and fewer clams here. Coming back to more normal bottom biota.
21:50			S	On top of sediment hill - dusted out; examining sonar for wall; sonar not operating well.
21:50:54	3235	225	E	Four-legged brasingid on sediment covered bottom.
21:55			S	Sonar target noted to starboard; ship turning right.
21:58	3235	290	P	We've just come over a sediment scarp down into a channel or a graben and we are heading for a CTFM reflector which looks like a scarp and is probably where the massive sulfide is.

				The sediment bottom is heavily bioturbated here and mounded. There is a brasingid, one holothurian, another brasingid and an anemone, but not much colonization here, pretty sparse. There is a recent burrow now with some white sediment around it, normal flat bottom.
21:58	3235	290	S	We may be in a graben(?) Bottom sighted – flat sediments with small mounds; Biology includes brasingids, holothurians, and crabs.
21:59	3233		P	Anyone watching the video from the starboard hand-held camera will see that we are flying the sub upside down, the bottom is going by over our heads. Now we are imaging both sides of the graben, I can see the graben on the CTFM.
21:59	3233		S	Changing course to 010°.
21:59:35	3232	332	E	Very reflective white mystery material.
22:00	3230	010	P	Over a flat sediment-covered bottom here, sloping up a bit to the port, not much bioturbation here.
22:00		010	S	From the sonar, we still appear to be in a graben trending 040°-050° true [compass reading]. Changing course 30° to starboard to maneuver to graben wall.
22:03	3227		P	Drops off deeply to port. We want to go down into that hole and I think we will find our sulfide deposit.
22:03	3327		S	Problem with CO_2; checked sensor; shifted to Battery B – still not working right.
22:04	3231	265	S	CTFM shows wall to starboard side; bottom in sight–sediment-covered.
22:05	3231	265	P	I can see a CTFM reflector, it looks like a scarp with a couple of bright spots on it, still off to the starboard a bit.
22:06	3235	261	S	On bottom, checking CO_2 sensor.
22:10	3235	260	P	On a smooth sediment-covered bottom. CTFM shows a scarp off to the starboard, almost parallel to our heading of 260°, and then another reflector dead of us which trends across our heading and is essentially north-south.
22:10			S	Maneuvering, nothing visible.

22:14	3231		S	Bottom sighted- flat sediment-covered with small mounds.
22:15	3231	330	P	Sediment-covered bottom moving slightly up a hill, normal flat bottom, no apparent colonization.
22:16	3229	340	P	Smooth sediment covered bottom.
22:17	3229	350	P	Just came down a 1 m drop.
22:18	3228	025	P	Sediment covered bottom, smooth, very little colonization.
22:18		025	S	Still maneuvering - using CTFM to locate wall.
22:19	3228	000	P	We've come over another 1 m drop, still over a smooth sediment-covered bottom.
22:20			S	Drove off scarp and lost bottom.
22:22	3226	080	S	Maneuvering - pilot getting very aggravated.
22:23			S	Control gave bearing (056°), range (335 m) to [Way] Point 'Lima'.
22:24	3224		P	Range and bearing to [WP] L, 056°, 330.
22:24			S	End of tape #3; replaced with tape #4.
22:25			S	Took Drager CO_2 sample which showed 1.2% CO_2.
22:28	3228	040	P	Smooth sediment-covered bottom sloping away to the front and to starboard, a holothurian, not much bioturbation, there is an orange shrimp here.
22:30	3230	080	P	Smooth sediment-covered bottom with a few small steps on it, some fish laying on the bottom, not much colonization, normal biota.
22:31	3228	025	S	Change course to 025° traveling along sedimented bottom to [Way] Point 'Lima'.
22:31:40	3228	045	P	
22:32	2332		S	Control recommended limiting bottom time to 2 hrs; sediment-covered bottom with rolling hills.
22:33	3232	065	P	Smooth sediment-covered bottom, a bit hummocky, some xenos, but not much in the way of animals.
22:34	3230	020	S	Control says to terminate by 00:30; not much life on bottom except brittle stars and holothurians.
22:34:30	3230	030	P	Hummocky sediment-covered bottom, about 1 m of relief on rolling hills, not much in the

					way of bottom fauna anywhere except some xenos and an occasional fish.
22:36	3232	060		P	Bottom as above.
22:36		060		S	Changed course [from 030°].
22:38	3235	060		P	Sediment-covered bottom, quite a bit of topography, normal biota.
22:39	3236	050		P	Bottom is about 2-3 m below me sloping away down to the starboard, fairly smooth, sediment covered, some holothurians, a purple anemone, but not much bottom fauna.
22:39	3256			S	Lost bottom.
22:40	3246	050		S	Recovered bottom - on steep slope that dips to starboard.
22:42	3246	050	3,4	P	Last picture was a close-up of xenos. On a steep slope which is dipping back behind us and to starboard. It is clearly a mass wasting slope, some tracks down it, some down-slope movement, but is old and is dusted with more recent sediment.
22:43			5	P	Last picture was a crinoid.
22:43:28	3243	034		E	Fresh bioturbation mound on sediment-covered slope.
22:44	3239	070		P	Still on sediment-covered bottom, occasional drop-offs in several directions, one to several meter drops. Just passed a dead bivalve.
22:44	3238			S	Irregular terrain - we keep losing and regaining bottom.
22:46	3238	040		P	Bottom as normal, several meters up now, just lost bottom.
22:47		079		S	Bottom sloping starboard to port.
22:48		090		S	Control gives [Way] Point 'Lima' at 70 m range, 160° bearing true.
22:48:30	3241			P	Off bottom on the port side, bottom on starboard is 3 m below. We are stopping to try to get a better fix.
22:49				S	CO_2 meter bad - all have headaches; swapping LiOH cannisters.
22:57				S	Decided special effects on starboard camera no longer needed - placed in upright position.
23:00				S	Finished cannister change.
23:03	3240	195	6	P	Swinging around to 165°, we are going to take a bearing of 165°, 70 m to target [WP] L. Last

					picture was a picture of a small blue fish. Over a hummocky sediment covered bottom.
23:03	3242	165		S	Leaving bottom to drive to [WP] 'Lima'.
23:04				S	End of tape #4. replaced with tape #5 starting at 23:10.
23:04:30	3239	175		P	Over a hummocky sediment-covered bottom.
23:06:30	3243	180		P	Fairly hummocky sediment-covered bottom, quite a bit of relief, some holothurians on it.
23:07	3242	165		P	There are abundant dead bivalves on a flat sediment-covered bottom. There are some galatheids as well. OK, I've got sulfide out to the port side out in front, just set down right here.
23:09	3242	085	7-16	P	There is a fairly small outcrop that I can see. We are right at the sediment-sulfide contact. Very slabby here, up the slope a bit there are some chimneys with some asteroids on them. Fairly highly weathered, I can see orange iron oxide. Just as we came into this site, I saw a field of dead bivalves. I can still see several dead clams and some galatheids and possibly what are either a smaller type of clam or possibly a conical barnacle shell. I doubt that is what it is, but if it is we will certainly try to sample it.
23:09:12	3242	092		E	Sediment disturbed by sub near sulfide deposit.
23:12				S	Landed near edge of small sulfide field composed of mounds and small chimneys <1m high. Started sampling.
23:14	3242			S	Taking core sample using middle push core from port side basket. (Corer has rubber core catcher.) Group of dead clams and live galatheids to port; Control gives bearing/range to [WP] 'Lima' as 010°, 70 m. Depth gauge acting funky with manipulators on.
23:16		055		P	Depth indicator says 3295 m which is in error. Last range and bearing from the surface was 010° at 70 m to target L. We are on a small sulfide deposit. We have just taken the first sediment core sample. First core is push core 1, which is the middle of

				the three push cores on the port side of the basket.
23:16:32		053	E	Sediment push core in arm.
23:22	3245		P	Core 1 placed in the basket, attempting to sample rock.
23:22			S	Core shaken up when put into basket. Commenced trying to get a sample of one of the sulfide chimneys. Control wants us to finish up ASAP as weather is worsening topside.
23:27:40	3244	067	E	Hydrothermal crust in sediment.
23:29:34	3244	071	E	Barite chimney before sampling.
23:30			S	Heroic efforts by pilot result in obtaining whole sulfide chimney.
23:36	3243		P	Still sitting at the same place, I can see some chimneys now. When we came up the sediment sulfide contact was very ledge-like with the sediment under the sulfides almost eroded back, no sediment under the edge of the sulfide, almost little caves underneath the sulfide. There are several chimney-like projections 20-30 cm high. The deposit looks fairly weathered, there are several galatheids on it, one asteroid. One of the galatheids has his pincers on an asteroid, but he doesn't seem to be doing too much with it, but they have been sitting there together for some time. They should show up in some of the hand held photos. I don't know the extent of this deposit, I'll try to get a look at it as we drive off and drop weights. There was a field of dead bivalve shells and some galatheids in the sediment in the immediate area surrounding the deposit. Picture of an orange shrimp on the small sulfide chimney.
23:32:17	3244	065	E	Barite chimney, note bacterial mat beneath crust and blobs of black hydrocarbon (?) below chimney.
23:40			S	Immediately after securing samples with manipulator, dropped ascent weights and terminated dive.
23:41			S	End of video tape #5.
23:44:30	3243	061	E	Sampling chimney.

23:48	P	All weights away.
	P	We have terminated the dive. A brief summary, we landed in about 3250 m. I had several problems with my tape recorder and lost most of the depth and heading information for the start of the dive. We drove towards our launch target, dropped into a channel, dropped down to about 3239 m and came to a fairly large, impressive massive sulfide deposit. There was a field of bivalves at the bottom, mostly dead but with some recent tracks, there may have been some live clams, several galatheids. We moved away from that deposit without sampling, and then headed for launch target L. We found a small sulfide deposit after crossing a channeled and hummocky sediment-covered terrain with a lot of relief from meters to tens of meters. We sampled a small deposit with shingled sulfide at the base which looked very much like the first deposit seen on the dive, which had shingled sulfide over sediment at the base. The sediment nearest the deposit had some dead clams and abundant galatheid crabs. The deposit itself was old and weathered. There were several 20-40 centimeter-high chimney projections, lots of iron oxide; some pyrrhotite was visible, possibly some of the chimneys were barite, but I couldn't see them well enough to determine that.
01:45	P	On the surface.
	P	Best location for samples from navigation X-59219, Y-54903.

DIVE SUMMARY 766-Port Observer

Dive 766 landed in about 3250 m and drove 200° towards our launch target, the large massive sulfide deposit discovered on DSV *Alvin* dive 2042.

The bottom in this area was very irregular with hummocky sediment hills up to a few meters high and channels and (or) grabens 5-10 m deep. One set of structures ran approximately N-S, but other steep walls trend obliquely to these. The bottom was current swept, poorly colonized, and had many large bioturbation mounds. After descending a few meters down into one of the depressions to about 3239 m, we encountered a fairly large, impressive massive sulfide deposit. There was a field of bivalves shells in the sediment at the base of the sulfide deposit. Most were dead, but there were some recent tracks and several live galatheids. We moved away from that deposit without sampling, and were unable to reoccupy the site, so we headed for launch target L. We found a small sulfide deposit after crossing a channeled and hummocky sediment-covered terrain with alot of relief, from meters to tens of meters. At one point, a N-S trending graben could be seen as linear reflectors on the CTFM, and a hard reflector in the direction and at the distance of the launch target location provided by surface control was imaged extending out from the west wall. On the way to this target we encountered a small sulfide deposit which we stopped to sample due to the limited remaining bottom time. The deposit had ledges of sulfide at the base, similar to the first deposit seen on the dive. The ledges of layered sulfide locally overhung sediment, which had probably been scoured from below the base of the sulfide. The sediment nearest the deposit had some dead clams and abundant galatheid crabs. A sediment core was taken about 1.5 m from the base of the deposit, apparently in an area with no bivalve shells. The deposit itself was old and locally weathered to iron oxide. There were several 20-40 centimeter-high chimney projections, one of which was sampled. This sample is a sulfide-rich barite chimney with an outer layer of barite with no sulfide (due to leaching) and a thin manganese-oxide coating. The dive was terminated at 23:48 due to deteriorating surface weather conditions; we surfaced at 01:45.

HAND-HELD CAMERA PHOTO LOG

Location: NESCA South West Hill
Port observer: Zierenberg
Starboard observer: Boudrias

Julian Day: 245
Date: 09/01/88
Pilot: Popovich

Time (GMT)	Depth (m)	Photo. #	Description
06:01	3282	9	Very dark picture of xenos.
		10	Out of focus picture of spiral sea pen.
06:24	3272	11	Dark picture of tree branch on bottom with white animals.
06:24	3272	12	Dark picture of tree branch on bottom with white animals.
06:30	3291	13	Venus flytrap anemone on a stalked animal.
06:31		14	Two Venus flytrap anemones on a stalked animal. [sea pen ?; see transcript]
06:31		15	Dark picture of stalked crinoids.
		16	Xenos on smooth sediment-covered bottom.
		17	Outcropping sulfide(?), lithified mudstone(?), colonized by anemones and sea pens.
		18	Large blocks of siltstone talus with original bedding planes preserved, some sea pens.
06:39	3303	19	Large robust starfish on sediment slope, also sea pen and white anemone.
06:43	3284	20	Cuttlefish (?) next to a mudstone talus block; also shown are a brisingid and a purple holothurian.
06:43	3284	21	Cuttlefish(?) next to a mudstone talus block; also shown are a brisingid and a purple holothurian.
		22	Mudstone or siltstone talus blocks.
06:45		23	White mudstone recently exposed and deposited by dredge; sea pens, brisingid, and spiral sea pen.
		24	Very dark picture of massive sulfide.
		25	Very dark picture of massive sulfide.
07:02		26	Stalked wine-goblet sponge, crinoid and mudstone talus in the foreground.
		27	Small fish.
07:38	3246	28	White holothurian in the water column.

08:58	3175	29	Dark picture of rat-tail fish.
09:00	3176	30	Dark picture of ripple marks near top of South West Hill.
		31	Holothurian in water column.
09:15	3170	32	Smooth sediment covered bottom at top of South West Hill, *f*-5.6.
09:15	3170	33	As above, *f*-3.5
09:15	3170	34	As above, *f*-8
09:15	3170	35	As above, *f*-4.5

HAND HELD CAMERA PHOTO LOG

Location: NESCA Central Hill
Port observer: Holmes
Starboard observer: Okita

Julian Day: 247-248
Date: 09/03/88
Pilot: Craver

All Pictures 1/60 sec *f* 4.5

Time (GMT)	Depth (m)	Photo #	Description
			Roll 1 of 2.
1840	3237	2	Camera not firing with strobe.
1842	3227	3	Sediment-covered bottom at location of touch-down. White (Spectrunculid?) fish at right. Underexposed.
1844	3234	4	Bottom covered by grayish-brown sediment. Small bumps are 3-5 cm high and about 15 cm in diameter. Some coarser-looking material that may be fecal casts.
1846	3234	5	Isolated sulfide chimneys and slabby boulders. Chimney about 60 cm high. Darker base presents a ropy texture. Appearance of broken surfaces suggests that barite(?) may be a significant component. Sea anemone and sea urchins in left center. Galatheid crab's legs can be seen extending from chimney throat.
1847	3234	6	Same as 5 above. Zoom shot, slightly out of focus.
1848	3233	7	Accidental triggering of camera.
1849	3227	8	Very massive and lightly sedimented sulfide 'pavement' on slope of about 40°. A white starfish and some small globular sponges can be seen. Underexposed.
1850	3222	9	Camera misfire.
1852	3212	10	Camera misfire
1854	3204	11	Steep flank of sulfide mound showing blocky massive outcrop. Some yellowish brown sediment in places (left foreground). Colonized by the white globular sponges. Slightly underexposed.
1900		12	Grayish-brown sediment-covered bottom with small darker clumps of what may be some sort of organic debris (fecal material?) or

			Xenophyophorian. Uppermost layer very fluffy. Small whitish bumps may be burrow casts or tips of mudstone blocks
1901	3196	13	Same general area as previous shot. Starfish in right center and anemone at lower left.
1901	3196	14	Sea pens on sediment-covered bottom. Subdued ridge trending about 030° crossing from lower right to upper left.
1901	3193	15	Sediment bottom. Galatheid crab in center, sea anemone upper right. Underexposed.
1903	3194	16	Low rounded hill near NW side of 'Curly' [Central Hill] summit. Steep drop-off in far background. Trending from right to left across the summit of the low hill is an apparent color change in the sediment from grayish brown to gray. May be lighting effect.
1918	3204	17	Northwest edge of summit of 'Curly'. Slope is about 40°. Small usually whitish bumps a few cm high and about 10-15 cm in diameter.
1918	3200	18	Starfish and galatheid crab on summit of 'Curly'. Small bumps and irregularities in "normal" sediment bottom appear to be a different texture (coarser) than surface layer.
1920	3200	19	A 40°-45° slope near edge of 'Curly' summit. The bottom shows small linear mounds suggestive of current ripples trending about 320°. Underexposed.
1922		20	Spectrunculid(?) fish over sediment bottom, NW flank of 'Curly'.
1924	3199	21	Starfish, anemone, holothurians on sediment bottom. Small scattered clumps of dark brown organic(?) debris. White fish in background.
1925	3195	22	Sinuous gouge mark in bottom near NW summit of 'Curly'. About 10-15 cm wide and 5-10 m long. May be camera track or submersible (DSV *Alvin*?) skid mark.
1925	3195	23	Better shot of gouge mark.
1931	3216	24	Sulfide blocks and tube worms on 30° slope. Old looking deposits, heavily sedimented.
1952	3221	25	Tube worms, possibly dead, on side of massive sulfide dome near Benchmarks 6X and 0. Underexposed

1953	3220	26	More tube worms on 30°-40° slope below Benchmarks 6X and 0. Sulfides present a 'pavement-like' appearance. Underexposed.
2008	3220	27	Tube worms and sulfides on slope below Benchmarks 6X and 0. Chimney fragment in foreground. Dark, coarse-grained sediment may be derived from the sulfide chimneys upslope.
2015	3222	28	Tube worms on rough sulfide slope, about 30°. Overexposed.
2015		29	Massive blocky sulfide slope near Benchmarks 6X and 0. Colonized by white globular sponges. Yellowish-brown coarse-grained sediment in pockets between sulfide blocks.
2015		30	Same slope as previous picture, slightly better exposure. Small anemones in lower left.
2016		31	"Venus-flytrap" anemone and white globular sponges(?) on steep sulfide slope. Sulfides below and to right of central anemone present a ropy appearance.
2016		32	Same outcrop as previous picture. Large crevice in sulfide slope colonized by anemone, crab, and the white globular sponges. Chimney(?) fragments upper and lower left.
2017	3217	33	Tube worm colonies, possibly dead, covering the sides of massive sulfide mound near Benchmarks 6X and 0. Stump-like growth in background.
2021	3216	34	Sulfide 'cairn' with Venus-flytrap anemone; tube worms above and below.
2037	3220	35	Sulfide stump in foreground, with large pile of sulfide talus in background. The surface of the stump is very knobby and 'shiny', unlike the rough and weathered sulfides photographed previously.
2038	3220	36	Edge of sulfide slab colonized by anemone and a crab in the center foreground. Tube worms on both upper and lower surfaces of the slab. Not too healthy looking.
2043	3267	36a	Benchmark 6X atop a large mound of massive sulfide. Colonized by tube worms, anemones, and small white sponges(?). The whitish patches on the sulfide could be either anhydrite or bacterial mat. Depth may be in error, 47 m too deep.

ROLL 2 0F 2

2048	3219	0a	Massive sulfides (old) and tube worms (tired) about 1 m from Benchmark 6X. Small anemones, crabs, and globular sponges. Some of the sulfide blocks (foreground) are coated with a white encrustation. Coarse-grained sediment, possibly derived from the sulfides, fill crevices between blocks.
2109	3217	1a	Benchmark 6X. Underexposed.
2111	3217	2a	Benchmark 0. The effects (shimmering) of the hot water seeping from the sulfide mound are easily seen. Healthy tube worms with extended red heads. Gelatinous growth on sides and bottom of the benchmark float may be bacteria, silica, or some type of sulfate. Stumpy chimney orifice at lower right.
2114	3263	3a	Small healthy tube worm colony about 3 m from Benchmark 0. Active vent orifice directly in front of colony has coated part of the worm tubes with anhydrite(?).
2116	3239	4a	Underexposed.
2116	3239	5a	Underexposed.
2118	3232	6a	Benchmark 6X. Underexposed.
2118	3232	7a	Benchmark 0. White patches mark sites of active venting. Underexposed.
2120		8a	Accidental shot inside the ball.
2121	3233	9a	Underexposed.
2121	3233	10a	Active vents below Benchmark 0 marked by patches of anhydrite(?). Underexposed.
2121	3233	11a	Same as above. Benchmark 0 in background.
2129		12a	Massive sulfide slope, mostly featureless, near Benchmark 0. Underexposed.
2129		13a	Same as above.
2133	3233	14a	Massive coarse-grained sulfide slope of the large mound on which Benchmarks 6X and 0 are sited. Colonized by crabs, anemones, small sponges, and starfish. Yellowish sediment in surface irregularities.
2135	3230	15a	Tube worm colony in an area of diffuse active venting on a large sulfide mound about 50 m SSE of Benchmark 0.
2135	3230	16a	Same as above; close-up view.

2140	3266	17a	Live tube worm colonies near the summit of the actively venting mound where Benchmark Orange/Yellow was deployed 50 m SSE of Benchmark 0. Slightly overexposed.
2140	3266	18a	Ditto.
2140	3266	19a	Ditto. Nice healthy red headed worms in the foreground being bathed in vent waters.
2140	3266	20a	Ditto.
2140	3266	21a	Ditto.

HAND-HELD CAMERA PHOTO LOG

Location: NESCA
Port observer: Wiltshire
Starboard observer: Koski

Julian Day: 248
Date: 09/04/88
Pilot: Poirier

Time (GMT)	Depth (m)	Photo #	Description
			roll 1
00:05	3247	7	Light-brown colored sediment with various holothurian tracks and mounds.
00:06	3250	9-12	Dark pictures of large fresh pillow basalts showing little sediment dusting.
00:15	3255	18-19	Large mound of coalesced pillows.
00:19	3255	22	Fresh pillows with attached brittle star.
00:20	3260	25	Large pillows showing bread crust texture.
00:24	3261	26	Bamboo coral on a pillow showing exfoliation.
00:24	3261	27	Brittle star on lightly sedimented surface of pillow.
00:26	3266	28	Large pillow about 8 ft in diameter.
00:27	3266	30	Large pillow showing bread crust-like structure.
		31	Bamboo coral growing on an isolated pillow.
Roll 2			
00:48	3280	5	Pillow lava showing flow features. Sponges along the edges.
00:51	3280	6	Sediment pocket between areas of pillows. Sponges on the sides of the pillows are about 8 in. in height .
		7	Area of pillows superimposed one on another. The pillows vary in size from 3 to 8 ft in diameter.
00:53	3280	8	Sea-cucumber floating by the port side.
		9	Toothpaste type extrusion in the pillows. There is a light dusting of sediment over the pillows.
00:57	3280	10	Sediment pocket amid pillows, note the large number of sponges along the sides of the pillows.
01:02	3280	11	Pillows of various sizes abutting against each other.
01:16	3280	12,13	Large round pillow on more elongated flow which illustrates a toothpaste-like extrusion structure. Pillows may be overlying sheetflows.

01:17		14,15	Sediment over lava pillows and debris.
01:18		21	Mound of coalesced pillows, showing some fresh surfaces. Basal material appears to be sheet flows.
		22	Transition from an area of predominantly pillow basalts to an area of sheet flow.
		23	Fresh surfaces and flow structures.
01:25		24	Flow structures on a pillow fragment.
01:32		27	Rat-tail fish about 3 ft long passes in front of the viewport.
		29	Transition to a flatter area with abundant basaltic debris.
01:34	3270	30,31	Transition into sediment-covered bottom. The contact is quite sharp.

Roll 3

01:50	3264	4-7	Debris, broken pillows, and sediment on a down-sloping hill at the edge of a pillow field.
01:52		8,9	Large pillows at the top of a slight hill. The earlier pictures represent an area that is topographically lower than this area of well-formed pillows.
02:04	3284	15	Transition area from pillows to flatter sheet flows. The sheet-flows are less irregular and more sediment covered.
02:05	3284	16	Sediment-dusted sheetflows showing major fracture and revealing internal layering.
02:07		18,19	Sheet flows at the base of pillow lavas. The sheet flows are much more heavily sediment covered than the pillows, perhaps indicating greater age.
02:10		21	Large fracture in the underlying sheet flows. This fracture may be related to episodes of local faulting.
02:23	3278	24-25	Sediment-covered bottom with abundant holothurian tracks.
02:28		31	Debris field in sediment near the edge of the pillows. This represents a change in bottom type from the pillows and sheet flows on the lower part of hills to the sediment zones higher up.

Note: only pictures reasonably well developed are described here; about 60% of the total number of hand-held pictures actually turned out.

HAND-HELD CAMERA PHOTO LOG

Location: NESCA Central Hill
Port observer: Zierenberg
Starboard observer: Karlin

Julian Day: 250
Date: 09/06/88
Pilot: Popovich

Time (GMT)	Depth (m)	Photo #	Description
		2	Flat sediment-covered bottom with xenos and brittle stars.
22:42	3246	3	Close-up of xeno.
22:42	3240	4	Close-up of brisingid and xenos, fresh holothurian excrement.
22:43	3240	5	Close-up of crinoid. Note light-colored shrimp to the upper right which shows a strong reflection from the back of the carapace where the "Van Dover eye" occurs on Atlantic vent shrimp.
23:03	3240	6	Blue rat-tail fish.
23:09	3242	7	Sulfide/sediment contact showing ledges of sulfide at the base topped by sulfide chimneys visible in the background.
23:09	3242	8	Sulfide sediment contact showing ledges of sulfide and galatheid crabs.
23:09	3242	9	Small weathered chimneys on sulfide mound, small orange shrimp.
23:09	3242	10	Small weathered chimneys on sulfide mound, small orange shrimp.
23:09	3242	11	Small weathered chimneys on sulfide mound, small orange shrimp in the foreground, galatheid crabs and a starfish on the chimney in the background.
23:09	3242	12	Small weathered chimneys on sulfide mound, small orange shrimp in the foreground, galatheid crabs and a starfish on the chimney in the background.
23:09	3242	13	Small weathered chimneys on sulfide mound, small orange shrimp in the foreground, galatheid crabs and a starfish on the chimney in the background.
23:09	3242	14	Small weathered chimneys on sulfide mound, small orange shrimp in the foreground, galatheid

			crabs and a starfish on the chimney in the background.
23:09	3242	15	Small weathered chimneys on sulfide mound, small orange shrimp.
23:09	3242	16	Small weathered chimneys on sulfide mound, small orange shrimp in the foreground, galatheid crabs and a starfish on the chimney in the background.

DSV *SEA CLIFF* VIDEOTAPE LOG

Location: NESCA Central Hill
Port observer: Holmes
Starboard observer: Okita

Julian Day: 247
Date: 09/03/88
Pilot: Craver

KEY: F = FRONT-LOOKING PAN AND TILT CAMERA ; S = STARBOARD FIXED POSITION CAMERA; H = HAND-HELD PANASONIC VIDEO CAMERA – VIEWING DIRECTION NOTED IN DESCRIPTION.

Counter	Time	Camera	Description
	15:14		In the ball.
	15:41		Vents open.
TAPE 1 OF 3			
00:00		F	Depth 3236 m, camera on no discernible images in water column.
00:28			Benthos camera set to 16 second interval.
00:50		F	Fish.
02:00		H	Switch to starboard-view port to follow fish.
03:05		H	Video of CTFM [in sub foward-looking horizontal scanning sonar system] sonar scans at 500 yd and 150 yd range.
04:00			Blank image, sound recorded. Probably on handheld camera.
04:45	18:35		Begin driving 090°.
05:15		S	Bottom from starboard fixed camera. Submersible (DSV *Alvin*?) tracks?
05:44		F	Switched to pan & tilt.
05:55	18:40	S	Back to starboard. Rock face reported dead ahead by pilot.
06:00			Through 07:05, camera check, external lights off. Return to starboard fixed camera.
07:55		S	Large fish swimming toward sub.
08:30		H	Starboard-view port. Orientation of camera off 90°.
09:50			Bottom in sight.
10:00		F	Forward view of rocky, blocky bottom. Sediment covered.
10:50			(no discernible image)
11:05		H	Hand-held video out the forward-view port. Small isolated chimneys. Large cracks and slabs of sulfide 2 m on each side. Mosaic of extension

			cracks in sulfide crust, partly covered by sediment with small sulfide chimneys.
11:55		H	Camera moved to starboard.
12:35	18:47	F	Moving past sulfide mound, 3234 m, Hdg. 123°.
14:08		S	
14:15		F	
15:05			Bottom barely in sight.
16:20			Approaching sulfide mound, 3227 m. Sulfide pavement reported.
16:35		S	
16:48		F	
17:15			Mound in sight again.
18:05		H	Switch to hand-held.
18:35		F	
18:55	18:54		Tube worms on mound south of 220° vent, 3204 m.
20:25		F	Forward looking view of mound.
21:30		H	Starboard view of flank of mound.
22:45	19:09		Check of oxygen meter, audible in background.
23:20		F	Quick flick to pan and tilt, then back to hand-held, view of water column!
24:25			Depth of 10500 feet (3200 meters) reported.
25:40		H	Flat, grey to brown sediment cover.
26:55			Anemones.
27:00			Bottom in view.
27:45		F	
29:18			3194 meters.
30:01			Posit[ion] check for Lima.
31:20			Reply 307°, 91 m.
32:22		H	Starboard view of block substrate. Starfish present, orange and brown sulfides, crabs, sponges.
35:14	19:33		
35:40		H	Forward view of tube worm on mound. Basalt?
36:40	19:34	H	Starboard view at 3223 m.
37:28	19:35		3231 m.
39:45	19:37	H	Starboard view of steep sulfide covered slope at 3231 m. Shimmering water issuing from tube worms.
41:40		H	Dialogue reports this view as forward [INCORRECT - view is starboard].
42:55		H	Starboard view of sulfides, large crevice in slope. Does not appear to be a recent feature.

		H	Mesotec sonar display.
44:11			Tape change in sphere.
45:15	19:46		Position approximately 20 to 30 m from Lima, depth = 3222 m.
45:45		F	View of cracks in mound
48:40		H	Starboard view.
49:00			Marker spotted.
49:10	19:50	F	Depth 3220 m.
49:35		F	Report that marker 0 (zero) spotted.
49:50			Correction that marker is 6X.
50:03		F	
50:55			Position within 10 m of Lima.
51:55		H	Forward view of hot water venting from mound.
52:04		F	Additional view of mound as approach is made.
52:25			Depth = 3220 m.
53:05		H	Starboard view of base of mound and flank.
53:55		S	
54:00		H	Forward view of mound showing tube worms, cracks in mound, and diffusive venting of hot water.
54:23			Camera hand-off.
54:35		H	Starboard view again.
54:45			Ambient seawater reported at 1.39°C.
54:50		F	View of mound at beginning of temperature measurements.
57:10			11.3°C
59:43		H	Forward view of temperature probe and venting fluid. Maximum temperature obtained in this attempt was just above 37°C.
60:13		H	Starboard view.
60:30	20:02	F	Pan of mound during next temperature measurement. 6X marker visible, temperature probe in mud; maximum temperature approx. 150°C. Inactive barite chimney on sulfide with crevasse.
62:18			End of tape 1
TAPE 2 OF 3			
00:01		F	Probe at vent as before.
00:35		H	Starboard view of mound flank. Still taking 150°C reading.
01:15			Small chimney visible, irregular shape — somewhat dendritic looking — fracture visible near base and extending away from chimney (toward sub), downslope and away from mound.

02:13		F	
02:16			[Break in signal ???? Possible tape change in the sub].
02:17		H	Forward view with hand-held camera of marker 6X.
03:07			Benchmark 0 (zero) is visible in upper left.
03:45	20:08	F	Leaving benchmark 6X to go to tall mound at benchmark 0 (zero).
05:31	20:10		Depth = 3219 m.
05:50			Approaching benchmark 0 (zero).
06:26		H	Starboard view of mound: tube worms abound, crabs, and blocks of sulfide(?), close pass by the benchmark reveals it is encrusted with bacteria(?), sulfides(?), very gelatinous appearance of surface coatings.
08:15			Old mound or block of sulfide in the sediment.
08:52		F	Approach to summit of mound.
09:13		H	Forward view of mound using handheld.
09:25		F	Mound approach.
10:18		H	Starboard view of blocky rubble, and lumpy bottom texture. Heading 062, Depth = 3222 m. Voice reports view to port [INCORRECT; view is starboard].
11:30			Still starboard view, brisingid.
12:00		F	Ascending mound and chimney, view of blocky nature of sulfides on the mound.
12:45	20:17		Depth = 3217 m.
14:04		H	Forward view of top of the mound showing tube worms and venting fluids. Base of mound is broken and blocky.
14:55			Close up of crack from which fluid is venting. This coincides with an apparent sharp lower limit of the worm colonies.
15:20		F	
15:27		H	Forward.
15:55		F	
16:28	20:20		Depth = 3217 m.
17:18		H	Forward view of very top of mound showing venting through tube worms. Depth = 3216 m.
17:35		F	
18:16		H	Forward view.
18:35		F	
19:44	20:24		Depth = 3217 m. View of sulfides and temperature measurements.

20:08			Temperatures ranging up to 15°C — not a successful attempt.
21:56		H	Forward view of the very top surface of the vents. Temperature probe in place. Very good close up.
22:35		F	Suggestion made for recovery of chimney.
24:58		H	Forward view of material before sampling attempt.
25:50		F	
27:28			Benchmark 0 (zero) in picture.
28:00			Audio lost through 28:12.
29:07			Lights dimmed.
29:35			Audio lost through 29:44.
29:55		H	Concentrated venting through chimney.
30:10		F	
30:27			Heading 180°, Depth = 3266 m [Note This depth is incorrect]. Attempt to measure temperature.
31:43			Large fish.
32:10	20:36		Heading 179°, Depth = 3219 m. Located at benchmark 0 (zero).
34:31		H	Forward close up of temperature probe in vent fluid. Highest reading was 199°C.
34:48			End of tape #3 Tape change in sub.
34:57	20:42	F	Note: Some time did lapse between end of Tape #3 and loading of Tape #4. (I don't think anything important was lost at the start of Tape #4 t=20:42); have just completed measurement of 222°C fluids from this site: benchmark 0 (zero), Depth = 3266 m [Note: This depth is incorrect].
35:07		H	Starboard view of rubble on flanks of mound.
35:20		F	Attempt to sample sulfides and worms from mound.
35:49		H	Forward, Depth = 3267 m [Note: This depth is incorrect]. Sampling attempts cracked open the mound. Venting rate increased immediately.
36:20	20:43		
36:30		F	
36:35		H	Forward view of small channel visible after block was removed. This is almost a vertical orientation and appears to be the conduit within the chimney. DSV *Alvin* manipulator mark visible.
37:15		F	
39:00			Venting still visible, more temperature measurements being attempted.
40:41	20:48		Depth = 3219 m.

46:19		H	Starboard view downslope showing more blocks of rubble.
47:06		F	View of site: mound, benchmark, chimney. White coatings visible on surface of chimney (barite?, anhydrite?). Temperature measurement approximately 1 meter above mound is about 8°C.
50:03		H	Forward, close-up of venting.
50:26		F	
50:47		H	CTFM sonar scan of site, heading 142°, range 50 yds.
51:14		H	"Up close and personal" view of our color commentator on the port side, followed by an action photo of our fearless pilot at the controls of his vehicle. This is of course succeeded by a view of those controls, after which you receive a quick tour of the myriad of switches, buttons, and lights surrounding us.
51:55			Starboard view of mud.
52:07		F	
54:42	21:02		
54:54			Depth = 3240 m.
55:15		H	Starboard view of slope, more damn mud.
56:01		F	Forward view of sample site. Attempt by pilot to sample while Okita tries to steady the vehicle.
60:31	21:08		Depth = 3,215 meters. Abandon efforts to sample this site.
61:50			Lights off.
61:54			END OF TAPE 2
TAPE 3 OF 3			
00:00		F	No discernible image.
00:16	21:09	F	Depth = 3217 m, approaching benchmark 0 (zero), chimney visible in distance.
01:15	21:10		Closing in on benchmark 0 (zero).
01:32			Blank. End of sub. tape #4.
	21:15		Start of sub. tape #5.
			Depth = 3239 m.
02:44	21:16		Depth = 3239 m.
02:59		H	Starboard view of sushi in the water column. Lost the bottom.
04:35		F	
07:21	21:21	H	Depth = 3233 m, still pointing into water column.
08:19		F	
08:30			Chimney top knocked off by arm.

10:20	21:24		Depth = 3237 m.
14:22		H	No discernible image. Lost the bottom.
17:18		F	No discernible image.
18:15			Approaching tall sulfide mound with tube worms south of benchmark 0 .
19:11	21:33		Depth = 3233 m.
20:54			Side of mound visible, diffuse but active venting visible across mound, tube worms abundant.
24:10		H	Forward close up of venting.
24:42		F	
24:50			Deploying benchmark "Orange /Yellow ".
25:10	21:39		Depth = 3266 m.
25:28			Depth = 10744 ft. This equals 3275 m. [Depth readings incorrect].
26:24	21:40		
33:54			End of sub. tape #5.
34:07	21:50	H	Start of sub. tape #6. Depth = 3259 m. Tube worms.
34:35		F	
36:15			Large fish.
37:39		H	Starboard view of a large octopus.
38:31	21:55		White crabs, Benchmark "Orange/Yellow".
39:29		F	View of the same old mound and tube worms.
39:41		H	Return of the Octopus.
40:46	21:57		
41:25		F	Initial attempt at tube worm sample, 3220 m.
44:05	22:00		Depth 3220 m. Pilot earns a free game by acquiring almost an entire colony of tube worms.
52:01		H	Close up of tube worm sample covering the entire basket.
52:25		F	
53:34		H	Check that the bio box is secured.
54:05		F	Preparation to terminate dive.
		H	Mesotec sonar display of sulfide, Hdg. 303°.
		F	Sample basket, depth 3211 m.
61:52			End of tape.

DSV *SEA CLIFF* VIDEOTAPE LOG

Location: NESCA Central Hill
Port observer: Wiltshire
Starboard observer: Koski

Julian Day: 248
Date: 09/04/88
Pilot: Porier

KEY: F = FRONT-LOOKING PAN AND TILT CAMERA; S = STARBOARD FIXED POSITION CAMERA; H = HAND-HELD PANASONIC VIDEOCAMERA – VIEWING DIRECTION NOTED IN DESCRIPTION.

Counter	Time	Camera	Description
22		F	Start of tape.
80	00:08	H	Sediment-covered pillows.
215	00:15		
250-270			Good shots of pillow lavas.
274	00:24		Pillows with 30 percent thin sediment cover, electronic interference on video.
474	00:27	F	
484		H	
780		F	Sample basket.
789		H	Water shots.
831	00:36		Pillows.
970		F	Basket.
1005		H	Water.
1080		F	Basket.
1085		H	Water.
1100			Pillows with sponges, reasonable picture but some interference.
1200		F	Basket.
1288		H	Hand-held shots out front of sub.
1300			Fish, pillows with sponges in the distance.
1330		H	Pillows on starboard side.
1360		F	Pillows.
1405		H	Water and sediment cloud.
1475		F	Pillows.
1505		H	Pillows.
1516		F	
1523		H	Pillows.
1546			Rat-tail fish.
1565			Flatter, more tubular pillows, reasonably good pictures.
1615			Back to large bulbous pillows.

1690	01:35		Sediment contact at 3260 m. Flows probably flowed into or under sediment hill. Sediment is hummocky, channeled, has bioturbation mounds suggesting very low sedimentation rates. There is mass wasting, with mudstone blocks and locally abundant talus of mudstone blocks.
1880			Dark.
1895	01:43	H	Sediment, lots of mudstone talus, 3263 m.
1975		S	
1980		H	Water
2030			Wiltshire reports basalt on sediment.
2040		F	Dark.
2065		H	Basalt with sediment cover, flat to bulbous pillows. Good quality video to 2200.
2100			Transitional to lobate flows.
2150			Inflated and trap-door pillows.
2290			Water, drop-off.
2315			Flatter pillows to lobate flows.
2330		F	Dark.
2350		H	Flat pillows to lobate flow
2385		H	Front view port, broken sheet flow.
2495		H	Starboard view port, lobate flow.
2480			Sediment cloud.
2495		F	Sheet flow, sampling attempt, no sample.
2550		F	Moving again, dark.
2560-2590			Blank.
2595	02:21		Sediment-covered bottom, 3283 m, flat with bioturbation mounds.
2650		F	Dark.
2670		H	Sediment-covered bottom.
2730		F	Dark.
2735		H	Sediment-covered bottom.
2740			Blank.
2745			Sediment-covered bottom.
2800			Channel margin.
2810			Water.
2850		F	Dark.
2880		H	Sediment-covered bottom.
2895		F	Dark.
2905		H	Sediment-covered bottom, channeled.
2965		F	Dark.
3000		H	Sediment-covered bottom.
3185			End of Dive.

DSV *SEA CLIFF* VIDEOTAPE LOG

Location: NESCA Central Hill
Port observer: Zierenberg
Starboard observer: Karlin
Julian Day: 250
Date: 09/06/88
Pilot: Popovich

KEY: F = FRONT-LOOKING PAN AND TILT CAMERA; S = STARBOARD FIXED POSITION CAMERA; H = HAND-HELD PANASONIC VIDEO CAMERA - VIEWING DIRECTION NOTED IN DESCRIPTION.

Counter	Time	Camera	Description
78			Bottom approach, 10670 ft.
180-200			Sediment-covered bottom, camera tilted.
200-220		F	Dark.
220-270			Sediment-covered bottom, 3247 m.
270-570			Water column, dark.
570-730		F	Basket.
680			Over deep channel?
730		H	Sediment-covered bottom.
750-900			Mudstone talus on channel margin, talus blocks 10-50 cm.
880			Clam shell reported.
900		F	Dark.
940-980		H	Sediment-covered bottom, top of channel.
980			Dropping down into channel.
1050			Lots of bioturbation features indicative of slow sedimentation.
1230			Vertical scarp exposing lighter sediment.
1570			Clams reported on port side, lots of clams on starboard.
1605		F	Dark.
1620-1640		H	Looking out front view port. Bacterial mat on sulfides, lots of clams. 3233-3235 m.
1640-1705		H	Starboard view port. Massive sulfide.
1710-1916		F	Tape change [audio?]. Dark, taking logs.
1916-1940		H	Front view port. Sediment cloud.
1940-2190		H	Starboard, sediment-covered bottom, camera sideways.
2190-2200		F	Dark.
2200-2245		H	Camera sideways.
2245		F	Dark, sediment cloud.
2690			Rat-tail fish.

2752	F	Dark, on bottom at 3234 m, dead clams.
2770-2800	H	Water.
2800-2810		Sediment-covered bottom. Camera sideways.
2845		Sediment cloud.
2850	F	Sediment-covered bottom, then sediment cloud.
3050	H	Camera sideways. Sediment covered bottom.
3750		Range and bearing to launch target 330 m, 056°.
4040	F	Dark.
4092		Sediment-covered bottom.
4100	H	Camera sideways. Sediment-covered bottom.
4230		End of Tape 1 [3/4 inch videotape].
46	F	On bottom in front of massive sulfide deposit, dark.
460		Sediment core taken, range and bearing to launch target 70 m, 010°.
965	H	Port view port, dark.
1010	F	Dark.
1150		Sampling barite chimney.
1630		Terminating dive.

Appendix 4

SAMPLE LOCATIONS

Sample #	Day/Time	Depth (m)	X	Y	Comments
DIVE 763	JD245				
763-C-1	0910	3170	57440	53077	Push core: taken at top of 'Moe', the South West Hill at NESCA.
DIVE 764	JD247				
764-B-1	2148	3220	58831	55353	Biology: large mass (entire colony) of tube worms from top of active vent atop large sulfide mound (at YELLOW/ORANGE Benchmark) about 50 m SSE of benchmark 0. Approximate weight 20-25 kg.
764-R-2	2148	3220	58831	55353	Rock: northwestern flank of 'Curly' (at YELLOW/ORANGE Benchmark) about 50 m SSE of benchmark 0 on a different active sulfide mound. Three small fragments: 1) sulfide (pyrrhotite) on barite replaced by Marcasite, 2) Porous, friable, brown granular crust–barite, Fe oxide stain, trace sulfide, 3) light & dark gray granular mass, encrusted by barite, several worms.
764-MP-3	-	-	-	-	Sediment samples from the DSV *Sea Cliff* skids collected for micropaleo work. Exact sample time and location not known.
DIVE 766	JD250				
766-C-1	2314	3227	59219	54903	Push core: 17 cm. gray brown mud.
766-R-1	2336	3227	59219	54903	Rock: Hourglass-shaped chimney composed of massive barite from top of pyrrhotite-rich sulfide mound (10 kg).

MARKER LOCATIONS
deployed by DSV *Seacliff*

YELLOW/ORANGE	3220	58831	55353	Deployed on dive 764.

Weight: +20 lbs.

Sample Number: SC766-1R

Sample Location: NESCA, east side of 'Curly'
Occurance: 0.3 m tall chimney on top of massive sulfide mound.

Rock Type: massive sulfide

Sample appearance (no. of samples, general shape, dimensions in cms):

Chimney has rough hourglass form with widest part at the top. Chimney and mound substrate is 30 cm long, approx. 20 cm across the top (which has nearly circular cross section), 8-9 cm across narrowest cross section (17 cm from the top), and has a base with elongate form, 21 cm by 13 cm. It is a sealed chimney or spout with no central orifice. The top of the chimney is flat and appears to have lateral fluid vents beneath. These are elongate cavities below the cap. Surface contained a few tiny white sponges and patches of gelatin.

Description (Porosity, friability, coloration, sea floor alteration, primary and secondary textures and mineralogy, veins, vugs, zonation, hydrocarbons, biology, etc.)

The outer surface is soft, porous weathering (sea-floor) rind with a consistent thickness of ~0.5 cm. This surface is covered by a film of brownish-black Mn or Mn + Fe oxide <1 mm thick. The outer surface has a boxwork texture similar to gossan. The underlying alteration rind has a grayish yellow color and is largely composed of barite, minor Fe oxide, and sulfide. There is no apparent change in texture between the weathering rind and interior of the chimney. The chimney interior (as seen from the broken basal platform) is zoned. The outer 3 cm is dark gray with lower (apparent) porosity than the interior. The central part of the chimney has vuggy appearance and a reddish cast — may contain pyrrhotite. The principal mineral is barite, much of it clear. The dark color is related to minor sulfide including sphalerite and, perhaps Sb-bearing phases. Tiny oil/tar globules also present. The top of the chimney appears to be a capping structure with underlying lateral vent openings. In the base, a 2 cm wide zone contains coarser grained barite; possibly a plugged channelway. The principal channelway, perhaps never a large opening, appears to have occupied the central core of the chimney structure.

Dive 764

Worms:

- Tube worms, Vestimentiferans, probably Escarpia spp. or maybe Ridgia spp.
- Palm worms, Alvinellids or Paralvinellids
- Scale worm, Polynoids, many with filamentous bacteria on their back
- Polychaete worm, Ampheretid worms living in mud tubes on the tube worms
- Bristle worm, few red swimming polychaete

Limpet:

- Type 1, grey "hooded" in appearance, very numerous
- Type 2, white, flattened, few in number

Gastropod:

- "red" snail, small gastropod with red meat and white nodules on shell
- "brown" snail, small coiled gastropod with light brown shell; some morphs with black shell (probably same species but needs further identification)
- Whelk, 1 large gastropod, beige with black markings
- "redddish brown" coiled Gastropod, whelk-like in appearance
- Misc. Gastropod, some empty shells of different shape and color from other preserved species

Bivalve: periostacum (outer layer) of Solemya

Sea spiders: Pycnogonids

Tanaids, Peracarid crustaceans

Copepods

Bacteria, small clumps and filaments preserved

DIVE 766

(attached to chimney sample 766-1R)

Glass sponges

Gelatinous white disk

Polychaete worm