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Bio-Optical Profile Data Report

Coastal Transition Zone Program
R/V Thomas Washington
June 24–July 21, 1988

Curtiss O. Davis
W. Joseph Rhea

December 1, 1990

Prepared for

Office of Naval Research

Through an agreement with

National Aeronautics and
Space Administration

by

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

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ABSTRACT

Twenty-three vertical profiles of the bio-optical properties of the ocean were made during a research cruise on the R/V Thomas Washington, June 24–July 21, 1988, as part of the Coastal Transition Zone Program off Point Arena, California. This report is a summary to provide investigators with an overview of the data collected. The entire data set is available in digital form for interested researchers, and requests for the data should be addressed to W. Joe Rhea, (818) 393-6095.

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INTRODUCTION

The Coastal Transition Zone (CTZ) Program, sponsored by the Office of Naval Research, is an interdisciplinary study of the physical causes and the physical, biological, and optical characteristics of the filaments of cold, salty water that extend over 300 km off the West Coast of North America. The cruise of the R/V Thomas Washington, June 24–July 21, 1988, was designed to study a representative filament off Point Arena, California. Guided by satellite sea-surface temperature maps, two surveys of the filament and adjacent waters were conducted. Additionally, two clusters of drifters were placed in the root of the filament and tracked by satellite for several months. One of the drifters in the first cluster was instrumented with a fluorometer, transmissometer, spectroradiometer, and a water sampler. At the end of seven days, the instrumented drifter was recovered approximately 300 km to the southwest of the launch site.

This report describes bio-optical profile data that were collected at 23 stations representative of the filament, freshly upwelled water near the coast, and the offshore water surrounding the filament. Of particular interest is a time series of seven stations taken at approximately noon each day next to the instrumented drifter.

DATA DESCRIPTION

Optical data were collected with a Bio-Optical Profiling System (BOPS), an updated version of the BOPS originally developed by Smith et al. (1984). The heart of the BOPS is a Biospherical Instruments MER-1048 spectroradiometer, which measured up- and downwelling spectral irradiance and upwelling spectral radiance. The MER-1048 also has sensors for Photosynthetically Available Radiation (PAR), depth, tilt, and roll. In addition, temperature and conductivity were measured with a Sea-Bird CTD, chlorophyll fluorescence was measured with a Sea Tech fluorometer, and beam transmission was measured with a Sea Tech 25-cm transmissometer. The MER-1048 acquired all the data 16 times a second, averaged it to four records a second, and sent it up the cable to a deck box and a Compaq-286 computer, which stored the data on the hard disk. The BOPS data (Table I) were filtered to remove obvious data spikes and then binned into one-meter averages and stored in the form of ASCII comma-separated files.

INDIVIDUAL STATION DATA PROFILES

For each station (Table II), eight profiles are presented to give a graphical overview of the data (Figures 1–23). Data files are identified by a filename of the format:

Nyymmddc.MER

where:

N = c for CTZ cruise of the R/V Thomas Washington, June 24–July 21, 1987

yy = Year

mm = Month

dd = Day

c = Cast order for each day.

i.e. 'a' = first cast of day

'b' = second cast of day, etc.

Temperature and salinity data were from the Sea-Bird CTD. Salinity was calculated from the temperature and conductivity measurements using the standard equations for practical salinity units (Millero et al., 1980). Occasional spikes in salinity were observed at the

surface and at the thermocline. This is an artifact caused by the fact that the response time of the conductivity sensor does not exactly match that of the temperature sensor.

Data from the Sea Tech fluorometer are presented in fluorescence units. The fluorometer data were calibrated using extracted chlorophyll and phaeopigment values from water samples taken immediately before or after a number of optical profiles. Average chlorophyll plus phaeopigment values for the entire cruise give the following equation for calibrating the Sea Tech fluorometer data: chl + phaeo = 0.288 + 0.218 fluor, where $r^2 = 0.77$ and $n = 136$.

Beam transmissometer (25-cm path length, 660-nm wavelength) data were recorded in percent transmission (%T; value in air was set to 100%). The attenuation of a beam of light is defined by Jerlov (1976):

$$c = a + b$$

and

$$T = e^{-cr}$$

where

- c is the beam attenuation coefficient in m^{-1}
- a is the absorption coefficient
- b is the total scattering coefficient
- T is the fraction of light transmitted over path length r.

Then, for this data set, c can be calculated from the following equation ($r = 0.25$ m):

$$c = -4 ((\%T/100)*.949)$$

The radiance, irradiance, and PAR data are presented in calibrated units based on a laboratory calibration conducted by Biospherical Instruments on June 21, 1988. A second calibration after the cruise showed no significant deviation from these values. The spectral light data are presented as a plot of spectra near the surface (dashed line) and then at every five meters (5 m, 10 m, 15 m, etc.). Typically, the surface reading is for 2 m; however, during rough weather, the first usable readings are from greater depth, as indicated on the figures. This is calibrated radiance data, but no corrections for ship shadow or other artifacts have been made to the data. We have developed routines for correcting such artifacts, calculating K, etc., following the guidelines of Smith and Baker (1984, 1986) and Gordon (1985), and the reader is referred to those references for a discussion of these problems.

The data are available in digital format for researchers who wish to work with the actual data. Individuals who are interested in working with the data should request it in digital form from Joe Rhea ((818) 393-6095). The data can be provided in a number of formats compatible with most standard computing environments.

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TABLE I.

Data Channels

0. Number of data points averaged into bin
1. 410-nm Downwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
2. 441-nm Downwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
3. 488-nm Downwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
4. 520-nm Downwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
5. 550-nm Downwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
6. 560-nm Downwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
7. 589-nm Downwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
8. 633-nm Downwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
9. 656-nm Downwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
10. 671-nm Downwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
11. 683-nm Downwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
12. 694-nm Downwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
13. 710-nm Downwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
14. Depth of averaged bin (m)
15. Tilt (angles in degrees (-45 to +45))
16. Roll (angles in degrees (-45 to +45))
17. 410-nm Radiance ($\mu\text{W}/\text{cm}^2/\text{nm}/\text{sr}$)
18. 441-nm Radiance ($\mu\text{W}/\text{cm}^2/\text{nm}/\text{sr}$)
19. 488-nm Radiance ($\mu\text{W}/\text{cm}^2/\text{nm}/\text{sr}$)
20. 520-nm Radiance ($\mu\text{W}/\text{cm}^2/\text{nm}/\text{sr}$)
21. 550-nm Radiance ($\mu\text{W}/\text{cm}^2/\text{nm}/\text{sr}$)
22. 633-nm Radiance ($\mu\text{W}/\text{cm}^2/\text{nm}/\text{sr}$)
23. 656-nm Radiance ($\mu\text{W}/\text{cm}^2/\text{nm}/\text{sr}$)
24. 683-nm Radiance ($\mu\text{W}/\text{cm}^2/\text{nm}/\text{sr}$)
25. 410-nm Upwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
26. 441-nm Upwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
27. 488-nm Upwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
28. 520-nm Upwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
29. 550-nm Upwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
30. 589-nm Upwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
31. 671-nm Upwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
32. 694-nm Upwelling Irradiance ($\mu\text{W}/\text{cm}^2/\text{nm}$)
33. Transmissometer - 25 cm (% transmission)
34. Fluorometer (fluorescence units)
35. PAR (10^{17} quanta/cm²/s]
36. Temperature (deg C)
37. Conductivity (mmho/cm)
38. Salinity (PSU)
39. Density (g/cm³)
41. 520-nm Surface Irradiance (ship mounted)
40. 410-nm Surface Irradiance (ship mounted)
42. 589-nm Surface Irradiance (ship mounted)
43. 683-nm Surface Irradiance (ship mounted)

TABLE II.

1988 R/V Thomas Washington CTZ Cruise-Station Summary

FILENAME yymmdd	Sta (Cast)	Time (Ship)	Latitude Deg Min	Longitude Deg Min	Comments
c880704c	1(1)	15:41	N39 15.0	W124 13.1	Drifter #1
c880705c	5(2)	08:01	N38 55.1	W124 10.9	South of drifter
c880705d	6(1)	10:40	N38 49.8	W124 20.1	Drifter #2
c880706b	10(2)	07:57	N38 20.3	W124 09.2	South of drifter
c880706c	11(2)	11:32	N38 24.2	W124 22.3	Drifter #3, C-14 prod
c880707a	16(2)	07:29	N38 06.6	W124 34.8	South of drifter
c880707b	17(2)	14:45	N38 07.2	W124 54.1	Drifter #4, C-14 prod
c880708a	21(2)	07:22	N37 45.5	W125 03.6	South of drifter
c880708b	22(2)	12:41	N37 53.5	W125 37.9	Drifter #5, C-14 prod
c880709b	27(2)	12:46	N37 29.7	W126 02.3	Drifter #6, C-14 prod
c880710a	31(2)	07:28	N37 07.6	W126 09.7	South of drifter
c880710b	32(1)	11:30	N37 16.2	W126 32.1	Drifter #7
c880711b	37(3)	10:07	N37 33.3	W126 34.4	Blue water
c880714a	52(2)	11:02	N38 43.4	W124 00.0	In nearshore eddy
c880715a	63(2)	11:25	N38 37.8	W124 33.2	West of jet, C-14 prod
c880716b	66(2)	12:09	N37 44.7	W125 29.8	2nd drifter, C-14 prod
c880717a	70(1)	11:05	N37 36.2	W126 23.7	2nd drifter, C-14 prod
c880718a	72(2)	11:05	N37 14.2	W127 15.5	2nd drifter, C-14 prod
c880719a	77(2)	10:57	N38 19.7	W126 44.5	Blue water, C-14 prod
c880720a	80(2)	09:01	N37 37.1	W124 28.6	South of jet, D-line
c880720c	82(1)	12:29	N37 45.8	W124 36.9	In jet, D-line, C-14 prod
c880720e	84(1)	16:51	N37 64.3	W124 45.0	North of jet, D-line
c880721a	91(1)	16:09	N38 57.6	W124 57.7	

CTZ 07-04-88 Loc: drifter pt 2 Lat: 39° 15.0' N Long: 124° 13.1' W File: c880704c

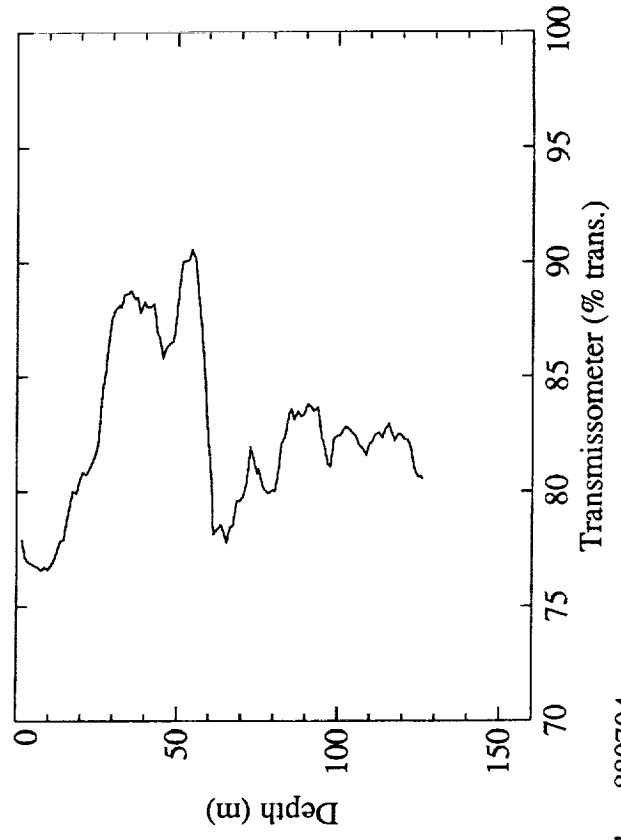
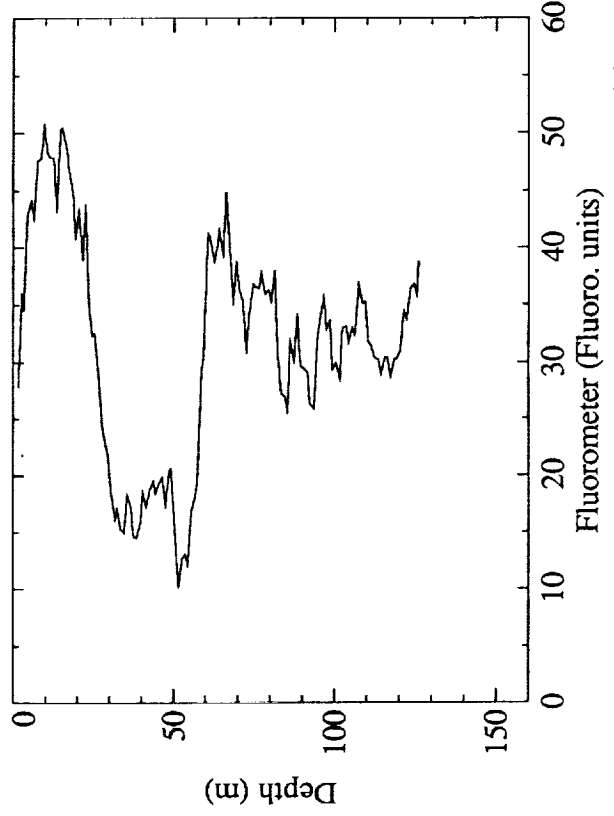
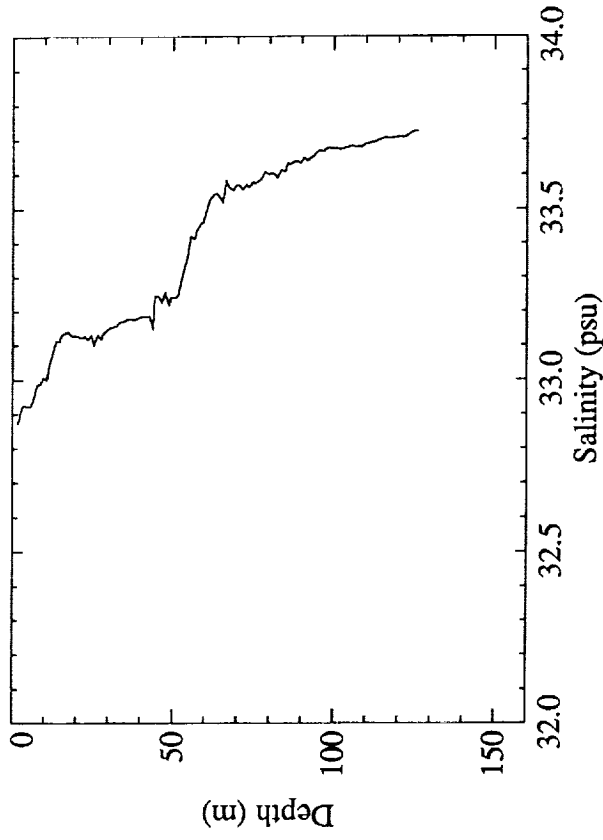
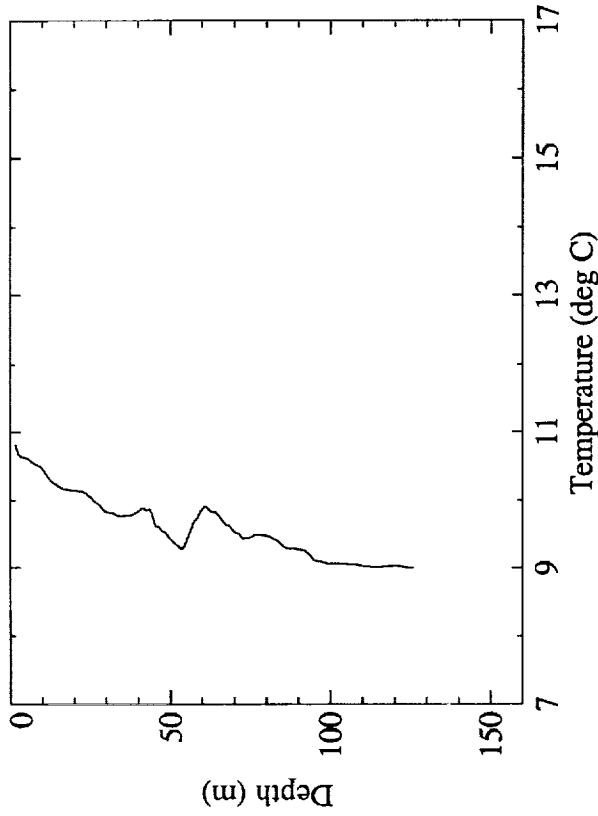


Figure 1. File: c880704c

CTZ 07-04-88 Loc: drifter pt 2 Lat: 39° 15.0' N Long: 124° 13.1' W File: c880704c

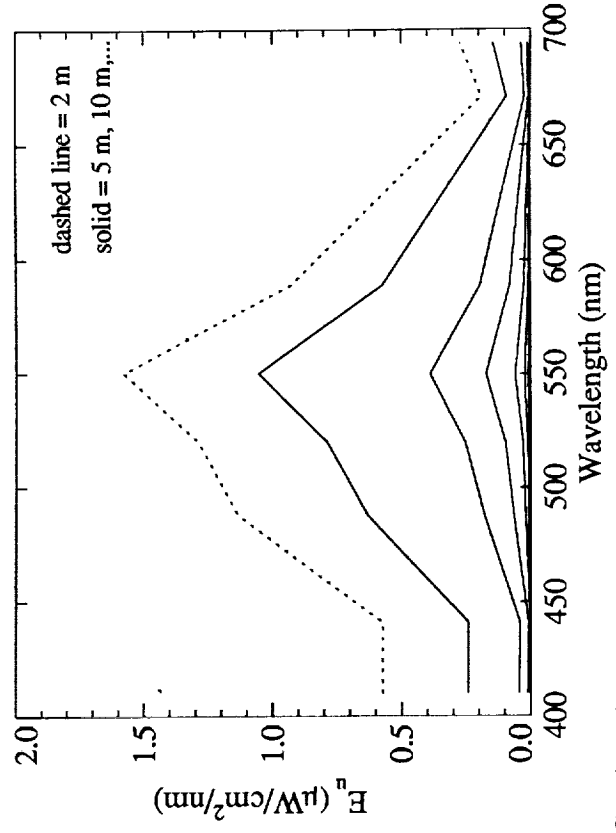
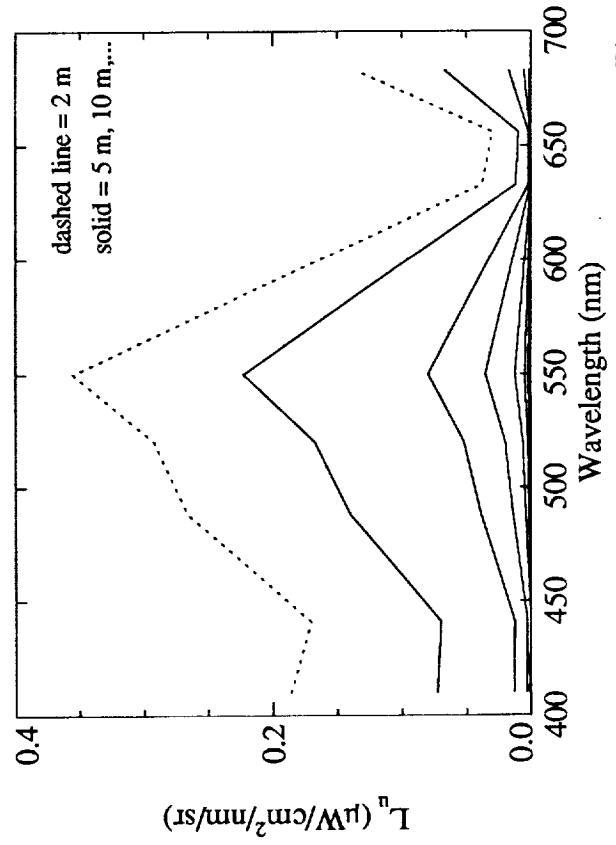
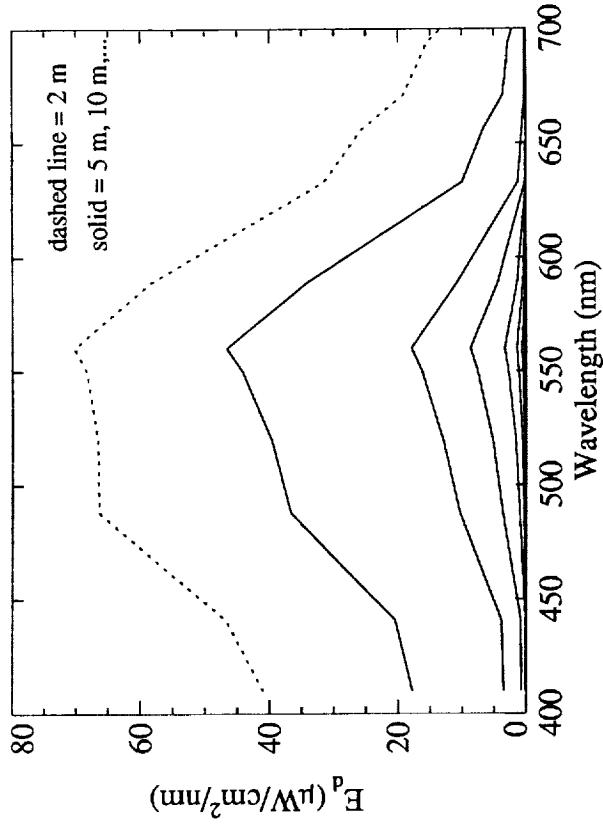
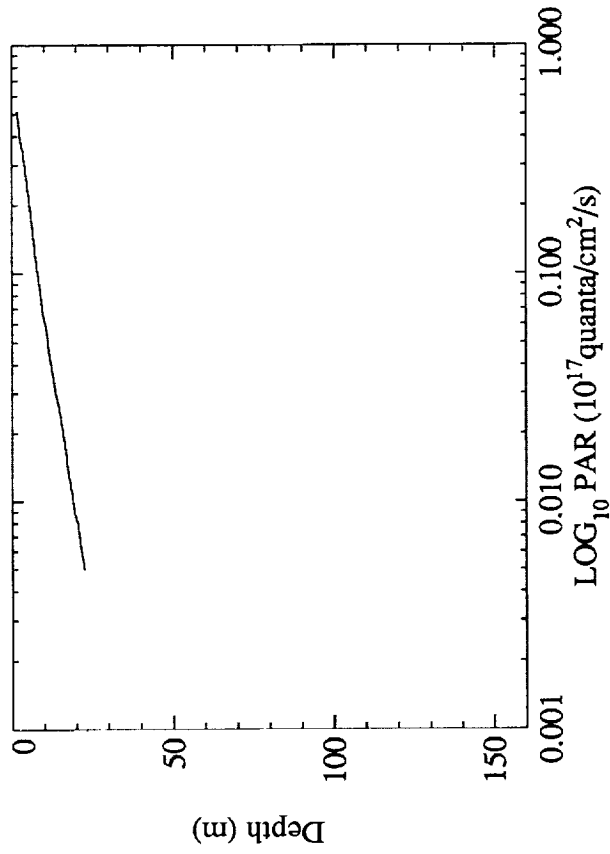


Figure 1. Continued

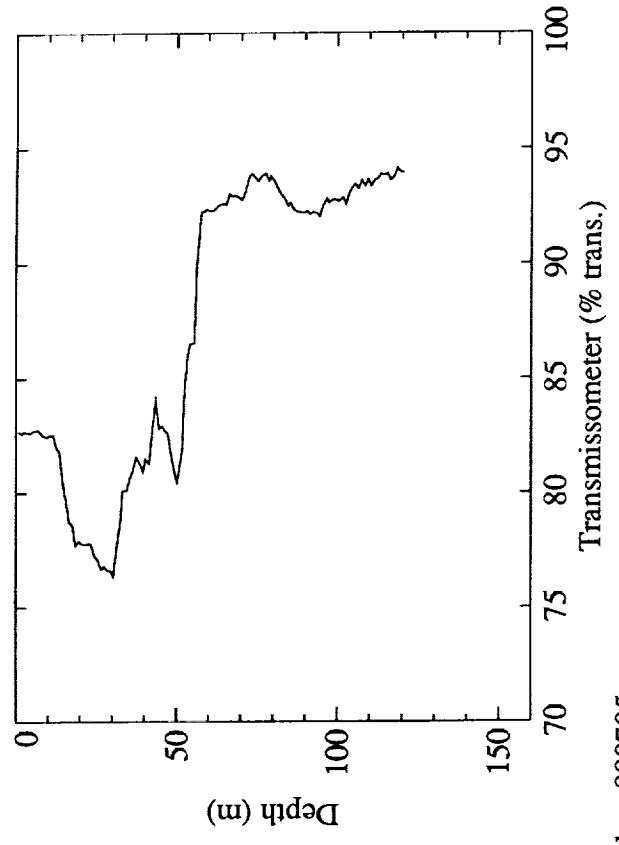
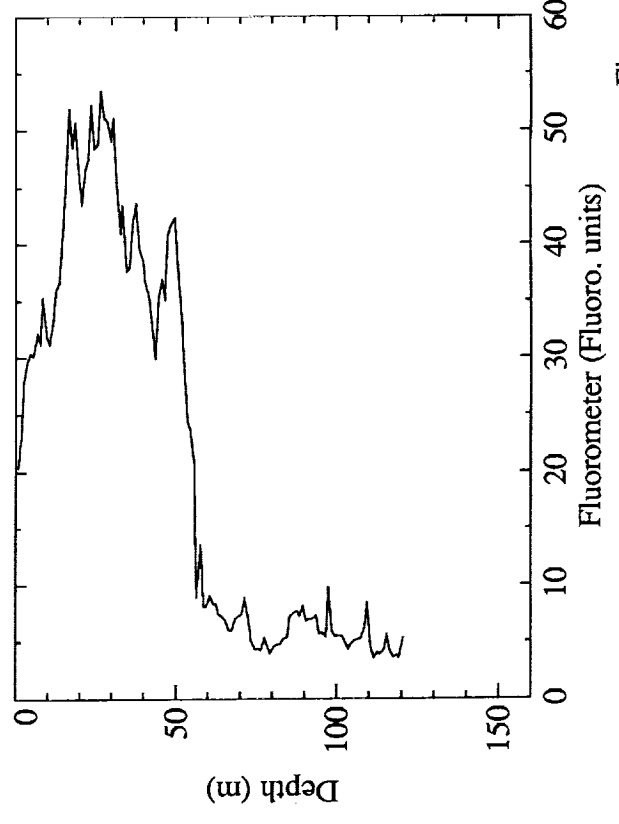
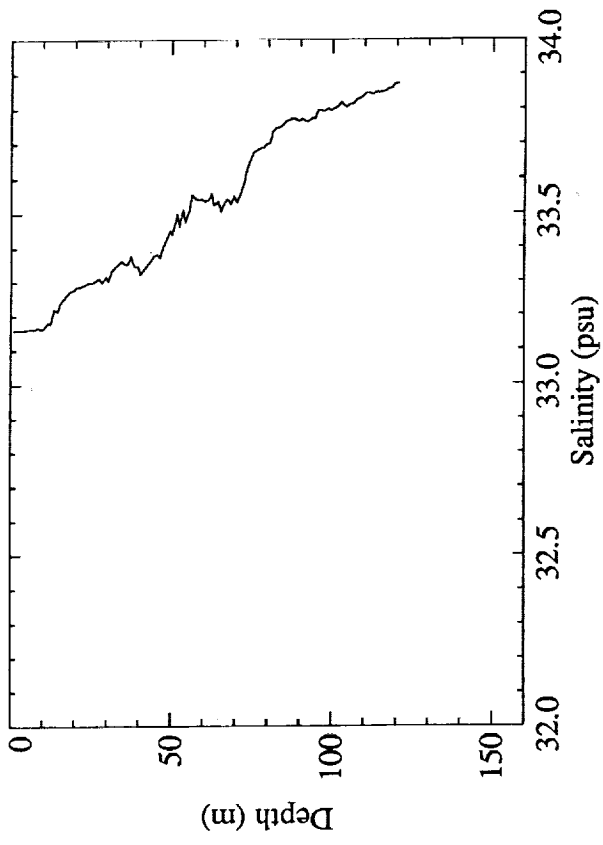
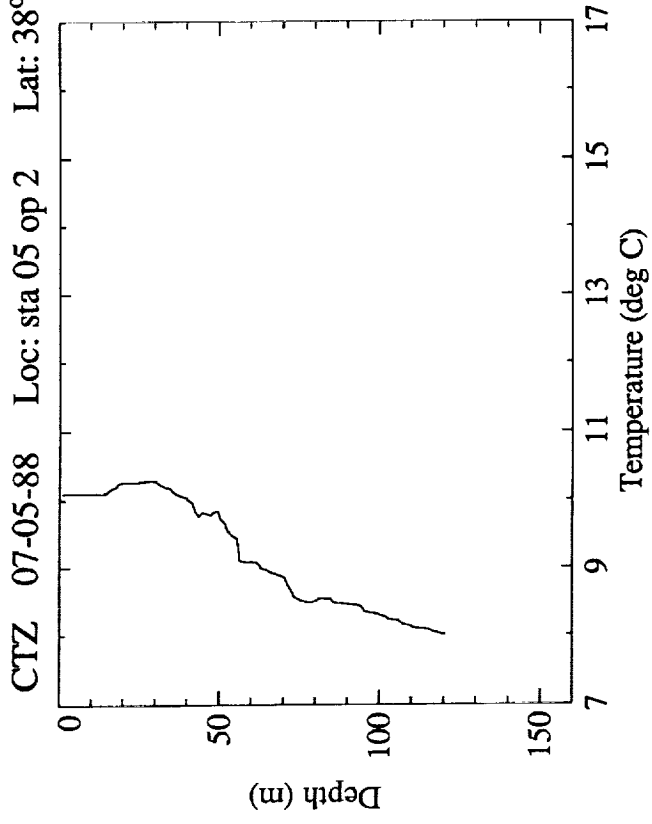


Figure 2. File: c880705c

CTZ 07-05-88 Loc: sta 05 op 2 Lat: 38° 55.1' N Long: 124° 10.9' W File: c880705c

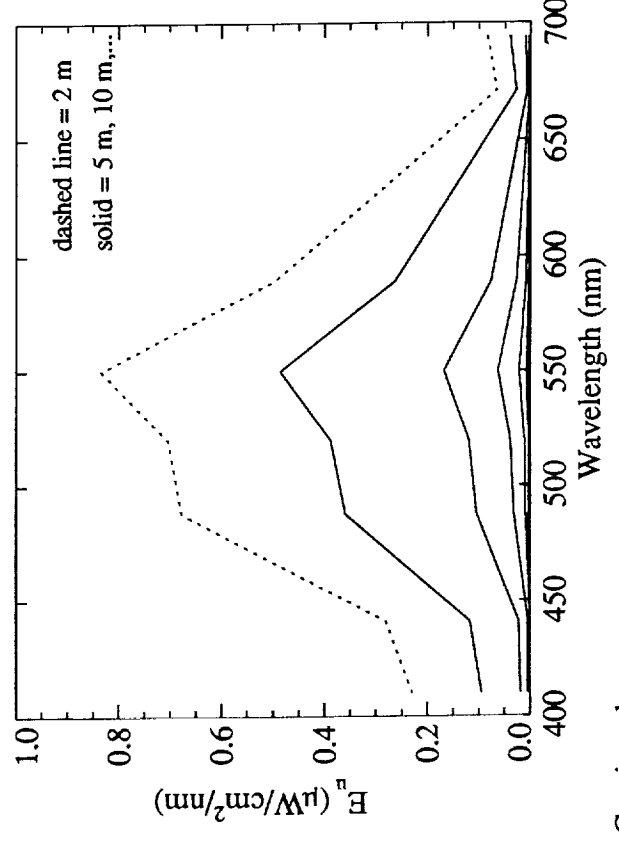
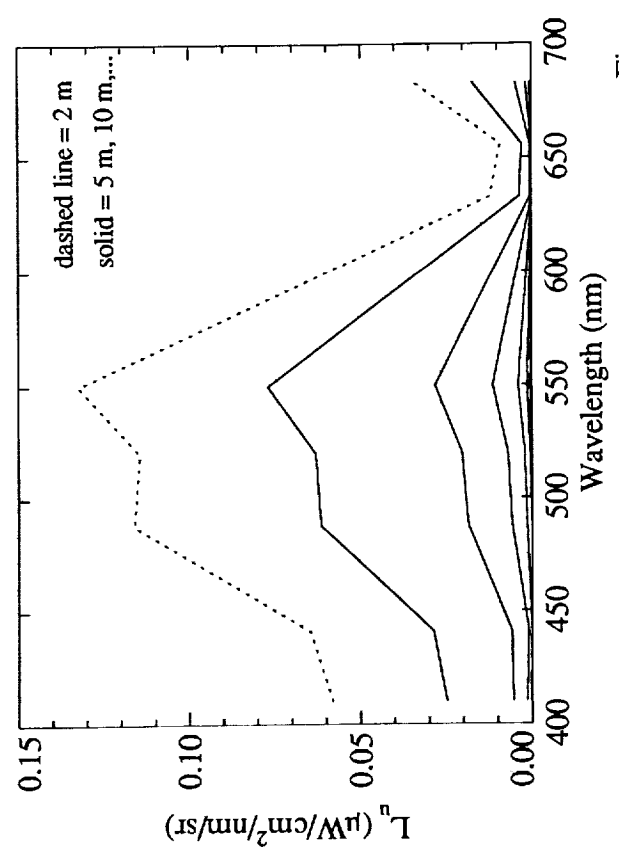
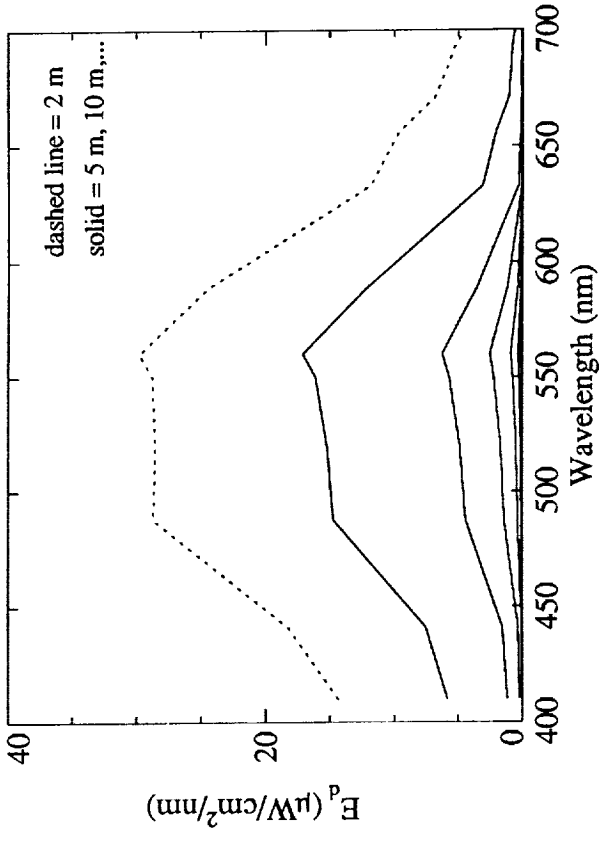
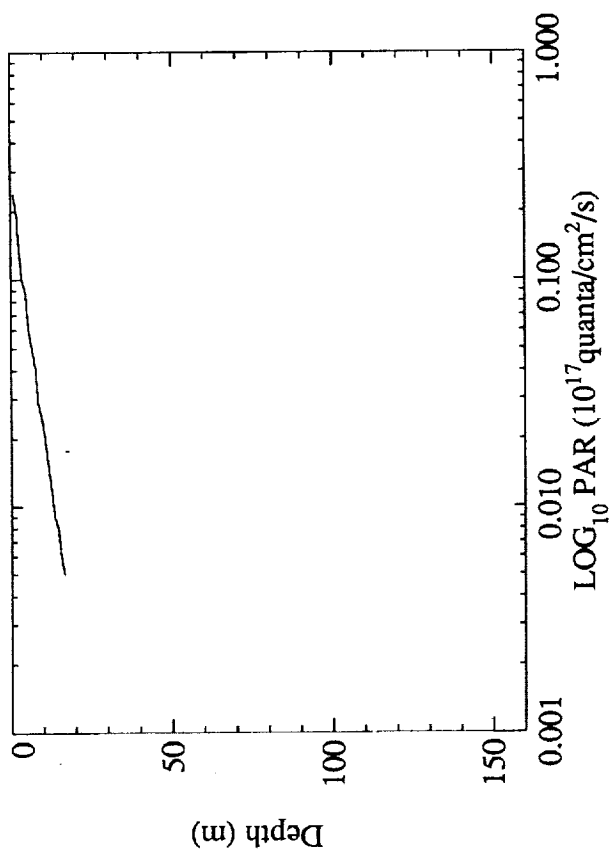


Figure 2. Continued

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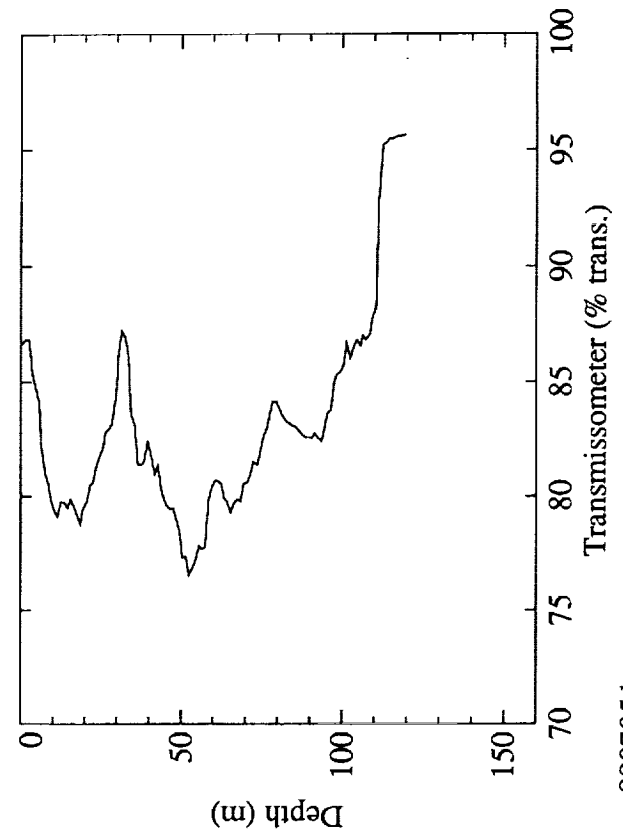
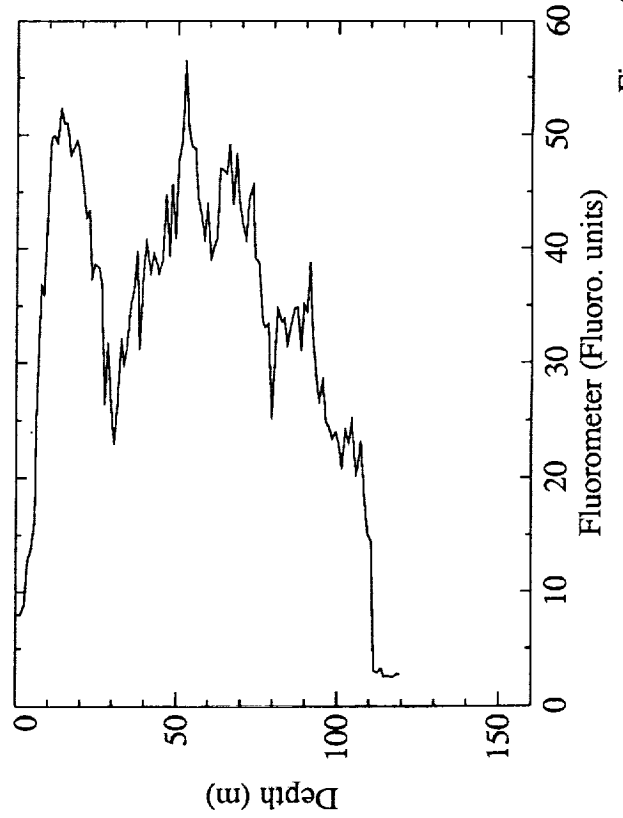
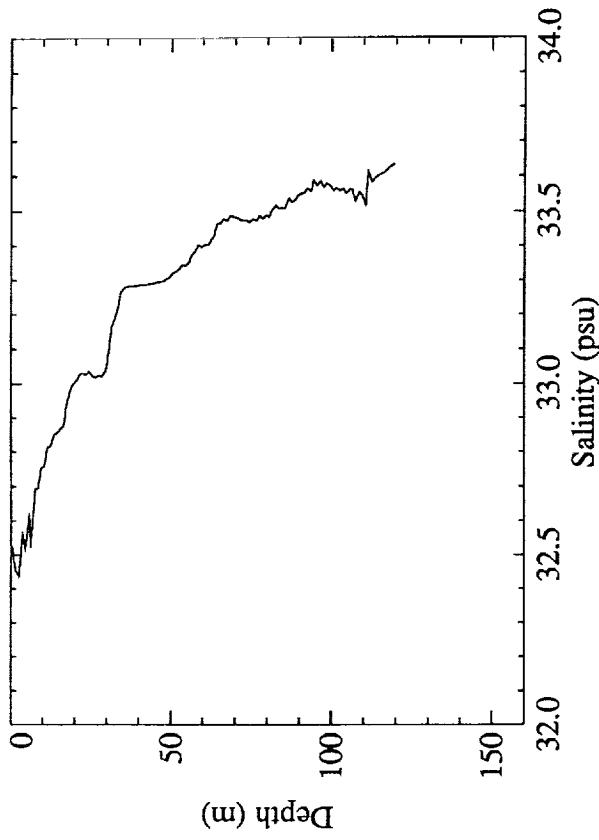
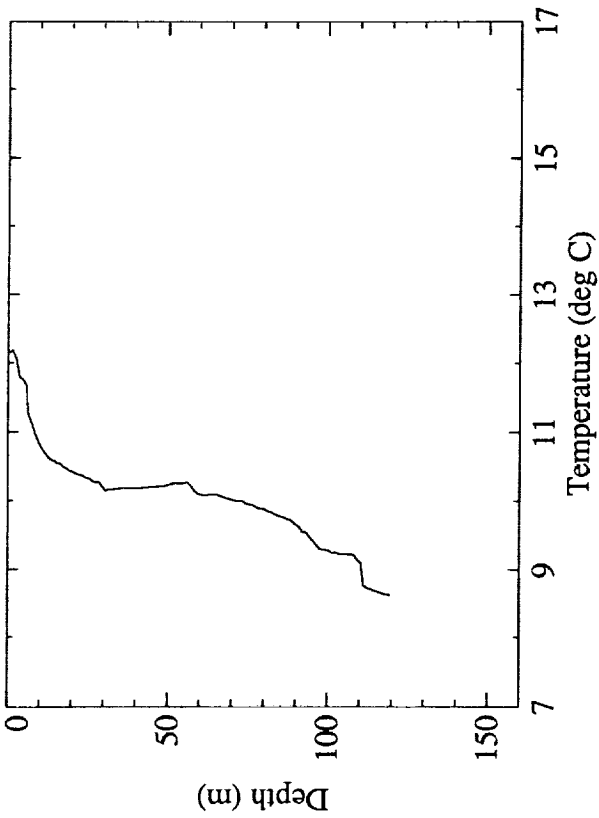


Figure 3. File: c880705d

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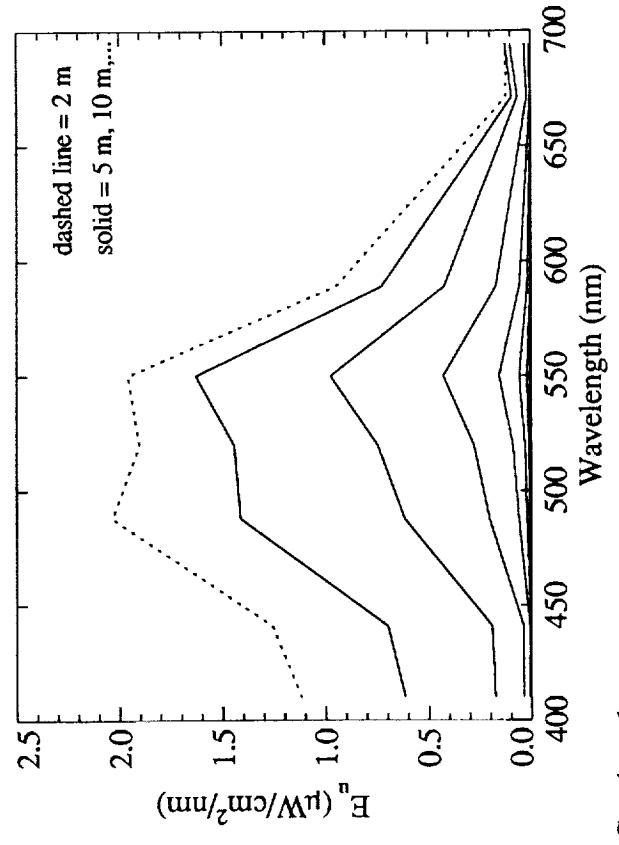
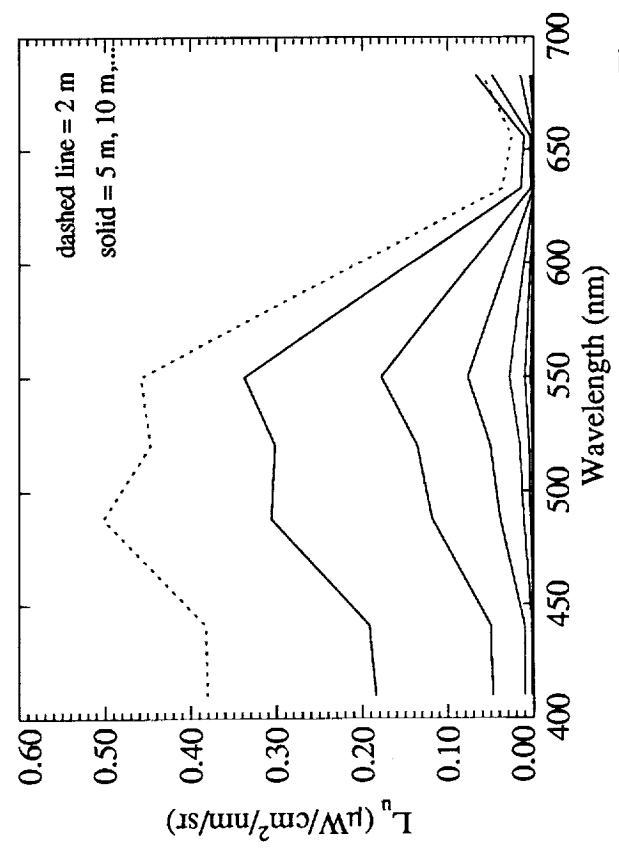
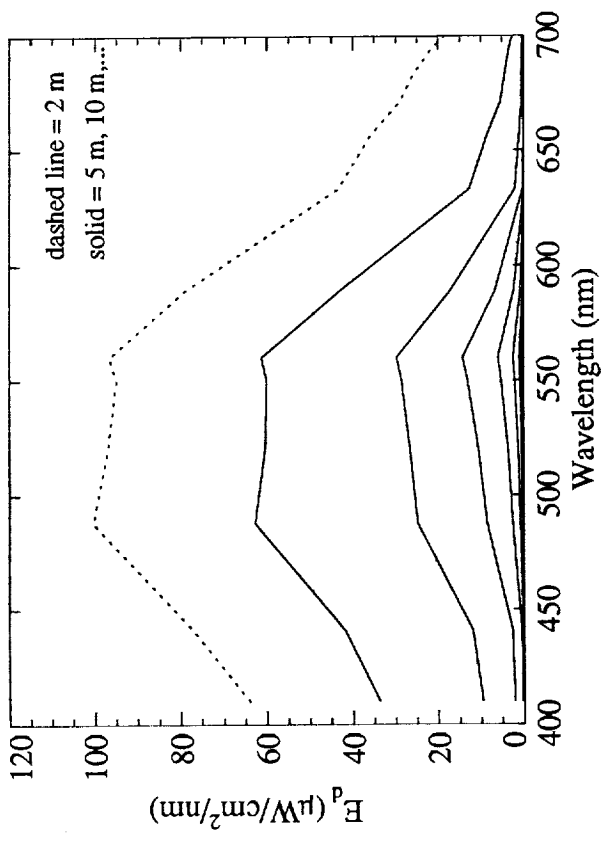
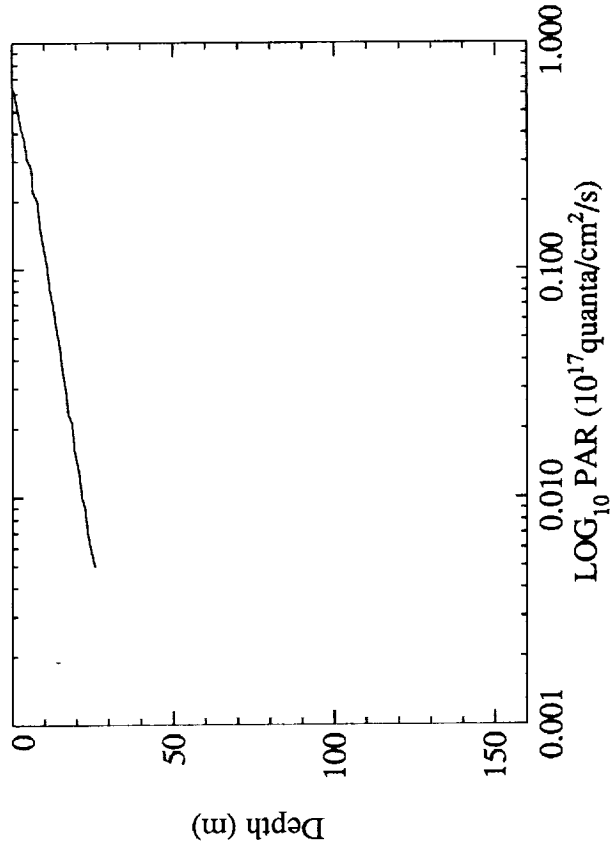


Figure 3. Continued

CTZ 07-06-88 Loc: sta 10 op 2 Lat: 38° 20.3' N Long: 124° 09.2' W File: c880706b

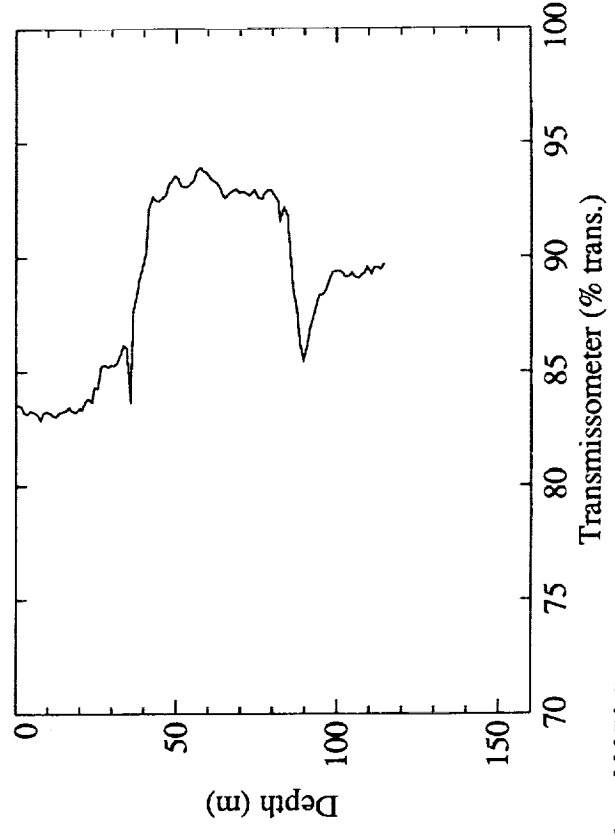
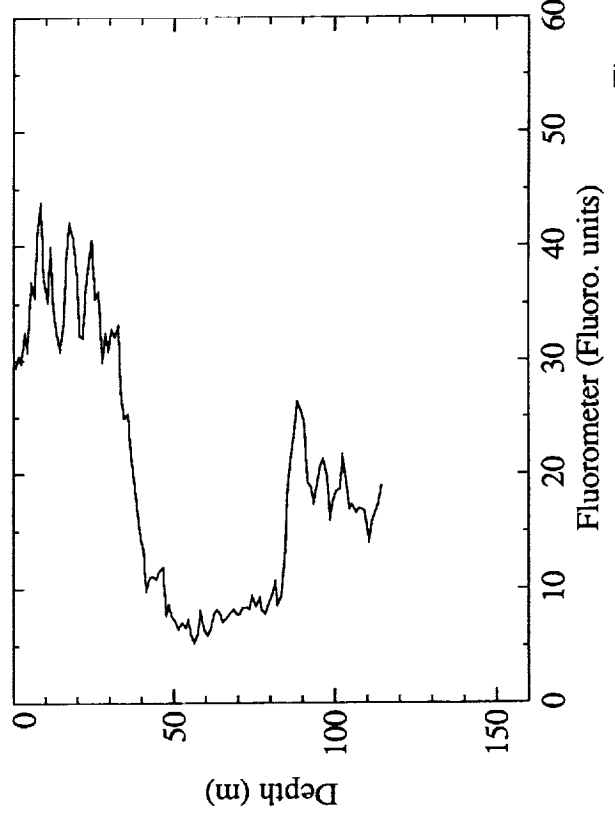
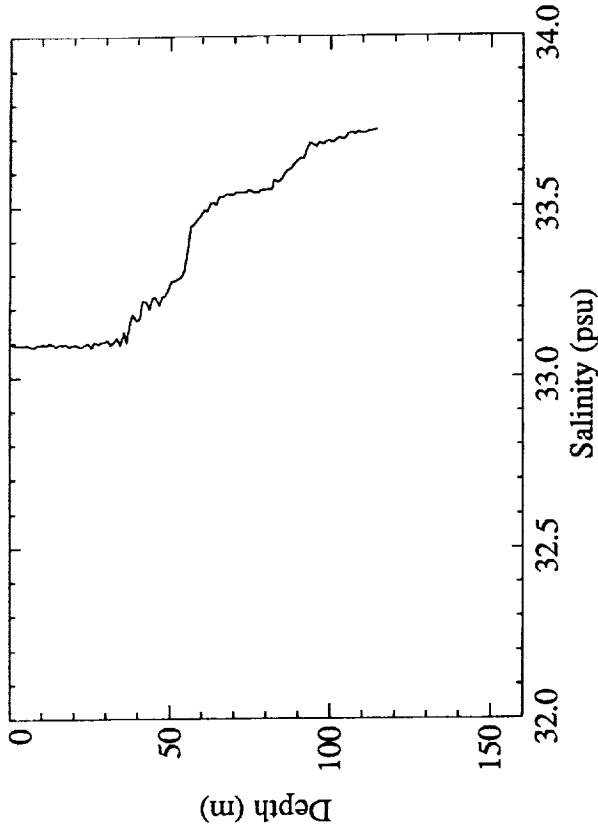
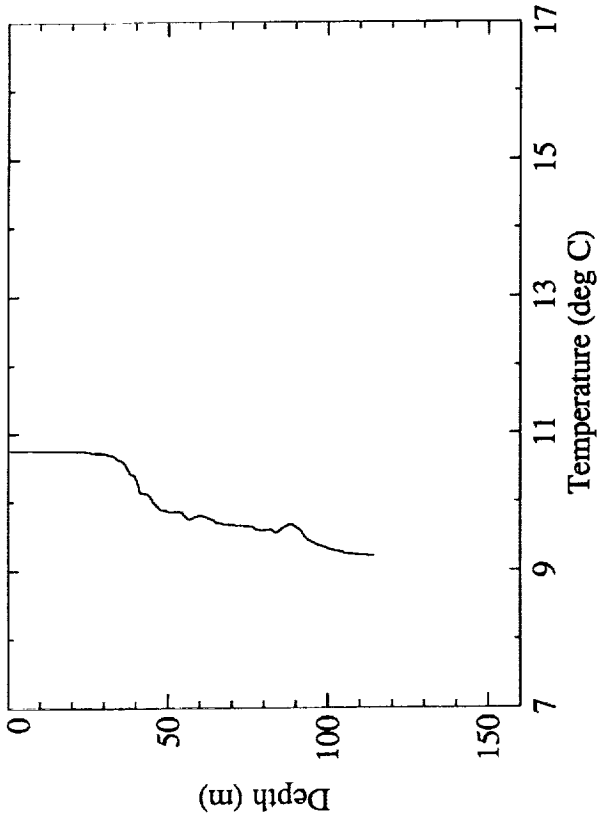


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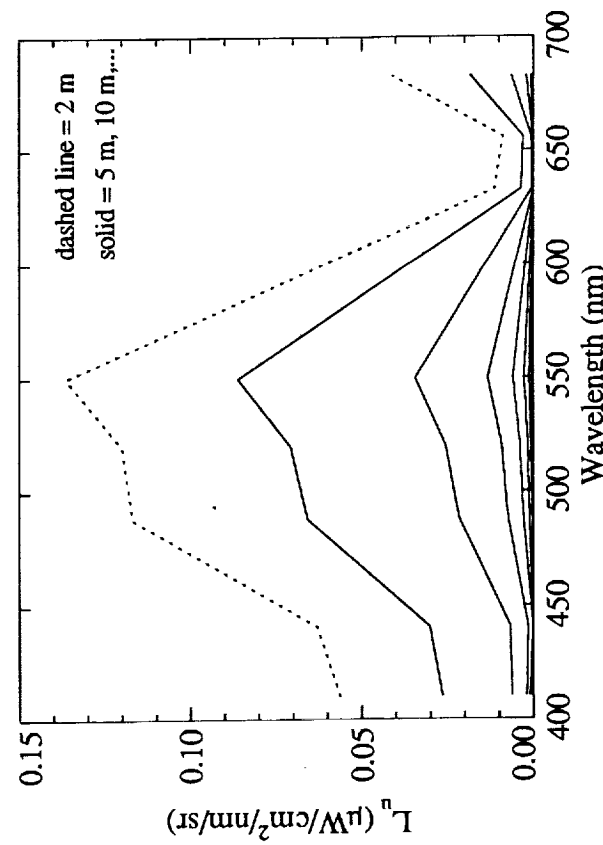
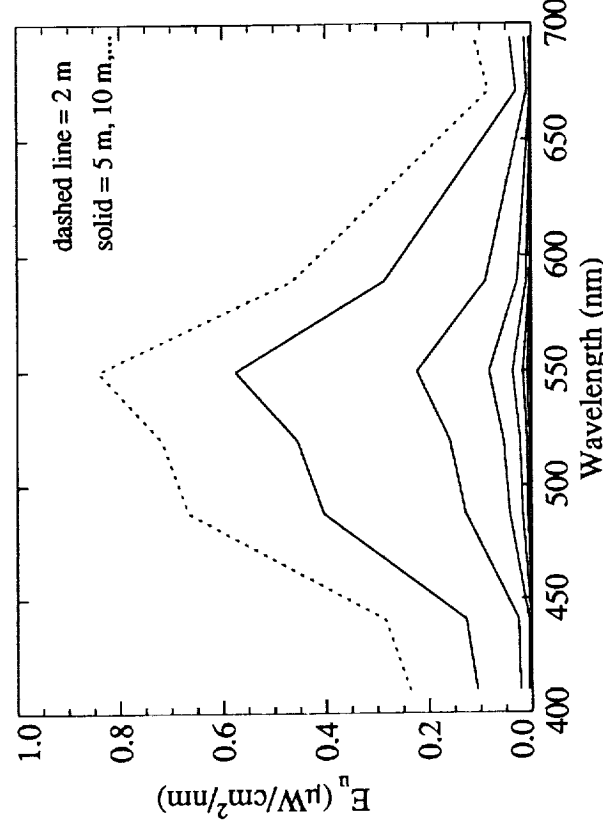
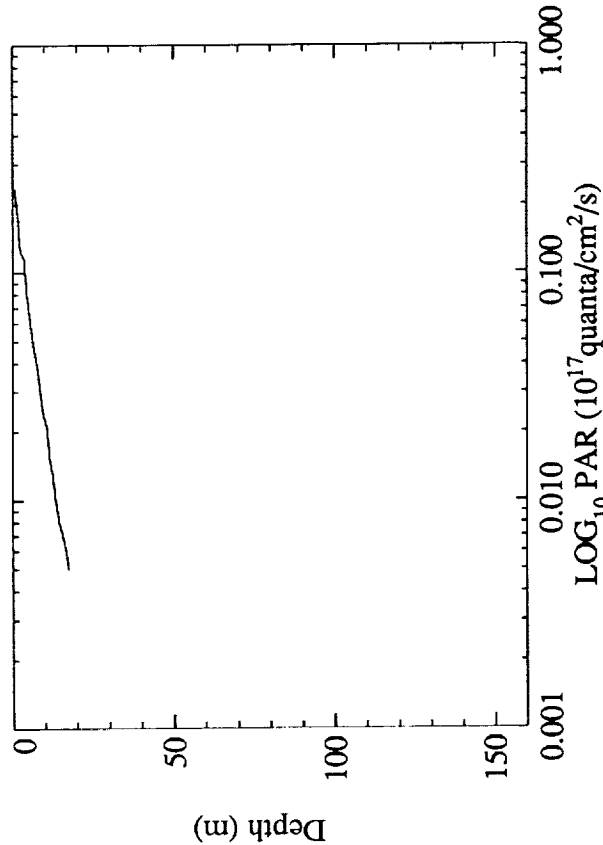
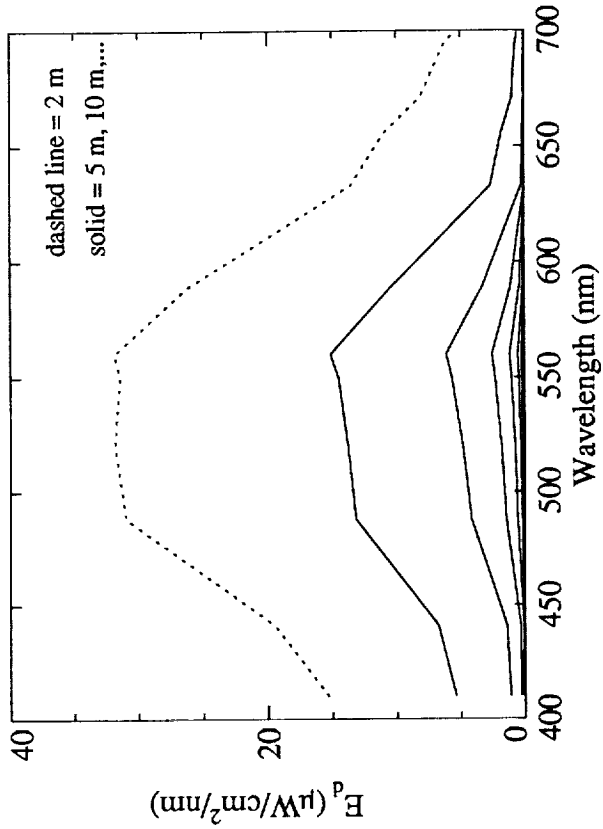


Figure 4. Continued

CTZ 07-06-88 Loc: sta 11 op 2 Lat: 38° 24.2' N Long: 124° 22.3' W File: c880706c

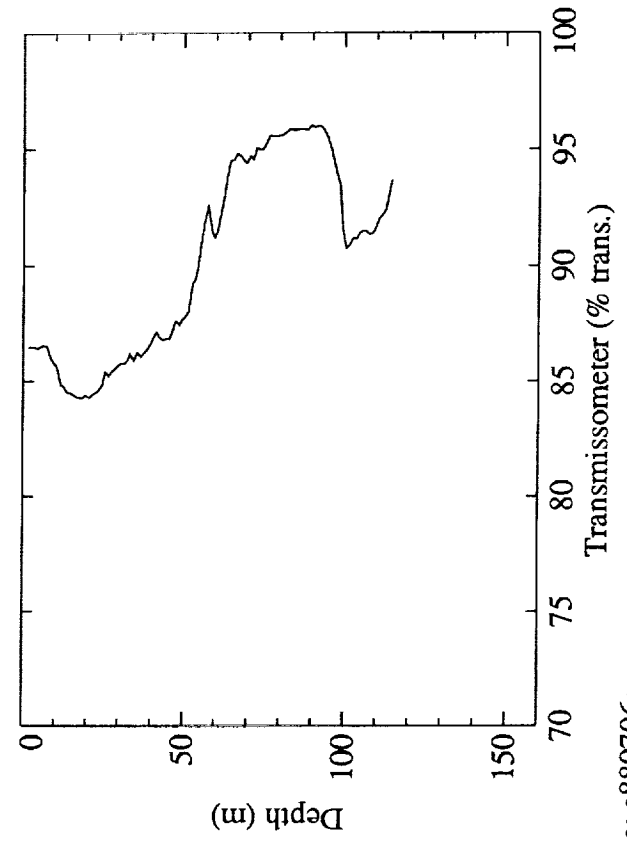
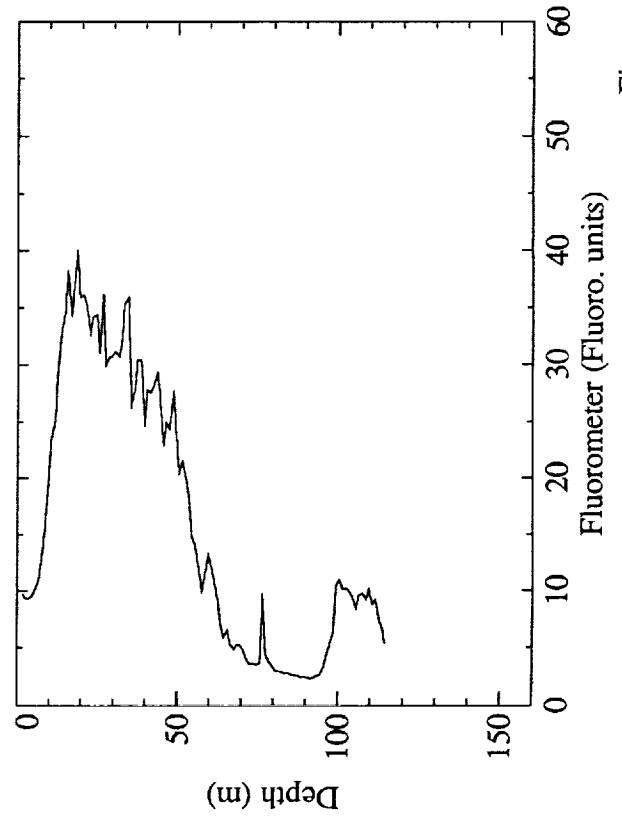
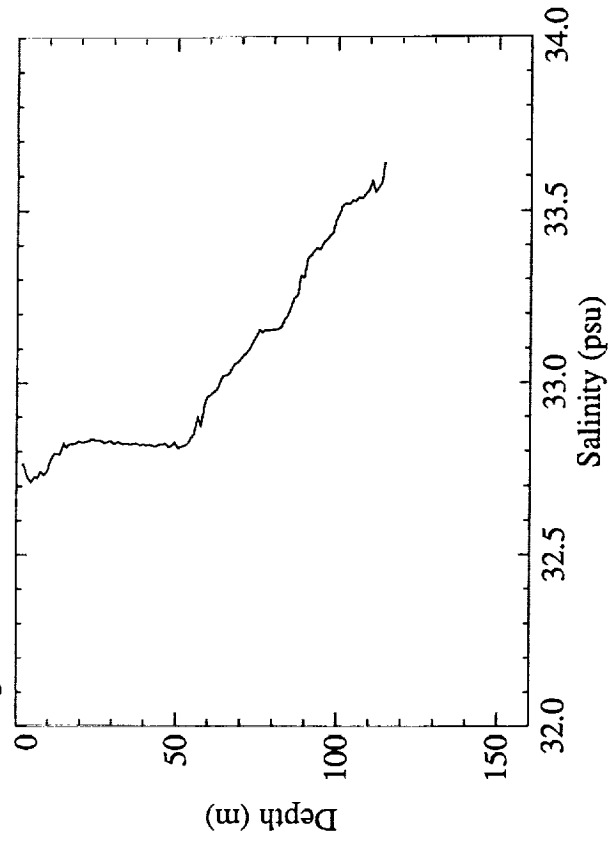
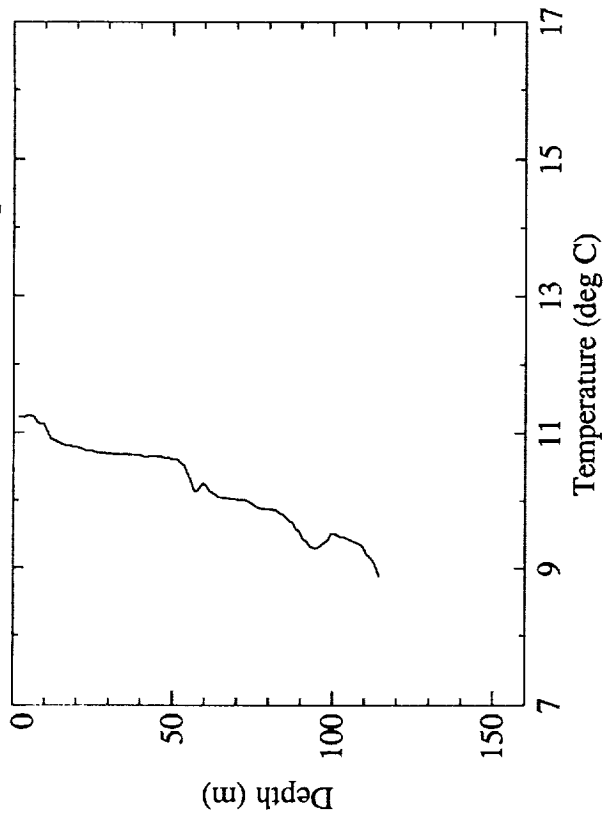


Figure 5. File: c880706c

CTZ 07-06-88 Loc: sta 11 op 2 Lat: 38° 24.2' N Long: 124° 22.3' W File: c880706c

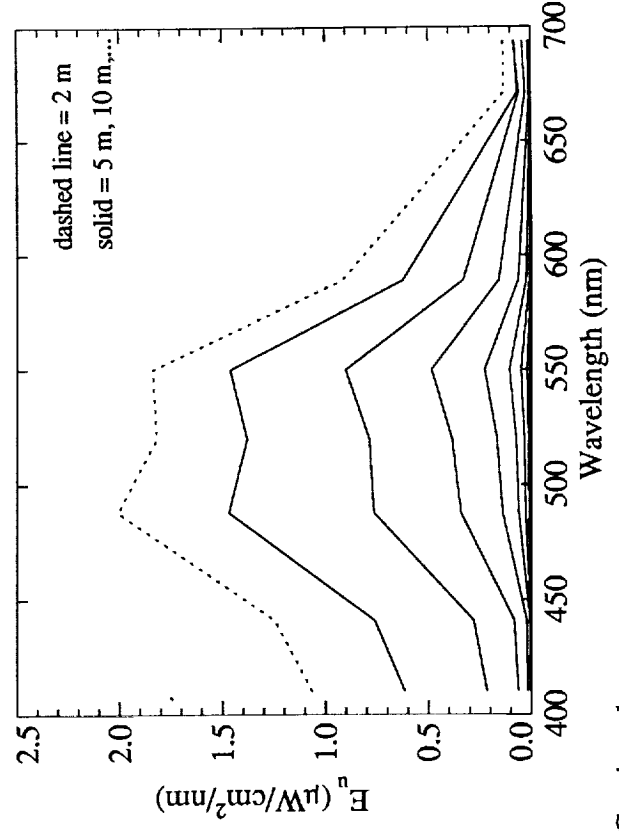
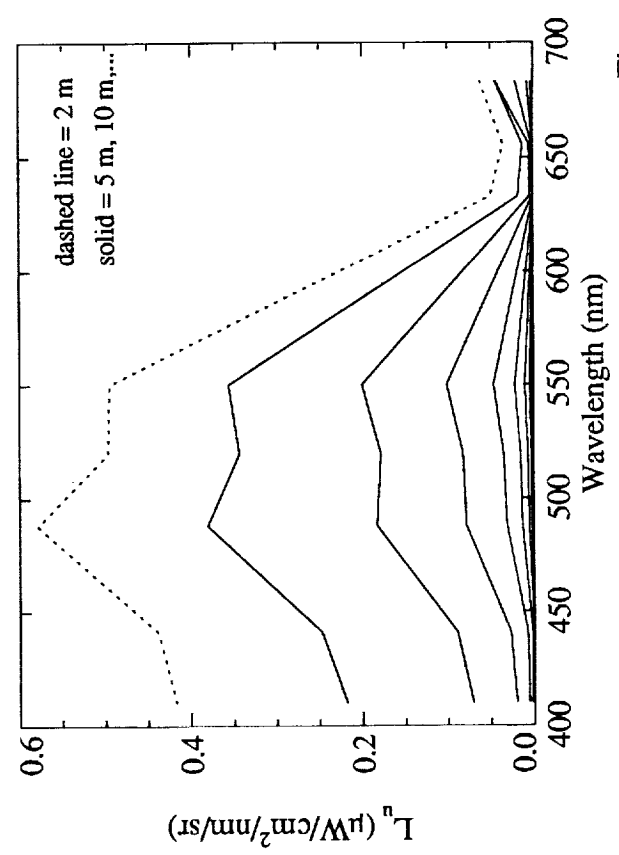
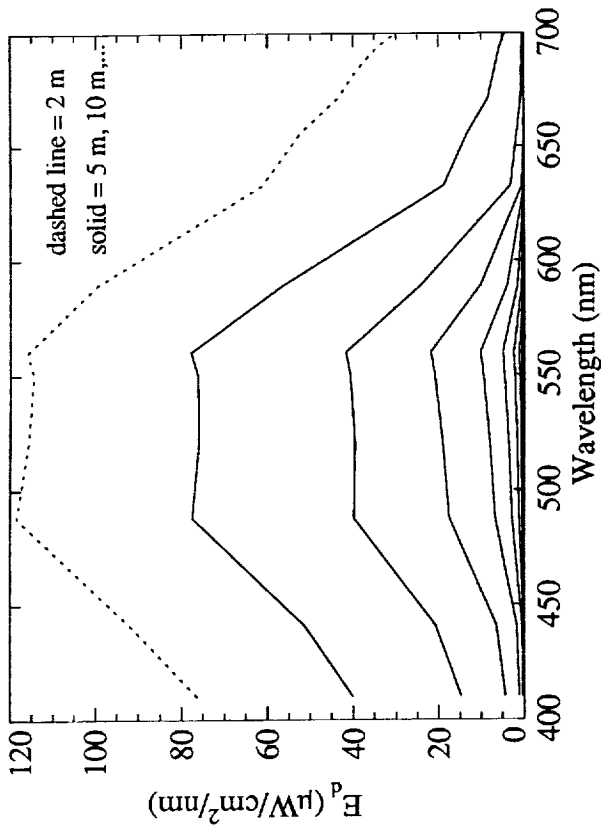
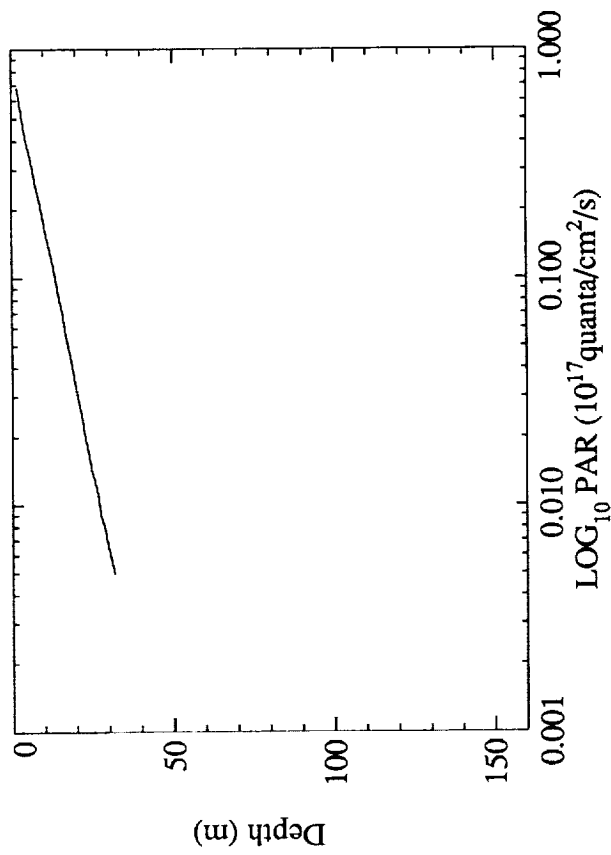


Figure 5. Continued

CTZ 07-07-88 Loc: sta 16 op 2 Lat: 38° 06.6' N Long: 124° 34.8' W File: c880707a

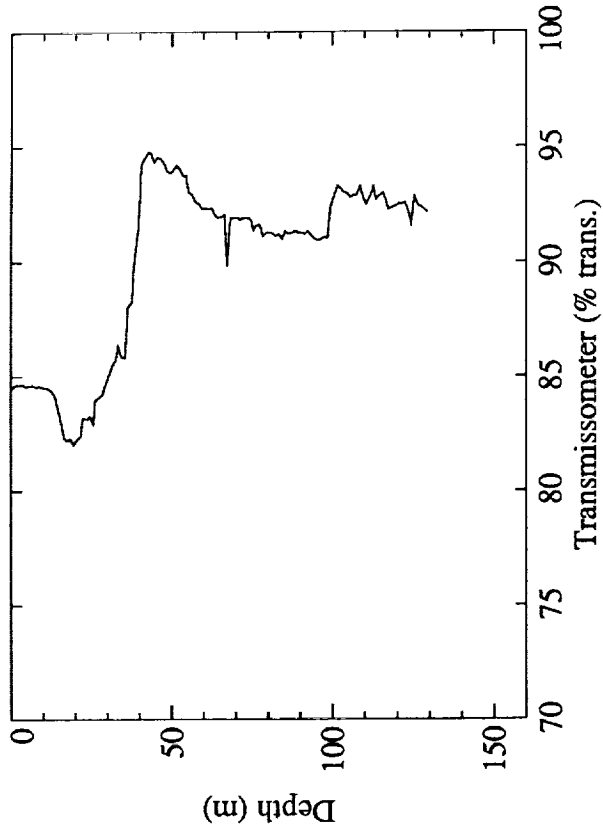
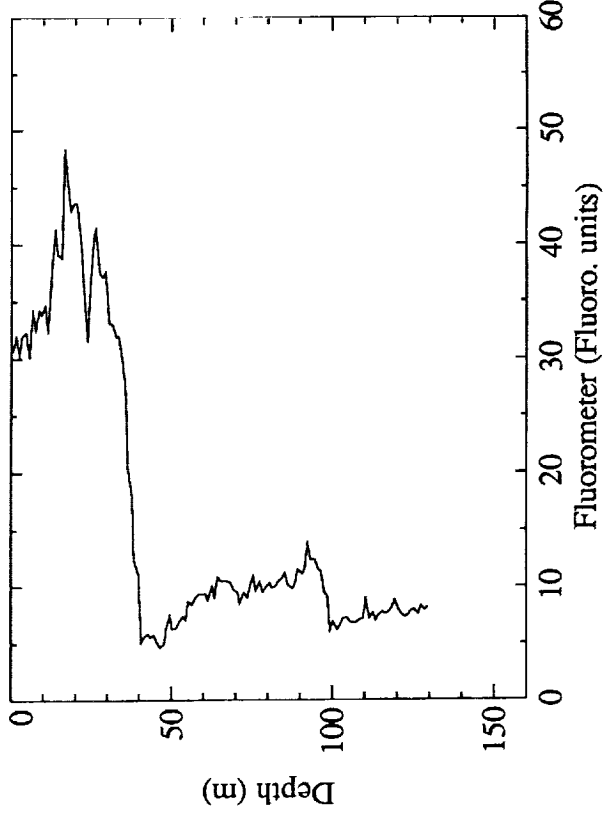
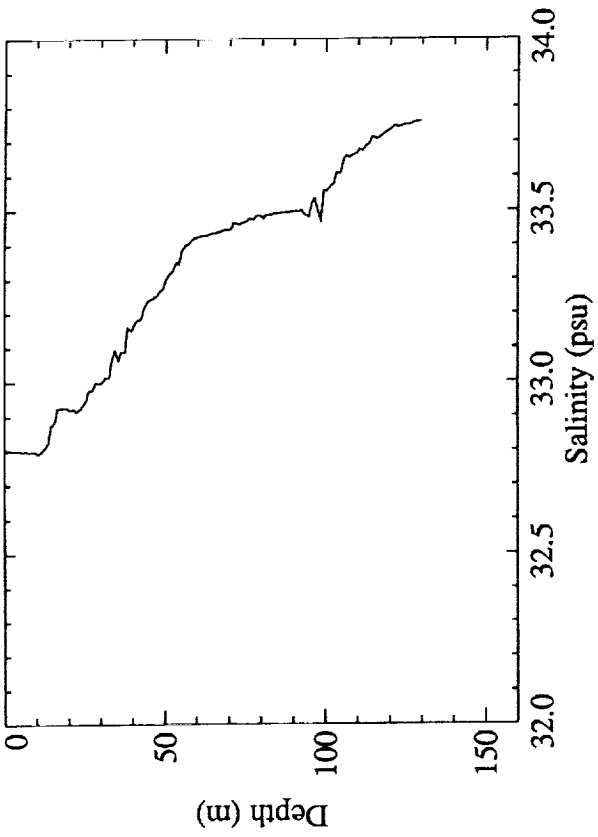
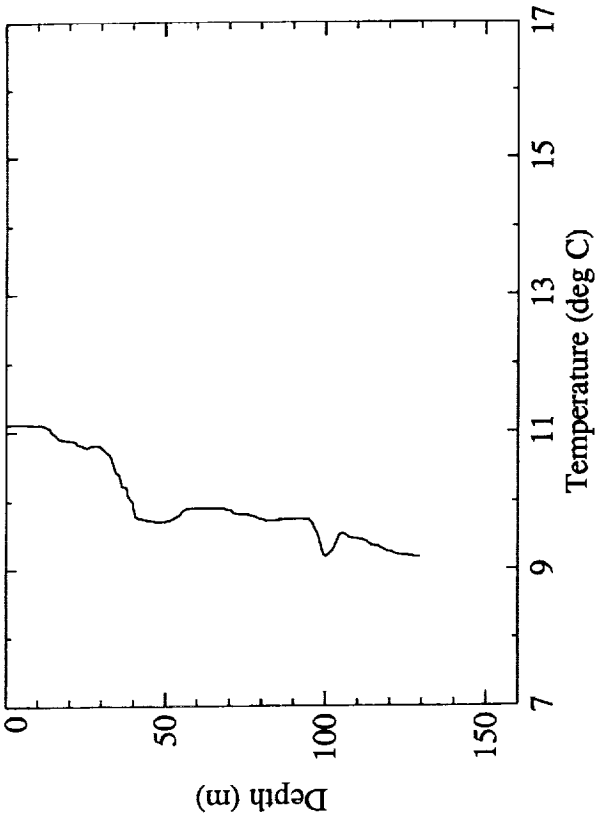


Figure 6. File: c880707a

CTZ 07-07-88 Loc: sta 16 op 2 Lat: 38° 06.6' N Long: 124° 34.8' W File: c880707a

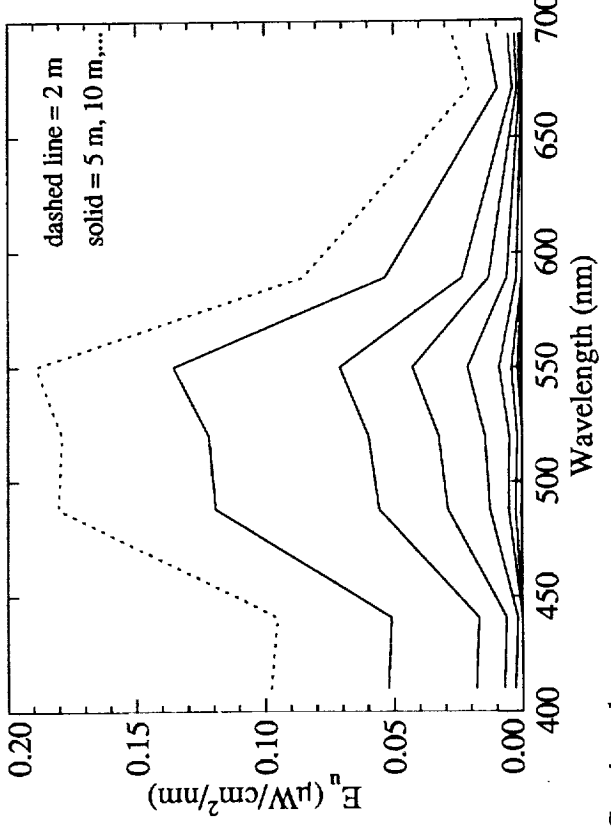
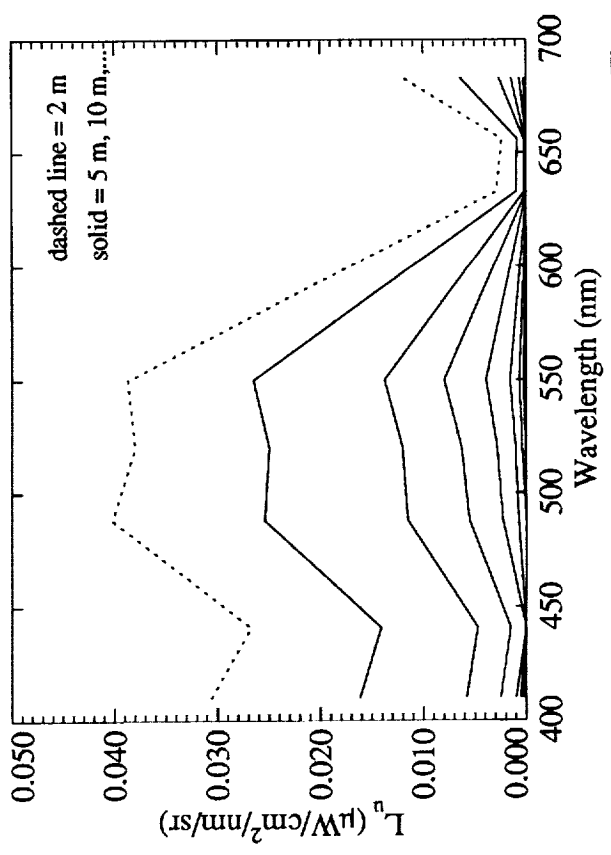
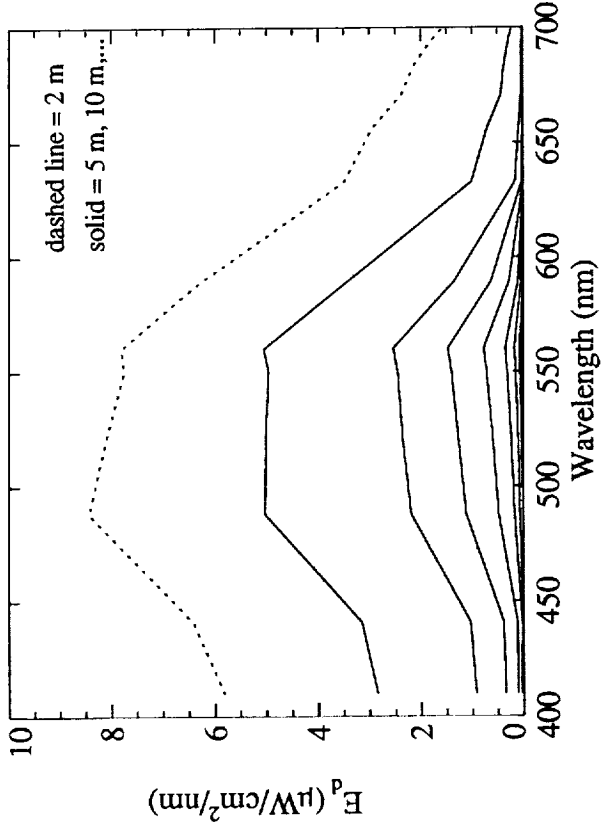
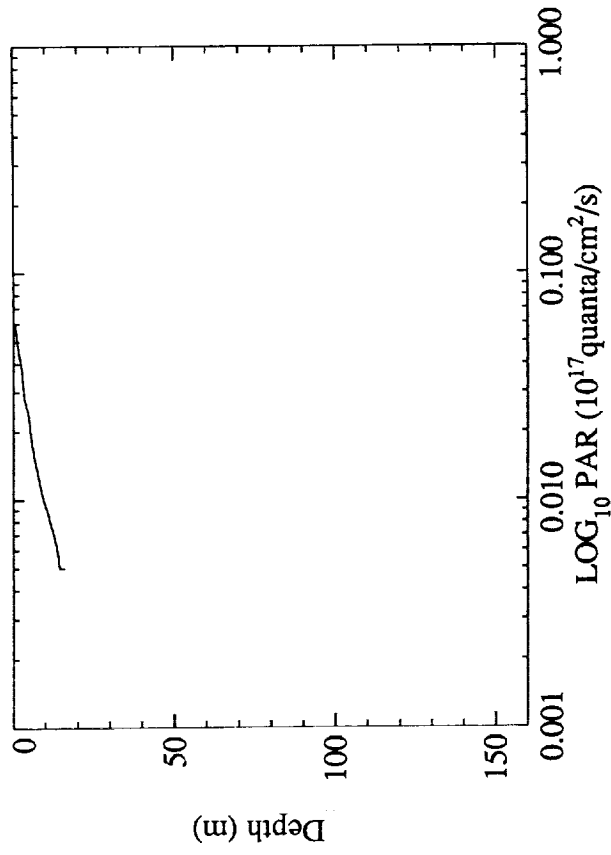


Figure 6. Continued

CTZ 07-07-88 Loc: sta 17 op 2 Lat: 38° 07.2' N Long: 124° 54.1' W File: c880707b

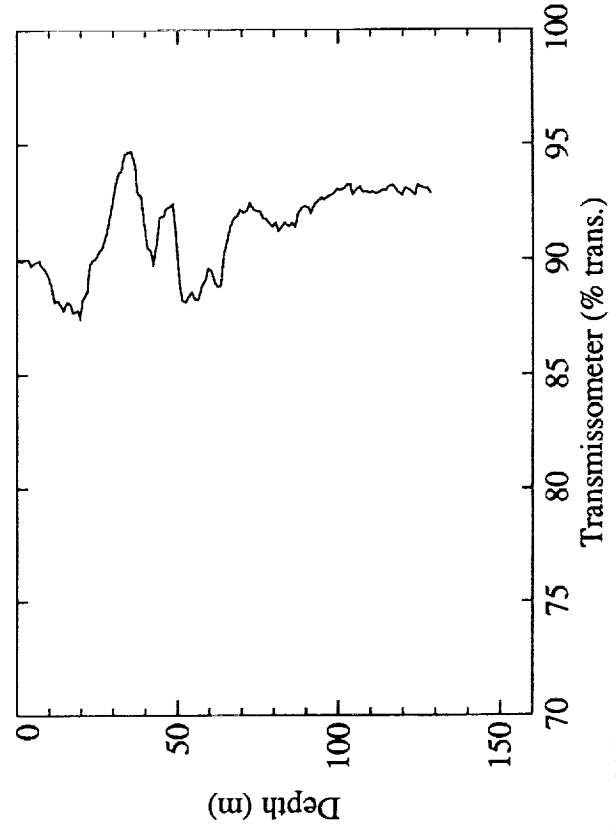
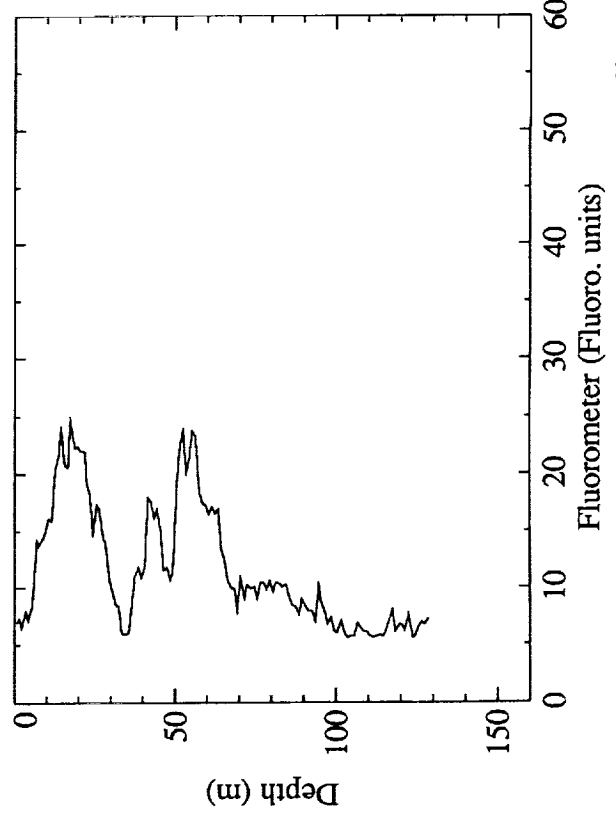
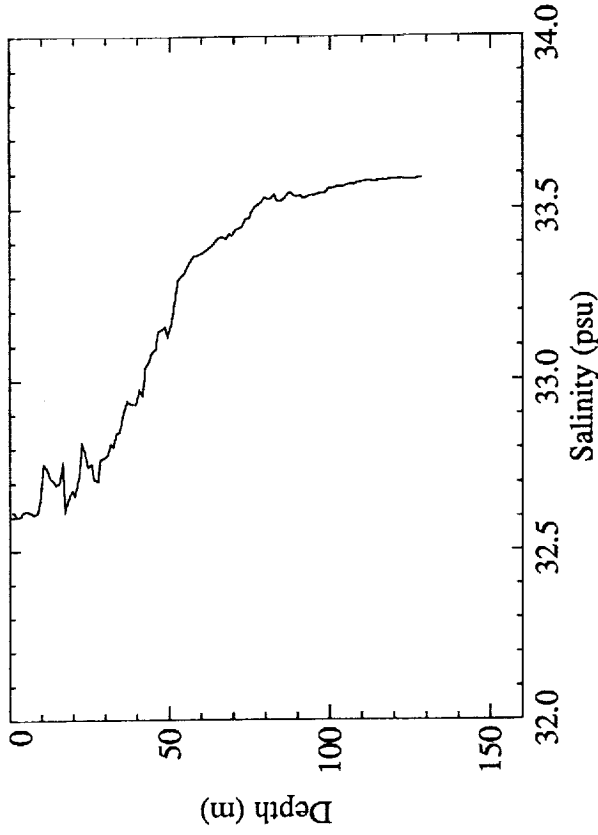
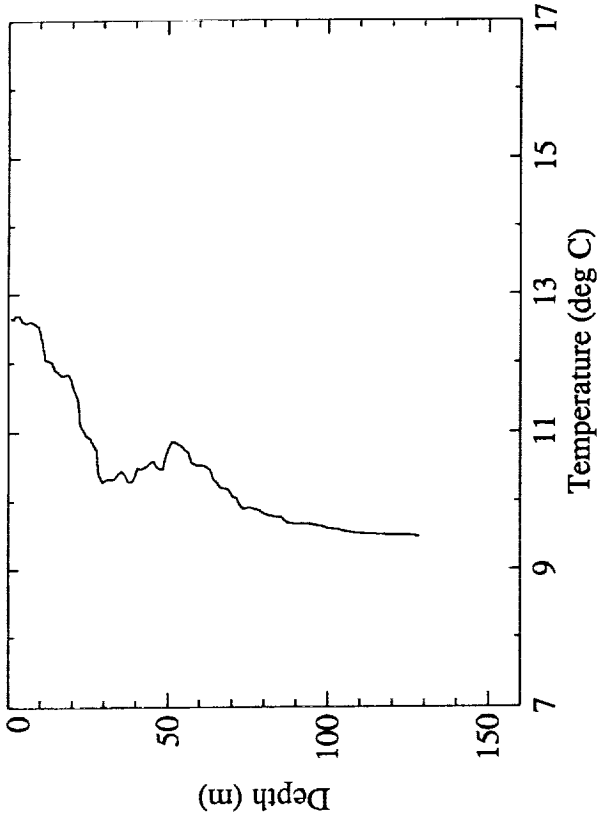


Figure 7. File: c880707b

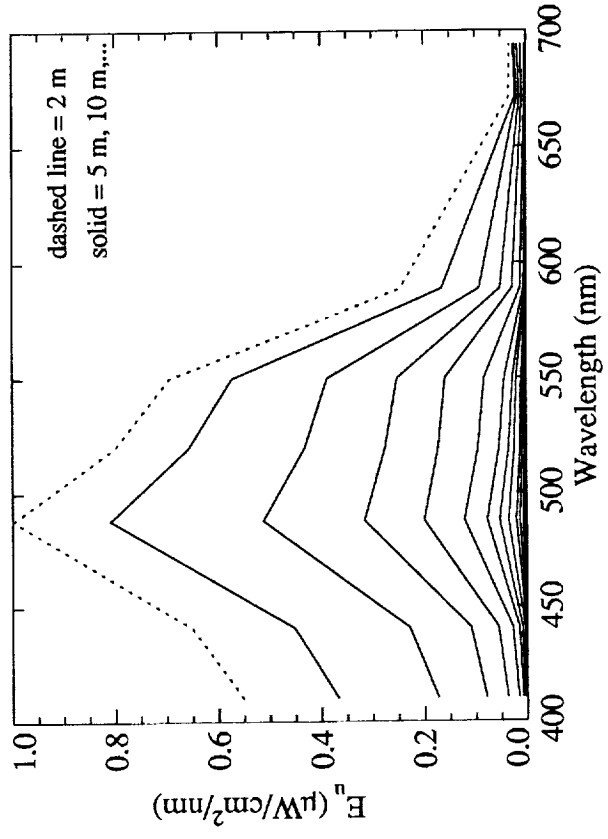
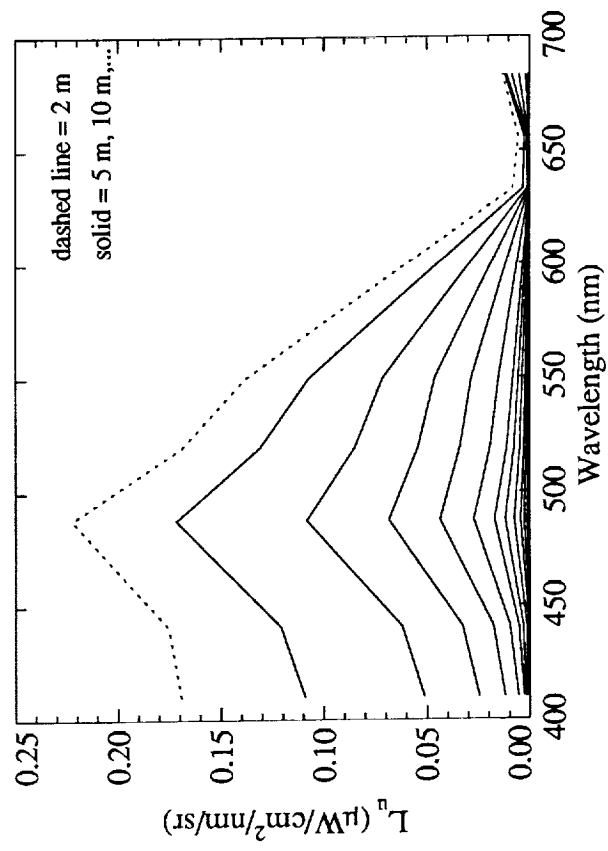
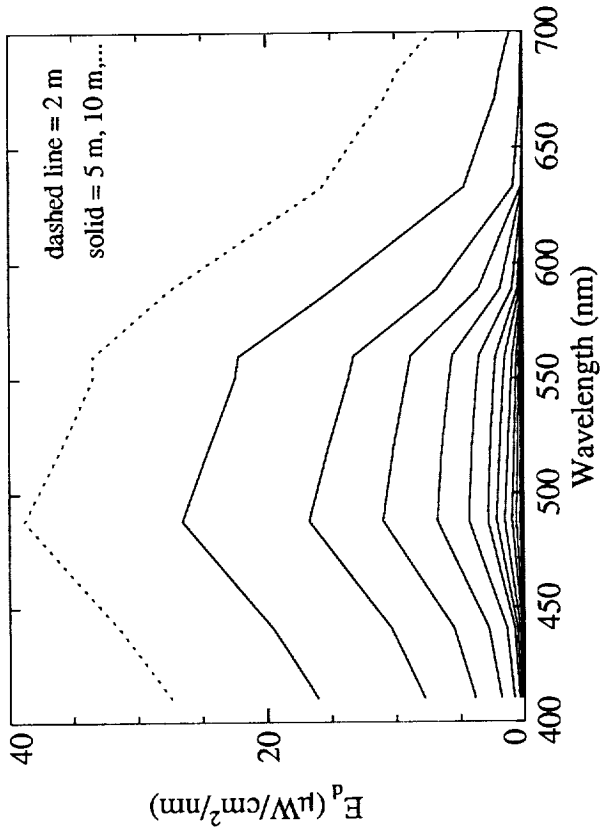
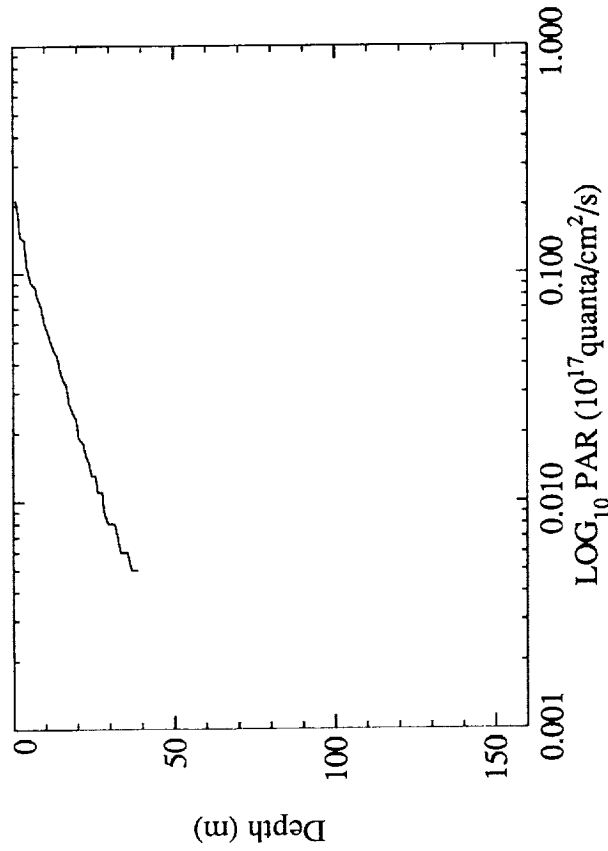


Figure 7. Continued

CTZ 07-08-88 Loc: sta 21 op 2 Lat: 37° 45.5' N Long: 125° 03.6' W File: c880708a

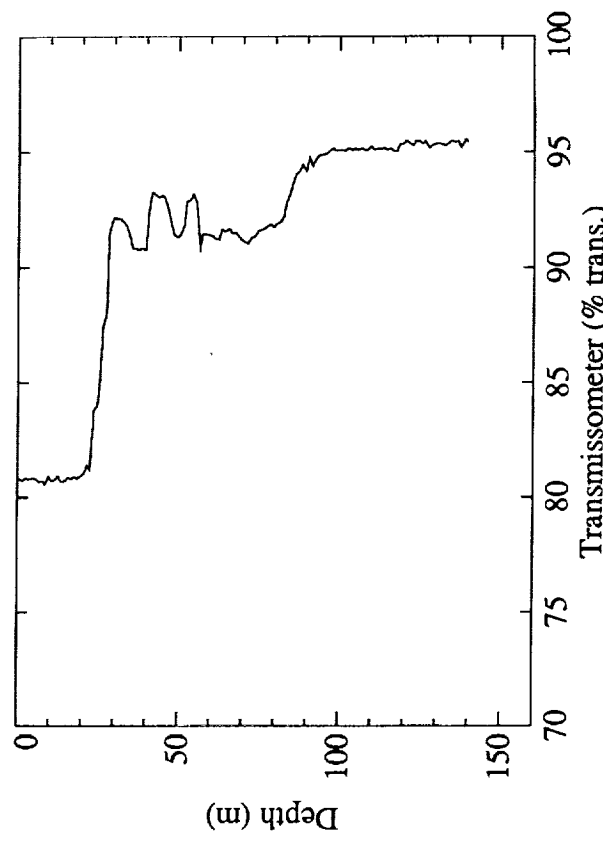
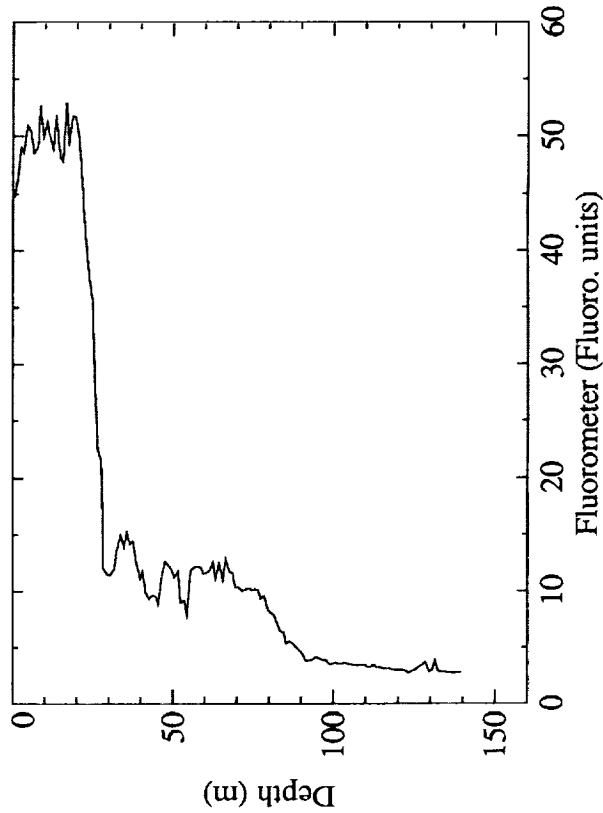
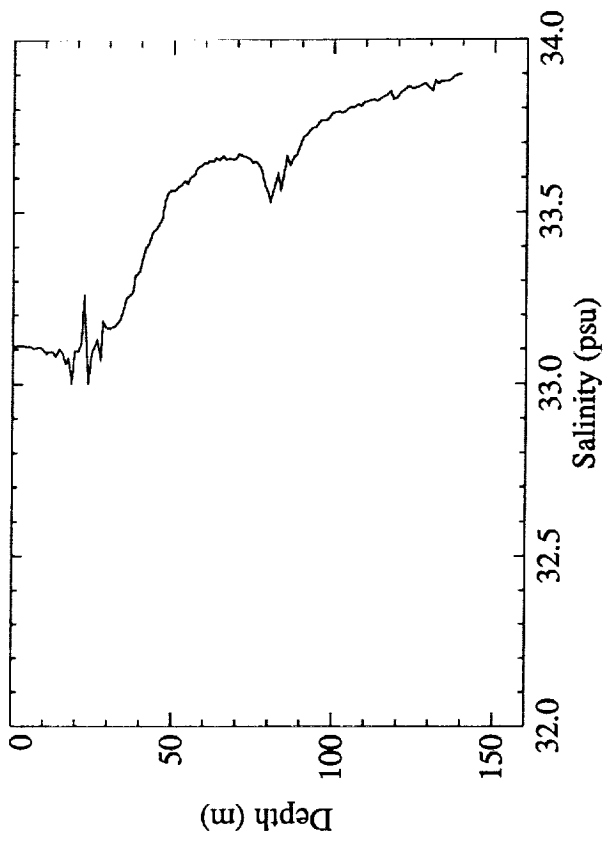
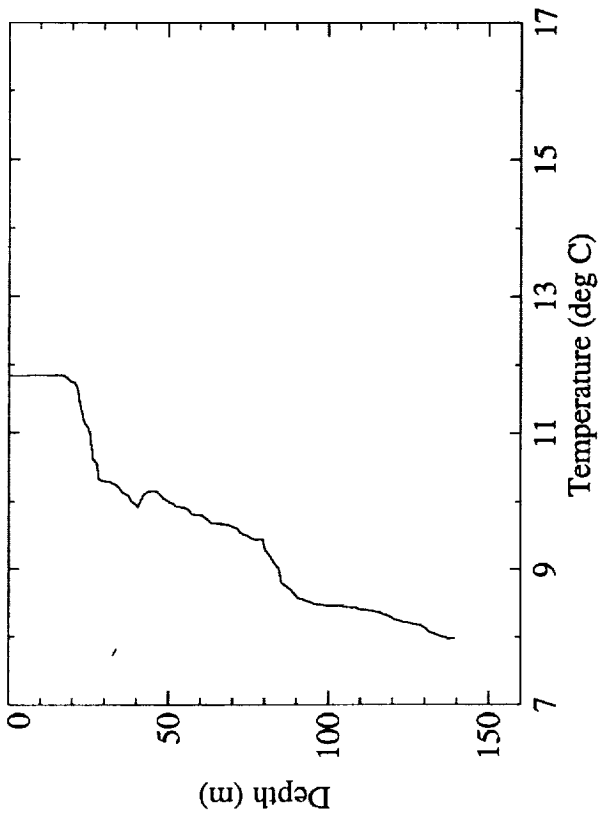


Figure 8. File: c880708a

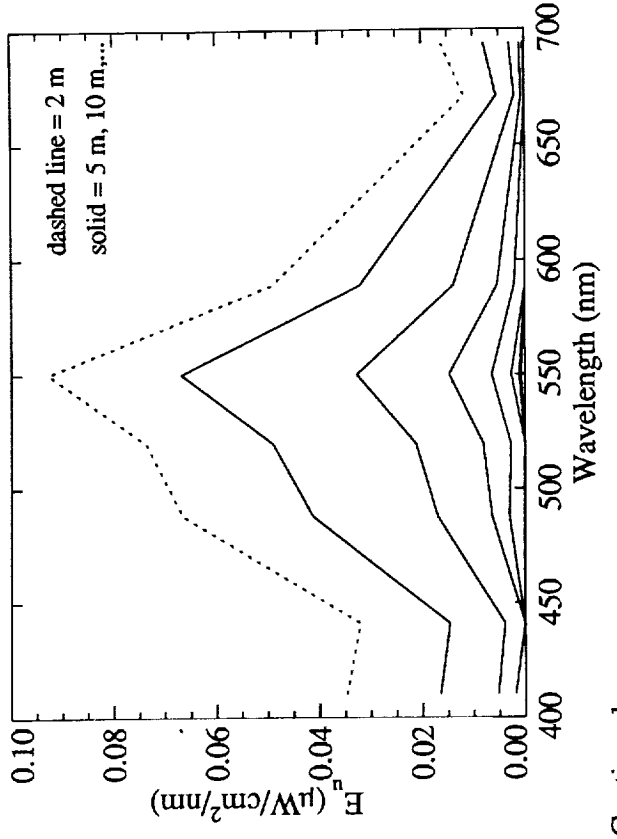
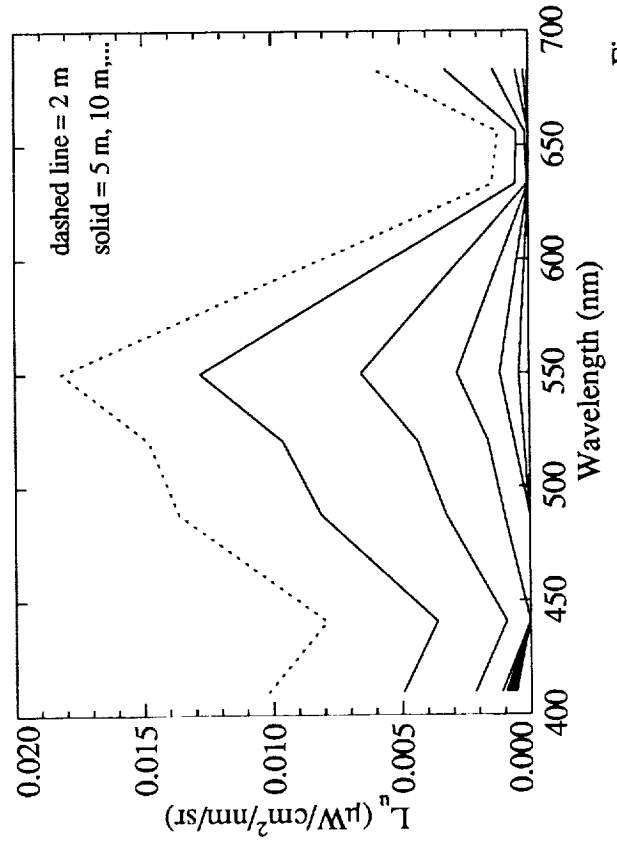
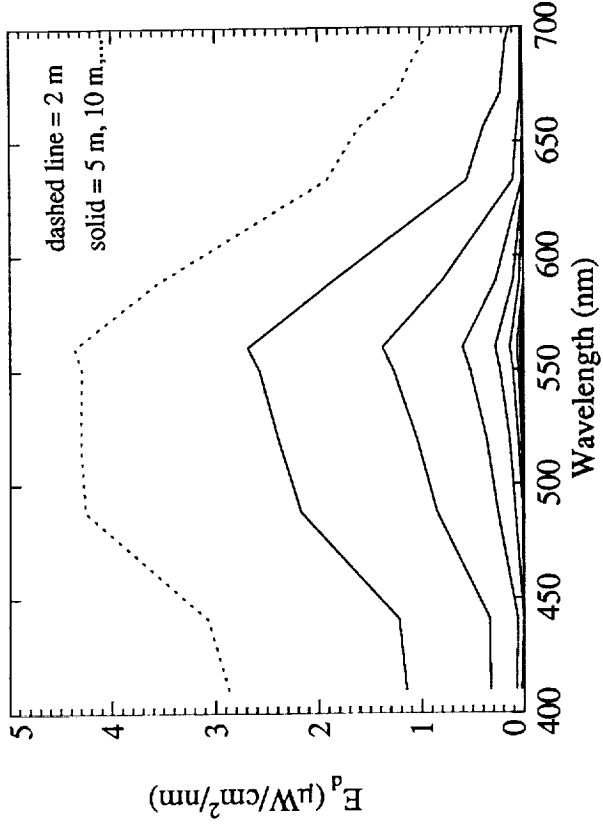
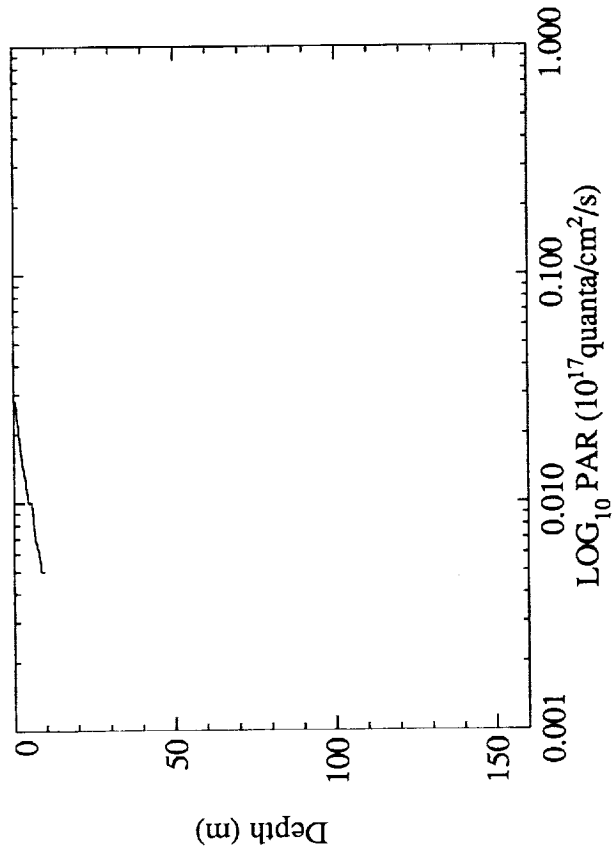


Figure 8. Continued

CTZ 07-08-88 Loc: sta 22 op 1 Lat: 37° 53.5' N Long: 125° 37.9' W File: c880708b

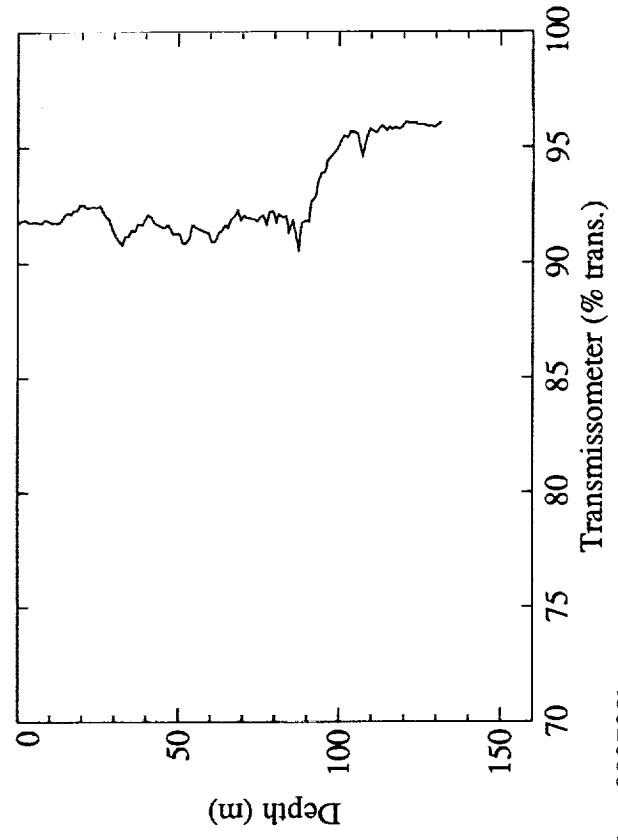
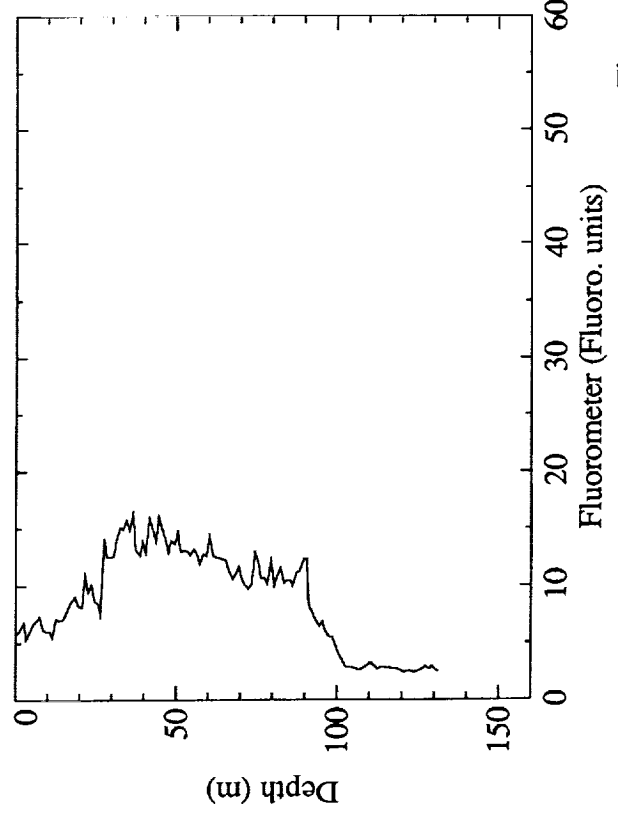
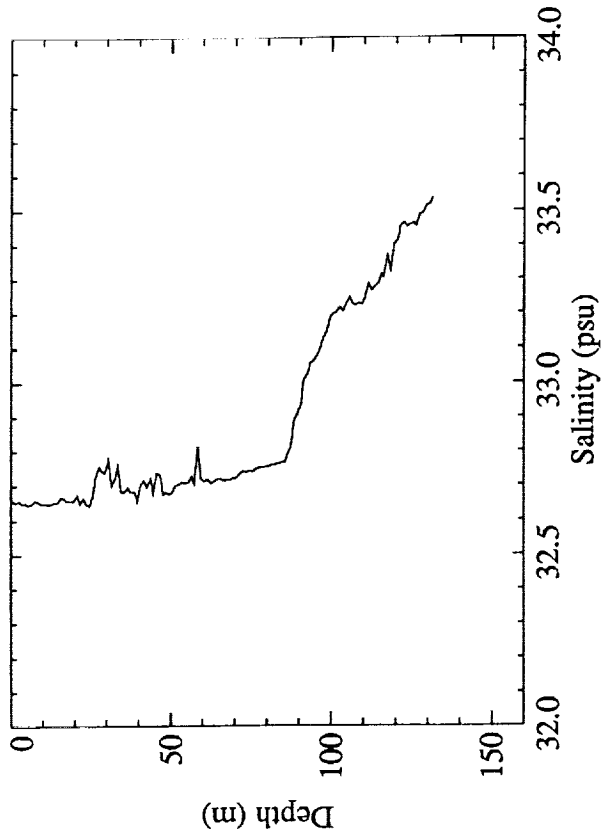
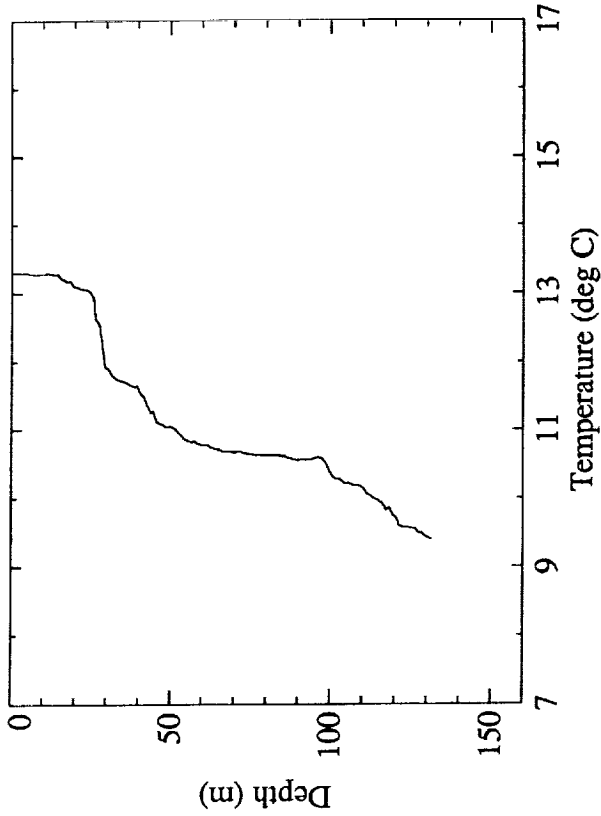


Figure 9. File: c880708b

CTZ 07-08-88 Loc: sta 22 op 1 Lat: 37° 53.5' N Long: 125° 37.9' W File: c880708b

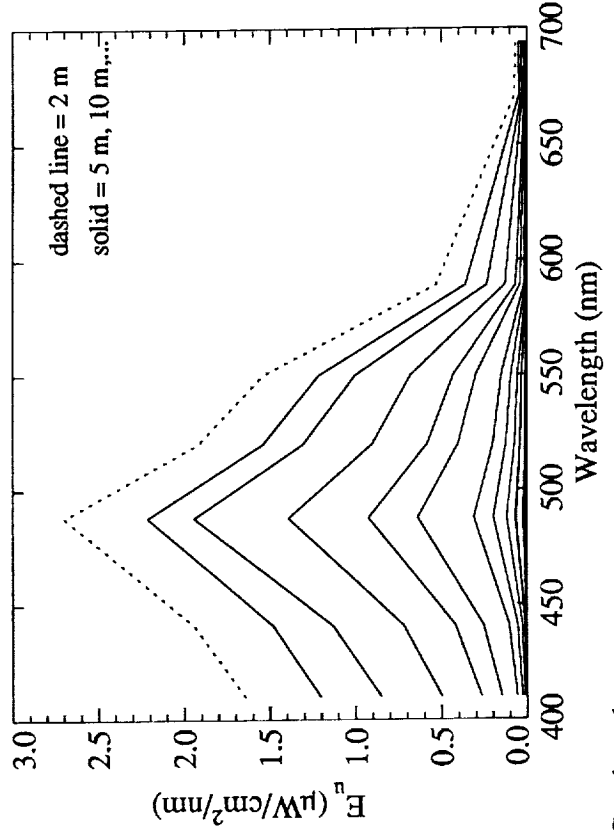
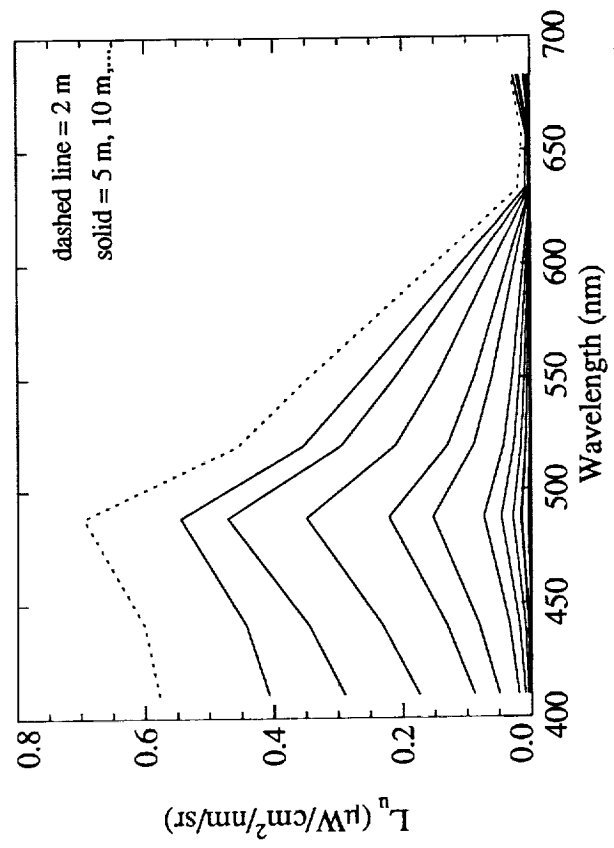
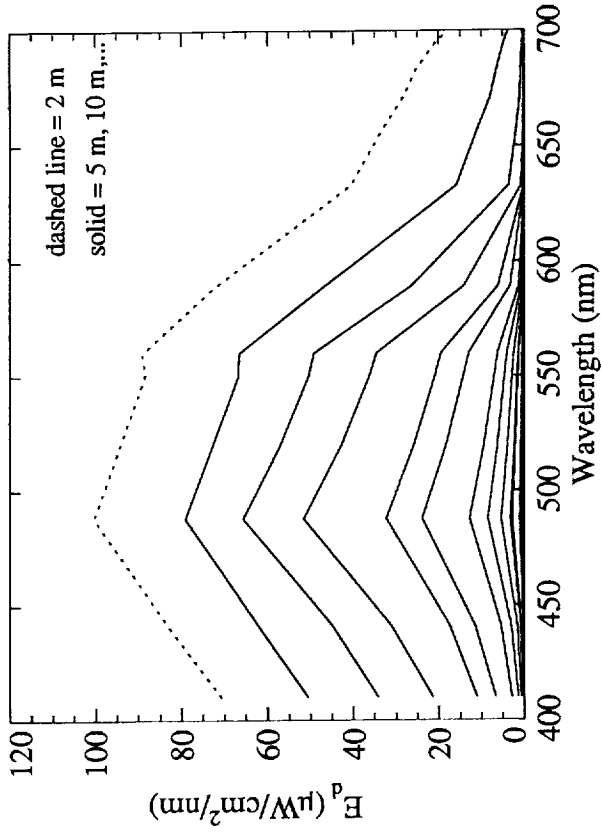
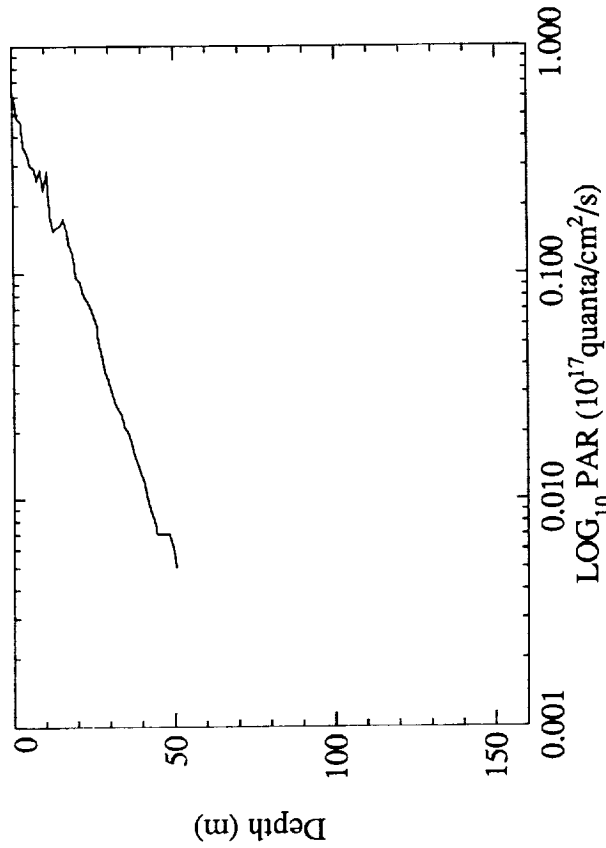


Figure 9. Continued

CTZ 07-09-88 Loc: sta 27 op 3 Lat: 37° 29.7' N Long: 126° 02.3' W File: c880709b

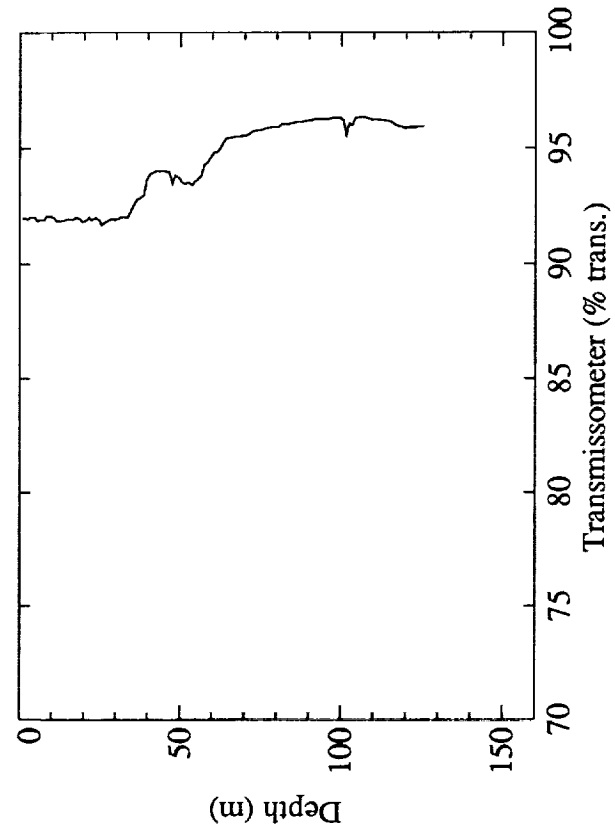
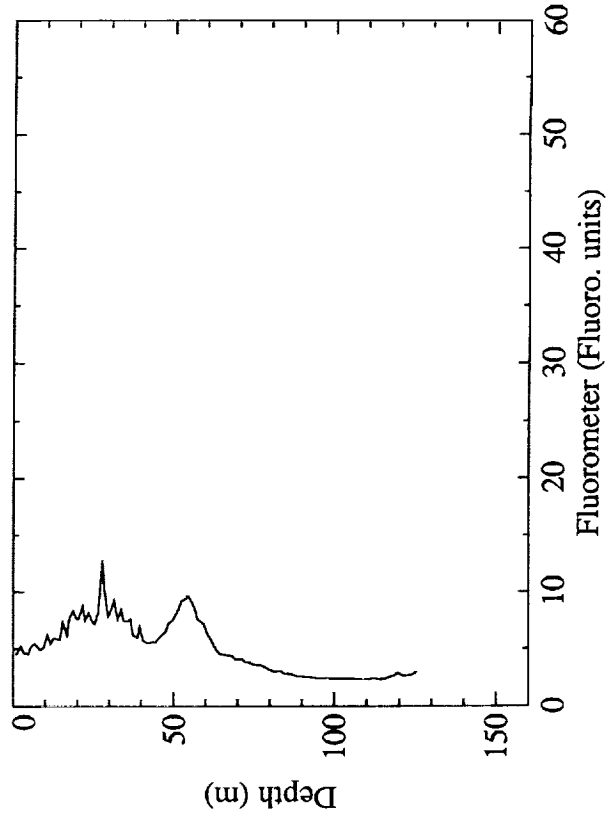
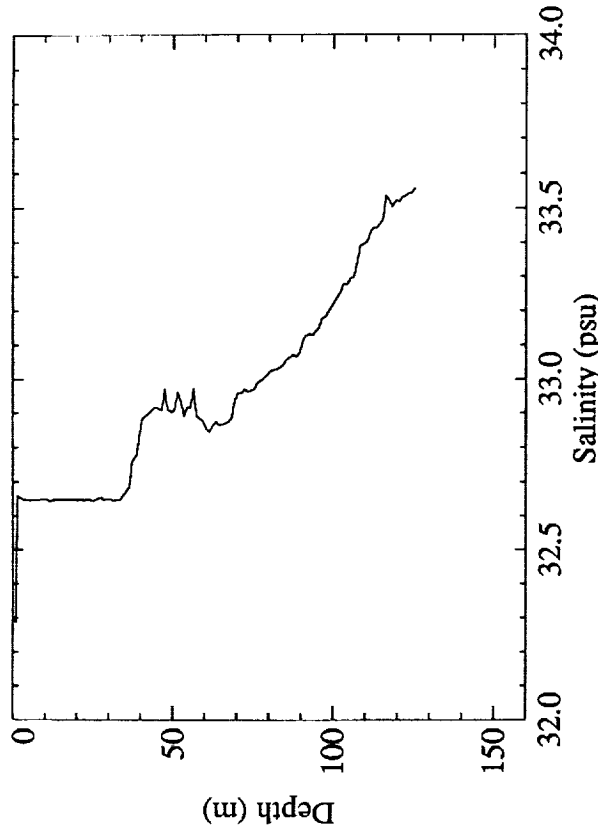
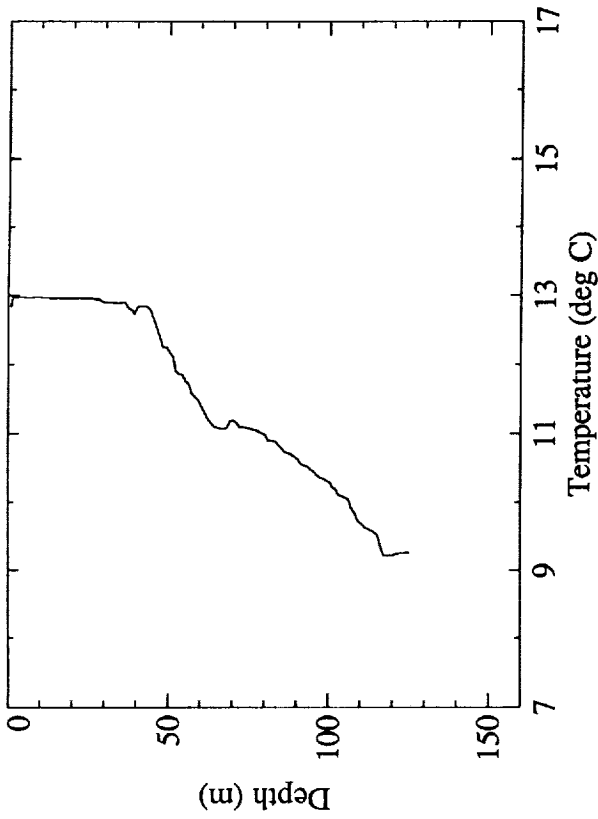


Figure 10. File: c880709b

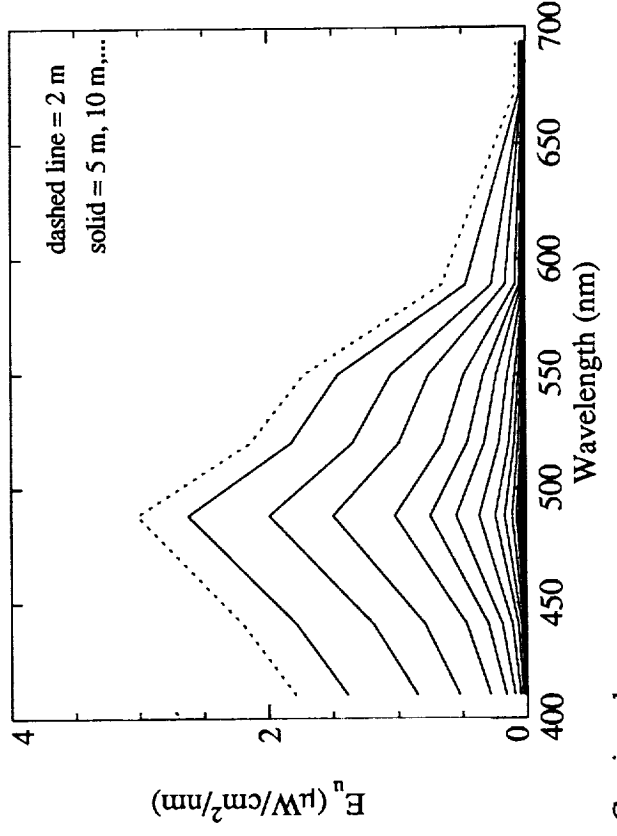
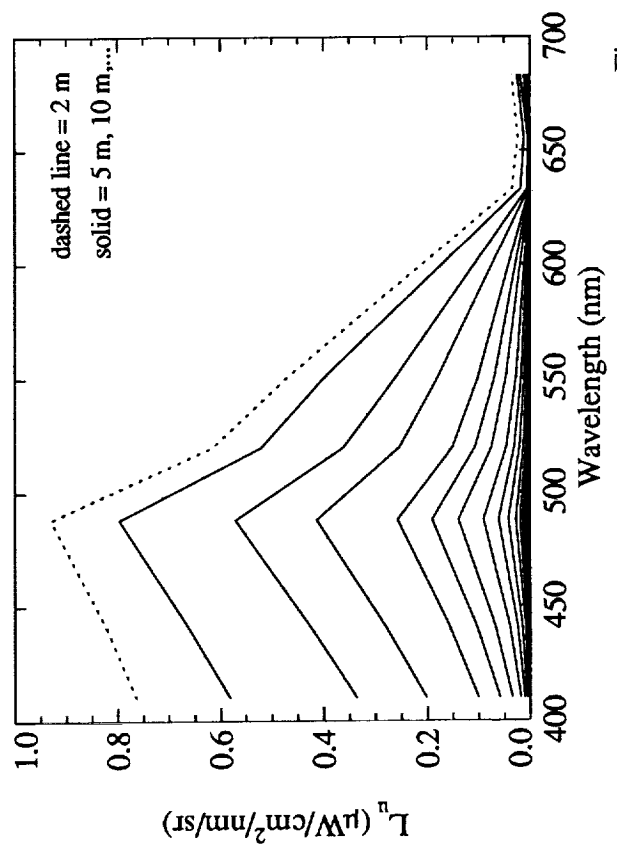
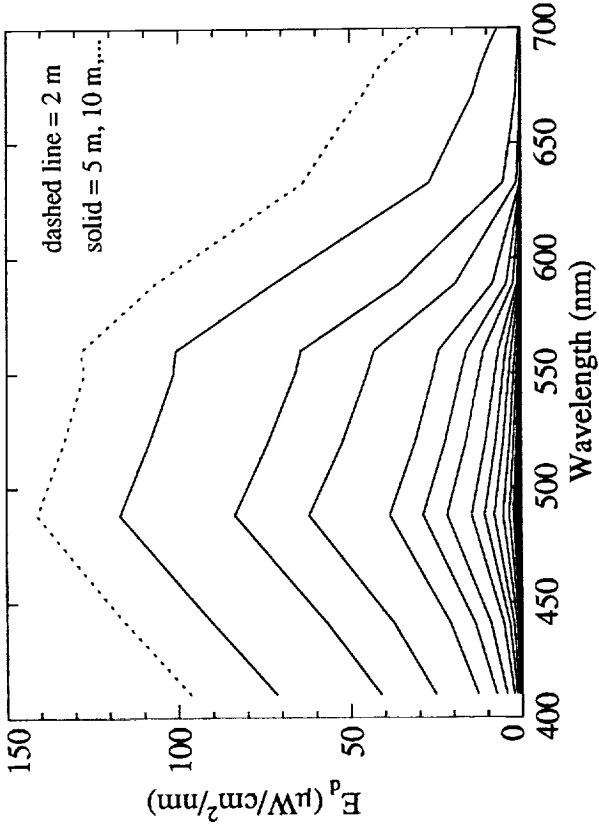
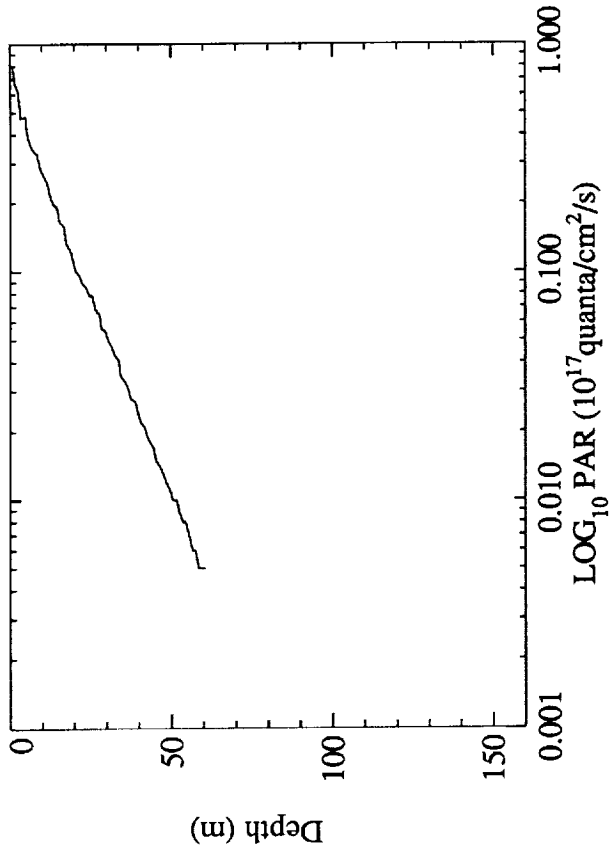


Figure 10. Continued

CTZ 07-10-88 Loc: sta 31 op 2 Lat: 37° 07.6' N Long: 126° 09.7' W File: c880710a

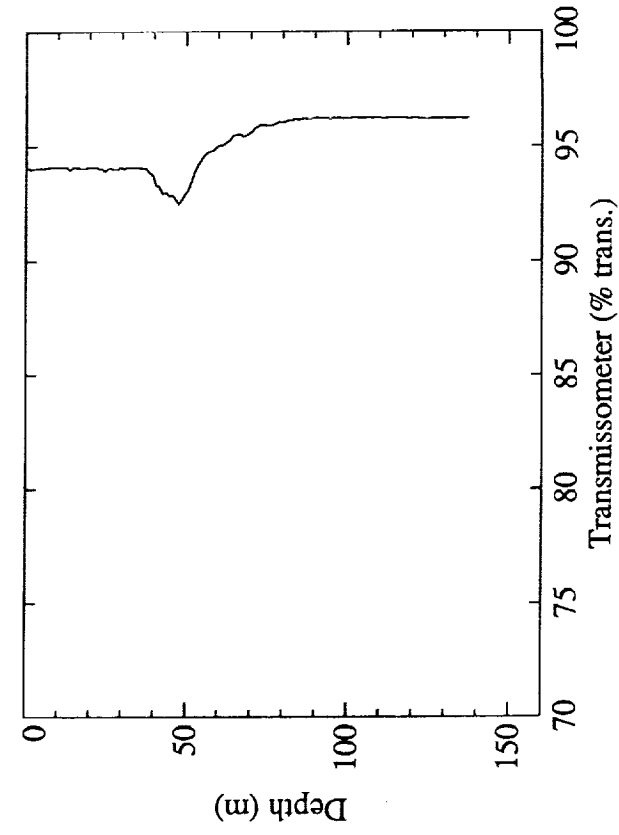
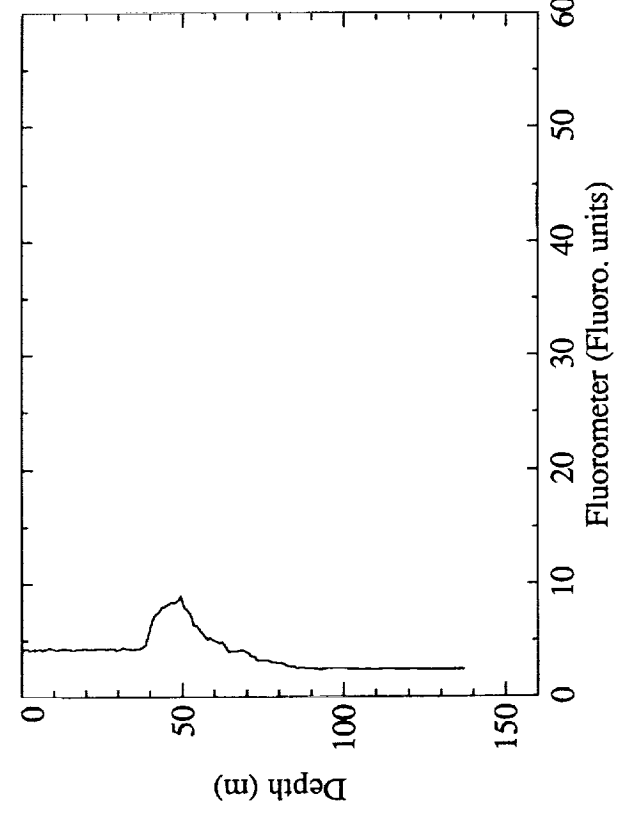
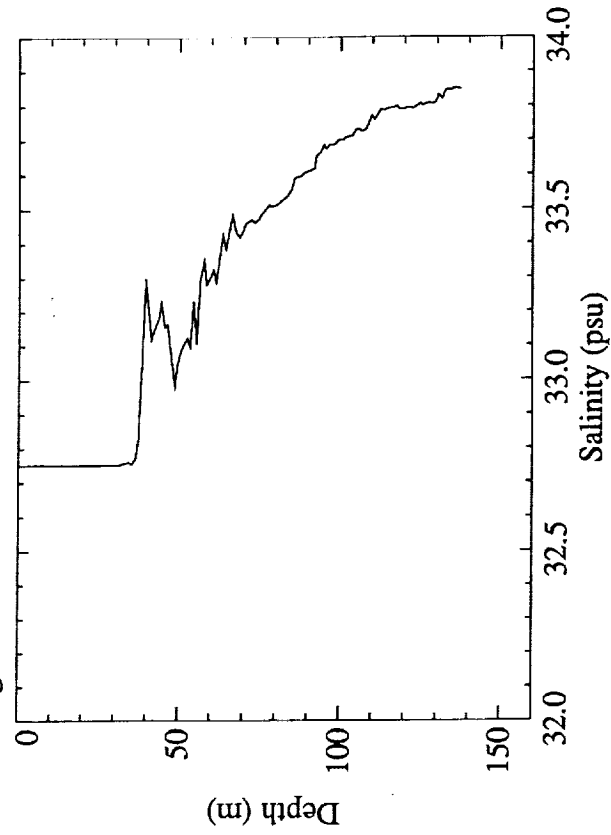
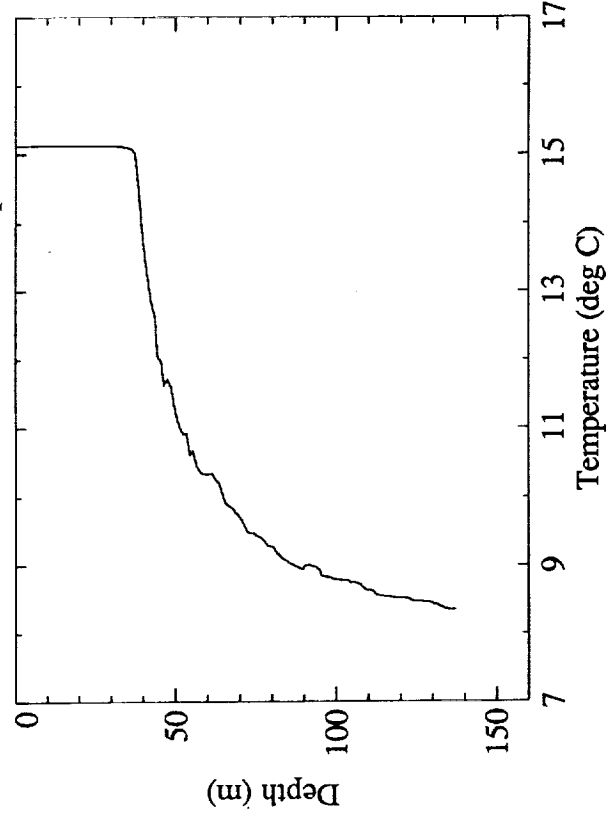


Figure 11. File: c880710a

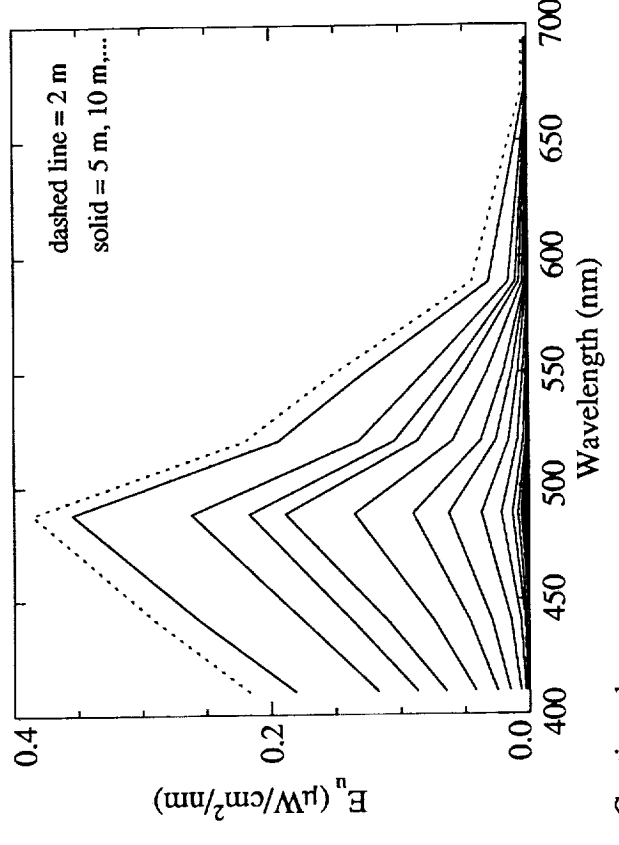
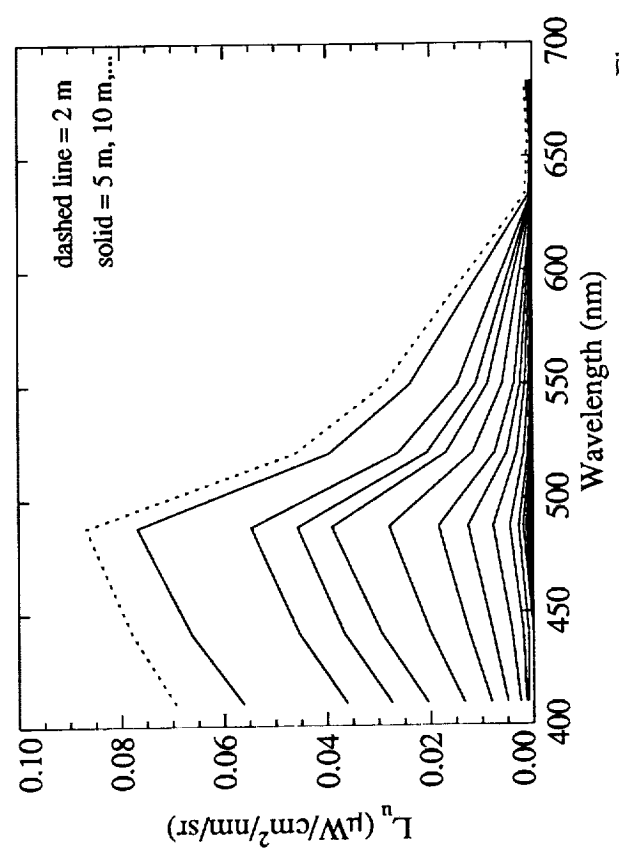
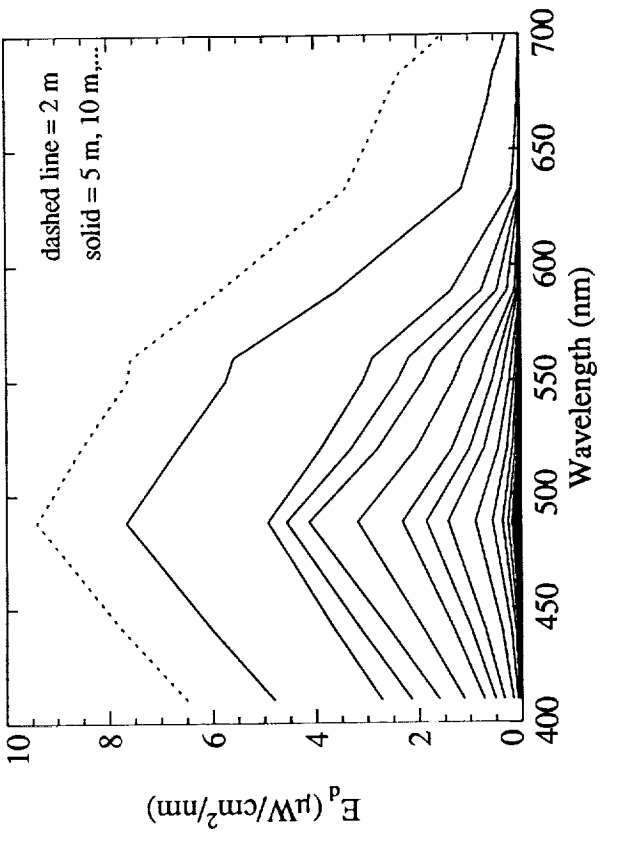
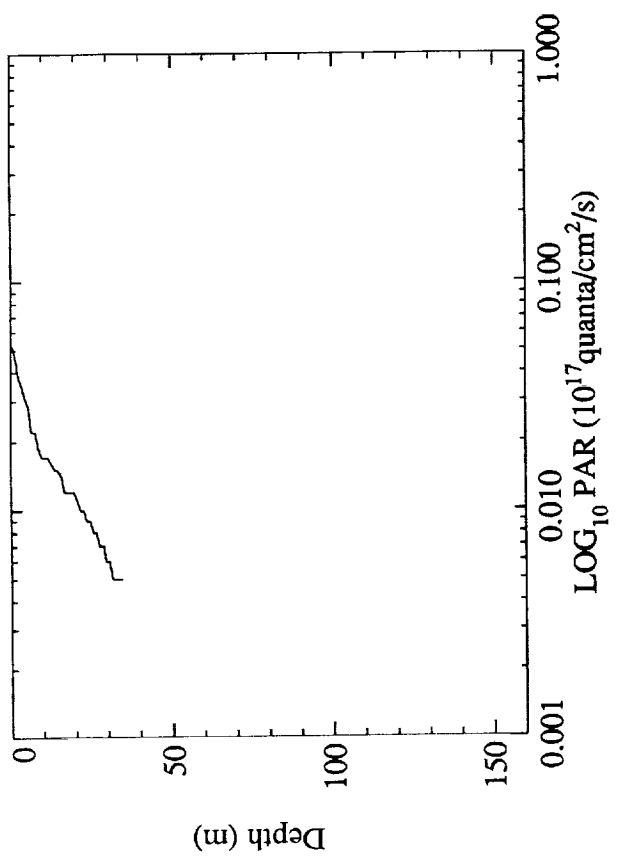


Figure 11. Continued

CTZ 07-10-88 Loc: sta 32 op 1 Lat: 37° 16.2' N Long: 126° 32.1' W File: c880710b

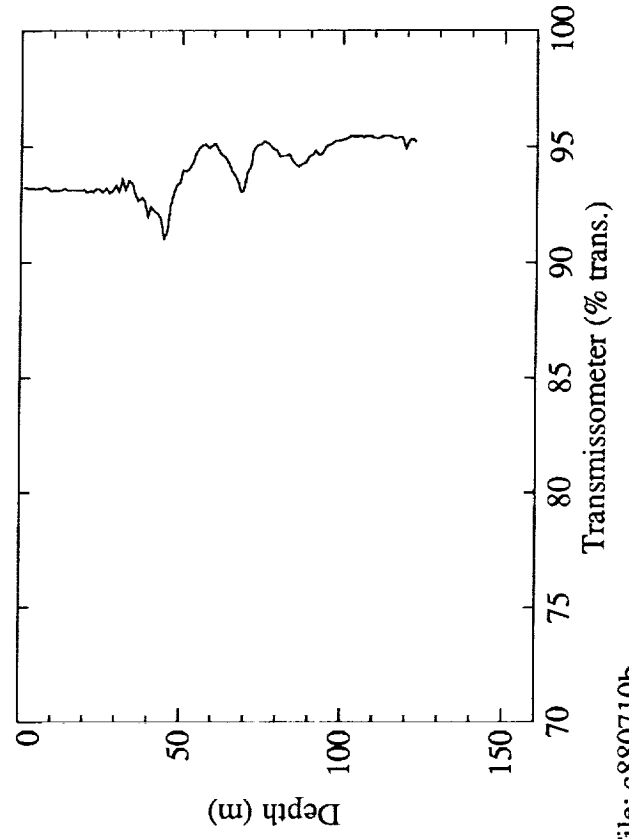
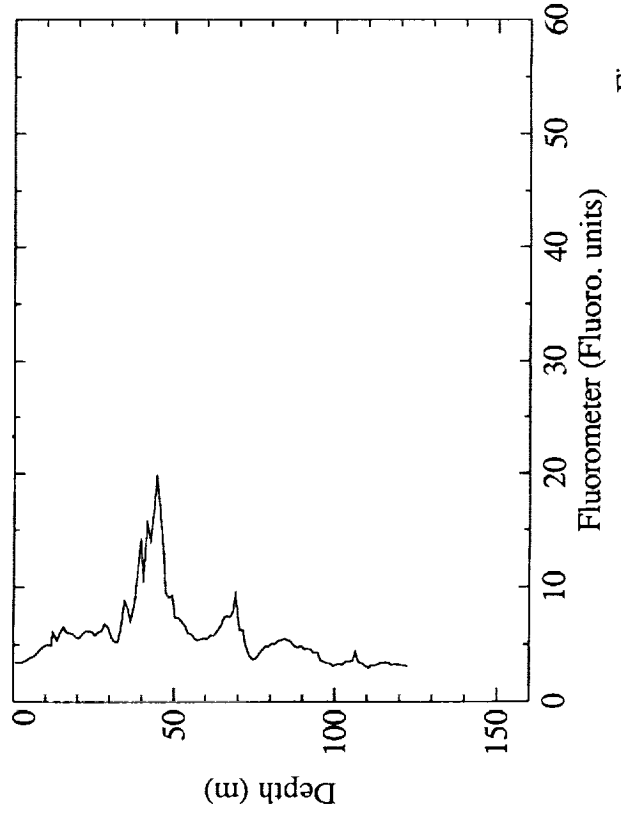
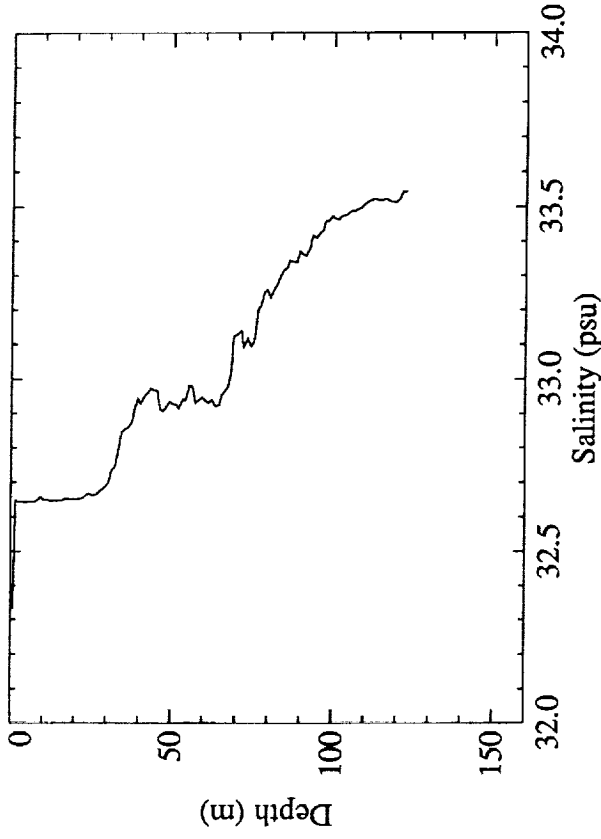
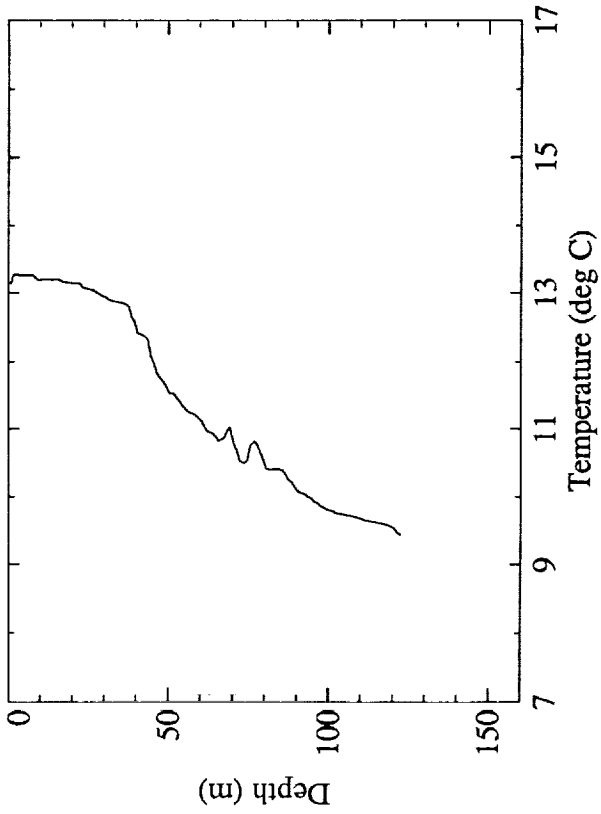


Figure 12. File: c880710b

CTZ 07-10-88 Loc: sta 32 op 1 Lat: 37° 16.2' N Long: 126° 32.1' W File: c880710b

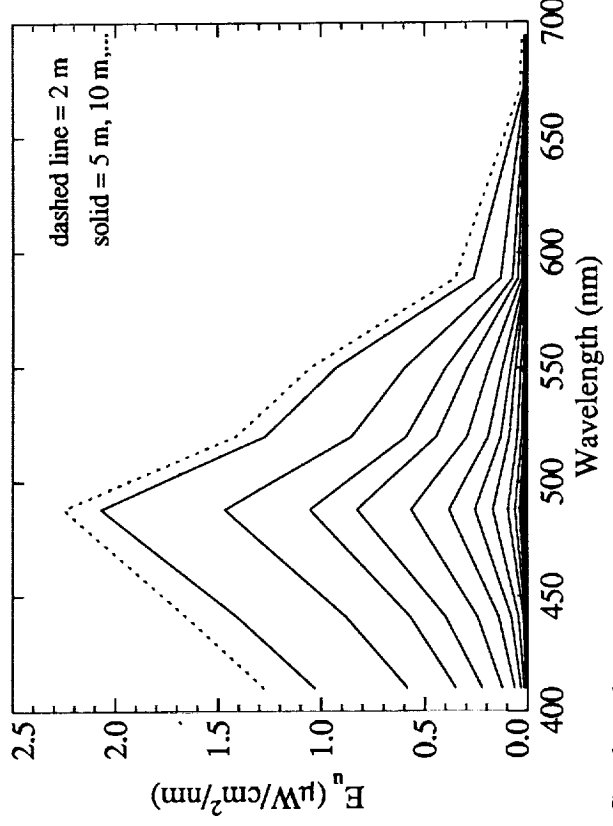
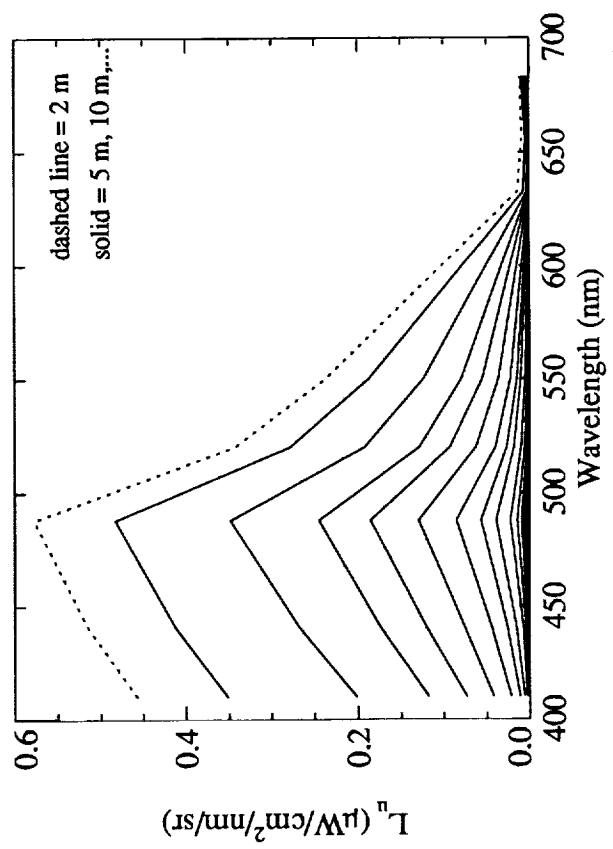
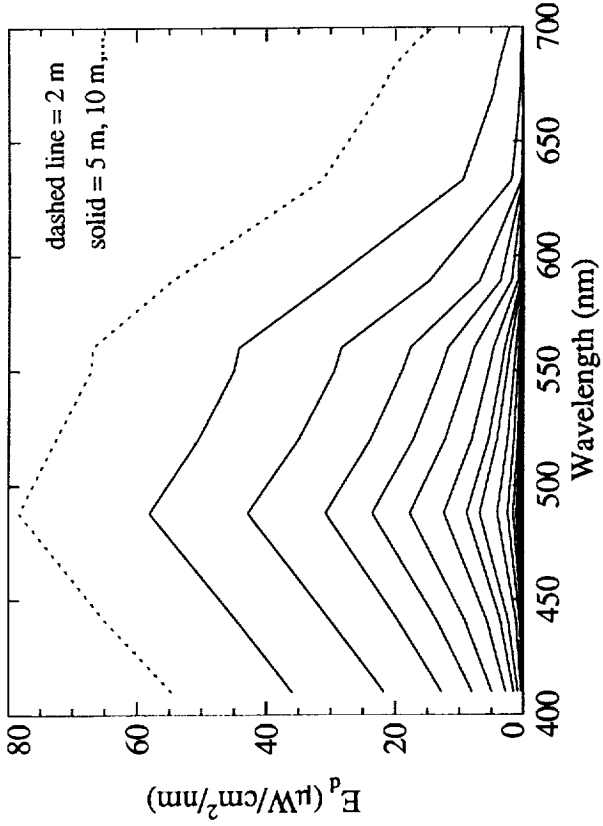
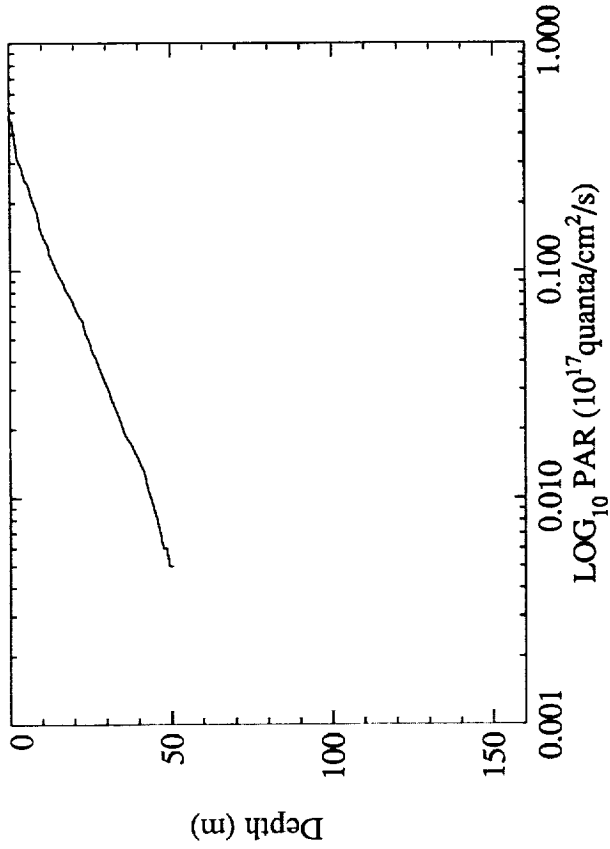


Figure 12. Continued

CTZ 07-11-88 Loc: sta 37 op 3 Lat: 37° 33.3' N Long: 126° 34.4' W File: c880711b

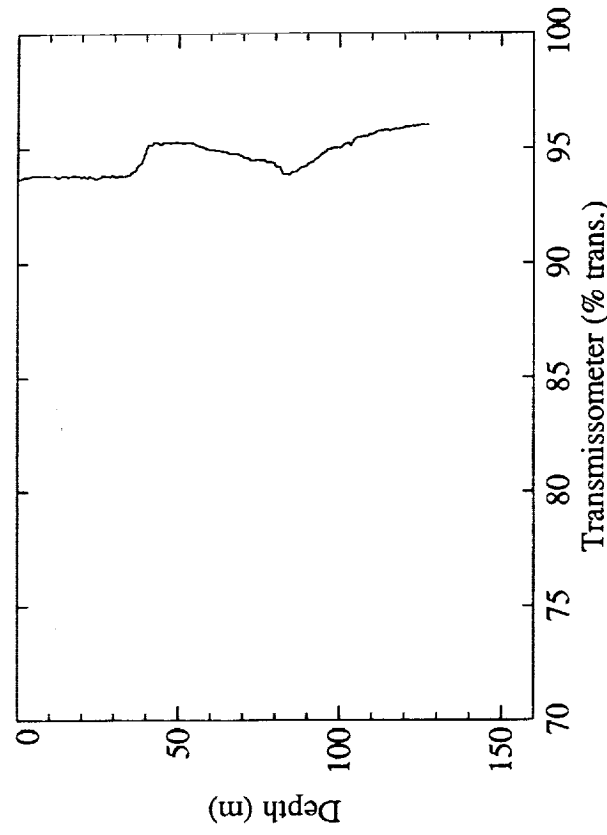
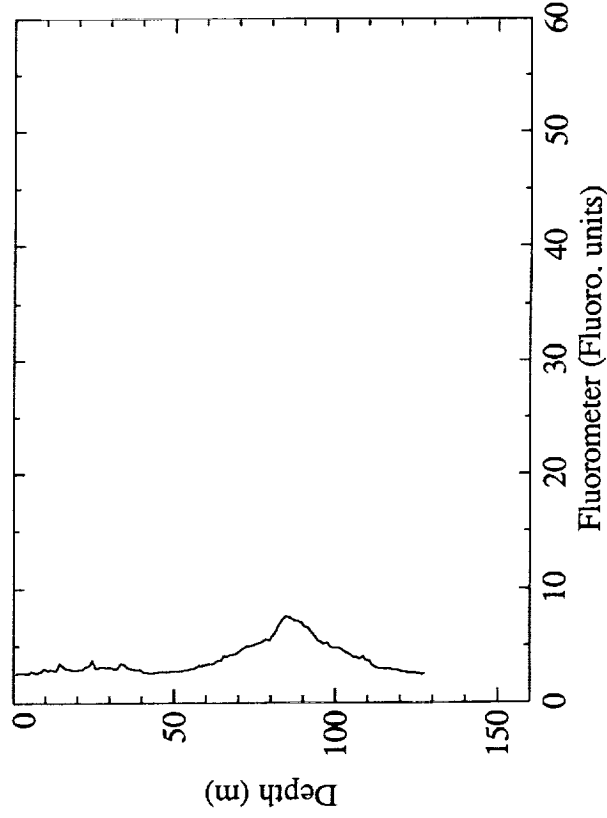
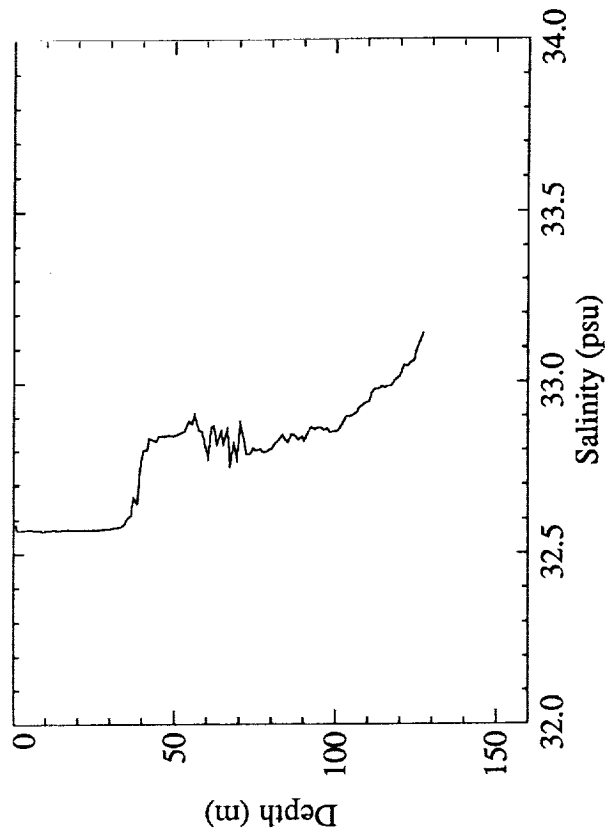
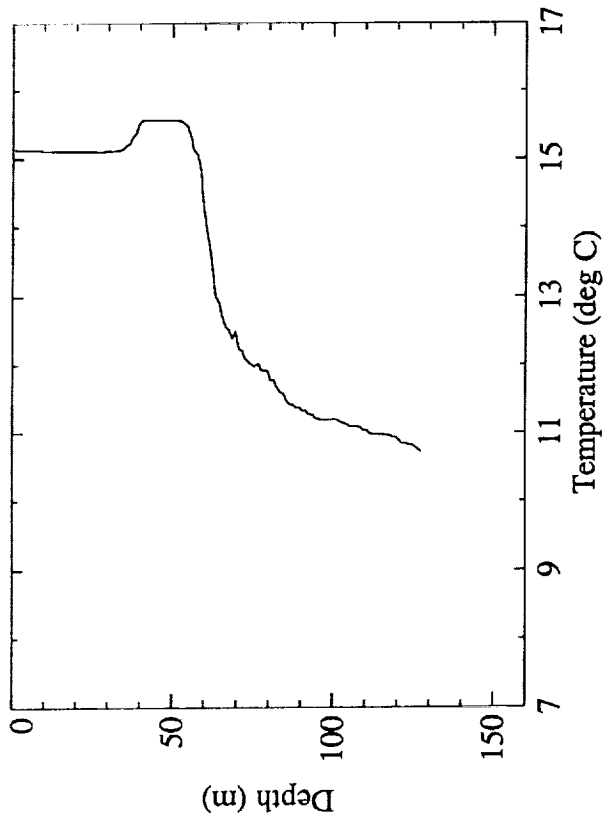


Figure 13. File: c880711b

CTZ 07-11-88 Loc: sta 37 op 3 Lat: 37° 33.3' N Long: 126° 34.4' W File: c880711b

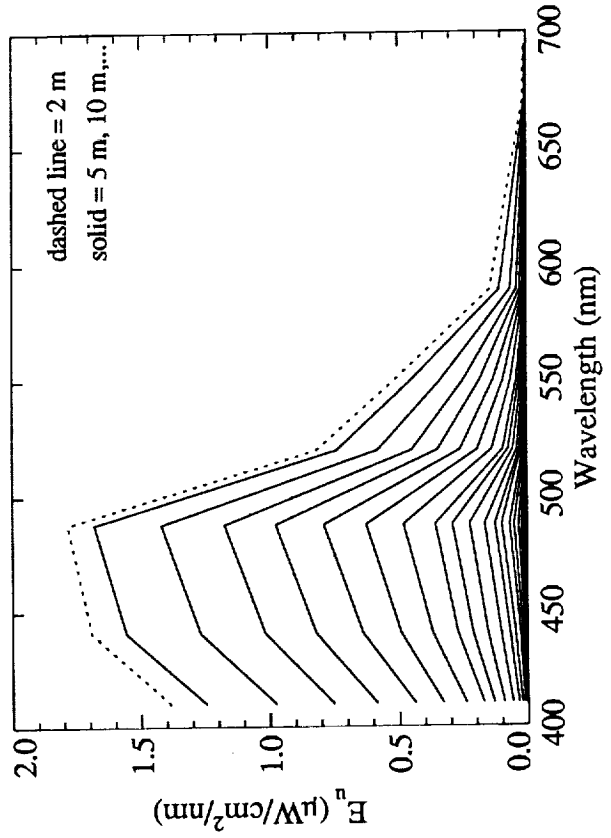
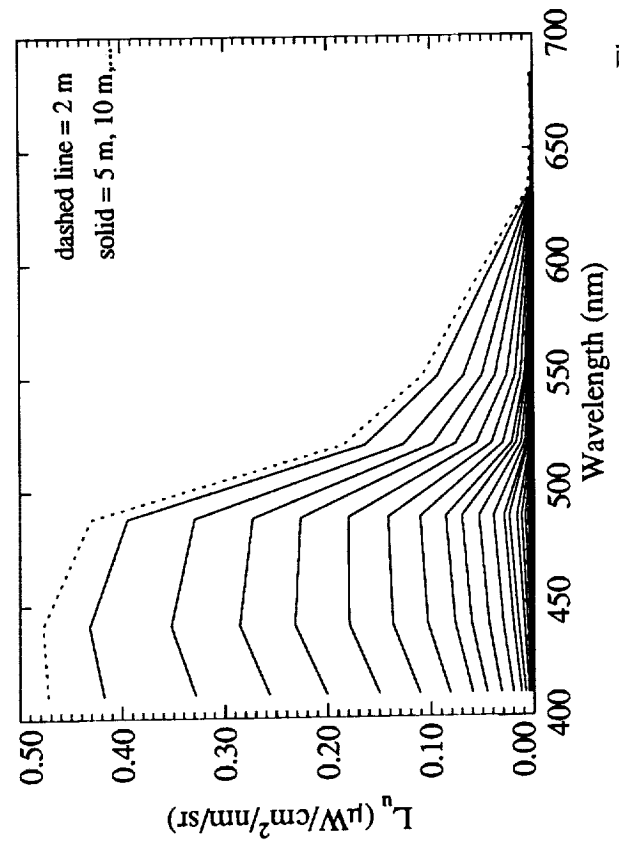
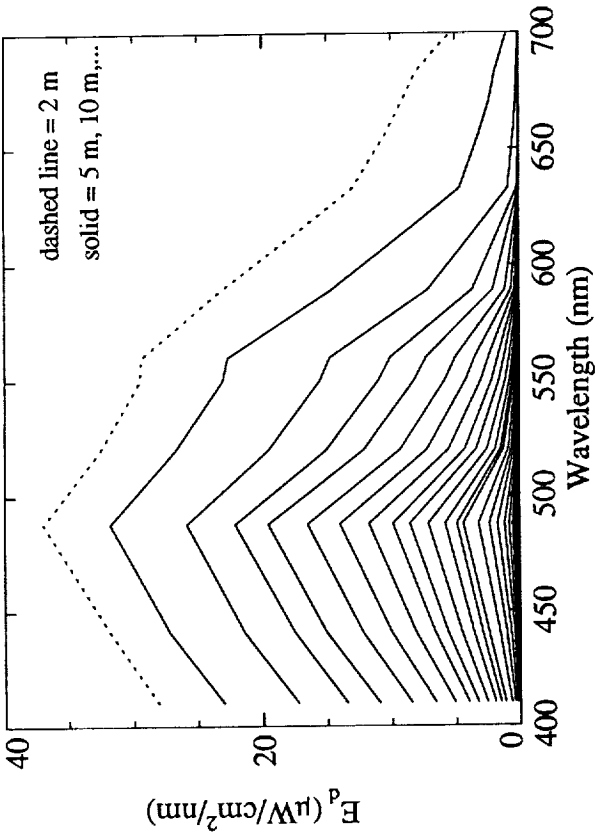
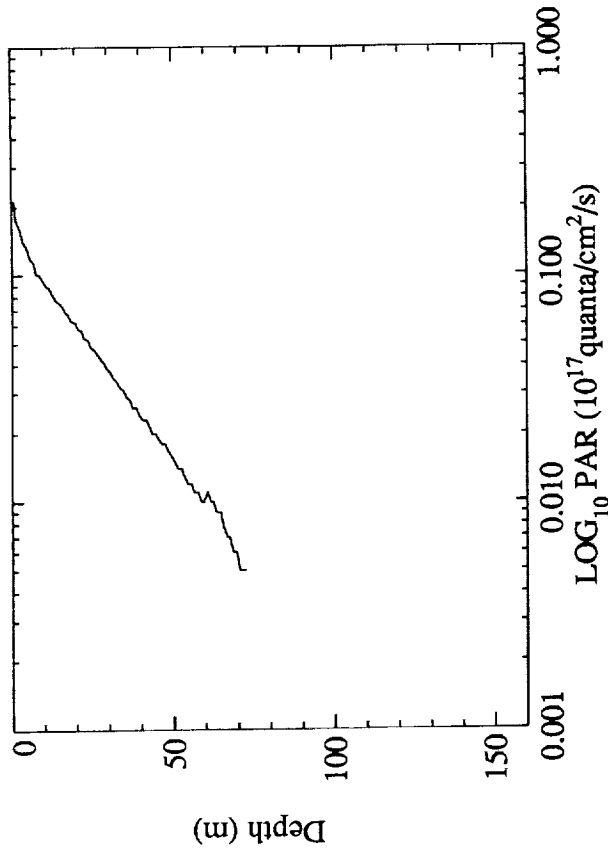


Figure 13. Continued

CTZ 07-14-88 Loc: sta 52 op 2 Lat: 38° 43.4' N Long: 124° 00.0' W File: c880714a

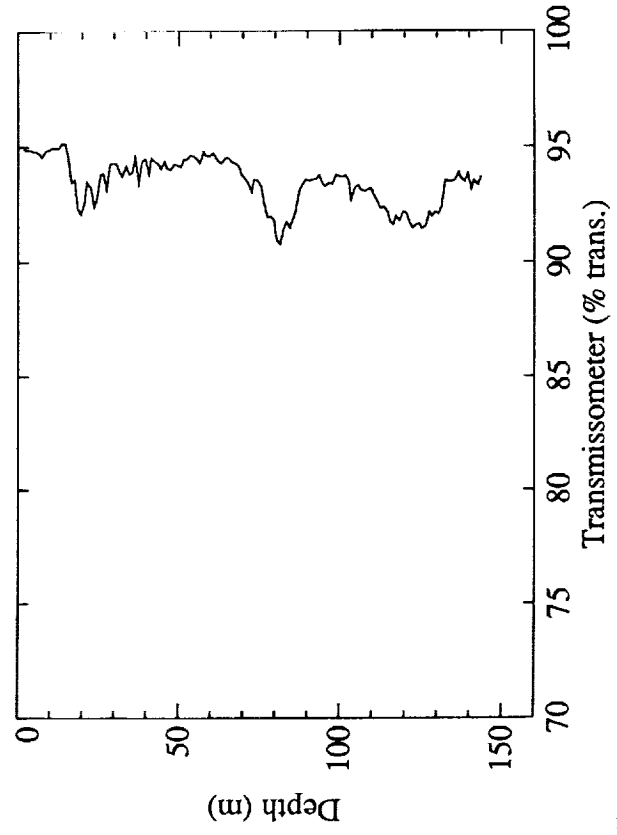
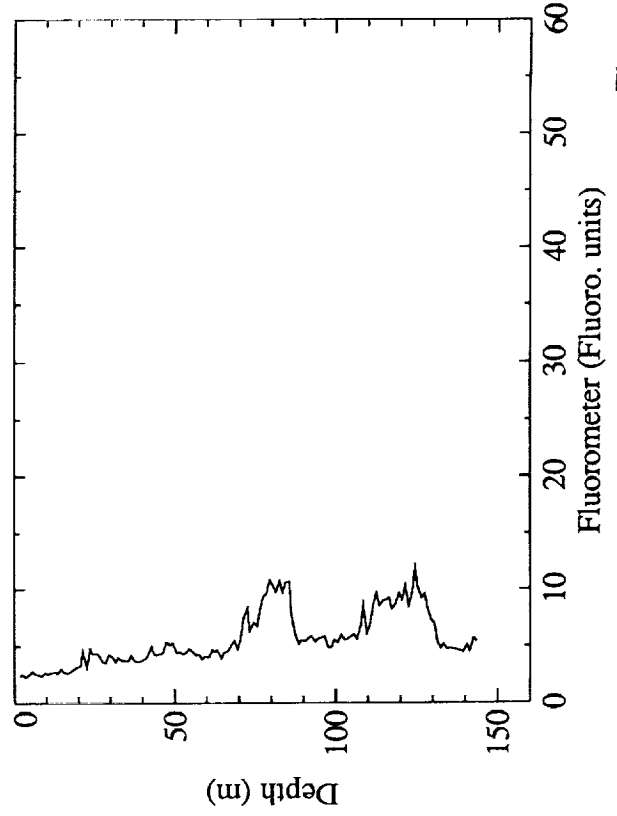
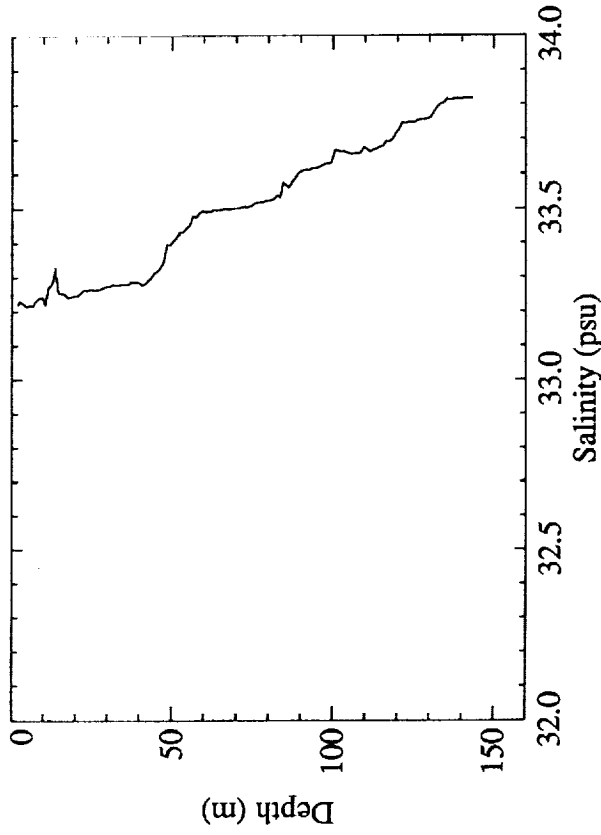
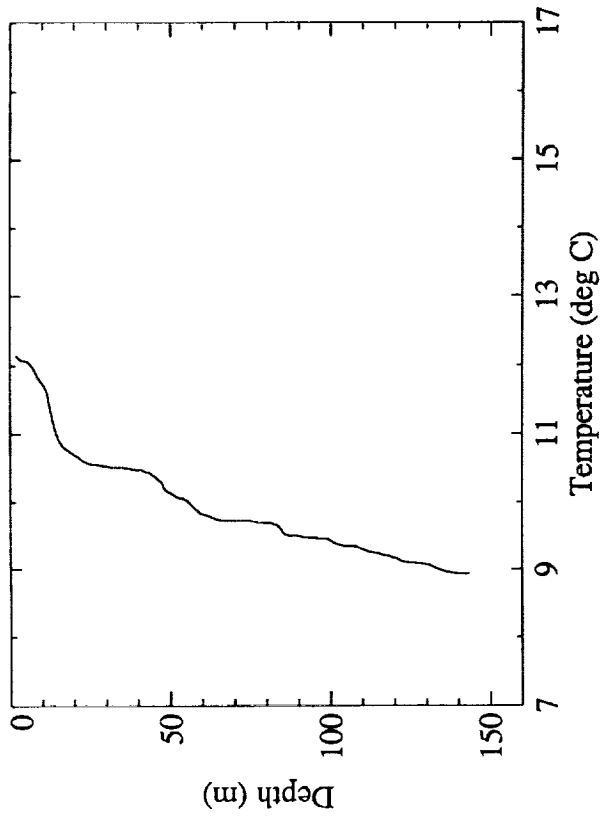


Figure 14. File: c880714a

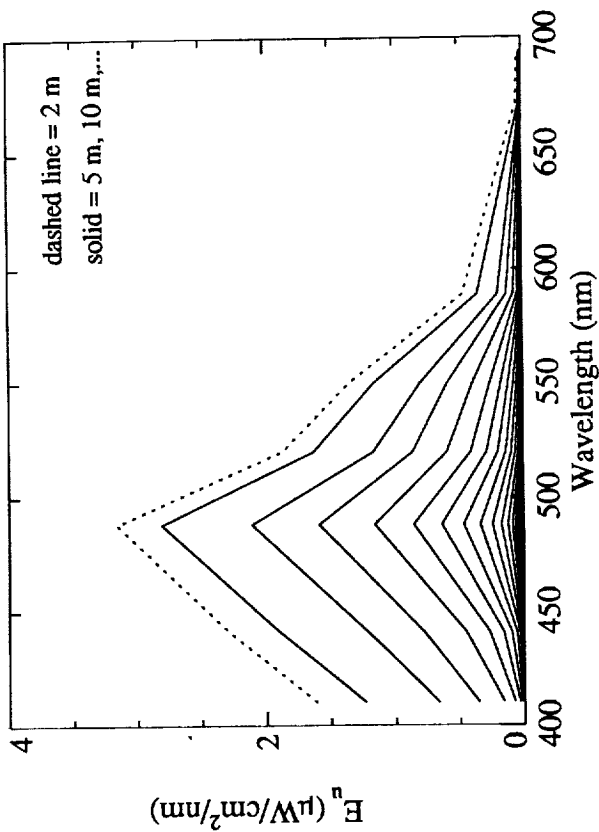
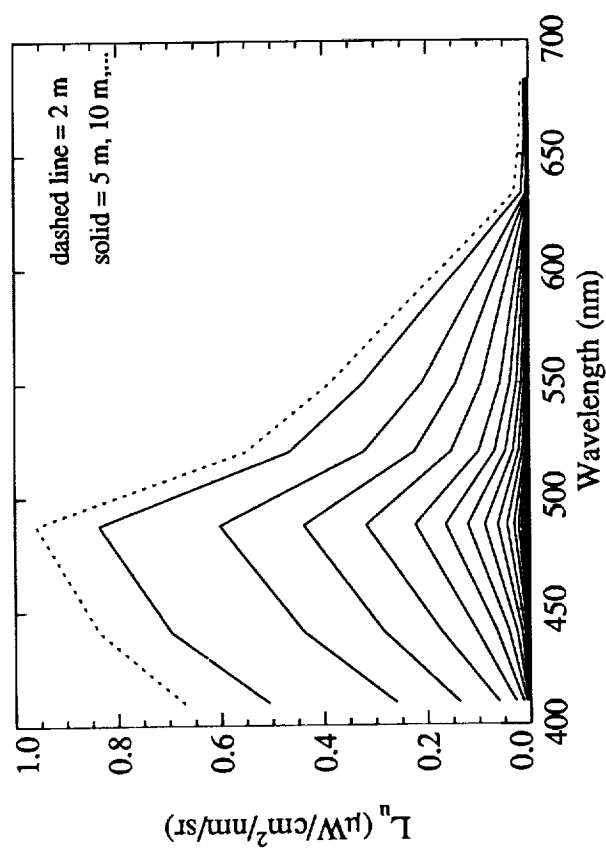
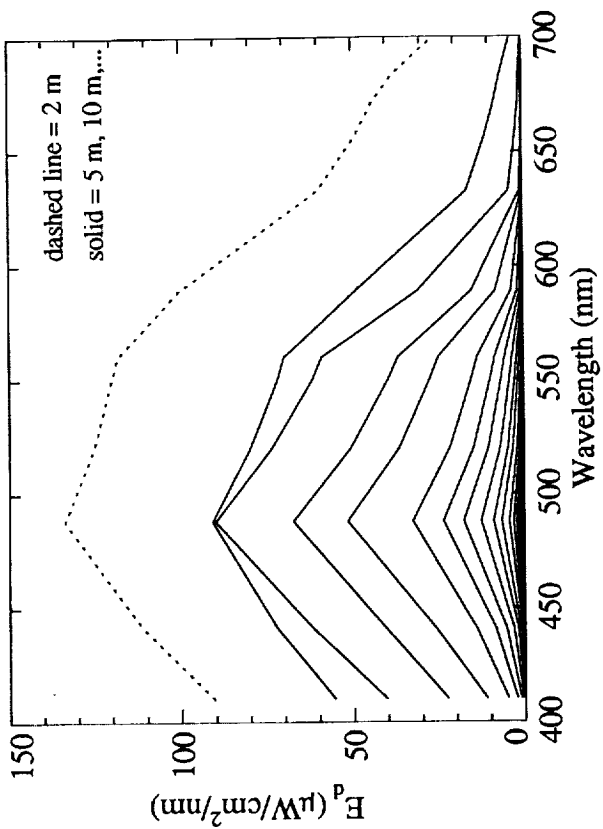
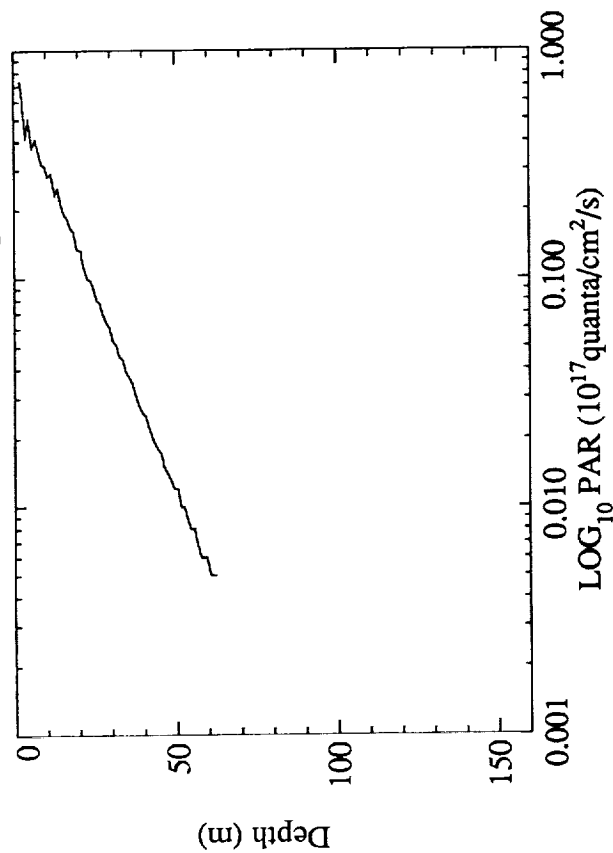


Figure 14. Continued

CTZ 07-15-88 Loc: sta 63 op 1 Lat: 38° 37.8' N Long: 124° 33.2' W File: c880715a

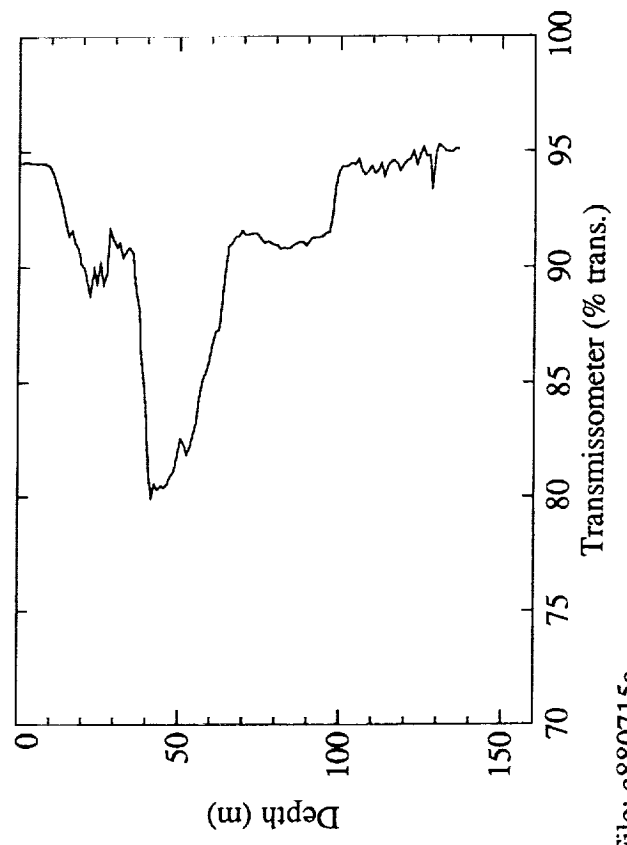
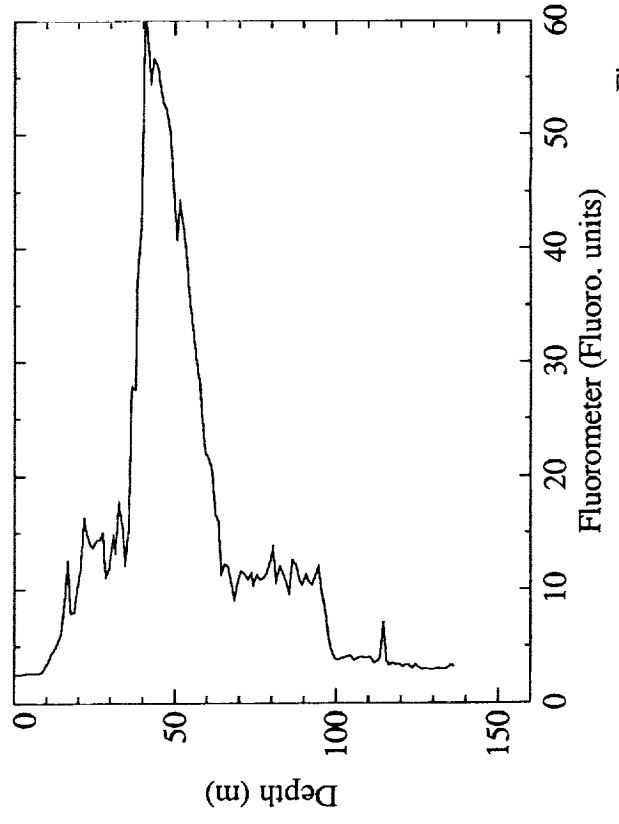
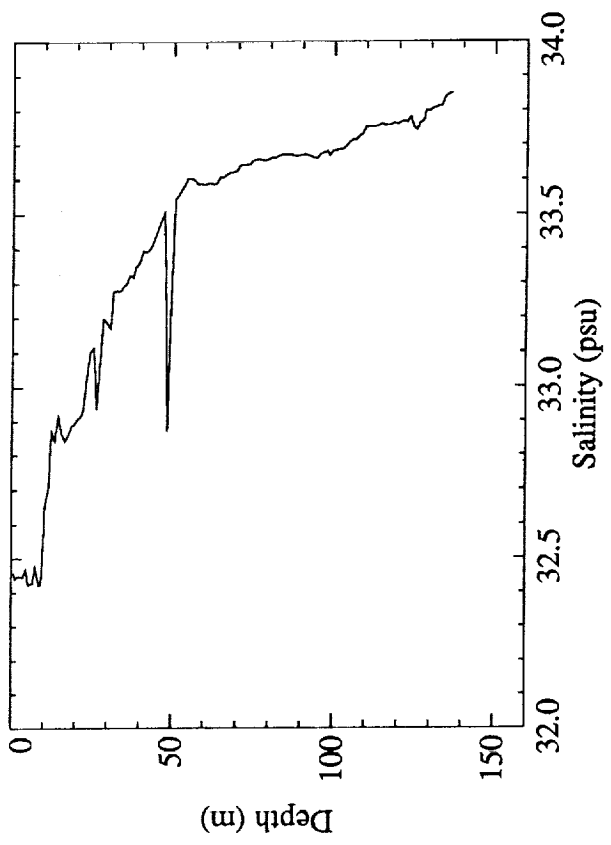
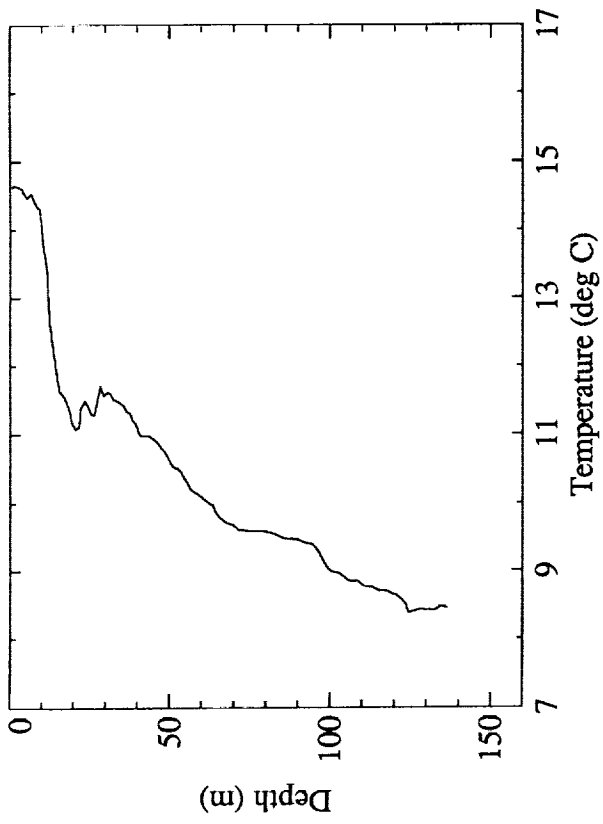


Figure 15. File: c880715a

CTZ 07-15-88 Loc: sta 63 op 1 Lat: 38° 37.8' N Long: 124° 33.2' W File: c880715a

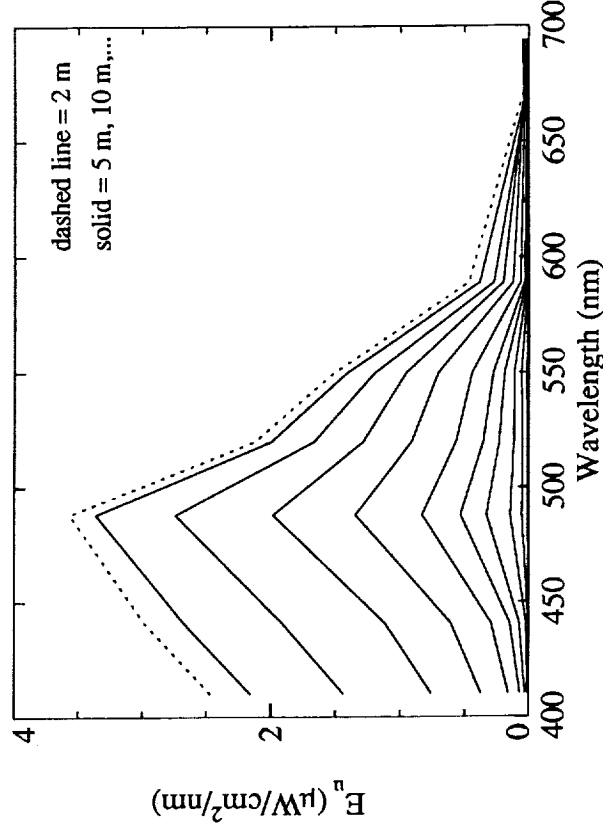
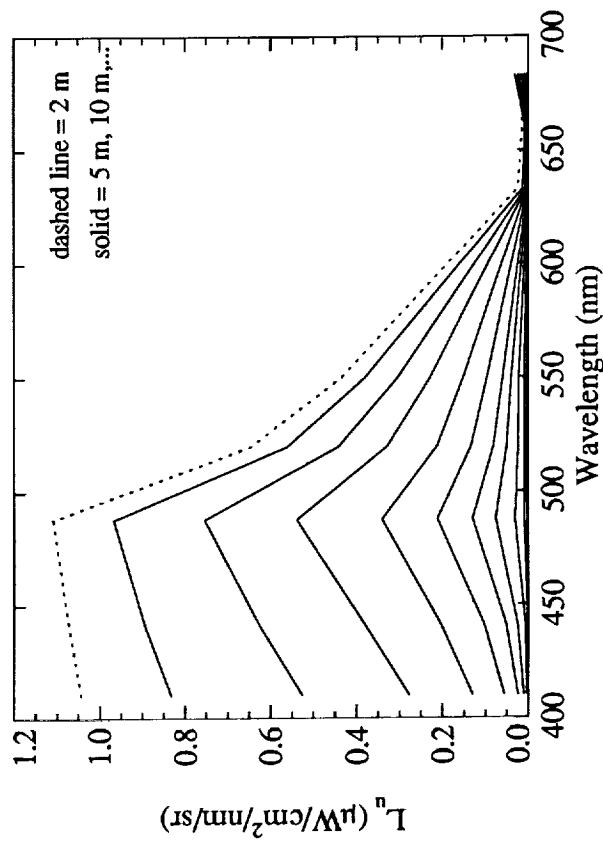
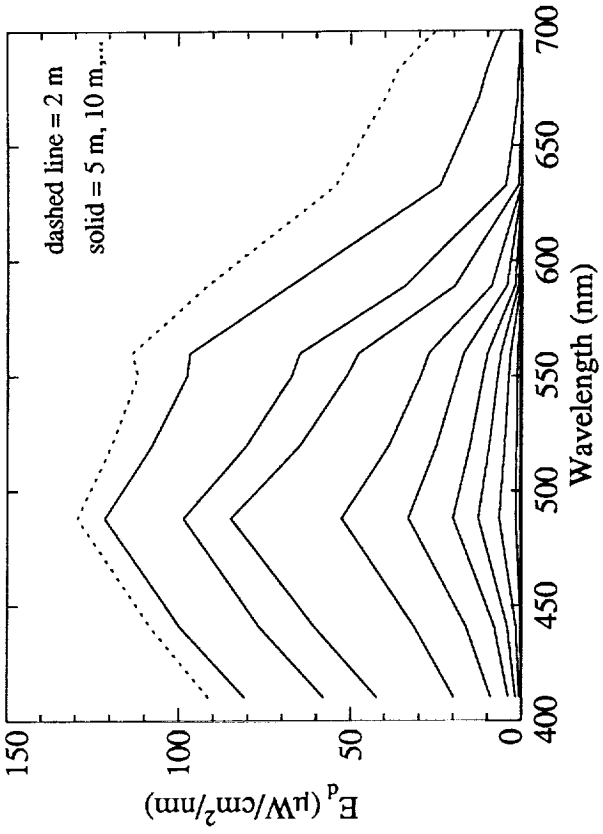
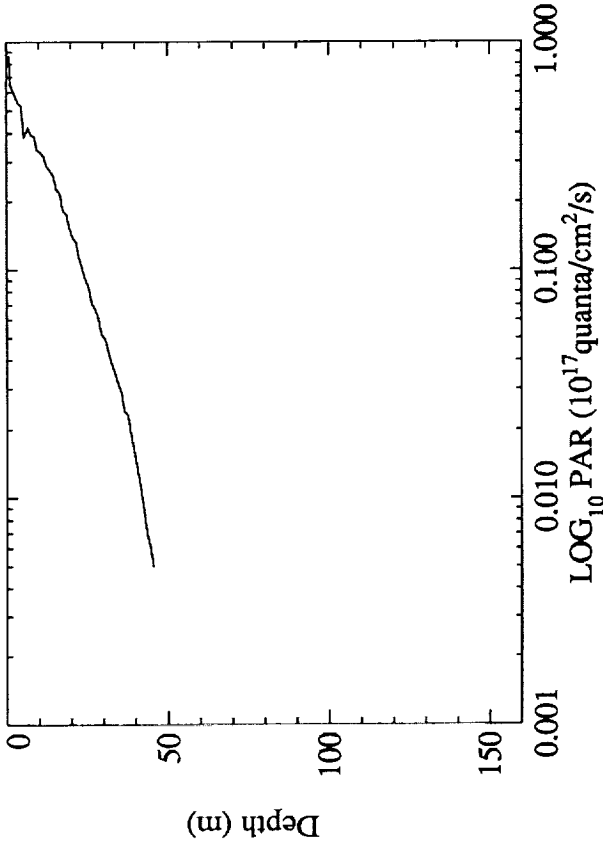


Figure 15. Continued

CTZ 07-16-88 Loc: sta 66 op 2 Lat: 37° 44.7' N Long: 125° 29.8' W File: c880716b

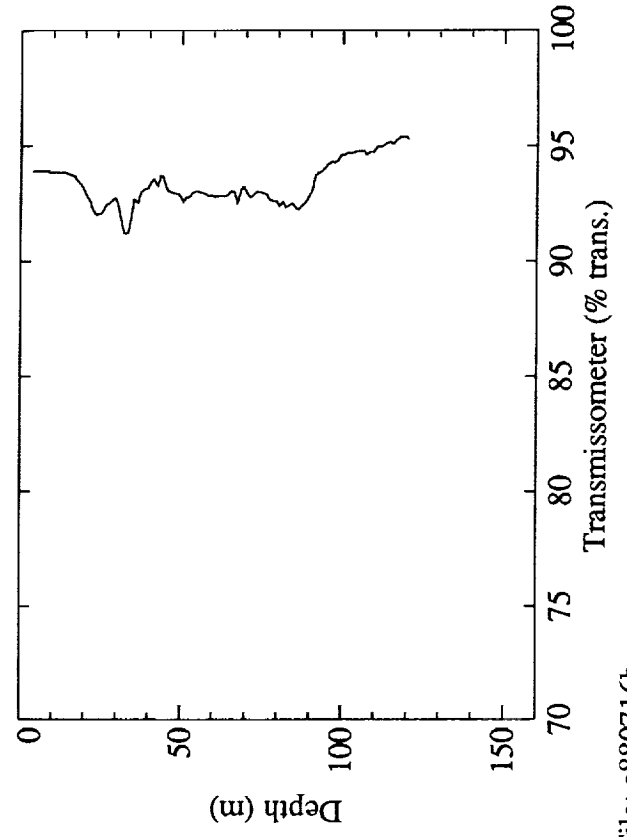
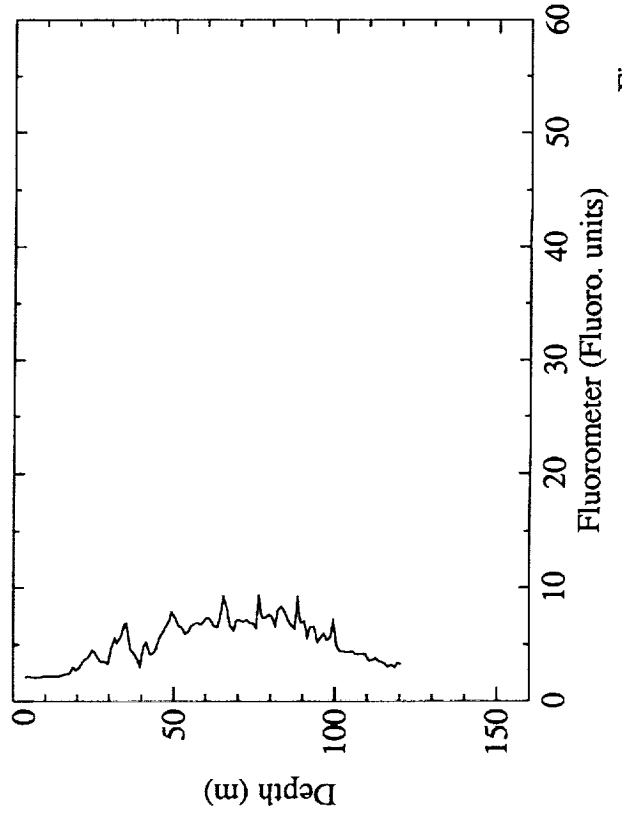
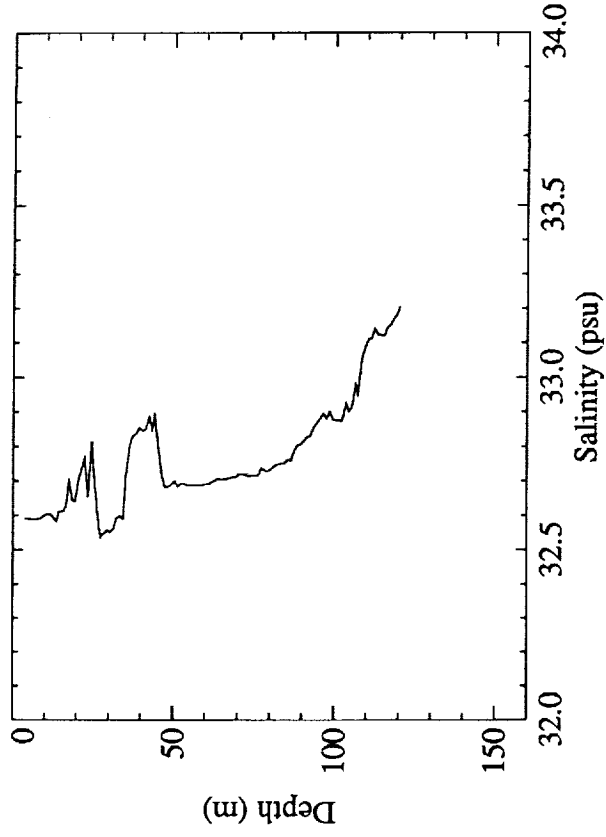
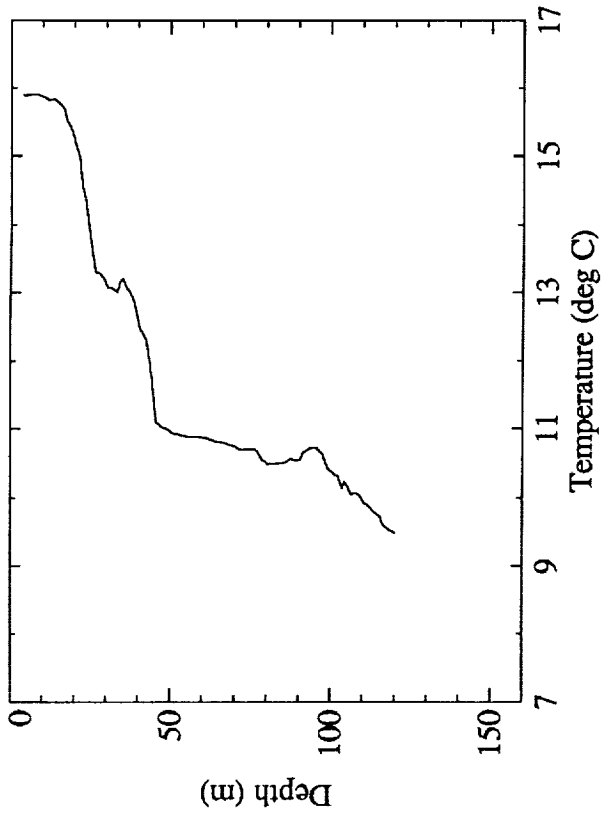


Figure 16. File: c880716b

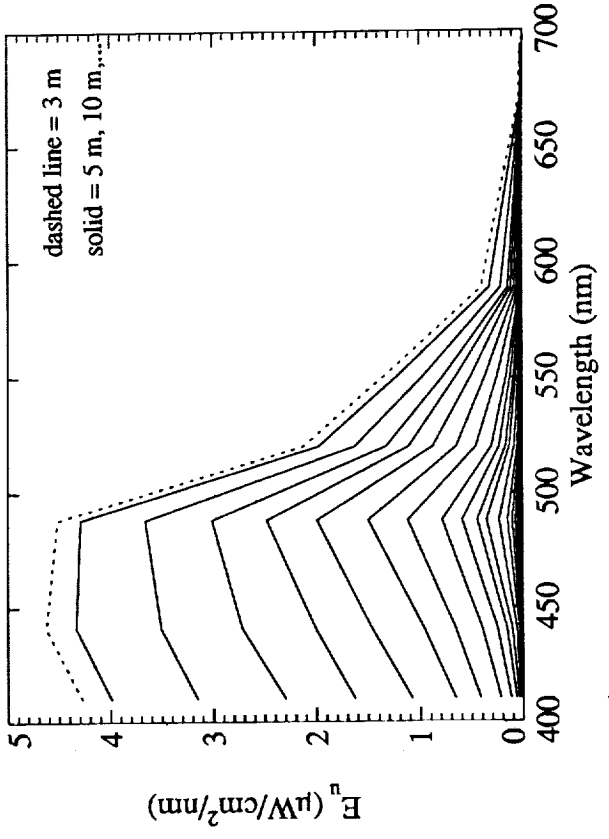
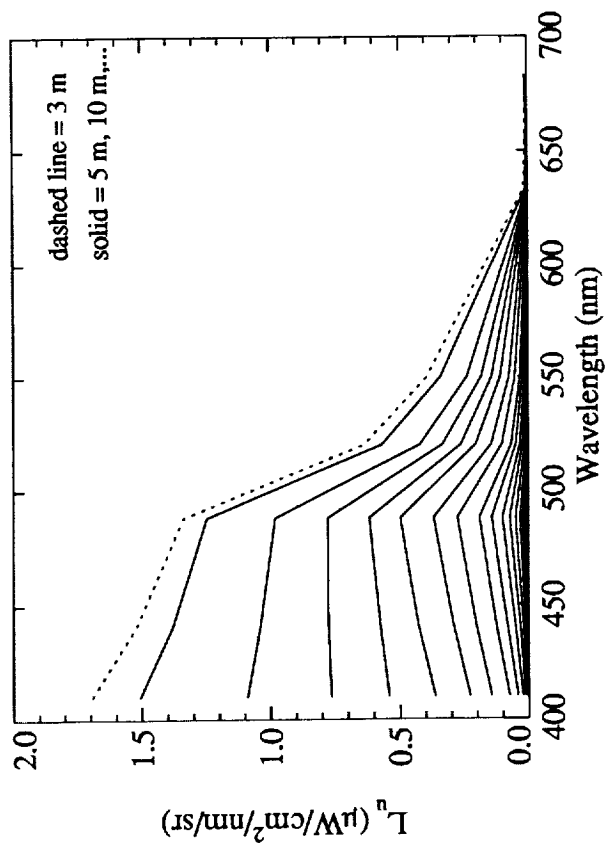
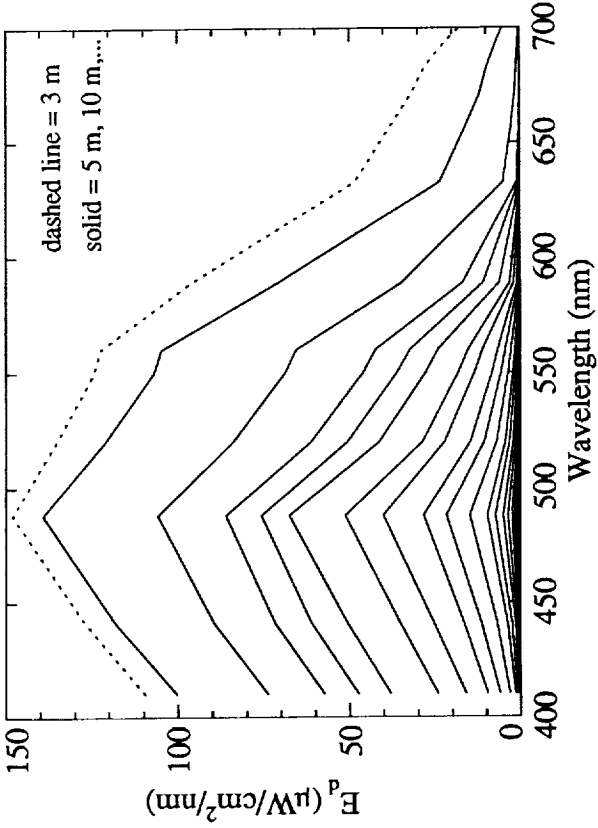
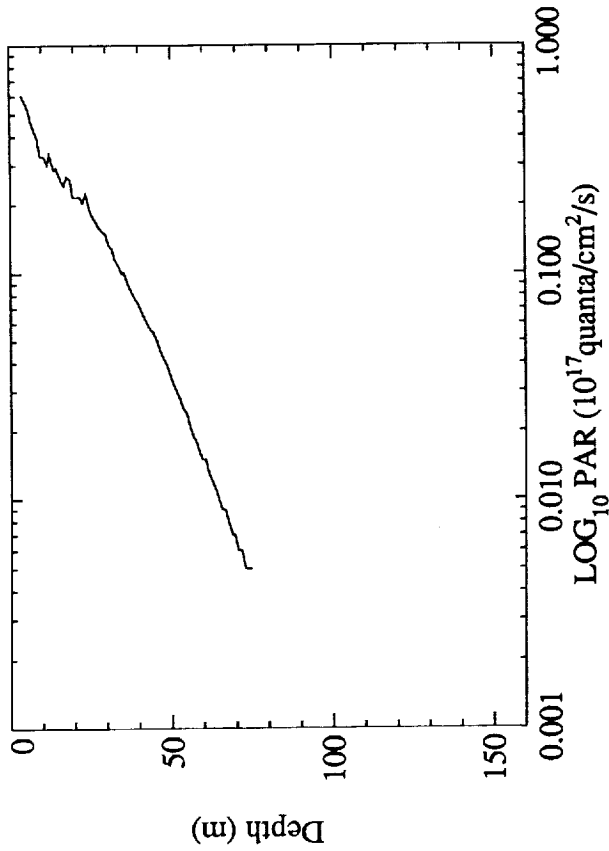


Figure 16. Continued

CTZ 07-17-88 Loc: sta 70 op 1 Lat: 37° 36.2' N Long: 126° 23.7' W File: c880717a

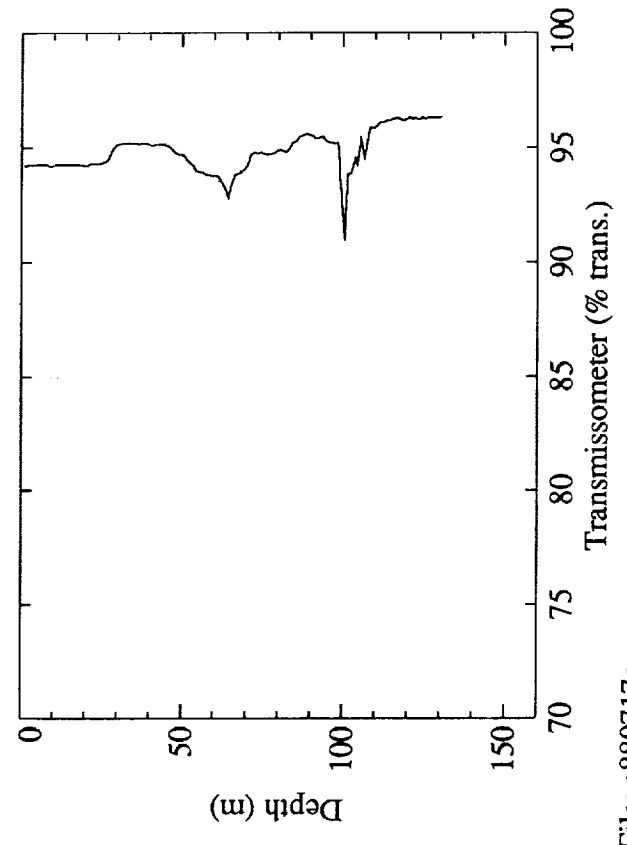
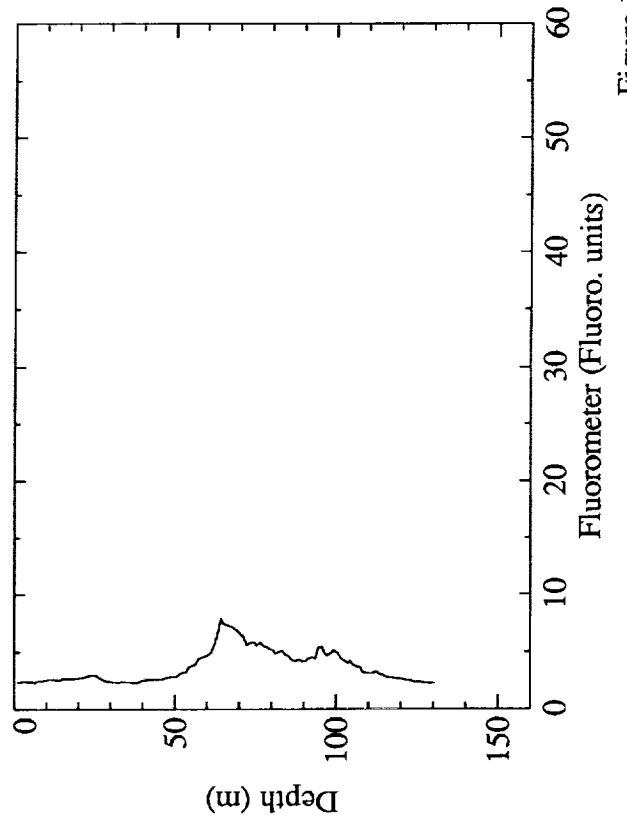
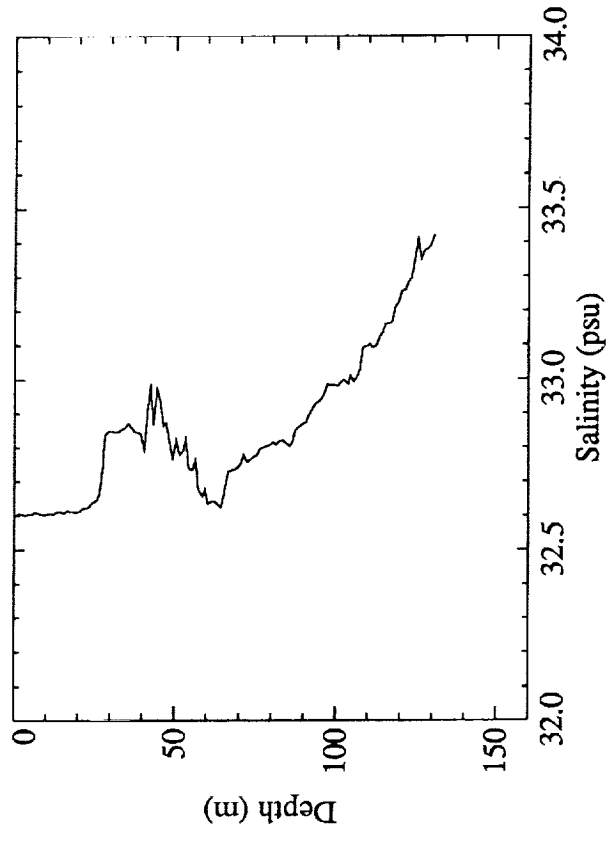
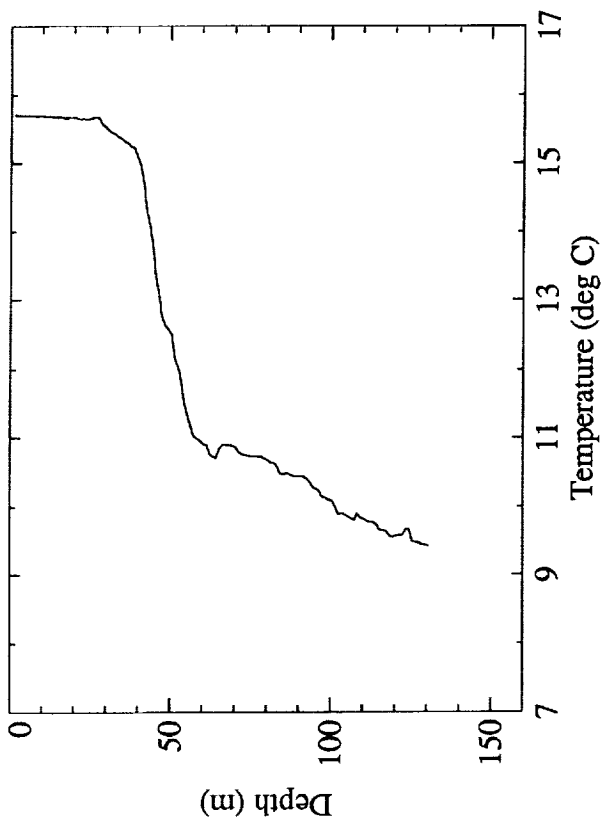


Figure 17. File: c880717a

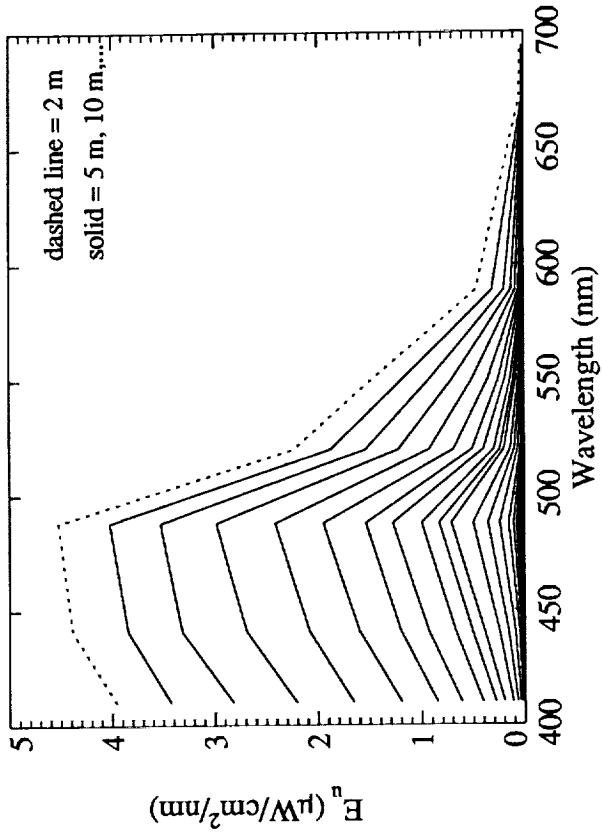
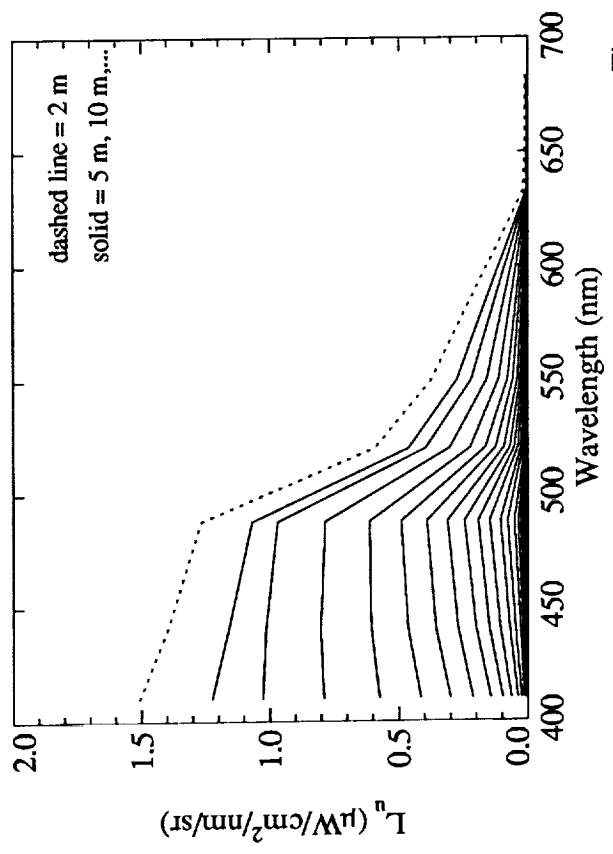
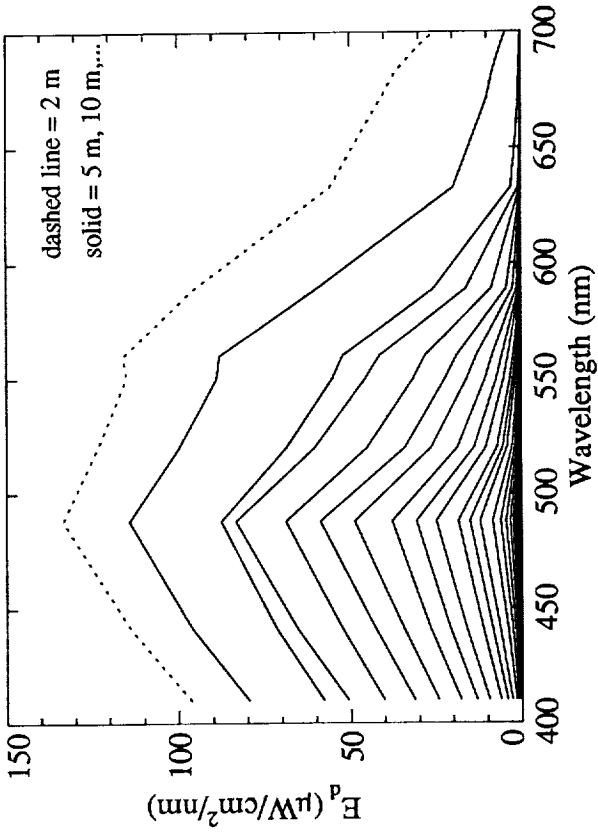
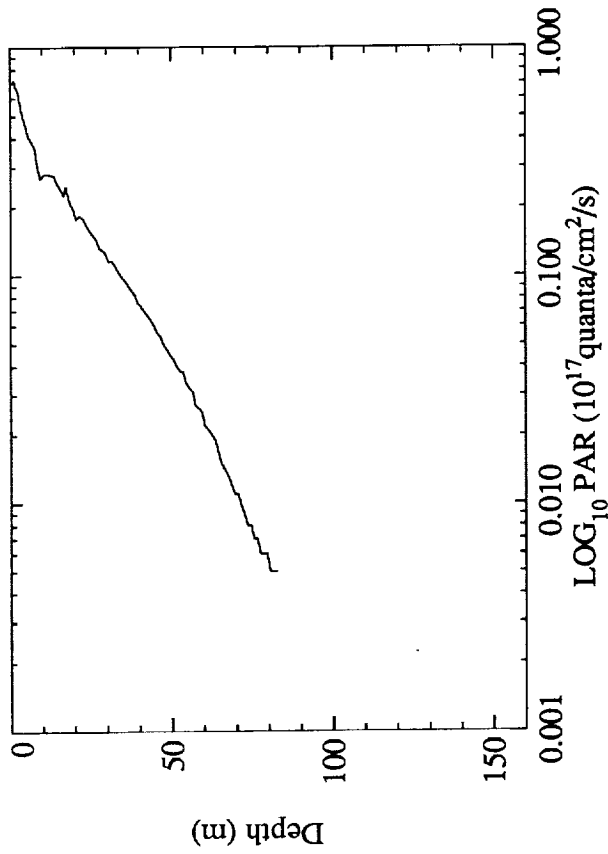


Figure 17. Continued

CTZ 07-18-88 Loc: sta 72 op 2 Lat: 37° 14.2' N Long: 127° 15.5' W File: c880718a

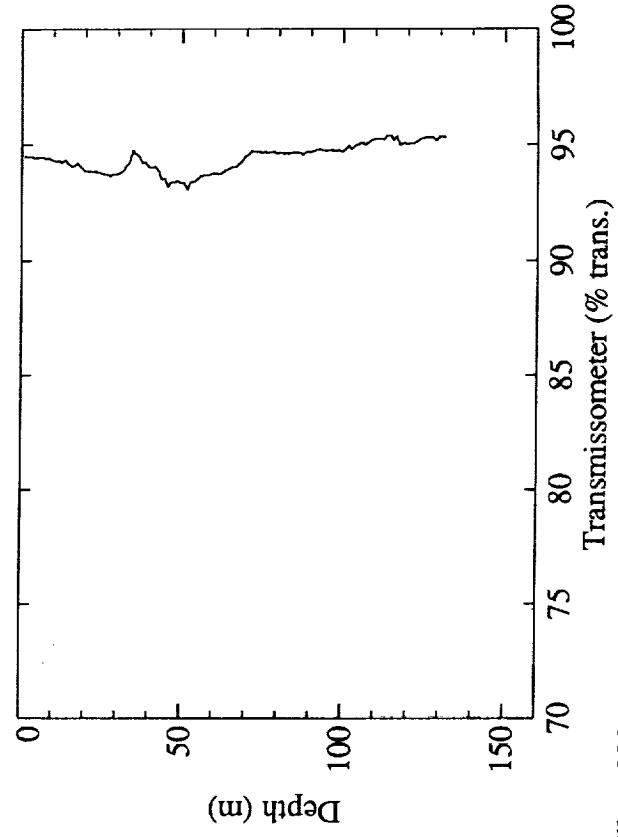
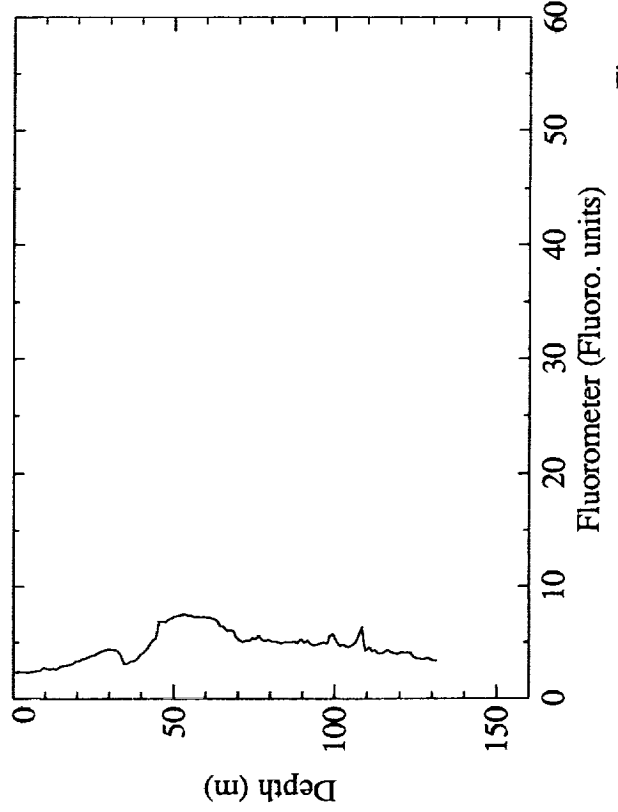
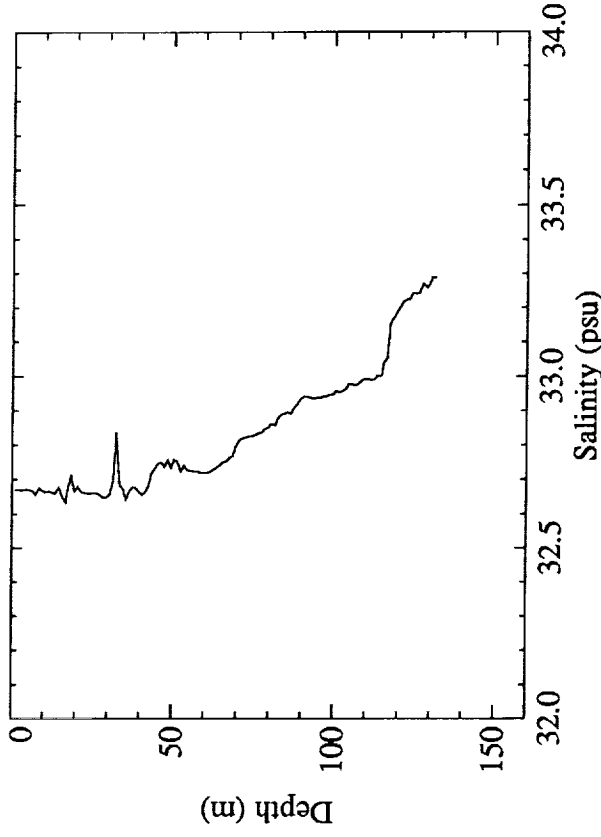
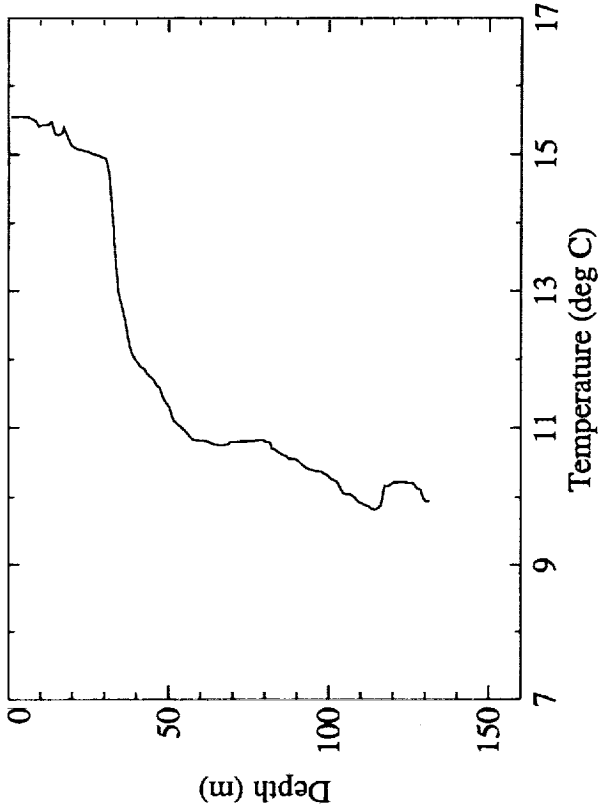


Figure 18. File: c880718a

CTZ 07-18-88 Loc: sta 72 op 2 Lat: 37° 14.2' N Long: 127° 15.5' W File: c880718a

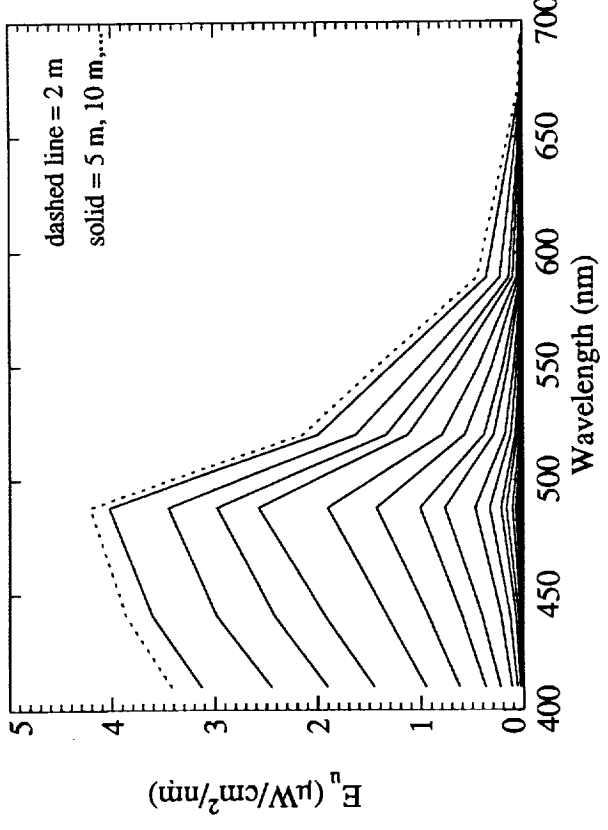
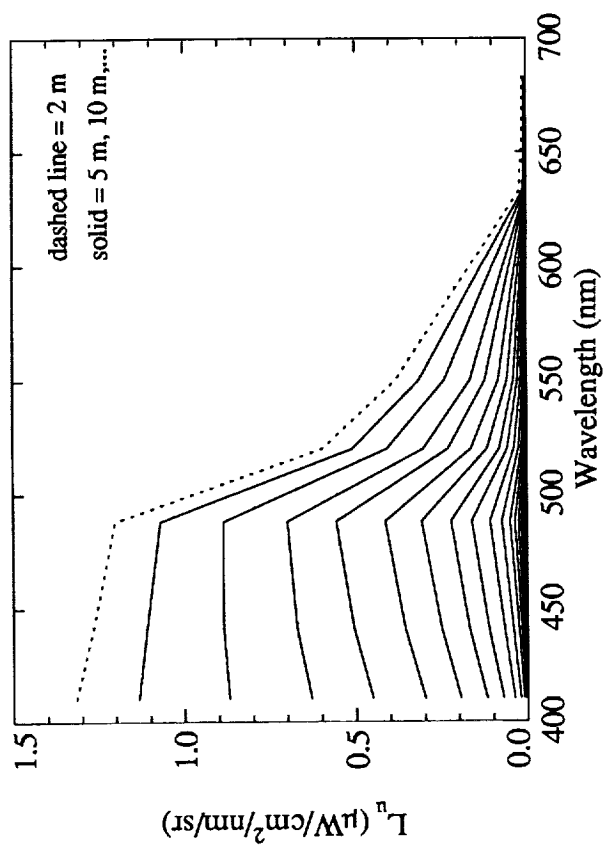
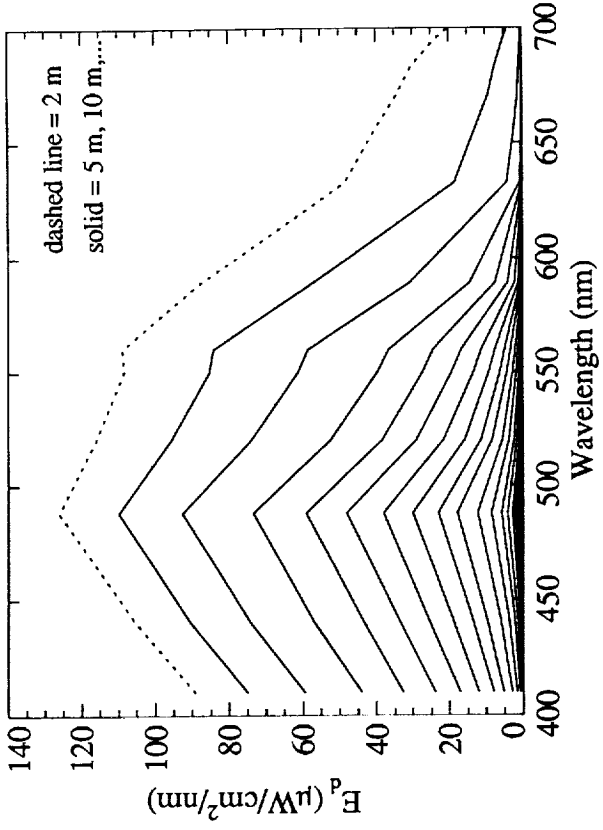
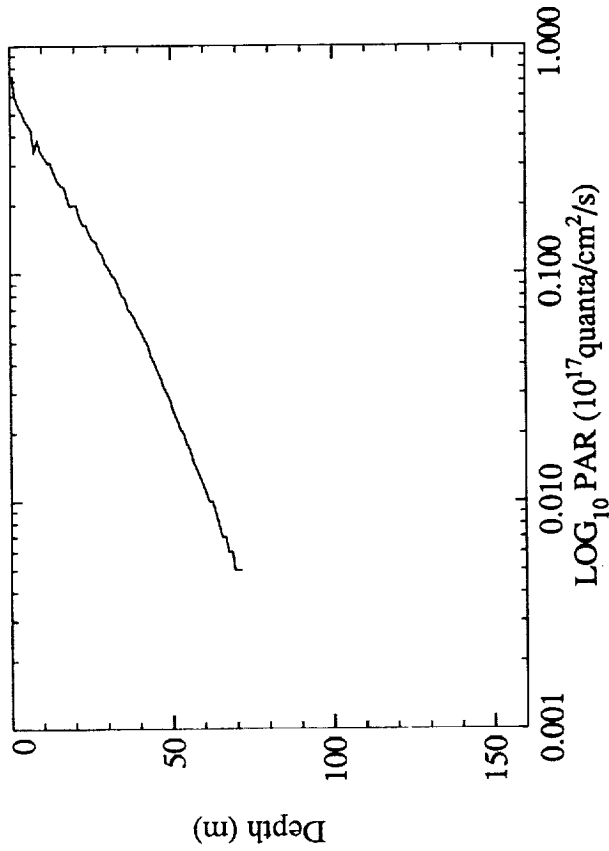


Figure 18. Continued

CTZ 07-19-88 Loc: sta 77 op 2 Lat: 38° 19.7' N Long: 126° 44.5' W File: c880719a

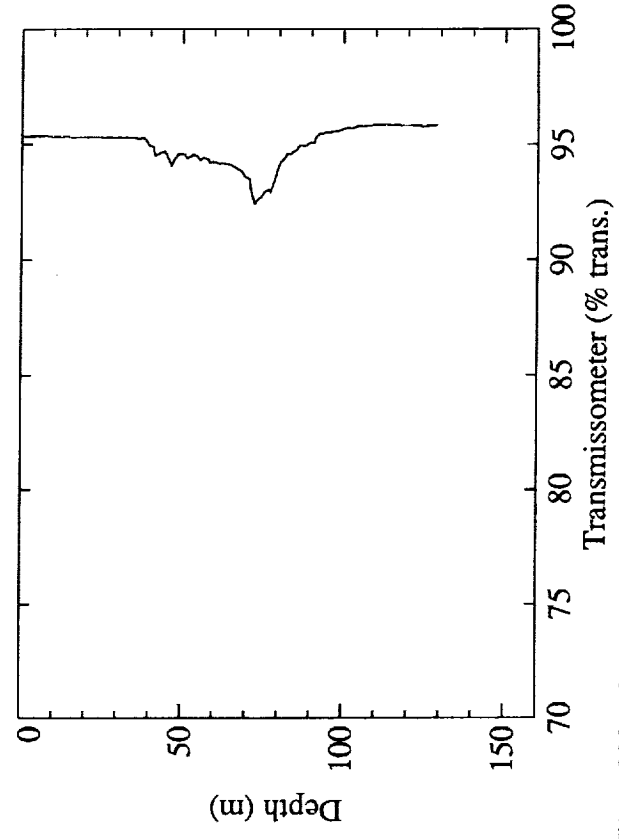
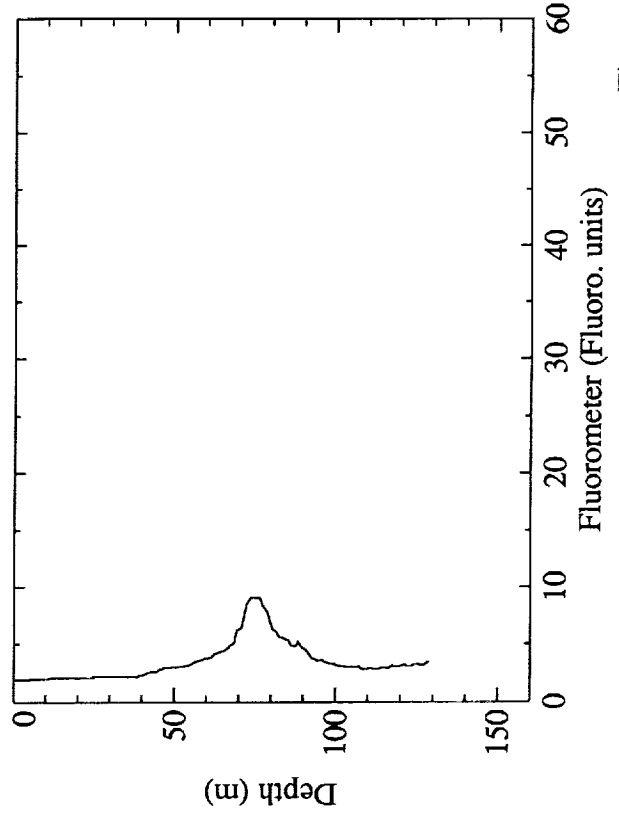
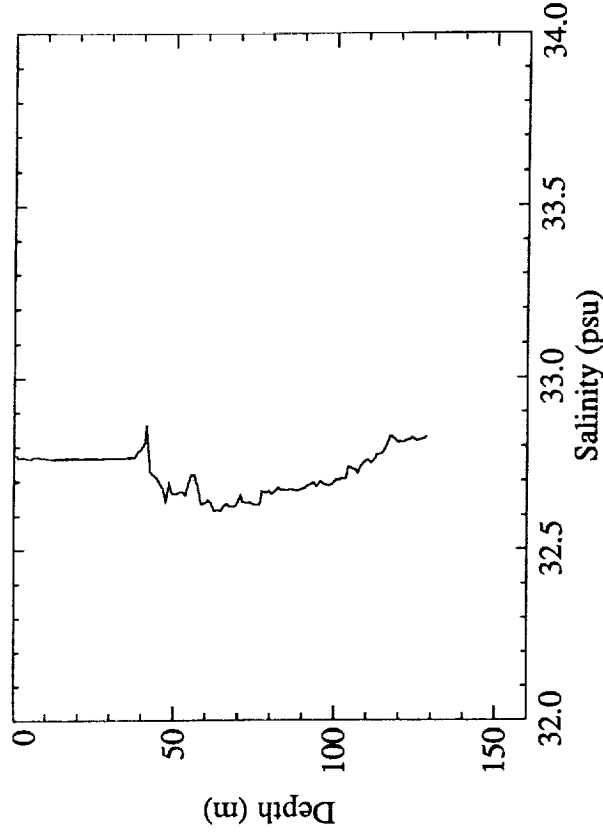
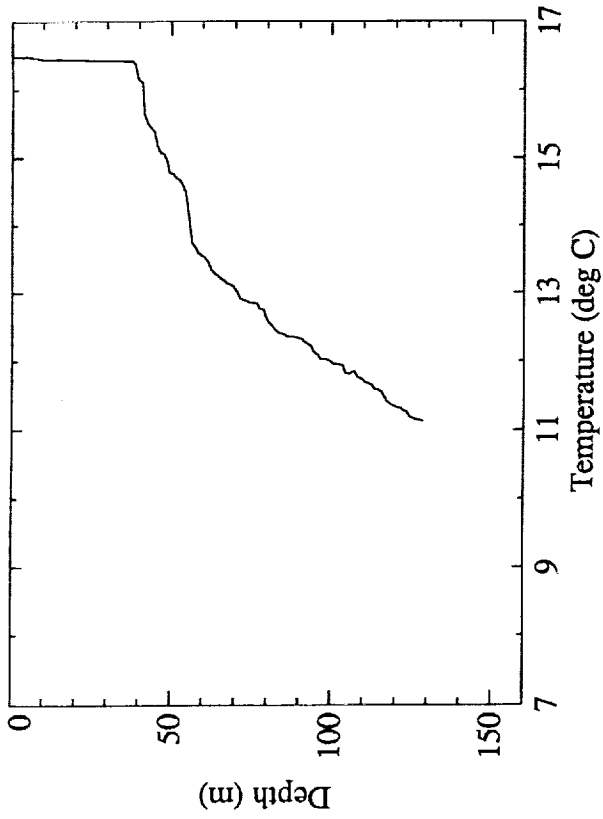


Figure 19. File: c880719a

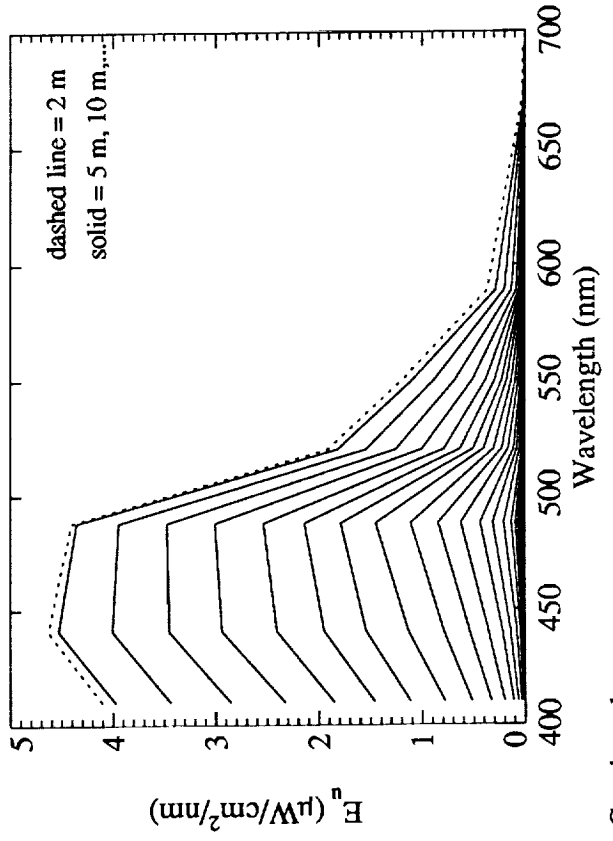
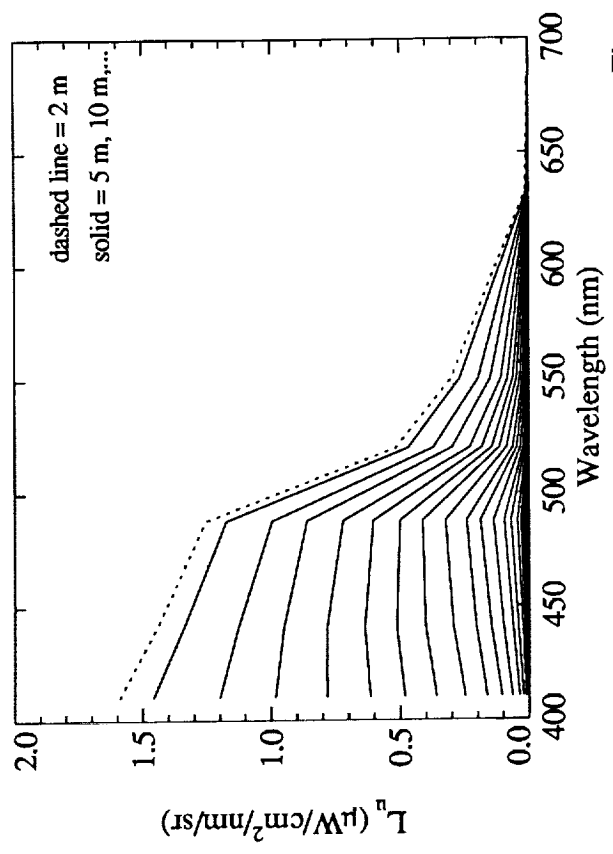
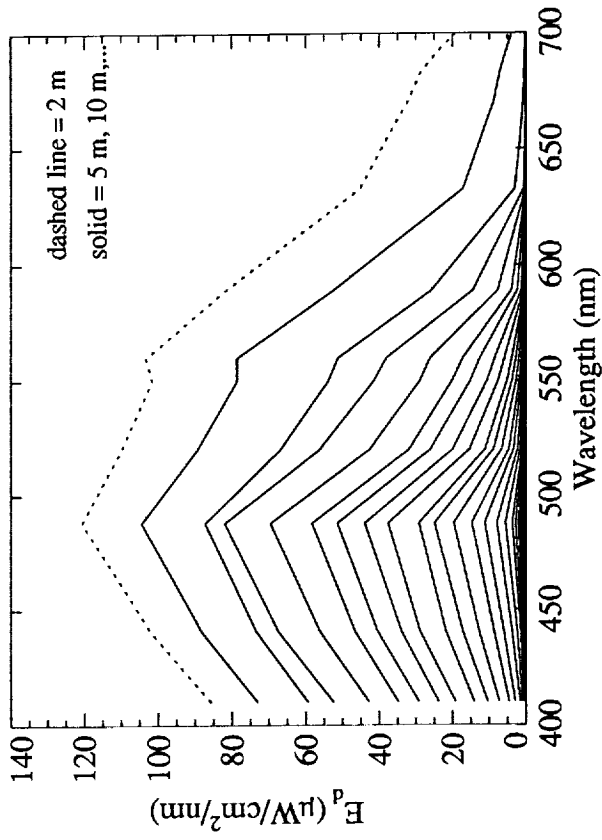
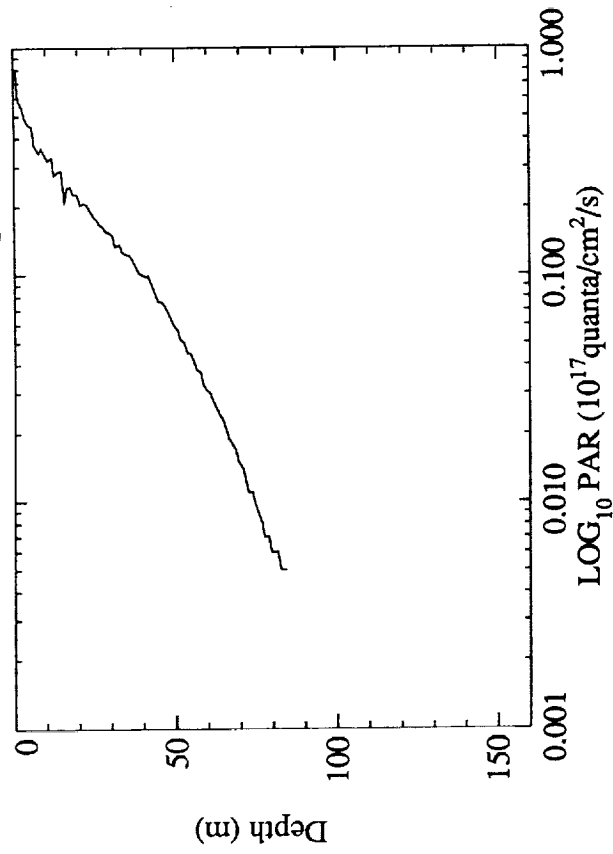


Figure 19. Continued

CTZ 07-20-88 Loc: sta 80 op 2 Lat: 37° 37.1' N Long: 124° 28.6' W File: c880720a

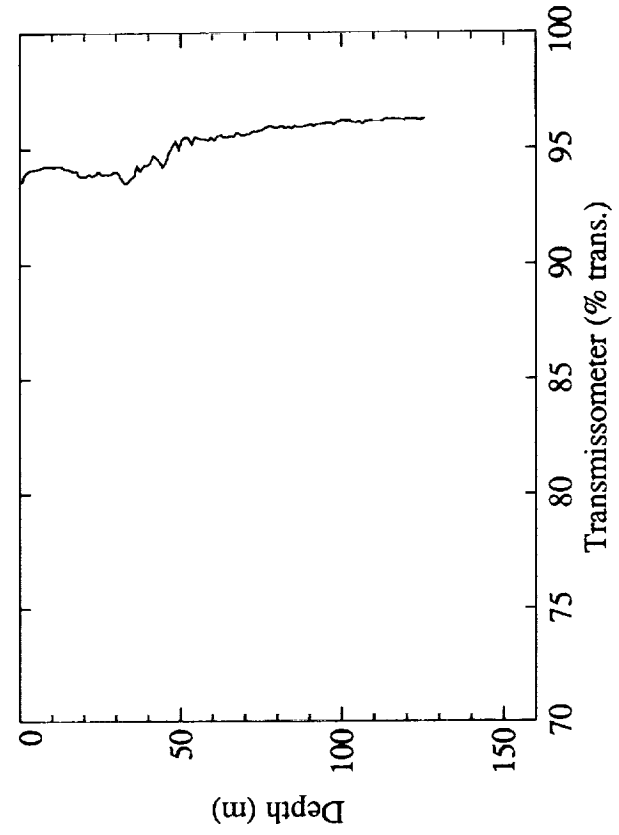
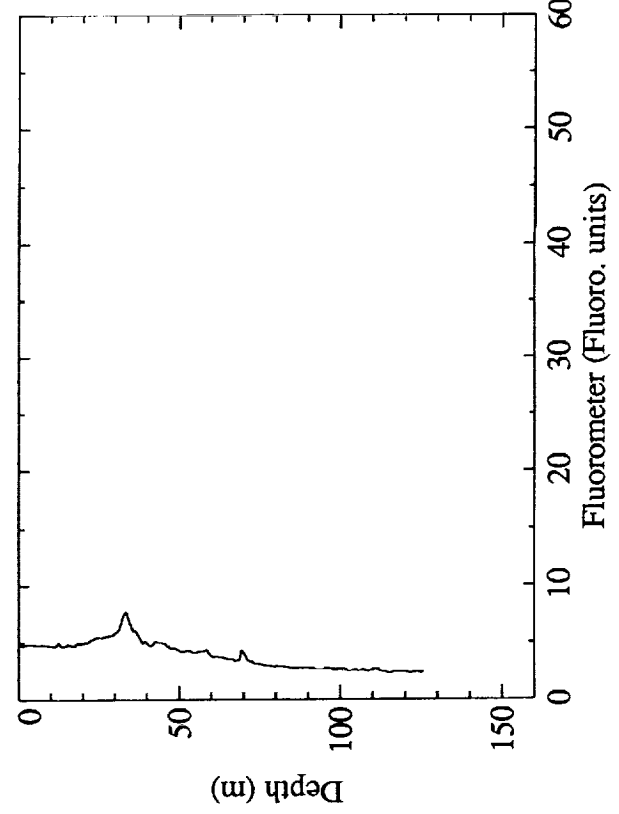
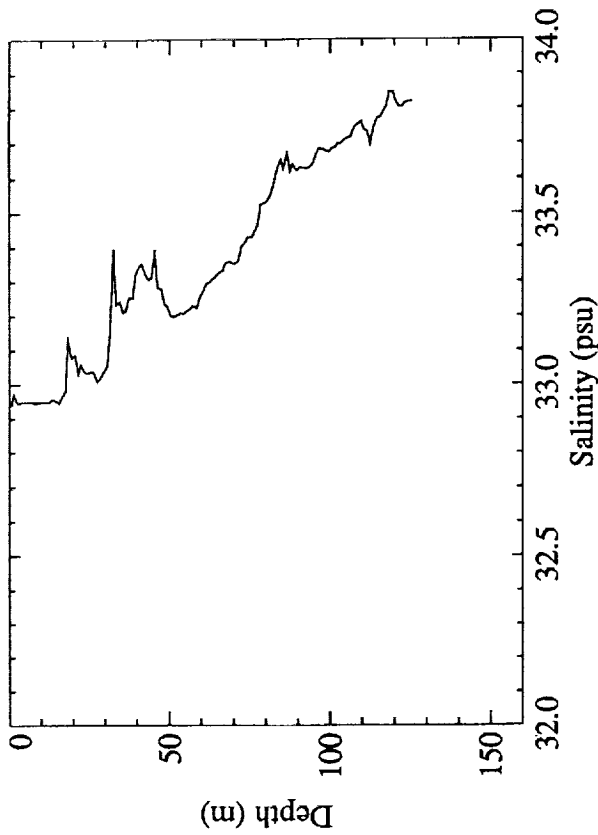
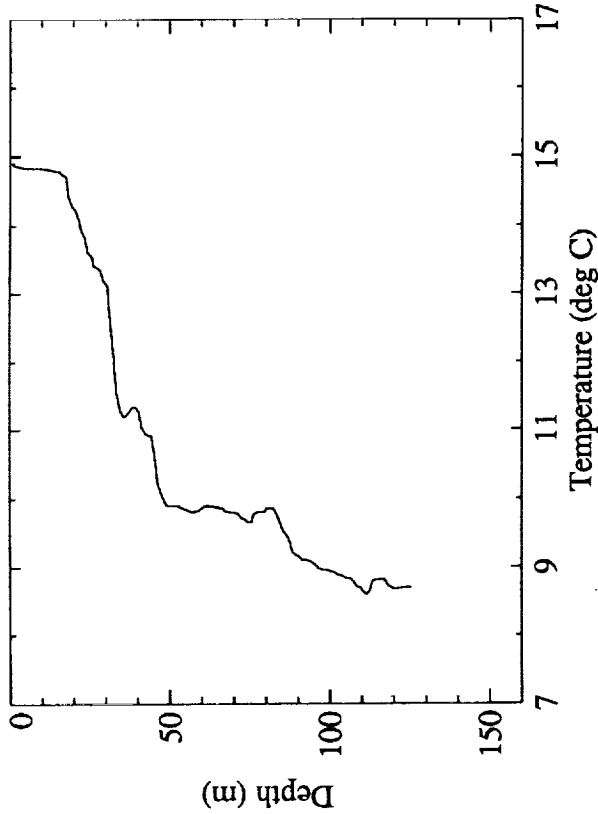


Figure 20. File: c880720a

CTZ 07-20-88 Loc: sta 80 op 2 Lat: 37° 37.1' N Long: 124° 28.6' W File: c880720a

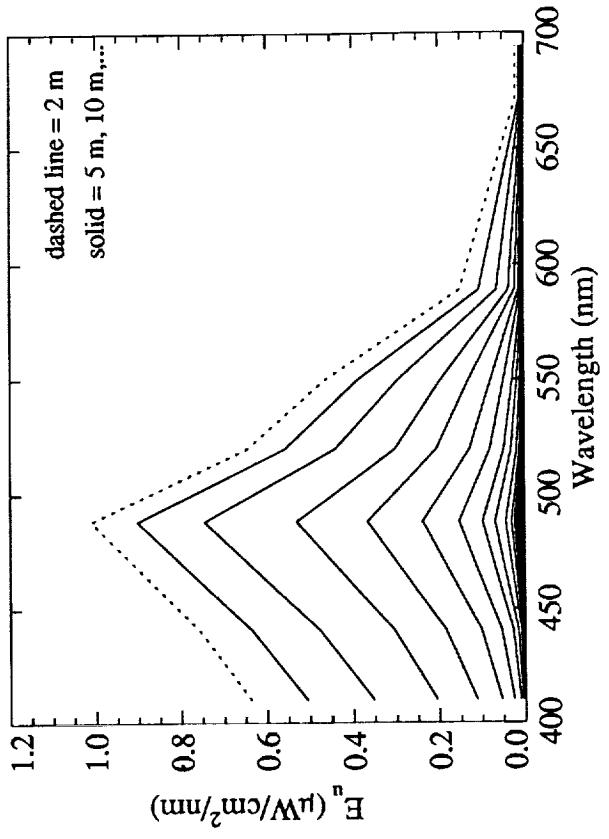
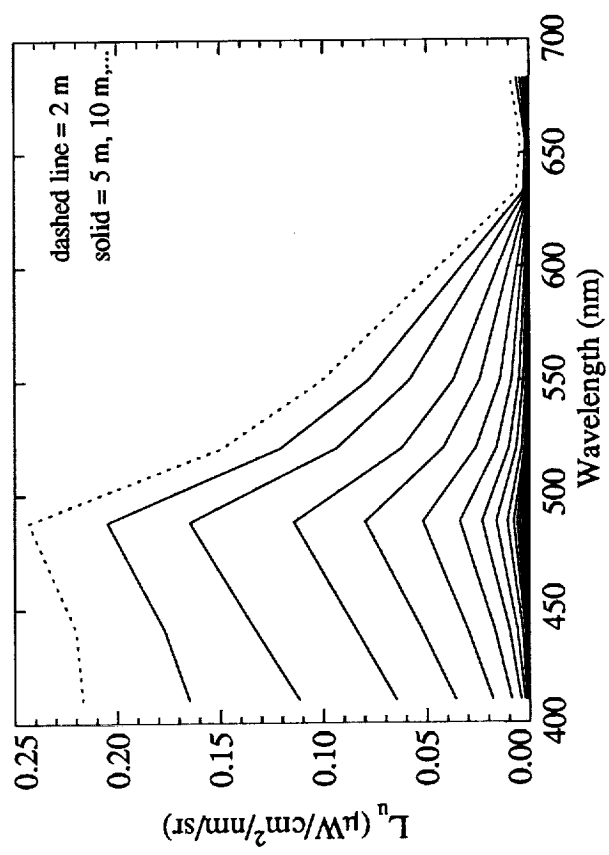
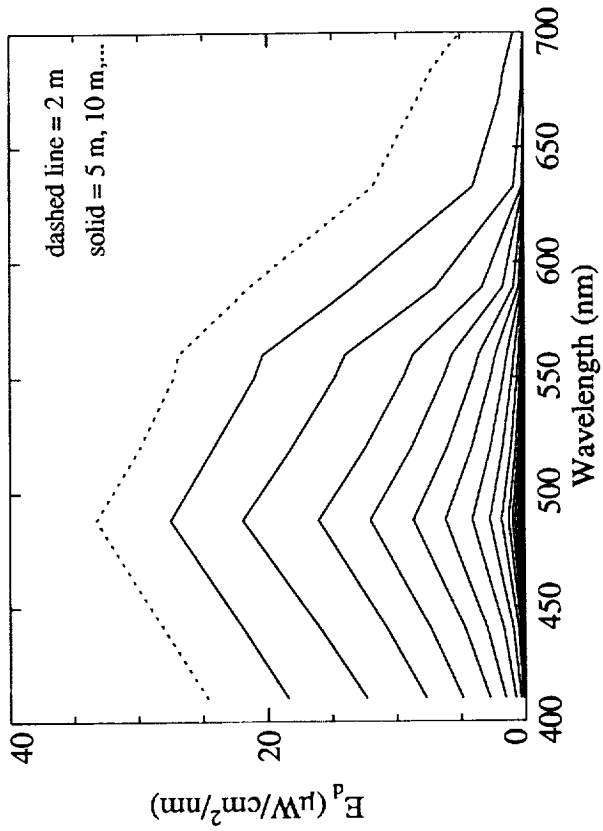
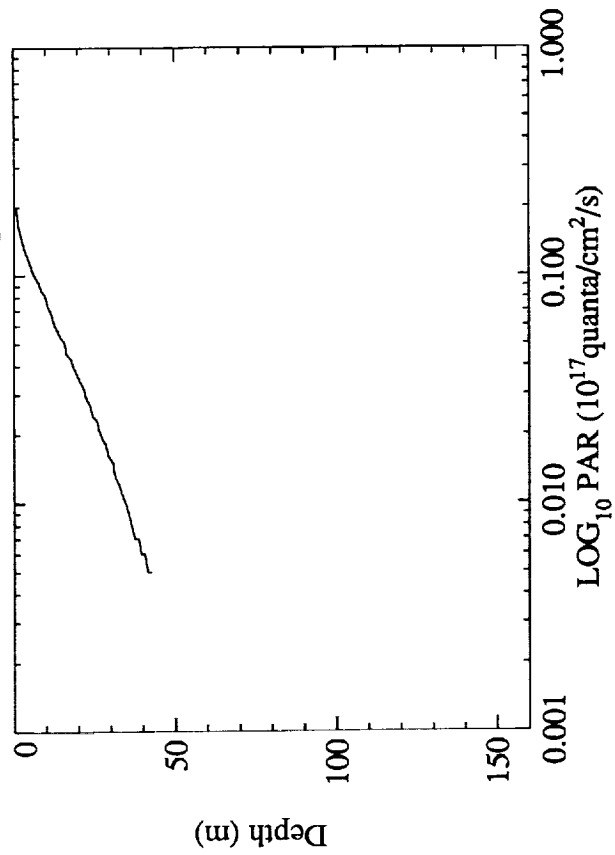


Figure 20. Continued

CTZ 07-20-88 Loc: sta 82 op 1 Lat: 37° 45.8' N Long: 124° 36.9' W File: c880720c

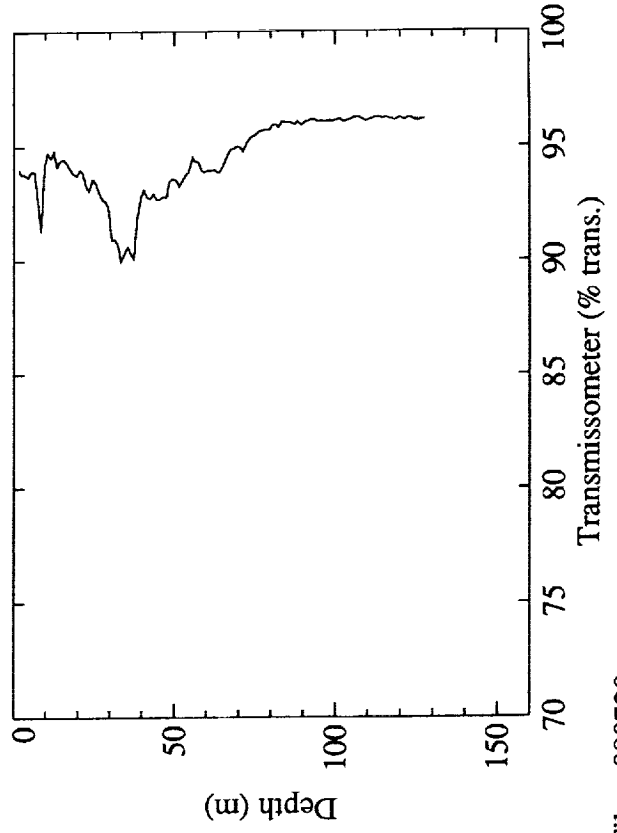
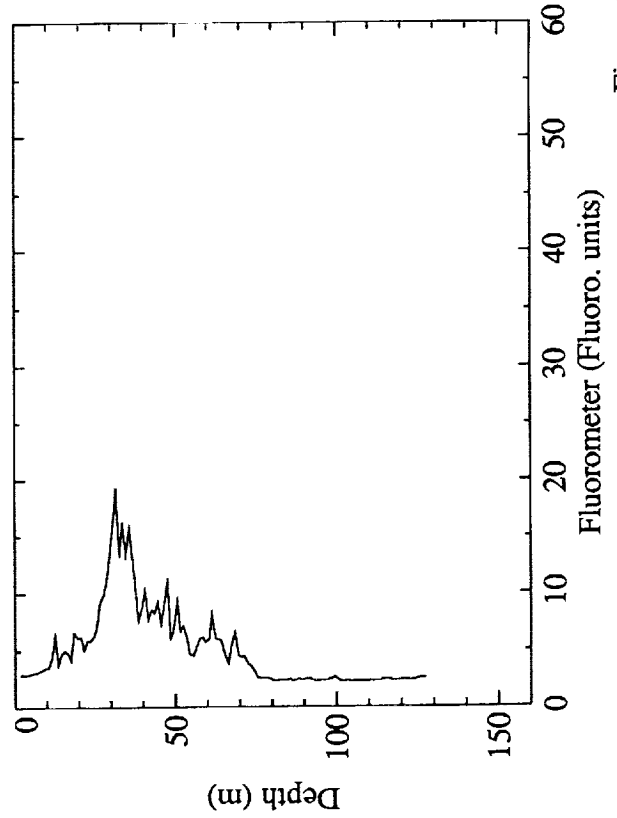
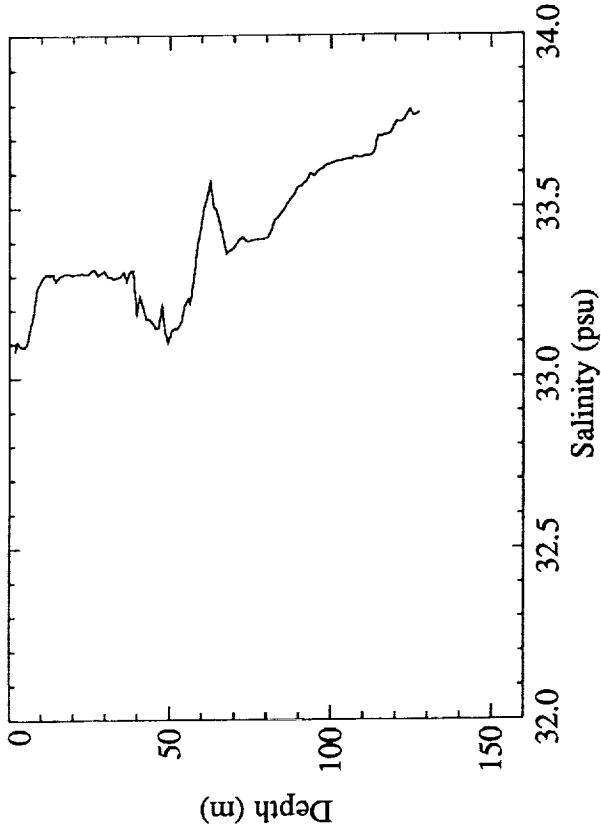
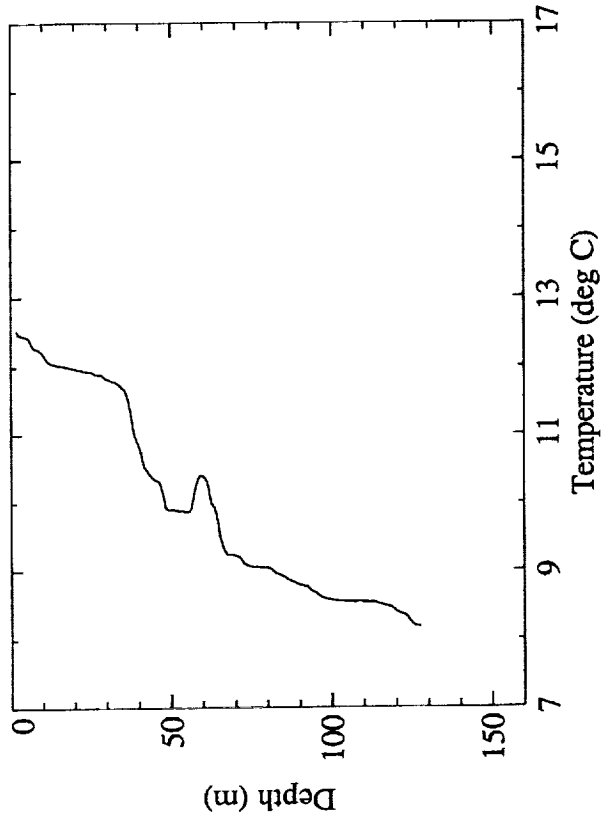


Figure 21. File: c880720c

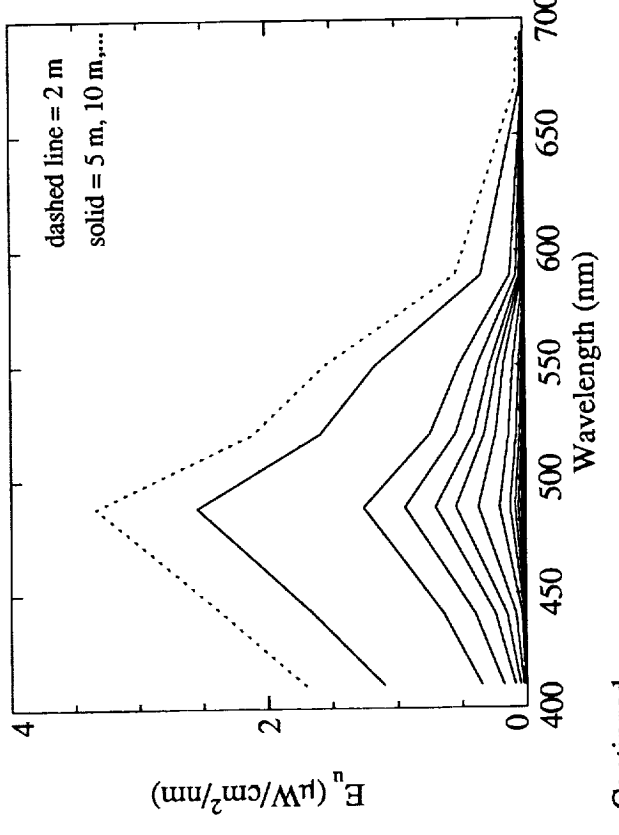
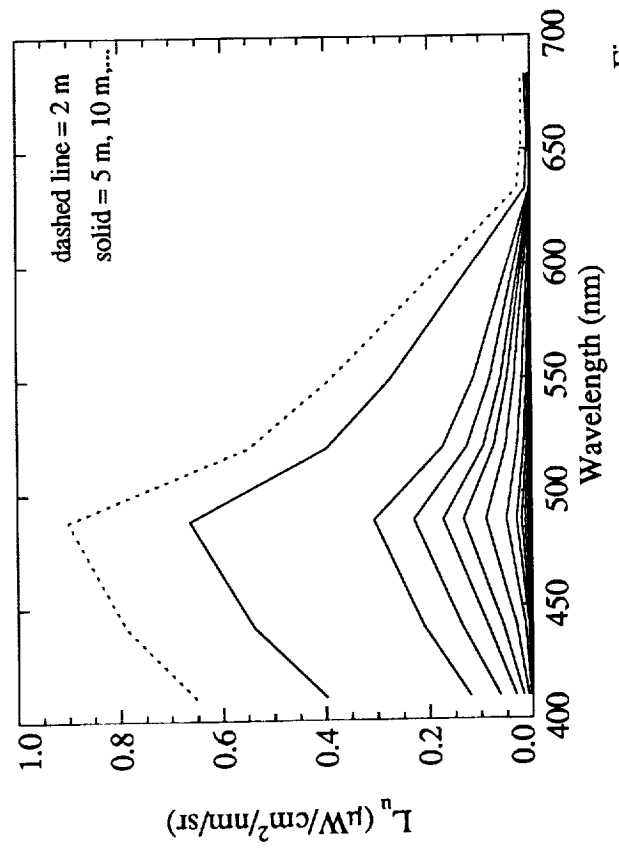
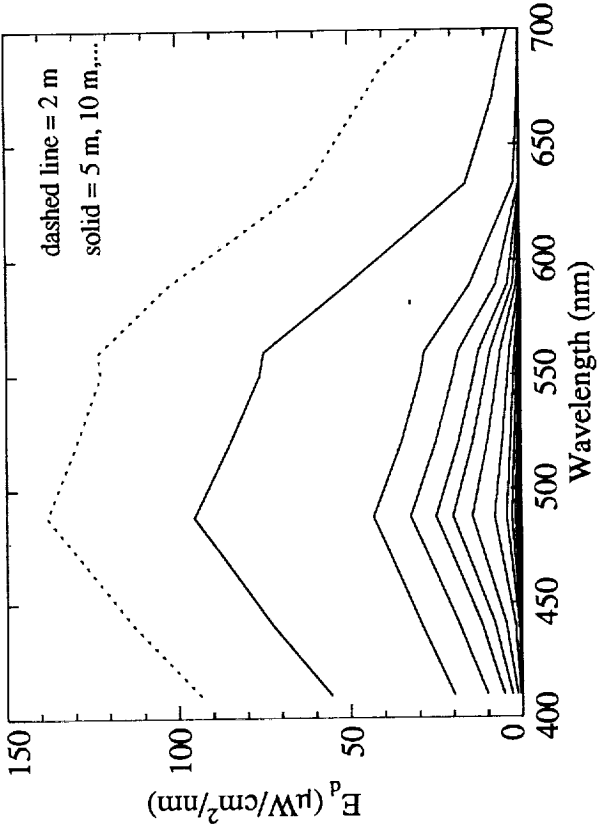
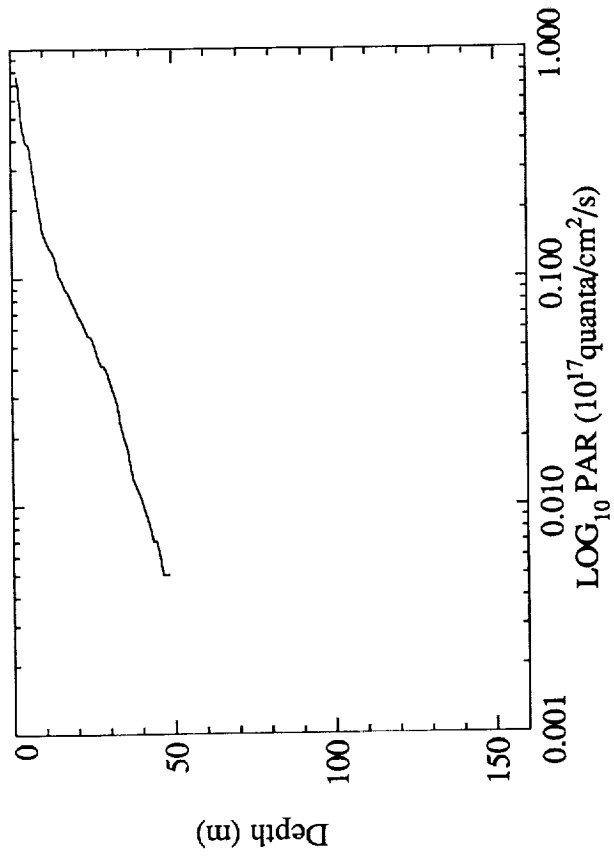


Figure 21. Continued

CTZ 07-20-88 Loc: sta 84 op 1 Lat: 37° 54.3' N Long: 124° 45.0' W File: c880720e

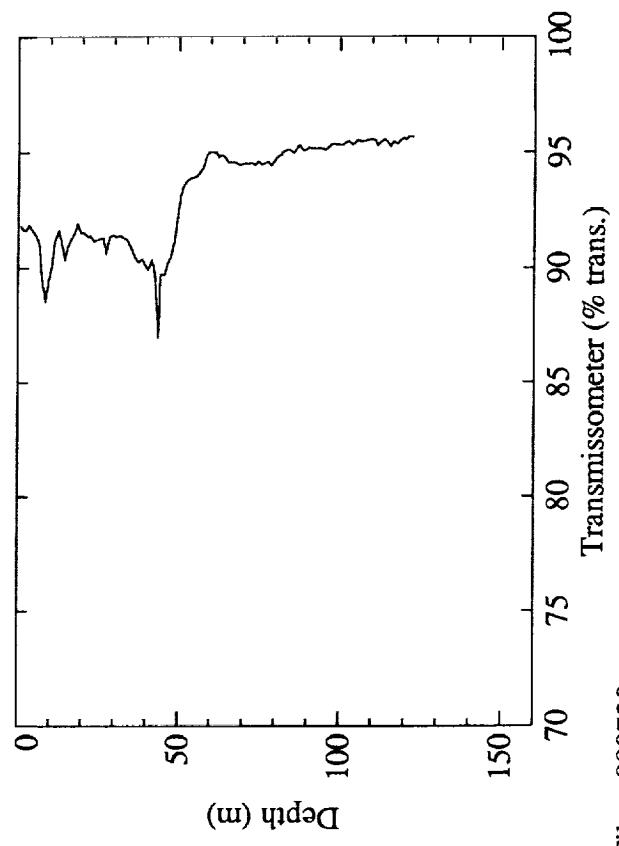
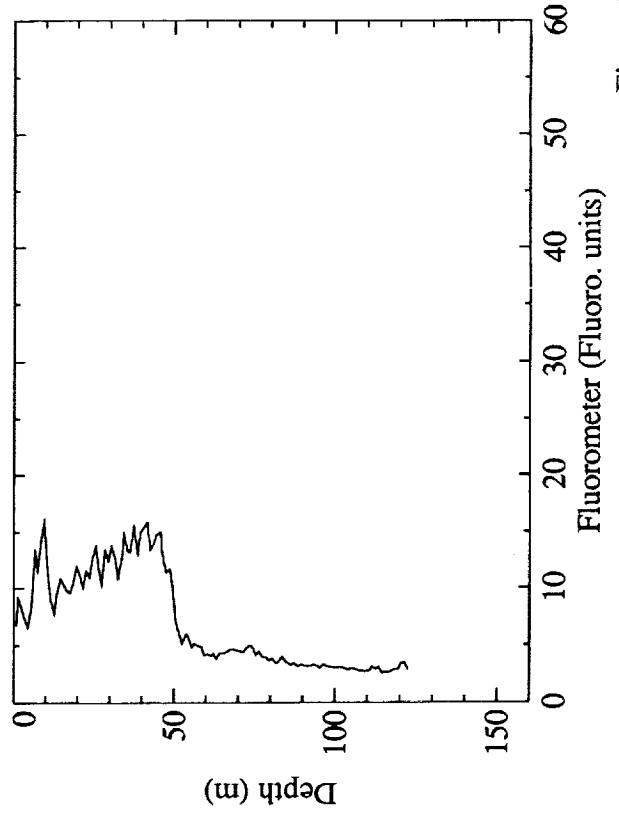
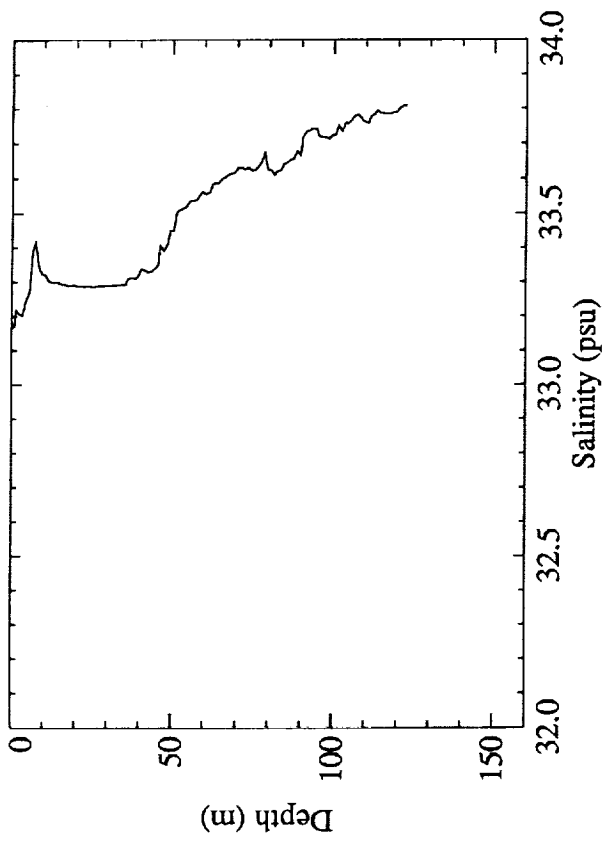
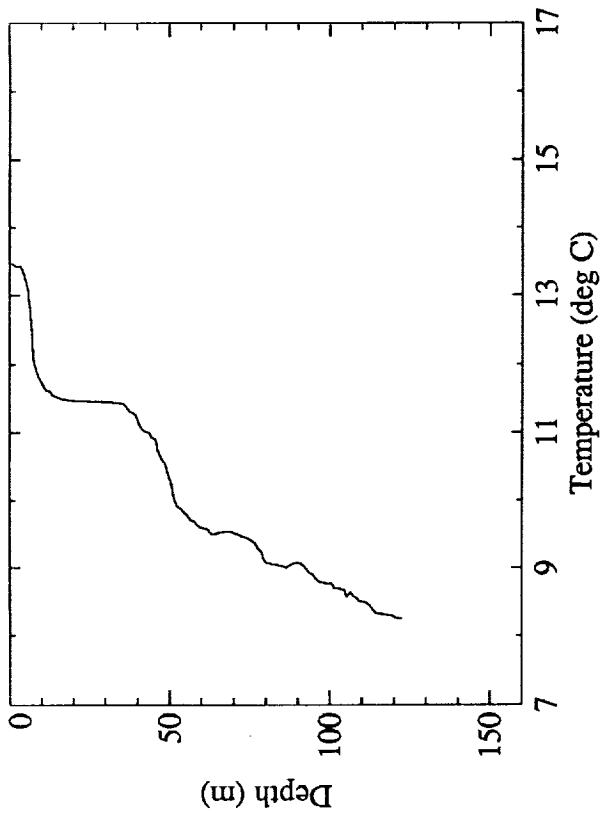


Figure 22. File: c880720e

CTZ 07-20-88 Loc: sta 84 op 1 Lat: 37° 54.3' N Long: 124° 45.0' W File: c880720e

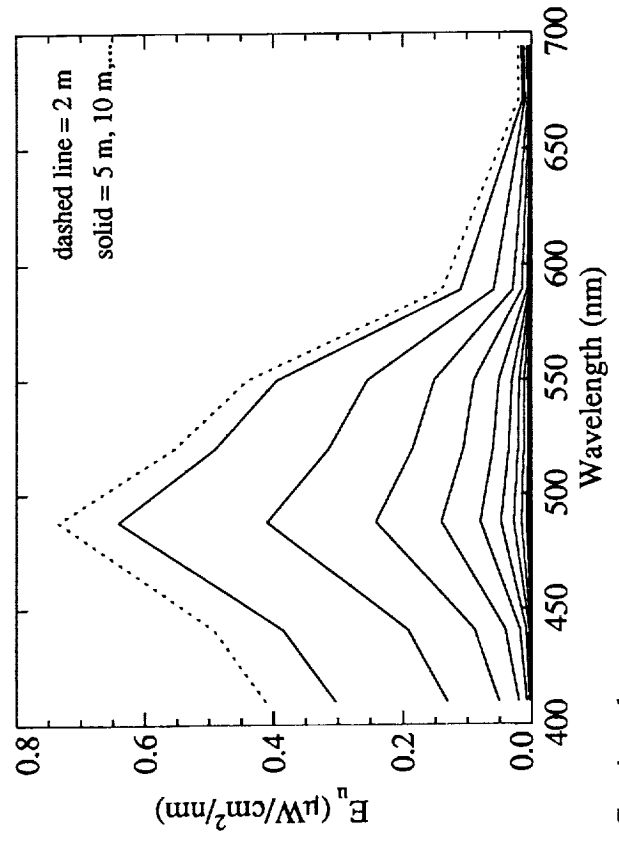
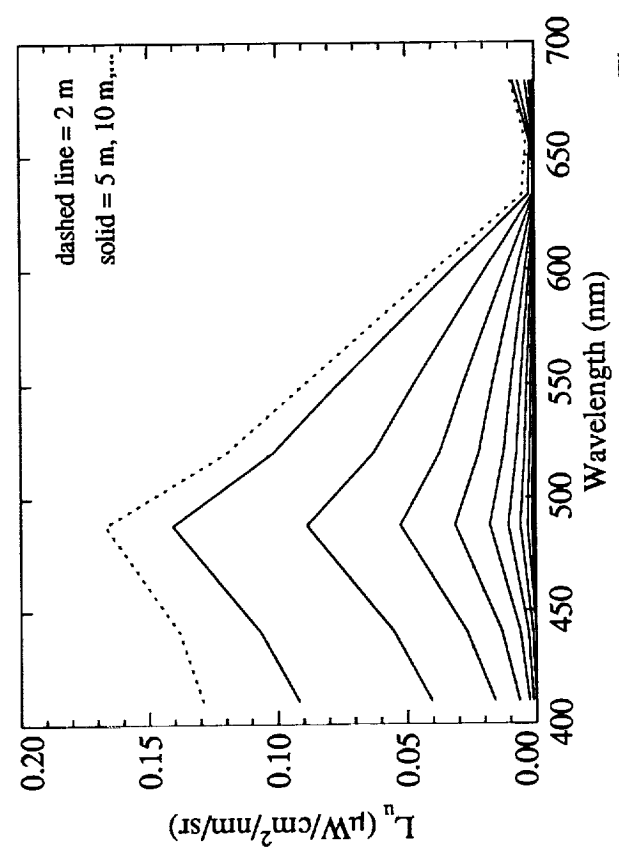
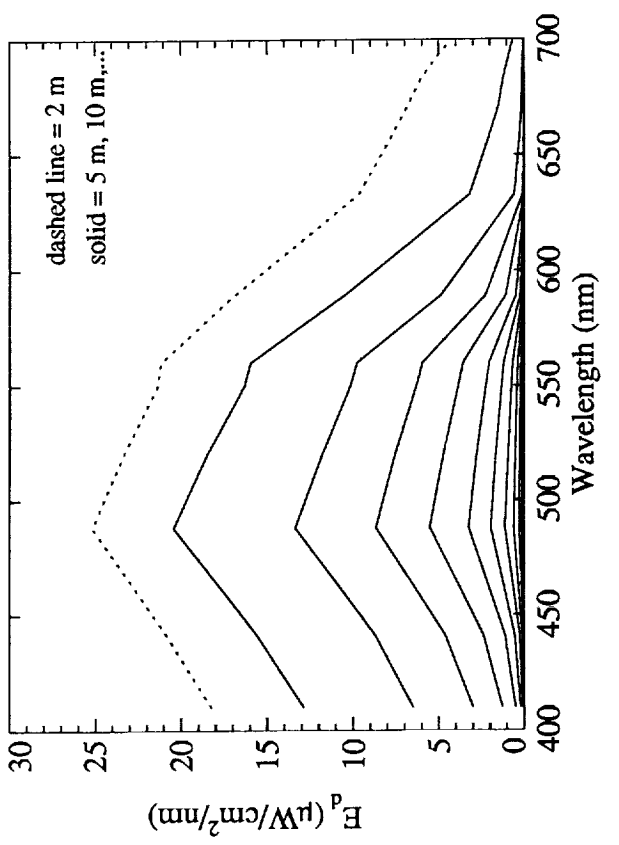
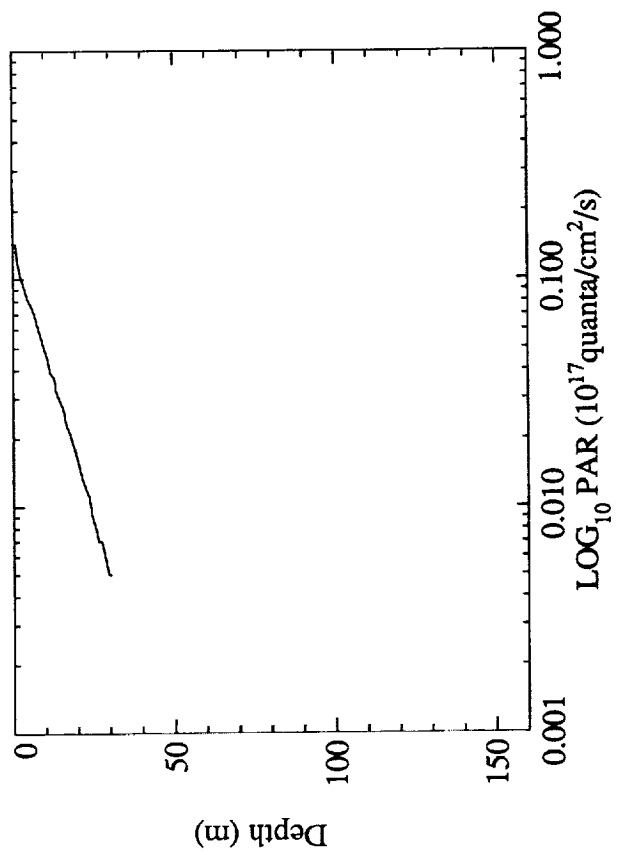


Figure 22. Continued

CTZ 07-21-88 Loc: sta 91 op 1 Lat: 38° 57.6' N Long: 124° 57.7' W File: c880721a

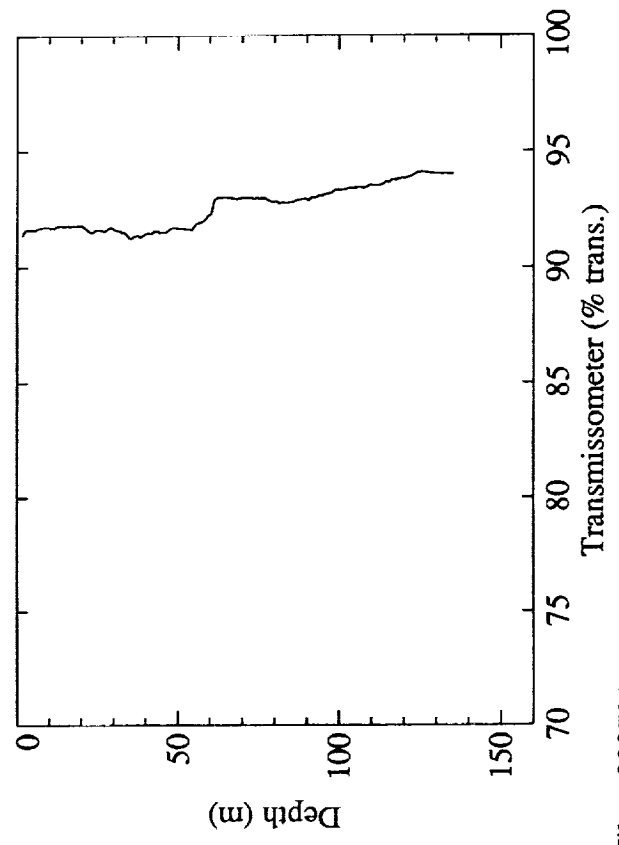
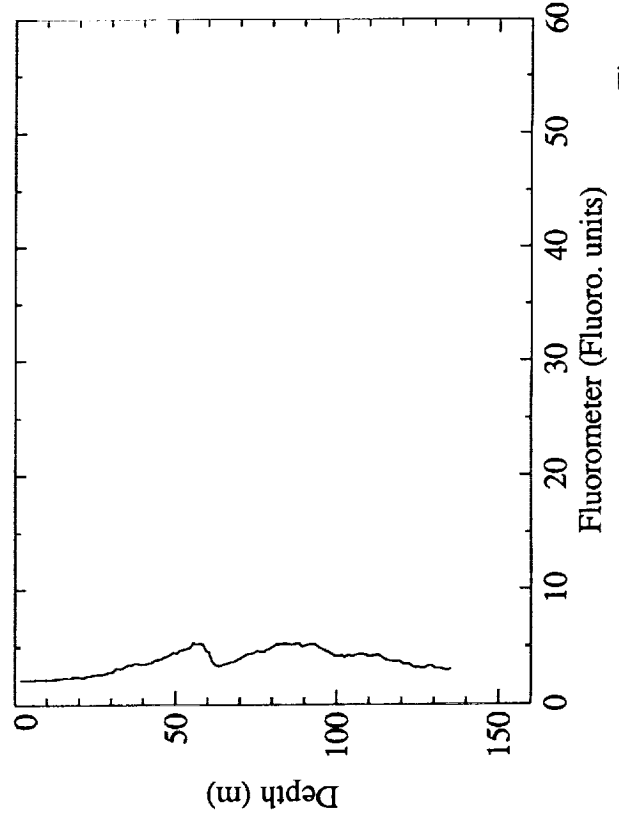
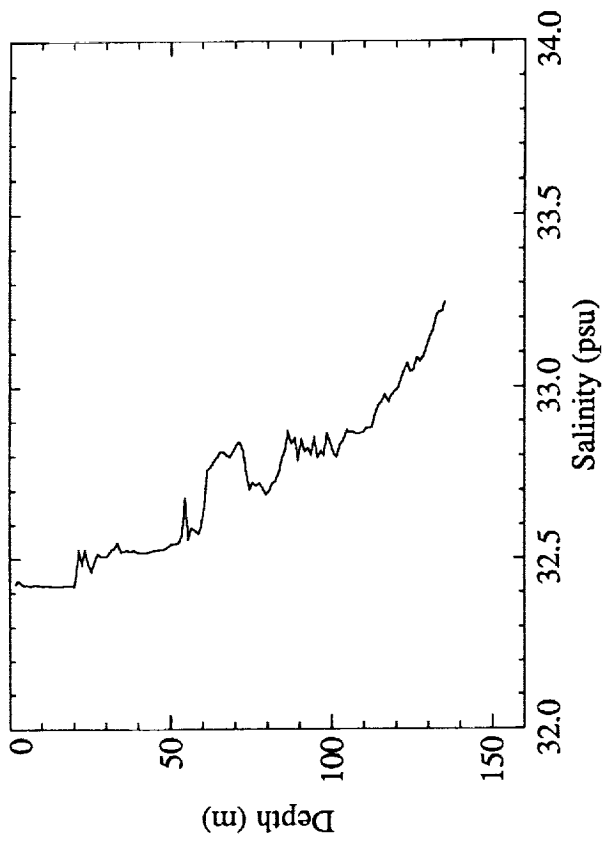
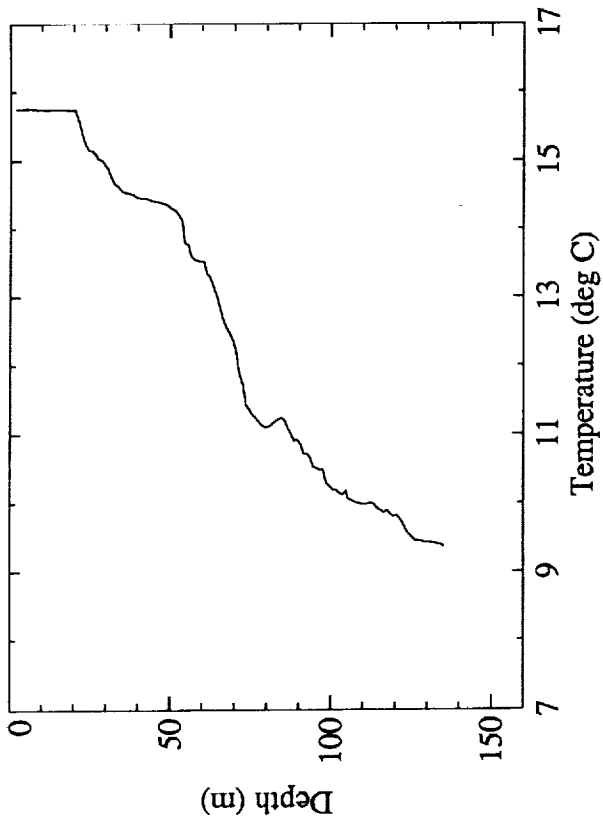


Figure 23. File: c880721a

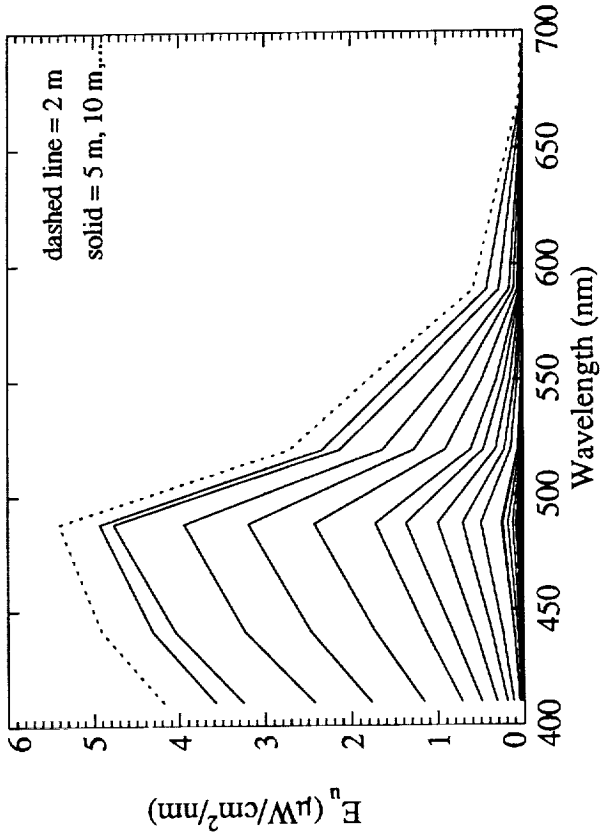
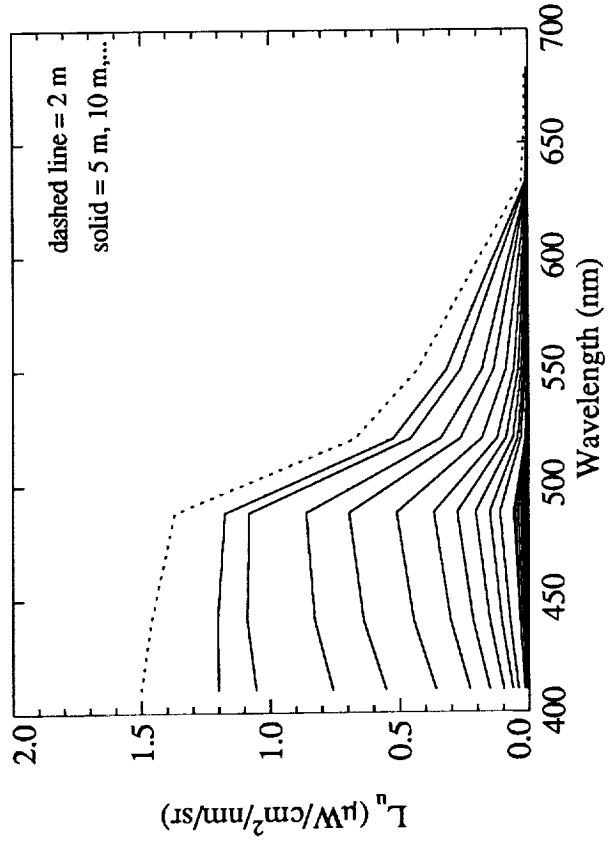
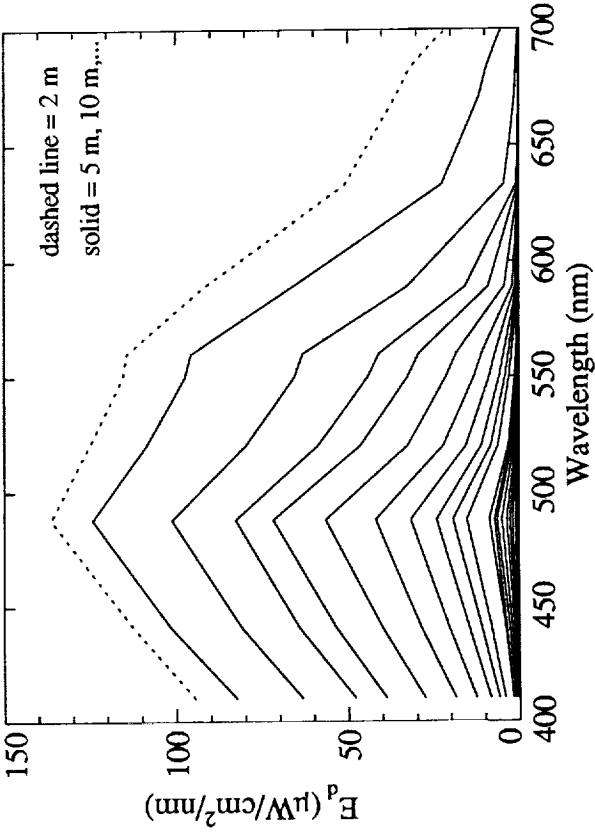
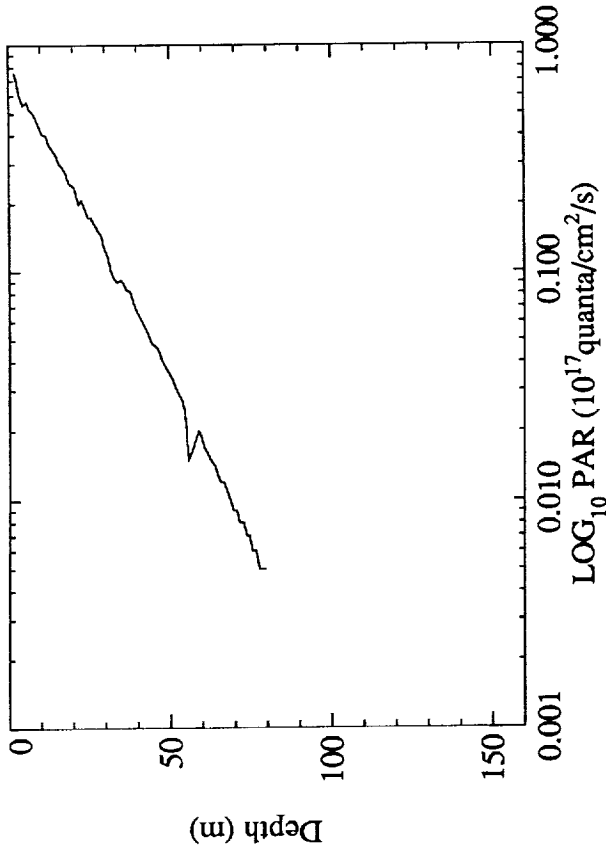


Figure 23. Continued



