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Basalt samples and water-column samples from the southern Juan de Fuca Ridge: Preliminary results of cruise L13-82-WF

by

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INTRODUCTION

In 1980 the U.S. Geological Survey began a detailed investigation of the southern Juan de Fuca Ridge as part of a long-term program to study metallogenesis on the deep-sea floor (Fig. 1). Cruises to the study area in 1980 and 1981 culminated in the discovery by bottom photography of 6 hydrothermal vents along a 12-km segment of ridgecrest (Normark and others, 1983; Lichtman and others, 1983). High levels of total dissolvable managanese (TDM) and helium-3 in the water column indicated a seventh active vent site (Normark and others, 1982). Zinc-rich massive sulfide deposits were recovered from one of the vent sites (Koski and others, 1982).

From 17 October to 29 October 1982 a third cruise to the study area was conducted aboard the U.S.G.S. vessel S.P. Lee. A total at 1660 kg of basalt was recovered from eight succesful dredge stations. In addition, one hydrocast station and one camera station were conducted (fig. 2). This report presents a brief description of the bottom photographs, of each dredge haul and the results of shipboard and laboratory water chemistry measurements.

METHODS

Acoustic transponder navigation was used to position the ship and instrument package during all station work. At the end of the 1981 cruise, one bottom transponder was left to mark the study area. After re-establishing contact with the marker unit, two additional transponders were deployed at the beginning of the 1982 cruise. A relay transponder attached to the wire 300 m above the dredge bag, 100 m above the camera sled or directly below the Niskin samplers provided excellent position control during station work.

One camera station used a 35 mm camera provided by the University of Washington and 30-m roll of high-speed ektachrome color film.

We used a round-frame chain-bag dredge for each of the eight dredge stations. A 12-khz pinger attached 300 m above the dredge permitted a short wire scope and limited on-bottom dredge paths generally to less than 600 m.

During the hydrocast station, six 30-liter Niskin bottles were placed at 50 m intervals between 1970 m and 2220 m depth within a water column of 2233 m. Immediate shipboard measurements of methane and radon were performed. Additional aliqouots were prepared for later laboratory measurements of hydrocarbons, manganese, and other major elements. The remaining water, approximately 20 l from each bottle, was acidified with HCl at 50 cc/20 l and is available for further analysis.

Two samples for hydrocarbon gas analysis were taken from each Niskin bottle: one in a liter can and the other in a liter glass bottle. A headspace was created in each container and the container was sealed after addition of sodium azide (NaN_3). After equilibration of the gas in the canned sample using a mechanical shaker, the head space was analyzed on a shipboard gas chromatograph. The samples were refrigerated until analysis in the shore-based laboratory. The same gas chromatograph was used for the shore-based work. The instrument is capable of measuring methane, ethane, ethene, propane,

propene, iso-butane, normal butane, and a backflush peak (C_{5+}) containing pentane and higher molecular weight hydrocarbons.

^{222}Rn 0.75l of water was drawn from each Niskin bottle for radon analysis. ^{222}Rn was measured onboard ship by Josh M. Been using a portable alpha scintillometer. This unit has a constant volume inlet system and is described elsewhere (Reimer, 1977). The 0.75l of water withdrawn from the Niskin bottles was transferred to a closed 1-l polypropylene bottle and agitated vigorously to degas the water into the air in the headspace. Then a 50 cm^3 sample of headspace air was withdrawn for the radon analysis.

RESULTS

Photography

Station # 12 latitute range: 44° 38.90' N to 44° 39.73'N

water depth: 2220 m camera elevation: 3-5 m

duration: 2 hours, 400 exposures film type: ektachrome 200

primary features: glassy sheet and lobate basalt flows, collapse pits.

Due to optical problems caused by a missing lens element, all of the photographs from the backup camera system were badly vignetted, giving a focused area of approximately one square meter. In each of the photographs we observed fresh, glassy basalt flows with sheet to lobate flow morphology. The basalt flows are identical in appearance to the basalt flows photographed during the 1981 cruise (Lichtman and others, 1983). No evidence for hydrothermal deposits or vent animal communities was seen in any of the photographs.

Dredge Samples

The eight dredge stations each recovered basaltic lavas identical to the lavas recovered from the axial valley during the 1981 cruise (Eaby and Clague, 1982). The lavas are very fresh, with minor Mn-oxide and amorphous iron oxides on fracture surfaces. No massive sulfide ores or hydrothermal sediments were recovered.

The lavas are massive, aphyric, nonvesicular basalt with glassy to microcrystalline groundmass; sparce phenocrysts of plagioclase (<1 %) are ubiquitous and range in size from 1 to 5 mm. Fifteen glomerocrysts (<1 cm^3) of plagioclase and clinopyroxene ± olivine have been found, but not are as large as the gabbroic xenoliths (up to 170 cm^3) recovered in 1981 (Eaby and Clague, 1982).

Basalt morphology is dominantely (70-95%) sheet, lobate, and hollow lobate flow fragments; pillow fragments are less common (0-30%). Samples with fresh glassy rinds (maximum thickness 13mm) on the upper flow surface are abundant in each dredge haul. Glass was sampled on board ship and has been analyzed by microprobe by Jean-Philippe Eissen. Representative analyses are identical to those reported in Normark and others (1983). Analysis of the major and trace element chemistry of the lavas and the mineral chemistry of

the xenoliths is in progress and will be reported elsewhere. Copious quantities of glass are available for further analysis.

A brief description of each dredge haul follows. Sample localities are shown in figure 2 and comparative data is summarized in table 1.

station #2 latitude: 44°41.03'N
longitude: 130°21.27'W

Recovery: 200 kg. Texture: aphyric, non-vesicular microcrystaline basalt. Morphology: 15% pillow flow fragments, 5% sheet and lobate flow fragments, 80% hollow lobate flow fragments. Glass: abundant fresh glass with no palagonite visible with hand lens. Alteration: very fresh with minor Mn-oxide and amorphous iron oxide on fracture surfaces. Xenoliths: 0.

station #3 latitude: 44°39.48'N
longitude: 130°21.90'W

Recovery: 200 kg. Texture: Same as station #2. Morpholoy: 50% sheet and lobate flow fragments, 50% hollow lobate flow fragments. Glass: same as station #2. Alteration same as station #2. Xenoliths: 1 glomerocryst, 0.5 cm^3, 50% plagioclase and 50% clinopyroxene. Comment: Abundant large, flat crusts 4-cm thick and up to 1300 cm^2.

Station #4 latitude: 44°39.30'N
longitude: 130°21.90'W

Recovery: 250 kg. Texture: Same as station #2. Morphology: <5% pillow flow fragments, <5% sheet and lobate flow fragments, 90% hollow lobate flow fragments. Glass: same as station #2. Alteration: same as station #2. Xenoliths: 11 glomerocrysts, <1 cm^3, 50% plagioclase and 50% clinopyroxene (10 samples), 50% plagioclase and 50% olivine (1 sample).

station #7 latitude: 44°41.25'N
longitude: 130°20.93'W

Recovery: 250 kg. Texture: same as station #2. Morphology: 30% pillow flow fragments, 70% sheet and lobate flow fragments and hollow lobate flow fragments. Glass: original surface glass occassionally present. Alteration; minor Mn-oxide and amorphous Fe-oxides on fracture surfaces and frequent white and gray coating. Xenoliths: 2 glomerocrysts, <1 cm^3, 50% plagioclase and 50% clinopyroxene

station #8 latitude: 44°40.09'N
longitude: 130°21.60'W

Recovery: 200 kg. Texture: same as station #2. Morphology: 10% pillow flow fragments, 10% sheet and lobate flow fragments, 80% hollow lobate flow fragments. Glass: same as station #2. Alteration: same as station #2. Xenolith: 0.

station #10 latitude: 44°41.19'N
longitude: 130°21.10'W

Recovery: 180 kg. Texture: same as station # 2. Morphology: 5% pillow flow fragments, 95% hollow lobate flow fragments. Glass: same as station #2. Alteration: same as station #2. Xenoliths: 0.

station #11 latitude: 44°39.30'N
longitude: 130°21.97'W

Recovery: 180 kg. Texture; same as station #2. Morphology: 10% pillow flow fragments, 5% sheet and lobate flow fragments, 85% hollow lobate flow fragments. Glass: same as station #2. Alteration: orange Fe-oxide deposits common on fractures. Xenoliths: 0.

station #13 latitude: 44°39.29'N
longitude: 130°21.88'W

Recovery: 200 kg. Texture: same as station #2. Morphology: 10% sheet and lobate flow fragments, 90% hollow lobate flow fragments. Glass: same as station #2. Alteration: same as station #11. Xenoliths: 1 glomerocryst, <1 cm^3, 60% plagioclase and 40% clinopyroxene

Hydrocast Samples

station #6 latitute: 44°41.09'N
longitude: 130°20.85'W

Water depth: 2033 m. Bottle depths: 1970 m, 2020 m, 2070 m, 2120 m, 2170 m, 2220 m. Bottle type: 30 liter Niskin samplers.

Methane was detected in all samples; ethane through C_{5+} were detectable (>1 nl/l) during shore-based analysis but were not detectable during shipboard analysis due to high noise levels. Laboratory methane measurements of both the canned and bottled water indicated a similar variation with depth; however, the methane concentrations in the bottled water were lower than in the canned water. Shore-based analysis of methane in the canned water samples is plotted as a function of depth in figure 3. The methane concentration increases with decreasing depth, reaching a maximum at 2120 m, then decreases to the shallowest bottle at 1970 m. The methane concentration at 2120 m is approximately 3 times the concentration at 1970 m (figure 3).

The shipboard radon detection unit had a fairly low sensitivity with a 4 pCi/l limit; however, radon activity was detected in all samples except the shallowest bottle at 1970 m depth. The ^{222} Rn activity profile is similar to the methane concentration profile with the highest values at 2170 m depth (19 pCi/l) and 2120 m depth (16 pCi/l) (figure 3). Above 2120 m depth, the ^{222}Rn values decrease steadily to 1970 m where ^{222}Rn was below the detection limit. The ^{222}Rn values at 2170 m and 2120 m depth are approximately two orders of magnitude greater than the ^{222}Rn activity for normal seawater and probably indicate a large component of hydrothermal fluid (Klinkhammer and others, 1977; Kadko, 1980).

Both the methane concentrations and the ^{222}Rn values indicate a possible hydrothermal component 50 to 100 m above the sea floor. The laboratory methods were experimental in both cases, however, and the results should be compared with analyses for other common hydrothermal tracers, which are not yet available for these samples. Helium-3 and total dissolvable manganese (TDM) concentrations were measured for two hydrocast stations during the 1981 cruise (Normark and others, 1982). The results from one of these hydrocasts, station 14 (indicated by the hydrothermal plume symbol in figure 2), are shown in figure 3. Both the Helium-3 and TDM values show a similar trend of enrichment at approximately 50 m above the sea floor as the methane and ^{222}Rn values from the 1982 cruise.

SUMMARY

One of the purposes of this cruise was to obtain additional samples and photographs from the area of hydrothermal vents discovered in 1981 on the Southern Juan de Fuca Ridge. Although no additional vent sites were located, the hydrocast results suggest that there is a hydrothermal component in the water column near photographed vent 3 of Normark and others (1983) approximately 5.5 km north of the hydrothermal plume detected in 1981. Additionally, two bottom transponder were deployed and surveyed relative to the 1981 transponder net, and were left as markers for the subsequent field work in 1983.

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FIGURE CAPTIONS

Figure 1. Bathymetry of the Juan de Fuca Ridge and surrounding regions (from Pacific Geoscience Center, Juan de Fuca plate map, 1978). Location of the U.S.G.S. work area shown by the crosshatched box.

Figure 2. Bathymetry of a 20-km segment of the southern Juan de Fuca Ridge (Normark and others, 1982) showing the location of dredge (D), hydrocast (H), and camera (C) stations for cruise L13-82-WF. For dredge and camera stations, the arrow indicates the direction of movement of the towed vehicle. Also shown are the location of the photographed vent sites and the hydrothermal plume identified in the 1981 cruise.

Figure 3. (Top) Profiles of $\delta(^3He)$ and total dissolvable manganese (TDM) for station 14 from cruise L11-81-WF (1981) on the Juan de Fuca Ridge. Location of this station is shown by the hydrothermal plume symbol in figure 2. (Bottom) Profiles of methane (CH_4) concentration measured in the canned water samples and ^{222}Rn activity for station 6 from cruise L13-82-WF.

TABLE 1: L13-82-WF Dredge Summary

Dredge Station	2	3	4	7	8	10	11	13
Location								
latitude	44°41.03'N	44°39.48'N	44°39.30'N	44°41.25'N	44°40.09'N	44°41.19'N	44°39.30'N	44°39.29'N
longitude	130°21.27'	130°21.90'W	130°21.97'W	130°20.93'W	130°21.60'W	130°21.10'W	130°21.97'W	130°21.88'W
Recovery								
total wt (kg)	200	200	250	250	200	180	180	200
Texture	aphyric to sparsely phyric (1% plagioclase), nonvesicular microcrystalline basalt							
Form: (% of dredge)								
Pillow fragments	15	0	<5	30	10	5	10	--
sheet & lobate flow frag.	5	50	<5	35	10	--	5	10
hollow lobate flow frag.	80	50	90	35	80	95	85	90
Glass	fresh glass abundant			original surface glass not as abundant	abundant fresh glass			
Xenoliths	No	Yes	Yes	Yes	No	No	No	Yes
Alteration	very fresh with minor Mn-oxide and amorphous iron oxides on fracture surfaces			frequent white & grey coating	very fresh with minor Mn oxide and amorphous Fe-oxides on fracture surfaces		Orange Fe-oxide deposits common on fractures	

Figure 1

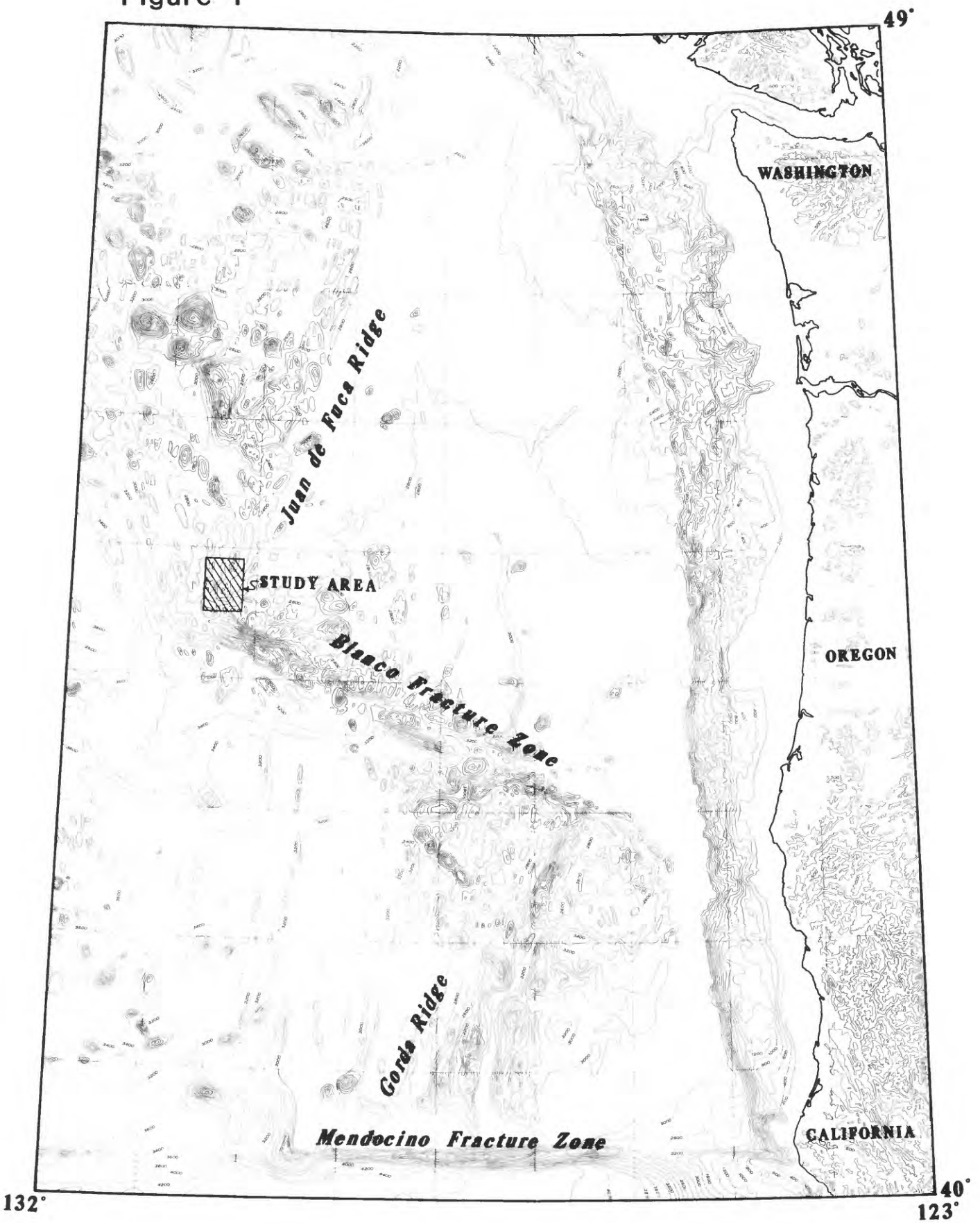

49°
WASHINGTON
Juan de Fuca Ridge
STUDY AREA
Blanco Fracture Zone
OREGON
Gorda Ridge
Mendocino Fracture Zone
CALIFORNIA
132°
40°
123°

Figure 2

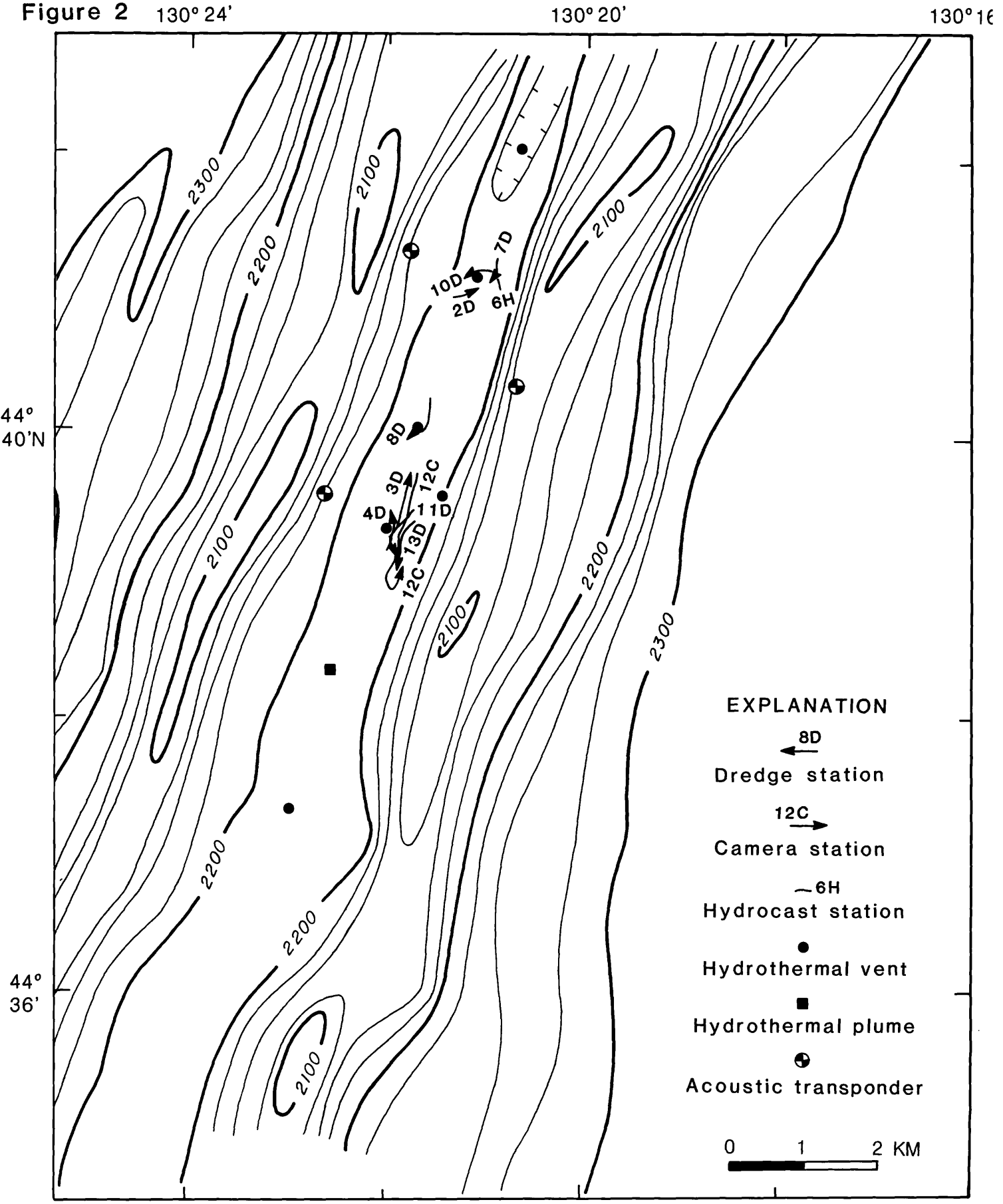
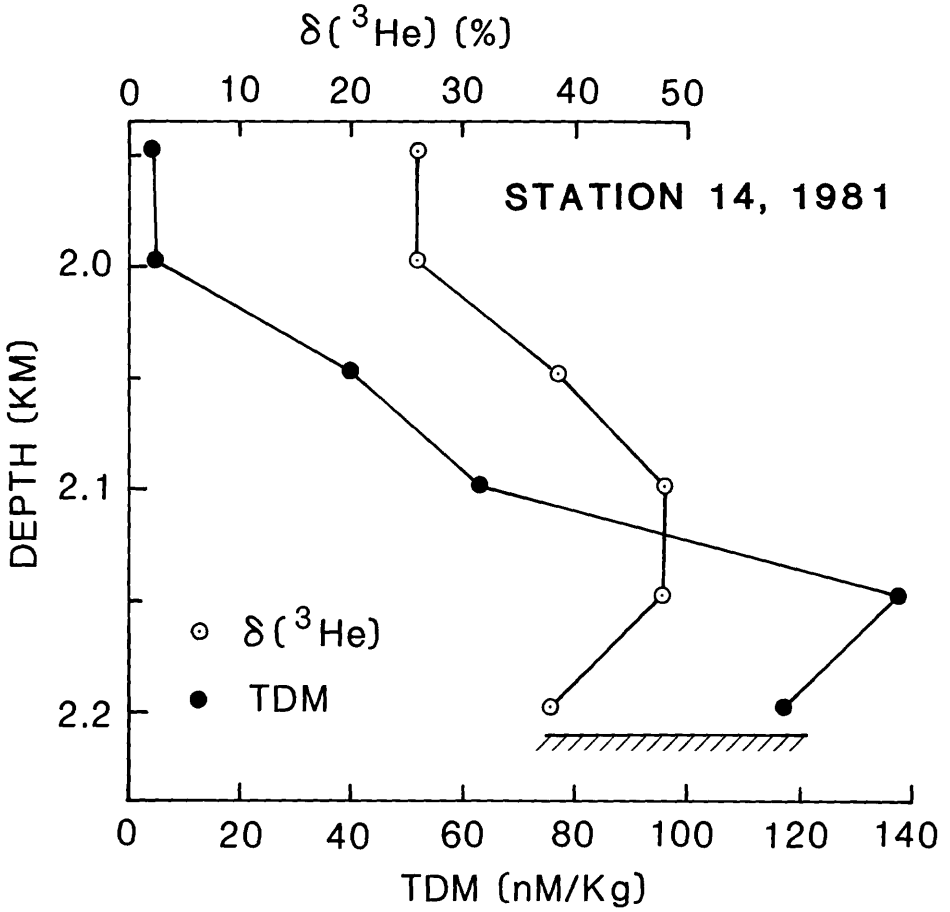
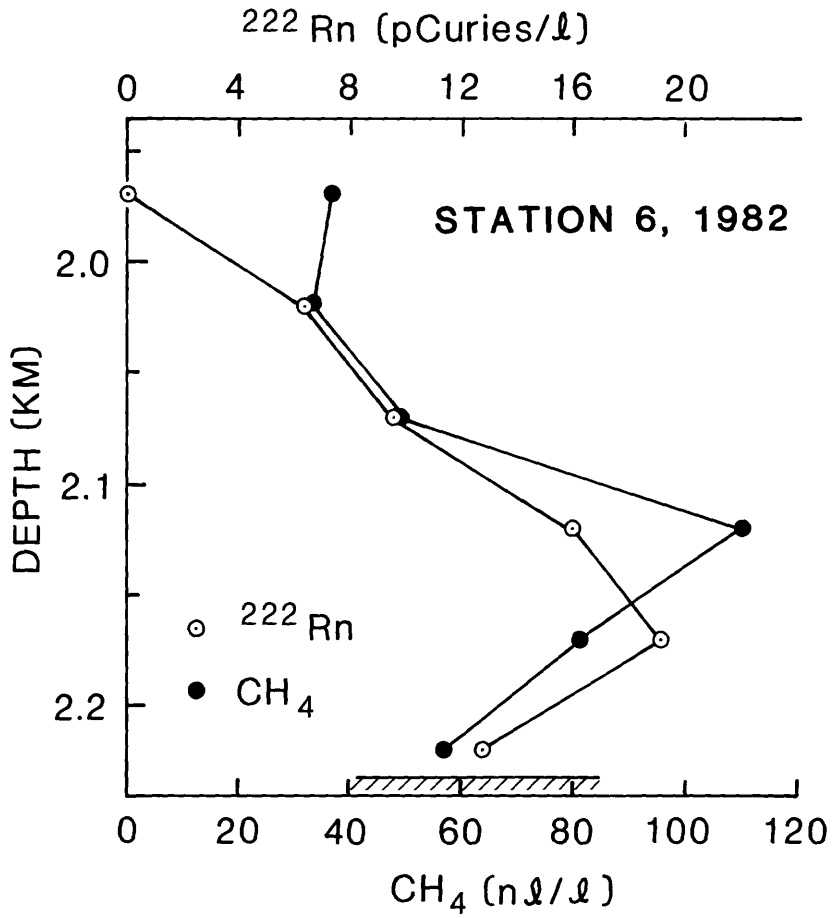

130° 24'
130° 20'
130° 16
44° 40'N
44° 36'
2300
2200
2100
10D
7D
2D
6H
8D
3D
12C
4D
11D
13D
12C
EXPLANATION
8D
Dredge station
12C
Camera station
6H
Hydrocast station
Hydrothermal vent
Hydrothermal plume
Acoustic transponder
0
1
2 KM

Figure 3


δ(³He) (%)
0 10 20 30 40 50
STATION 14, 1981
DEPTH (KM)
2.0
2.1
2.2
δ(³He)
TDM
0 20 40 60 80 100 120 140
TDM (nM/Kg)


²²²Rn (pCuries/ℓ)
0 4 8 12 16 20
STATION 6, 1982
DEPTH (KM)
2.0
2.1
2.2
²²²Rn
CH₄
0 20 40 60 80 100 120
CH₄ (nℓ/ℓ)