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USCGC *Polar Sea* Ross Sea cruise, 1983–1984

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The Ross Sea continental shelf is the most highly sampled region of the antarctic continental margin. However, investigations of sediment distribution patterns and sedimentary processes have been hindered by a scarcity of surficial sediment samples, particularly from the outer shelf. During the 1984 oceanographic expedition of the USCGC *Polar Sea*, 59 phleger core and grab samples were collected in the Ross Sea (figure 1, table). These additional samples enable us to better define Ross Sea sedimentary processes.

Ross Sea surficial sediments include unsorted ice-rafted debris (IRD), siliceous biogenic material (mostly diatom frustules), calcareous shell debris, and suspension deposited silts and clays. Differences in the relative concentrations of these components reflect the relative influence of glacial, oceanographic,

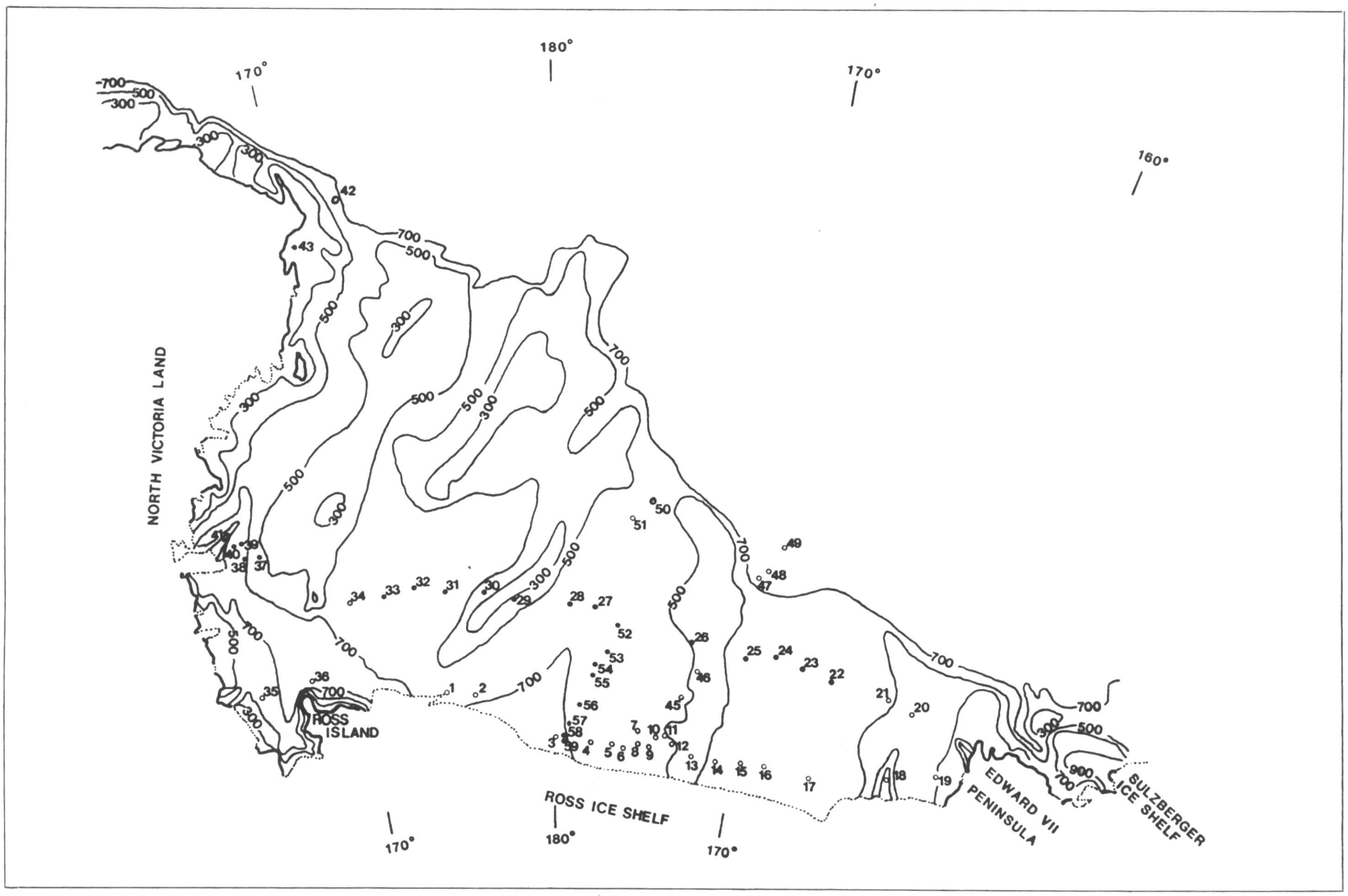

Figure 1. Ross Sea bathymetry and austral summer 1983–1984 sample locations. (Open circles are grab samples; solid circles are phleger core samples.)

and biologic processes. The main features of surficial sediment distribution (figure 2) are outlined as follows:

- Sulzberger Bay, the eastern and outer shelf of the central Ross Sea, and the relatively narrow shelf of the northern Victoria Land coast contain sediments with greater than 50 percent IRD. These are the only areas where ice-rafting is a significant contributor to bottom sediments today.
- The shelf edge-upper slope, and the tops of banks in the western Ross Sea are covered by residual (current winnowed) glacial marine sediments with abundant calcareous shell debris.
- Terrigenous silts and clays comprise more than 85 percent of those surface sediments collected along the front of the Ross Ice Shelf east of 180°.
- Biogenic silica comprises 10–40 percent by weight of surficial sediments west of 180°.

The concentration of IRD increases in an offshore direction away from the Ross Ice Shelf (figure 3). Grain-size data show that most samples contain some bed load material (3.0ø to 2.75ø traction modes, figure 3), implying that bottom currents are strong enough to winnow finer (>3ø) sediments and concentrate the coarser ice-rafted component. Although the silt/clay content increases in an onshore direction, the size of bed load populations (3.0ø to 2.75ø) and the size of the coarsest material eroded from the bottom remain constant. This suggests that the

Figure 2. Surface sediment distribution map for the Ross Sea. ("RCM" denotes residual glacial marine sediment; "CGM" denotes compound glacial marine sediment; "DCGM" denotes diatomaceous compound glacial marine sediment; "SiM" denotes siliceous mud; "Si0" denotes siliceous ooze; "CZ" denotes clayey silt; and "S" denotes sand.) (Samples are from *Eltanin* cruises 27, 32, and 52, and Deep Freeze cruises 76, 78, 80, 83, and 84.)

1984 Geologic stations

Station number	Latitude	Longitude	Depth (in meters)	Sample
1	77°25.9′S	174°00.9′E	740	G[a]
2	70°30.0′S	175°58.0′E	690	G
3	78°01.1′S	179°59.8′E	713	G
4	78°08.8′S	177°44.7′W	630	G
5	78°10.3′S	177°09.3′W	610	G
6	78°08.8′S	176°29.4′W	615	G
7	77°57.7′S	175°28.7′W	588	G
8	78°06.2′S	175°29.6′W	556	G
9	78°11.2′S	175°00.5′W	540	G
10	77°47.9′S	173°59.6′W	556	G
11	78°00.5′S	174°25.9′W	560	G
12	78°12.1′S	173°48.5′W	540	G
13	78°13.9′S	172°31.1′W	440	G
14	78°14.8′S	171°09.4′W	548	G
15	78°16.2′S	169°48.9′W	556	G
16	78°17.2′S	168°30.5′W	580	G
17	78°18.9′S	165°50.1′W	490	G
18	77°53.2′S	161°47.7′W	706	G
19	77°43.2′S	159°07.5′W	302	G
20	77°00.9′S	161°26.5′W	520	G
21	77°00.1′S	162°59.7′W	604	G
22	77°00.4′S	165°59.8′W	420	P[b]
23	76°56.8′S	167°31.3′W	472	P
24	76°52.8′S	169°00.2′W	487	P
25	76°49.9′S	170°36.2′W	456	P
26	76°42.0′S	173°36.2′W	490	P
27	76°28.9′S	178°03.1′W	585	P
28	76°24.9′S	179°27.1′W	588	P
29	76°18.9′S	177°38.0′E	405	P
30	76°17.0′S	176°06.4′E	438	P

[a] Grab sample.

[b] Phleger core sample.

1984 Geologic stations (continued)

Station number	Latitude	Longitude	Depth (in meters)	Sample
31	76°15.3′S	174°24.9′E	605	P[b]
32	76°14.9′S	172°59.9′E	608	P
33	76°12.5′S	171°27.5′E	612	P
34	76°12.1′S	169°54.5′E	630	P
35	77°04.7′S	164°31.1′E	425	G[a]
36	77°04.7′S	167°00.3′E	870	G
37	75°39.6′S	166°12.2′E	544	P
38	75°29.8′S	165°51.7′E	752	P
39	75°19.4′S	165°36.4′E	760	P
40	75°14.5′S	165°13.5′E	950	P
41	75°10.1′S	164°56.1′E	1,100	P
42	71°43.4′S	172°05.7′E	575	G
43	72°13.9′S	170°34.6′E	450	P
44	77°48.5′S	173°59.2′W	530	G
45	77°30.0′S	173°29.8′W	533	G
46	77°06.9′S	172°41.7′W	498	G
47	76°01.2′S	170°16.3′W	740	G
48	75°56.3′S	170°04.1′W	1,016	G
49	75°34.5′S	169°14.9′W	2,020	G
50	75°05.9′S	176°18.9′W	1,005	G
51	75°20.9′S	176°28.9′W	567	G
52	76°49.3′S	177°00.9′W	572	P
53	77°01.5′S	177°29.9′W	570	P
54	77°15.5′S	178°01.1′W	610	P
55	77°28.6′S	178°29.7′W	642	P
56	77°41.9′S	178°59.6′W	665	P
57	77°51.9′S	179°17.8′W	692	P
58	77°56.9′S	179°24.9′W	704	P
59	78°01.2′S	179°31.3′W	716	P

[a] Grab sample.

[b] Phleger core sample.

maximum velocity of bottom currents on the shelf is relatively constant [11–13 centimeters per second, based upon total grain size distribution/velocity determinations of Singer and Anderson (1984)]. Because the finer sediments will settle from suspension only when and where current velocities fall below 4 centimeters per second (Singer and Anderson 1984), the association of residual ice-rafted modes and bottom-traction modes with fine-grained material implies episodic flow conditions.

During high velocity episodes, finer material is swept from the bottom, leaving behind a thin surficial lag. When current velocities decrease, fine material settles to the bottom. These two components are mixed by burrowing and scavenging organisms. Thus, a decrease in the residual IRD/current-derived sand mode in an onshore direction (toward the Ross Ice Shelf) is attributed to a decrease in the frequency of strong flow events in that direction. In this manner, fine-grained sediments, including diatom frustules, are gradually transported toward the deeper, ice-shelf marginal basins where more quiescent bottom conditions exist. Despite their relatively high opaline silica content (15 percent), sediments of central Ross Sea basins have low organic carbon contents (less than 0.75 percent) compared to siliceous sediments in basins of the western Ross Sea (total organic carbon greater than 1 percent). This suggests enrichment of biogenic phases via reworking of modern deposits in the region.

Aside from shallow banks, the western shelf is covered mainly by siliceous muds and oozes (figure 2). Results from analyses show that biogenic silica content increases from east-to-west

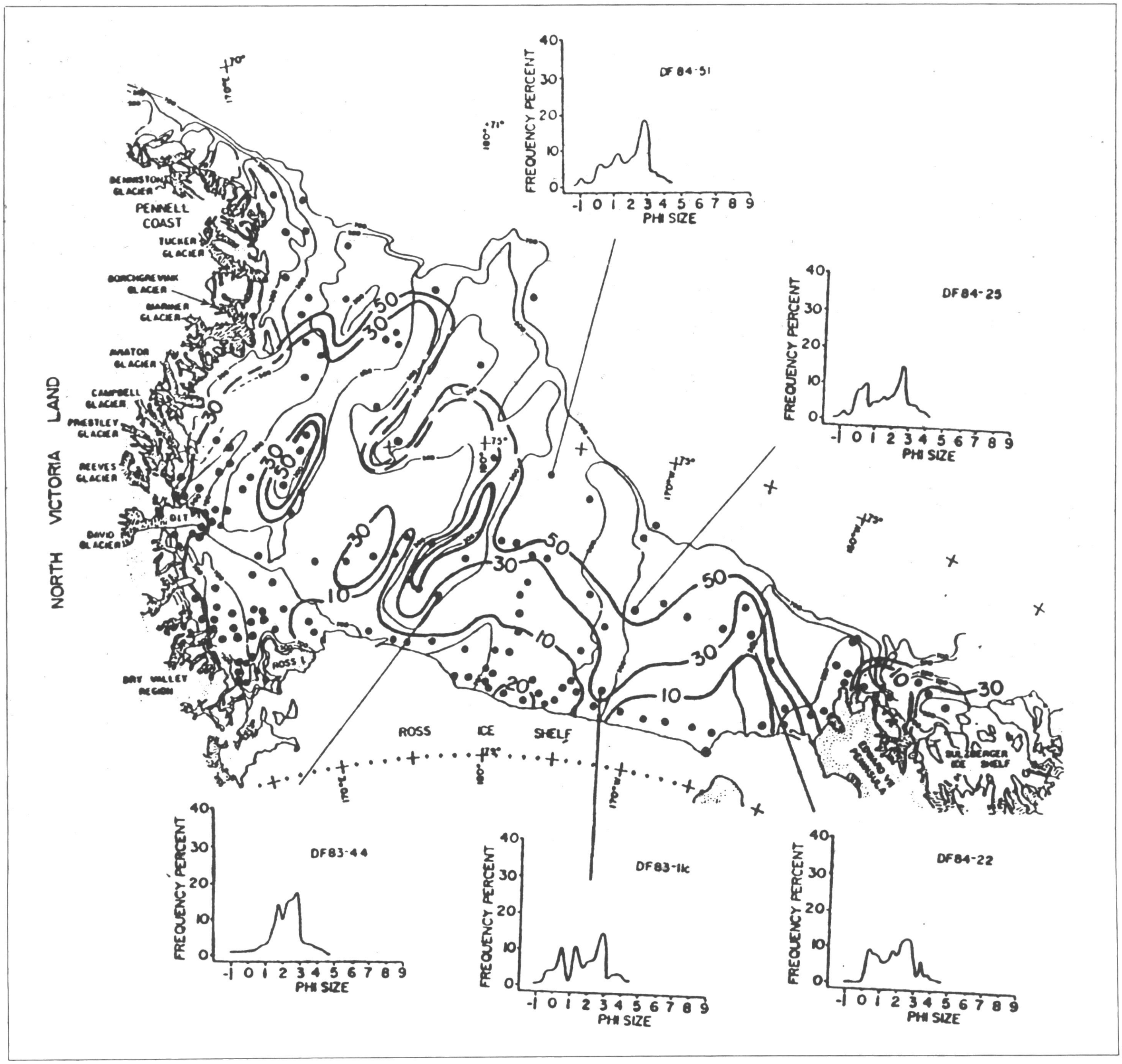

Figure 3. Contour map of the relative percentage of ice-rafted debris (unsorted sand and gravel) on the Ross Sea shelf, along with representative grain size curves from the outer shelf.

across the shelf (see Dunbar, Dehn, and Leventer, *Antarctic Journal*, this issue). This distribution was first noted by Truesdale and Kellogg (1969), who attributed it to less extensive summer sea ice cover in the western Ross Sea. This is probably not the sole factor regulating the distribution of siliceous sediments on the shelf, because open seas are also prevalent across the inner shelf near the Ross Ice Shelf and western shelf sediments contain low biogenic silica. There is also an east-to-west increase in organic carbon content across the shelf (see Dunbar, Dehn, and Leventer, *Antarctic Journal*, this issue). Higher organic carbon/opal ratios in biogenic sediment of the western Ross Sea indicate less reworking via suspension within the water column than occurs in the central Ross Sea.

Diatomaceous oozes from the Ross Sea shelf are mainly in the 16–63-micrometer size range. This size material is maintained in suspension by currents with velocities above 5 centimeters per second. Thus, the distribution of diatomaceous ooze will be strongly influenced by marine currents. Westerly flowing surface currents on the shelf may significantly contribute to the corresponding westerly increase in biogenic silica. In addition, diatom frustules may be transported onto the shelf by the impinging warm core water. As this water mass overrides high salinity shelf water as an impinging surface layer, bottom circulation may be more sluggish on the western shelf so that these fine-grained sediments can accumulate there.

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Marine geological and geophysical investigations in the Ross Sea, Antarctica

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During February 1984, the U.S. Geological Survey (USGS) conducted marine geological and geophysical studies of the Ross Sea continental margin as the second half of the 1984 USGS marine antarctic program. Several thousand kilometers of geophysical trackline data and numerous geologic samples were collected aboard the R/V *S.P. Lee* in the Victoria Land basin and Iselin Bank areas of the Ross Sea (figure 1). A geophysical trackline, with multichannel seismic-reflection data, was recorded along the western side of McMurdo Sound and crossed existing MSSTS (McMurdo Sound Sediment and Tectonic Studies) and planned CIROS (Cenozoic Investigation in western Ross Sea) shallow drilling sites.

Special emphasis was placed on the collection of multichannel seismic-reflection data (2,350 kilometers) although a large suite of other underway geophysical measurements were made, including single-channel seismic-reflection (850 kilometers), sonobuoy seismic (39 stations), high-resolution seismic-reflection (1,850 kilometers), 3.5-kilohertz and 12-kilohertz bathymetry (4,500 kilometer), magnetic gradiometer (3,100 kilometers), and gravity data (3,950 kilometers). Sampling operations included 3-meter gravity coring (15 cores from 10–258 centimeters in length), chain-bag dredging (two stations with

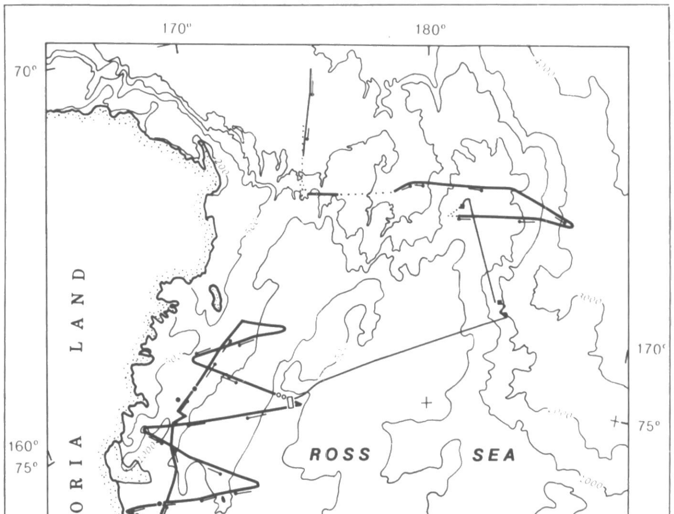

Figure 1. Index map of the Ross Sea, Antarctica, showing locations of geophysical tracklines and geologic sampling sites occupied by the U.S. Geological Survey research ship R/V *S.P. Lee* during February 1984.