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6. The camera system was designed to have a small diameter (15 cm) in order to fit through the proposed drill hole. When a larger hole became available the strobe reflector diameter was increased to 18 cm to provide better illumination. The length of the package is 137 cm. We use a 35-mm F/2.8. Leitz Summaron lens behind a plain glass window. A Brailsford motor transports 9 m of 35mm film, giving 200 exposures with an interval between them of 40 seconds. There is no shutter. Severe lens fouling occurred as a result of DFA (Diesel Fuel Arctic) and slush ice in the hole. The system designed to locate instrument distance above bottom did not perform as anticipated. These factors reduced photograph quality and necessitated the fabrication on site of a lens cap that could be removed below the ice shelf and a trigger weight to sense the bottom. Bait (a piece of knockwürst) was suspended below the camera on some lowerings, including the two on which fish were photographed.
7. The traps were first constructed of 1.3-cm mesh steel screen around a cylindrical steel frame 20 cm in diameter, 60 cm in length. The end of the trap that was up during transit through the hole contained a funnel opening. Later modifications included a finer mesh screen over the bottom quarter of the trap and 12 holes, 2.5 cm in diameter, in the upper part. Traps were self-guided through the hole by way of 45-cm cones made from eight steel rods on each end. Each trap contained three bags of seal meat. Holes were cut in the bait bags to permit easier entry to smaller animals and to reduce specimen losses to turbulence during raising of the trap. Water was poured over the bags and allowed to freeze to avoid contamination from hydrocarbons in the hole. The ice would later melt in the water column (*8*). Two traps were used on each of three separate lowerings, and were set on bottom for periods up to 5.8 hours.
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18. L. Watling (University of Maine) believes the "appendages" could be the last three peropods of an amphipod whose pleon is folded ventrally. On the original Ektachrome film are indications of cross stripes on the portion with "appendages"—possibly body segments. Further, there appears to be a color change near the first "appendage" pair, possibly demarking the upper jaw of the fish.
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Occurrence and Metabolic Activity of Organisms Under the Ross Ice Shelf, Antarctica, at Station J9

Abstract. *Seawater samples below the Ross Ice Shelf were collected through an access hole at J9, approximately 400 kilometers from the Ross Sea, Antarctica. The 237-meter water column had sparse populations of bacteria (8.7×10^6 to 1.2×10^7 per liter), microplankters (10^2 to 10^3 per cubic meter), and zooplankters (10 to 20 per cubic meter) at the depths studied. Microbial biomass estimates from cellular adenosine 5'-triphosphate measurements were very low (10 to 150 nanograms of carbon per liter), comparable with values for the abyssal ocean. Microbial populations assimilated tritiated* D-*glucose, thymidine, uridine, and adenosine triphosphate at extremely low rates, comparable with deep-sea heterotrophic populations. Sediment samples had 10^7 to 10^8 bacteria per gram (dry weight), which were metabolically active as shown by respiration of uniformly labeled* D-[^{14}C]*glucose. From this study it cannot be determined whether these organisms in the water column and sediments constitute a functioning food web.*

The water under the Ross Ice Shelf, Antarctica, is a unique marine environment for living organisms; it has no euphotic zone because of virtually complete attenuation of light by the overlying layer of ice, which is 400 to 600 m thick. This physical environment is similar to the abyssal ocean in being cold (~ -2°C) and aphotic, but differs with respect to the hydrostatic pressure; the water column at the drill site is 237 m deep, but the actual depth is 597 m because of the ice cover. Although there were a few reports (*1*) on the occurrence of fish and a diversified benthic fauna under the Ross Ice Shelf at short distances from the edge of the ice, it was not known prior to the Ross Ice Shelf Project (RISP) if any plants or animals existed at greater distances from the open Ross Sea.

During the 1977-1978 RISP field season an access hole was drilled at J9 (82°22.5'S, 168°37.5'W), approximately 400 km from the Ross Sea, which enabled us to sample the water column under the shelf. At all depths studied, we have found that the water column has sparse populations of micro- and macroorganisms, components of which might comprise a food web. These include bacteria, algae, microzooplankton, and large zooplankton.

The access hole was drilled with a Browning thermal drill (*2*). We sampled the water column below the ice at depths between 20 and 200 m by hydrocasts with Van Dorn bottles or with an impeller-type submersible pump. Since Diesel Fuel Arctic (DFA) fueled the thermal drill the hydrocast samples were often contaminated with DFA, as judged by their odor. Therefore, pumped samples were used primarily in this study.

Seawater samples were filtered through membrane filters or microfine glass-fiber filters, and the collected particulate matter was analyzed for adenosine 5'-triphosphate (ATP) as an indicator of viable cells (*3*). Low levels of ATP (0.04 to 0.6 ng liter^{-1}) (*4*) were found at all depths from 20 to 200 m below the ice. These values are two to three orders of magnitude lower than those for seawater in the Ross Sea (*5*). If a carbon/ATP ratio of 250 is used (*6*) there would be 10 to 150 ng of microbial cell carbon per liter of seawater.

Bacteria in seawater samples were enumerated by epifluorescent microscopy (*7*). Bacterial numbers were 1.2×10^7 per liter in the 66-m sample and somewhat lower in the deeper samples (8.7×10^6 to 9.5×10^6 per liter). A sample from 20-m depth was not available. Most bacteria were rod-shaped or coccoid. These bacterial densities are similar to those reported for deep-sea samples (*8*). Assuming each bacterium has 10^{-14} g of cell carbon (*9*) there would be roughly 100 ng of bacterial carbon per liter of seawater.

Microbial heterotrophic activity was measured as rates of assimilation and respiration of several isotopically labeled substrates (*10, 11*), and also by microautoradiography. D-Glucose assimilation and respiration of samples incubated at 0°C yielded turnover times (*10*) of the or-

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der of 5×10^5 hours. This is 10^3 to 10^4 times less activity than in the Ross Sea around McMurdo Sound (*5*), and is probably the slowest rate of turnover of D-glucose pool reported for any oceanic environment.

[Methyl-^{3}H]thymidine, [5,6-^{3}H]uridine, and [2,8-^{3}H]ATP ($5 \times 10^{-9} M$, at very high specific activity) (*12*) were assimilated at measurable rates. Assimilation of uridine was the slowest, the turnover time approximating 6×10^5 hours. Thymidine and ATP pools were turned over somewhat faster with turnover times of 1.5×10^5 and 1.2×10^5 hours, respectively. Since these rate measurements were done at $5 \times 10^{-9} M$ added substrates, they probably represent enriched substrate pools. The observed rates are therefore probably not the in situ turnover rates of these compounds. The data, however, do indicate that the microbial populations were metabolically active with respect to the substrates used. This is supported by autoradiographic observations of the samples incubated with labeled substrates which showed that up to 50 percent of the total bacterial cells were labeled during incubation; in the small volumes examined, no phytoplankton was seen. Moreover, the assimilation of thymidine and uridine suggests macromolecule synthesis.

Microbial populations were also size-fractionated after incubation with the labeled substrates. The objective was to distinguish between the assimilation by free-living bacteria and other organisms smaller than 1 μm in nominal diameter from that by the larger organisms and attached bacteria. A large fraction of assimilated radioactivity (29 to 89 percent) was found in the size fraction larger than 1.0 μm. This is in contrast with the generally observed fractionation in seawater samples where only about 10 percent of assimilation is due to the larger than 1.0-μm fraction (*13*).

Occurrence and metabolic activity of bacteria was also examined in the sediment samples (collected by J. H. Lipps and T. E. DeLaca, with a sphincter corer). Epifluorescent microscopy of samples stained with acridine orange showed the presence of 8.7×10^7 and 1.6×10^8 bacteria per gram of sediment (dry weight) in the top 2 cm of the two samples examined. The second core was also examined at 8 to 10 cm for bacterial numbers; 3.9×10^7 bacteria were found per gram (dry weight).

Respirometry of the sediment cores with D-[U-^{14}C]glucose as substrate (*14*) yielded respiration turnover times of 5.8×10^3 and 1.1×10^4 hours for samples 0 to 3 cm and 3 to 5 cm deep, respectively. Thus, the rates of mineralization of D-glucose in the sediment samples were about 100 times faster than in the water column, and were similar to the rates reported for several organic substrates for in situ incubations in the deep sea (*15*).

Formaldehyde-preserved samples from three depths (20, 110, and 200 m), concentrated on 35-μm mesh Nitex and equivalent to approximately two-thirds of a cubic meter of seawater, have been examined for microplankton by the Utermöhl inverted microscope procedure (*16*) at a magnification of at least $\times$ 200. Organisms apparently living at the time of collection, as evidenced by the presence of material staining with rose Bengal (presumably protoplasmic), were found at each depth. Greatest abundance, several hundred organisms per cubic meter, was found at 20 m; abundances were more than an order of magnitude lower at both 110 and 200 m. Pennate diatoms accounted for about 80 percent of the microplankton numbers at 20 m. Forms of several genera, including *Amphiprora, Fragilariopsis, Navicula, Nitzschia, Pinnularia*, and *Pleurosigma*, were observed (Fig. 1). No pennates were seen at 200 m; only two specimens, an *Amphiprora* and a naviculoid form, were found in the material examined from 110 m. Centric diatoms were represented by a few empty frustules of *Coscinodiscus* and *Trinacria* found at 20 and 110 m. The only dinoflagellates recognized were specimens of *Peridinium* (*Protoperidinium*), principally *P. depressum* (*P. antarcticum*) (Fig. 1), seen in a range of girdle sizes, although a single specimen which may have been a nonthecate dinoflagellate was also found at 200 m. The abundance of *Peridinium* was estimated at tens per cubic meter at 20 m, decreasing to about 1 to 3 per cubic meter in the deeper samples. A few specimens of the silicoflagellate *Distephanus speculum* were seen, including several which retained the protoplast. However, the small size of this form makes it doubtful that it is quantitatively retained by the 35-μm mesh net.

While no protozoans were seen in the sample at 20 m, the skeletal elements of a simple nassellarian radiolarian were found in the deeper samples (110 m, one specimen; 200 m, two specimens). In addition, a single lorica of a tintinnid (com-

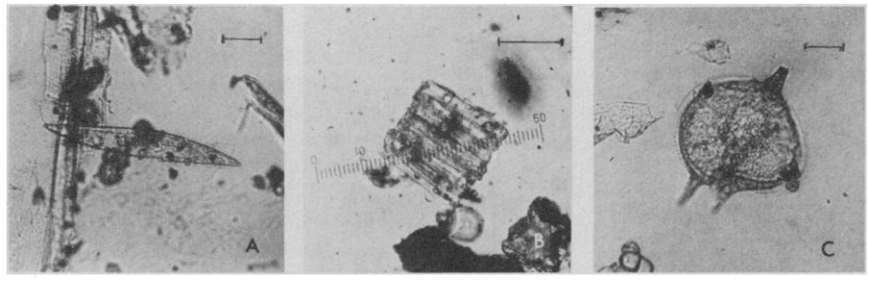


Fig. 1. Representative phytoplankton taxa found in the sample from 20 m (station J9, Ross Ice Shelf). (A) *Pleurosigma* sp., (B) *Fragilariopsis* sp., and (C) *Peridinium depressum*. The bar (upper right) is 30 μm.

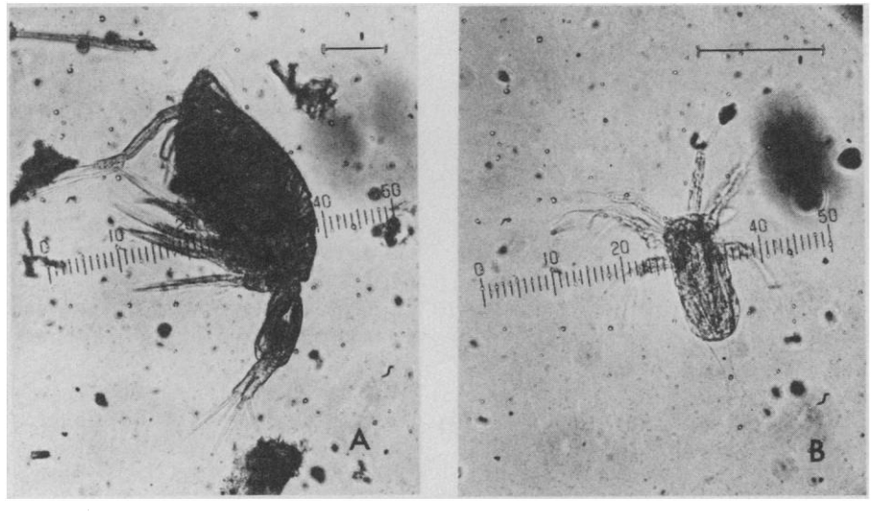


Fig. 2. Postnaupliar (A) and naupliar (B) stage copepods (an oithonid) from the water column beneath the Ross Ice Shelf at station J9. The bar (upper right) is 80 μm.

pare *Salpingacantha* sp.) containing the apparent protoplast of the ciliate was identified in the materials from 200 m.

Metazoan forms observed included naupliar (at 20 m) and postnaupliar (at 20 and 110 m) copepods of the family Oithonidae (Fig. 2). The estimated abundances at 20 m were 6 nauplii and 18 postnauplii per cubic meter; and at 110 m, there were 7 postnauplii per cubic meter. The nauplii seen were all early stages (that is, the first and second stages). Postnauplii observed included a female carrying a pair of spermatophores and several specimens that appeared to have large oil sacs. In addition to the copepods, two specimens of another segmented metazoan, probably a polychaete larva, were found in the sample at 20 m.

Unconcentrated preserved samples from 20, 66, 110, 154, and 200 m were examined for small microplankters using the Utermöhl inverted microscope procedure at ×400 magnification. Samples (100 ml) were stained with rose Bengal, and an area corresponding to 4 ml of seawater settled was viewed. Cells identified as probable monads were seen, the sample from 200 m having the largest number (1.1×10^4 per liter). A few naked dinoflagellates (10 to 20 μm in length) were observed in the samples from 66 and 110 m.

Thus, albeit in low abundances, several components of what might comprise a planktonic food web were found in the waters under the Ross Ice Shelf at J9. With the data available, we cannot state whether these microbial organisms represent an indigenous population or if they represent the remnants of populations advected from the Ross Sea. Currents up to 17 cm sec^{-1} were measured at the drill site, but the main component was tidal, and hence the net flux cannot be determined. Tritium and ^{14}C measurements from the J9 site indicate that the water below the ice shelf has exchanged with Ross Sea water within the last 20 years (*17*). The level of activity of these microbial organisms and their interactions cannot be determined at present and await studies in which dynamic factors such as rates of production and trophic transfer are investigated.

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Terrestrial Ages of Four Allan Hills Meteorites: Consequences for Antarctic Ice

Abstract. *The terrestrial ages of three Allan Hills meteorites are between 3×10^4 and 3×10^5 years and one is $(1.54^{+0.14}_{-0.28}) \times 10^6$ years old. The Antarctic ice sheet is therefore older than $(1.54^{+0.14}_{-0.28}) \times 10^6$ years and the meteorite accumulation process at Allan Hills probably began between 3×10^4 and 3×10^5 years ago.*

Allan Hills is a 100-km^2 area in Antarctica where many distinct meteorites lie exposed on the ice (*1, 2*). The first meteorite locale of this type was discovered on the other side of the continent near the Yamato Mountains chain (*3, 4*). On the basis of the glaciological and geological settings at the two sites, the following reasonable picture (*1, 3*) has emerged. Meteorites that fall on the Antarctic ice sheet are preserved and carried along with the flow of ice to the continental margin. If the ice flow is halted at a barrier where the ice is sufficiently dissipated by wind ablation, exposed meteorites accumulate in front of the barrier. The terrestrial ages of the Allan Hills and Yamato meteorites are important time markers for the history of Antarctic ice.

Terrestrial ages for meteorites are based on the amount of a cosmic-ray-produced radioactivity in the sample and the amounts in observed falls that have similar cosmic-ray exposure histories. The cosmic-ray exposures are obtained from stable cosmic-ray-produced noble gas isotopes. Terrestrial ages for seven Yamato and seven Allan Hills meteorites have been estimated from their ^{53}Mn (3.7×10^6 year half-life) activities (*5*). Six of the Yamato and six of the Allan Hills specimens have ^{53}Mn activities indistinguishable from those of contemporary falls, and hence ^{53}Mn terrestrial ages of less than $\sim 2 \times 10^6$ years estimated from the scatter in ^{53}Mn data for falls. One Yamato specimen, number 7301, has a ^{53}Mn activity about one-quarter of that of the others, so that its ^{53}Mn terrestrial age is approximately 7×10^6 years; however, the ^{10}Be and ^{26}Al activities in Yamato 7301 were measured and gave terrestrial ages of $\sim 1 \times 10^6$ years (*5*). The inconsistency makes the 7×10^6 year terrestrial age questionable. The low ^{53}Mn activity could be caused by weathering. Manganese-53 is produced in iron and is more affected by weathering than are the radioactivities produced in silicates.

We measured the terrestrial ages for Allan Hills specimens 5, 6, 7, and 8 by determining the radioactivities of ^{14}C (5.74×10^3 year half-life) and ^{26}Al (7.3×10^5 year half-life) and the contents of stable noble gases. The precision of the terrestrial ages is better than that in previous determinations because of the

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