Carbonate chemistry during WEPOLEX–81

CHEN-TUNG ARTHUR CHEN

School of Oceanography
Oregon State University
Corvallis, Oregon 97331

As part of the U.S.-U.S.S.R. Weddell Polynya expedition (WEPOLEX-81), my Soviet counterparts and I measured acidity and alkalinity of seawater samples on board the ship. Library seawater samples were collected for later measurements of total carbon dioxide (CO_2) and partial pressures of CO_2 (by T. Takahashi at Lamont-Doherty Geological Observatory) and for density and calcium (at Oregon State University). Some melted ice samples also were collected for measurements (at Oregon State University) of conductivity, chlorinity, density, calcium, and alkalinity. The objectives are (1) to use the calcium and carbonate data as water tracers, (2) to estimate the effect of pack ice on air-sea exchange of gases and on calcium and carbon cycles, (3) to quantify the CO_2 flux between atmosphere and the polar water, (4) to estimate the penetration depth of the fossil fuel CO_2, and (5) to quantify the error in densities calculated from the seawater equation of state.

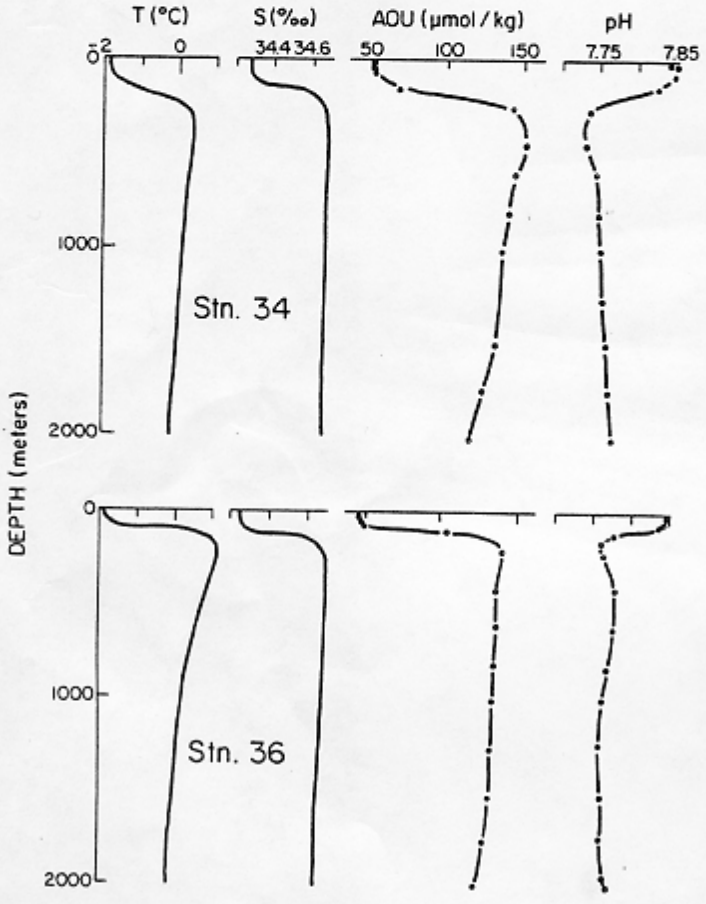

Figure 1. The vertical distributions of temperature (T), salinity (S), apparent oxygen utilization (AOU), and acidity (pH) at WEPOLEX stations 34 (59°30'S 0°30'E; 12 November 1981) and 36 (58°21'S 0°46'E; 13 November 1981). µmol/kg = micromoles per kilogram.

Preliminary analysis indicates that acidity is useful in identifying the source of waters. For instance, a large portion of the water near the broad S_{max} (salinity maximum) layer at station 34 (see figure 3 of Gordon, *Antarctic Journal*, this issue) seems to come from modified North Atlantic deep water (NADW). By the time NADW signal is incorporated into the Weddell Gyre from the circumpolar ocean, it is characterized by low acidity and high apparent oxygen utilization (see figure 1). In contrast, the warmer, saltier S_{max} layer at station 36, which represents circumpolar water just north of the Weddell Gyre, has a broad maximum acidity within the S_{max} layer from approximately 250 to 1,000 meters and lower apparent oxygen utilization than that observed in the S_{max} at station 34 (figure 1). This suggests that not as much decomposition of organic material has occurred in the circumpolar S_{max} water at station 36 as has occurred within the Weddell Gyre, represented by station 34.

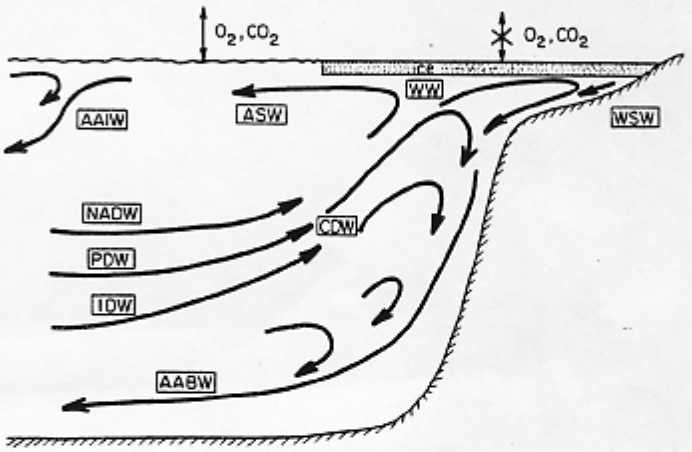

Figure 2. A schematic diagram showing the water masses in the southern ocean. The pack ice blocks the air-sea exchange of gases. AAIW = antarctic intermediate water; ASW = antarctic surface water; WW = winter surface water; WSW = western shelf water; NADW = North Atlantic deep water; CDW = circumpolar deep water; PDW = Pacific deep water; IDW = Indian deep water; AABW = antarctic bottom water.

Preliminary shipboard data indicate that the pack ice effectively blocks the air-sea exchange of oxygen and CO_2. Consequently, the homogeneous surface layer, which has approximately 30 percent deep water, is not in equilibrium with the atmosphere and contains less fossil fuel CO_2 than expected. Most of the winter surface water (identified as WW in figure 2) eventually is exposed to the atmosphere as the ice melts, and exchanges of gases with the atmosphere occur rapidly. Some of the surface water may flow southward beneath the ice toward the continental margin and thus undergo no air-sea gas exchange. There it mixes with western shelf water (WSW) and circumpolar deep water (CDW) to form antarctic bottom water (AABW) (Foster and Carmack 1976; Weiss, Ostlund, and Craig 1979). Since the circumpolar deep water was formed before the industrial revolution and the winter surface water is also deficient in the excess CO_2, the newly formed antarctic bottom water has little or no fossil fuel CO_2 (Chen 1982).

Laboratory analyses of library samples currently are being performed. Complete data interpretation and reports should be available by the summer of 1983.

I was assisted in the shipboard operations by V. Fedorov and V. Hazitonov of the Arctic and Antarctic Research Institute, U.S.S.R.; G. Metcalf and D. Woodroffe of the Lamont-Doherty Geological Observatory; the expedition chief, E. Sarukhanyan; U.S. chief scientist A. L. Gordon; and the *Somov's* captain and crew. This work was supported by Department of Energy grant 81 EV 10611 and by National Science Foundation grant OCE 80-18770.

References

Chen, C.-T. 1982. On the distribution of anthropogenic CO_2 in the Atlantic and southern oceans. *Deep-Sea Research*, 29, 563–580.

Foster, T. D., and Carmack, E. C. 1976. Frontal zone mixing and antarctic bottom water formation in the southern Weddell Sea. *Deep-Sea Research*, 23, 301–317.

Gordon, A. L. 1982. The U.S.-U.S.S.R. Weddell Polynya Expedition. *Antarctic Journal of the U.S.*, 17(5).

Weiss, R. F., Ostlund, H. G., and Craig, H. 1979. Geochemical studies of the Weddell Sea. *Deep-Sea Research*, 26, 1093–1120.