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The biogeochemistry of carbon cycle in summer of the Prydz Bay, Antarctic iv: Characteristics of DOC distribution

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Abstract The distributions and changes of dissolved organic carbon in the Prydz Bay and out open sea were investigated during CHINARE-15 (the 15th Chinese National Antarctic Research Expedition). The results showed that the content of DOC was higher in the Prydz Bay and outer open sea compared to those typical of surface oceanic levels (70-80 μM), average content of DOC in the surface water was 102.32 μM, the range was 68.23-125.92 μM. The vertical distribution of DOC in the water column was similar to many ocean sites, that is to say, the content of upper water is higher than deep water, a subsurface maximum persisted between 25-50 m. The DOC pool in the Prydz Bay were consisted with labile, semi-labile and refractory pools, in which refractory pools was mainly part. The concentration of refractory DOC was 92.34 and 76.89 μM in Prydz Bay and outer open sea, and account 77% and 82% for total DOC, respectively.

Key words distribution of DOC, Prydz Bay, Antarctic.

1 Introduction

At the present time, there is every indication that the earth becoming warmer and warmer (Liu *et al*. 1995), as one of the warm house gases, CO_2 play an important role in the changing of the temperature and environment of the globe. The exchanging of CO_2 between the atmosphere and ocean, make the ocean being the large pool of carbon, and the changing of carbon cycle in the ocean would bring distinct effect on the atmosphere. The Southern Ocean is the water body that has the enormous energy and exchanges substance with other oceans in the globe, and its ecosystem play an important role in the globe biogeochemistry cycling of biogenic elements, such as carbon, nitrogen and so on,

so it is important to understand basic biogeochemistry processes in this area and to monitor environmental changes as possible indicators of global climate change. The study of carbon fluxes and cycle in the Southern Ocean is important for revealing the Southern Ocean act as the "sink" or "source" of the CO_2.

The data set presented in this paper is mainly focus on the concentration and distribution of DOC in Prydz Bay, Antarctic, collected during the 15th CHINARE cruise.

2 Sampling and Methods

Samples were collected from 18 December 1998 to 22 January 1999, during the cruise of CHINARE-15. Sampling was conducted along the IV transect running through the Pryaz Bay and north area of the Pryaz Bay (Fig. 1), stations located in south of the 67.5°E were in the Prydz Bay. Water sample were obtained with a rosette sampler attached to the CTD system, filtration onto Whatman GF/F filters was performed immediately after sampling. DOC analyses were performed with a commercially available automatic analyzer (Shimadzu TOC-5000A).

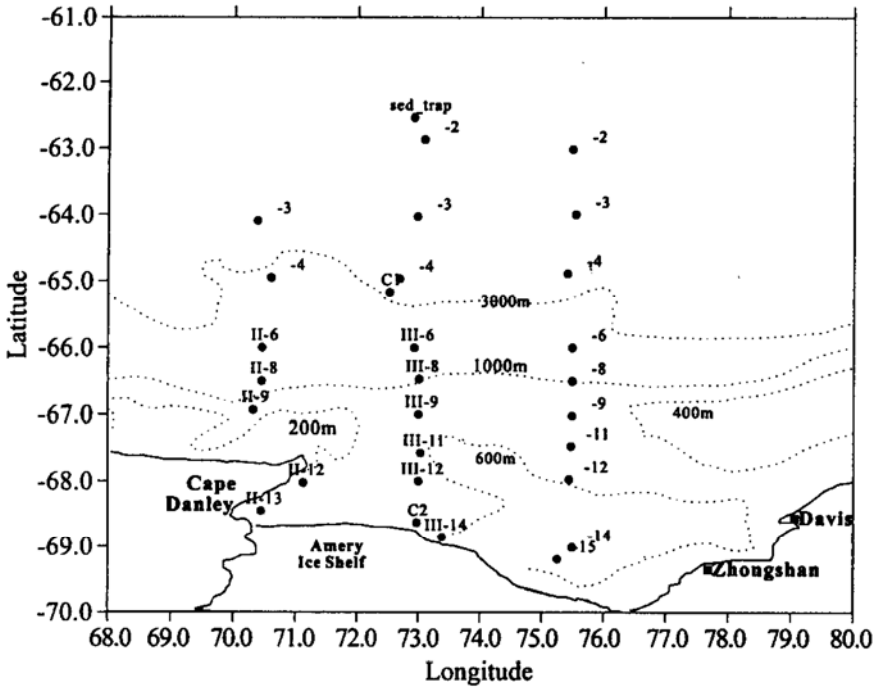

Fig. 1. The sampling stations in CHINARG-15 in Prydz Bay and outer open sea.

3 Results

3.1 Hydrographic conditions

Surface water temperature of the Southern Ocean was controlled by the sun radiation, the thaw of the sea ice and the spatio-temporal changing of the weather and current, however, temperature of deep water was mainly controlled by water mass, current and so on. On the whole, the trend of the surface temperature changing in Prydz Bay was that highest temperature occurred in the Prydz Bay, and decreased gradually to the mouth of the bay, the temperature of surface layer in the mouth of the bay was the lowest, but the temperature of surface layer in the outer area of the bay was higher in some degree. Compared with temperature changing, the changing of salinity of surface layer was simply, the value of surface layer salinity was changing from 33.00 to 33.99. The low salinity was due to the thaw of sea ice. The distribution of surface layer salinity is similar to that of the temperature (Hu *et al*. 2001).

3.2 DOC concentration and distribution

The latitude distribution of DOC and Chla (Fig. 2a, b) showed the similar pattern that the concentration increased with latitude and in the bay the concentrations were higher than that in the out areas of the bay. At the surface, DOC concentration was range from 68.23 to 125.92 μM, average 102.32 μM. Station ㉒2, which located in the out open sea, had the lowest concentration, and station ㉑14, located in the Prydz Bay had the highest concentration. On the whole, the concentration of DOC in study area, was higher than that of other areas of the globe, especially in the surface water, in which the concentration of DOC is higher than the typical concentration 70-80 μM of DOC(Guo *et al*. 1995). We presume that these were due to the production of DOC higher than the consumption, and DOC accumulation in the surface water, so the much high concentration of DOC resulted.

Vertical profiles of DOC (Fig. 3) show that the concentration of DOC in the upper layer (0-25 m) was higher than that in the deep layer, which was similar to the distribution in the other areas. Peak concentration occurred at the depth about 25 m, and under 100 m the concentration decreased obviously, with depth increased the concentration was distributed homogeneously. The profile distributions indicate that the labile DOC produced by phytoplankton present in the surface waters but absent in the deeper layer wa-

ters. The increase of DOC concentrations in upper layers are likely due to the result of the increase of DOC produced from primary productivity. The linear regression between DOC and chla in the upper 200 m waters was significant (Fig. 4, $r = 0.659$ $n = 44$). Recent studies indicate that transport of DOC from surface waters (0-100 m) to the mesopelagic zone (100-1000 m) can be substantial, and studies of the chemical composition of DOM (dissolved organic matter) indicate dramatic diagenetic alterations occur in this region of the water column. This region of the ocean can be considered the largest "heterotrophic digester". In study area DOC concentration decreased obviously under the 100 m, indicate that most remineralization of organic matter occurred.

4 Discussion

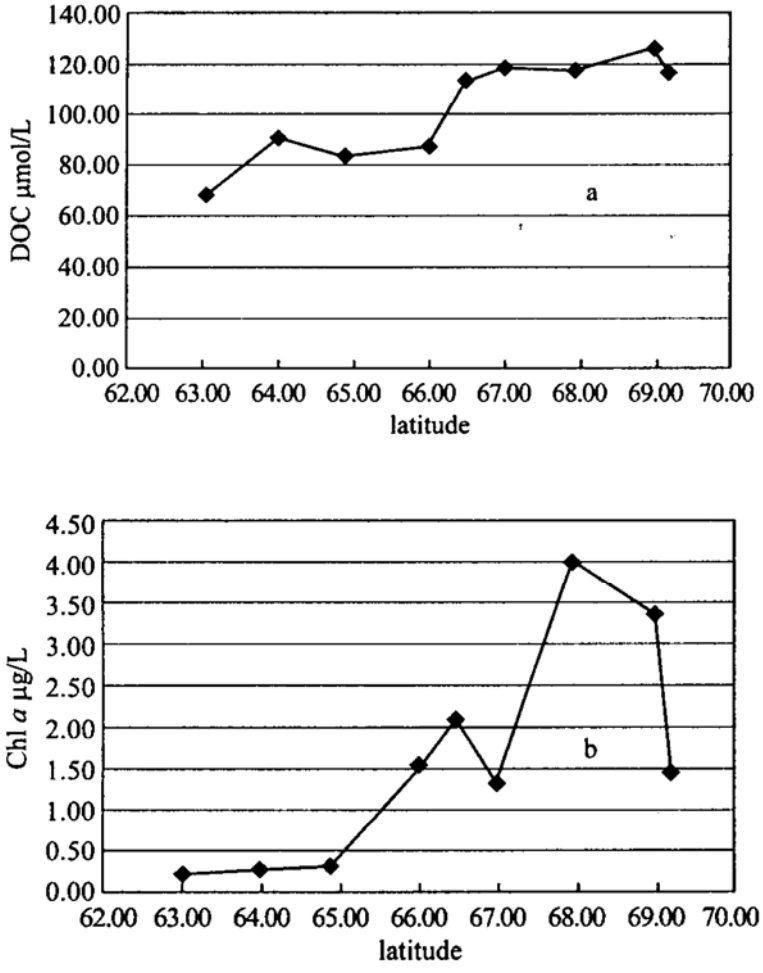

Fig. 2. The distribution of DOC in surface water in section-IV CHINARE-15.

Prydz Bay is a semienclosed sea characterized by stable water column, which is in favor of phytoplankton growth (Ning *et al*. 1993). In summer, sea-ice melted with temperature increased, which advantaged to the bloom of phytoplankton quickly in short term. The latitude distribution of DOC concentration in the surface water show a clear trend with chl a, moreover, DOC concentration in the upper water was higher than that in deeper layer, all of these indicate that in situ biological production of DOC in the euphotic zone, and primary production is the ultimate source of DOC production, but the exact mechanisms are still under investigation (Wiebinga *et al*. 1998).

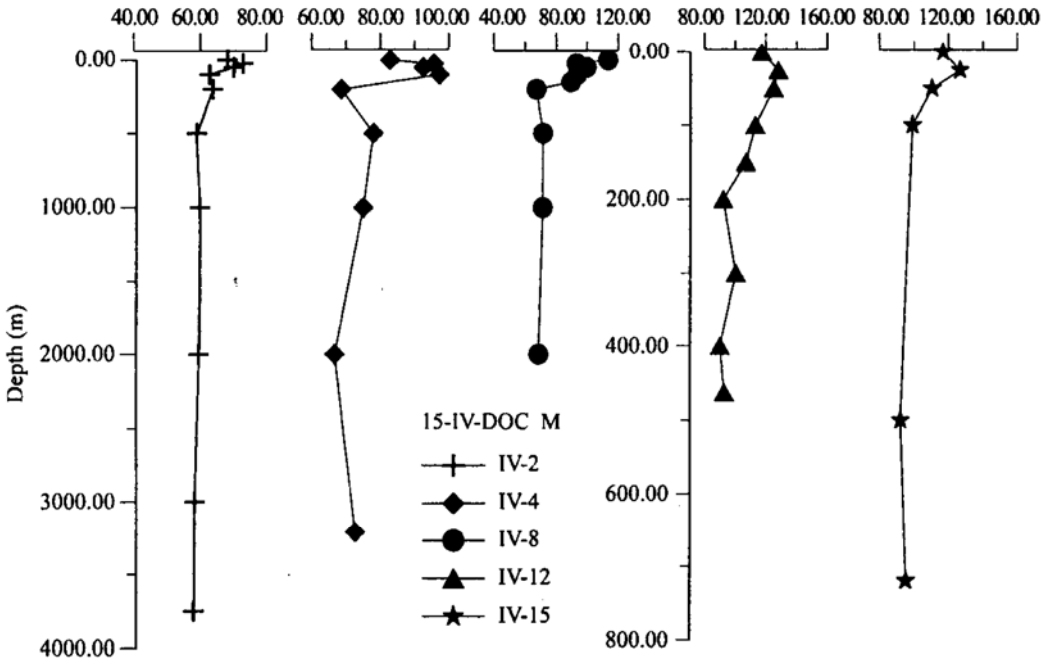

Fig. 3. The vertical distribution of DOC in section-IV in CHINARE-15.

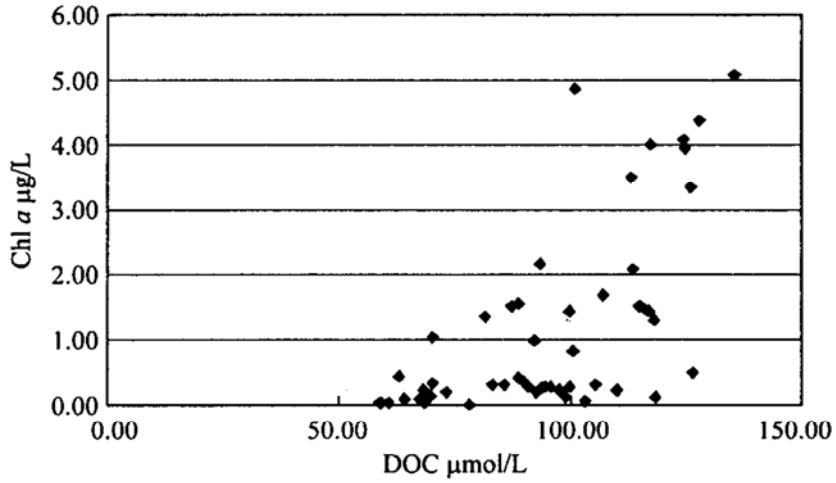

Fig. 4. The correlation between DOC and Chla in upper 150m water columns.

An important issue regarding dissolved organic mater is its availability to micro-organisms. The bulk DOC pool can be separated into the highly labile, the semi-labile and refractory pools (Doval *et al*. 1999; Kirchman *et al*. 1993). DOC partitioning has been estimated with a simple 1-D model as used Carlson and Ducklow (1995). In our study, the average DOC was 119.97μM in the surface water, 108.85 μM for waters at 100 m and 92.34 μM for waters below 500 m in the Prydz Bay, and in the out open sea of Prydz Bay, was 93.50 μM, 87.18 μM and 76.89 μM, respectively. In surface waters, all pools of DOC (highly labile, the semi-labile and refractory) are present. Based on the 1-D mode, we assume that the recalcitrant material is homogeneously distributed in the water column (Carlson and Ducklow 1995), and that the DOC pool at depth > 500m is essentially refractory. So 92.34 μM and 76.89 μM would correspond to the recalcitrant DOC concentration, in the bay and out open sea respectively. It would constitute 77% of total DOC in the surface water in the Prydze Bay and 82% in the outer open sea. Assuming the presence of two main fraction of DOC at 100m depth (refractory and semi-labile), the semi-labile pool would then account 16.51μM, which corresponds to 14% of surface DOC in the bay, 10.29 μM and 11% in the out open sea. Finally the remaining 11.12 μM and 6.32 μM in the bay and out open sea respectively, obtained from the difference between average surface DOC and the other two fractions, was the labile pool of DOC, and about 9% of the surface DOC in the bay, and 7% in the outer open sea. The percentage of recalcitrant DOC (77% and 82% of surface DOC) was higher than that in other areas (ca. 60%, Carlson et al. 1995; Thomas *et al*. 1995; Chen *et al*. 1996). Some researchers propose that significant fraction of DOC in sea surface water consists of structurally related and biosynthetically derived acyl oligosaccharides that persist after more labile organic matter has been degraded (Tanoue *et al*. 1995; Aluwihare *et al*. 1997; Aluwihare *et al*. 1999). However, in study area very little is known about the chemical composition of DOC, and the connection between photosynthetic production and DOC accumulation is not well understood.

5 Conclusions

The content of DOC was increased with latitude, average content of DOC in the sur-

face water was 102.32 μM, 119.97 μM and 93.50 μM in the bay and out open sea respectively. The vertical distribution of DOC in the water column was similar to many ocean sites, that is to say, the content of upper water is higher than deep water, a subsurface maximum persisted between 25-50 m. The DOC pool in the Prydz Bay were consisted with labile, semi-labile and refractory pools based on the 1-D mode, in which refractory pools was main part. The concentration of refractory DOC was 92.34 and 76.89 μM in Prydz Bay and out open sea, and account 77% and 82% for total DOC, respectively, .

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