Antarctic Research, Vol. 7, No. 2, 118～125, December 1996

# Preliminary study on late Quaternary foraminiferal assemblage in the Bransfield Strait, West Antarctica and its significance of environment*

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Received May 21, 1996

**Abstract** 21 species foraminifera, including in 14 genera were encountered from 39 samples of core PC10, which were drilled in the Bransfield Strait of Antarctic Peninsula. They are divided into 3 assemblages as follow: 1. Siliceous shell assemblage; 2. Calcareous shell assemblage; 3. Mixed shell assemblage. The Siliceous shell assemblage occurred in normal deep-sea, with weaker water dynamic condition. The Calcareous shell assemblage was formed by turbidity flow, while the Mixed shell assemblage represented intense to weaker water dynamic condition. It changed from warm to cold to warm during the late Quaternary.

**Key words** Antarctica, Bransfield Strait, late Quaternary, Foraminifera, sedimentary environment.

## 1 Introduction

Piston core PC10 was sampled in the Bransfield Strait, West Antarctica, by R/V Haiyang Ⅳ in her first cruise of investigation to Antarctica and South Pacific Ocean during 1990～1991. It is located at 57°29.9′W, 62°17′S, at the water depth of 2000 m, and has a length of 753 cm. The sediments mainly are composed siliceous clayey silt and silty ooze with turbidity current sediments. The foraminifers are mainly of siliceous shell but are rare in the sediment of 39 samples. This paper is focused on the research of the characteristics of foraminifers in the stratigraphy and its palaeoenvironmental significance.

## 2 Method of analysis

The intervals of sampling are 10～40 cm. Each specimen weighs 10 g and is submerged in water with a few $H_2O_2$ to let it loose. Then it is filtered by sieve of 0.063 mm. When being dried up, specimens are observed with microscope for identification of species and statistics of number. The complex diversity $H(s)$ was calculated by (Wang *et al.*,

* This project was supported by the State Antarctic Committee of China.

1988):

$$H(s) = -\sum_{i=1}^{s} pi\ln pi$$

Where $pi$: the content of the $i$th species; $s$: the number of species.

## 3 The characteristics of foraminiferal assemblages

21 species of 14 genera are identified from the core PC10, of which 14 calcareous are benthonic species, 6 siliceous and agglutilated species and 1 planktonic species. The foraminiferal fauna is characterized by rare planktonic species and dominated by siliceous species. 3 foraminiferal assemblages may be divided in the core by the component of shell, dominant species, charateristic species and $H(s)$ value(Tabel 1).

### *3.1 Assemblage* Ⅰ : *siliceous shell assemblage*

Section 0～130 cm: The sediment is gray yellow siliceous clayey silt and silty clay. The assemblage is characterized dominantly by siliceous spicies *Miliammina arenancea*, with content of 82%～97%, next are agglutinated species *Cribrostomoides subglobosus*, *C. jeffreyi* and *Portatrochammina antarctica*. They occurred concentratedly in the section of 0～50 cm, in good preservation; only a few broken shells were found in the section of 0～10.5 cm. The foraminiferal shells usually are only 2～8 in numder per 10 g dry sample, but 38 and 37 in number in section of 120～130 cm respectively. $H(s)$:$s$ less than 0.8. Section 130～510 cm: The sediment is gray yellow and gray siliceous silty ooze, bearing rare foraminifers, only a few of *Miliammina arenancea*, *pullenia* sp. and *Globocassidulina* sp. were found in this section.

### *3.2 Assemblage* Ⅱ : *calcareous shell assemblage*

Section 510～530 cm, the sediment is gray black medium-grained and roase sand. Calcareous benthonic foraminifers are dominant. The major species are: *Bolivina seminuda*, *Cassidulina subglobosa*, *Fursenkoina earlandi*, *F. fusiformis*, *Bulimina seminuda*, *Pullenia subcarinata*, *Neogloboquadrina pachyderma*, *Miliammina arenancea*. Only one planktonic species wich sinistral shell: *Neogloboquadrina pachyderma* was found with its content of 7.4%～19.4%, *Miliammina arenancea* is still dominant species, with its content of more than 36%. The foraminiferal shells are 189 and 172 in number, most of which are broken. The $H(s)$ value is 1.3～>2. There are plentiful brown resedimented shells in the section.

### *3.3 Assemblage* Ⅲ : *mixed shell assemblage*

It is distributed in section 530～753 cm. The section is maily composed of gray yellow and gray black siliceous silty ooze. The foraminifers are characterized by mixture of agglutinated and calcareous species. The major species include calcareous species: *Pul-*

Table 1. Distribution of light of foraminifera in core PC10

| Foraminifera | ① | ② | ③ | ④ | ⑤ | ⑥ | ⑦ | ⑧ | ⑨ | ⑩ | ⑪ | ⑫ | ⑬ | ⑭ | ⑮ | ⑯ | ⑰ | ⑱ | ⑲ | ⑳ | ㉑ | assemblages |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0～10.5 | ○ | | + | − | | | | | | | | | | | | | | | | | | Siliceous shell assemblages |
| 40～50 | − | | | | − | | | | | | | | | | | | | | | | | |
| 80～90 | + | | | | − | | | | | | | | | | | | | | | | | |
| 110～120 | + | | | | | | | | | | | | | | | | | | | | | |
| 120～130 | ○ | | − | | | | | − | − | | | | | | | | | | | | | |
| 160～170 | | | | | | | | | | | | | | | | | | | | | | Rare Foraminifera |
| 200～210 | − | | | | | | | | | | | | | | | | | | | | | |
| 240～250 | | | | | | | | | | | | | | | | | | | | | | |
| 260～270 | | | | | | | | | | | | | | | | | | | | | | |
| 280～290 | | | | | | | | | | | | | | | | | | | | | | |
| 310～320 | − | | | | | | | − | | | | | | | | | | | | | | |
| 320～330 | − | | | | − | | | | | | | | | | | | | | | | | |
| 330～340 | | | | | | | | | | | | | | | | | | | | | | |
| 360～370 | | | | | | | | | | | | | | | | | | | | | | |
| 390～400 | | | | | | | | | | | | | | | | | | | | | | |
| 420～430 | | | | | | | | | | | | | | | | | | | | | | |
| 440～450 | | | | | | | | | | | | | | | | | | | | | | |
| 460～470 | − | | | | | | | | | | | | | | | | | | | | | |
| 480～490 | − | | | | | | | | | | | | | | | | | | | | | |
| 490～500 | − | | | | | | | | | | | | | | | | | | | | | |
| 510～520 | ○ | | | | | | | | | ○ | + | + | + | + | + | ○ | ○ | | | | | * * |
| 520～530 | ○ | | | | | | | | | | ○ | | ○ | | | | | ○ | ○ | | | |
| 530～540 | ☆ | | | | | | | | | | | | | | | | | | | | | Mixed shell assemblages |
| 540～550 | | | | | | | | | | | | | | | | | | | | | | |
| 550～560 | | | − | | | | | | | | | | | | | | | | | | | |
| 560～570 | △ | | | | | | − | | | | | | | | | | | | | | | |
| 570～580 | | | | | | | | | | | | | | | | | | | | | | |
| 580～590 | | | | | | | | | | | | | | | | | | | | | | |
| 590～600 | − | | | | | − | | − | | | − | − | − | | | | | | − | | | |
| 610～620 | △ | | | | | | + | | | | − | | | | | | | | | | | |
| 620～630 | − | \ | | | − | | | | | | | | | | | | | | | · | | |
| 630～640 | − | − | | | − | − | | | | | | | | | | | | | + | | | |
| 640～650 | | | | | | | | | | | | | | | | | | | | | | |
| 650～660 | + | | | | | | − | | | | | | | | | | | | | − | − | |
| 670～680 | − | | | | | | − | | | | | | | | | | | | | | | |
| 690～700 | + | | | | | | | | | − | − | | | | | | | | | | | |
| 710～720 | − | − | | | | | | | | | | | | | | | | | | | | |
| 730～740 | ○ | | | | | | | | | | | | | | | | | | | | | |
| 740～753 | | − | | | | | | | | | | | | | | | | | | | | |

①*Miliammina arenancea*; ②*M. lata*; ③*Cribrostomoides subglobosus*; ④*C. jeffreyi*; ⑤*Portatrochammina antarctica*; ⑥*Pullenia bulloides*; ⑦ *P. subcarinata*; ⑧ *P. quinqueloba*; ⑨ *Globocassidulina* sp.; ⑩ *Bolivina seminuda*; ⑪ *Neogloboquadrina pachyderma*; ⑫*Cyclammina trulissata*; ⑬*Cassidulina subglobosa*; ⑭*Nonionella iridea*; ⑮*Nonin* sp.; ⑯*Fursenkoina earlandi*; ⑰*F. fusiformis*; ⑱*Cibicides lobatulus*; ⑲*Bulimina seminuda*; ⑳*B. aculeata*; ㉑*Virgulina* sp..

−: 1～2; +: 3～10; △: 11～20; ○: 30～100; ☆: >100; * *: Calcareous shell assemblage

*lenia subcarinita*, *Bulimina aculeata*, siliceous species: *Miliammina arenancea*, *M. lata* and agglutinated species: *Portatrochammina antarctica*. The dominant species still is *Miliammina arenancea*, with its content of 68%～93%. Foraminifers are rare, usually are 4～12 in number per 10 g dry sample. But in 3 sections of 590～600 cm, 610～620cm and 730～740 cm, they are more than 12 in number per 10 g dry sample. $H(s)$ value is less than 1.

## 4 Preliminary reseach on palaeoenvironment

The Bransfeild Strait is a complicated topographic area in northwestern Antarctic

Peninsula and is controlled by different water mass. The topographical features are clearly different on the sides of north and south, cliffy in north and gentle in south. The isodepth contour line of 1000 m on north side is close to coste, while the continental shell of the peninsula is less than 5 km wide but it is about 45 km wide in the south (Zhen and Wu, 1989). The history of sedimentary environment changes from late Quaternary will be known by analysis of foraminiferal assemblage.

2 kinds of foraminiferal assemblage, including normal sedimentary and turbidity sedimentary assemblages, were found in the core. The former was found in the top and lower parts of the core corresponding to assemblage Ⅰ and Ⅲ, the later was found in the middle, corresponding to assemblage Ⅱ. Assemblage Ⅰ is deep water agglutinated shell assemblage in center of the strait, characterized by high content of big and thick siliceous shell, and by rare calcareous species with good preservation. The assemblage is found in depth of 1500～2000 m in the central trough of the strait (Lindenberg and Auras, 1984). The core taken was under CCD, where dissolution is strong and few calcareous shells are preserved (Zhen and Wu, 1989; Anderson, 1975). It was mainly controlled by the low temperature and high salinity water of southern Bransfield Strait and Weddell sea and it was normal deep water sedimentary assemblage. *Cribrostomoides subglobosa* and *Portatrochammina antarctica* are typical deep-water agglutinated species in south ocean, and as for agglutinated foraminifers, few calcium carbonate needed for their shell explains why they are still abundant below CCD and in low salinity water, common in Antarctica and Arctic cool water area. *Miliammina* was the only one siliceous agglutinated species in the core. Water in the Bransfield Strait contains much nutrition of various kinds and provides a good environment for the growth of siliceous species (Li *et al.*, 1987). *Miliammina* is distributed wildly and dominantly in the strait. The shells of assemblage Ⅰ are well preserved except for a few breakings. It indicates weak hydrodynamic condition and stable sedimentary environment.

There are rare foraminifers in section of 130～510 cm. The reason is complex, but it can be known from the distribution of foraminifers in surfacial sediment. According to the analysis of foraminifers in the Bransfield Strait during the cruise of 1990～1991. There are different assemblages in different water mass area, and rare foraminifers in the conjuction of water masses. It was referred that lack of foraminifers in the core may be in such case. While it got cold and the sea-level was lowering, the boundary between north water mass and central water mass in the strait moved southward and was close to the location of the core. Rarity of foraminifers may be the result of unstable water masses under the sea. Foraminifers are rare and have think shell, and so they can tolerate to be eroded and are difficult to be moved.

Assemblage Ⅱ was product of turbidity current. The calcareous shells were more than siliceous shells, most of them were shallow water species (Li and He, 1985), such as: *Fursenkoina earlandi*, *Cassidulina parkerianus*, *Cibicides lobatulus*, *Nonionella iridea*, which were found in coast and shallow sea arounding the Antarctica and the islands, and their distribution is usually in depth of less than 800 m. Rare planktonic foraminifers were found in the core. Only one species of planktonic foraminifer *Neogloboquadrina pachyderma*, which is cool water species and common in poles, is found. As to the

species, besides the species is of dextral shell in warm area, but of silistral shell in cool water(Wang *et al.*, 1983). All samples in the core are of sinistral shell, *N. pachyderma* is rare in number with varied and smoth shell, and with mouth close to abdomen. The assemblage is characterized by having broken shells and more resedimented brown shells, such as *Cribrostomoides subglobosa*, *Miliammina arenancea* and *Cassidulina biora*. The later ones live in depth of less than 300 m. The resedimented shells may come from the north of the Bransfield Strait and its surroundings. Because of unstable water mass at that time , some exotic materials that were subject to transportation and reworking were redeposited over there. In addition, also some previously deposited sediments turned to overlie the post-deposited layer because of the oscillation of water body. Sediments in the section became medium-coarse in grainsize. Clastic minerals are mainly of terrigenous sediments (Lin and Zheng, 1989). The foraminifers in the assemblage are much different from those in the overlying and underlying sections, for they show the characteritics of turbidity current sedimentation.

Assemblage Ⅲ has rare calcareous foraminifers, the buried foraminnifers are affected by turbidity, resulting in a mixture of foraminifers of different periods. Obviously, calcareous foraminiferal shells contained in the section are exotic. Because there are few runoffs that bring mud and sand into the sea, sea-bottom sediments in the Antarctic Peninsula and on the margin of Antarctic continent are deposited predominantly by coastal glaciation. Therefore, when it is warm and ice melts, it is the active period for transportation and deposition of sediments. Except that *Miliammina arenancea*, *M. lata* is of high content. The resedimented shells are common, but disappear in the part below 600 cm. Some of the shells are broken which mean that calcareous shell is relic of turbidity current. Below 600 cm in the core, the foraminifers are preserved well, number of species increase and hydro-dynamic condition is weaker than that of assemblage Ⅱ . The sedimentary environment returns from the strong hydro-dynamic condition of turbidity current to normal deep sea.

## 5 Conclusion

(1) 3 assemblages from late Quaternary present 3 different sedimentary environments: siliceous shell assemblage presents the normal deep-sea sedimentary environment, the calcareous shell assemblage is the relic of turbidity current, the mixed shell assemblage is normal deep-sea sediment. The hydro-dynamic condition in sea-bottom was an important factor of controlling the foraminiferal assemblages .

(2) The climatic change indicated by the core (from top to bottom )is in a sequence of warm-cold-warm based on research on the foraminiferal assemblages. Assemblage I presents warm period of post-glacial. The part of lack of foraminifers presents cool period of last glacial. Assemblage Ⅱ and Ⅲ present warm period of the last interglacial (Fig. 1).

(3) The foraminiferal species and number are controlled and affected by the complicated hydro-dynamic condition in the Bransfield Strait. Alternation of cold and warm climates and fluctuation of sea level consequently bring about landslide and scouring pro-

| Age | Depth (cm) | Lithologic description | Foraminifera assemblages | Themoluminescent(ka)* | Uranium series (ka)* | Paleoclimate |
|---|---|---|---|---|---|---|
| Holocene | 130 | Grey-yellow siliceous silt, siliceous argilite, greyish dark sandy silt, the bottom is disconformable with the underlying starta | Siliceous shell assemblage | ● 13.2 ±1.0 | ● 7.7 | Post glacial |
| Late Pleistocene | 510 | Yellow grey siliceous coze, with odd patches and stripe | Rare Foraminifera | | ● 33.7<br>● 61.0 | Last glacial |
| | 530 | Light-colored muddy silt, greyish dark medium-coarse sand | Calcareous cell assemblage | ● 76.0 ±5.4 | ● 79.2 | Last interglacial |
| | 753 | Greyish dark giliceous silty ooze | Mixed shell assemblage | ● 83.7 ±6.7 | ● 91.3<br>● 106.4<br>● 112.5 | |

Fig. 1. Comprehension column showing lithological units, biologic variation and chronology of core PC10. * Bulk-rock themoluminescent dating and uranium series dating are done by Director of Guangzhou Branch, Institute of Geochemitry and South China Sea Institute of Oceanology, Chinese Academy of Sciences.

cesses. Transportation and reworking happen by current after foraminifers are deposited.

(4) The Bransfield Strait is under CCD line from late Quaternary.

**Acknowledgment** The author is very grateful to geologist Duan Weiwu for his advice and suggestions.

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## Plate I
(Plate explanation)

1. *Pullenia subcarinata*(D' Orbigny)
   side view, ×143, depth 590～600 cm
2. *Miliammina arenancea*(Chapman)
   side view, ×106, depth 510～520 cm
3. *M. lata* Heron-Allen and Earland
   side view, ×86, depth 620～630 cm
4. *Nonionella iridea* Heron-Allen and Earland
   ventral view, ×152, depth 490～500 cm
5. *Cribrostomoides subglobosus*(Cushman)
   ventral view, ×100, depth 0～10.5 cm
6. *Cyclammina trullissata*(Brady)
   ventral view, ×106, depth 490～500 cm
7、11. *Neogloboquadrina pachyderma*(Ehrenberg)
   ventral view, ×116, ×117, depth 550～560 cm
8. *Pullenia quinqueloba*(Ress)
   ventral view, ×125, depth 120～130 cm
9. *Fursenkoina earlandi*(Parr)
   side view, ×125, depth 490～500 cm
10. *Pullenia bulloides*(D' Orbigny)
   side view, ×125, depth 620～630 cm
12. *Cassidulina globosa* Brady
   side view, ×106, depth 510～520 cm

Plate I