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The substance composition of sterols in the sediments from the Chukchi Sea, the Bering Sea and global climatic significance

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Abstract The compounds of sterols such as C_{27}、C_{28}、C_{29} and C_{30} are recorded from C-8 core of the Chukchi Sea. The double bond position is located at 5-, 5, 22 as well as 22-, 24-. The compound of sterols such as C_{27}、C_{28}、C_{29} are recorded from B2-9 core of the Bering Sea. The double bond position is located at 5-, 5, 22 as well as 22. The composition characteristics of sterols indicate that the substance is mainly contributed by the terrigenous origin and marine silicate organisms. The results are also suggest that the record of abnormal sterols from the surface sediments (2- 0 cm) in the Chukchi Sea and the Bering Sea represent the period from 1980s to the late 1990s. The strong signal of the Arctic warming is preserved in the sediments, which indicates the eco- environmental change responding to climatic effect of circumjacent.

Key words the Chukchi Sea, the Bering Sea, biological indicator, sterols, substance composition.

1 Introduction

So far, people know little about Arctic. Since 1980s, researches about the relationship of geological evolvement in Arctic and global changes have been one of the hottest subjects of Arctic scientific research. On the one hand, studies of global changes caused by the Arctic evolvement should ascend the self-changes of Arctic area, on the other hand, should know how the ecological changes of Artic area affect the globe environment and the process of climate changes (Chen *et al.* 2003). The changes of the plankton content in Arctic Ocean directly relate to oceanic matter flux and energy transformations. Marine ecological evolvement parallels with the changes of the regional or global climate, and it also may restrict the biological processes in the polar region.

The ebb and flow of organic matters and their geochemical characteristics could reflect varieties of the ancient climate and the ancient environment. In the far-flung aggradations process, although the composition and structure of the substance in sediments were almost changed, *yet aliquots* could hold their basic natural carbonic framework. Sterols and their derivants in modern sediment strata were typical biologic biomarkers relating to the life actions. The subtle structure and compositions of sterols can show origins of organic matters in the oceanic sediments at molecular level. The early evolvement and ecosystem in deposit regions take on most information of life actions (Volkman *et al.* 1987; Duan *et al.* 1998). Scientists have paid more attention to biological organic geochemistry of sterols, which become more and more available to the study of global and regional changes.

This study mainly focuses on the composition and distribution of sterols of the C-8 and B2-9 station in the Chukchi Sea and the Bering Sea, respectively. Furthermore, by comparisons of these two sea areas, the author tried to find out abnormal records of these compounds and their effects to the climate around.

2 Sample collection and Methods

2.1 *Sample collection and observation*

The samples were collected in the Chukchi Sea and the Bering Sea in the course of the first Arctic scientific research of China by the "Snow Dragon" icebreaker. The cores were from C-8 zone (70°00′34″N, 174°59′01″W) and B2-9 zone (59°17′32″N, 178°41′50″W). The zones were showed as Fig. 1. The samples were conserved hermetically in situ. The cores were cut at the interval of 1 cm, and every sub-sample split into three equal parts in the laboratory. In this study only the upper 10 cm sediment (0– 10 cm) samples were analyzed.

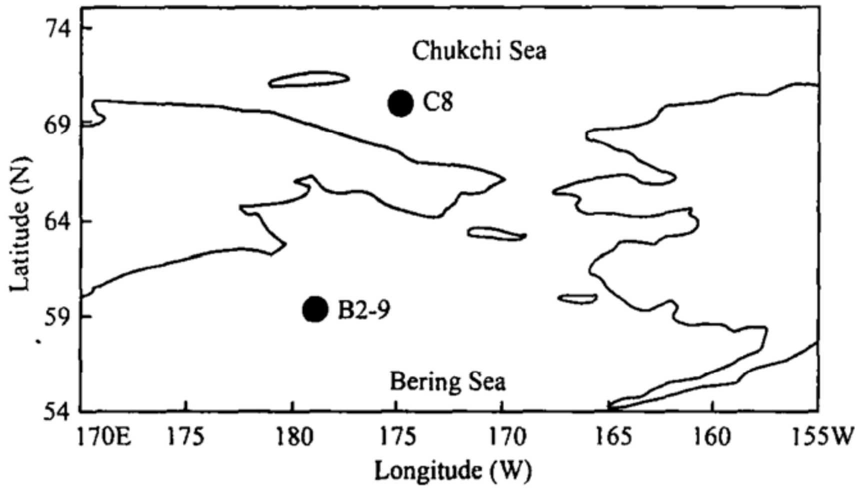

Fig. 1 Locations for sampling

2.2 *Methods*

The sediments were saved refrigerated, natural dried and crushed to 100th order. Then these samples were extracted with dichloromethane-methanol (3∶1, V: V) for 72 h, and desulfured by copper. The extractions were concentrated in rotary evaporator. The residuals were injected to the silica gel columns, and washed with n-hexane, benzene and methanol to separate alkyl, aromatic hydrocarbon and nonhydrocarbon, respectively. The nonhydrocarbon was regurgitated and saponated with methanol-potassium hydroxide solution (1 mol/L). Then mix the separated sterols with BSTFA A [bis(trimethy1)-trifluoroa-cetamide], and the products (TMS-ether, derivants of trimethyl silicic ether) were detected with GC and GC/MS. The identification of compounds was on the base of retention times, mass spectrum and comparison with the standard spectrum (Brooks *et al.* 1968; Deleeuw *et al.* 1983; Volkman *et al.* 1990).

Primary analysis was conducted by HP5890 gas chromatography equipped with a flexible quartz capillary column (DB-5, 30 m × 0.25 mm (i. d.), film thickness 0.25 μm). The initial column temperature was 80 ℃, and ramped at 5 ℃min^{-1} to 300 ℃, followed by an isothermal hold at 300 ℃ for 30 min. GC-MSD (Finigan-MATTSQ70B), was carried out for confirmatory analysis. The MSD was operated in the electron-impact ionization mode (EI, 70 eV, 250 ℃) and the carrier gas was He (helium).

Dating of the sediments was obtained by $^{210}Pb^{ex}$ detection, using GWL-120210 detector in the State Key Laboratory of Estuarine and Coastal Research, East China Normal University. The granularity of sediments was analyzed by MAM 5005MS-S Laser Diffraction Particle Analyzer.

3 Site descriptions

The Chukchi Sea is a margin sea of the Arctic Ocean, which situates on continental shelves off the northwest coast of Bering Sea. The south of the Chukchi Sea is connected with the Bering Sea through the Bering Strait, the north is connected with the Chukchi plateau and deep-sea plain of Canada, the east is connected with Alaska and the Beaufort Sea. The water depth of the Chukchi Sea was generally within 60m except somewhere near continental slope. The Bering Sea is at the end of the north part of the Pacific Ocean, connecting with Siberia at the west, adjoining to Alaska at the east, separating from northern Pacific Ocean through Aleutian Islands at the south and connecting with Bering Strait at the north. At the southwest of the Bering Sea is Aleutian Basin, 40% of which depth is over 3500m. The Bering Strait connects the Pacific Ocean with the Arctic Ocean, and is the channel of mass and energy transportation. Arctic Ocean system is affected by changes of global climate and environment sensitively, and there obviously exists interaction and feedback.

4 Results and discussions

4.1 Deposit stratum observation and dating

The sediment cores of B2-9 station were French grey with some shells and fragments. B2-9 station, of which water depth is 2200 m, located between continental slope and sea basin in Bering Sea, with characteristics of steep gradient of the sea bed, high speed flow and rough sediment. In contrast to B2-9, the depth of C-8 station in the Chukchi Sea is 50 m, with a flat gradient of sea bed and fine sediment. The surface sediment of C-8 station was covered with buff mud and abundant inorganism, however, the sediment under the surface was gray black with dense odor.

The results of ^{210}Pb dating of sediments indicate that sedimentation rates and fluxes of the Chukchi Sea and the Bering Sea are lower. The sedimentation rates and fluxes of C-8 station are 0.03–0.19 cm·a^{-1} and 0.20–1.22 g·cm^{-2}·a^{-1}, respectively, and the corresponding averages were 0.10 cm·a^{-1} and 0.69 g·cm^{-2}·a^{-1} (Table 1). This average sedimentation rate consisted with the result of northeast ocean area of Greenland 0.7 mm·a^{-1} (Roberts 1995), and 0.89 mm·a^{-1} of the sedimentation rate in west Arctic Ocean (Huh 1993). The sedimentation rates and fluxes of B2-9 zone were 0.04–0.21 cm·a^{-1} and 0.29–1.42 g·cm^{-2}·a^{-1}, respectively, and the corresponding averages were 0.10 cm·a^{-1} and 0.72 g·cm^{-2}·a^{-1}. These results consisted with the research of Tsunogai and Yamada, that the average deposit velocity of Bering Sea was 1 mm·a^{-1}. The time range of sediments in C-8 and B2-9 was about 119 (1880–1999) and 138 (1861–1999) years, respectively.

4.2 Composition of sterols in sediments

The sterols and their derivants are very popular biomakers in the modern sediment, which have a common steroidal nucleus, and have various species because of differences in the length of the branch strain at C_{17} and methyl-substituent at C_4. Generally speaking, the majority of C_{29} sterols come from terrestrial higher plants, C_{28} sterols are both from phytoplankton and higher plant, however, C_{27} sterols are mainly marine phytoplankton origin. In C_{30} sterols, 4-methyl sterols are generally dominant in dinoflagellate. Thus, they can be taken as substitute parameters of terrestrial matter and ancient primary productivity, and differences in composition of sterols in sediments of different sedimentation condition and periods, and undoubtedly reflect different entironment.

Table 1 Result of ^{210}Pb dating, sedimentation rate and flux of core C_8, B_{2-9}

Station area	Depth and sediment characteristic	Longitude and Latitude	Depth (cm)	age (a)	Sedimentation rate (cm·a^{-1})	Sedimentation flux (g·cm^{-2}·a^{-1})
			0—1	0	0.19	1.22
Arctic	59(cm)	70°00′34″N	1—2	5.8	0.16	1.03
			2—3	12.5	0.13	0.83
Chukchi Sea	Muddy buhr,	174°59′02″W	3—4	21.6	0.12	0.75
	Gray black,		4—5	31.5	0.10	0.61
C_8	abundant in		5—6	44.2	0.08	0.51
	organism		6—7	60.8	0.06	0.44
			7—8	82.9	0.05	0.32
			8—9	118.7	0.03	0.20
			0—1	0	0.18	1.10
North Pacific	2200(cm)	59°17′32″N	1—2	6.2	0.21	1.42
Ocean			2—3	11.3	0.15	0.97
	Muddy buhr, French		3—4	18.9	0.11	0.80
grey, with some	178°41′50″W		4—5	29.1	0.15	1.02
Bering Sea	shells and		5—6	36.8	0.08	0.57
	fragments		6—7	52.6	0.07	0.49
B2-9			7—8	71.2	0.07	0.47
			8—9	89.7	0.07	0.46
			9—10	109.9	0.05	0.36
			10—11	137.6	0.04	0.29

4.2.1 Chukchi Sea Deposit Stratum

Sterol compounds such as C_{27}、C_{28}、C_{29} and C_{30}, whose double key position is located at 5-, 5, 22- as well as 22, 24-, are recorded from C-8 core of the Chukchi Sea. Thereinto, C_{29} sterols have predominance, accounting for 50.0% - 70.1%, while C_{28} sterols and C_{27} sterols account for 18.4% - 32.4% and 9.0% - 17.0%, respectively, and C_{30} sterols the least. According to the relative content of sterol, they can be separated into two sources, include terrigenous clastic matters carried by river, ocean current, glacier, sea ice and dust, and marine silicate organisms (diatom, zooplankton, and mucky granule) (Gao and Lin 2003). The former took the majority.

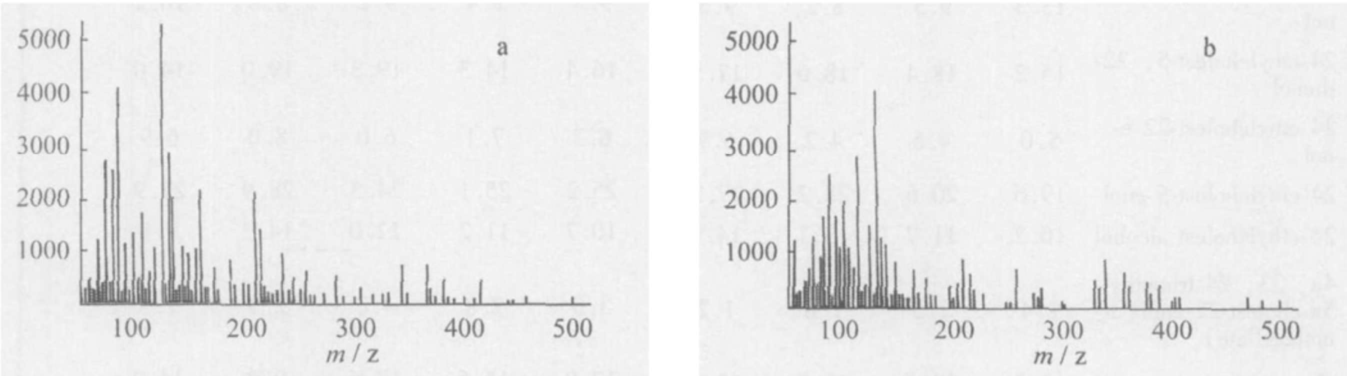

Fig.2 Mass spectra of cholest-5-en-3β-ol(a), 24-methylcholest-5, 22-dien-3β-ol(b) TMS ether in studied samples

24-ethylcholest-5-enol (Plant sterol) and 24-ethylcholest-5, 22-dienol (Plant sterol) are the most abundant C_{28} sterol in C-8 zone, which take averagely 21.2% of total sterol. They were the main sterol of terrigenous higher plants (Nytoft *et al.* 2000, Goad and Goodwin 1972), and markers of terrigenous organic matter with the most characteristic; however in some diatom dominant species and microalgea also were one of origin (Volkman 1986). The chromatography arrange from n-alkanes nC_{15} to nC_{33} of sediments in C-8 station presented as a double-peak image, with high-carbon peak advantaged. The CPI (composition molecular peculiar index) and the ratio of heavy-hydrocarbon and light-hydrocarbon (C_{21-33}/C_{15-20}) were 2.488 and 2.671 (Lu *et al.* 2002), respectively. All the results conformed that 24-ethylcholest and 24-ethylcholest-5, 22-dienol were markers of terrigenous higher plants. C-8 station was very near the coast with shallow depth. Influenced by terrigenous input and alongshore productivity as well as the input of terrigenous matter and coastwise erodent substances would play an important part in contemporary deposit progress of longshore areas. Recently Boucsein and Syein (2000) indicated that surface sediment of Arctic Ocean were mainly terrigenous organic matter accounting for 78%, while 99% of organic matter in continental shelf origined from continent and that of sediment in upper slope was as much as 20%-40%. All these substances were buried by sedimentation. Low temperature avails to the conservation of organic matter.

The most abundant C_{28} sterol in C-8 zone are 24-methyl-5, 22-dienol (diatom sterol) and 24-methylcholest-5-enol, which take averagely 9.3% of total sterol. They can be discovered in the most of diatom and was considered to be the marker of diatom lipid (Li *et al.* 1994; Rieley *et al.* 1991). Organic matter in water was mainly produced by alga, and organic matter and lipid matter in cell was aggregate to algous matter after alga died. All al-

Table 2 Content of sterol in the core of C_8 and B_{2-9} (%)

C_8	1993-1999 0–1 cm	1986-1993 1–2 cm	1977-1986 2–3 cm	1967-1977 3–4 cm	1956-1967 4–5 cm	1938-1956 5–6 cm	1916-1938 6–7 cm	1880-1916 7–8 cm	-1880 8–9 cm
cholest-5-enol	8 4	8 0	6 6	8 5	8 5	10 2	8 0	5 2	8 6
5α-cholest alcohol	4 0	3 5	3 3	3 5	5 5	3 5	3 2	2 8	3 5
cholest-5, 22-dienol	3 8	2 0	2 1	1 5	3 0	1 8	1 4	1 0	2 6
24-methylcholest-5, 22-dienol	12 1	10 6	8 4	6 2	7 3	8 3	7 9	7 6	8 1
24-methyl-5a-cholest-22-enol	7 0	8 7	5 7	4 0	3 9	6 3	4 5	2 0	7 2
24-methycholest-5-enol	13 3	9 5	8 2	9 5	9 3	9 4	9 2	8 8	10 2
24-ethylcholest-5, 22-dienol	15 2	18 4	18 6	17 5	16 4	14 3	19 3	19 0	14 0
24-ethylcholest-22-enol	5 0	4 5	4 2	6 9	6 2	7 1	6 0	8 0	6 9
24-ethylcholest-5-enol	19 6	20 6	28 2	27 2	25 2	25 1	24 5	28 9	27 9
24-ethylcholest alcohol	10 2	11 7	13 1	14 0	10 7	11 2	12 0	14 2	9 5
4a, 23, 24-trimethyl-5a-cholest-22-enol(dinoflagellate)	2 4	2 5	1 6	1 2	3 0	2 8	4 0	2 5	1 5
C_{27} sterol	16 2	13 5	12 0	13 5	17 0	15 5	12 6	9 0	14 7
	32 4	28 8	22 3	19 7	20 5	24 0	21 6	18 4	25 5
C_{28} sterol	50 0	55 2	64 1	65 6	58 5	57 7	61 8	70 1	58 3
C_{29} sterol	2 4	2 5	1 6	1 2	3 0	2 8	4 0	2 5	1 5

B2-9	1993-1999 0–1 cm	1988-1993 1–2 cm	1980-1990 2–3 cm	1970-1980 3–4 cm	1966-1970 4–5 cm	1946-1962 5–6 cm	1928-1946 6–7 cm	1909-1928 7–8 cm	1889-1910 8–9 cm	1861-1889 9–10 cm
cholest-5-enol	16 8	16 0	12 6	18 5	15 3	14 2	17 0	12 8	14 6	15 2
5α-cholest alcohol	6 6	6 8	6 9	7 4	7 2	6 8	7 5	8 0	6 4	8 2
24-methylcholest-5, 22-dienol	10 8	10 2	14 5	12 3	13 8	14 7	15 6	14 2	9 2	12 4
24-methyl-5a-cholest-22-enol	12 4	9 2	8 0	6 3	5 9	10 1	9 6	9 7	8 4	8 4
24-methylcholest-5-enol	15 0	16 4	12 4	8 2	10 1	8 7	10 5	10 5	10 3	10 9
24-ethylcholest-5, 22-dienol	7 5	7 1	3 1	10 2	9 5	6 7	8 5	5 5	6 5	7 2
24-ethylcholest-22-enol	8 8	10 2	12 5	12 6	10 0	9 4	9 0	7 8	16 0	10 8
24-ethylcholest-5-enol	13 5	9 9	10 5	18 8	11 5	9 6	8 9	12 4	11 9	11 8
24-ethylcholest alcohol	9 2	14 1	19 3	12 6	16 7	19 8	14 9	19 1	16 7	12 4
C_{27} sterol	23 4	22 8	19 5	25 9	22 5	21 0	24 5	20 8	21 0	24 4
C_{28} sterol	38 2	35 8	34 9	26 8	29 8	33 5	35 2	34 4	27 9	31 3
C_{29} sterol	39 0	41 3	45 4	54 2	47 7	45 5	40 3	44 8	51 1	42 2

gous lipid matters were belong to nonhydrocarbon compound which had simple molecular structure and oxygen functional groups and part of hydrocarbon D iatom was the main phytoplankton in Chukchi Sea, and it took 99.9% in total cell density of phytoplankton. The alga, such as *Nitzschia grunowii*, *Thalassiosira nordenskioldi*, *Chactocetoceros socialis* and *Ch. Subsecundus*, which universally distributed in deep water and shallow water in Chukchi Sea, was possible contributors to diatom sterol. The high density of phytoplankton in the shallow water of Chukchi Sea might be related to the invasion of Bering sea which have abundant nutriment and high salinity during thaw ice period (Chen *et al.* 2003).

Unsaturated cholesterol of C_{27} sterol took 8.0% of total sterol in C-8 zone, biochemistry study has confirmed that all plankton in sea has cholesterol, especially, sterol-5-enol of high concentration was generally from zooplankton and its feces. The average value of total biomass was 690.8 mg/m^3, which was much larger than that of the adjacent sea at middle and low latitude. The main zooplankton in Chukchi Sea was *Copepod*, *Acalephe*, *Amphipoda*, *Chaetognatha*, *Euphausiids*, *Ostracoda*, *et al.* All those were possible origin of cholesterol.

A small quantity of 4α, 23, 24-trimethyl-5a-cholest-22-enol (dinoflagellate) of C_{30} sterol was determined at C-8 zone in Chukchi Sea. Dinoflagellate sterol was reliable marker of oceanic dinoflagellate, and was also the source of 4-methylcholest in deposit. Although the pure north polar species of dinoflagellate has not discovered in depost stratum in Chukchi Sea, without doubt, *Protoperidinium pellicidum* and *Protoperidinium depressus* of dinoflagellate were one of direct contributors to sterol. The determination of subtle structure of biomarkers, in view of biochemistry, supplied a rational evidence for enucleating origin life behavior of 4-methyl sterol of C_{30} sterol.

4.2.2 *Bering Sea Deposit Stratum*

Sterol compounds such as C_{27}, C_{28} and C_{29} whose double bond located on 5-5, 22- and 22- was found in the deposit sratum of Bering Sea B2-9 (Table 2, Fig. 2). The percent of C_{27}, C_{28} and C_{29} sterol was 19.5% – 25.9%, 26.8 – 38.2% and 39.0 – 54.2% respectively. According to the relative content of sterol, one part of them was mainly from terrestrial higher plants which contributed more, another part was from ocean origins.

In B2-9 zone, 24-ethylcholest-5-enol (Plant sterol) and 24-ethylcholest-5, 22-dienol (Plant sterol) of C_{29} sterol which considered as marker of terrigenous organic matter took 9.6% of total sterols. Plant sterol was the main sterol of higher plants, however, microalgea, such as *Cyanobacteria*, was possible important sources of 24-ethylcholest-5-enol. The chromatography arrange from n-alkanes nC_{23} to nC_{31} of sediments in B2-9 station presented as a double-peak image, and the high-carbon peak was advantaged. The CPI and the ratio of heavy-hydrocarbon and light-hydrocarbon (C_{21-23}/C_{15-20}) were 2.392 and 4.932, respectively. All the results conformed that 24-ethylcholest-5-enol and 24-ethylcholest-5, 22-dienol were from terrigenous higher plants.

In B2-9 zone, 24-methyl-5, 22-dienol (diatom sterol) and 24-methylcholest-5-enol of C_{28} sterols which considered as markers of diatom lipid took 12.0% of total sterol. Diatom was the main species of phytoplankton in Bering Sea which took 99.4% in total cell density of phytoplankton. The station B2-9 was rich in Northern subarctic and northern temperate zone species of diatom such as *Denticula seminae*, *Nitzschia delicatissima*, *N. seriata* and *Thalassothrix longissima*, and so on. The concentration of diatom in B2-9 station was up to

3558 × 10^4 /g, which was the highest of all observed points in Chukchi Sea and Bering Sea. As a result, in this special environment, diatom was direct contributor to C_{28} sterols.

In B2-9 station, the unsaturated cholesterols of C_{27} sterols took about 15.3% of total sterols. The main species of zooplankton in Bering Sea as well as in Chukchi Sea were *Copepod, Acalephe, Amphipoda, Chaetognatha, Euphausiids, Ostracoda, et al.* All of these may be sources of cholesterols.

4.3 Comparisons of the chosen sediments and climate effect

C_{27}, C_{28}, C_{29} and C_{30} sterols of sediments in Chukchi Sea were average 12.41%, 29.45%, 54.13% and 4.0%, respectively, and the corresponding values in Bering Sea were 22.55%, 32.78% and 45.12%. But the content of C_{30} sterols in Bering Sea sediments was very few. The composition and origins between the two stations both had similarities and differences. On the one hand, considering relative content, all of the sterols in the two stations were both from terrigenous higher plants and oceanic matters, and the former was more important. On the other hand, the content of plant sterols C_{30} in Chukchi Sea was about 10% higher than that in Bering Sea. Because C-8 station was near the coast and with shallow depth, so the inputs of terrigenous and coastwise erodent substances as well as water moving materials by Bering Sea would play an important part in contemporary deposit progress of longshore areas. Besides, the content of diatom sterol C_{28} in Bering Sea was about 11% higher than that in Chukchi Sea. Although both the Bering and Chukchi sea areas were characteristic with high productivity (Sambrotto *et al.* 1984; Conkringt *et al.* 1994), the former was more representative. Chukchi Sea is the routeway connecting northern Pacific Ocean with Arctic Ocean. There structure of ecosystem, productivity and oceanic fluxes were all influenced by northern Pacific and Arctic Ocean. According to indicated element Fe, whose process of transportation and enrichment were close relative to environment, its content was almost uniform with three different deposit types (sand, sandy silt and silt sand) in the two sea areas (Gao and Liu 2003). It indicated that the content of Fe became higher along with granularity from thin to thick, and accounted that the chosen areas had similar origins as well as mass and power exchange. Compared with Bering Sea, the productivity in surface water of Chukchi Sea was limited due to much more effect of low temperature and low saline water in long-term (Coachman *et al.* 1975; Walsh 1989). Thus, changes of polar climate and environment may not only affect synthesis and decomposition of organic matter in partial sea, but also effect terrestrial inputs and conservation by interactions between sea and land or sea and sea. Furthermore, all these results can feed back.

It has reported that the global temperature has ascended by 0.3 – 0.6 ℃ in the last century, especially in the last twenty years. The temperature of western Bering Sea was added by 0.25 ℃ per ten years, and the square of the sea ice have shrunk 5% in thirty years (Chen 2002). Water temperature of continental slope has increased by about 1 ℃ since 1993 (Aaggard *et al.* 1996), which become the symbol of Arctic warming. In Chinese first research expedition of Arctic, scientists detected the average temperature rise of middle and deep water was universally higher than that of any season in many years (Zhao *et* *al.* 2004). It could be concluded that on the background of global warming the climate of Arctic changed obviously.

The composition of sterols in current sediments could reflect different sources of organic matter and biologic composing of sedimentary areas in that period, while the latter tied up with extreme entironment and climate of polar region. Fig. 3 (a) indicates compounds of sterols such as C_{27}, C_{28}, C_{29} in Bering Sea B2-9 station have differences along with the depth of sediments. In the section of 7.5~5.5 cm (corresponding to period of 1920–1950) and 3.0~0 cm (corresponding to period of 1980–1999) the average contents are 4% higher than others, and especially the contents of 24-ethylcholest-5-enol and 24-ethylcholest-5, 22-enol had prominent advantage comparing with other C_{28} sterols and have obvious climate effect. In this two sections, relative contents of C_{28} sterols are similar. C_{27} sterols did not change obviously and the total relative contents of sterols are also nearly. That implies oceanic phytoplankton increased.

Fig. 3(b) pointed out that the sterols composing of Chukchi Sea station C-8 which were in section 0–2 cm (corresponding to period of 1986–1999) had similar trend with the same section of Bering sea. Comparative content of C_{28} sterols was 3% higher than that in other sections in average, especially the content of 24-ethylcholest-5, 22-enol, but the contents of 24-ethylcholest-5-enol and 24-ethylcholest-5, 22-enol were accordingly decreased, and the content of C_{27} sterols did not change obviously. Along with the change of stratum depth, composing of sterols didn't have obvious change contrasted with station B2-9 of Bering Sea. The unusual records of top sediment stratum in Chukchi Sea and Bering Sea were roughly demarcated in warm increasing stage of Arctic area and global (Yang *et al.* 2002). So we could conjecture that in warm increasing stage of Arctic area and global, import matter from land sources (including longshore erosive matter) decreased correspondingly, which availed to the increasing of ocean phytoplankton especially diatom. Phytoplankton is the primary producer in ocean ecosystem, and has un-substituted effect on matter recycle and energy flow of ecosystem. As photosynthetic layer which phytoplankton stay is prone to be influenced by environment, effect of environment and feedback are prominent, with which it can be deduced how ocean biological pump respond to change of climate in Arctic area.

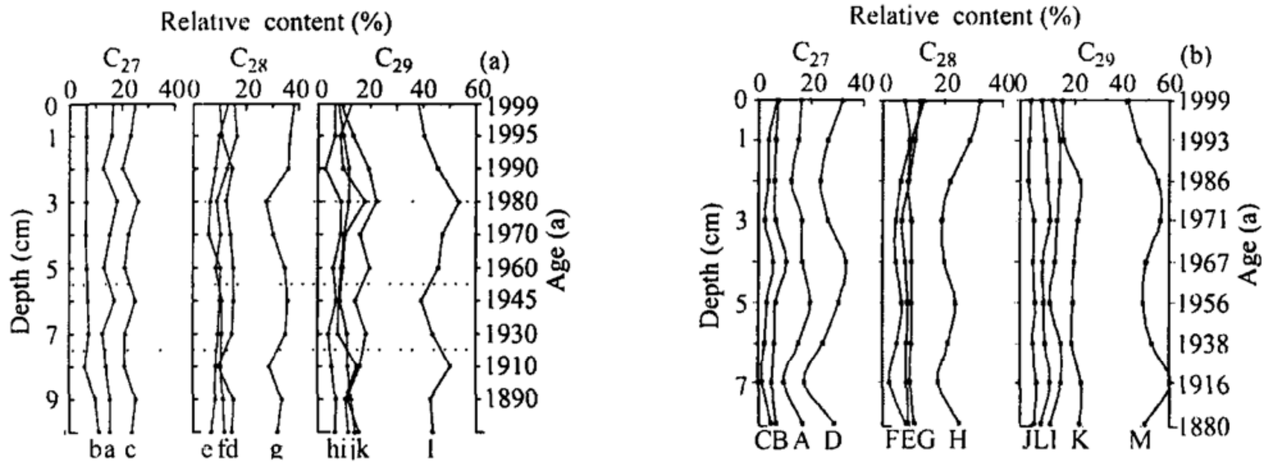

Fig. 3 Distribution of C_{27}, C_{28} and C_{29} sterols during different periods (a. Chukchi Sea b. Bering Sea)

5 Conclusion

(1) The compounds of sterols such as C_{27}, C_{28}, C_{29} and C_{30} whose double bond position are located at 5, 5, 22 as well as 22, 24 were recorded from C-8 core in Chukchi Sea sediments; the compounds of sterols such as C_{27}, C_{28}, C_{29} whose double bond position are located at 5, 5, 22 as well as 22 were recorded from B2-9 core in the Bering Sea sediments. According composition characteristics of sterols, it indicated that the substance is mainly contributed by the terrigenous origin and marine silicate organisms, and the former took the majority. The Chukchi Sea and the Bering Sea locate at the two sides of Bering Strait, which is the only channel for northern Pacific Ocean water coming into the Arctic Ocean, connects the two oceans and becomes an exchange channel of material and energy. Thus, records of sediments in the Chukchi Sea and the Bering Sea have the same characteristic and the composition of sterols have some similarity.

(2) Comparing with relative content and distributing characteristic in sedimentary stratum of Chukchi Sea and Bering Sea, there are differences in sterol distributing and environmental geology information in stratum recording. Maybe because differences between substances input from regional river and nutrition element and organic matter taken by longshore erosive matter, would influence life action of ocean biology differently. This regional difference (between arctic and subarctic) brought that effect on entironment change.

(3) Stratum of sediment molecule in Chukchi Sea and Bering Sea have kept the signal of increasing warm in last 20 years, which has direct relationship with Arctic regional and global climate change, and also respondence of biological progress of polar region to the climate change in Arctic area.

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