7.6 POC isotope composition in the Ob estuary as compared with the Yenisei system

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Our research in the Kara Sea are aimed to understand the pathway of organic carbon from biological sources to bottom sediments by the use of stable carbon isotope ratios in the different components of the carbon cycle with emphasis on organic matter in sea water, sediments, and sea-ice, as an integral part of the Arctic sedimentation. Data on organic carbon isotope composition of surface (0-2 cm) sediments in the Ob and Yenisei estuaries and adjacent sea area for samples of the expeditions BP-95 and BP-97 are shown in Figure 7.9 (Kodina 2000). As expected, all studied samples are isotopically depleted relative to the typical "marine" $\delta^{13}C$ values of about 21-22‰ found somewhere in the west part of the Kara Sea area, being influenced by the Barents Sea water (Kodina et al. 2000; Kodina & Peresypkin, this volume). The gradual enrichment of the total organic carbon in the ^{13}C-isotope towards the open sea is clearly manifested in both estuaries. It is particularly remarkable that there exists a well-pronounced difference between the two estuaries. Sediments of the Ob Bay are isotopically depleted (around –1,3‰) compared to the Yenisei estuary. The lowest $\delta^{13}C$ value of –28,7‰ is situated in the center of the Ob Bay, whereas the highest $\delta^{13}C$ value of –24,5‰ was found in the sea area under Yenisei influence.

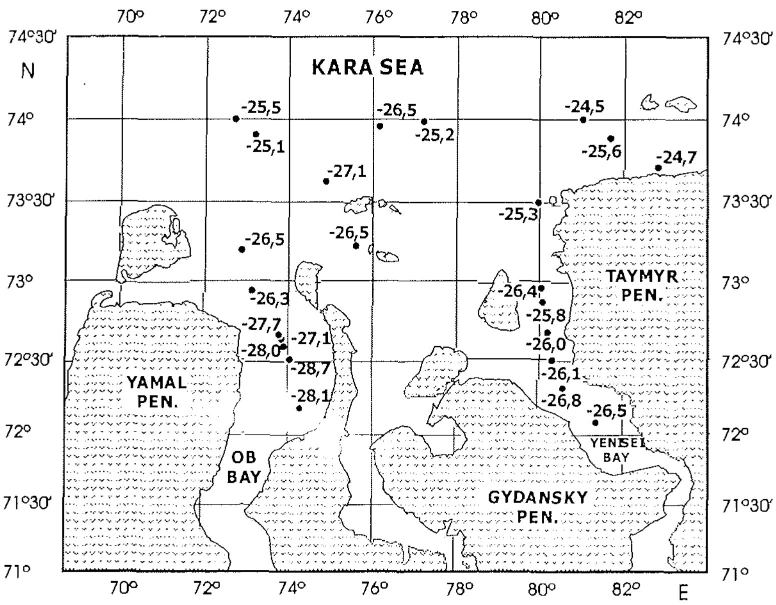

Fig 7.9. Organic carbon isotope composition of the top sediments (0-1cm) in the Ob and Yenisei estuaries and adjacent Kara Sea area (BP-95 and BP-97).

Yenisei system

The pattern of the stable carbon isotope ratio distribution in sediments of the Yenisei Bay was shown to correspond well with the correlation of the particulate organic carbon distribution and the salinity gradient in the Yenisei Estuary and adjacent Kara Sea area (Kodina et al. 1999). The $\delta^{13}C$ -values in the area range from -28,8 to -24,5‰. The distribution of the POC isotope values against water salinity shows that there exists a rather good correlation between the two parameters (R=0,8). It's notably, that the regularities occur both vertically through the water column and spatially throughout the study area.

In this way, in the study area the variations of the POC isotope composition are directly related to the variations of water salinity, with the isotopically lightest organic carbon (-28,8 ‰) being characteristic of the fresh water (S=1,2‰), whereas the maximum $\delta^{13}C$ -enrichment (-25,4‰) of the POC is observed in the marine surface water of highest salinity (S=14,9‰).

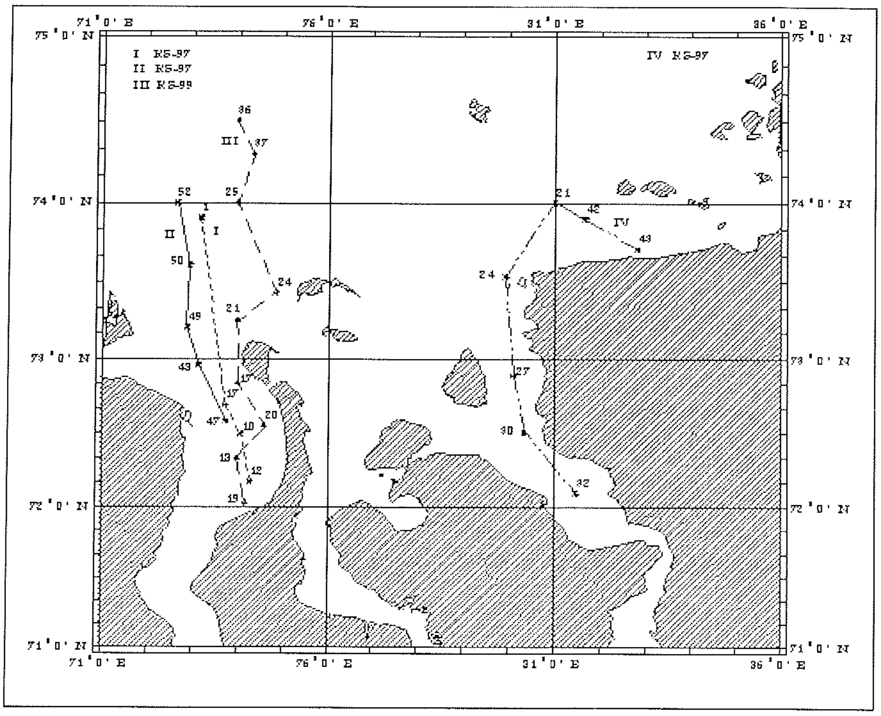

Fig. 7.10. POC sampling stations in BP-97 and BP-99 expeditions. I, II- meridional Ob sections , BP-97; III- - meridional Ob sections , BP-99; IV- meridional Yenisei section, BP-97.

The regularity discussed above manifests itself spatially as well. The $\delta^{13}C$-values generally paralleled water salinity: $\delta^{13}C$-values were lower in the south river part of the section and increased gradually from -28,2 to -25,4‰ to the northern estuary and open sea.

This regularity is also true for the much more extended section "Yenisei-river-estuary-open sea", BP-2000. The POC isotope data for this whole section are given in the Table 7.6. The presence of a hydrological front is a special feature of the section. Some peculiarities of the POC behavior in the frontal zone were presented earlier (Bogacheva et al. 2001). The sharp decrease of the POC concentration and the co-occuring enrichment of the POC in 13C by a value of 3,4‰ to the precipitation of the bulk terrestrial load.

Ob section

The Ob hydrology and hydrochemistry are characterized by some pecularities, which appear noteworthy with respect to the POC isotope geochemistry.

The absence of a clearly defined local hydrological front resulted in a diffuse boundary between marine and riverine waters in the Ob Estuary. Limited penetration of marine water into the Ob Bay and a more pronounced influence of the Ob fresh water to the open sea area were suggested to be the most outstanding distinctions from the Yenisei section (Burenkov & Vasilkov 1994; Köhler & Simstich 2001). The overall phytoplankton biomass in Yenisei was more than one order of magnitude lower than in the Ob Bay and adjacent coastal areas of the Kara Sea (Larionov & Makarevich 2001).

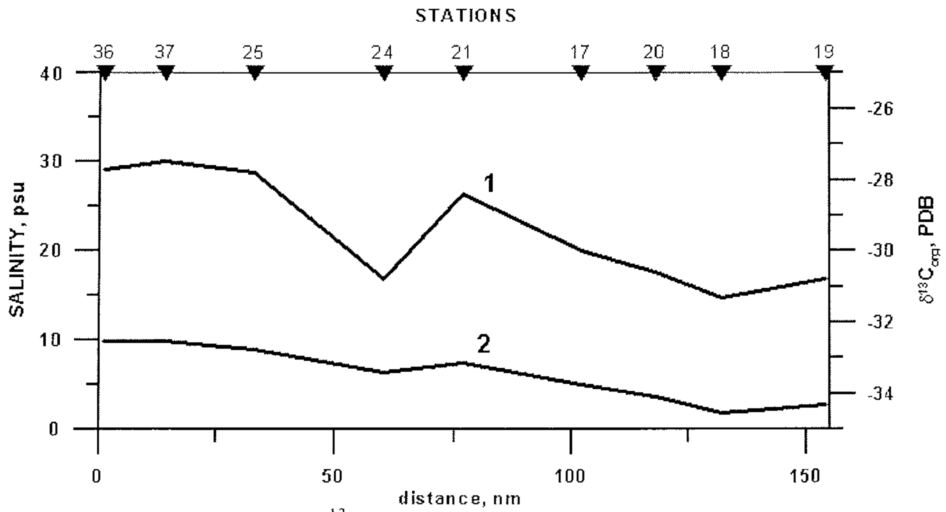

Fig. 7.11. Distribution of the $\delta^{13}C_{POC}$ values (curve 1) against the surface water salinity (curve 2)along the Ob section III (BP-99).

Ob water contains a higher HCO_3^- concentration (76,3 mg/l) than Yenisei (55,2 mg/l) (Gaillardet et al. 1999; Gordeev 2000). In the Ob River, water pCO_2 is much higher than in Yenisei because Ob watershed include mainly a marshland area with a swampy acidic soil. Oxidation of soil OM in the river water is responsible for pCO_2 rise in Ob water (Makkaveev 1994). The degradation of organic material produces isotopically light CO_2 that impacts the carbon balance and its isotopic composition in the Kara Sea (Erlenkeuser et al. 1999).

Samples for investigations were obtained during the two Joint Russian-German expeditions BP-97 and BP-99. Sea water area between the latitudes of 72° and 74° N was studied in 1997 and between 72° and 74°30'N in 1999. Water sampling for POC filtration was carried out in BP-97 along two short sections: in the R/V direct southward trip 13-15 September (section I, Fig. 7.10) and during the return R/V trip 22-23 September (section II, Fig. 7.10), with a time span of one week in between.

There is a principal difference in the hydrological situation between these both sections. The first section was carried out with a fresh water plume of a maximum salinity of 12,7 psu in the marine part. During work on the section II an increase in surface water salinity up to 13,8-20,8 psu occurred due to the strengthening of the Yamal current (Churun & Ivanov 1998).

$\delta^{13}C$-values vary from –30,7 to –26,9‰ within section I (Tab. 7.7), when salinity rose from 2-3 psu in the southern estuary up to 12,7 psu in marine water. This reflects the normal correlation of the POC isotopic composition and salinity gradient and is similar to the observation for the Yenisei estuarine sections.

The change in the hydrological situation resulted in the occurrence of surface water with an irregular salinity trend within the section II (Fig. 7.10), and correspondingly in the absence of a correlation of salinity and the POC isotope distribution. The $\delta^{13}C$-values varied from –29,6 to –26,6 ‰ without any relation to the water salinity (Table 7.7).

Water sampling in BP-99 was performed from 30 August up to 7 September along the meridional section III, and consisted of 9 stations in estuary and adjacent sea area (Fig. 7.10). The Influence of the river water to the north is seen throughout the section in the low surface water salinity ranged from 1,8 psu in southern estuary up to 9,9 psu in the open sea area. POC isotope composition ranged in surface water from –31,3 to –27,5‰, with the known correlation of $\delta^{13}C$ values and salinity being preserved (Table 7.8, Fig. 7.11).

In summary, one can say, that in spite of a pronounced variability of the hydrological situation in the Ob Estuary and adjacent sea, variations of the POC isotope values between two years (sections I and III) are very close to each other: for minimal salinity (the average value is of 2,1 psu) the difference is 0,6‰, and the same magnitude is observed for the maximal salinity. For the Ob Estuary, the most ^{13}C-depleted average POC isotope composition is -31‰, the most enriched is of –27,2 ‰. The corresponding values for Yenisei estuary (the average values for 1997 and 2000 years) are – 29,0 ‰ and –25,8 ‰. This means, the difference in sedimentary organic carbon isotope composition between the Ob and Yenisei estuaries is inherited from the carbon isotopic signature of the water particulate material.

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Table 7.6: Particulate organic carbon isotope composition along the "Yenisei -Sea" section , 2000

Station N	Depth, m	S, psu	$\delta^{13}C_{POC}$, ‰ PDB
19	0 - 1	0.00	- 30.4
	21.7	0.07	- 30.4
18	0 - 1	0.06	- 30.3
	15.0	0.00	- 30.9
20	0 - 1	0.00	- 30.1
	17.0	5.70	- 30.3
17	0 - 1	0.00	- 29.3
	17.0	0.40	- 30.9
21	0 - 1	0.20	- 30.3
	12.0	5.60	- 29.4
	24.5	22.90	- 27.6
	wood	-	- 26.2
16	0 - 1	2.30	- 29.3
	15.5	13.30	- 28.4
	23	20.1	-28.4
15	0 - 1	6.70	- 28.4
	6.5	7.30	- 27.9
22	0 - 1	6.60	- 29.7
	3,7	11,60	- 28.6
	10,0	29.90	- 27.3
13	0 - 1	22.80	- 27.6
	3,5-3,7	25,50	- 27.0
	10,5	29,6	-27.4
23	0 - 1	28,40	- 26.1
	11,5	30,70	- 26,6
	31,0	33,00	- 26,4
24	0 - 1	23,7	- 26,7
	11,5	26,00	- 26,6
	32,0	32,30	- 26,1
7	0 - 1	16,50	- 27,5
	11,0	25,30	- 25,9
	35,0	32,80	- 26,9
8	0 - 1	21,00	- 27,0
	9,5	26,40	- 26,4
	37,0	33,30	- 25,8
9	0 - 1	23,80	- 26,4
	14,0	27,90	- 25,2
	44,0	33,50	- 24,4
35	0 - 1	26,60	- 25,5
	14,5	30,40	- 25,2
	46,0	33,50	- 26,1
28	0 - 1	25,60	- 27,3
	16,0	29,20	- 26,6
	47,0	34,10	- 25,3
29	0 - 1	27,30	- 26,1
36	0 - 1	27,20	- 26,4
	17,0	31,20	-
	64,0	33,90	- 26,1

Table 7.7: Particulate organic carbon isotope composition along the "Ob - Sea" sections (1,2),1997.

Station N	**Depth, m**	**S, psu**	**$\delta^{13}C_{POC}$, ‰ PDB**
Section 1 (13 - 15.09).			
12	0	3,1	-28,8
	8	3,8	-29,0
	12	20,1	- 29,7
10	0	2,4	- 30,7
	10	3,3	- 29,4
	11,5	25,1	- 29,8
	13	25,0	- 28,9
17	0	7,0	- 28,4
	5	14,0	- 27,8
	9	29,3	- 28,7
	16	29,8	-28,6
1	0,5	12,7	-26,9
	7,4	13,0	-27,0
	9,9	25,7	-27,4
Section 2 (22 - 24.09)			
47	0	18,9	-29,6
	10,1	29,4	- 28,9
	16	29,6	- 29,7
48	0	13,5	- 27,6
	7	16,5	- 27,5
	10,9	30,3	- 27,9
	23,9	31,4	- 27,3
49	0	16,4	- 28,6
	11,1	22,6	- 27,2
	15,9	30,5	- 25,8
	27,0	31,6	- 25,6
50	0	20,8	- 26,6
	9,4	20,8	- 26,7
	14,2	31,5	- 26,3
	26,0	31,8	- 26,6
52	0	18,2	- 28,2
	7	22,1	- 27,1
	10	31,0	- 27,0
	27	31,8	- 26,4

Table 7.8: Particulate organic carbon isotope composition along the " Ob - Sea " section , 1999.

Station N	Depth, m	S, psu	$\delta^{13}C_{POC}$, ‰ PDB
19	3,0	2,7	- 30,8
	10,0	20,6	- 30,2
	11,6	21,5	- 30,9
18	2,0	1,8	- 31,3
	8,7	25,2	- 29,5
	11,7	26,1	- 30,1
20	3,2	3,7	- 30,6
	6,1	3,5	- 30,9
	11,0	10,8	- 29,6
	14,6	27,7	- 29,4
17	2,0	5,0	- 30,0
	7,0	22,6	- 30,3
	16,0	30,4	- 29,0
21	2,5	7,5	- 28,4
	9,0	21,6	- 28,0
	15,0	30,1	- 28,4
24	2,2	6,4	- 30,8
	12,0	27,3	- 27,6
	18,4	29,6	- 27,8
25	2,8	8,9	- 27,8
	8,4	21,7	- 26,2
	15,0	31,0	- 26,0
	22,7	32,0	- 26,9
37	3,0	9,8	- 27,5
	8,6	24,2	- 26,8
	28,2	32,2	- 26,7
36	3,2	9,9	- 27,7
	8,5	25,6	- 28,2
	28,7	32,0	- 27,6