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AND ANTARCTIC PENINSULA**

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QUATERNARY OF SOUTH AMERICA AND ANTARCTIC PENINSULA

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on the Holocene of South America,
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Edited by

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Nature and origin of recent sediments in the Scotia Sea (northeastern Antarctic Peninsula)

ABSTRACT

The study of three cores sampled in the Scotia Sea allows to determine the processes of recent Quaternary sedimentation and to give its mineralogical and geochemical features. Three sources of unequal proportions appear depending on the location of the cores:

- 1) a continental source of which the chemism goes from the acid pole to the basic pole; it supplies a coarse-grained quartz-feldspar phase and clay minerals of chlorite-illite type. This source was determined from the study of a variety of ice-rafted lithoclasts;
- 2) a volcanic source, not too abundant, except in the clay phase characterized by smectites, and the trace element assemblages;
- 3) a siliceous biogenous source, sometimes very abundant, composed of radiolaria and diatoms.

RESUMEN

El estudio de tres testigos obtenidos en el Mar de Scotia permite determinar los procesos de sedimentación del Cuaternario reciente y proporcionar sus características mineralógicas y geoquímicas. Tres fuentes de aporte de proporciones

desiguales aparecen dependiendo de la ubicación de los testigos:

- 1) una fuente de aporte continental de la cual el quimismo oscila desde el polo ácido al básico; proporciona una fase cuarzo-feldespática de grano grueso y minerales de las arcillas del tipo clorita-illita. Esta fuente fue determinada a partir del estudio de una variedad de litoclastos acarreados por témpanos;
- 2) una fuente de aporte volcánico, poco abundante, excepto en la fase arcillosa caracterizada por esmectitas y en las asociaciones de elementos traza;
- 3) una fuente de aporte silíceo biogénico, a menudo muy abundante, constituida esencialmente por radiolarios y diatomeas.

INTRODUCTION

Oceanographic research in the austral regions is often difficult due to climatic conditions; however, numerous French missions organized by the TAAF (Terres Australes et Antarctiques Françaises) have been undertaken within the framework of the important program of recognition of paleoclimate in the Southern Ocean. Also, the multidisciplinary APSARA 3 -MD.54 oceanographic mission (March 2 to May 3, 1987) took place in the Southern Atlantic Ocean: numerous cores were taken from the northeastern of the Antarctic Peninsula and particularly from the Scotia Sea which, due to its morphology, presents one of the most reliable environments for recording the sedimentation with glacial characteristics and paleoclimate.

The Scotia Sea is located within a subduction geodynamic context which is similar to the Caribbean domain. The Scotia Sea is framed by a series of islands (the volcanic arc of the South Sandwich, South Georgia, the South Orkney and the South Shetland islands) and the Antarctic Peninsula. It is connected to the Pacific Ocean

through the Drake Strait. Up until now, the studies of this fairly harsh region are very general and those specialized ones are rare (Warnke, 1970; Anderson, 1972; Ruddiman, 1977; Long, 1986; Bareilles, 1987).

This paper is, therefore, the preliminary survey of a sedimentological reconnaissance which will be developed later in these southern regions based on the cored sediments sampled during APSARA 1-2-3-4 missions. This study aims to determine the characteristics of the coarse and fine-grained detritical phase and their nature and origin and also the ice-rafted lithoclasts by the observation on thin slides, the latter issued from the rock substratum of the Antarctic continent. These lithological facies are considered to be representative of at least a part of the parent rock of marine sediments in the Scotia Sea.

PETROGRAPHY OF POTENTIAL SOURCES: LOCATION AND LITHOLOGY OF CORED SEDIMENTS

Petrography of potential sources (Dalziel & Elliot, 1973)

The South American continent metamorphic formations are essentially made up of chloritic schists and, except for the chlorite, there is no other index mineral which characterizes the regional metamorphism. Intrusive granitic plutonic rocks with porphyroblasts of biotite are also observed.

The South Orkney islands and South Georgia are essentially constituted of a metamorphic complex including micaschists, marbles and amphibolites.

The terrains of the South Shetland islands are composed of quartzites, biotitic gneiss and hornblende associated with granitic plutons.

The Antarctic Peninsula is basically formed of orthogneisses and schists but also of metadolerites and amphibolites.

Finally, the South Sandwich Archipelago is a group of volcanic islands: basalts and basaltic

andesites represent 95% of the lavas, the remainder being dacites and rhyolites.

Petrography of rock samples in cored sediments

The petrographic nature determination on thin slides under a polarizing microscope of numerous rock samples present in the Kullenberg cores, allows to obtain specific information on the different parent rocks which, on varied granulometric scales, participate in the Scotia Sea sedimentation.

Three series of samples were observed in cores KS.87735, 87748 and 87750, located south of the Scotia Sea for the first one and in the northern part for the two others (Figure 1).

Southern Scotia Sea

Core KS.87735

This core is located west of the South Orkney islands. All the rocks encountered in this core belong to the category of metamorphic rocks, product of ancient magmatic and sedimentary formations. The minerals likely to be released from these different rocks are especially the basic ones, such as: plagioclases, augites, actinolites, chlorites, epidotes, but also, biotites, muscovites and sericites: quartz is not very abundant in these facies. The tectonic or non-tectonic volcanic and plutonic rocks always present crystallization in vesicles and fractures or recrystallization from pre-existing minerals (plagioclases, biotites, etc.)

Northern Scotia Sea

Core MD.87748

Out of the 14 observed samples, only 4 belong to the category of volcanic or basic plutonic rocks more or less transformed by metamorphism. For these rocks, the mineral association is the same as stated previously: plagioclases, actinolites, epidotes and chlorites, to which the possibility of supplying hydrothermal products such as saponite,

chlorite and zeolite must be added for some of them. The 10 other samples can be classified in the category of acid, granitic or sedimentary rocks of which the main feature is the invariable quartz content. The minerals which can be released from the latter of these rocks are quartz, feldspars, sericite, biotite but also chlorite, epidote and calcite, following a post-magmatic recrystallization that affected some facies.

Core MD.87750

Although it is located in a zone close to the preceding one, the relative proportions of the two categories of rocks, basic and acid, were totally different. Out of the 8 samples, indeed, only 2 were of granitic composition; the others were in the category of basic plutonic or volcanic rocks: dolerites, gabbros, etc.

In summary, the rocks present in the Kullenberg cores belong, in most cases, to the category of basic, magmatic or metamorphic rocks. The paragenesis observed make it possible to suppose that these have been, by alteration, the main constituents of the fine-grained fraction.

Location and lithology of the cores

The three cores studied (Fig.1) were taken by means of an interface piston-core (cores KI.8711 and KI.8709) and a TAAF 1/4 m² piston-core (core KI.8709) during the TAAF mission (MD.54 - APSARA 3). It is possible to sample the uppermost 50 cm of recent sediments without disturbing the water-sediment interface.

- The core KI.8703 is located west of Coronation island (South Orkney islands). The sediments are composed of very homogeneous, gray, silty clays with no special structure; carbonates are absent. Water content ranged between 25% (base) and 38% (summit) with a maximum of 37% at 20 and 30 cm.

- The core KI.8709 is located northeast of Clarence and Elephant islands (South Shetland

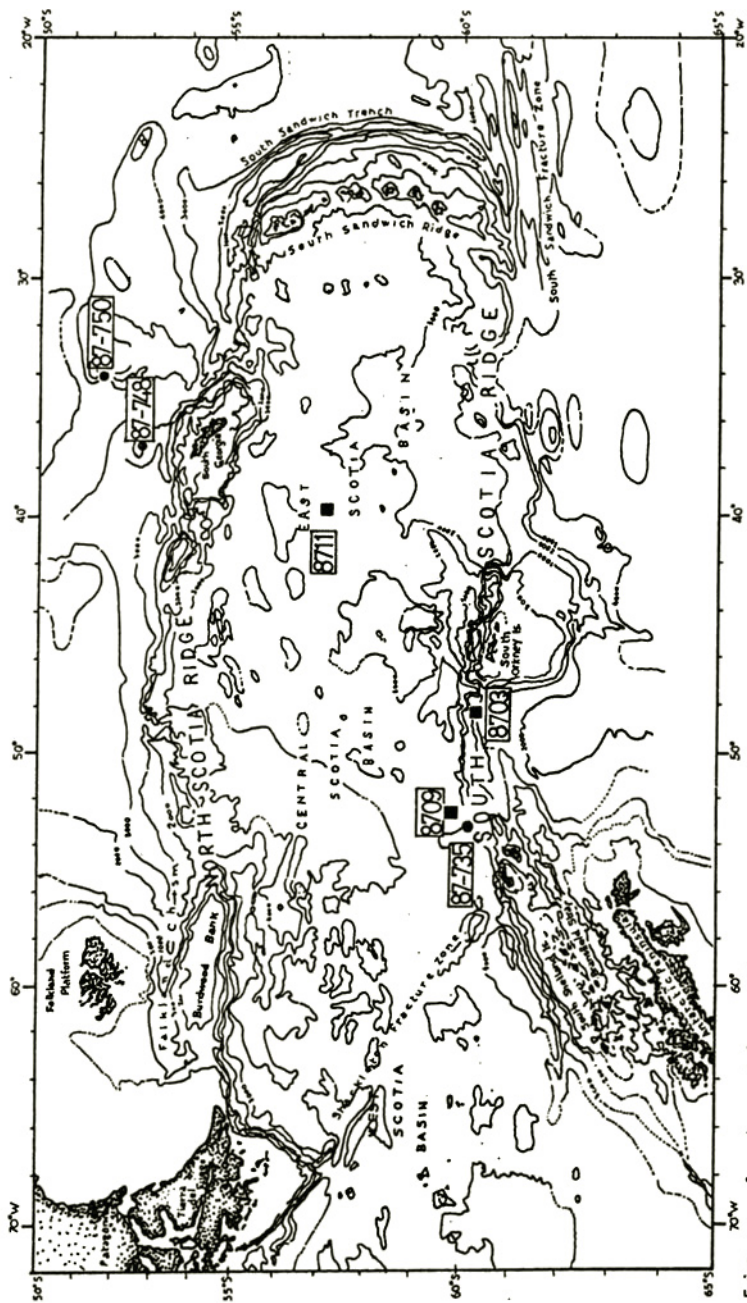


Figure 1. Location of studied cores in the Scotia Sea. Bathymetry after Kroenke and Woolard (1968).
 ● Kullenberg core ■ Reineck core

islands). The sediments are also made up of very homogeneous, silty clays without carbonates. Water contents were between 53% (base) and 67% (summit) with a minimum of 48% at about 20 cm.

- The core KI.8711 is located in the Scotia Sea, halfway between the South Orkney, the South Sandwich and the South Georgia islands. The sediments are alternatively composed of siliceous muds and silty siliceous clays. Water contents were between 61% (base) and 67% (summit) with a minimum of 52% around 8-9 cm.

METHODOLOGY

Mineralogical characteristics of sediments were determined by X-Ray diffractometry (XRD). The diffractometer used was a Philips model PW.1730. Two analytical techniques have been employed:

- The oriented paste technique allows the determination of the main clay minerals in the $< 2 \mu\text{m}$ fraction and their relative abundance. The thick paste obtained was spread across three slides with a standard spatula. The first slide was scanned untreated, the second was saturated with ethylene glycol before analysis, the third was heated at 550 °C for 1 hr. Percentages are given by diffraction peak heights [(010) rays]. Mineral crystallinity is evaluated according by the Biscaye (1965) tests.

- The powder technique allows to determine the main mineral contents other than clay minerals (feldspars, quartz, etc.) and the amorphous constituents, particularly the biogenous silica (Bareilles, 1987; Lapaquellerie, 1987). A calibration curve was established for each mineral.

Chemical quantitative analyses were carried out on the $< 2 \mu\text{m}$ fraction by X Ray fluorescence (XRF). The spectrometer used was a Philips PW.1350-1400. Two types of analyses were made:

- major elements (Si, Al, Fe, Ti, Ca, Mg, K, Mn and P) were analyzed by a dilution technique. Powdered samples diluted with spectroflux were melted at 1050° C. Major element contents were calculated in oxide form.

- Trace elements (Pb, Cu, Zn, Ba, Ni, Zr, Br, Rb, Sr, S, Cr, Co, Nb, and Ga) were analyzed in powdered and treated sample: artificial standards from NBS were simultaneously analyzed. Overall errors could be estimated at $\pm 10\%$.

MINERALOGICAL AND GEOCHEMICAL CHARACTERISTICS OF THE SEDIMENTS

MINERALOGY

Total fraction

The cored sediments are mostly composed of clay minerals and plagioclases (Table 1); a high content of quartz and biogenous silica was sometimes observed (radiolaria and diatom tests; KI.8703: 23% quartz - KI.8711: 37% biogenous silica). Although the mineralogical composition of all three cored sediments is, on the whole, uniform (low standard deviation), the vertical distribution of the constituents shows major variations from one level to another (Fig. 2 - Table 2). However, it should

		KI.8703	KI.8709	KI.8711
quartz	%	23	12	15
	σ	7	2	6
feldspars.	%	37	41	23
	σ	9	11	7
clay min.	%	36	36	25
	σ	11	13	9
biog. Si	%	3	11	37
	σ	3	4	6

clay min.: clay minerals. biog. Si: biogenous silica
 σ : standard deviation.

Table 1. Mean content of minerals and amorphous constituents in the cored sediments.

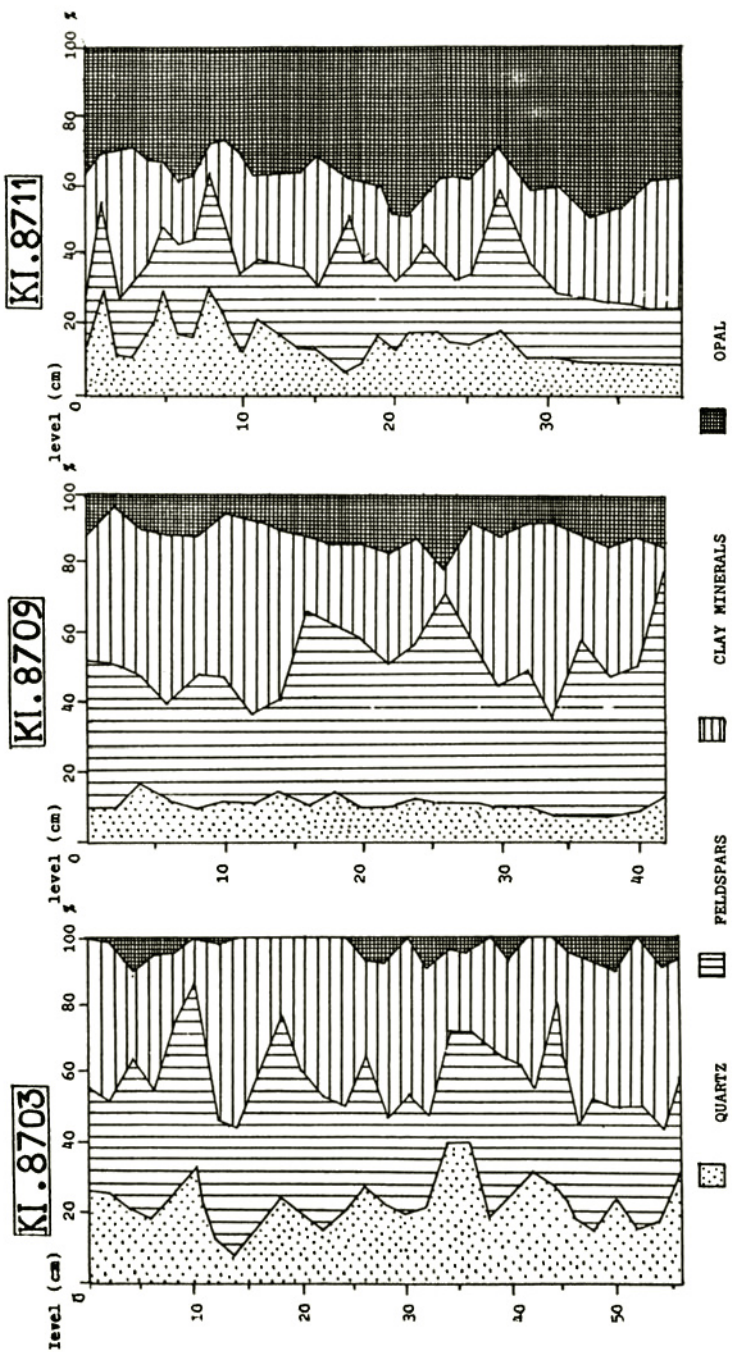


Figure 2. Mineralogy of cored sediments in the Scotia Sea.

level cm.	quartz %	feldspars %	opal %	clay min. %
0-2	27	28	0	45
2-4	26	25	2	47
4-6	21	44	9	26
6-8	18	38	5	39
8-10	26	49	5	20
10-12	33	54	0	13
12-14	13	35	2	50
14-16	8	38	0	54
16-18	16	45	0	39
18-20	25	52	0	23
20-22	19	43	0	38
22-24	15	40	0	45
24-26	20	32	0	48
26-28	28	38	7	27
28-30	23	25	8	44
30-32	20	22	10	48
32-34	22	26	10	42
34-36	40	33	5	22
36-38	40	33	5	22
38-40	17	50	0	33
40-42	26	38	7	29
42-44	32	24	0	44
44-46	28	55	0	17
46-48	19	28	5	48
48-50	15	38	8	39
50-52	24	27	10	39
52-54	15	36	8	41
54-56	18	27	9	46
56-58	17	46	6	31

clay min.: clay minerals.

Table 2a. Mineralogy of cored sediments. Core KI.8703

be noted that the general appearance of the quartz + feldspars fluctuations on one hand, and the biogenous silica fluctuations on the other, are similar in the three cores and the smoothed curves for the contents are comparable (Fig. 3). Thus, the high percentages of coarse-grained detrital (quartz and feldspars) are observed at the levels of 34-36 cm, 26 cm, 18-20 cm, 10 cm, 5 cm and 0-2 cm and the

level cm	quartz %	feldspars %	opal %	clay min. %
0-2	10	42	12	36
2-4	10	41	3	46
4-6	17	31	10	42
6-8	12	27	12	49
8-10	10	39	12	39
10-12	12	36	5	47
12-14	12	25	7	56
14-16	15	26	10	49
16-18	11	56	12	21
18-20	15	45	14	26
20-22	10	49	14	27
22-24	10	42	17	31
24-26	13	44	12	31
26-28	12	60	21	7
28-30	12	48	8	32
30-32	11	34	12	43
32-34	11	39	8	42
34-36	8	37	8	47
36-38	8	51	12	29
38-40	8	47	15	30
40-42	10	40	13	37
42-44	13	55	15	17

clay min.: clay minerals.

Table 2b. Mineralogy of cored sediments. Core KI.8709.

high biogenous silica contents appear at the 32-38 cm, 22 cm, 12-16 cm and 8 cm levels.

>60 μ m fraction

The nature of the coarse-grained phases (>60 μ m fraction) of the three cored sediments was determined with direct observation of the sifting residue (Table 3).

- KI.8703. These are essentially quartzitic-micaceous sediments and they could only be the result of the alteration of granitic, gneissic, micaschistous or sandstone rocks. Though the minerals of the fine-grained fraction do not show any wear, the coarse quartz grains are round, revealing an evolution in a littoral marine

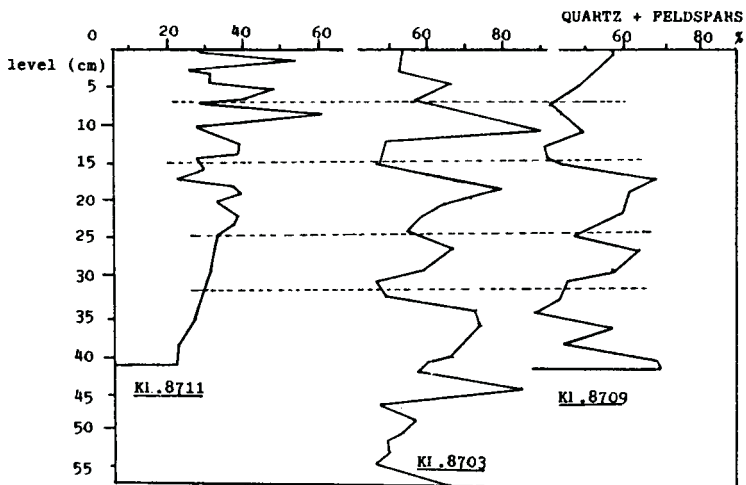
level %	quartz %	feldspars %	opal %	clay min. %
0-1	12	16	37	37
1-2	30	25	31	14
2-3	11	16	30	43
3-4	11	20	29	40
4-5	13	24	32	31
5-6	30	19	33	18
6-7	17	26	39	18
7-8	16	38	27	19
8-9	30	32	28	10
9-10	24	32	26	28
10-11	12	16	31	35
11-14	21	18	37	24
14-15	13	23	36	28
15-17	12	18	31	39
17-18	7	43	38	11
18-19	9	28	39	24
19-20	17	22	40	21
20-21	12	20	46	20
21-22	18	18	49	15
22-23	17	26	43	14
23-24	18	20	38	24
24-25	15	18	37	30
25-27	14	20	38	28
27-29	19	41	28	12
29-31	11	28	41	21
31-33	10	19	40	31
33-35	9	18	49	24
35-37	9	17	46	28
37-39	9	15	38	38
39-41	9	16	37	28

clay min.: clay minerals.

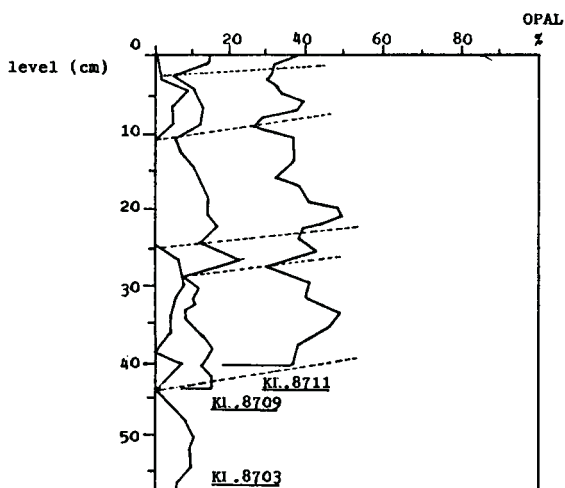
Table 2c. Mineralogy of cored sediments. Core KI.8711.

environment and transportation towards a deeper environment.

- KI.8709. This core shows at the base a quartz detritical sedimentation similar to those sediments of the core KI.8703. At the top, the sedimentation is more fine-grained, quartzitic and specially micaceous; this results in a change of



(a)



(b)

Figure 3. Distribution of Quartz+Feldspars and Opal in cored sediments of Scotia Sea.

the process sedimentation at about the 42 cm boundary.

-KI.8711. The constituents of these sediments are identical to those already found in other cores (KI.8703 and 8709), but, here, the sedimentation

level	KI.8703
0-2	Fine-grained, homogeneous and quartz detritic constituents -
8-12	biotite, muscovite, chlorite and rare Fe-Mg minerals.

34-36	Quartz detritic constituents - coarse, round and worn \pm flat quartz - little coloured and ferriferous elements.

50-52	Silt with coarse, round and worn \pm flat quartz - few fragments of brown and vesicular volcanic glasses - little folia of muscovite.

54-56	idem with sparse Fe-Mg minerals.

level	KI.8709
2-4	Quartz-micaceous, rich-chlorite and sericite silt - little quartz fraction.

24-26	idem - few biogenous silica fibres.

40-42	Quartz-micaceous silt with few biogenous silica fibres and sponge spikelet.

42-44	Fine-grained, quartz and homogeneous matrix - coarse, round and worn quartz - abundant coloured elements.

level	KI.8711
0-1	Abundant quartz detritic fraction - coarse, round and worn quartz - biotite, brown and vesicular volcanic glasses - felting of biogenous silica fibres.

1-2	Abundant quartz detritic fraction with coarse and roll elements - biotite - coarse, brown and vesicular glasses - little biogenous silica.

23-25	Quartz-micaceous silt - felting of biogenous fibres and spikelets.

33-35	Quartz-micaceous silt - coarse and worn quartz - few coloured and ferrigenous elements - little biogenous silica.

37-39	Quartz-micaceous silt with coarse elements - felting of biogenous silica.

Table 3. Lithology and mineralogy of $> 60 \mu\text{m}$ fractions in the cored sediments.

has a rhythmic characteristic. Essentially, quartz levels are followed by other levels characterized by a mainly biogenous silica sedimentation which reflects much quiet hydrodynamic conditions. It

	CHLORITES %	ILLITES %	SMECTITES %
KI.8703	56	33	11
KI.8709	69	24	7
KI.8711	45	37	18

Table 4. Mean contents of clay minerals in the clay phases ($< 2 \mu\text{m}$ fraction) of the cored sediments.

should be noted the presence of basalt, volcanic glass, sometimes in large pieces, as a result of a nearby source, most likely the South Sandwich islands.

$< 2 \mu\text{m}$ fraction

The clay phases of the three cores are mainly composed

of very well-crystallized chlorites and illites (Table 4); the chlorites are always dominant, specially in core KI.8709 (69%) followed by illites (KI.8711: 37%). The smectites in core KI.8711 (18%) and in a few levels of core KI.8703 (Table 5) are, on the other hand, very poorly crystallized. In all samples studied, quartz and especially plagioclases are observed, often in large quantities, indicating the fineness of their granulometry, a characteristic of glacial sediments.

The vertical distribution of the percentages of the three clay mineral families shows major variations in the cores KI.8703 and 8709 (Table 5):

- in core KI.8703, the chlorites increase from the base to the top; on the contrary, illites decrease. Substantial percentages of smectites are observed at the base (50-56 cm) and at the top (0-16 cm).

- in core KI.8709, the chlorites are abundant in the upper levels (0-20 cm).

- in core KI.8711, the mineralogy is homogeneous and the smectites relatively abundant, in relation to what is found in the other cored sediments.

level cm.	chlorite %	illite %	smectite %	other minerals
KI. 8703.				
0-2	63	22	15	quartz-feldspars
2-4	60	23	17	quartz-feldspars
10-12	60	24	16	quartz-feldspars
14-16	64	23	13	quartz-feldspars
18-20	68	26	6	quartz-feldspars
22-24	61	39	0	quartz-feldspars
26-28	54	38	8	quartz-feldspars
30-32	51	43	6	quartz-feldspars
34-36	52	40	8	
38-40	56	34	10	quartz-feldspars
42-44	57	36	7	
46-48	47	44	9	
50-52	38	32	30	quartz-feldspars
54-56	48	33	19	
KI. 8709.				
0-2	76	24	0	quartz-feldspars
4-6	76	24	0	quartz-feldspars
8-10	68	24	8	quartz-feldspars
12-14	65	25	10	
16-18	75	25	0	
20-22	68	22	10	
24-26	63	25	12	
28-30	75	21	9	
32-34	70	25	0	
36-38	64	27	9	
40-42	67	25	8	
KI. 8711.				
0-1	43	32	25	quartz-feldspars
2-3	49	30	21	
4-5	51	33	16	
6-7	44	37	18	
8-9	45	36	19	
9-10	45	37	18	
10-11	47	36	17	
14-15	44	41	15	
15-17	40	47	13	
17-18	46	36	18	
19-20	48	37	15	
21-22	40	42	18	
23-24	53	41	6	
25-27	44	42	14	
29-31	44	40	16	
33-35	46	35	19	
37-39	48	34	18	

Table 5. Mineralogy of $< 2 \mu\text{m}$ fraction in the cored sediments.

CHEMICAL COMPOSITION OF THE CLAY PHASES

The chemical composition of clay phases in cores KI.8703 and KI.8709 is similar (Table 6). The high SiO₂ content of core KI.8711 can be explained by the abundance of biogenous silica. The low values of standard deviation show that the chemical composition of these clay phases is relatively homogeneous. The lower Al₂O₃ and the higher MgO contents of core KI.8709 are probably related to the presence of magnesian and low-aluminium chlorite. The low Fe₂O₃ and high K₂O contents in core KI.8703 are related to the presence of illites. The vertical distribution of the main major elements makes it possible to suggest the following conclusions (Table 7):

- the first cm of the deposits present, overall, a higher MnO content; this content decreases rather rapidly with depth (KI.8703, between 0 and 30 cm; KI.8709 between 0 and 7 cm; KI.8711, between 3 and 10 cm).

- the K₂O content in core KI.8703 increases regularly between 0 and 32 cm, then decreases down to the base. Conversely, the MgO and CaO contents decrease from the top to 34 cm, then increase towards the base. These variations are to be related to the mineralogical composition and especially the presence of chlorite and illites.

	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	MgO %	CaO %	K ₂ O %	TiO ₂ %	H ₂ O %
KI.8703	65.73	13.07	5.90	3.17	2.27	2.13	0.76	5.18
σ	1.80	1.56	0.41	0.63	0.60	0.48	0.15	1.01
KI.8709	60.37	11.03	7.70	3.99	2.62	1.64	0.88	9.95
σ	1.99	0.45	0.50	0.58	0.15	0.09	0.04	1.54
KI.8711	71.72	6.48	4.04	2.06	0.97	1.41	0.04	11.21
σ	2.25	0.76	0.35	0.31	0.16	0.17	0.04	1.72

σ: standard deviation.

Table 6. Mean chemical composition of clay phases (<2 μm fraction) in the cored sediments.

The $\text{SiO}_2 / \text{Al}_2\text{O}_3$, $\text{Al}_2\text{O}_3 / \text{Fe}_2\text{O}_3$, $\text{Al}_2\text{O}_3 / \text{MgO}$, $\text{Al}_2\text{O}_3 / \text{CaO}$, $\text{Al}_2\text{O}_3 / \text{K}_2\text{O}$, $\text{Al}_2\text{O}_3 / \text{TiO}_2$, $\text{Fe}_2\text{O}_3 / \text{TiO}_2$, MgO / CaO and $\text{K}_2\text{O} / \text{MgO}$ relations confirmed the different nature between the clay phases of cores KI.8703 and KI.8709 on one hand and those of core KI.8711 on the other: this reflects their different origins. The analysis of these relations provided additional information, as well; thus, the relation $\text{SiO} / \text{Al}_2\text{O}_3$ (Fig.4a) shows that a substantial quantity of Si ($\pm 50\%$) is not related to Al: such silica is opal form. The $\text{Al}_2\text{O}_3 / \text{K}_2\text{O}$ relation (Fig. 4b) shows that the clay phases of core KI.8711 are richer in K than those in cores KI.8703 and KI.8709. Al and K are always positively correlated these two elements make up the composition of illites, among others. The $\text{Al}_2\text{O}_3 / \text{Fe}_2\text{O}_3$, $\text{Al}_2\text{O}_3 / \text{CaO}$ and $\text{Al}_2\text{O}_3 / \text{MgO}$ relations (Fig. 4c, d, e) show a peculiar behaviour for these elements: in core KI.8711 these elements are correlated positively, as in the oceanic clays (Parra, 1980), whereas they are negatively correlated and have, as a result, identical behaviour. The particular behaviour of Fe, Ca and Mg in cores KI.8703 and KI.8709 could be due to the nature of the parent rocks of these cored sediments. It should be noted, in fact, that the cored sediments presenting positive correlations are the farthest from the potential terrigenous sources; on the contrary, the two other cores are located, respectively, near King George island and Clarence island. In the latter case, Fe, Ca and Mg may have come from basic rocks which were very rich in calcic-ferro-magnesian elements such as amphiboles, epidotes, chlorites, etc. (see Petrography of potential sources); these minerals are present, as quartz and feldspars, in the fine-grained fraction. Elements like P, Cl, S and Mn are positively correlated (Fig. 5 - $\text{P}_2\text{O}_5 / \text{MnO}$) and they have identical behaviour in the three cores, leading us to believe that they are more linked to the marine environment than to the allochthonous detritical materials.

Level cm.	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	MnO %	MgO %	CaO %	TiO ₂ %	K ₂ O %	Na ₂ O %	P ₂ O ₅ %	H ₂ O %
0-2	67.67	11.45	6.05	0.0889	3.21	2.67	0.7757	1.50	0.72	0.22	5.44
2-4	65.67	11.96	5.97	0.0812	4.03	2.76	0.7735	1.59	1.16	0.22	5.55
4-6	65.50	12.12	6.31	0.0847	3.95	2.83	0.8075	1.69	0.84	0.22	5.39
6-8	65.59	10.99	5.86	0.0787	4.18	2.77	0.7570	1.50	1.48	0.21	6.30
8-10	65.47	12.27	6.13	0.0828	3.88	2.87	0.8042	1.63	1.30	0.21	5.10
10-12	67.10	11.50	5.95	0.0804	3.60	2.72	0.8209	1.63	0.87	0.20	5.28
12-14	64.09	11.30	5.80	0.0793	4.72	2.73	0.7864	1.62	1.77	0.20	6.57
14-16	67.69	12.71	6.10	0.0804	3.35	2.76	0.8380	1.72	0.34	0.20	4.04
16-18	67.35	12.91	6.06	0.0794	3.17	2.92	0.8712	1.79	0.52	0.21	3.91
18-20	66.76	12.67	6.10	0.0805	3.40	2.89	0.8631	1.79	0.71	0.21	4.30
20-22	66.30	13.13	5.63	0.0763	3.81	2.78	0.8246	1.76	0.90	0.22	4.34
22-24	66.50	13.35	5.98	0.0780	3.20	2.67	0.8747	2.00	0.47	0.21	4.38
24-26	67.46	13.49	5.98	0.0759	3.01	2.52	0.8810	2.10	0.31	0.20	3.78
26-28	67.20	13.47	5.18	0.0593	2.79	1.75	0.7588	2.21	1.95	0.20	4.25
28-30	65.13	15.10	5.33	0.0524	2.56	1.21	0.7730	2.62	1.91	0.20	4.92
30-32	62.43	13.77	6.40	0.0514	2.02	1.02	0.8688	3.29	2.14	0.20	7.53
32-34	62.43	15.99	6.09	0.0502	2.35	0.85	0.8441	3.14	1.83	0.20	6.05
34-36	63.27	13.92	5.82	0.0526	2.23	1.13	0.7993	2.92	2.33	0.20	7.07
36-38	64.84	13.47	5.57	0.0589	3.20	1.69	0.7514	2.47	0.93	0.21	6.52
38-40	67.22	12.22	5.64	0.0671	2.79	2.30	0.7320	2.00	2.05	0.21	4.40
40-42	65.20	14.15	5.31	0.0613	3.09	2.00	0.7134	2.23	2.42	0.22	4.40
42-44	66.89	18.74	5.32	0.0670	3.31	2.51	0.7501	2.08	1.15	0.21	3.96
44-46	68.94	11.82	5.43	0.0666	2.29	2.52	0.7562	2.03	1.82	0.22	3.86
46-48	68.65	11.35	5.83	0.0594	2.20	2.19	0.7432	2.22	1.77	0.20	4.58
48-50	63.02	12.69	7.01	0.0599	3.23	2.06	0.7636	2.38	2.60	0.20	5.70
50-52	64.41	12.30	6.85	0.0594	3.20	2.20	0.7493	2.29	2.46	0.20	5.07
52-54	65.74	12.01	5.80	0.0597	3.46	2.43	0.7114	2.20	1.11	0.21	6.00
54-56	63.67	13.15	5.99	0.0620	3.00	2.21	0.7706	2.52	2.75	0.20	5.44
56-58	63.28	13.78	5.70	0.0558	2.77	1.78	0.7498	2.70	2.61	0.21	5.13

Table 7a. Chemical composition of clay phases (< 2 μm fraction) in the cored sediments. Core KI.8703.

TRACE ELEMENTS IN CLAY PHASES

The clay phases of the three cores are relatively rich in trace elements and the average contents present important variations especially in Ba, Zn, Rb, Sr and Cr (Table 8): the values of the standard deviation are, on the whole, relatively low, revealing a homogeneity observed earlier with the mineralogy and the chemical composition. Variations in the vertical distribution of these contents appear in core KI.8703 for example (Table 9); the clay fraction becomes progressively rich in Rb between 0 and 34 cm: this increase in Rb is compared to that of the illites and of K₂O

level cm.	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	MnO %	MgO %	CaO %	TiO ₂ %	K ₂ O %	Na ₂ O %	P ₂ O ₅ %	H ₂ O %
0-2	58.92	10.81	8.10	0.1732	4.47	2.66	0.8856	1.60	1.08	0.24	10.69
2-4	55.60	10.16	8.34	0.1433	5.22	2.81	0.8944	1.49	1.75	0.26	12.93
4-6	59.45	10.92	8.11	0.1191	4.39	2.68	0.9085	1.63	0.83	0.23	10.40
6-8	60.27	10.92	7.95	0.1071	4.09	2.55	0.8961	1.59	1.04	0.23	10.03
8-10	58.61	10.56	8.95	0.1174	4.08	2.91	0.9772	1.74	1.04	0.21	10.47
10-12	60.42	11.11	8.09	0.1073	3.96	2.73	0.9077	1.68	1.05	0.21	9.43
12-14	57.43	10.83	7.78	0.1023	5.08	2.71	0.8723	1.56	1.58	0.22	11.45
14-16	59.76	10.59	8.14	0.1051	4.68	2.61	0.8900	1.65	1.05	0.21	10.01
16-18	61.78	11.05	7.36	0.1013	4.34	2.61	0.8524	1.55	1.02	0.21	8.85
18-20	62.83	10.91	7.54	0.1074	3.88	2.93	0.9009	1.58	0.69	0.21	8.16
20-22	62.05	10.75	7.45	0.1023	4.12	2.64	0.8656	1.56	0.89	0.21	9.05
22-24	62.84	10.66	7.32	0.1022	3.31	2.55	0.8583	1.61	1.64	0.21	8.65
24-26	60.28	11.92	7.94	0.1063	4.27	2.71	0.9085	1.83	0.98	0.21	8.58
26-28	61.66	11.39	8.13	0.1084	3.50	2.56	0.9041	1.73	1.77	0.21	7.76
28-30	60.39	10.64	7.48	0.1003	4.52	2.54	0.8461	1.67	1.10	0.21	10.15
30-32	62.14	10.50	7.76	0.1061	3.48	2.58	0.8924	1.78	1.09	0.21	9.17
32-34	58.94	11.55	6.74	0.0909	3.53	2.36	0.8006	1.60	1.86	0.21	11.95
34-36	58.88	11.51	6.88	0.0941	3.65	2.43	0.8037	1.73	1.47	0.20	11.95
36-38	60.54	11.11	7.19	0.0940	3.35	2.27	0.8198	1.79	0.91	0.20	11.35
38-40	62.45	11.70	7.58	0.1023	3.53	2.58	0.8770	1.56	0.71	0.21	8.42
40-42	58.59	11.43	7.19	0.0998	3.20	2.53	0.8545	1.52	1.68	0.21	12.28
42-44	64.38	11.68	7.50	0.1046	3.08	2.71	0.8871	1.54	0.54	0.21	7.12

Table 7b. Chemical composition of clay phases (<2 μm fraction) in the cored sediments. Core KI.8709.

level cm.	SiO ₂ %	Al ₂ O ₃ %	Fe ₂ O ₃ %	MnO %	MgO %	CaO %	TiO ₂ %	K ₂ O %	Na ₂ O %	P ₂ O ₅ %	H ₂ O %
0-1	72.23	5.37	3.49	0.0618	1.89	1.17	0.4121	1.03	1.04	0.17	12.80
1-2	75.77	5.85	3.99	0.0874	1.79	1.19	0.4979	1.31	0.62	0.18	8.45
2-3	73.06	6.63	4.03	0.1059	2.01	1.23	0.5206	1.24	0.92	0.17	9.78
3-4	71.69	6.42	3.61	0.0497	2.23	1.06	0.4598	1.44	1.23	0.17	11.28
4-5	72.75	6.39	3.97	0.0472	2.18	1.24	0.5044	1.21	0.96	0.17	10.23
5-6	73.18	6.38	3.83	0.0443	2.05	1.17	0.4787	1.18	0.96	0.17	10.25
6-7	73.87	6.35	3.67	0.0427	2.33	1.20	0.4851	1.22	0.87	0.17	9.51
7-8	76.44	5.80	3.71	0.0438	1.89	1.18	0.4968	1.26	0.54	0.17	8.22
8-9	72.95	7.87	4.01	0.0396	1.72	1.01	0.5199	1.66	1.97	0.17	7.82
9-10	72.12	7.63	4.32	0.0394	1.74	0.90	0.5101	1.70	0.70	0.17	9.88
10-11	73.32	6.41	3.92	0.0359	1.89	0.81	0.4555	1.36	0.67	0.17	10.67
11-14	73.27	6.04	3.99	0.0364	1.72	0.70	0.4498	1.35	0.94	0.17	11.07
14-15	72.48	5.68	3.78	0.0351	2.01	0.79	0.4136	1.43	0.95	0.16	11.94
15-17	71.66	5.14	3.75	0.0378	1.88	0.92	0.4185	1.13	1.19	0.16	13.36
17-18	69.87	6.55	3.61	0.0369	2.22	1.03	0.3952	1.29	1.33	0.17	13.12
18-19	73.54	5.53	4.16	0.0370	1.85	0.78	0.4321	1.38	0.94	0.16	10.90
19-20	70.69	6.94	4.07	0.0388	2.35	0.87	0.4522	1.45	1.39	0.17	11.22
20-21	73.70	5.60	3.84	0.0397	1.51	0.77	0.4612	1.45	1.55	0.16	10.63
21-22	70.10	6.31	3.93	0.0400	2.95	1.16	0.4718	1.44	1.12	0.17	11.96
22-23	72.94	6.30	4.02	0.0408	1.79	0.81	0.4901	1.48	1.71	0.17	9.98
23-24	68.08	8.15	4.17	0.0415	2.62	0.97	0.5077	1.65	1.08	0.17	12.18
24-25	68.57	7.38	4.23	0.0406	2.33	0.98	0.4966	1.49	0.92	0.16	13.03
25-27	69.71	7.62	4.31	0.0407	2.29	0.92	0.5126	1.63	0.85	0.17	11.55
27-29	71.01	7.36	4.83	0.0450	1.72	0.91	0.5518	1.68	1.72	0.16	9.73
29-31	70.12	6.11	4.84	0.0417	1.84	0.91	0.5088	1.58	1.85	0.19	11.60
31-33	70.97	6.56	4.62	0.0387	2.23	0.88	0.4754	1.49	0.63	0.17	11.62
33-35	70.20	5.92	4.52	0.0369	2.22	0.84	0.4243	1.35	1.07	0.17	12.92
35-37	73.35	5.98	3.97	0.0393	1.86	0.78	0.4415	1.39	0.76	0.18	10.84
37-39	67.57	7.03	3.74	0.0396	2.28	0.92	0.4422	1.50	1.22	0.16	14.70
39-41	66.46	7.32	3.50	0.0367	2.48	0.91	0.4307	1.54	1.55	0.16	15.23

Table 7c. Chemical composition of clay phases (<2 μm fraction) in the cored sediments. Core KI.8711.

previously noted. For this core, the high values of Pb should be noted in the first 10 cm.

The Al_2O_3 /trace element relations also make it possible to differentiate the clay phases of cores KI.8703 and KI.8709 from those of core KI.8711 (Fig. 6). The latter shows a correlation with Al12013 for the following elements: Rb, Ga, Nb, Ni, Cr, Sr and Zr; therefore, the clay minerals are likely to be including these elements in their structure. This type of relation is characteristic of clay detrital sediments from deep-sea environment (Parra, 1980). However, the part of the feldspars in this type of relation must be considered since the fine-grained fraction is rich in plagioclases. The fine-grained fraction of cores KI.8703 and KI.8709 shows two types of relations: 1) Rb, Ga, Nb, Sr (Fig. 6 a, b, c, d) are positively correlated with Al_2O_3 as it is the case for the preceding site. Part of the sediment involved has, therefore, the same origin as in core KI.8703. 2) Ni, Cr, Sr, Ba and Cu (Fig.6 e, f) are, on the other hand, negatively correlated and belong, as a result, to a different sedimentary source. In the Caribbean basin, the two latter elements characterized in a more particular way a volcanogenic source (Parra et al., 1986; Gandais, 1987; Pons, 1987); this could be the case for the Scotia Sea.

The K/Rb ratio shows that cores KI.8703 and KI.8709 have identical characteristics (Fig. 7) since the average value for each one of them was 143 and 145, respectively. Core KI.8711 is characterized by a lower ratio of 113. For a comparison, the products of sialic origin alteration from a Brazilian drainage basin to the east of Rio de Janeiro (Brazil) (Pons, unpublished) have a K/Rb ratio of 95: the calco-alkaline volcanic rocks have, on the contrary, a ratio between 220 and 560 (Smith et al., 1983). These values suggest that the sediments in the Scotia Sea are the result of a mixture between an acid sialic phase and a basic phase issued from

ppm	Pb	Ba	Zn	Ni	Rb	Sr	Cr	Co	Nb	Ga	Cu
C. 8703	25	445	89	30	140	123	57	5	28	16	18
σ	15	89	4	3	29	35	9	5	3	3	4
C. 8709	7	609	113	38	94	357	70	11	23	16	33
σ	4	89	6	13	3	13	5	6	1	2	4
C. 8711	8	960	101	25	103	254	45	0	22	14	37
σ	5	137	22	5	12	20	9	2	3	3	11

	Zr
C. 8703	141
σ	17
C. 8709	87
σ	6
C. 8711	77
σ	14

σ : standard deviation.

Table 8. Trace element mean content of clay phases (<2 μ m fraction) in the cored sediments.

volcanic and metamorphic rocks, which characteristics have been specified during the study of the potential sources of sediments.

DISCUSSION: ORIGIN OF RECENT SEDIMENTS IN THE SCOTIA SEA

The lithological, mineralogical and geochemical characteristics of the recent Quaternary sediments from the Scotia Sea show that detrital materials have been issued from a variety of rocks which chemism goes from the acid extreme to the basic extreme. This dual origin appears with the nature of the ice-rafted rocks; the latter makes it possible to determine the parent rocks indirectly. Sampling on land was impossible during the oceanographic missions carried out.

Taking into account that the geological environment and the climatic conditions are similar to those existing today in Greenland, we have compared the sediments studied here with those from

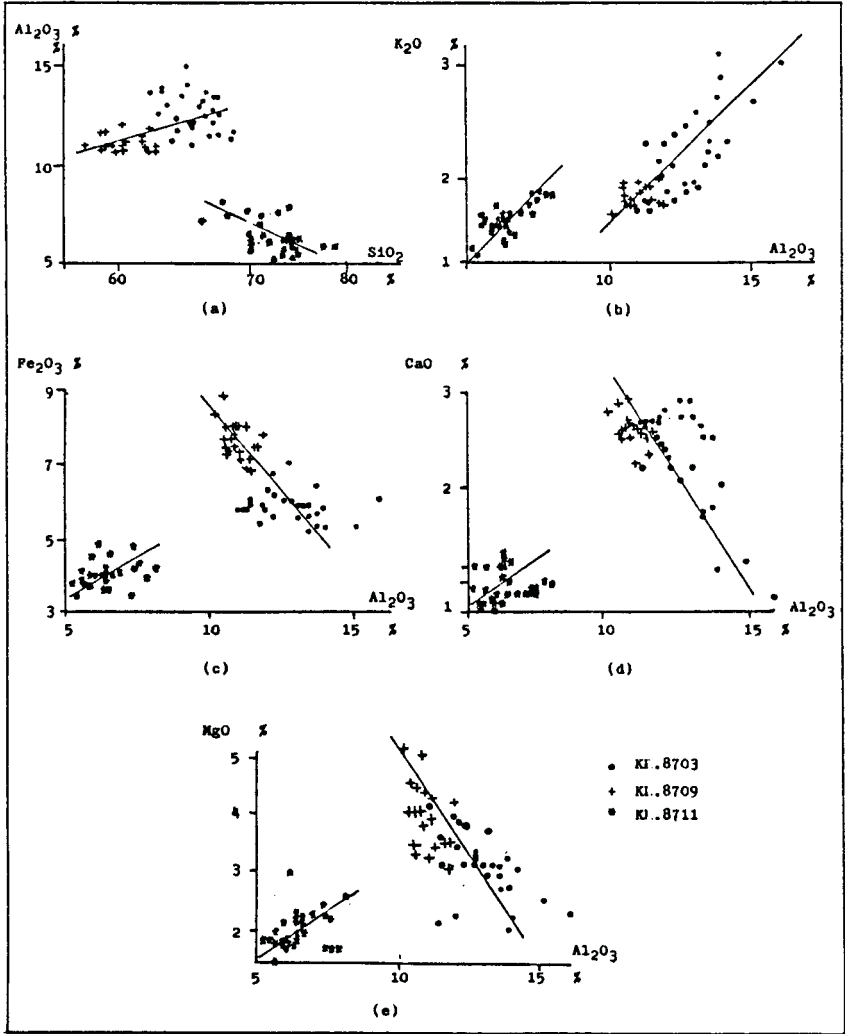


Figure 4. Relation major elements/ Al_2O_3 of clay phases in the cored sediments.

the Kangerdlugssuaq fjord (west coast of Greenland). The sedimentary materials in this fjord result from glacial erosion of acid continental metamorphic rocks, essentially micaschists and gneiss (Berthois et al., 1972). The sediments present substantial mineralogical homogeneity, but

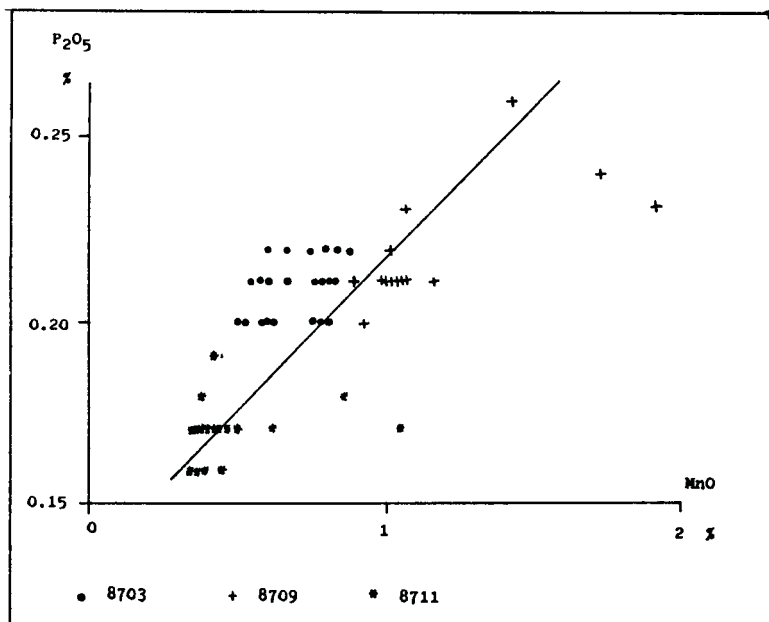


Figure 5. Relation P₂O₅ /MnO of the clay phases in the cored sediments.

they are richer in quartz and illite associated with trioctahedral micas but less abundant in feldspars and chlorites than those from the Scotia Sea. This suggests the existence of two sources for the sediments of Scotia Sea releasing products of different nature, which participate in the sedimentation of the three studied cores at variable degrees.

A very clear difference appears, indeed, between the clay phases of core KI.8711 located at the center of the Scotia Sea and the other two cores (KI.8703 and KI.8709) located farther south, towards the Antarctic Peninsula. For the $> 60 \mu$ inorganic fraction, the three cored sediments present homogeneity, on the contrary to what it might be expected: the quartzitic phase is always dominant. This characteristic has been also found in other cored sediments farther east, towards the

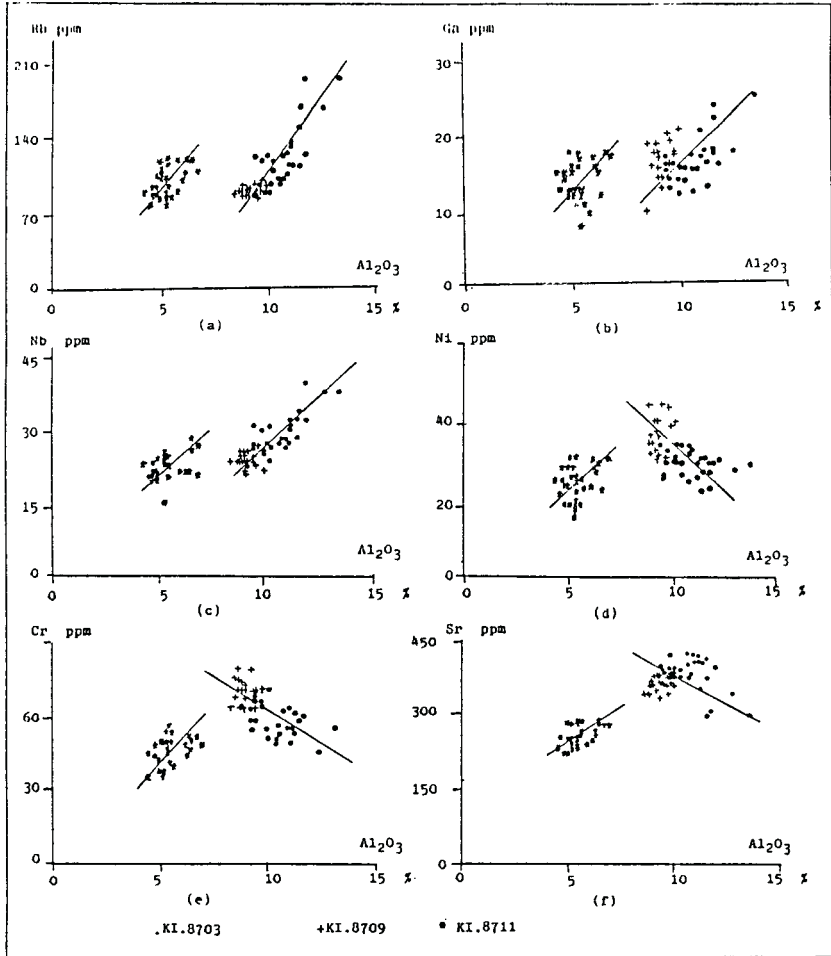


Figure 6. Relation trace elements/ Al_2O_3 of the clay phases in the cored sediments.

Kerguelen islands (southern Indian Ocean) (Long, 1986). Concerning the clay phase, the chlorites and illites derived from the mechanical disaggregation of acid continental rocks, especially the basal ones.

Observation of the lithoclasts shows, effectively, that various petrographic facies could release these minerals. This is the case for some rocks which are found along the southern uttermost end of

level cm.	Pb ppm	Cu ppm	Ba ppm	Zn ppm	Ni ppm	Zr ppm	Br ppm	Rb ppm	Sr ppm	S ppm	Cr ppm	Co ppm	Nb ppm	Cl %	Ga ppm
0-2	81	17	483	91	34	117	184	94	398	845	68	6	26	0.6419	14
2-4	56	20	421	84	32	109	240	95	381	989	64	13	26	0.9100	12
4-6	46	19	446	89	35	117	254	94	389	1138	55	17	27	0.9585	15
6-8	28	23	405	96	35	125	350	96	401	1242	53	0	22	1.1478	17
8-10	41	21	448	99	36	131	205	99	393	867	51	3	26	0.7845	14
10-12	11	12	435	89	31	118	228	97	380	966	59	14	25	0.9931	13
12-14	19	19	467	89	28	111	445	91	385	1444	59	5	24	1.3747	15
14-16	12	12	296	92	33	132	69	100	400	540	49	0	27	0.3943	15
16-18	13	18	478	91	34	137	71	103	419	558	53	19	28	0.4859	15
18-20	21	19	389	93	35	139	143	102	420	802	55	3	27	0.7537	17
20-22	18	24	375	91	30	156	154	106	423	732	55	2	26	0.6473	14
22-24	20	22	430	92	32	147	111	114	404	605	56	10	27	0.5435	18
24-26	26	17	508	85	28	156	41	116	407	442	50	9	30	0.3550	13
26-28	15	22	295	86	23	170	70	136	367	472	54	4	31	0.3557	16
28-30	14	23	568	90	29	178	1	172	338	277	45	11	36	0.1658	18
30-32	41	14	576	96	28	162	331	196	296	826	62	4	39	0.7144	24
32-34	39	20	451	99	30	162	0	195	293	300	55	0	37	0.1840	25
34-36	37	19	546	92	31	145	277	171	303	808	20	0	33	0.6963	22
36-38	19	15	130	84	32	140	341	143	346	1499	64	1	29	1.0678	16
38-40	20	9	532	82	28	145	101	113	390	2146	51	2	23	0.6292	15
40-42	19	18	445	84	32	144	88	129	398	713	60	0	31	0.4565	16
42-44	15	19	497	85	30	145	95	114	411	719	58	14	28	0.5334	17
44-46	16	21	405	84	30	146	55	120	425	915	68	12	29	0.4400	16
46-48	13	13	491	88	27	133	67	123	388	527	64	0	30	0.4094	16
48-50	6	9	445	87	26	126	127	125	379	637	57	5	27	0.6301	12
50-52	23	15	536	87	31	132	84	119	378	527	71	2	30	0.4362	15
52-54	20	14	468	89	30	138	268	123	399	1120	65	0	25	1.2805	14
54-56	21	28	490	85	27	155	190	133	399	751	62	2	28	0.7614	20
56-58	19	21	461	89	24	160	151	153	363	783	58	0	31	0.7485	18

Table 9a. Trace element content of clay phases (<2 μ m fraction) in cored sediments. Core KI.8703)

level cm.	Pb ppm	Cu ppm	Ba ppm	Zn ppm	Ni ppm	Zr ppm	Br ppm	Rb ppm	Sr ppm	S ppm	Cr ppm	Co ppm	Nb ppm	Cl %	Ga ppm
0-2	7	30	628	107	42	81	666	92	359	1304	66	15	23	1.1623	18
2-4	5	29	556	100	27	77	920	89	342	1657	65	19	23	1.5559	10
4-6	6	31	692	112	32	80	626	94	345	1153	64	20	23	0.9530	15
6-8	1	34	814	119	39	87	536	96	367	986	65	11	21	0.7817	17
8-10	6	33	614	112	33	83	624	95	355	1168	71	7	23	1.2021	16
10-12	8	32	649	120	47	89	480	94	363	935	74	13	25	1.2089	17
12-14	10	37	667	110	34	84	819	94	369	1515	75	13	25	1.4561	15
14-16	10	40	357	118	38	89	678	91	365	1228	80	7	25	0.9947	16
16-18	19	35	524	108	33	93	522	93	375	911	71	16	23	0.7879	13
18-20	8	27	455	98	40	96	456	91	376	952	72	13	20	0.7908	14
20-22	1	31	554	115	36	89	453	90	375	1166	65	5	24	0.8808	19
22-24	9	37	614	115	36	95	300	100	363	645	76	8	24	0.7692	18
24-26	6	35	599	118	42	92	388	97	358	967	72	0	21	1.1223	21
26-28	8	31	677	117	44	92	263	98	358	938	79	23	23	0.5220	20
28-30	7	39	663	113	38	86	487	99	365	1439	64	8	25	0.8968	16
30-32	8	42	617	121	46	84	445	95	343	956	68	11	23	1.2652	19
32-34	7	26	637	111	38	81	749	91	342	1626	69	6	22	1.2192	19
34-36	14	28	645	112	45	78	788	93	341	1801	64	8	22	1.2028	16
36-38	5	34	583	120	38	78	738	93	331	1630	68	16	22	1.0440	14
38-40	7	40	650	124	41	94	321	101	368	1001	78	4	24	0.6035	18
40-42	1	35	542	116	32	80	888	89	336	1913	66	12	22	1.1716	19
42-44	10	27	662	108	37	94	224	93	366	826	70	16	26	0.5233	17

Table 9b. Trace element content of clay phases (<2 μ m fraction) in the cored sediments. Core KI.8709

level cm.	Pb ppm	Cu ppm	Ba ppm	Zn ppm	Ni ppm	Zr ppm	Br ppm	Rb ppm	Sr ppm	S ppm	Cr ppm	Co ppm	Nb ppm	Cl ppm	Ga ppm
0-1	11	24	790	83	22	73	784	83	248	1106	35	0	20	1.2042	13
1-2	5	31	948	86	25	103	339	90	280	797	47	3	19	0.7122	13
2-3	1	32	895	88	26	90	509	88	282	1015	40	5	22	1.0531	11
3-4	2	32	841	84	18	94	739	93	277	1354	34	6	22	1.2085	11
4-5	8	31	954	94	21	97	551	92	285	1187	44	0	25	1.0474	16
5-6	6	29	921	93	26	90	536	91	273	1066	36	0	22	0.9968	13
6-7	8	39	880	84	16	67	360	80	231	1003	37	0	15	0.9987	16
7-8	5	31	871	88	25	103	337	99	280	721	21	0	23	0.6195	12
8-9	0	35	744	99	23	104	292	122	276	745	50	0	26	0.7234	18
9-10	11	31	722	89	28	98	528	121	272	958	44	0	25	0.8004	15
10-11	10	26	927	98	19	83	538	108	252	866	46	0	24	0.7487	17
11-14	16	40	835	95	19	89	449	111	236	731	37	2	25	1.0840	13
14-15	14	42	912	91	20	64	507	94	218	1072	41	0	20	1.0970	13
15-17	10	32	917	97	26	64	823	95	234	1100	44	0	23	1.1369	15
17-18	9	30	871	93	20	64	834	99	265	1323	49	0	20	1.1254	8
18-19	10	37	1024	112	26	67	410	96	223	798	42	0	19	1.0809	14
19-20	7	38	965	107	25	63	747	93	235	1275	38	0	21	1.0927	10
20-21	15	71	1081	117	29	69	359	97	225	664	45	0	20	0.5447	15
21-22	9	55	1145	119	27	76	609	108	259	951	48	0	24	1.2878	12
22-23	12	45	1186	122	32	72	341	109	243	614	55	0	23	0.5098	18
23-24	9	29	1207	115	33	79	662	112	272	1209	46	0	20	0.9727	17
24-25	12	24	1227	119	24	74	724	111	263	1231	42	0	21	1.0160	16
25-27	21	22	1236	115	31	79	716	118	281	1343	50	6	25	0.9747	12
27-29	3	40	1112	121	29	74	317	122	259	630	52	0	28	0.6567	16
29-31	12	31	1028	123	31	70	536	116	249	1870	76	0	24	1.2072	18
31-33	10	28	1000	123	23	73	612	119	257	870	52	0	24	0.7270	13
33-35	12	40	881	116	29	62	693	106	245	1034	48	0	21	1.2316	12
35-37	6	56	938	127	32	65	391	107	229	2141	53	0	20	0.8778	15
37-39	7	63	837	127	27	55	909	101	237	1492	48	0	24	1.3721	16
39-41	5	37	893	120	32	58	911	101	246	1351	46	0	21	0.8985	17

Table 9c. Trace element content of clay phases (<2 μ m fraction) in the cored sediments. KI.8711

the South American continent. As for the smectites, they may be issued from a few altered continental volcanic facies but most are supplied by the volcanic arc of the Sandwich islands; this is the reason why the higher contents are located at the center of the Scotia Sea where the bottom currents are in an east-west direction. This trace element association confirms the originality of these cored sediments compared to the two others. Concerning essentially coarse-grained quartz phase, it represents the most resistant fraction of all the different parent rocks: it is ubiquitous background, transported by floating ice and the currents, which become dominant upon the breaking up of drift-ice in the spring.

Table 10 sums up the parent rock - marine environment mineralogical evolution as it appears

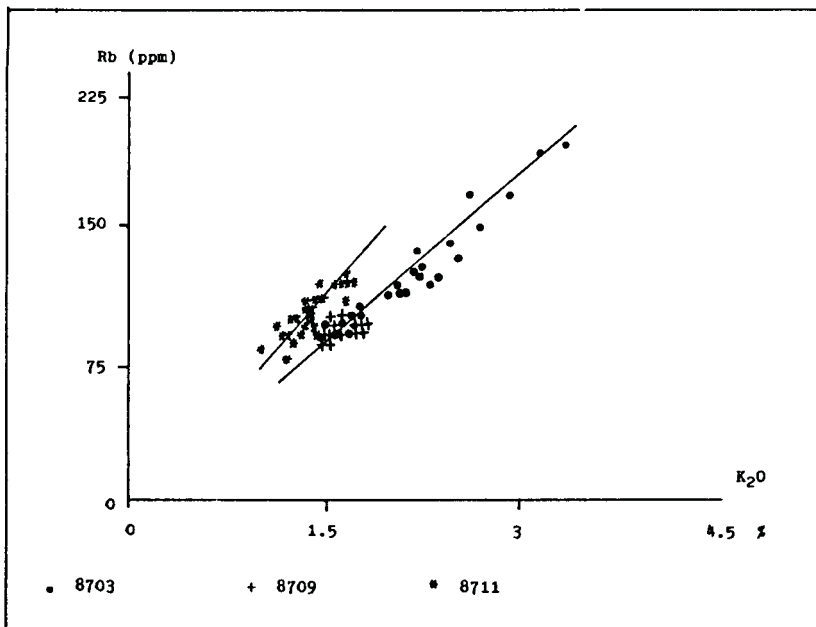


Figure 7. Relation Rb/K₂O of the clay phases in the cored sediments.

in the Scotia Sea. The products are derived from the varied foliated crystalline rocks in the South Orkney islands, the South Shetland islands, South Georgia and the Antarctic Peninsula, which are likely to supply a wide range of minerals. In fact, after mechanical disaggregation and wearing in a littoral marine environment (rounded quartz grains in the $> 60 \mu\text{m}$ fraction), only the most resistant quartz-feldspathic and micaceous phase is present; the fine-grained products are made up of chlorites and illites, mostly issued from the basic phase of the parent rock. The vertical fluctuations observed may be related to seasonal changes, which cause the breaking up of drift-ice and the cold periods to alternate. The homogeneity of the clay phase composition should also be noted, representing continuous and constant inputs over time. The appearance of smectites at a few levels in cores KI.8703 and KI.8709 shows that, at certain periods,

the currents deliver in the southern part of the Scotia Sea, clay materials derived from volcanic rocks in the South Sandwich islands. Core KI.8711 records this volcanic influence all the time, including pumice fragments in the coarse-grained phase, but in a transitory manner.

The geodynamic context of the zone under study in this paper is comparable to that of the Caribbean region. In both cases, it is a subduction zone, characterized by an active volcanic arc and a tributary sedimentation of the two petrographically clearly differentiated poles: a predominant acid continental pole and a subordinate basic intermediate volcanic pole.

The climatic factor plays a major role in determining the nature of clay minerals: in the Caribbean domain, alteration is dominant and the clay assemblage is in the order of smectites, kaolinites, illites and chlorites (Pons, 1987). In the austral domain, alteration is almost inexistent and clay minerals are directly inherited from metamorphic and magmatic continental rocks due to ice wearing; the mineralogic assemblage is, in this case, of chlorites, illites and smectites.

In the austral domain, the siliceous biogenous sedimentation (radiolaria and diatomea) is sometimes very important since it represents around 50% at certain levels of core KI.8711, located at the center of the Scotia Sea. This biogenous phase has, on the contrary, a very low representation near the South Orkney and South Shetland islands (KI.8703 and KI.8709).

CONCLUSIONS

The Scotia Sea sedimentation is related to three poles, for which their significance varies depending on the location of the cored sediments: 1) a continental pole, which has a large range of minerals with a varied petrographic composition in

C O N T I N E N T A L O R I G I N				VOLCANIC		ORIGIN	
ICE-RAFTED		LITHOCLAST		SEDIMENT		NATURE	
CHEMISM	NATURE	MINERALS	> 60 um fraction	< 60 um fraction	> 60 um fraction	< 60 um fraction	
ACID ROCKS	.Granites	Quartz Calcite Biotite Muscovite Sericite Chlorite Feldspars	.Quartz	.Chlorites	.Glasses		
	.Corneals .Sandstones		.Muscovite				.Smectites
BASIC ROCKS	.Basalts	Plagioclases Clinopyroxenes Orthopyroxenes Hornblende Actinote Epidote Chlorite Sericite	.Feldspars	.Illites			
	.Dolerites .Quartz .Gabbros .Gabbros .Metagabbros .Metadolerites .Green rocks .Sericitic and chloritic schists		.Fe-Mg opaque minerals	.Smectites	.Pumices		

Table 10. Origin and nature of inorganic fraction in the cored sediments of the Scotia Sea.

the magmatic and metamorphic rocks, due to ice-rafted lithoclasts. The wear of these rocks by the ice supplies only a coarse-grained quartz-feldspar residual phase and a fine-grained phase composed of two cardinal components: chlorites and illites.

2) a volcanic pole, which is less important except for the clay sedimentation (smectites) in the central zone of the Scotia Sea.

3) a siliceous biogenous pole, which is also well-represented in this same central zone.

Taking into account the climatic context and the potentiality offered by the parent rocks, it seems that the clay minerals are directly inherited from the parent rocks following their release by gelifraction and by mechanical action of continental ice.

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