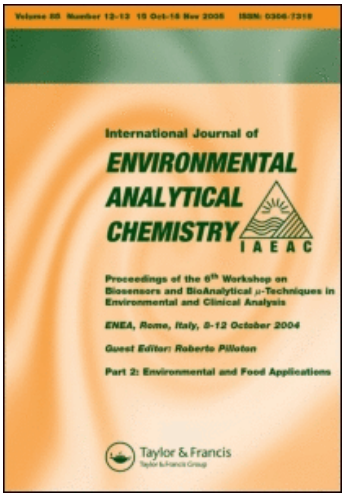

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Vertical Distribution of ^{137}Cs in The Lacustrine Areas and Preliminary Results of ^{7}Be Activity in Snow Samples at Terra Nova Bay (ANTARCTICA)

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VERTICAL DISTRIBUTION OF ^{137}Cs IN THE LACUSTRINE AREAS AND PRELIMINARY RESULTS OF ^{7}Be ACTIVITY IN SNOW SAMPLES AT TERRA NOVA BAY (ANTARCTICA)

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^{137}Cs activity in samples from lacustrine areas around the Italian base in Antarctica is reported as an integration of a previous work. Preliminary data of cosmogenic ^{7}Be activity determined in snowfalls, total atmospheric depositions, soil and air particulate collected during the 1990–91 and 1991–92 Italian expeditions in Antarctica is presented. The results obtained point out the efficiency of snow in the processes of air particulate scavenging and provide useful information for the development of research in Antarctica in the study of air/snow transfer processes by means of natural radionuclides.

KEY WORDS: Antarctica, sediments, snow, ^{137}Cs, ^{7}Be.

INTRODUCTION

The vertical ^{137}Cs distribution in some lake sediment cores and soils are discussed herein, following the progressive collection of data from samples collected during the IV national expedition (1990–91), in order to integrate the results outlined in our previous work (1) and with the purpose of deriving our conclusive evaluation of the environmental impact from artificial fallout in Antarctica.

Preliminary data of ^{7}Be activity in samples of snowy precipitations, total atmospheric depositions and soils collected during the 1990–91 and 1991–92 expeditions, which will constitute the base of future investigations, are presented. The interest in ^{7}Be ($t_{0.5}$ = 53.3 d) originates from the fact that this cosmogenic radionuclide, continuously produced by spallation reactions of cosmic rays on atmospheric gases, can be effectively used as an

atmospheric tracer, since it readily attaches to sub-micron sized particles, of which the main mechanism of removal from the lower troposphere is by precipitation scavenging.

However, while substantial literature on the application of ^{7}Be exists for middle latitudes, only a limited number of papers concerning ^{7}Be in the Antarctic environment have been published to date and moreover, they cover different fields of applications of this radionuclide.

A few papers concerning radionuclidic composition of Antarctic aerosol, have reported ^{7}Be activity data in association with other natural and artificial radionuclides in order to assess the origin of atmospherically derived species and to derive models of atmospheric circulation patterns (2, 3). More recently, the cosmogenic radionuclides ^{32}P and ^{7}Be and their activity ratios were employed to estimate stratosphere to troposphere exchange at Dumont d'Urville (4). Wagenbach *et al.* (5) have carried out long-term observations of the chemical and radiochemical composition of bulk aerosol samples at a coastal site in Antarctica to distinguish continental (by ^{210}Pb) and stratospheric (by ^{7}Be) components and to assess seasonal variations. Savoie *et al.* (6) have studied the relationship between nitrogen and sulphur species to ^{210}Pb and ^{7}Be at Mawson both in bulk aerosol and in ice cores and have found discrepancies between seasonal cycles in the two series of data, attributable to post-depositional processes in firn. An interesting approach, related however to Greenland ice sheet and not to Antarctica, for getting a potential clue to the study of air to snow transfer processes and to post-depositional snow modifications, is outlined by Dibb (7, 8) who suggests determining ^{7}Be in aerosol, fresh snow and shallow snowpits in order to find correlations between atmospheric chemistry and radionuclides profiles in the layers near the surface. Due to the scarce knowledge concerning atmosphere to snow transfer processes, efforts in this direction are presently being strongly encouraged and in particular, this application of ^{7}Be appears to be quite promising.

Therefore, the goals of our future research in Antarctica will be:

1) to gain a better knowledge of the air/snow transfer processes with the aim of evaluating snow as being a representative sink of atmospheric components.

2) to use the physical decay of the deposited radionuclide the point out the early post-depositional modifications of snow, namely the short-term processes it is subject to.

EXPERIMENTAL

Lake sediment cores and soil pits for ^{137}Cs determinations were sampled at Edmonson Point and at Inexpressible Island. Details on sample processing and subsequent γ - spectrometry have been previously reported (1).

Determination of ^{7}Be, through its γ emission at 477.6 keV, was carried out in samples processed as follows: total (wet and dry) atmospheric depositions sampled on a bi-weekly (1990–91 samples) and on a weekly (1991–92 samples) basis and precipitations from single events (only from the 1991–92 expedition) were collected in large polyethylene trays previously rinsed using 1M HCl. After complete recovery of ^{7}Be with diluted HCl, all of the samples were counted in a suitable constant ring geometry.

The lowest detectable activity (LDA), calculated as 4σ relative to counting statistics, at a 95% confidence level and at the considered counting time, was equal to 12 Bq/m^2 for ^{137}Cs and to 1.0 Bq/m^2 for ^{7}Be respectively.

Absence of ^{137}Cs in some of the counted samples appears in the tables as "n.d." (not detectable).

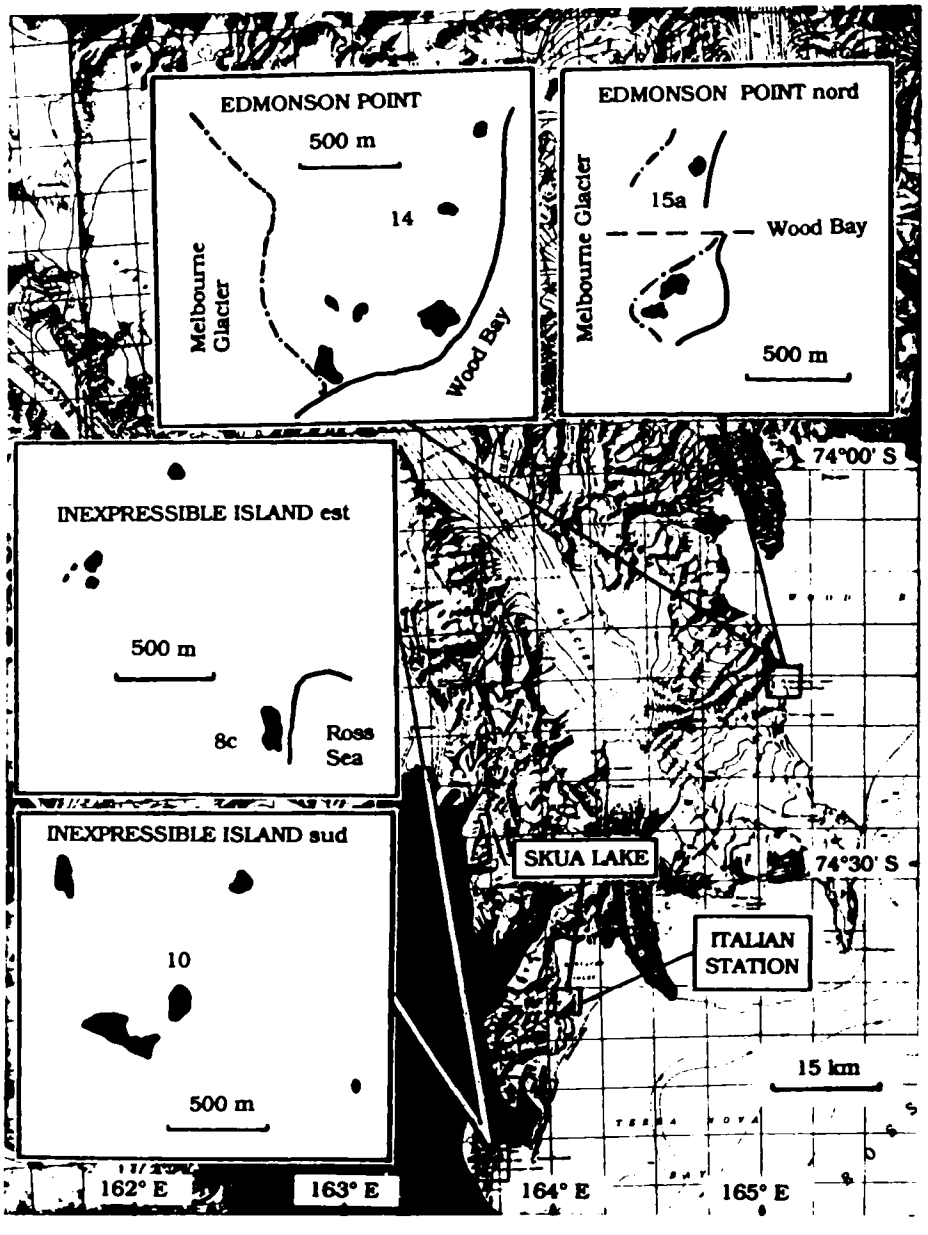

Figure 1 Lake districts at Terranova Bay.

RESULTS

The territory surrounding the Italian base at Terra Nova Bay is characterized by the presence of five lake districts, the classification of which is presently in progress at the Institute of Hydrobiology of the National Research Council in Pallanza, Italy.

Figure 1 shows a map of the areas investigated. All of the lakes are generally small in size and rather shallow in depth. The general origin of these lakes is meltwater accumulation; moreover, they are frozen for most of the year. Because of logistical requirements, coring of lake sediments, where feasible, was effected around the shore-line.

^{137} Cs activities in samples from lacustrine areas collected during the IV (1990–91) expedition have allowed us to integrate the data from the samples of the previous expedition and to give our conclusive overview of the local artificial fallout impact.

Vertical distribution of ^{137} Cs in lake sediment cores and soil pits and the corresponding inventories (total concentration of the radionuclide distributed throughout a profile) decay-corrected to 1963, the year of maximum nuclear testing activity, are reported in the following Tables (1 a,b-3). The lacustrine areas considered herein are: Edmonson Point, Inexpressible Island and Base Camp Area.

Edmonson Point

On the average, the mineralogical composition of sediments and soils examined reflect the volcanic origin of the whole area. Lake 14, situated at 20 m a.s.l., has a surface area of 4000 m^2 and a maximum depth of 1.5 m. Two sediment cores were sampled at a depth of 30 cm; the first layer showed traces of vegetable material. A soil sample was taken at approximately 100 m. Data is not reported for another soil sample analyzed, since no ^{137} Cs was detected, probably because of meltwater washout of the site.

Lake 15A lies at 3 m a.s.l., it has a surface area of 4600 m^2 and a maximum depth of 60 cm. Two cores were sampled at a depth of about 20 cm. Soil a was collected in the proximity of the lake in an area covered with moss; Soil b was collected near a water stream originating from the lake and flowing towards the sea.

Table 1a ^{137} Cs activity (Bq/m^2) in Lake 14 samples.

Depth	*Sediment*		*Depth*	*Soil*
(cm)	Core 1 *(08LSIV)*	Core 2 *(08LSIV)*	*(cm)*	*(08SLIII)*
0–2	42.0 ± 3.9	51.6 ± 3.9	0–5	250 ± 19
2–4	35.6 ± 4.7	33.4 ± 4.1	5–10	n.d.
4–6	28.2 ± 5.1	18.4 ± 3.2	10–15	n.d.
6–8	15.0 ± 2.9	13.9 ± 3.4		
8–10	n.d.	n.d.		
Inventory d.c.	236 ± 17	229 ± 14	Inventory d.c.	473 ± 36

Table 1b ^{137} Cs activity (Bq/m^2) in Lake 15A samples.

Depth	*Sediment*		*Depth*	*Soil*	
(cm) *(08LSIII)*	Core 1 *(08LSIII)*	Core 2 *(08SLIII)*	*(cm)* *(08SLIII)*	Soil a	Soil b
0–2	139 ± 5	127 ± 6	0–5	349 ± 11	139 ± 13
2–4	193 ± 6	141 ± 6	5–10	122 ± 9	n.d.
4–6	75.1 ± 4.5	116 ± 6	10–15	114 ± 19	n.d.
6–8	18.5 ± 3.9	50.7 ± 5.0			
8–10	<LDA	<LDA			
10–12	n.d.	<LDA			
Inventory d.c.	791 ± 18	808 ± 21	Inventory d.c.	1106 ± 19	263 ± 25

Inexpressible Island

At Inexpressible Island (area of metamorphic rocks) two water bodies were sampled. A core was sampled inside Lake 8C, the surface area of which was estimated to be approximately of 1000 m^2, and which lies at sea level, near the sea shore and which is consequently affected by seawater washout. Sediment was of the sandy type. Another core was collected in Lake 10, with a surface area of about 1500 m^2 and a maximum depth of 70 cm; presence of vegetable matter was noted. Sediment had a muddy aspect.

Base Camp Area

Skua Lake (Lake 2) is situated at 120 m a.s.l. and has a surface area of 2200 m^2 and a maximum depth of 1 m. The lake appeared rather rich in vegetable matter. The core was collected at a depth of about 40 cm.

As an introduction to our new research program concerning the application of the cosmogenic radiotracer ^{7} Be to the Antarctic environment, some preliminary data of ^{7} Be activity in samples of bulk (wet and dry) atmospheric depositions, snowy precipitations and soil collected during the IV and the V National expeditions in Antarctica are presented.

Figures 2 and 3 report the trend of total (wet and dry) atmospheric depositions of ^{7} Be (Bq/m^2) and of the corresponding snowy precipitations, expressed as water equivalent cm,

Table 2 ^{137} Cs activity (Bq/m^2) in samples from a pond near lake 8C and in Lake 10.

Depth	*Sediment cores*	
(cm)	*Lake 8C (18LSIII)*	*Lake 10 (18LSIV)*
0–2	19.1 ± 4.6	<LDA
2–4	<LDA	13.1 ± 3.3
4–6	<LDA	n.d.
Inventory d.c.	36.0 ± 9.0	25.6 ± 6.4

Table 3 ^{137}Cs activity (Bq/m^2) in a Skua Lake (Lake 2) core sample.

Depth (cm)	*Sediment core Skua Lake (20LSIII)*
0–2	56.6 ± 5.4
2–4	54.4 ± 5.2
4–6	<LDA
6–8	n.d.
Inventory d.c.	210 ± 13

collected respectively on a bi-weekly base during the IV (1990–91) and on a weekly base during the V (1991–92) national expeditions at Terra Nova Bay.

During the IV expedition, ^{7}Be activities detected in the 6 bi-weekly samples of snowy precipitations ranged from under the lowest detection limit to 14 Bq/m^2 and appear to be correlated to the scarce snowfall of the period (Figure 2).

During the V expedition, which only lasted one month, abundant and prolonged snowfalls accompanied by a remarkable ^{7}Be deposition were observed (Figure 3).

Figure 4 reports the progress of a single snowfall of unexpected duration, 4.5 days, (a rather unusual event during the Antarctic summer), during which consecutive samplings, extending over 12 hours, were carried out.

In order to test ^{7}Be activities in field samplings in comparison to those ones detected in total atmospheric depositions collected in tanks, inventories of the radionuclide (total

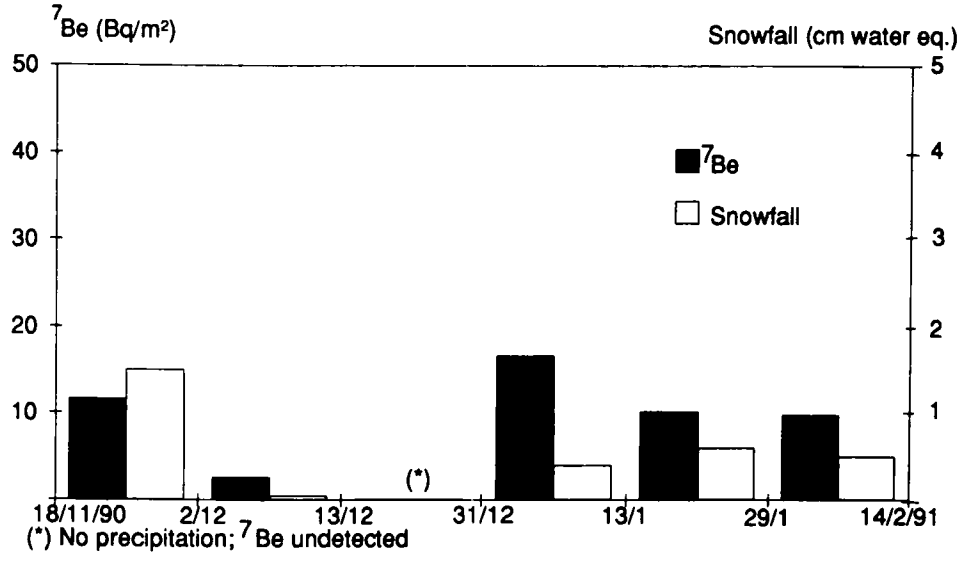

Figure 2 Bi-weekly samples of total depositions of ^{7}Be and atmospheric precipitations during the expedition 1990–91.

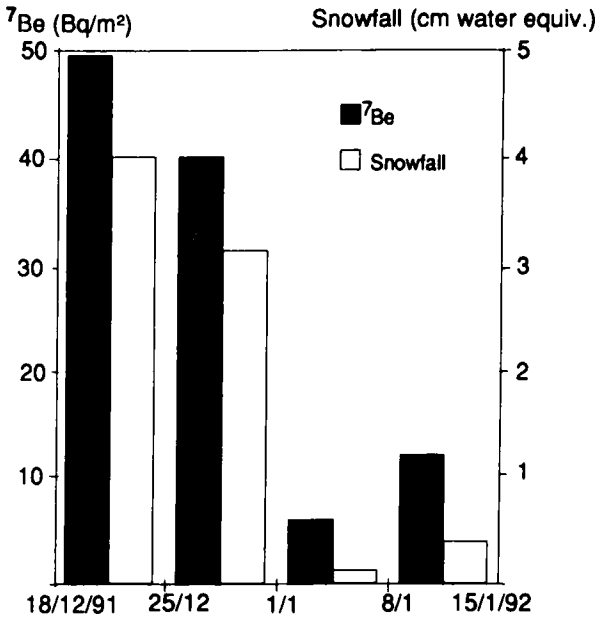

Figure 3 Weekly samples of total depositions of ^{7} Be and atmospheric precipitations at during the expedition 1991–92.

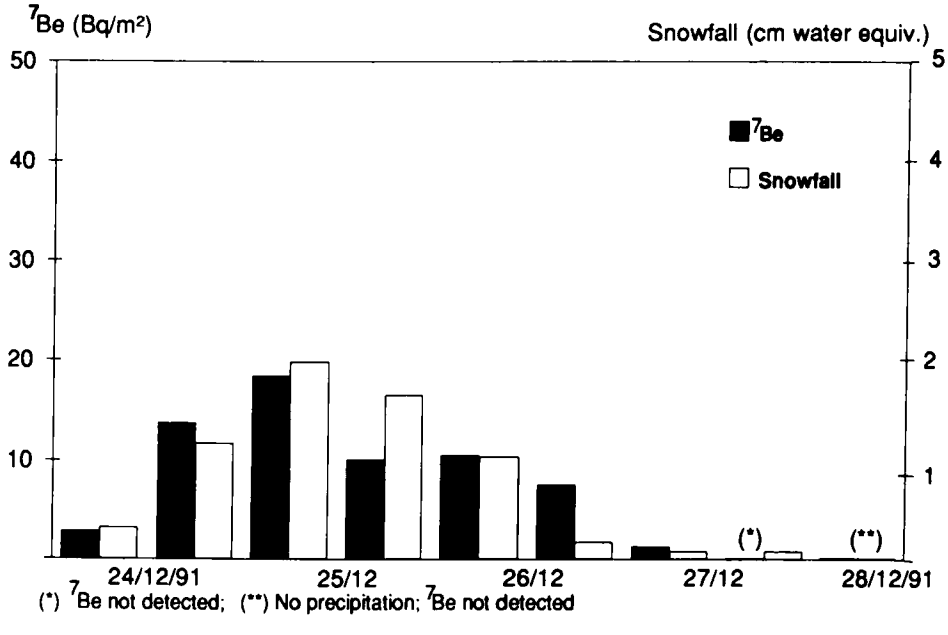

Figure 4 Progress of a single event of snowfall and corresponding ^{7} Be deposition in the austral summer 1991–92.

activity distributed along a vertical profile following atmospheric deposition) along a soil profile were determined in the area surrounding the base camp itself at the beginning and at the end of the stay at Terra Nova Bay; the choice of soil as the comparison matrix was due to total absence of snow accumulated in the same site were atmospheric sampling was effected and that, for sake of homogeneity, would have been a more appropriate term of comparison. The result obtained (75 + 8 Bq/m^2) in good correspondence with the amount detected by weekly samplings (100 + 10 Bq/m^2), validates the sampling methods employed for both the matrices.

CONCLUSIONS

The values of ^{137} Cs determined in the samples from the IV expedition confirm the results already widely discussed in our previous paper (1). However, it must be pointed out that inventory data must be strictly correlated both the local peculiarities of the investigated lacustrine areas and the sampling points.

With regard to ^{7} Be, the results obtained seem to support the evidence that in Antarctica as well, at least on coastal areas, its deposition mainly occurs by wet deposition as already observed by the Authors at middle latitudes.

However, snow probably produces a less efficient scavenging effect, as compared to rainfall; in fact, while during the huge snowfall of the late December 1991 (see Figure 4) the ratio of ^{7}Be to water equiv. cm remained practically constant, similar observations of a short but intense rainfall event, in an area adjacent to our Chemistry Department, pointed out a progressive decrease in the radionuclide activity to total depletion (work presently in progress).

The results obtained can be considered encouraging for the development of the Authors' research in Antarctica as regards the study of the complex air/snow transfer processes by means of natural radionuclides.

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