



Characterization of the element content in lacustrine ecosystems in Terra Nova Bay, Antarctica

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ABSTRACT

The distribution of a series of elements in lacustrine environments from Terra Nova Bay, Northern Victoria Land, Antarctica, has been examined, in order to gain insight into the natural processes regulating species distribution, and to detect possible present or future local and/or global anthropogenic contamination. Attention was focused on freshwaters, algae, mosses, and lichens (one site only). Lake water composition was found to be influenced by marine spray, lake geographical position and meltwater input. Bioaccumulation of elements by algae was observed. Higher element concentrations in algae than in mosses have been interpreted taking into account this phenomenon. Data processing by chemometric techniques showed correlations between elements and similarities among samples. No evidence of a detectable metal contamination was found in the investigated area.

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1. Introduction

The terrestrial ecosystems of the Antarctic region are among the most uncontaminated on Earth and are considered one of the most suitable places for estimating the natural presence, concentration and variability of organic and inorganic compounds with a minimum level of anthropogenic influence. From these ecosystems it is therefore possible to gain insight into the natural processes regulating organic and inorganic species distribution in different environmental compartments. Antarctic lake waters have been less extensively studied than other matrices, such as seawater or snow (e.g. [1–5]). Most available data on Antarctic lake waters derive from the McMurdo Dry Valleys area in southern Victoria Land, West Antarctica, in particular Lake Vanda and Lake Wilson, and the Larsemann Hills, East Antarctica (e.g. [6–10]).

The lacustrine Antarctic ecosystems of the Terra Nova Bay area (Northern Victoria Land) have been studied since 1985 within the framework of the Italian National Research Program in Antarctica (PNRA) (e.g. [11–21]). The comparison of results obtained over a relatively long period of time (1993–2001) has demonstrated that human activity has not resulted in detectable metal contamination in that area [20]. The monitoring program at Terra Nova Bay is useful to establish contaminant baseline levels and to detect the occurrence of possible local and/or global anthropogenic contamination [22,23].

In this study, the distribution of a series of elements in lacustrine compartments from Terra Nova Bay has been examined. Attention was focused on freshwaters, algae, mosses and (for one site) lichens, from Edmonson Point (EP) lakes 13, 13A, 14, 15, 15A, 16, Carezza (CA), Gondwana (GW), Tarn Flat (TF) and Inexpressible Island (II). The lakes are located in the vicinity of the “Mario Zucchelli” Italian station. Element concentrations have been determined by optical emission, atomic absorption spectroscopy and ICP mass spectrometry. The experimental results have been processed by multivariate chemometric techniques.

The study has two main aims. First, to verify whether anthropogenic trace metal contamination is present in the area around Terra Nova Bay. Second, to shed some light over the biogeochemical cycles of the investigated elements, taking into account the relationships among the different matrices.

2. Experimental

2.1. Location and setting

Fig. 1 shows a map of the investigated area, which stretches from about 74°10' to 75°20'S and from 162°00' to 165°50' E around Terra Nova Bay, in the Ross Sea. Terra Nova Bay is relatively ice-free in summer owing to the presence of western katabatic winds blowing from the plateau seawards. More than a hundred small lakes and ponds, as well as meltwater and periglacial lakes, are present in this ice-free area [12,20,21]. Table 1 shows the main geographical features of the ten investigated lakes together with the location of each site.

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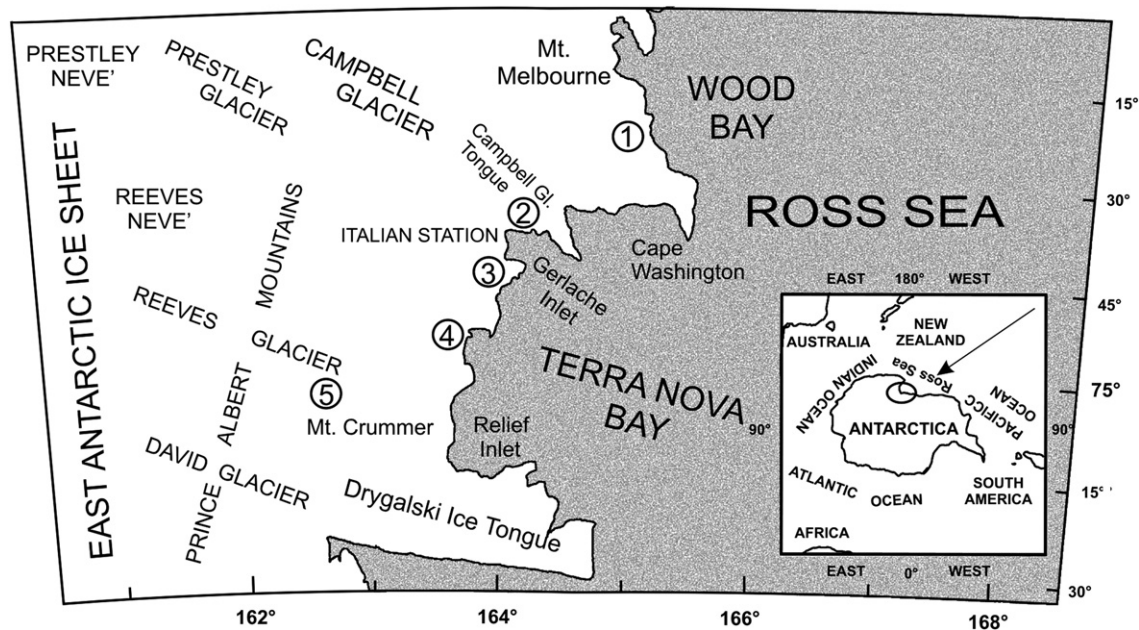


Fig. 1. Map of Terra Nova Bay showing the position of the investigated lakes: 1) Edmonson Point; 2) Gondwana; 3) Carezza; 4) Inexpressible Island; 5) Tarn Flat. The inset map of Antarctica shows the approximate location of the investigated area.

Such lakes are small, shallow and are usually unfrozen only for a few months during the Antarctic summer. They are fed by surface streams deriving from glacial or snow meltwater and/or by groundwater and have no definite outflow, but water is lost by evaporation, sublimation or spraying induced by the persistent katabatic winds; the latter result in the lakes being well-mixed during the summer. In a previous study we identified the major mineralogical species present in the regoliths catchments (Table 2) [21]; in summary, these include: 1) quartz, alkaline feldspars, plagioclase, amphibole, biotite, chlorite and muscovite in CA, II and TF and 2) plagioclase, alkaline feldspars, pyroxene and olivine at EP. We concluded that: 1) for CA, II and TF, the soils and the sediments derive from intrusive rocks, in particular from granitic (CA and II) and granodioritic (TF) rocks and 2) the soils and the sediments of EP lakes derive from effusive rocks (basalts, rhyolites and pumice fragments). Each investigated site has some specific features. In particular, Edmonson Point is close to Mount Melbourne, a dormant volcano, and has a relatively abundant terrestrial plant community, favored by the availability of marine- and bird-derived nutrients (a penguin rookery is present in that area). Inexpressible Island is almost completely free from glaciers and the lake considered in this study is the closest to the sea. Tarn Flat area is heavily affected by glacial erosion, which generated undulations with hilly reliefs and depressions; the lake sampled in this study lies at -70 m below sea level and is characterized by a

noticeable amount of inflowing and outflowing water. It is fed by the waters generated by a small glacier (Mount Gerlache) and by surface waters produced by the melting of permafrost and small snowfields. The water outflow feeds a nearby lake at -80 m below sea level. Carezza Lake lies in the Northern Foothills, an area characterized by rounded hilly reliefs with small local glaciers and large amounts of snow. It is the closest to the Italian station; Gondwana Lake is located near the former German station. Further details on Terra Nova Bay can be found in [21].

2.2. Sampling and sample pre-treatment

2.2.1. Lake waters

Water samples were collected with previously cleaned 500 ml-polyethylene containers, immediately filtered through acid-washed $0.45\ \mu\text{m}$ cellulose acetate filters and frozen at $-20\ ^\circ\text{C}$. All samples were maintained at $-20\ ^\circ\text{C}$ during all stages of storage and transportation to laboratory. Before analysis, the water samples were unfrozen and acidified with $500\ \mu\text{l}$ of purified nitric acid. The sample blanks were prepared similarly to samples in the laboratory without the field sampling step. These pretreatment steps were carried out under a Class-100 laminar flow bench-hood placed in a controlled atmosphere laboratory.

Table 1
Geographic features of the investigated lakes and summary of the available lacustrine matrices.

Lake	Coordinates	Altitude (m a.s.l.)	Depth (m)	Surface (m^2)	Distance from the sea (km)	Water	Alga	Moss	Lichen
EP13	$74^\circ19'S; 165^\circ08'E$	4	n.a.	17800	~ 0.1	X		X	
EP13A	$74^\circ19'S; 165^\circ08'E$	n.a.	n.a.	n.a.	~ 0.3	X		X	
EP14	$74^\circ19'S; 165^\circ08'E$	20	1.5	4000	~ 0.5	X	X	X	
EP15	$74^\circ19'S; 165^\circ08'E$	2	~ 2	3600	~ 0.2	X		X	
EP 15A	$74^\circ18'S; 165^\circ04'E$	3	4	4600	~ 0.2	X	X	X	
EP16	$74^\circ18'S; 165^\circ04'E$	n.a.	n.a.	n.a.	~ 0.5	X	X	X	
CA	$74^\circ42'S; 164^\circ02'E$	175	1.5	7900	1	X		X	
II	$74^\circ54'S; 163^\circ40'E$	32	2.5	6800	~ 0.8	X			
TF	$74^\circ58'S; 162^\circ30'E$	-70	3.9	17700	35	X	X		
GW	$74^\circ36'S; 164^\circ12'E$	86	~ 2.0	3000	n.a.	X	X	X	X

n.a. = not available.

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