Palaeoclimatic studies in South Shetland Islands, Antarctica, based on numerous stratigraphic variables in lake sediments

Svante Björck 1, Hannelore Håkansson 1, Siv Olsson 1, Lena Barnekow 1 & Jan Janssens 2
1 Department of Quaternary Geology, Lund University, Tornav. 13, S-223 63 Lund, Sweden; 2 Department of Ecology, Evolution and Behaviour, University of Minnesota, 109 Zoology, 318 Church Street S.E., Minneapolis, MN 55455, USA

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Abstract

The hitherto longest found lake sediment sequence on Byers Peninsula, Livingston Island, South Shetland Islands, was analysed with respect to lithology, chronology, diatoms, *Pediastrum*, pollen and spores, mosses, mineralogy, and sediment chemistry. During the ca. 5000 year long development the sediments were influenced by frequent tephra fall-outs. This volcanic impact played a major role in the lake’s history during two periods, 4700–4600 and 2800–2500 BP, but was of importance during the lake’s entire history with considerable influence on many of the palaeoenvironmentally significant indicators. The large and complex data set was analysed and zonated with different types of multivariate analysis. This resulted in a subdivision of the sequence into 8 time periods and 21 variables. Redundancy analysis (RDA) of this data set, both without and with the tephra periods, and with 4–6 of the variables as explanatory environmental variables, reveal that climatic/environmental signals are detectable. The palaeoclimatic picture that emerged out of the tephra ‘noise’ suggests that the first 100 years were characterized by mild, humid conditions. This was followed by a less mild and humid climate until ca. 4000 BP when a gradual warming seems to have started, coupled with increased humidity. These mild and humid conditions seem to have reached an optimum slightly after 3000 BP. At ca. 2500 BP a distinct climatic deterioration occurred with colder and drier conditions and long seasons with ice cover. This arid, cold phase probably reached its optimum conditions at ca. 1500 BP, when slightly warmer conditions might have prevailed for a while. Except for the modern sample with rather mild climate, the last 1400 years seem to have been fairly arid and cold, and the effects of the frequent volcanic activity during this period is only vaguely seen in the records.

Introduction

Only recently have researchers begun to use stratigraphic studies of lake sediments in the Antarctic Peninsula region to evaluate Holocene environmental and climatic changes (Tatur & del Valle, 1986; Mäusbacher *et al*., 1989; Zale & Karlén, 1989; Matthies *et al*., 1990; Schmidt *et al*., 1990; Björck *et al*., 1991a; Mäusbacher 1991). Previous attempts have indicated that
these types of studies have the greatest potential to describe and analyse the Holocene terrestrial environmental history of this part of the world.

Byers Peninsula on Livingston Island is probably the area in Antarctica that has the highest concentration of lakes. The lakes have also proven to contain fairly thick sediments (Björck et al., 1991a) and tephra layers that can be used for correlations and datings (Björck et al., 1991b). These type of time-markers would be perfect for lake level studies, with transects from the shore out to the deeper parts (cf. Digerfeldt, 1988); but because the latter are mostly shallow and flat-bottomed, such studies are not feasible.

Our first lake sediment study from this region (Björck et al., 1991a) was a pilot-study to evaluate the possibilities for performing palaeoenvironmental investigations in the Antarctic environment. Since the results were promising, we decided to carry out a wide variety of detailed stratigraphic studies of the hitherto longest found lake sediment sequence on Byers Peninsula.

Area of investigation

Geography, climate and vegetation

Within the South Shetland Islands, Livingston Island is the second largest of ca. 10 more-or-less large islands. It is situated ca. 150 km west-northwest of the northernmost tip of the Antarctic Peninsula (Fig. 1). Except for Byers Peninsula (Fig. 2) most of the island is covered by glaciers, of which the Rotch Ice Dome borders the peninsula in the east. Apart from the northwestern part of the peninsula, which reaches a maximum of 268 m above sea level, few areas reach higher than 100 m. Exceptions are a few volcanic plugs of which Chester Cone in the central part of the peninsula is the highest (193 m) and most prominent feature. The main part of the peninsula forms a ca. 40 km² large undissected, 85–100 m high, inland platform with an irregularly undulating topography. On the platform margins is a 30–50 m platform gently sloping seaward. Further down follow the 11–17 m and the sea level platforms.

According to a 21-year long (1947–1967) meteorological record (Orvig, 1970) from nearby