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Chemical and biological characterization of soils from the Antarctic east coast

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Abstract In a study of pedogenesis, soil samples from five sites were taken along an almost 6,000-km-long zone of coast in the northeast Antarctic continent (between 70°46'S–11°50'E and 66°33'S–93°01'E). A poor microflora (bacteria, fungi and algae) was evidenced. Indicators of vital and enzymatic activities, as well as the Biological Synthetic Indicator, show the existence of certain potentials of mineralization and biosynthesis, capable of soil-forming processes, but the almost year-round frost and the scarcity of weathered rock accumulated in the small depressions under the stone shelter do not permit the humification of organic material.

Introduction

Subdivision of continental Antarctic regions based on ecological and climatological criteria has been achieved by Weyant (1966) and Walton (1984), cited by Böltet al. (1995). Soils have been subdivided into intrazonal or azonal soils, existing in a very primary stage, at least in the zones of the Antarctic Cold Desert, by Ugolini (1970) and Campbell and Claridge (1987). Due to the harsh climatic conditions, most of the soil formation results from weathering processes or microbial activities on sparse organic material, produced in small depressions or under stone shelter (Bockheim 1997; Beyer et al. 1999). These conditions are met only for 2–3% of the continental permafrost territory.

Studies of macro- and microclimates connected with moss ecology of the Antarctic east coast were performed by Matsuda (1977) in the sector of the Prince Harald Coast near the Japanese station, Syowa (cited after MacNamara 1993), not far from Molodezhnaya station. Microclimatic data from Enderby Land Coast, in the area of Molodezhnaya station, have been reported by MacNamara (1993) on the 12th and 13th Soviet Antarctic Expeditions (1963–1967). This report refers to 1967. The surface temperatures and ranges reported in this study exceed those reported from other areas. In general, the differences are small and probably related to the latitudinal position. The maximum and minimum soil surface temperatures were +41 and –41°C. The standard air temperatures (mean parameters 1963–1967) in January, February and March were +5, +3 and 0°C, respectively.

The corresponding values for Novolazarevskaya station, in Queen Maud Land, were +26 to –37°C (Averianov 1968). Soil surface temperatures of +25 to –32°C have been reported for the Mirny Station area.

In Enderby Land oases, the average depth of thaw is almost 1 m under normal moisture conditions and it is considerably greater in drier deposits.

Sampling sites

Our soil and biological researches refer to a coast territory, almost 6,000 km long (between Novolazarevskaya station, 70°46'S 11°50'E and Mirny, 66°33'S 93°01'E), covered by T.G. Negoită in 1998, from January till July, as a participant in the 43rd Russian Expedition in Antarctica.

A brief description of the researched zones (Fig. 1) is as follows: Novolazarevskaya is placed in Queen Maud Land and the Novolazarevskaya station zone is 80–90% located on the rock-like ground around some lakes at about 100 km distance from the sea. In some small depressions there are some accumulations of shiver rock and sand, forming 2- to 10-cm-thick layers. On these spots, the polar flying birds nestle, producing some organic material in summer.

Molodezhnaya station zone is situated at 67°40'S 45°51'E, in the Talla Hills area. The oasis is one of the
numerous small ice-free areas along the Western Enderby Land Coast. There are some locations on stony ground, weathered on the surface, forming some silt-gravel soils in small depressions, around the lakes. Here, in summer, the flying birds (*Stercorarius skua*) and penguins (Adélie) nestle. On the promontory, there are microzones with mosses under the shelter of the stones. In these biotopes, weathered rocks and droppings of the flying birds accumulate. These zones stretch from the sea as far as 150–250 m inside the continent.

Progress station is located at 69°23′S 76°24′E. The first zone, from 0 to 100 m from the sea, is characterized by different places with weathered rocks, gravel, sand and silt without organic matter, with a depth of 5 or 10 cm, and a second zone at 200 m distance from the sea at the border of the lakes where the flying birds (skua) nestle in summer. Here, the weathered ground is silt and gravel of a blackish colour and a thin skin of algae.

Stornes Peninsula is situated at 69°24′S 76°07′E. The sea influence makes it possible to form a mineral soil on the reduced surfaces under the shelter of the stones. At 30 m of cliff there are different patches of mosses. The soil has only 3–4 cm depth.

Mirny station is situated at 66°33′S 93°01′E, being the nearest Russian station from Casey (Australian station) to the east. A zone of sampling of the weathered ground is a summit that penetrates the ice cap. The ground is monolithic, but in small depressions (0.3–0.5 m²) sand has accumulated, with a depth of 2–3 cm. Another (larger) zone for soil sampling was Haswell archipelago. The mineral soil resulting from weathered rock is carried as gravel and silt in small depressions by the wind and waters. In these places, there are rich droppings deposits of Adélie penguin and flying birds, and patches of mosses.

The nature of the soils, as described, can be judged as a geological formation, rather than a pedological structure. In all cases, we considered that the ground is covered with weathered rocks, from large stones to gravel and sand, the biotopes having sizes of some square decimetres, where polar birds nestle.

**Materials and methods**

The ground samples of weathered rocks were collected from the stations Novolazarevskaya (six locations), Molodezhnaya (five locations), Progress (seven locations), Stornes Peninsula (three locations) and Mirny (nine locations) between January and July. The samples were conditioned on the spot, by a sieve of 2 mm, aseptically introduced into plastic bags, transported and stored in frozen state until the moment they were analysed. The depth of sampling was 1–10 cm, which is the maximum achievable.

**Chemical analyses**

Organic matter in these mineral soils was analysed by sulphochromic oxidation. It was determined as total organic carbon (C, %) by spectrometric methods (Kononova and Belchikova 1961; Saffeld 1974). Total nitrogen content in soils was determined by the Kjeldahl method. Organic phosphorus (Pₐ) was assessed by the Legg and Black method (1955). Soil chemical reaction was determined as pH (H₂O) by an electrometric method.

**Microbial analyses**

The number of bacteria (colony forming units – cfu) was determined by the soil decimal dilutions method, with fertile soil extract