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Soils and landforms from Fildes Peninsula and Ardley Island, Maritime Antarctica

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ABSTRACT

Fildes Peninsula (F.P.) and Ardley Island (A.I.) are among the first ice-free areas in Maritime Antarctica. Since the last glacial retreat in this part of Antarctica (8000 to 5000 years BP), the landscape in these areas evolved under paraglacial to periglacial conditions, with pedogenesis marked by cryogenic processes. We carried out a detailed soil and geomorphology survey, with full morphological and analytical description for both areas; forty-eight soil profiles representing different landforms were sampled, analyzed and classified according to the U.S. Soil Taxonomy and the World Reference Base for Soil Resources (WRB).

Soils are mostly turbic, moderately developed, with podzolization and strong phosphatization (chemical weathering of rock minerals and formation of amorphous Al and Fe minerals) in former ornithogenic sites while in areas with poor vegetation show typical features of cryogenic weathering. Nivation, solifluction, cryoturbation, frost weathering, ablation and surface erosion are widespread. The most represented landform system by surface in Fildes Peninsula is the periglacial one, and 15 different periglacial landforms types have been identified and mapped. These features occupy about 30% of the land surface, in which patterned ground and stone fields are the most common landforms. Other significant landforms as protalus lobes, rock glaciers or debris lobes indicate the extensive presence of permafrost. Soil variability was high, in terms of morphological, physical and chemical properties, due to varying lithic contributions and mixing of different rocks, as well as to different degrees of faunal influence.

Three soil taxonomy orders were identified, whereas thirty four individual pedons were differentiated. Fildes Peninsula experiences a south–north gradient from periglacial to paraglacial conditions, and apparently younger soils and landforms are located close to the Collins Glacier. Arenosols/Entisols and Cryosols/Gelisols (frequently cryoturbic) are the most important soil classes; Leptosols/Entisols, Gleysols/Aquents and Cambisols/Inceptisols also occur, all with gelic properties, and with varying faunal influences. Both soil classification systems are adequate to distinguish the local pedogenesis processes. The WRB system is broader, since it was designed to be applied in all Polar Regions; the family classes adopted by the ST were effective in separating soils with important differences with regard to texture and gravel content, all important attributes accounting for the ecological succession and periglacial processes. An altitudinal organization of landforms and processes can be recognized from geomorphological mapping. Periglacial features are dominant above 50 m a.s.l. although are present at lower altitude.

1. Introduction

Antarctic terrestrial ecosystems develop under extreme conditions and are highly sensitive to environmental changes (Bargagli et al., 1998). Once exposed due to the retraction of glaciers, mineral substrates undergo several possible processes depending on the characteristics and interaction of climate, relief, parent material, biological activity and time of exposure. Alterations in the regional climate, especially the oscillations around de freezing point of water (0 °C), cause important changes in biological activity, chemical and physical weathering, regional hydrology and geomorphic processes.

Pedological studies in Antarctica developed on extremely dry continental areas, such as the Dry Valleys region (e.g. Pastor and Bockheim, 1980; Campbell and Claridge, 1987; Bockheim, 1997; Beyer et al., 1999). There, soils are formed under cold desert conditions, being poorly

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developed, with negligible organic carbon content, little horizon differentiation and with conspicuous salt accumulations. During the last ten years a considerable amount of soil and geomorphological studies have been made in warmer and moister parts of Antarctica (Michel et al., 2006; Navas et al., 2006, 2008; Simas et al., 2006, 2007, 2008; Schaefer et al., 2007; Serrano et al., 2008; Francelino et al., 2011; López-Martínez et al., 2012; Moura et al., 2012; Balks et al., 2013). The relationship between landforms and soil distribution in Antarctica has been addressed in a comprehensive study (Balks et al., 2013).

In the northernmost part of the Antarctic Peninsula and offshore islands, mild temperatures compared to continental Antarctica intensify hydrological and biological cycles (Groeneweg and Beunk, 1992; Moreno et al., 2012). Cryoclastic weathering and cryoturbation are active processes in soils, due to the high number of daily freeze-and-thaw cycles (Balks et al., 2013). Although chemical alteration is generally very low, it is important for soil formation, especially in areas where acidity is generated by the oxidation of sulfides in the parent material or due to microbiological decomposition of bird guano (Simas et al., 2006, 2007).

Ice-free areas in the South Shetland Islands are marked by periglacial processes and landforms (López-Martínez et al., 2012), which influence soil development as well as vegetation distribution (Cannone and Guglielmin, 2008). Topography, soil characteristics, vegetation and slope orientation are cited as the major aspects affecting permafrost occurrence and distribution.

Due to the high number of scientific stations and increasing anthropic activity in the South Shetlands, the understanding and mapping of terrestrial ecosystems is crucial for appropriate conservation and land use strategies. The objectives of the present work are to investigate soil–landscape relationships, characterize and classify soils from Fildes Peninsula and Ardley Island, in order to analyze soil diversity and spatial distribution.

2. Materials and methods

2.1. Study area

King George is the largest island in the South Shetlands Archipelago, with approximately 1400 km^2 (Fig. 1). Similar to the rest of the archipelago it is almost completely glaciated, with only 5% of its area being ice-free (Simões et al., 1999; Rakusa-Suszczewski, 2002). Fildes Peninsula (F.P.) and Ardley Island (A.I.) are situated in the extreme southwestern

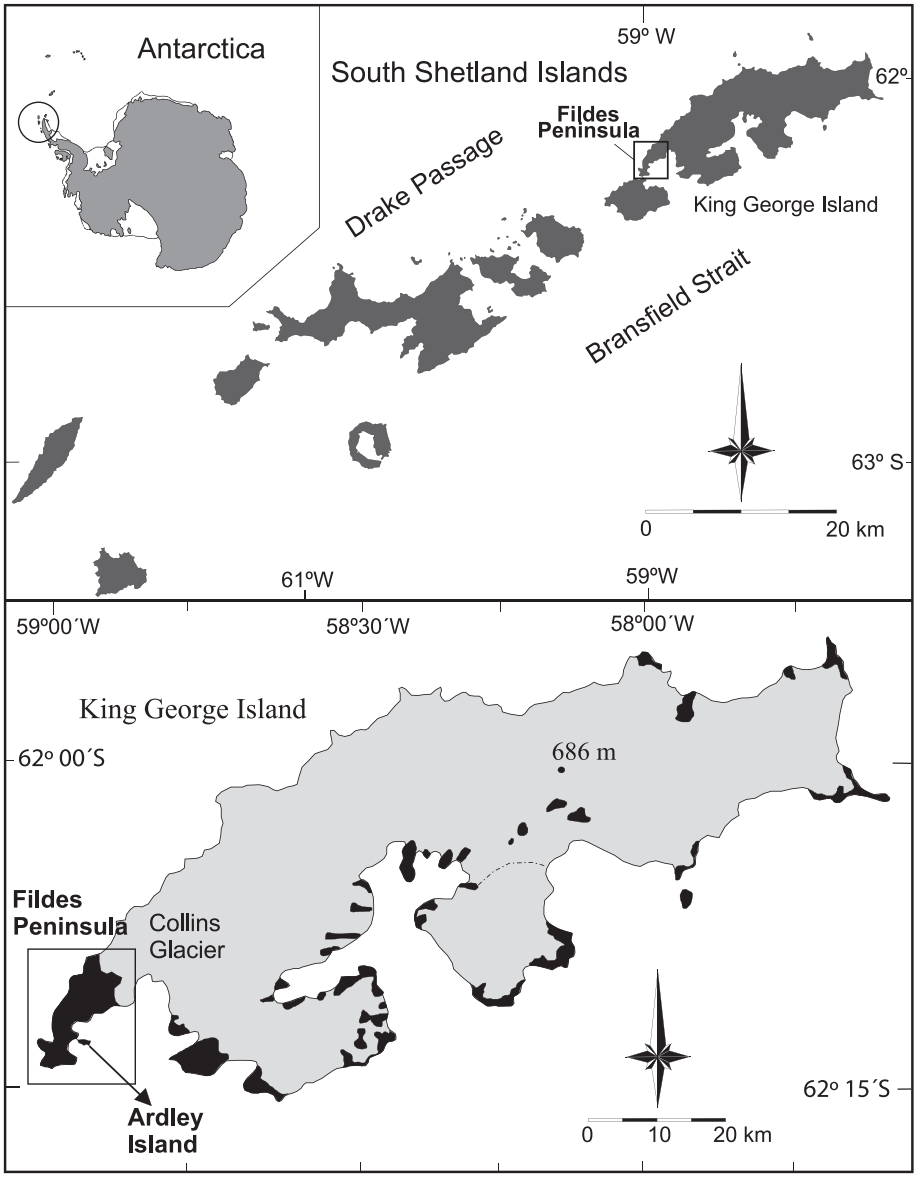

Fig. 1. Location of Fildes Peninsula and Ardley Island within Antarctica and the South Shetland Islands.