Soil processes in recently deglaciated environments in Maritime Antarctica: a study case from Elephant Point (Livingston Island, South Shetland Islands)

Ana Navas[1*], Marc Oliva[2], Jesús Ruiz-Fernández[3], Laura Quijano[1], Leticia Palazón[1], Iván Lizaga[1]

[1] CSIC Consejo Superior de Investigaciones Científicas

[2] Universidade de Lisboa

[3] Universidad de Oviedo

* anavas@eead.csic.es

SSS9.15
Soils in Space and Time: Soils in Mountain, Boreal and Polar Environments

Introduction and Objectives

In Elephant Point Peninsula the glacier retreat recorded during the second half of the XX century has exposed 17% of its 1.16 km2 surface (Oliva & Ruiz-Fernández, 2016).
This study aims at characterizing the upper soil layers of recently formed soils developed on different geomorphic features to investigate the properties that can reveal features related to recent processes of the glacier retreat (Navas et al., 2014).

Materials and methods

A total of 10 soil profiles were sampled along a transect crossing different geomorphological units (beach, raised beaches, moraine, proglacial environment), following the direction of glacier retreat.

Sampling was done on the surface layers until 12 cm, sectioned at 3 cm depth intervals.

Soil properties analysed: pH, EC, SOC, $CO_3^{=}$. Grain size fractions (sieve + laser Coulter). Elemental composition (total extraction HF, ICP-OES). FRNs and ERNs (Ge coaxial gamma detector 50% eff., 226000", 2 -15 % analytical precision).

Results

Study area

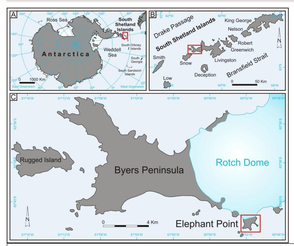
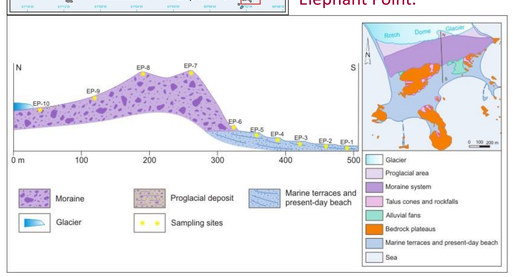


Fig. 1. Location of Elephant Point.

Photographs of different geomorphological units in which the studied soils are located



Glacier retreat has exposed new ice-free land surface in the northern part of Elephant Point: a moraine extending from the western to the eastern coastlines and a relatively flat proglacial surface. Besides, a sequence of present-day beach, Holocene marine terraces and bedrock plateaus are also distributed in the southern margin of the peninsula (Oliva & Ruiz-Fernández, 2016). The underlying materials are mainly composed by highly weathered bedrock mainly composed of basalts. The moraine sediments are also constituted by some granodiorites and shales. Periglacial processes are widespread in the peninsula.
Soils are developed in permafrost environment with a variety of active processes (Oliva & Ruiz-Fernández, 2015). Development of stone fields, patterned grounds and mudboils are common in the raised beaches. In the beaches and lowest marine terraces the soils present different mosses and lichens coverage and support local fauna (elephants seals and penguin rockeries).

Fig. 2. The studied soil profiles along Elephant Point transect

Soil characteristics

Cryosols are very stony with no clear horizon differentiation with sandy, loamy sand textures (Fig 3). Clays are scarce specially in the marine terraces and beaches.

The soils are slightly acidic with no carbonates and low salinity: pH ranges between 4.52 and 6.73, and EC from 0.051 of 0.388 dS m^{-1}.

Soil organic carbon contents vary from 1.8 to 11 % being higher in the beaches and marine terraces related to fauna activity.

Bedrock disintegration by freezing-thaw cycles within the soil active layer are main soil forming processes as in other areas of Livingston Island (Navas et al., 2008).

	EP 10	EP 9	EP 8	EP 7	EP 6	EP 5	EP 4	EP 3	EP 2	EP 1
pH	6.67	6.73	6.10	6.70	5.97	4.54	4.87	4.60	4.52	6.37
EC dS m^{-1}	0.077	0.065	0.388	0.051	0.049	0.237	0.114	0.243	0.081	0.072
SOC %	2.59	2.48	3.43	2.84	2.88	1.83	3.30	11.13	5.18	5.04

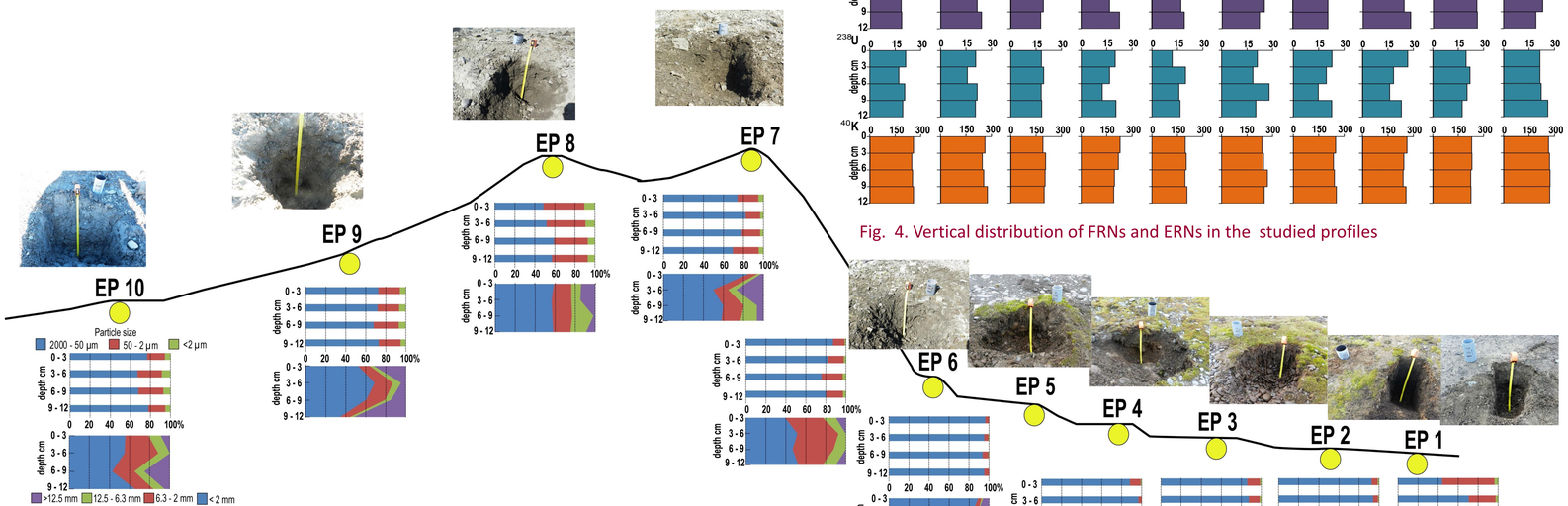


Fig. 3. Photographs of the soil profiles and depth distribution of coarse and fine grain sizes in the soil profiles

FRNs and ERNs radionuclides

Fallout ^{137}Cs is only present in EP1 to EP5 profiles on marine terraces and beaches (0.3 - 10 Bq/kg) where its depth distribution indicates some soil disturbance.

$^{210}Pb_{ex}$ activities are below detection limits. The activities of ^{226}Ra differ between soils on moraines and on marine terraces and beaches, more homogeneous are the depth distributions of ^{232}Th, ^{238}U and ^{40}K activities. (Fig. 4)

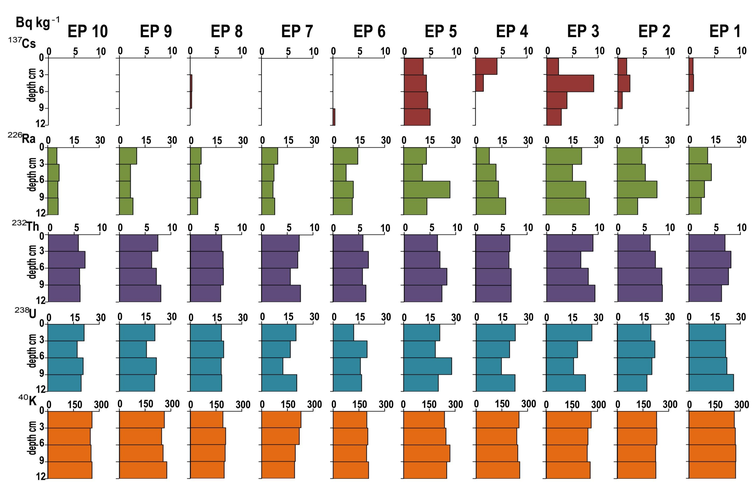


Fig. 4. Vertical distribution of FRNs and ERNs in the studied profiles

Elemental composition

The major elements Fe, Al, Ca and Na, were the most abundant in that order, followed by Mg, Ti, K, B and P, and then Mn, S, V, Sr, Tl, Zn, Bi, Cr, Pb, Ni, Li, whereas Se, Rb, Mo, Cd and Be are present as trace elements (Fig. 5). Concentrations are quite homogeneous in the moraine soils whereas larger variations are observed in the marine terraces and present day beaches suggesting mineralogical differences of parent materials as well as fauna activities.

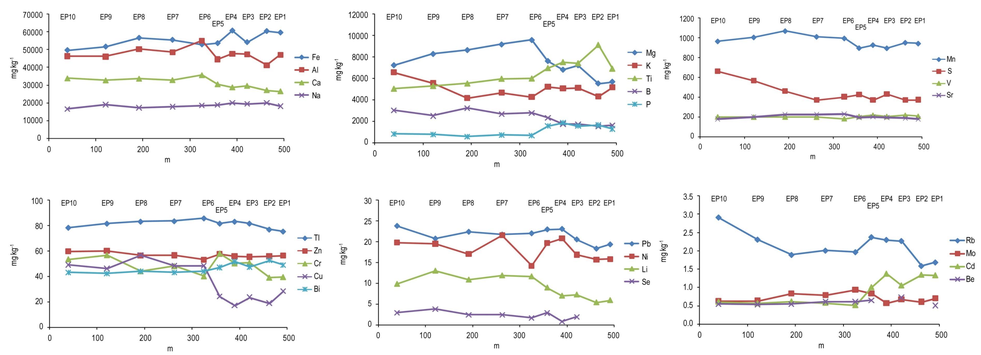


Fig 5. Elemental composition in the studied profiles.

Conclusions

Combining geomorphological, edaphic, geochemical and radioisotopic data has proved very useful to derive information on the influence of different stages of glacier retreat in the study soils.
The type and characteristics of soils depend on the timing of glacier retreat and the parent material. More fine grained soil appear on moraines. The active layer at variable depths might also affect soil processes as indicated by geochemical differences in soils on moraines and on marine terraces and beaches.
The rapid retreat of the glacier between 1956 and 2010, can be traced by the ^{137}Cs signal, which is inexistent in soils on moraines and is only found in soils on marine terraces and beaches.

References & Acknowledgements

Navas, A., López-Martinez, J., Casas, J., Machín, J., Durán, J.J., Serrano, E., Cuchí, J.A., Mink, S. 2008. Soil characteristics on varying lithological substrates in the South Shetland Islands, maritime Antarctica. Geoderma, 144: 123-139.

Navas, A., Laute, K., Beylich, A.A., Gaspar, L. 2014. Variations of soil profile characteristics due to varying time spans since ice retreat in the inner Nordfjord, western Norway. Solid Earth, 5, 485-498.

Oliva M, Ruiz-Fernández J. 2015. Coupling patterns between para-glacial and permafrost degradation responses in Antarctica. Earth Surface Processes and Landforms 40: 1227–1238.

Oliva, M., Ruiz-Fernández, J. Geomorphological processes and frozen ground conditions in Elephant Point (Livingstone island, South Shetland Islands, Antarctica). Geomorphology http://dx.doi.org/10.1016/j.geomorph.2016.01.020

Projects CGL2014-52986-R and HOLOANTAR and PROPOLAR (Portuguese Science Foundation) are gratefully acknowledged