A fifth-order reconnaissance soil map of ice-free areas of the Transantarctic Mountains, Antarctica

M. McLeod,[1] J. G. Bockheim,[2] and M. Balks[3]

[1]Landcare Research, Private Bag 3127, Waikato Mail Centre, Hamilton 3240, New Zealand (mcleodm@landcareresearch.co.nz)
[2]Department of Soil Science, University of Wisconsin, 1525 Observatory Drive, Madison, WI 53706-1299, USA (bockheim@wisc.edu)
[3]Earth Sciences, University of Waikato, Private Bag 3015, Hamilton, New Zealand (m.balks@waikato.ac.nz)

Summary A fifth-order reconnaissance soil map of ice-free areas of the Transantarctic Mountains, Antarctica from Northern Victoria Land to the Shackleton Range has been drafted with nearly 80% of the area digitised and stored in a GIS. Currently, the soil map is useful at scales greater than 1:1 000 000. Soil map units have been classified to Subgroup level using the USDA Soil Taxonomy Gelisols Order and have also been given a relative confidence rating based on the amount of soil information available in the region. Soils in the relatively moist coastal areas of the Transantarctic mountains are dominated by Haplorthels as precipitation recharges soil moisture lost through evaporation and as a consequence ice-cemented permafrost occurs at a depth of <70 cm. In contrast, in drier inland areas ice-cemented permafrost is not recharged and depth to ice-cemented permafrost increases with age leading to Anhyorthels where depth to ice-cement exceeds 70 cm. Lithic Subgroups occur predominantly on steeper land or where high wind speed facilitates removal of shattered rock material. The electronic version of the map can be considered to be work in progress that can be updated whenever researchers have improved soil information covering a significant area. This reconnaissance soil map of the Transantarctic Mountains contributes to the aim of the Antarctic and Sub-Antarctic Permafrost, Soils and Periglacial Environments Group (ANTPAS) to produce an Antarctic-wide soil map similar to that of the Arctic region.

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Introduction

A 5th order reconnaissance soil map of ice-free areas of the Transantarctic Mountains from Northern Victoria Land to the Shackleton Range has been compiled. Soils were classified to Subgroup level using USDA Soil Taxonomy (Soil Survey Staff, 2006). So far, approximately 80% of the area has been digitised and stored in a GIS. Currently the soil map is useful at scales greater than1:1 000 000. The underlying topographic base map is compiled from electronic geo-referenced 1:250 000 scale collarless US Geological Survey maps downloaded from http://usarc.usgs.gov/drg_dload.shtml.

Methods

To compile the soil map, the topographic map base was printed at a scale of 1:500 000 onto stable polyester film. Soil polygons and registration points were hand-drawn onto an overlying matte polyester film and scanned into a raster file (tiff). The raster file images were vectorized and edited using MicroImages TNTmips® then exported as shapefiles suitable for use within ArcGIS®. Polygons from the resulting ArcGIS® file were tagged with USDA Soil Taxonomy Soil Subgroup, nature of the permafrost, and reliability or confidence data.

Allocation of soil classes

Soils on ice-free areas, as depicted on the 1:250 000 topographic maps, were classified to subgroup level using criteria from USDA Soil Taxonomy Gelisol Order. Where published or unpublished soil data were available they were applied directly or used to develop soil/landscape models which were applied to the landscape as depicted on the 1:250 000 topographic map.

There are two types of regions for which we classify the soil for the reconnaissance map. First, regions for which there are published data (Bockheim, 1990; Bockheim and McLeod, 2006; Bockheim et al., in press; Bockheim et al., 1989, 1990; Claridge and Campbell, 1968; Denton et al., 1986) or where the authors are familiar with the soil environment, having worked in the region. These are considered benchmark regions and in Victoria Land include Rennick Glacier, Cape Hallett, McMurdo Dry Valleys including Ross Island, Victoria Valley system, Wright Valley, Taylor Valley, Quartermain Mountains, Royal Society Range, Convoy Range. Benchmark regions also include the Darwin-Hatherton-Bryd Glacier region, Beardmore Glacier region Shackleton and Scott Glaciers.

Second, where there are no published data and authors have not visited the region. These are extrapolated regions, and in the Pensacola and Shackleton Mountains, include Patuxent, Neptune, Forrestal and Argentina Ranges as well as the Shackleton Mountains. In Northern Victoria Land, extrapolated regions include Mt. Discovery, Brown Peninsula and Black Island regions.

The criteria used to classify and delineate soil map units at extrapolated sites are based on soil/landscape relationships established within the benchmark regions and are shown in Table 1. Underlying concepts include:

- Stipple pattern on topographic map indicates patterned ground.
- Commonly, soils proximal to the coast have a greater moisture supply and shallower ice-cemented permafrost and are classified as Haplorthels.
- Commonly, soils distal to the coast have low moisture supply and are classified as Anhyorthels.

Table 1 Criteria used to classify and delineate soil map units at extrapolated sites

Map unit classification*	Criteria
Glacic Haploturbel	Stippled pattern on ice in coastal areas indicating medial moraine.
Glacic Haploturbel–Typic Haploturbel	Stippled pattern on ice indicating medial moraine. Areas adjacent to glaciers with stippled pattern on ice and a narrow stippled pattern on land, indicating patterned ground.
Lithic Anhyturbel	Nunataks with abundant snow and ice nearby.
Lithic Anhyturbel–Typic Anhyturbel	Larger nunataks with both snow and ice and unconsolidated sediments nearby.
Lithic Haploturbel	Nunataks in coastal areas.
Typic Anhyturbel	Distal from coast where stippled moraine pattern from USGS 1:250 000 topographic maps suggesting patterned ground.
Typic Anhyorthel–Lithic Anhyorthel	Broad, isolated ice-free areas 25 km × 10 km and larger in size; no apparent patterned ground from lack of stipple pattern.
Typic Haploturbel	Proximal to coast where stippled moraine pattern from USGS 1:250 000 topographic maps suggesting patterned ground.
Typic Anhyorthel	Large ice-free areas with low relief and no apparent patterned ground from lack of stipple pattern.
Typic Haplorthel	Proximal to coast with no stipple pattern on USGS 1:250 000 topographic maps suggesting no patterned ground.

* USDA Soil Taxonomy.

Criteria for evaluating relative confidence of soil mapping

Regions of soil polygons, e.g., the Victoria Valley system, were tagged with the same relative confidence rating depending on:

- soil observation density (geo-referenced descriptions)
- the similarity of physiography (proximity to glaciers, water bodies; relative distance from coast) to that of a benchmark site,
- the presence of patterned ground on air photographs or topographic maps,
- previous pedological work in the area not including geo-referenced descriptions.

The relative numeric weighting given to each criterion is shown in Table 2 below. The numeric values for each criterion were added to produce a final Relative Confidence Rating given in Table 3.

Table 2 Numeric weighting given to each criterion used to evaluate relative map unit confidence

	Relative rating and numeric score			
Criterion	**High**	**Medium**	**Low**	**None**
Soil observation density	6	4	2	0
Similarity of physiography	3	2	1	0
Patterned ground	3	1	1	0
Pedological work	2	2	1	0

Table 3 Relative confidence rating and component scores for soil classes depicted in various regions of the Transantarctic Mountains

Region	Soil obs. density	Similarity of physiography	Patterned ground	Pedological work	Relative confidence rating
North Victoria Land					
Rennick Glacier	4	3	0	1	8
Tucker-Mariner Glaciers	0	3	0	0	3
Aviator-Campbell-Priestley Glaciers	0	3	0	0	3
Reeve-David-Mawson Glaciers	0	3	0	0	3
McMurdo Dry Valleys					
Allan Hills-Coombs Hills-Convoy Range	4	3	1	1	9
Victoria Valley system	4	3	1	2	10
Wright Valley	6	3	3	2	14
Taylor Valley	6	3	3	2	14
Quartermain Mountains	6	3	3	2	14
Ross Island	2	3	3	2	10
Royal Society Range	6	3	3	2	12
Mt. Discovery-Minna Bluff-Black Island	0	3	3	0	6
Other regions					
Skelton-Mulock Glaciers	0	3	3	0	6
Darwin-Byrd Glaciers	6	3	3	0	12
Starshot-Nimrod Glaciers	0	3	0	0	3
Miller-Geologist Ranges	0	3	0	0	3
Queen Elizabeth Range	0	3	0	0	3
Beardmore Glacier	6	3	3	0	12
Queen Maud Mountains	0	3	0	0	3
Horlick Mountains	0	3	0	0	3
Thiel Mountains	0	3	0	1	4
Pensacola Mountains					
Forrestal Range	0	3	0	0	3
Neptune Range	0	3	0	0	3
Patuxent Range	0	3	0	0	3
Shackleton Mountains	0	3	0	0	3
Ellsworth Mountains					
Sentinel Range	4	3	0	0	7
Heritage Range	4	3	0	0	7

Discussion

Soils in relatively moist coastal areas of the Transantarctic mountains are dominated by Haplorthels as precipitation recharges soil moisture lost through evaporation and as a consequence ice-cemented permafrost occurs at a depth of <70 cm. In contrast, in drier inland areas ice-cemented permafrost is not recharged, and depth to ice-cemented permafrost increases with age leading to Anhyorthels where depth to ice-cement exceeds 70 cm. Lithic Subgroups occur predominantly on steeper land or where high wind speed facilitates removal of shattered rock material.

The nature of fourth-order reconnaissance soil mapping does not allow accurate spatial depiction of, for example, "A Zonal" soils such as Salic Subgroups associated with evaporite deposits marginal to small lakes or Nitric Subgroups associated with remnants of old till deposits.

The electronic version of the map can be considered to be work in progress which can be updated (as funds allow) whenever researchers have improved soil information covering a significant area.

This reconnaissance soil map of the Transantarctic Mountains contributes to an aim of the Antarctic and Sub-Antarctic Permafrost, Soils and Periglacial Environments Group (ANTPAS) to produce an Antarctic-wide soil map similar to that of the Arctic region. The soil map will provide data useful to climate change scenarios and researchers requiring underpinning soil data to spatially regionalise research results. It will also contribute to Antarctic Environmental Domain analyses by allowing input of a further data layer into current analyses.

In future, soil polygons could be refined, minimum polygon size reduced and tagged with results from chemical and/or physical analyses so single factor maps for a range of soil properties can be produced quickly.

Summary

A 5th order reconnaissance soil map of ice-free areas of the Transantarctic Mountains from Northern Victoria Land to the Shackleton Range has been compiled. Soils were classified to Subgroup level using USDA Soil Taxonomy. Soils in relatively moist coastal areas of the Transantarctic mountains are dominated by Haplorthels as precipitation recharges soil moisture lost through evaporation. As a consequence ice-cemented permafrost occurs at a depth of <70 cm. In contrast, in drier inland areas ice-cemented permafrost is not recharged and depth to ice-cemented permafrost increases with age, leading to Anhyorthels where depth to ice-cement exceeds 70 cm. Lithic Subgroups occur predominantly on steeper land or where high wind speed facilitates removal of shattered rock material. The electronic version of the map can be considered to be work in progress that can be updated whenever researchers have improved soil information covering a significant area.

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