Effects of hydrocarbon contaminants on the temperature and moisture regimes of cryosols of the Ross Sea region, Antarctica

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ABSTRACT. Soils in the Ross Sea region of Antarctica are formed in an arid and relatively pristine environment. Hydrocarbon spills occur when fuel oils are moved or stored. We are investigating how the biological, chemical and physical properties of Antarctic soils are impacted by hydrocarbon contamination by comparing the properties of existing oil-contaminated sites with those of nearby controls. Soil samples were collected from oil-contaminated, and control sites, at Scott Base (Lithic Haplorthel), the old Marble Point Camp (Glacic and Typic Haplorthel), and Bull Pass in the Wright Valley (Typic Anhyorthel). Hydrocarbon levels were elevated in fuel-contaminated samples. Chemical characterisation of hydrocarbons at spill sites identified predominantly *n*-alkanes with lesser amounts of polyaromatic hydrocarbons.

Climate stations were installed at all three locations. The climate stations continuously measure a number of parameters including: soil moisture and temperature at a number of depths; solar radiation; wind speed and direction; air temperature; relative humidity; and soil electrical conductivity. Soil surface temperatures intermittently above 0° C were recorded at all three sites from October through to February, with soil temperatures of > +18° C recorded in December/January, even though air temperatures rarely exceeded +2° C. Of the three sites, Bull Pass was warmest in summer and coldest in winter, while Scott Base was the windiest site and the coolest in summer. Soil surface temperatures in summer fine weather were generally 1—2 ° C warmer, and sometimes more than 7° C warmer, at the Scott Base and Marble Point hydrocarbon-contaminated sites than their respective control sites. The increased temperature extended at least 20 cm into the soil at both sites. It is likely that the increased temperatures are the result of decreased albedo, and possibly some increase in thermal conductivity as a result of the presence of hydrocarbons. Some of the hydrocarbon contaminated soils were weakly hydrophobic, whereas the control soils did not exhibit any hydrophobicity. Total soil available water capacity was low and reported field soil moisture contents are often lower than the moisture content at 1500 kPa tension.

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Introduction

Soils in the Ross Sea region of Antarctica are formed in an environment of low precipitation and mean annual air temperatures of less than -10° C. Because of the slow rate at which Antarctic soil processes operate, the soils are considered to be particularly susceptible to human-induced damage (Campbell *et al.* 1998a). All human activities in Antarctica depend on fuels for transport and energy, hence the most widespread contaminants are petroleum related (Cripps and Priddle, 1991). At most Antarctic sites where intensive human activity has been undertaken fuel spills have occurred, and they have been reported at most major bases (e.g. Kerry 1990, Tumeo and Wolk 1994, Cripps and Shears 1997, Balks *et al.* 1998, Aislabie *et al.* 1998). Oil contamination of soil was also a consequence of the Dry Valley Drilling Project (Parker and Howard 1977). Hydrocarbons can accumulate in Antarctic soils and migrate into the subsurface (Balks *et al.* 1998), and changes in microbial diversity have been reported at fuel contaminated sites (Aislabie *at al.* 1998). Very little is known of the effects of hydrocarbon contaminants on soil physical properties in Antarctic soils.

The gravimetric moisture content of the active layer of soils in the Ross Sea region of Antarctica is typically between 1 and 10% (Campbell *et al.* 1994, 1997a). There is some seasonal variability at sites where snow-melt has been shown to result in an increase in soil moisture content to values of up to 15% for short periods (up to 14 days, Campbell *et al.* 1997a). Within the underlying permafrost in coastal areas, moisture contents are variable ranging from lenses of ice (100% moisture), to moisture contents of less than 10%, with an average of about 40% (Campbell *et al.* 1998b). In dry inland areas soil moisture contents, in both the permafrost and the active layer are generally less than 10%. Moisture retention in