Chinese Journal of Polar Science, Vol. 16, No. 1, 55 – 58, June 2005

Evidence for warmer event from quartz grains in the soil of Grove Mountains, East Antarctica

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Received April 15, 2005

Abstract The cold desert soil has been discovered at first time in southern ridge of Mount Harding, Grove Mountains of interior East Antarctica Ice Sheet. Based on the micro structural observation, dominant characteristics of quartz grains include: distinct surface stria and fractures, and clean features of frost action at both of crystal margins and micro crannies of quartz grains. These features show a pedogenesis environment of few water, short transportation and frost action, revealing a warmer climatic event existed in this region.

Key words Grove Mountains, soil, quartz.

1 Introduction

The southern polar region has the Earth's coldest climate, primarily because of both high latitudes and altitude in comparison with the Arctic region. Antarctic soils have been widely studied since 1950s and 1960s in Antarctic peninsula and Transantarctic mountains (Tedrow and Ugolini 1966; Campbell and Glaridge 1969; McCraw 1967). It indicated the existence of special soil processes in the frigid and arid Antarctic environment. The soils in inland east Antarctic have never been discovered because of extremely environment during the past half century. In 1998 – 1999 austral summer, the 15th Chinese Antarctic Research Expedition (CHINARE 15th) teams entered into the Grove Mountains, interior East Antarctica Ice Sheet, and found many spots of soil.

The Grove Mountains, including 64 nunataks distributed in about 3200 km^2, is situated on the Princess Elizabeth land (72°20′– 73°10′S, 73°50′– 75°40′E), inland of ice sheet of east Antarctica. It is about 450 km south from Chinese Zhongshan Station (69°22′ S, 76°22′E). The Grove mountains are attributed to east Antarctic inland plateau climate zone, with less precipitation and extreme lower temperature.

The soil spots have been founded on the southern slope of Mount Harding in central part of the Grove Mountains. It is the first case that soils are discovered in the interior East Antarctica Ice Sheet, which is still highlight in Antarctic soil study. The main features of the soil include abundant water-soluble salts, slightly acid and negligible organic matter content (Li *et al*. 2003).

2 Experimental procedure

2.1 Specimen preparation

About 3 g of quartz grains (±0.25 mm in diameter) were sieved from sample, they were boiled in dilute hydrochloric acid for 10 minutes and washed in distilled water and drying it. Selected with microscope, tens of these quartz grains then were adhered line up parallel on the electroconductive paper.

2.2 Scanning Electron Microscope (SEM) condition

These grains were observed with the LEO-1450 VP scanning electron microscope (SEM), with variable pressure condition, the degree of vacuum is 1×10^{-4} T. The quartz grains were not mounted electro-conductive coating. The pedogenesis mechanism of Antarctic soil processes were studied by some special micro textures of these quartz grains which differentiated from other regions (Zhang and Yang 1999).

3 Result and discussion

All the micro textures indicate that the soil were eroded by wind, frost, and experienced short-distance transport by melted water. Photo 1 and 2 show the rounded aeolian quartz grains, and the polished surface contained percussion cracks and scrapes caused by wind occasionally. Photo 3 and 4 show scrapes and fractures. The shape of the quartz grains is often angular, with sharp ridges and edges (Xie 2000). The conchoidal fractures of large grains indicated that the soil parents are originated from the weathering of the base rocks upstream of soils, suffered of short-distance transport by melted water. The photo 5 and 6 indicate that these soils experienced physical weathering such as frost action. Under the processes of freezing and unfreezing again, some ice wedges occur in the surface micro-crevice of quartz crystalline, which damage the shape of texture of quartz grain greatly.

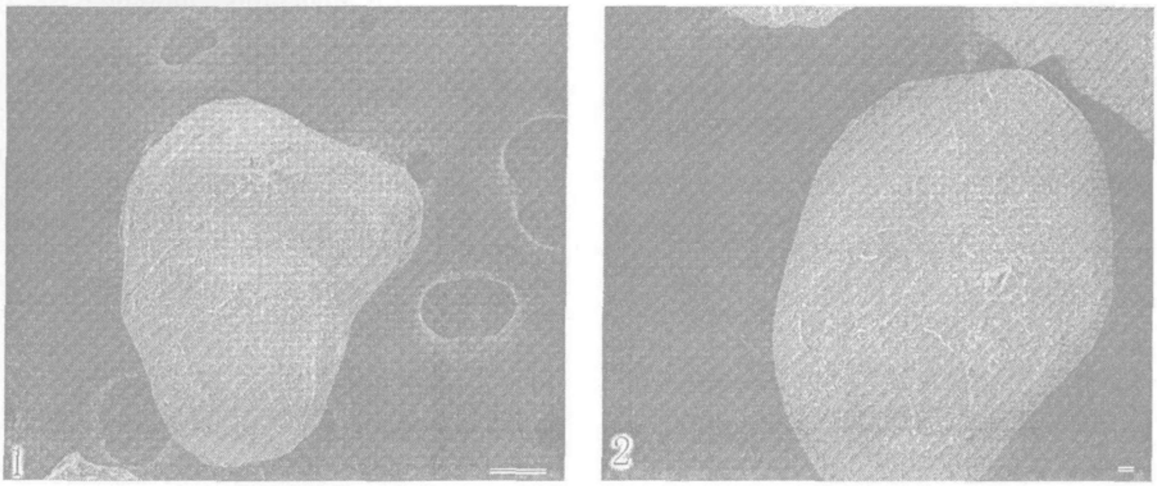

Fig. 1,2 Image of aeolian quartz grains. (Pho. 1 Bar = 100 μm, Pho. 2 Bar = 20 μm)

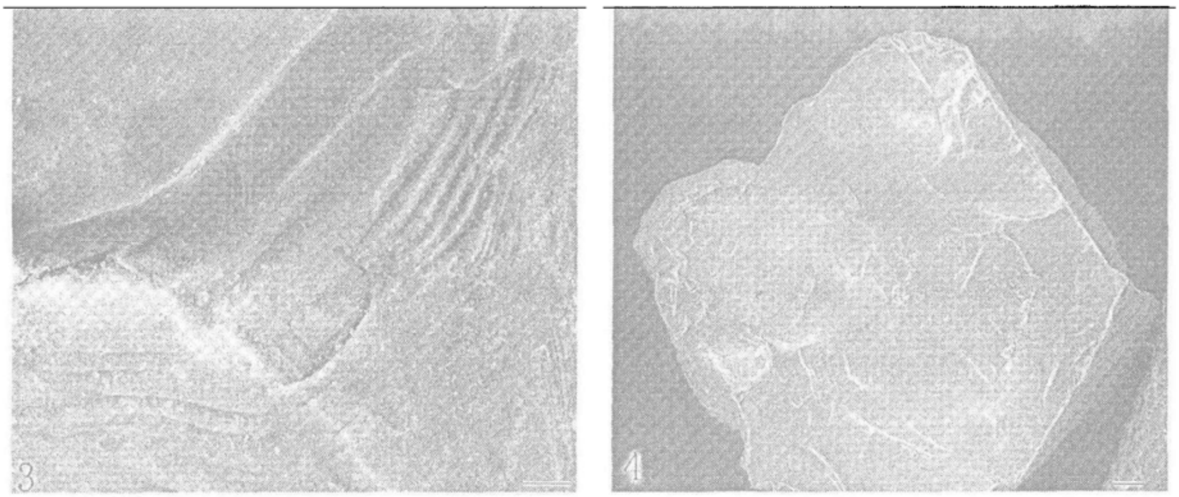

Fig. 3 ,4 Image of quartz grains with stria and fractures(Bar = 20 μm)

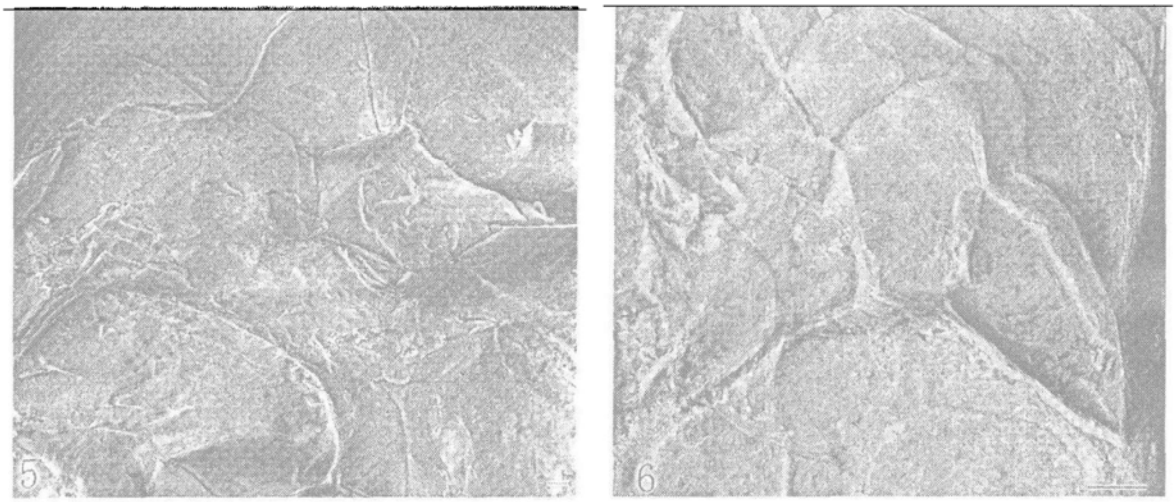

Fig. 5 ,6 Image of quartz grains suffered frost action(Fig. 5 Bar = 20 μm , Pho. 6 Bar = 10 μm)

These quartz grain's micro textures and grain shapes suggest that the sands are mainly originated from sheet flow deposit, and partly from aeolian origin. The soils of Grove Mountains developed on slopes of the nunataks, have not been experienced alpine glaciation. The soils parents originated from the weathering materials of the base rocks. The highest temperature during austral summer in Grove Mountains is less minor 10 ℃, it is therefore reflected that the temperature was much warmer at one time than today, resulted in the formation of soils. The existence of these soils reveals also the fluctuation of ice sheet surface should not be acue after the soils have been formed in this region, because the ice sheet surface did not reach the latitude of soil sites, even during the Last Glacial Maximum, so the soils have been preserved until today.

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