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Provenance and depositional environment of epi-shelf lake sediment from Schirmacher Oasis, East Antarctica, vis-à-vis scanning electron microscopy of quartz grain, size distribution and chemical parameters

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Abstract

The scientific study of quartz grains is a powerful tool in deciphering the depositional environment and mode of transportation of sediments, and ultimately the origin and classification of sediments. Surface microfeatures, angularity, chemical features, and grain-size analysis of quartz grains, collectively reveal the sedimentary and physicochemical processes that acted on the grains during different stages of their geological history. Here, we apply scanning electron microscopic (SEM) analysis to evaluating the sedimentary provenance, modes of transport, weathering characteristics, alteration, and sedimentary environment of selected detrital quartz grains from the peripheral part of two epi-shelf lakes (ESL-1 and ESL-2) of the Schirmacher Oasis of East Antarctica. Our study reveals that different styles of physical weathering, erosive signatures, and chemical precipitation variably affected these quartz grains before final deposition as lake sediments. Statistical analysis (central tendencies, sorting, skewness, and kurtosis) indicates that these quartz-bearing sediments are poorly sorted glaciofluvial sediments. Saltation and suspension seem to have been the two dominant modes of transportation, and chemical analysis of these sediments indicates a gneissic provenance.

Keywords: Scanning electron microscopy; Glaciofluvial; Aeolian; Epi-shelf Lake; Schirmacher Oasis

1. Introduction

The Schirmacher Oasis is a ~34 km^2, ice-free area along the Princess Astrid Coast in Dronning Maud Land, East Antarctica. In this oasis, the exposed bedrock geology comprises part of a poly-metamorphosed terrain, in which Proterozoic granulite facies rocks have been overprinted by an upper amphibolite tectonothermal event (Ravikant and Kundu, 1998). The most extensive basement lithounit of the Schirmacher Oasis is an amphibolite facies biotite-, hornblende-, and garnet-bearing quartz-ofeldspathic gneiss. The Schirmacher Oasis forms a relatively narrow E–W trending belt of exposed

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bedrock, and is flanked to the south by the East Antarctic Ice Sheet (EAIS), and to the north by a huge ice shelf dotted with a number of epi-shelf lakes and bays (Fig. 1). These lakes are connected with ocean that lies beneath the ice shelf, and are frequently subjected to tidal influences.

In this paper, we present the results of a detailed investigation of sediment characteristics of lake deposits sampled from epi-shelf lakes (ESL-1 and ESL-2) situated at the northern edge of the Schirmacher Oasis (Fig. 1). These two lakes are amongst the larger epi-shelf lakes of this region, and also represent parts of larger catchment areas linked with drainage of the Schirmacher Oasis (Fig. 1). We present the results of chemical analysis of bulk sediment samples (i.e., determination of major oxide and trace element compositions by X-ray fluorescence (XRF)), Scanning Electron Microscopy (SEM) of selected quartz grains, and determination of grain-size distributions of epi-shelf lake sediments. The results of surface textural analysis of quartz grains (for grain sizes ranging from 1 to 4Φ) and grain-size analysis of sediment samples, are used to identify and distinguish between the various sedimentary processes that affected these detrital grains during transport and sedimentation.

1.1. Previous work

A diverse suite of sediment characteristics covering a wide range of deposit types in Antarctica have been focused on in several previous research studies (e.g., Asthana and Chaturvedi, 1998; Mahaney et al., 1996; Margolis and Kennett, 1971; Shrivastava et al., 2009; Strand et al., 2003; Tulaczyk et al., 1998). Asthana and Chaturvedi (1998) carried out grain-size determinations and morphoscopy studies of modern supraglacial sediments, highlighting the polymodal distribution patterns of sediments. Shrivastava et al. (2009) studied the imprint of climatic fluctuations on quartz grains from lake sediments, observing glacial, glaciofluvial, and aeolian effects. Asthana et al. (2009) characterized and highlighted surface microtextures of quartz grains originating from glaciolacustrine sediment cores. In that study, various microtextures were used to document grain damage originating from sediment transport processes, during movement of grains from inland ice and eventually into the landlocked lakes of the Schirmacher Oasis. The characterization of Antarctic sediments by SEM along with other properties was also carried out in several of these previous studies (Mahaney et al., 1996; Margolis and Kennett, 1971; Strand et al., 2003; Tulaczyk et al., 1998). In the present study, emphasis has been placed on SEM imaging, determination of grain-size distribution patterns, and measurement of chemical compositions of representative samples of epi-shelf lake sediments.

2. Methodology

A total of eight sediment samples were collected from two different epi-shelf lakes named ESL-1 and ESL-2. These sediment samples were then macerated in hydrogen peroxide and acetic acid separately to remove organic matter and carbonate respectively, before rinsing it 3−4 times with distilled water to make

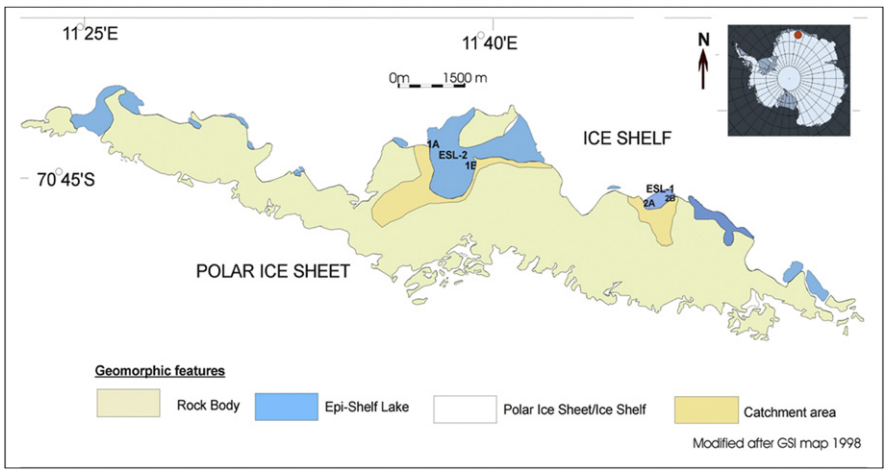

Fig. 1. Location map of epi-shelf lakes and their approximate catchment areas within the Schirmacher Oasis of East Antarctica. The locations where sediment samples were collected from two epi-shelf lakes (ESL-1 and ESL-2) in this study are also highlighted.