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A Subglacial Topographic Model of the Southern Drainage Area of the Lambert Glacier/Amery Ice Shelf System – Results of an Airborne Ice Thickness Survey South of the Prince Charles Mountains

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Abstract - The overall aim of the PCMEGA expedition (Prince Charles Mountains expedition of Germany and Australia) during the Antarctic season 2002/03 was to characterise the principal Precambrian crustal blocks in the ice-covered area extending south of 73°S within the Lambert Glacier basin in East Antarctica, by conducting a wide-scale airborne geophysical survey. One principal objective for airborne geophysics was to provide basic topographic data of the ice-covered morphological structures by using an ice penetrating radar. A dense grid of flight lines spaced 5 km apart and a total length of 30 000 km were flown covering an area of approximately 100 000 km². A 150 MHz pulse radar was used to measure the ice thickness along the flight lines. Based on all data acquired in the southern part of the drainage system of the Lambert Glacier/Amery Ice Shelf system, maps of ice thickness and bedrock elevation were compiled after data processing. Maximum thickness of the ice exceeded more than 3600 m, the maximum range of the radar. The remarkably deep graben structure of the drainage basin can be followed to 77.5°S, where it bends to the west. The subglacial relief between the grounding line at 73.2°S and the southernmost border of the survey area at 77.5°S is characterised by steep graben flanks with a relief of more than 2000 m. The bottom of the deep graben structure deepens from 600 m b.s.l. in the south to 2500 m b.s.l. close to the grounding line. A 3-dimensional sub-ice topographic model is compiled, which provides a much more detailed data set for the Lambert Glacier basin then the BEDMAP model.

INTRODUCTION

The Lambert Glacier–Amery Ice Shelf system is located between 68.5°S and 81°S latitude and 40°E and 95°E longitude (Fig. 1). It is the largest ice drainage system in Antarctica and accounts for 1.6 x 10^6 km², which represents 16% of the total area of grounded ice in East Antarctica (Rignot & Thomas, 2002). The ice of this basin drains through the narrow and deep Lambert Graben to the front of the Amery ice shelf, representing only 1.7% of the East Antarctic coast line, with a very strong flow convergence and acceleration as the ice approaches the coast. Due to these unique features, the Lambert Glacier–Amery Ice Shelf system is of special importance for ice sheet stability and mass balance studies of East Antarctica.

The Lambert Graben, which hosts this large outflow glacier system, is regarded as one of the most important crustal-scale structures in the geological inventory of East Antarctica. It extends inland for at least 700 km to a latitude of ~75°S, and is inferred to represent a failed rift emanating from a triple point or four armed junction (Stagg, 1985). However, the details of the crustal structure, the sub-glacial topography within the Lambert Glacier Drainage Basin (LGDB) and the southern extension of the Lambert Graben are largely unknown.

The major goal of an extensive airborne geophysical survey conducted during the PCMEGA 2002/03 campaign was to develop a model of the deeper crust for the area in order to study the main Precambrian crustal blocks (Damaske et al., 2004). The aeromagnetic and gravity results have been discussed in Damaske & McLean (2005) and McLean & Reitmayr (2005). This paper presents the methodology and results of the ice penetrating radar survey, which provide the best data set available so far for the LGDB area. In addition to providing a detailed assessment of sub-ice morphology, the resulting 3-dimensional sub-ice topographic model allows an ice thickness correction for the acquired airborne gravity data and provide the basis for subsequent glaciological studies.

PREVIOUS ICE THICKNESS SURVEYS IN THE AREA

There are dense grid airborne datasets available from the northern part of the LGDB acquired during the Soviet Antarctic Expedition (SAE35) 1989/90 and Russian Antarctic Expedition (RAE39) 1994/95 (Lythe et al., 2001), but the area south of 73°S has only been sparsely covered by ice penetrating radar surveys in the past. Figure 2 shows the tracks for