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Due to a printer's error (fig.2 on page 318 is upside down), pages 317 and 318 have been reprinted and is sent to you with apologies for any inconvenience this may have caused.

Using multiple data sources to enhance photogrammetry for mapping antarctic terrain

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Extensive aerial photography cover is available for parts of the British Antarctic Territory, but the characteristics of the photography, combined with the sparsity of ground control information and rugged snow-covered terrain, make photogrammetric mapping techniques difficult to apply. This paper shows, by reference to a new 1:50,000 scale topographic map of part of the Antarctic Peninsula, how merging topographic data from various sources in a GIS environment can make photogrammetric mapping more effective. Information sources used in the map compilation include three types of aerial photography, geo-referenced satellite imagery, surveyed points in a control network and satellite image-derived control points. A shape-from-shading algorithm was used to generate contours for snowfields where absence of surface detail prevented photogrammetric contouring. A horizontal and vertical accuracy of better than ±5 m was achieved in orientation of photography covering almost all of the map area. Such errors have allowed the construction of an accurate large-scale map for an area where previous mapping had been restricted to medium and small scales.

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Introduction

Despite extensive aerial photography cover of parts of the British Antarctic Territory (BAT), rigorous photogrammetric compilation of large-scale topographic maps is precluded for many areas because of inadequate ground control. The acquisition of comprehensive new geodetic data is unlikely, even with the application of GPS survey techniques in BAT, due to the large areas to be covered, difficult access and severe climate. Furthermore, the polar terrain can make photogrammetric techniques difficult to apply. For example, problems are encountered during the construction of photogrammetric blocks across large snowfields where suitable pass-point features are absent; plotting contours on snow-covered areas is difficult because of insufficient surface detail for stereo-matching; areas of dead ground on the photographs, due to the rugged terrain and low flying heights, are common. These difficulties have hindered large-scale topographic mapping of BAT in the past, and the largest scale maps available with any extensive coverage are at 1:250,000 scale.

To enable the compilation of high quality, large-scale maps it is necessary to develop methods for more effective use of aerial photography. Regarding digital, photogrammetrically derived topographic data simply as "3-D digitising" (rather than as the principal map compilation material) allows the merging of photogrammetric map data with other remote sensing data sources within a GIS environment. In referring to the compilation of a 1:50,000 scale map of Wright Peninsula (BAS SCISTAMAP Series, sheet 1B), this paper shows how merging several data sources can enhance photogrammetric techniques and enable map compilation for an area where effective topographic mapping would not otherwise be possible. It is hoped that the techniques discussed may have wider application in other areas which present similar obstacles to large-scale topographic mapping.

Description of project

Wright Peninsula is an ice-covered peninsula on the eastern side of Adelaide Island, BAT (Figs. 1 and 2). Rothera, the main British Antarctic Survey (BAS) research station on the Antarctic Peninsula, is situated on a low, rocky promontory at the southeastern tip of Wright Peninsula. The

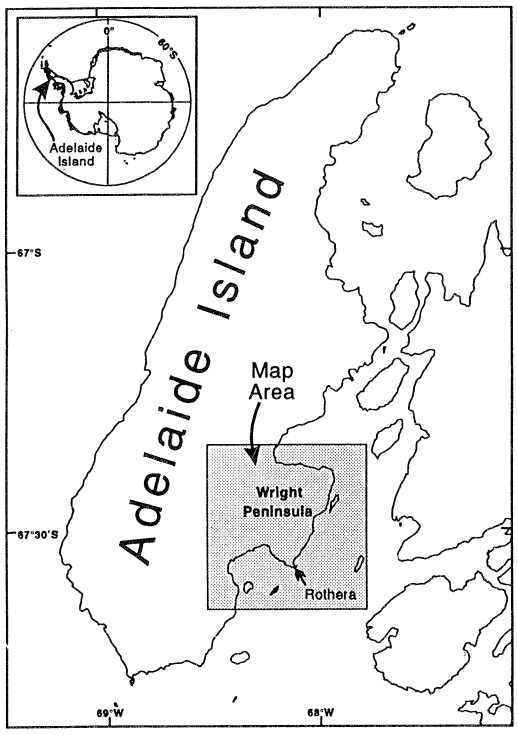

Fig. 1. Wright Peninsula on the eastern side of Adelaide Island, showing the area covered by BAS SCISTAMAP Series, sheet 1B.

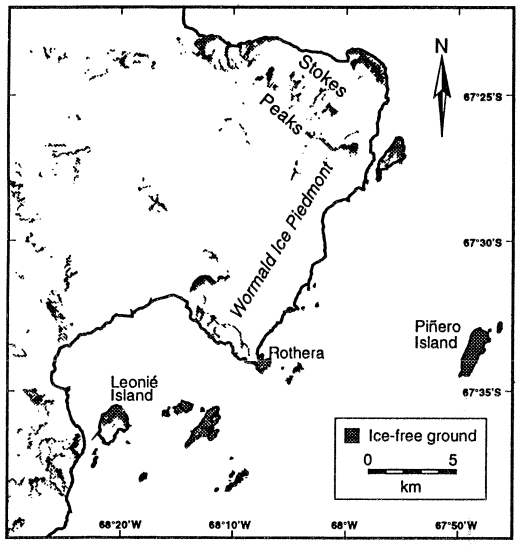

Fig. 2. Wright Peninsula, showing features within the map area.

majority of the area is open snowfield, rising from sea level to about 300 m, but isolated nunataks reach an elevation of more than 400 m. The terrain rises steeply to more than 1950 m to the west and more than 750 m to the north. There are many heavily crevassed areas.

The most detailed existing map of the area was compiled at 1:250,000 scale from hard-copy satellite imagery and is published as part of the SCAR Antarctic Digital Database (BAS, SPRI, & WCMC, 1993). A 1:50,000 scale topographic map was needed to support fieldwork on Wright Peninsula and the offshore islands, and as a travel map for safe access from Rothera research station to the rest of Adelaide Island.

Data

The data available for this map are from the following four sources:

The map area is relatively well surveyed due to the proximity of Adelaide base, an old BAS station at the southern end of Adelaide Island. The map contains eight points with both plan and height coordinates from the BAT triangulation/trilateration network. For historical reasons this survey network developed as a number of small networks local to bases operating during the 1950s and 1960s. These small networks have since been linked together by tellurometry and the whole adjusted to fit thirteen Geoceiver positions acquired in 1975/76 and 1977/78 (Renner 1982; Sturgeon & Renner 1983). The RMS residual error after this adjustment was ±11 m (Knight 1988; unpubl. rep. ES2 EW 300/38, Brit. Antarc. Surv.). GPS re-occupation of old stations (Perkins, 1993, unpubl. rep. AD6/2R/1992/L2, Brit. Antarc. Surv.) and residuals from aerotriangulation work show that local clusters surveyed together, such as the points in the Wright Peninsula area, may have a relative accuracy of ±5 m.

Small-scale aerial photographs were acquired by the Institut für Angewandte Geodäsie (IfAG), Frankfurt, as part of a collaborative project with BAS, 10–19 February 1989. The photography was flown at an altitude of 6,000 m using a Zeiss RMK camera with a super-wide-angle lens (focal length [f] = 85.5 mm), giving a nominal photo-scale of 1:70,000. The survey was flown with 80% endlap. The Wright Peninsula map area is covered by a block of 11 models (stereo-pairs) on three strips (5 + 5 + 1).