CHAPTER V RESULTS OF THE FIELD MEASUREMENTS

The field campaign on Commonwealth Glacier lasted from January 19 to 26 and on Howard Glacier on January 27, 1999. Two SAR images were acquired: an ERS-2 on January 15 (Figure 5.1), and a Radarsat on January 19, 1999 (Figure 5.2). During this time the weather and the surface conditions of the glaciers did not vary. Along with the data collected specifically for this investigation, the LTER data collection of snow pit and stake measurements is also utilized (Appendix A). During the 1999 field season Paul Langevin made the mass balance measurements at the stakes. These data include snow layer thickness, mass, density and crystal structure.

Imagery.

The ERS-2 image is a high-resolution image with 12.5 m pixel spacing, and with VV polarization (Figure 5.1). The average incidence angle of the SAR beam was 23.1°, pixel spacing was 12.5 m, yielding 30 m resolution, and covering a

108 km² area. The image covers a small slice of Taylor Valley fortunately including all of Commonwealth Glacier. Unfortunately, almost all of Taylor Valley including Howard Glacier is off the image (Figure 5.3). The glaciers are identified on the SAR image by the shape, darker ablation area, and bright accumulation area. Lake Vanda is the only ice covered lake visible and is a middle-gray surrounded by dark bare earth (Figure 5.1).

Radarsat. The Radarsat image is a ScanSAR image with 50 m pixel spacing, and HH polarization (Figure 5.2). The average incidence angle of the SAR beam was 35°, pixel spacing was 50 m, yielding 75 m resolution, and covering a 512 km square area. The image includes the East Antarctic Ice Sheet, Ross Island, the McMurdo Dry Valleys including Taylor Valley, and Drygalski Ice Tongue. Glaciers are identifiable on the image, but because of the large pixel size, smaller glaciers like Howard require familiarity of the area to identify. Like the ERS-2 image, the (large) glaciers show flow lines (Drygalski Glacier), darker ablation areas, and bright accumulation areas. The Ross Sea is the darkest area of the image and bare earth a dark gray.

Transects.

<u>Commonwealth Glacier</u>. The ice roughness between the measurements perpendicular and parallel to the SAR beam is very similar and they correlate at $R^2 = 0.8$ because of this, the orientation of the measurements are disregarded and the roughness measurements pooled. Standard deviation of roughness ranged from 0.7 to about 3 cm (Figure 5.4).

On both glaciers, I observed dune-like formations of snow that ranged from $0.10 \text{ to } 100 \text{ m}^2$ in area and 4-48 cm deep. Because of their frequent flat-topped and steep sided edges, I called them called "snow tables" (Figure 5.5). Areal coverage of snow tables ranged from 10 to 50% (Figure 5.4), and the snow depths averaged 12 cm. Ice roughness and snow table coverage generally followed a similar pattern of roughness (Figure 5.4).

Areal coverage (density) of cryoconite holes (Figure 5.6) varied 0-10% (Figure 5.4), with depths to the exposed ice bottom averaging 14.4 cm deep with a maximum of 28 cm (Appendix B). The bottoms of the holes frequently contained a layer of sediment. The sediment, absorbing sufficient solar heat to melt ice, forms pools of water (Wharton et al., 1985). Many cryoconite holes had re-frozen caps, and because of this, I could not measure these depths (Appendix B). The cryoconite holes were difficult to spot because some were covered with snow and some of the ice caps were difficult to distinguish from the surrounding glacier ice.

Near-surface snow temperature measured as low as -3.7° , averaging -2.1° , and ice temperature as low as -3.5° , averaging -1.6° C (Appendix B). Air temperature was measured at the beginning of each day and ranged from -2.2 to -1.3° C.

The snowline on the transect began just below transect site #12 (T12) with an average snow depth of 15.3 cm and the maximum average depth on the transect measured at T16 of 67.6 cm (Figure 5.7). The snowline is an ambiguous demarcation: ascending the glacier snow patches become more-and-more frequent until the ice surface is completely ice covered. The snowline is defined in this study where the fraction of the ice surface is at least 90% covered by snow. Ascending the glacier, snow patches on the ice become more frequent, until they begin to merge, isolating ice patches until the surface is completely snow-covered. The transition at the snowline is much like M. C. Escher's "Sky and Water" woodblock print, where a black sea of fish (ice) transforms into a white sky of geese (snow) (Figure 5.8).

I dug snow pits at T12, and T9 (Figure 5.9). Depth of the layers, snow crystal descriptions, and hardness were recorded (Appendix B). Snow grains were separated into six categories: facets, rounds, wind crust, honeycomb, broken stellar, and hoar. Densities of the layers were not determined. At sites T13, T15, and T16 hard layers were noted as the rod was pushed through the snow to glacier ice and these depths recorded as layers (Figure 5.10). The snow was dry and ranged from fluffy and loose to a consistency of Styrofoam. I judged the snow to be dry by the look and feel and the fact that no melt on the snow, or the ice (which has a higher albedo and should melt first) was observed. The hard layers were wind-compacted snow or thin (1-2 cm) ice crusts.

<u>Howard Glacier</u>. My data collection was less extensive on Howard Glacier. Percent coverage (of ice, snow, snow tables, and cryoconite holes), snow depth, and roughness were recorded (Figure 5.5f, Table 5.1). I only collected five sample sites because the transect quickly entered deep snow (Figure 5.11). Site 1 and 2 are in the ablation zone, site 3 is just above the snowline, site 4, and 5 were in the accumulation zone. Ice roughness averaged 2.0-4.5 cm and ice temperatures were not recorded.

| Site | Distance (m) | Percent cover | Percent cover | Snow depth |
|--------------|--------------|---------------|------------------|------------|
| | | of snow | cryoconite holes | (cm) |
| 1 (Stake 31) | 0 | 5 | 15 | 0 |
| 2 (Stake 30) | 800 | 75 | 2 | 4.5 |
| 3 | 1200 | 100 | — | 10 |
| 4 | 1300 | 100 | — | 24.8 |
| 5 | 1600 | 100 | | 40.7 |

Table 5.1: Cover and snow depth at sites near the snowline.