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Geophysical Survey at Talos Dome (East Antarctica)

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INTRODUCTION

Talos Dome is an ice dome on the edge of the East Antarctic plateau (Fig. 1), about 290 km from the Southern Ocean and 250 km from the Ross Sea. It is adjacent to the Victoria Land mountains and overlies the eastern margin of the Wilkes Subglacial Basin. To the West, an ice saddle (2260 m) divides the Dome from an ice ridge coming from Dome C. Ice flows south-eastward from this ridge into outlet glaciers (Priestley, Reeves and David Glaciers) which drain into the Ross Sea, and north-westward into the Rennick and Matusevich Glaciers which drain into the Southern Ocean. Another ice ridge trends northward from the Dome, passing behind the USARP Mountain.

As part of the ITASE project, two traverse surveys were carried out in the Talos Dome area in November 1996 (Frezzotti et al., 1998) and January 2002 (Frezzotti et al., this volume). Airborne radar surveys were conducted in 1997, 1999 and 2001. Research aimed to better understand the latitudinal (North-South) and longitudinal (East-West) gradient along two East-West (Talos Dome - D66) and North-South (GV7 - Talos Dome - Taylor Dome) transepts, documenting climatic, atmospheric and surface conditions in the Talos Dome area and northern Victoria Land throughout the last 200-1000 years. The study of the Talos Dome area aimed to find the best location to extract an ice core down to the bedrock.

Six shallow snow-firn cores (two during 1996 and four during 2001-02), up to 90 m deep, were drilled in the Talos Dome area. An eight century-long record of volcanic signal and climatic change was obtained at Talos Dome through geochemical analysis of the deepest core (TD, 90 m deep), drilled in 1996 (Becagli et al., 2003; Narcisi et al., 2001; Stenni et al., 2002). The core was dated through seasonal variations in nss SO_4^{2-} concentrations coupled with the recognition of tritium marker level (1965-66) and the nss SO_4^{2-} spikes attributed to the most important historical volcanic events (Pinatubo 1991, Agung 1963, Krakatoa 1883, Tambora 1815, Kuwae 1452, Unknown 1259).

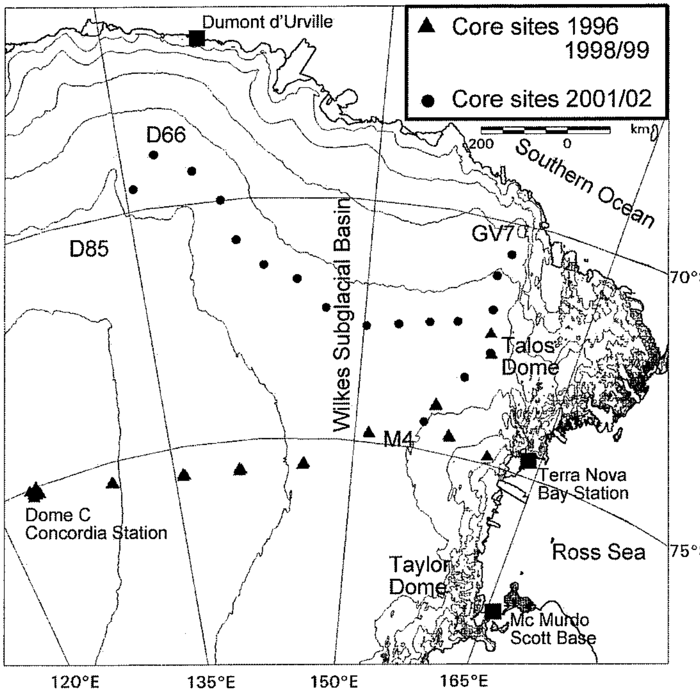

Fig. 1 – Schematic map of Talos Dome. ITASE 1996, 1998/99, 2001/02 firn core location.

RESULTS AND DISCUSSION

Talos Dome morphological feature was delineated by Drewry (1983). ERS-1 Radar Altimeter data (Rémy et al., 1999) located the dome at 159°04'E 72°46'S (Frezzotti et al., 1998). A new plano-altimetric map of the Talos Dome area (Fig. 2) was drawn up from 2002 kinematic GPS data (450 km). According to this map, the Dome culmination (2318.5 m) is located about 1.5 km North of the previous ERS-1 position. A temperature of -41.0°C was recorded at a depth of 15 m at Talos Dome (Frezzotti et al., 1998). Figure 3 shows firn temperatures at depths of 10-15 m, collected during the traverses, plotted against elevation. Temperature strongly correlates with the surface elevation and the decrease in temperature with elevation shows a super-adiabatic lapse rate (2.5°C 100 m^{-1}) along the ice divide between Talos Dome and the Southern Ocean coast (GV7). The -10 m temperature at Taylor Dome follows the same super adiabatic lapse rate between GV7 and TD. Along the traverses from Terra Nova and Dumont d'Urville to Dome C (Frezzotti & Flora, 2002) we observed a near-dry-adiabatic lapse rate (about 1.0°C 100 m^{-1}) with good correlation ($R^2 = 0.98$). These data are quite different from the sub-adiabatic lapse rate (0.5°C 100 m^{-1}) calculated by Stenni et al. (2000) using 10 m core temperatures for the mountain areas of Victoria Land. The super-adiabatic lapse rate calculated along the Talos Dome ice divide suggests prevailing calm conditions with a strong temperature inversion during the winter season, while wind turbulence mixes the inversion layer along the Terra Nova Bay-Dome C and Dumont d'Urville - Dome C traverses. A stakes farm (40 poles) was installed during 2002 and an Automatic Weather Station with snow sensor will be installed during the next season in order to characterise spatial and temporal variability and covariance of snow precipitation on local and seasonal scales.

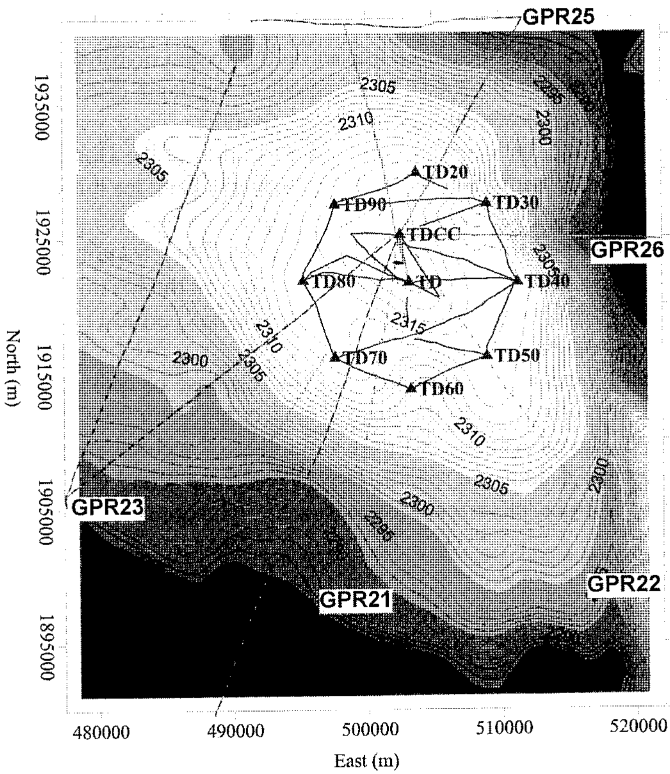

Fig. 2 – New plano-altimetric map of the Talos Dome area and GPS GPR profile.

The surface strain network of nine stakes was measured using GPS in November 1996, December 1998 and January 2002. The network centre is located at the deepest core site (TD), centre of the topographic Dome obtained by ERS-1 radar altimeter data provided by Rémy et al. (1999). In order to determine the growth or shrinkage of the Dome, in 2002 a submerge velocity system was installed and measured using GPS. Preliminary data indicates that ice at the TD core site moves SSE a few centimetres per year. The other stakes move radially with velocities from 12 to 36 cm a^{-1}. The higher velocities are recorded in the steeper parts of the Dome to the South-SW and East-NE.

Airborne radar measurements were carried out on a 70 x 75 km rectangular grid (5250 km^2) centred on the Dome area. The data were acquired by means of a radar system operating at 60 MHz frequency (Tabacco et al., 1999; Frezzotti et al., 2000). Results indicate that the bedrock, at the Talos Dome summit, is about 820 m (WGS84) in elevation and is covered by 1500 m of ice. The Dome is situated above relatively flat bedrock; about 30 km to the NE, it is bordered by the NW-SE parallel sharp ridge of the Transantarctic Mountain.

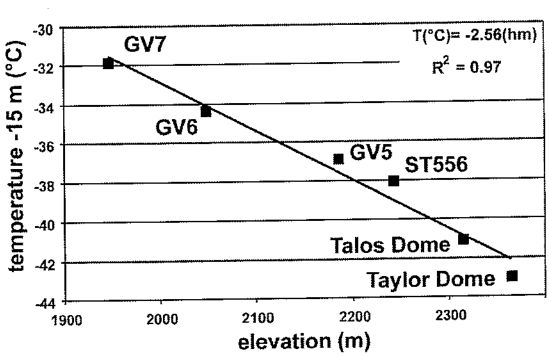

Fig. 3 – Temperatures in firn at depths of 10-15 m as a function of ice sheet elevation. The line shows the linear regression of data.

Three hundred kilometres of snow radar (GPR) and GPS surveys were performed in order to link core sites and obtain detailed information on the spatial variability of snow accumulation and topography. Preliminary analysis of snow radar and GPS data shows that the internal layering is continuous and horizontal up to 15 km from the Dome. The undulated internal layering of the steeper eastern areas (GPR26 and

GPR25) results from the interaction between snow surfaces and winds. Subtle variations in surface slope in the direction of winds have a considerable impact on the spatial distribution of snow over short and long distances (Frezzotti et al., 2002). The analysis of the depth distribution of layers shows that accumulation decreases downwind of the Dome (N-NE).

The combined geophysical surveys allow us to identify the exact location of the Dome and ice divides, the main ice flow directions, variations in the thickness of snow layers, ice thickness and bed morphology.

Talos Dome ice contains a well-preserved record of the palaeoclimate. Snow accumulation (80 kg m^2 a^{-1}) at this site is higher than in other domes in East Antarctica, and the ice thickness (about 1500 m) could provide data covering more than a glacial/interglacial period (150-200 kyr) with a ten-year resolution (Deponti & Maggi, this volume).

Deep drilling at Talos Dome could improve our knowledge of the response of near-coastal sites to climate changes. Moreover, it might provide the history of accumulation rates in the Holocene, constraints on deglaciation, and an estimate of future variability of accumulation and dynamic changes in these sensitive areas. A long ice record from Talos Dome might provide a better understanding of atmospheric and oceanic circulation and ocean teleconnections in the Southern Hemisphere.

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