RADAR STRATIGRAPHY OF THE NORTHERN AND CENTRAL GREENLAND ICE CAP: GROUNDTRUTH FOR SHARAD DATA. M. Di Primio[1], L. Marinangeli[1], [1]International Research School of Planetary Sciences, Università d'Annunzio, V.le Pindaro 42, Pescara, Italy, diprimio@irsps.unich.it

Introduction: The aim of this work is to understand how the ice structure (both in therms of microscopic and macroscopic features) may affects the return of the radar signals, in order to correctly interpret the data of martian ice-caps subsurface acquired with the SHAllow Radar (SHARAD) instrument [7].

Ice penetrating radar measurements of the Greenland ice sheet show internal reflections that highlight changes of the ice composition. As discussed by several authors [1,2,3], the Greenland ice layers can include material of different origin transported by wind; primarly dust of volcanic origin has been clearly identified and related to specific volcanic event. The concentration of these materials in the ice sheet and their composition varies along the sequence, causing changes in the internal permittivity [4,5,6]. In particular, as the impurity compositions changes in the ice, the permittivity and conductivity change, determining different PRC (Power Reflection Coefficient) values and, thus, different internal reflections (i.e. radar layers).

SHARAD data of the polar deposits show similar reflections. As ground-truth is not currently feasible on Mars, we intend to use the available information of the Greenland campaigns to extrapolate information on the ice characteristics of the Mars ice caps. The first step is an integration of the radargram and core analysis of Greenland in order to understand the causes of the radar reflections. The initial result of this work is presented in this paper.

Greenland radar data were acquired by CReSIS using an airborne radar [8]. The radar parameters are: frequency range of 140-160 MHz; nominal aircraft altitude (AGL) of 500 m; bandwidth of 20 MHz; pulse duration of 3 to 10 microseconds linear FM upchirp and vertical resolution (in ice) of 4.2 m. SHARAD is an orbital, chirped radar operating at 20 MHz center frequency (15 meters free-space wavelenght) with 10 MHz bandwidth and 85 µs pulse duration. At these frequencies we can recognize different geologic features and radar facies, that suggest different electrical properties of ice. The analyzed CReSIS profile (acquired on 23rd May 2001) intersects the GRIP (Greenland Ice Sheet Project) ice core, and another radar profile (14th May 1999), intersecting the NGRIP (NorthGRIP) ice core and passing close to the GRIP (Fig.1).

Ice radar stratigraphy: We recognized four different radar facies (Fig.2) based on the CReSIS acquisition and tried to further characterise these units with the core macro and microscopic analysis.

Unit A (GRIP 3029 m – 1750 m / NGRIP 3085 – 1625 m) sits on top the rocky bedrock and is characterized by a small number of reflectors, increasing in reflectivity next to the NGRIP site. These reflectors are discontinuous and are located at the same depth. This unit is divided into three sub-units:

- unit A1 (about 2500-2750 m of depth) that is characterized by absence of reflectors;
- unit A2 (about 2000-2700 m of depth), showing a few continuous and strong reflectors that can be followed for long distance.
- unit A3 (about 2100-1650 m of depth) is characterized by very discontinuous reflectors.

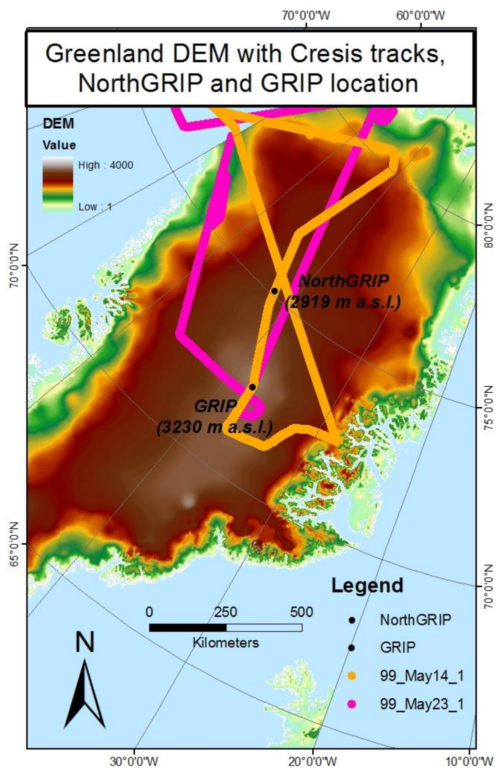

Figure 1. The map shows the location of the GRIP and NGRIP ice cores and the closest CReSIS tracks.

Unit B (about 1650-375 m of depth) shows a change of the radar facies: we can, in fact, recognize continuous and very marked reflectors, changing in thickness and, in some cases, assuming a lenticular shape. The reflectors become thin and closer on the top of this unit. An alternation of bright and dark bands outlines a different power of reflection and it is cyclically repeated along the ice sequence.

This unit can be divided into two sub-units:

- unit B1(about 1650-800 m of depth) characterised by marked reflectors discontinuous at places;
- unit B2 (about 800-375 m of depth) characterized by thinner and very close reflectors.

The unit C (GRIP 375 m – 250 m/NGRIP 375 m – 225 m) is not consistent with a real geologic unit, but it is an artifact, resulting from the Sensitivity Time Control [8], that represents an algorithm of correction of the radar signal.

The unit D (GRIP 250 m – 0 m/NGRIP 225 m – 0 m) seals the radar sequence and is characterized by a stratification weakly defined. This layer is mainly formed by fresh snow.

Direct information about the crystallography and the microstratigraphy of the ice sheet derive from ice cores GRIP and NGRIP [9,10], that can be interpolated with radar data. Generally an increase of the ice grain size is observed with depth, reaching the maximum size of 15 mm at the cores bottom. This trend seems to be sligthly correlated with the radar reflections, though several authors consider the origin of radar reflections in Antartica as mostly due to a transition in crystal fabric [11,12]. Millimetric layering identified with the visual stratigraphy inspection [9] of the core is also under consideration to better define the ice characteristics. The composition of the ice available for the NGRIP will be also considered to better understand the cause of the radar reflections.

Conclusions: Our intent was to characterise the radar reflections using the microscopic information from Greenland cores. Based on our preliminary result, this approach is rather promising and can be used to provide modeling for the radar interpretation of the Polar Layered Deposits (PLD) of Mars.

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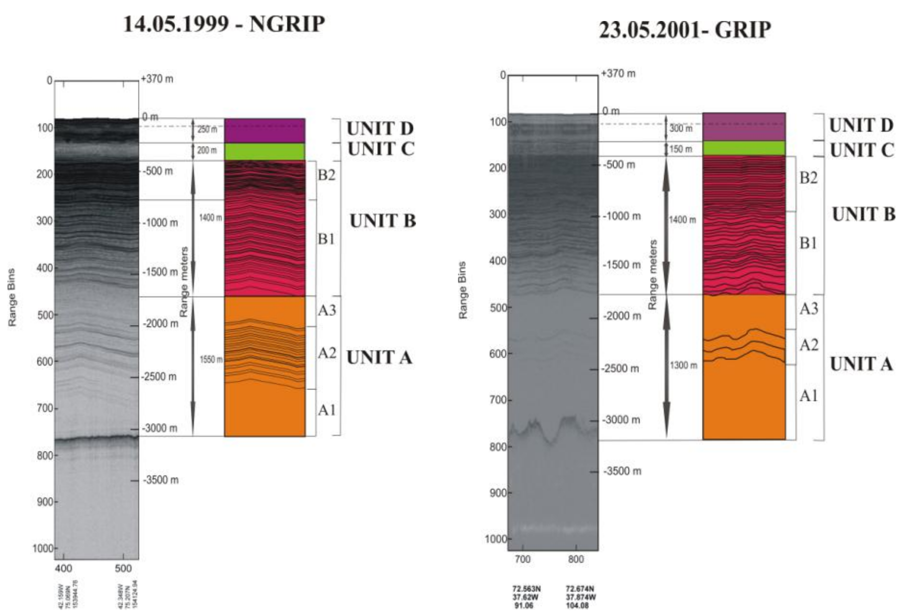

Figure 2. The radar stratigraphy of the Greenland ice sheet observed in the CReSIS radargrams at the GRIP and NGRIP core sites.