EARLIEST ACCUMULATION HISTORY OF THE NORTH POLAR LAYERED DEPOSITS, MARS FROM SHARAD RADAR-FACIES MAPPING. S. Nerozzi[1,2] and J. W. Holt[2], [1]Dipartimento di Scienze Biologiche, Geologiche ed Ambientali, Università di Bologna, Italy (stefano.nerozzi@studio.unibo.it), [2]Institute for Geophysics, Jackson School of Geosciences, University of Texas at Austin (jack@ig.utexas.edu),

Introduction: The north polar layered deposits (NPLD) are the largest accumulation of water ice in the northern hemisphere of Mars, yet little is known about their age or accumulation history. Recent studies of radargrams obtained with the Shallow Radar (SHARAD) onboard Mars Reconnaissance Orbiter revealed the presence of three large-scale stratigraphic sequences bounded by erosional surfaces [1,2] that may represent the key for understanding the accumulation and climate history of the NPLD [3,4].

Detailed stratigraphy of the uppermost layers and their evolution have been studied extensively since the first Mariner 9 images of the NPLD [5]. However, great portions of the polar cap are still unmapped and no detailed studies of the lowermost layered deposits have been performed to date, primarily due to a general lack of visible exposures.

The aim of this study is to use internal radar stratigraphy from SHARAD to reconstruct the first stages of water ice accumulation and climatic changes of Mars. This objective will be achieved by indentifying and mapping radar reflectors and unconformities with the highest detail possible.

Methods and Assumptions: This study involves the tracking of radar reflectors in SHARAD radargrams of the NPLD. Single reflectors are assumed to represent isochron surfaces and to result from changes in the concentrations of dust that significantly alter the dielectric constant [6,7].

A set of 7 horizons was tracked across 400+ radargrams inside a seismic interpretation environment (Landmark DecisionSpace) and after depth conversion with the assumption of a bulk composition equivalent to water ice, thicknesses are calculated for each stratigraphic interval using ArcGIS. Along with the quantitative analysis of derived isopach maps, this study is based on the qualitative comparison of “radar facies” in different locations (Fig. 1). Radar facies are evaluated on the basis of thickness ratios between the 7 mapped layers and relative brightness variations along the same reflectors. The first can be used to identify subtle thickness variations over long distances, while the second is still poorly understood and may depend on the composition of the reflecting layer or properties of the interface. The detailed depositional history extrapolated in this study is then compared with the earliest stages of modeled NPLD accumulation. This model links climate and atmospheric processes to changes in orbital parameters and predicts global ice accumulation [8]. A comparison of the model and SHARAD stratigraphy for the NPLD shows overall consistency [9], but the number and extent of retreat events preserved in SHARAD statigraphy (especially for the earliest NPLD history) has remained a question. This work helps to address that question.

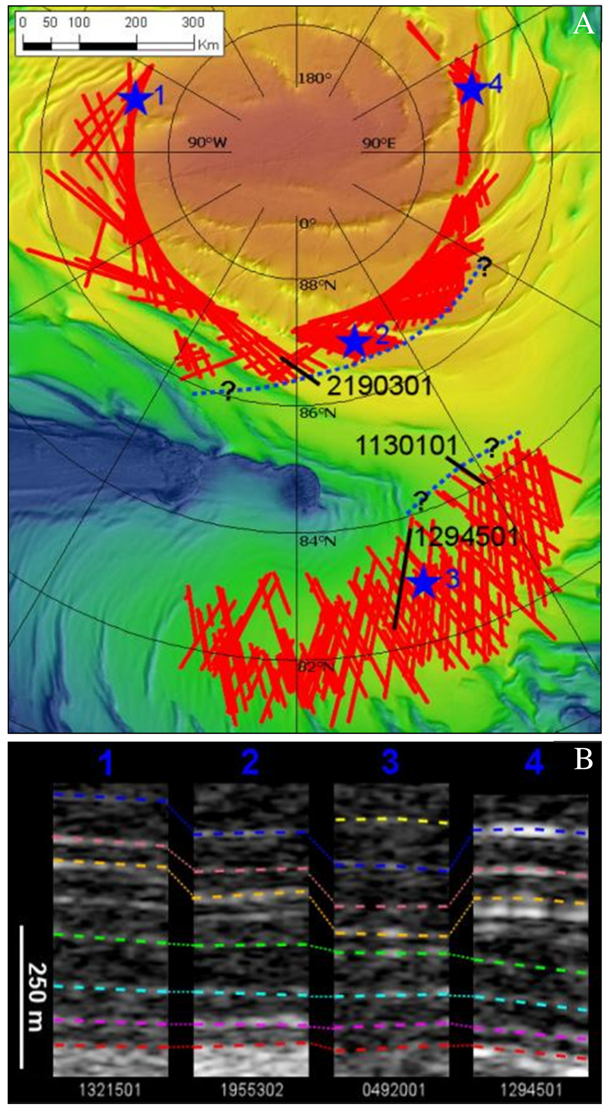

Figure 1: *(a) MOLA DEM of the north polar cap showing the position of the radar facies examples (blue stars) and sample radargrams, along with the extension of the lowermost reflector in the NPLD (red); the pinch-out terminations are highlighted with blue dashed lines. (b) Example radargrams from four locations showing lowermost radar facies, and the correlations obtained from mapping between them.*

Results: Preliminary results include significant second-order stratigraphic variations within single radar layers, consisting of pinch-outs and subtle thickness variations over long distances. The latter is clearly evidenced by radar facies of the first sequence in different locations of the NPLD (Fig. 1b).

Two retreats (or periods of diminished accumulation) are indicated by this mapping. The lowermost reatreat is evident with two reflectors that appear to be similar, and occur at the base of the NPLD, just above the top of the basal unit where it is present (Fig. 2a). Their pinch-outs delineate a zone of non-deposition (or a thickness below the ~ 9 m resolution of SHARAD in water ice [10]) between 84 - 87° N (Fig. 1a). These most likely delineate the same deposit, characterized by two different depocenters or, alternatively, they are separate deposits with distinct depositional histories.

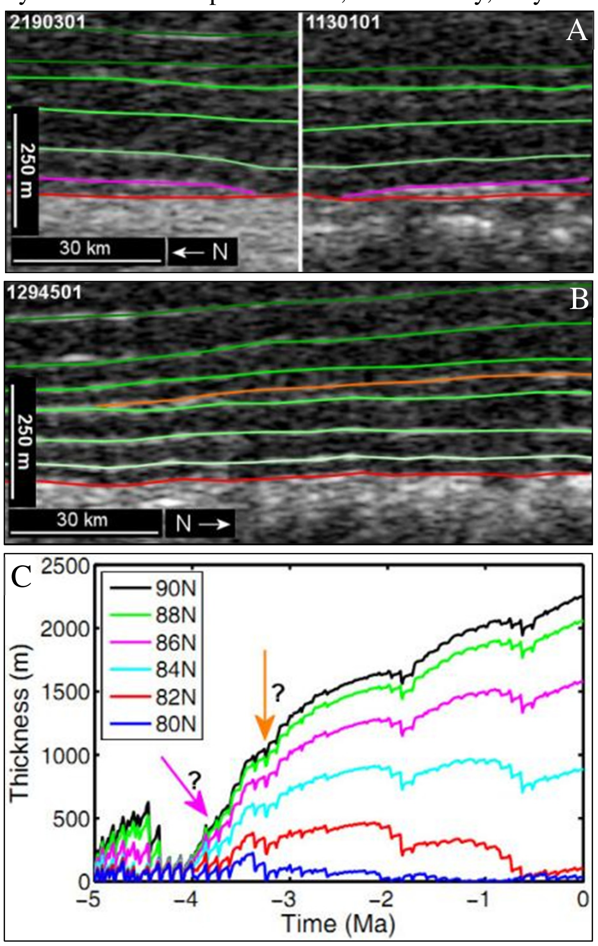

Figure 2: *(a) Samples of interpreted radargrams 2190301 and 1130101 (Fig. 1a) showing the pinch-outs of the lowermost horizon (pink) over the top of the Basal Unit (red). (b) Interpretation of radargram 1294501 (Fig. 1a) showing the pinch-out of the orange horizon. (c) Model of ice accumulation for the north pole [7,8]. The pink and orange arrows indicate retreat phases that may match with the pinch-outs shown above.*

Another pinch-out has been found in the middle part of the first sequence, indicating a large-scale latitudinal retreat of ice deposition. This one is a few layers higher in the sequence (Fig. 3b) and indicates a simpler, northward retreat of deposition.

These events may correlate with early hiatuses of accumulation as predicted by a zonally-averaged, global ice accumulation/climate model [8] that was modified to include only the volume of the NPLD [9] (Fig. 2c).

Future Work: Large portions of the polar cap are still unmapped in the lowest NPLD, along with the entire second sequence (immediately overlying this mapped radar facies). Preliminary mapping of the 90 - 180° E quadrant revealed the possible presence of a first-order unconformity that may be related to the known erosional surfaces [9]. Further detailed mapping in that quadrant will allow stratigraphic, and hopefully temporal, correlation between the erosional surfaces. Once mapping is complete, the resulting isopach maps will lead to the construction of a more complete and detailed accumulation model of the NPLD, including both depositional patterns and erosional events. In turn, these may be used to constrain models of recent climatic changes on Mars.

Conclusions: In general, the NPLD is characterized by uniform layering. However, the detailed mapping of the lowermost sequence revealed interesting second-order stratigraphic features that are likely due to climatic variations induced by orbital forcing. Interpretation of these preliminary results suggests temporary changes in the locations of depocenters and latitudinal variation of the water ice deposition area, possibly matching the first phases of the an orbitally-forced ice accumulation model.

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