MODELING AN ICE-RICH LOBATE DEBRIS APRON IN DEUTERONILUS MENSEA. J L Fastook\(^1\), J W Head\(^2\), J-B Madeleine\(^3\), F Forget\(^3\) and D Marchant\(^4\) (\(^1\)University of Maine, Orono, ME 04469, fastook@maine.edu, \(^2\)Brown University, Providence, RI, \(^3\)-LMD, CNRS/UPMC/IPSL, \(^4\)Boston University, Boston, MA.)

Introduction: Models of ice sheets on Mars have helped to identify and interpret glacial deposits observed from orbit \([1]\), while also testing hypothetical scenarios that may have been responsible for their formation \([2, 3]\). In many of these cases the ice sheets themselves existed only in the past during periods of different climate dictated primarily by dramatic changes in obliquity \([2, 4]\). Here instead we are looking at lobate debris aprons (LDA) that have recently been proven to contain hundreds of meters of relatively pure water ice \([5, 6, 7]\).

LDAs in the Deuteronilus Mensae region in the fretted terrain along the dichotomy boundary \([8]\) have been recognized to involve significant amounts of water ice since Viking observations \([9, 10]\), but controversy over the amount of water ice involved has ranged from very low (~20-30%, ice assisted talus flow \([11, 12]\)), medium (~30-80% rock-glaciers \([13]\), and high (>80% debris-covered glaciers \([14, 15, 16, 17]\). In addition, the low number of craters on the LDA surfaces requires mid-to-late Amazonian ages for either formation, or at least, significant deformation \([18]\).

Recent subsurface radar sounding from orbiting spacecraft (SHARAD on MRO \([19]\)) has confirmed that many, if not most, of the LDAs contain relatively pure water ice covered only by a thin layer of debris shed from adjacent scarps \([5, 6, 7]\). Their requirement that the valley floor extend undistorted beneath the observed LDAs dictated a dielectric constant consistent with pure (<10% contaminant) water ice. In addition, they can constrain the surface debris layer to be less than ~10 m due to the lack of a shallow soil-ice interface in the radar data, but they point out that it must be greater than 0.5 m to explain the lack of a hydrogen signal in gamma ray/neutron data \([20, 21, 22]\).

Figure 1 shows a radargram and ground track from \([7]\) for a LDA at 39.1N, 24.2E in the Deuteronilus Mensae region. We will focus on the feature in the left-hand side of the track, where it crosses between two mesas. The profile in (b) of the figure shows a classic convex profile indicative of viscous flow.

Modelings: UMISM, as used here, is an adaptation for the Martian environment \([23, 24, 25]\) of a thermo-mechanically coupled shallow-ice approximation terrestrial ice sheet model used for time-dependent reconstructions of Antarctic, Greenland, and paleo-icesheet evolution in response to changing climate on Earth \([26]\).

The grid used in this exercise, with topography from MOLA, is shown in figure 2, and spans 2 degrees of latitude and longitude, centered on 40N, 23E. With a MOLA spacing of 0.0078125 degrees, this yields a 256X256 grid with 65536 nodes, 65025 elements, and approximately 400 m resolution. While the surface comes directly from MOLA, the bed is assumed to be an extension of the surface outside the LDA and is flat at an elevation of -3578 m (the nominal elevation of the edge of the LDA). To preserve the mesas, only those surfaces lower than -2738 m (the nominal elevation of the top of the LDA) are modified.

Experiments: Two hypotheses are tested in this experiment: 1) alcove-only accumulation, and 2) collapse from a larger more extensive ice sheet.
For the first case, for which the Earth analog is the Mullins Glacier in the Dry Valleys of Antarctica [27, 28, 29, 30], a small catchment at the base of the scarps is prescribed [31] with minimal ablation elsewhere. We begin with no LDA and observe the formation time and compare the modeled surface with the present. Figure 3 shows a sample of a possible velocity field where alcove accumulation is 2.5 mm/yr and ablation elsewhere is -0.15 mm/yr.

For the second case, we assume a climate from a GCM run at an obliquity of 35 degrees [4, 32] and build a much more extensive ice sheet covering a broader region. As this ice sheet collapses, we compare remnants with the observed LDA.