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Ice megadunes on Mars: analogy with Antarctica

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Mass and energy balance of ice sheets are driven by complex interactions between the atmosphere and the cryosphere. Feedbacks between katabatic winds and the cryosphere may lead to the formation of sedimentation waves, so-called megadunes, at the surface of ice sheets. These have been first described in Antarctica. Here we use topographic data, optical images, and spectroscopic data acquired by Mars orbiters. We show that the surface of the Martian North Polar Cap displays two superimposed sets of sedimentation waves with differing wavelengths. These sedimentation waves have similarities with Antarctic ice megadunes regarding their surface morphology, texture, grain size, and internal stratigraphic architecture. Their shallow-dipping upwind sides, their tops and the intervening troughs are covered by young ice and occasional sastrugi fields, indicative of net accumulation. On the other hand, their steep-dipping downwind sides either expose exhumed layers of dusty old ice or correspond to smooth surfaces of coarse-grained ice, indicative of net ablation or reduced net accumulation associated with sublimation and metamorphism. These surface characteristics and the internal stratigraphic architecture revealed by radar sounding are consistent with the interpretation that both sets of Martian sedimentation waves grow and migrate upwind in response to the development of periodic accumulation/ablation patterns controlled by katabatic winds. The smaller waves, characterized by reduced net accumulation on their downwind sides, are probably analogous to the Antarctic megadunes that have been described so far. On the other hand, a terrestrial equivalent remains to be discovered for the larger ones, characterized by net ablation on their downwind sides. The recognition of these sedimentation waves provides the basis for the development of a common model of ice/wind interaction at the surface of Martian and terrestrial ice sheets and for future investigations on the respective roles of wind-driven particle transport, heat and mass transfer of water vapor, ice metamorphism and glacial flow of ice sheets.