THE ROLE OF REPTATION IN DUNE SLIPFACE DYNAMICS. Stephen L.F. Sutton[1], C. McKenna Neuman[1] and W. Nickling[2], [1]Dept. of Geog., Trent University, Peterborough, ON, Canada, K9J 7B8, stephensutton@trentu.ca, cmckneuman@trentu.ca, [2]Dept. of Geog., Univeristy of Guelph, Guelph, ON, Canada, N1G 2W1.

Introduction: The sediment dynamics of dune lee slopes has received very little attention when compared with the stoss face. Historically, this interest has focused on the bedding strata or laminations formed through avalanching and grainfall (e.g. [1-3]). However lack of understanding of the process of avalanching, specifically the linkage between the rate of sediment transport over the dune brink with the frequency and magnitude of the event, has hampered the use of laminae in reconstructing dune dynamics from these preserved records.

Two 2-D kinematic dune avalanche models have been developed [4,5], although neither have been field tested. Through their development both avalanche models demonstrated the requirement of an accurate predictive description of the spatial distribution of lee slope grainfall settling (S) for use in determining the changing angle of the slipface slope, and thus the moment of avalanche when the slope reaches its angle of initial yield (θ_i). As the grainfall rate drops off with distance from the crest a “pillow” of sand develops on the upper reach, avalanche initiation will occur when the slope inflection point (the maximum slope of the changing surface) exceeds θ_i. Figure 1 shows an avalanche which initiated mid-slope, and the length of the scarp receding towards the crest shows the extent of this sand “pillow”.

Laboratory, field and modeling studies into the grainfall pattern [5-9] have all relied on direct capture of the falling grains and have not examined the redistribution of the grains through reptation, grains rebounding from the bed yet lacking the energy to be considered saltators [10].

Experiments were conducted to investigate the significance of reptation to the pre-avalanche sediment dynamics on dune slipfaces, and its impact on avalanching.

Methods: The experiments were carried out in a Dune Simulation Tunnel (Fig. 1), constructed jointly by the University of Guelph’s Wind Erosion Laboratory, and the Desert Research Institute of Nevada. Located in Harley, Ontario, Canada, this tunnel was designed to simulate a small 1.2 m crest height, aspect ratio 0.08 h/L dune for which field observations existed [9], and contained both lee and stoss slopes with a 1:1 scaling.

Measurements of grainfall rates through cup collection, reptation rates with custom reptation traps, and changes in elevation (both through solely grainfall/ reptation, and through grainfall/ reptation/ avalanching) were made using a 3-D laser scanner (Konica-Minolta

Figure 1: Avalanching in the Dune Simulation tunnel. Main avalanche (left) progressing through scarp recession, smaller center avalanches show paralel recession paths and were triggered through excavation by the larger slide.

9i). Reptation pathways were observed at several distances from the dune brink through the use of a laser sheet and recorded with a digital camera.

Results: The evidence indicates that reptation is a significant mode of sediment redistribution on the slipface. Fig. 2 compares the rate of grainfall settling (S) with that of the rate of net deposition or erosion (dQ/dx), where Q is the sediment flux in kg m^{-1} s^{-1}, and x is the distance from crest in m, for the same spatial location. Significantly, reptation sediment delivery rates (dQ/dx > 0) frequently exceed the rate of grainfall by as much as an order of magnitude, especially over the lower slope. Indeed, in only 15% of the observations in Fig. 2 does S account for more than 75% of the total sediment transport for a given location.

Recognizing reptation as a significant mode of sediment transport alters our understanding of dune slipface dynamics. Through redistribution of settled grains further downslope, reptation will alter the rate of change of the slipface angle (θ) as well as the volume of sediment poised to avalanche once θ_I is reached. Previous models [4,5] used solely the settling rate distribution to predict the change in slipface angle and sand volume.

By altering these two parameters reptation becomes an important factor to consider when modeling slipface sediment dynamics, avalanching, and by extension dune grainflow lamane.

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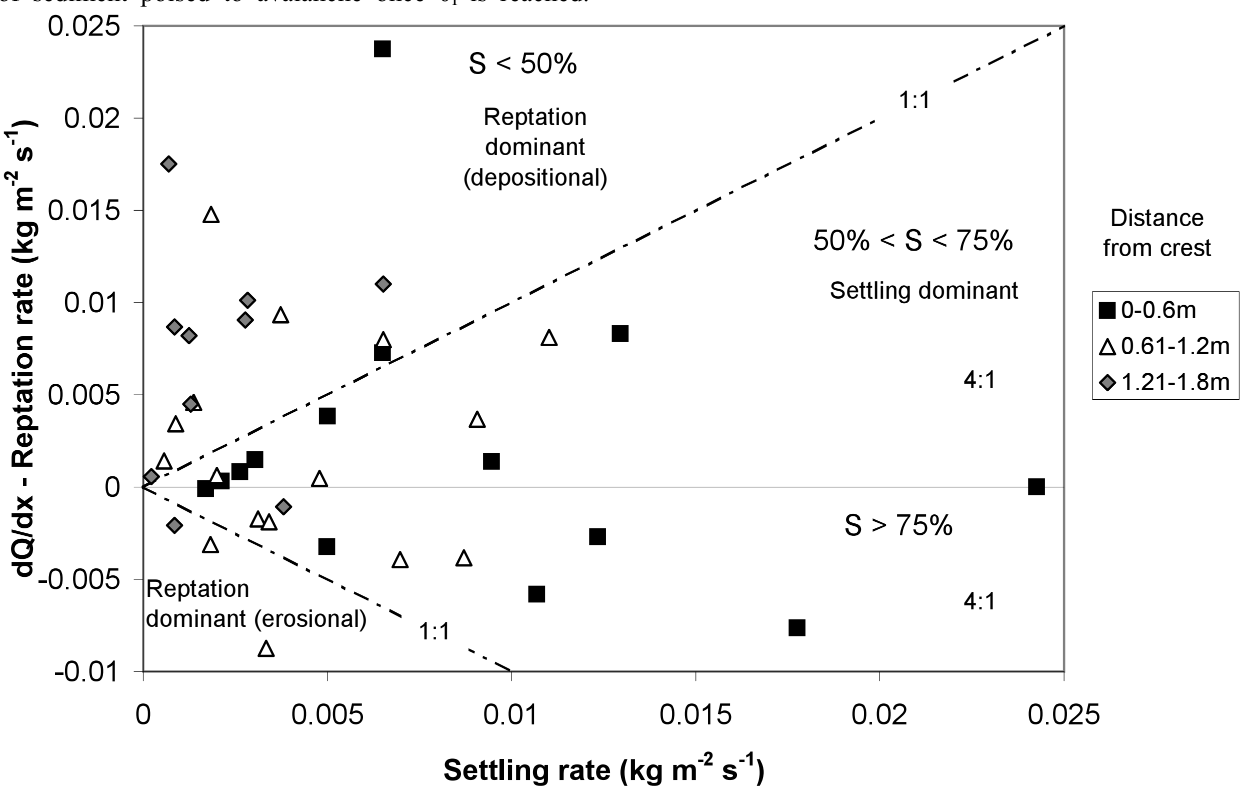

Figure 2: Demonstration of the variability in the importance of reptation compared with grainfall. Delineated are zones where reptation is responsible for the majority of localized sediment dynamics (S<50%), where grainfall exceed reptation by a factor of 4x (S > 75%), and where grainfall is dominant yet repatation accounts for over ¼ of the sediment activity (50% < S > 75%). Reptation tends to dominant for the lower reaches of the dune slipface, and is of less importance higher on the slope where the rate of grainfall is greater.