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WHAT SETS THE SIZE OF RIPPLES?

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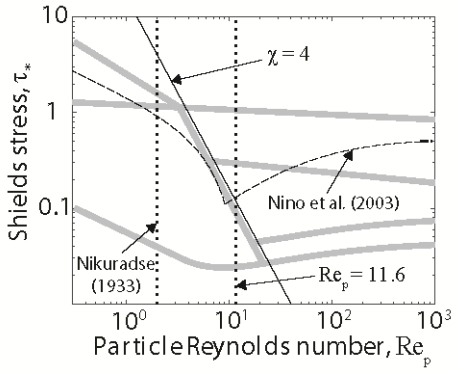

Figure DR1. Different hypotheses for ripple-dune transition on the bedform stability diagram from Fig. 1A (thick gray lines). Solid black line corresponds to a Yalin number of 4, which is the upper bound on the ripple regime in Fig. 2A. The dashed line corresponds to threshold for the onset of suspension from Nino et al. (2003), converted to the $\left(\mathrm{Re}_\mathrm{p}, \tau_*\right)$-space using the settling velocity formula of Ferguson and Church (2004). The latter study uses a different definition of the particle Reynolds number, $r_\mathrm{p} = \frac{\sqrt{RgD}D}{\nu}$, such that $r_\mathrm{p} = \frac{\mathrm{Re}_\mathrm{p}}{\sqrt{\tau_*}}$. The dotted lines correspond to the transition from hydraulically-smooth to hydraulically-rough flows (Nikuradse, 1933) and the critical condition for the laminar sublayer to become thicker than a grain diameter, at $\mathrm{Re}_\mathrm{p} = 11.6$ (Engelund and Hansen, 1967), respectively.

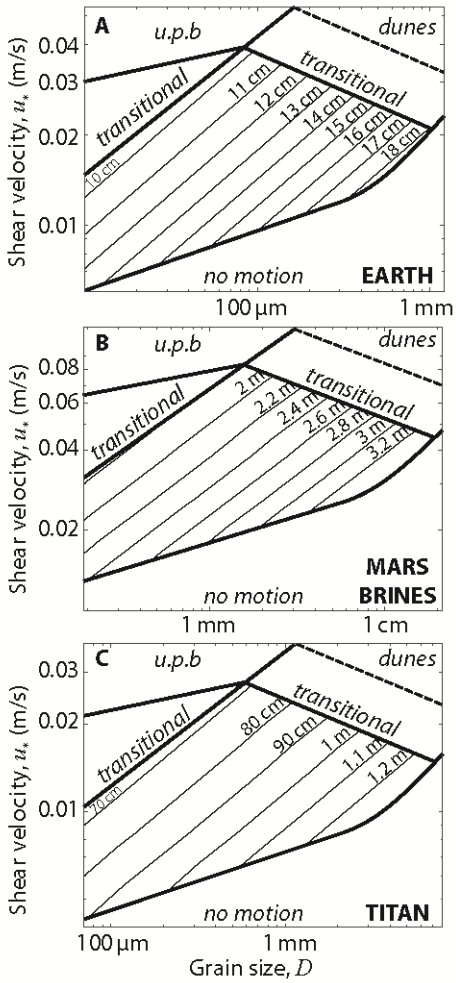

Figure DR2. Close-up of the ripple field in the bedform stability diagram (as compiled by Lamb et al. (2012) based on previous diagrams by Southard and Boguchwal, 1990, and vand den Berg and van Gelder, 2009) with predicted ripple wavelength for (A) fresh water on Earth, (B) brines on Mars, (C) water ice clasts in methane on Titan (Table DR2). Acronym "*u.p.b.*" designates the "upper plane bed" regime. The transition zone between ripples and dunes (dashed lines) correspond to Yalin numbers between 4 and 9.

Table DR1. (In ancillary MsExcel data file). Bedform data compilation. We build on the data compilation of Yalin (1985), which comprises experiments with sand and glass beads and where the fluid was either water or glycerine and water solutions (Barton and Lin, 1955; Vanoni and Brooks, 1957; Vanoni and Hwang, 1967; Alexander, 1980). We added datasets for both lower (Mantz, 1978; Grazer, 1982), and similar and higher (Stein, 1965; Guy et al., 1966; Williams, 1967; Bishop, 1977; Baas, 1994; Gabel, 1993; Baas, 1999; Leclair, 2002; Venditti et al., 2005) Yalin numbers.

REFERENCES

Alexander, L.J.D. (1980), On the geometry of ripples generated by unidirectional open channel flows [M.S. Thesis]. Queens University, Kingston, Canada.

Baas, J.H., 1994, A flume study on the development and equilibrium morphology of current ripples in very fine sand. Sedimentology, v. *41*, p. 185-209.

—, 1999, An empirical model for the development and equilibrium morphology of current ripples in fine sand: Sedimentology, v. 46, p. 123-138.

Barton, J.R. and P. Lin., 1955, A Study of the Sediment Transport an Alluvial Channels. Report no. 55, JRB 2, Civil Engineering Department, Colorado A and M College, 1955. Colorado. Agricultural and Mechanical College, Fort Collins.

Bishop, C.T., 1977, On the time-growth of dunes [M.S. Thesis], Queen's University, Kingston, Ontario, Canada.

Burr, D.M., Perron, J.T., Lamb, M.P., Irwin, R.P., Collins, G.C., Howard, A.D., Sklar, L.S., Moore, J.M., Adamkovics, M., and Baker, V.R., 2013, Fluvial features on Titan: Insights from morphology and modeling: Geological Society of America Bulletin, v. 125, p. 299-321, doi: 10.1130/B30612.1.Engelund, F., and Hansen, E., 1967, A monograph on sediment transport in alluvial streams, Teknisk Forlag Skelbrekgade 4 Copenhagen V, Denmark., p. 63.

Gabel, S.L., 1993, Geometry and kinematics of dunes during steady and unsteady flows in the Calamus River, Nebraska, USA: Sedimentology, v. 40, p. 237-269.

Grazer, R.A., 1982, Experimental study of current ripples using medium silt [M.S. thesis], Massachusetts Institute of Technology, Cambridge, Massachussetts.

Grotzinger, J., Hayes, A., Lamb, M., and McLennan, S., 2013, Sedimentary processes on Earth, Mars, Titan, and Venus, *in* Mackwell, S., Bullock, M., and Harder, J., eds., Comparative Climatology of Terrestrial Planets, University of Arizona Press, p. 439-472.

Guy, H.P., Simons, D.B., and Richardson, E.V., 1966, Summary of alluvial channel data from flume experiments, 1956-61, Volume No. 462-I, U.S.G.S, p. 104.

Lamb, M.P., Grotzinger, J.P., Southard, J.B., and Tosca, N.J., 2012, Were aqueous ripples on Mars formed by flowing brines: Sedimentary Geology of Mars, v. 102, p. 139-150.Leclair, S.F., 2002, Preservation of cross-strata due to the migration of subaqueous dunes: an experimental investigation: Sedimentology, v. 49, p. 1157-1180, doi: 10.1046/j.1365-3091.2002.00482.x.

Mantz, P.A., 1978, Bedforms produced by fine, cohesionless, granular and flakey sediments under subcritical water flows: Sedimentology, v. 25, p. 83-103.

Nino, Y., Lopez, F., and Garcia, M., 2003, Threshold for particle entrainment into suspension: Sedimentology, v. 50, p. 247-263, doi: 10.1046/j.1365-3091.2003.00551.x.

Perron, J.T., Lamb, M.P., Koven, C.D., Fung, I.Y., Yager, E., and Adamkovics, M., 2006, Valley formation and methane precipitation rates on Titan: Journal of Geophysical Research: Planets, v. 111, doi: 10.1029/2005JE002602.

Southard, J. B., and Boguchwal, L. A., 1990, Bed configurations in steady unidirectional water

flows. Part 2. Synthesis of flume data: Journal of Sedimentary Research, v. 60, no. 5.
Stein, R.A., 1965, Laboratory studies of total load and apparent bed load: journal of Geophysical Research, v. 70, p. 1831-1842.
Tosca, N.J., McLennan, S.M., Lamb, M.P., and Grotzinger, J.P., 2011, Physicochemical properties of concentrated Martian surface waters: Journal of Geophysical Research: Planets, v. 116, doi: 10.1029/2010JE003700.
Vanoni, V.A., and Brooks, N.H. (1957), Laboratory studies of the roughness and suspended load of alluvial streams. Report no. E-68, Publicayion No. 149, California Institute of Technology, Pasadena, CA.
Vanoni, V.A., and Hwang, L.S. (1967), Relation between bed forms and friction in streams: Journal of the Hydraulics Division, ASCE, v. 93, no. HY3.
Venditti, J.G., Church, M., and Bennett, S.J., 2005, Morphodynamics of small-scale superimposed sand waves over migrating dune bed forms: Water Resources Research, v. 41, doi: 10.1029/2004WR003461.
Williams, G.P., 1967, Flume experiments on the transport of a coarse sand, Volume No. 562-B, U.S.G.S., p. 37.
Yalin, M.S., 1985, On the determination of ripple geometry: Journal of Hydraulic Engineering, v. 111, p. 1148-1155.