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**Lubrication forces in dense granular flow with interstitial fluid: A simulation study with Discrete Element Method** OLEH BARAN, DENIZ ERTAS, THOMAS HALSEY, FUPING ZHOU, ExxonMobil Research and Eng. —

Using three-dimensional molecular dynamics simulations, we study steady gravity-driven flows of frictional inelastic spheres of diameter $d$ and density $\rho_g$ down an incline, interacting through two-body lubrication forces in addition to granular contact forces. Scaling arguments suggest that, in 3D, these forces constitute the dominant perturbation of an interstitial fluid for small Reynolds number $Re$ and low fluid density$\rho$. Two important parameters that characterize the strength of the lubrication forces are fluid viscosity and grain roughness. We observe that incline flows with lubrication forces exhibit a packing density that *decreases* with increasing distance from the surface. As the incline angle is increased, this results in a severely dilated basal layer that looks like "hydroplaning" similar to that observed in geological subaqueous debris flows. This is surprising since the model explicitly disallows any buildup of fluid pressure in the base of the flow, and suggests that hydroplaning might have other contributing factors besides this traditional explanation. The local packing density is still determined by the dimensionless strain rate $I \equiv \dot{\gamma} d \sqrt{\rho_g / p}$, where $p$ is the average normal stress, obeying a "dilatancy law" similar to dry granular flows.

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