ERRATUM – DARCY SHEAR STRESS

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This document arises from a conversation with Renaud Delannay on June 5, 2010. It could elicit an erratum to our JGR paper on sand ripples.

1. Erratum

In our paper on sand ripples [1], we state "A consequence of equation (9) is that $\mu(1-\nu)[(\nabla\otimes\mathbf{v})+(\nabla\otimes\mathbf{v})^T]\equiv\mathbf{0}$, so that gas shear stress vanishes identically within the porous bed." In fact, the shear stress in the fluid phase does not vanish, as the simple counterexample based on our pressure solution indicates.

The viscous macroscopic Ergun's equation is

$$\mathbf{u}=-(K/\mu)\nabla p, \tag{1}$$

where $\mathbf{u}\equiv(1-\nu)\mathbf{v}$ is the superficial gas velocity vector, $\mathbf{v}$ is the interstitial gas velocity,

$$K\simeq\frac{d^2}{150}\frac{(1-\nu)^3}{\nu^2} \tag{2}$$

is the bed permeability, and μ is the gas viscosity. For a porous medium of uniform solid volume fraction ν, the shear stress on the fluid phase is

$$\tau=\mu[(\nabla\otimes\mathbf{u})+(\nabla\otimes\mathbf{u})^T]. \tag{3}$$

Using Eq. (1), we find

$$\tau=-2K\nabla\otimes\nabla p. \tag{4}$$

For the pressure gradient in sand ripples of wavelength L

$$\nabla p=-2\pi\frac{p_0}{L}\exp(-2\pi y/L)\{\sin(2\pi x/L)\hat{\mathbf{x}}+\cos(2\pi x/L)\hat{\mathbf{y}}\}, \tag{5}$$

we find the non-vanishing shear stress tensor

$$\tau=2K\left(\frac{2\pi}{L}\right)^2 p_0\exp(-2\pi y/L)\begin{pmatrix}\cos(2\pi x/L) & -\sin(2\pi x/L) & 0\\ -\sin(2\pi x/L) & -\cos(2\pi x/L) & 0\\ 0 & 0 & 0\end{pmatrix}. \tag{6}$$

However, because it is divergence-free, the stress tensor in the fluid phase does not exert a net force on the solid matrix,

$$\nabla\cdot\tau=-2K\nabla\cdot\nabla\otimes\nabla p=-2K\nabla(\nabla^2 p)=0. \tag{7}$$

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Consequently, our equations (A2) and (A3) in reference [1], and none of their subsequent derivations, remain unchanged.

2. Acknowledgements

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References

[1] Louge, M. Y., A. Valance, A. Ould el-Moctar, and P. Dupont (2010), Packing variations on a ripple of nearly monodisperse dry sand, *J. Geophys. Res.*, 115, F02001, doi:10.1029/2009JF001384, 1–12.