Predictive formulation of high solid content complex dispersions

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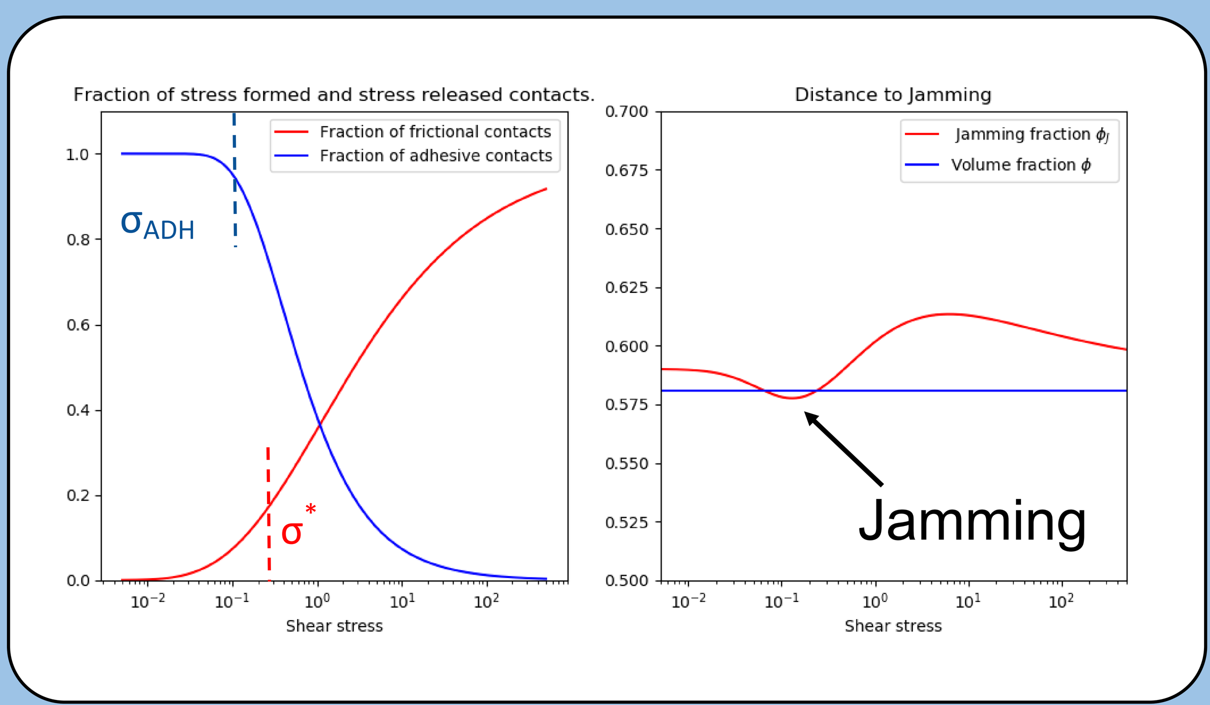
1. Introduction

Granular suspensions are pervasive in industry, such as drilling fluid, however most studies rely on idealised suspensions. Can real complex suspensions with multiple non-Newtonian effects be understood and so predicted by a simple model?

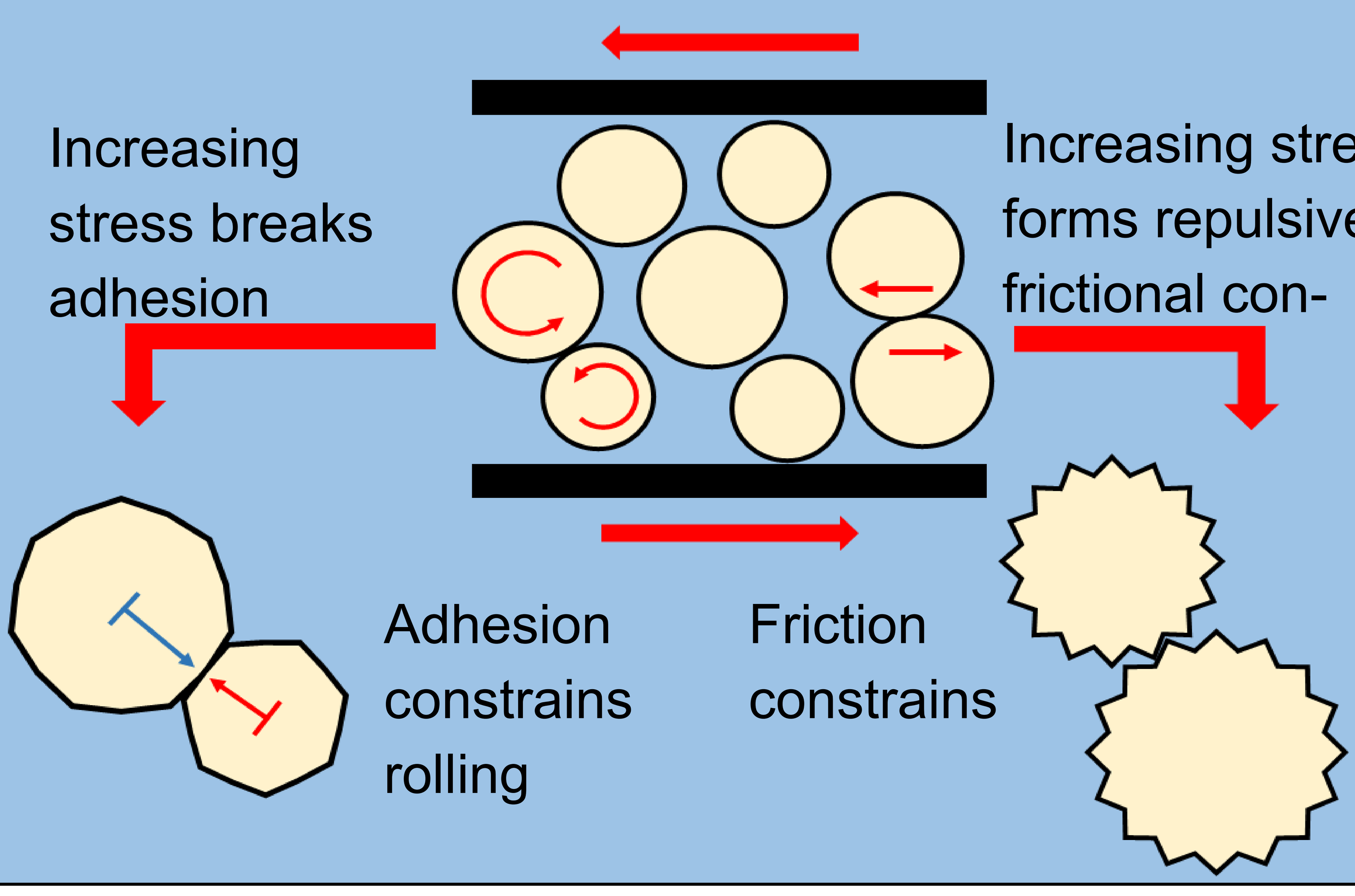
2. Constraint theory

Particle-particle pairs have five degrees of freedom. "ideal" suspension flow is dictated by inter-particle contacts: sliding and rolling and how these jam when constrained by friction or adhesion. [1]



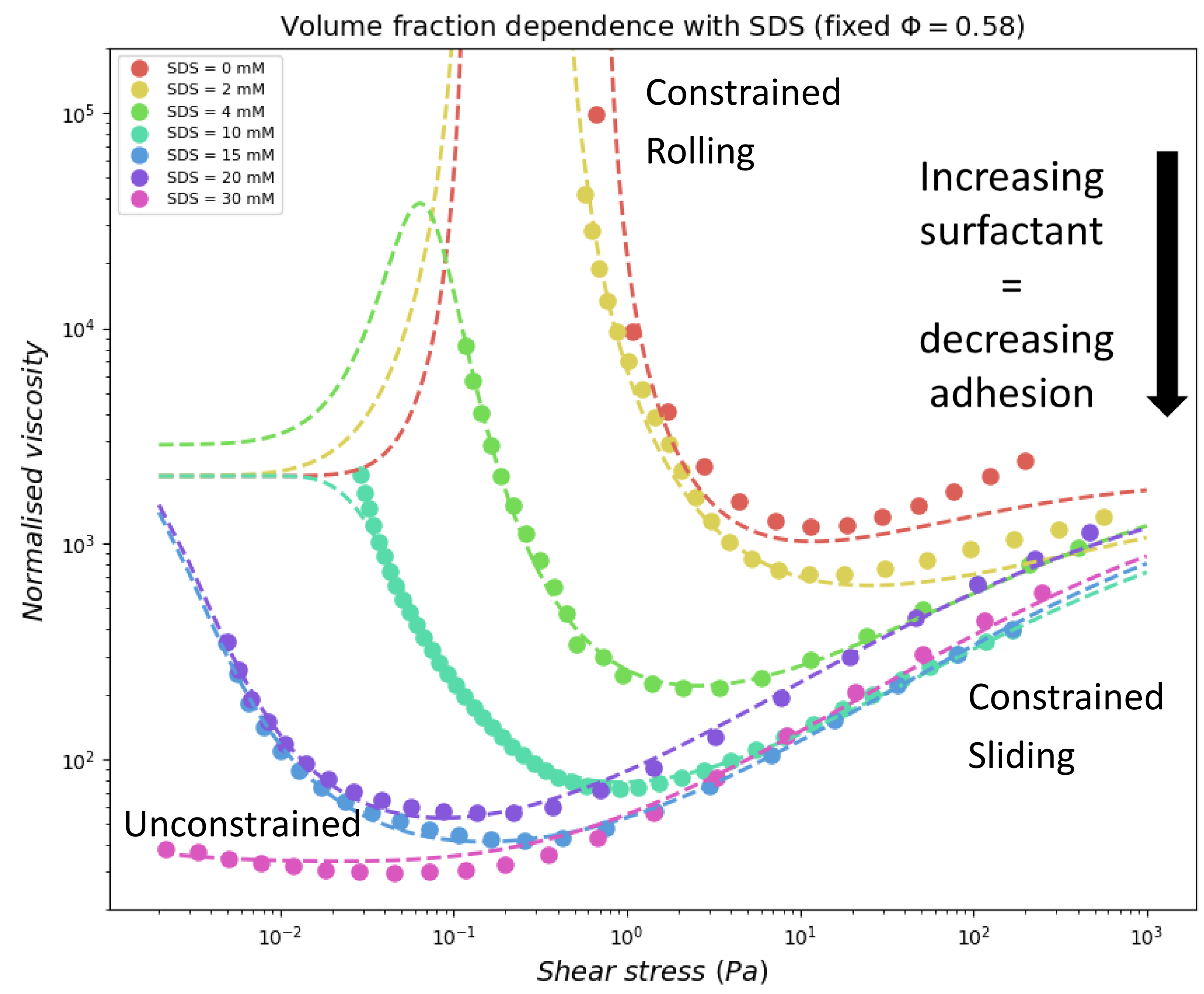
ϕ_J is set by the fraction of constrained contacts.

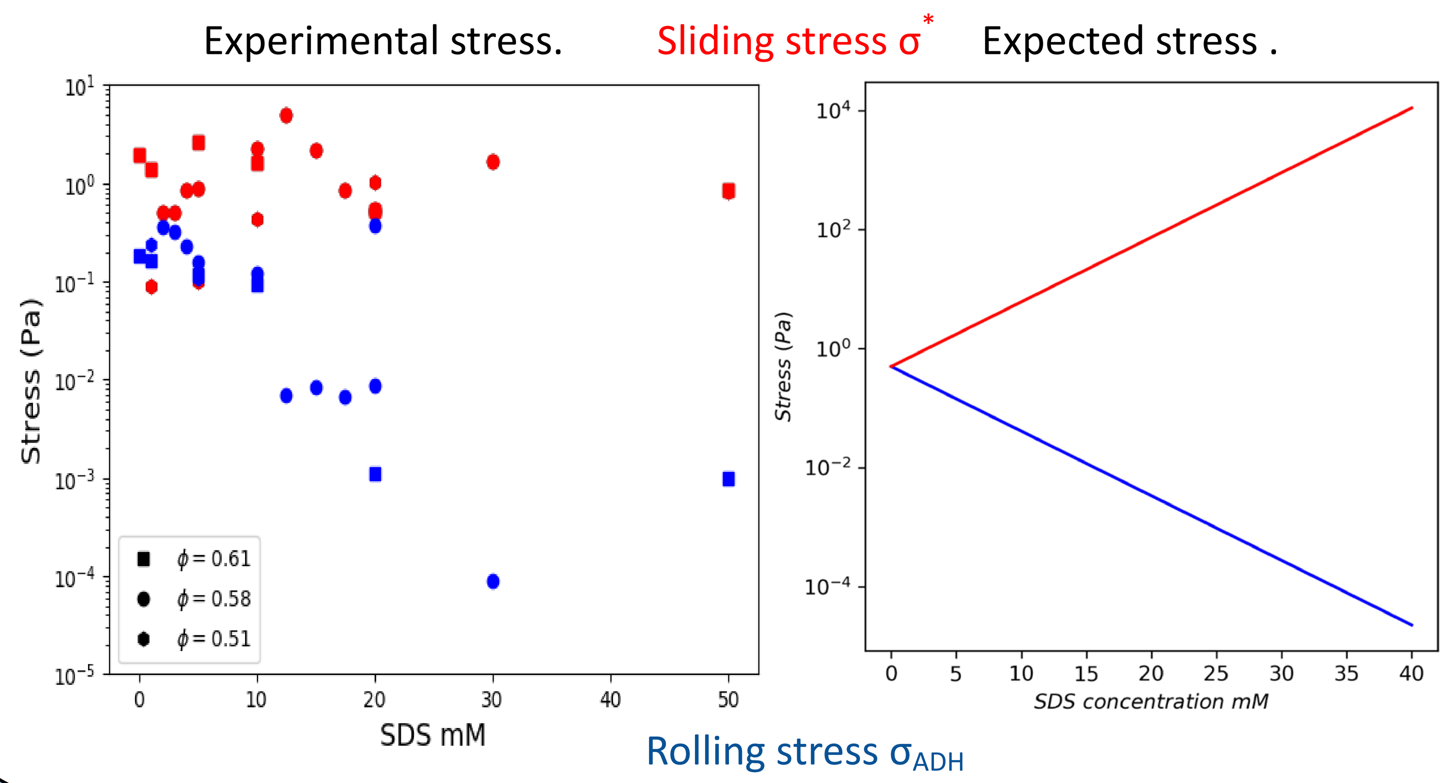
Viscosity is set by the distance to jamming.



3. Quartz flour rheology

Quartz flour silica in an aqueous suspension can be tuned from yield stress to shear thickening via the inclusion of an anionic surfactant (SDS). The surfactant adds additional repulsion to the particle surface. These flow curves are directly fit by constraint theory (dashed lines).





σ^* is Proportional to surface repulsive force

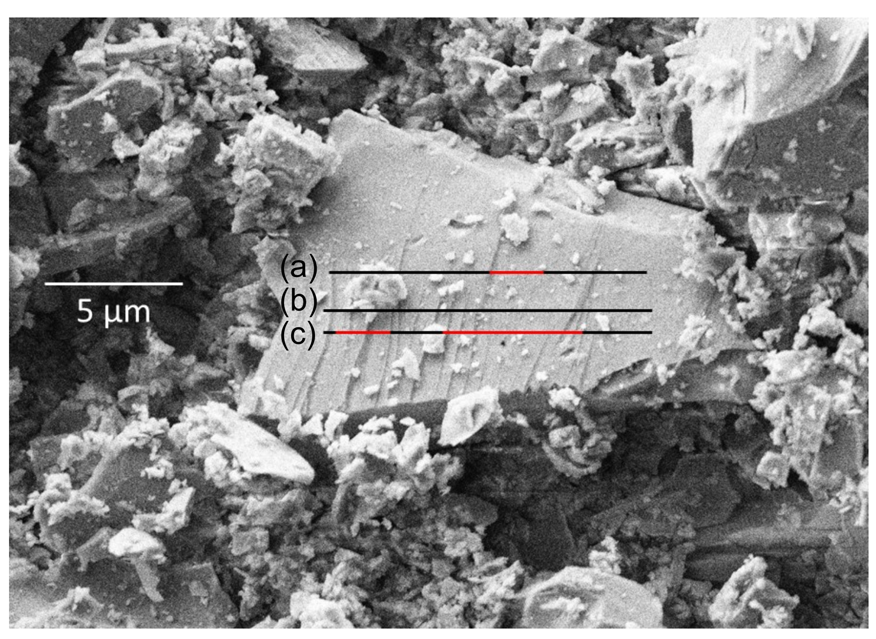
4. Patchy particles

σ^* independence of SDS could be explained by localised adhesive patches.

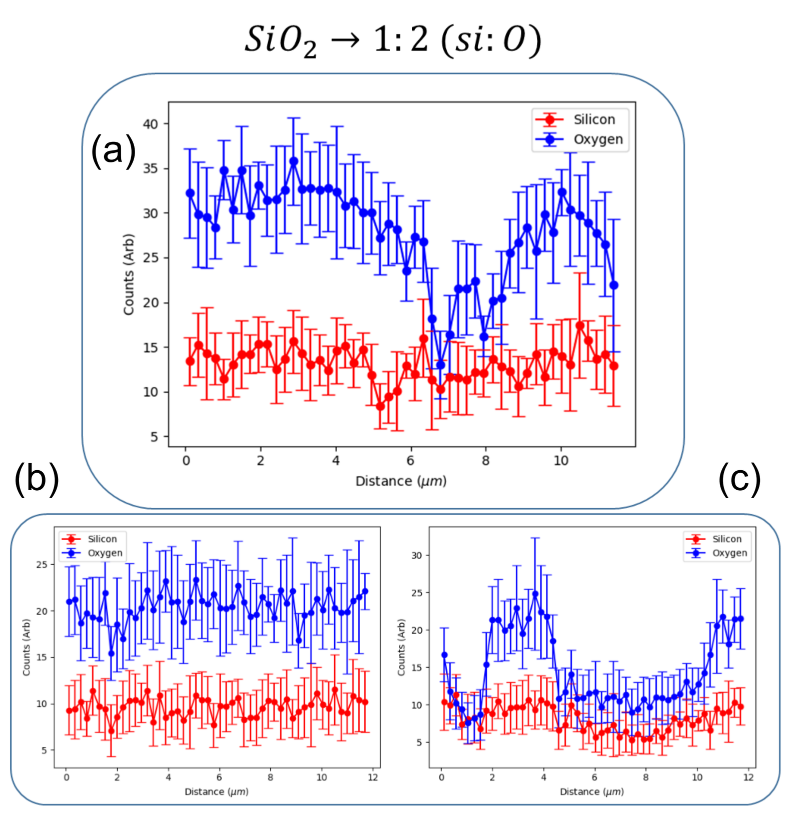
EDS of particle surface 100 nm shows variation in oxygen to silicon from the expected 2:1 to low oxygen areas.

Suggesting hydrophobic Silane patches.

Quartz flour SEM



Low Oxygen areas



5. Summary

Complex suspensions can be described by constraint theory. We observe unexpected adhesion which arises from heterogeneous surface chemistry due to a "Patchy" surface, giving a three scale understanding of this suspension from macroscopic, particle to elemental scale. This allows the controlled formulation of suspensions.

References

[1] B.M. Guy, J.A. Richards, D.J.M. Hodgson, E. Blanco, and W.C.K. Poon. Constraint-based approach to granular dispersion rheology. *Phys. Rev. Lett.* **121**, art. 128001 (2018).

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