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THE TIRE-ROAD CONTACT: A MECHANICAL MIXING SEEN AS A SHEAR-INDUCED DIFFUSIVE PROCESS

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ABSTRACT

Longitudinal sections of tire tread show that road minerals penetrate inside the tire. The aim of this work is to study the process leading to this penetration. In order to take a closer look at the behavior of such a sliding interface, several numerical methods have been proposed. The Multibody Meshfree Approach implemented in a code called MELODY, in particular, appears promising [1]. The model involves shearing a layer of minerals on the surface of a rubber-like material, modeled as a collection of discrete and soft particles. This discrete modeling of the rubber-like material allows the migration of minerals, as shown in fig. 1.

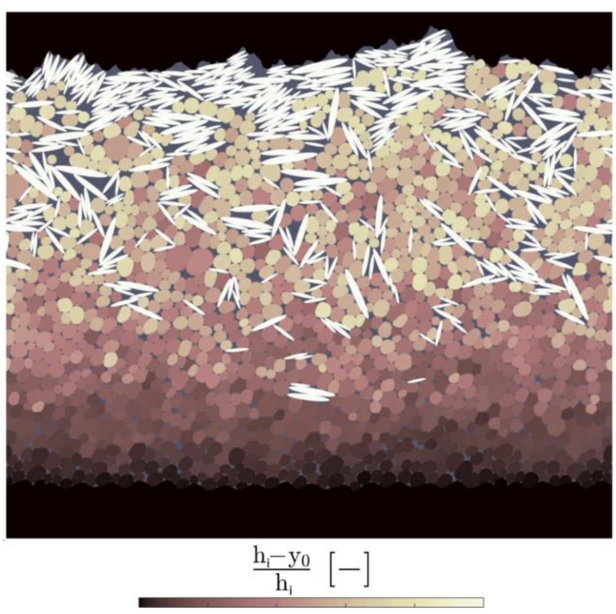

Fig.1 Snapshot of a simulation studying a mixture of minerals in a tire tread; h_i is the thickness of the interfacial layer and y_0 is the initial position of each centroid.

An initial focus is devoted to the early penetration of minerals into the rubber-like material. Indeed, they differ from long-term mechanisms and several penetration modes have been identified. When the minerals are sufficiently embedded into the rubber-like material, migration is now close to a stochastic process, with many characteristics associated to diffusion. For this reason, mineral migration will be considered as a diffusive process, enabling the use of several tools from this field. In particular, results are analyzed using the Green-Kubo framework [2].

Diffusion is driven by mineral transverse velocity, which is very localized in space and brief in time. A characteristic transverse velocity is derived from its standard deviation. This characteristic velocity is held during a characteristic time, called the persistence time. This is computed using the integral of the transverse velocity autocorrelation function. From these two quantities, a diffusion coefficient can be derived.

Firstly, the rheology of the interfacial layer (i.e. third body) is analyzed in detail. There is a close link between the shear rate in the layer containing the minerals and their diffusion. The influence of several parameters on velocity fluctuation, persistence time and diffusion coefficient is investigated. For example, the influence of external parameters such as mineral quantity or contact pressure is examined. Parameters related to material properties are also studied, such as the rubber's elastic modulus. This allows empirical laws to be derived for the dependence of shear rate and diffusion coefficient on a multitude of parameters.

REFERENCES

[1] G. Mollon, Solid Flow Regimes Within Dry Sliding Contacts. Tribology Letters, 2019, Vol. 67, 120
[2] M. Macaulay and P. Rognon, Shear-induced diffusion in cohesive granular flows: effect of enduring clusters. Journal of Fluid Mechanics, 2019, Vol 858, R2