Granular friction: from building the pyramids to the anatomy of individual contacts at the nanoscale

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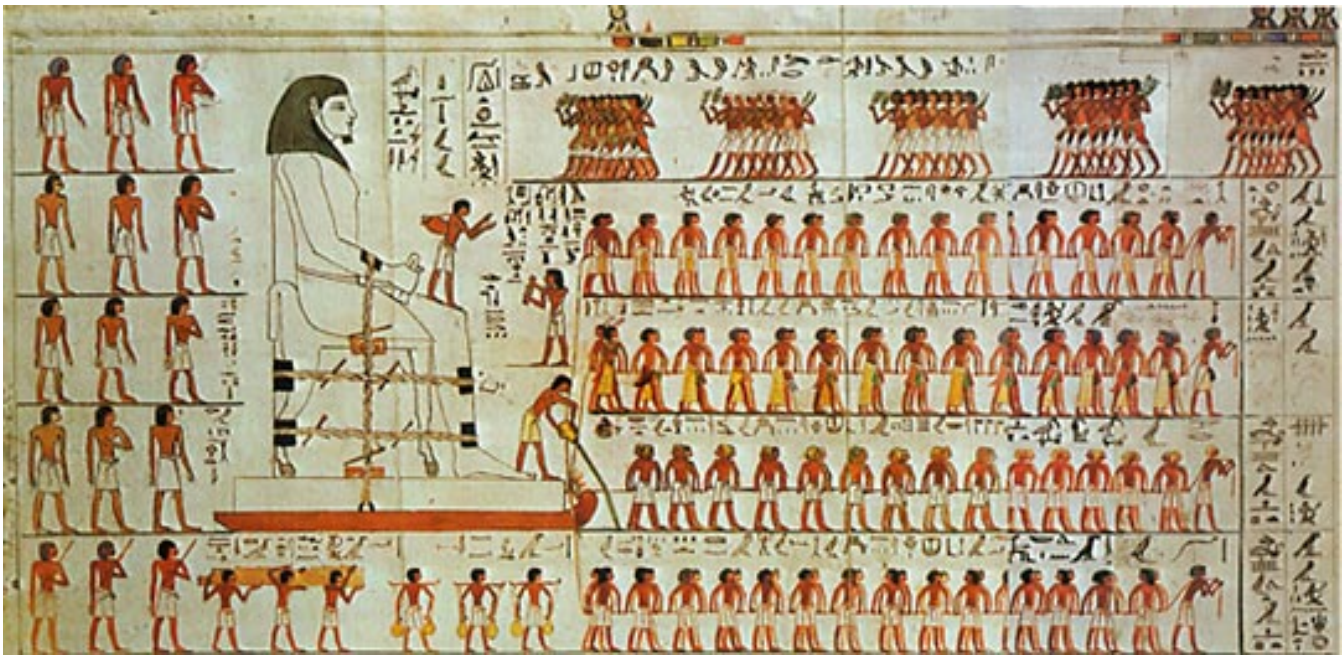
I will discuss the rheology and mechanical properties of wet granular materials, and show why the behavior can be very subtle. Once one understands the mechanical properties, I will show that one can use this knowledge to construct the perfect sandcastle, or to understand why the ancient Egyptians wetted the desert sand with water before sliding heavy stones over it (Figure).

I will then go on to show some new results on friction at the microscopic scale, between 2 grains. Amonton's famous friction law states that the friction force is proportional to the normal force since both are proportional to the area of contact. However for spherical grains, the contact area is not proportional to the normal force, as shown by Hertz long ago. We use a new fluorescence technique that allows us to probe the real area of contact between 2 rough surfaces. In our case, we conclude that important deviations from Amonton's law are observed.



One of the mysteries of sand is why the Egyptians wetted the sand with water if they wanted heavy constructions to slide over it, as is shown explicitly in this wall painting of 1880 BC on the tomb of Tehuti-hetep (Fig.1(a)). Was this done to facilitate the sliding? According to archeologists, this is not the case: "Another figure standing from the base pours water from a jar in front of the sledge, perhaps only a ceremonial act, since even in large quantities water poured upon the ground could not assist the dragging."