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Logarithmic Compaction in Porous Rocks, Granular Solids and Other Disordered Materials

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This presentation describes recent research investigating fundamental physical processes governing time dependent compaction behaviour within porous rocks and granular materials, and, by extension, disordered materials in general. In particular, it concentrates on the logarithmic type compaction rate 'laws' that are frequently reported and applied in an empirical, ad-hoc manner, in a number of disciplines (e.g. soils, rocks, glasses, etc.) but are problematic to extrapolate or explain.

A derivation based on statistical mechanical principles is set out that demonstrates that a logarithmic type compaction process with a finite limit is to be expected for a frustrated or jammed diffusive system and spontaneously emerges as the natural asymptotic limit behaviour for such systems. The derived functional form also meets the Biot (1958) requirement that the relaxation process can be decomposed into a set of exponential decay terms.

It is then shown that the predicted upscaling relationship for such a frustrated diffusion (logarithmic type with finite bounding value) is consistent with the observed time dependent compaction determined at both the laboratory scale and at the field scale (multiple orders of magnitude range) for a porous rock case study example. This is of practical significance, as it provides the ability to predict field scale time dependent behaviour from laboratory scale measurements.