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New approaches to high-precision measurements of heterogenous materials and the path to predictive models: Controlling variation, measuring in situ brittle failure, and understanding their complex dynamic response[1]

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Heterogenous materials such as powders or minerals are far more common and varied than their homogeneous counterparts. To measure all of the varieties one might wish to understand is impractical: for example, pure quartz powder comes in many grain size distributions and bulk densities, which historically were each treated as its own material. As the community is increasingly focused on heterogeneous materials, this historic approach is too inefficient. Instead, we must have robust models for the micromechanical response and equations of state that can account for the inherent variety of these materials. High precision dynamic and static measurements are essential to develop these models, yet most measurements of heterogeneous materials suffer from (often much) larger uncertainties than their homogeneous counterparts. As a result, the very models we need most lag behind. Our groups strategy to close this gap has focused on three major areas: identifying and controlling the sources of uncertainty; developing models to understand the dynamic response of these materials; and designing new classes of experiments to inform these models. The variation that defines these materials makes it much harder to create well-controlled samples and to measure their dynamic response to compressive loading. We estimate the contribution to uncertainty by sample variation such as cracking, intra-sample density variation, and density/packing variation between samples. I will discuss how we control these issues during target fabrication and metrology, and how much variation one should expect if advanced metrology tools such as CT are not available. I will also discuss the results of our recent quasi-static and dynamic experiments examining compaction, failure, and the development of force networks, and the limitations and successes of our mesoscale models.

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