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Mechanical behaviors of gas hydrate system: Ongoing development of phase-transition mechanics

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Natural gas hydrates are ice-like crystalline substances in which gas molecules are physically trapped inside the polyhedral cavities of water molecules1–3. They occur abundantly in both petrochemical production lines4 and hostile environments such as seafloor sediments, arctic or permafrost regions and even the surfaces of other planets. Natural gas hydrates distribute widely in the offshore marine sediments and onshore permafrost area under specific low temperature and high-pressure conditions. Over the last few decades, much attention has been directed toward them as energy resources and for their environmental impact. Understanding the mechanical behaviors of gas hydrate-bearing sediments (GHBS) is important for their associated applications in wellbore stability, stratum deformation during exploitation, geological disaster prevention, and the risk assessment of replacing CH_4 with CO_2 in hydrate reservoirs and CO_2 sequestration in oceans. In our work, we reveal the mechanical mechanism of gas hydrate system at microscale level using molecular dynamic simulations, AFM and CT scan, investigate the static and dynamic mechanical responses at the lab scale using direct shear tests and sonic measurements. Then we used our mechanical correlation into the wellbore and reservoir stability evaluation at the filed scale. Here we firstly propose the conception of phase transition mechanics which mainly investigate phase transition behaviors caused by force, and mechanical response and flow behavior during phase transition procedure by taking gas hydrate for instance.

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