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Methane Bubble Growth in Muddy Aquatic Sediment: Insight from Modeling

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Methane (CH4) is the most abundant hydrocarbon and one of the most important greenhouse gases in the atmosphere. CH4 bubble growth and migration within muddy aquatic sediments are closely associated with sediment fracturing. We present the modeling results of buoyancy-driven CH4 bubble growth in fine-grained muddy aquatic sediment prior to the beginning of the bubble rise. The designed coupled mechanical/reaction-transport numerical model enables a differential fracturing over the bubble front, simulating the dynamics observed in the nature. We show that this differential fracturing over the bubble front controls bubble shape and size temporal evolution. The intercalated stages of elastic expansion and fracturing during the bubble growth subside with time as bubble approaches its terminal size prior to ascend. Our simulations reveal a high asymmetry in the bubble shape growing with time, with respect to its initial symmetric penny-shaped configuration. It is found that the bubble grows allometrically, when the importance of the bubble surface area growth with time, making it more sensitive to the ambient field of methane concentrations. We analyze the affect of the different sediment characteristics on the bubble shape and size evolution. Modeling of the terminal parameters of the mature bubble emitted from the sediment will permit predicting the delivery of gaseous methane to the atmosphere via the water column.