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Modeling methane bubble growth in fine-grained muddy aquatic sediments: correlation with sediment properties

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Gassy sediments contribute to destabilization of aquatic infrastructure, air pollution, and global warming. In the current study a precise shape and size of the buoyant mature methane bubble in fine-grained muddy aquatic sediment is defined by numerical and analytical modeling, their results are in a good agreement. A closed-form analytical solution defining the bubble parameters is developed. It is found that the buoyant mature bubble is elliptical in its front view and resembles an inverted tear drop in its cross-section. The size and shape of the mature bubble strongly correlate with sediment fracture toughness. Bubbles formed in the weaker sediments are smaller and characterized by a larger surface-to volume ratio that induces their faster growth and may lead to their faster dissolution below the sediment-water interface. This may prevent their release to the water column and to the atmosphere. Shapes of the bubbles in the weaker sediments deviate further from the spherical configuration, than those in the stronger sediments. Modeled bubble characteristics, important for the acoustic applications, are in a good agreement with field observations and lab experiments.