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The Viscous-Grain-Shearing (VGS) theory of wave propagation in marine sediments

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The grain-shearing (GS) theory of wave propagation in a marine sediment is based upon the idea that, as grains slide against one another, the dissipation becomes progressively stronger, a phenomenon known as strain hardening. The GS theory predicts a sound speed showing weak, logarithmic dispersion and an attenuation that scales linearly with frequency. At frequencies above about 10 kHz, such behavior matches the sound speed and attenuation data obtained during the SAX99 experiment in the Gulf of Mexico. But at lower frequencies, the measured dispersion curves show a lower sound speed and higher attenuation than predicted by the GS theory. A generalized version of the GS theory, designated the VGS theory, takes account of the effective viscosity of the molecularly thin layer of pore fluid between contiguous grains, which limits the degree of strain hardening that can occur during sliding. The VGS dispersion expressions are the same as those of the GS theory, except for the appearance of a simple algebraic function that has an effect only at low frequencies, below 10 kHz. The resultant VGS curves match the sound speed and attenuation measurements from SAX99 over the measurement frequency band from 1 to 400 kHz. (Research supported by ONR.)