A Simple Way to Improve AVO Approximations

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Abstract
Some twenty years ago it was suggested that the average angle, \( \theta = (\theta_1 + \theta_2) / 2 \), in the Aki-Richards approximation could itself be approximated by the angle of incidence, \( \theta_1 \). Numerical computations however suggest that approximating \( \theta \) by \( \theta_1 \) can actually increase the accuracy of the theory at low angles (although the original \( \theta \) formulation is still superior near the critical angle). A theoretical study rigorously validates this observation for converted-wave reflections, while in the case of P-wave reflections it reveals varying behavior based on two different regimes of earth parameters. In the regime more typical of exploration seismology earth models, the observation again holds that the \( \theta_1 \) formulation is more accurate than the \( \theta \) formulation. In the other regime, the opposite conclusion holds.

The theoretical study also suggests a means by which the strengths of both the \( \theta \) and \( \theta_1 \) formulations may be combined into one theory. This new theory is given, and is accurate over a wider range of pre-critical angles than the \( \theta_1 \) formulation. It is therefore promising for use with pre-critical AVO studies. An analogous approach can also be applied to various methods derived from the Aki-Richards approximation, such as the Fatti and Smith-Gidlow approximations.