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THE COMPOSITION OF SEISMIC REFLECTIONS

by

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Abstract

EDITOR'S NOTE: The paper from which this abstract has been made appears in full in Geophysics, Vol. XXI, No. 2, April, 1956, page 261. Dr. Woods' talk was based on this paper. It discusses in full the operation of the acoustic model and the results. Series of reflections are shown to illustrate different conditions within the apparatus.

When one thick seismic layer lies over another there is an isolated seismic interface which will cause a single seismic reflection. However, if there are many thin layers of sand and shale, there will be reflections from the sand-shale interfaces; these reflections will overlap and interfere with each other, and each line-up on the seismic record will be the sum of several such reflections. The reflection seismograph makes use of a seismic pulse about 300 feet long; however, where thin layers are present there are many reflections which cannot appear separately on the seismic record, but rather must appear as a composite of such reflections.

The thin layers may have generally parallel interfaces, but they may also be present as wedges, pinch-outs, or lenses such as sand bars. Often such interfaces will generate two pulses which will interfere. A seismic record is usually complex and difficult or impossible to use for demonstration of this phenomenon, and some sort of model must be used to illustrate what happens. For this purpose an acoustic model or sound tube has been constructed. It is a steel pipe three hundred feet long and two inches in diameter. At one end of this pipe an electric pulse in a speaker produces a sharp click which is transmitted by way of the pipe to a microphone, corresponding to a geophone. The microphone is connected to a standard set of seismic reflection instruments.

In a one trace record taken with this arrangement the click is shown to create a deflection as it reaches the microphone from the speaker; this is the explosion, or time break. A second deflection of the trace is caused by sound which travels the length of the pipe and is reflected from the closed end of the pipe back to the microphone. This is not a seismic model, since the system is one dimensional sound with no shear waves, surface waves or divergence of energy. The attenuation of the sound waves differs from the attenuation of seismic waves in the earth, and the process of reflection differs from the process of reflection of seismic waves in the earth.

To create additional reflections in the sound tube a stick two inches wide, one inch thick and twenty feet long is placed in the pipe. Such a stick reduces the area within the pipe available for the transmission of sound and changes the acoustic impedance of the pipe. Because of this, when sound travels down the pipe a reflection will occur when the sound comes to the top of the stick, and a second reflection will occur when the sound comes to the bottom of the stick.

As stated, these reflections in the sound tube arise from changes in area within the tube, or the reciprocal area. By comparison, reflections in the

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earth arise from changes in seismic velocity. However, the sound tube is regarded as an analog of the earth, and for this purpose quantities which belong to the earth are associated with the sound tube. In the construction of diagrams from the reflections in the sound tube certain changes are made in the sound tube constants.

1. Distances are scaled up thirty times.
2. Velocity is scaled up ten times.
3. Frequency is scaled down three times.
4. Time is scaled up three times.
5. Reflection coefficients remain the same.

Different combinations of wooden sticks are used to create different conditions giving rise to different types of records. These conditions represent wedges, pinch-outs, sections containing varying numbers and thicknesses of thin layers, and multiple reflections, the latter being created not only by adjustments of the stick in the sound tube but by moving the speaker so as to bring about a double impulse, one from a reflection from the bottom of the pipe and one from a reflection from the top of the pipe. An attempt is also made to cause variable results by cutting one of the sticks to scaled thicknesses from a resistivity log, in place of a velocity log, in order to bring about changes in the space within the pipe and thereby a succession of reflections of different amplitude.

The results of this study emphasize the argument that each reflection on a seismic record is nearly always a composite of several reflections. A constant source of error in the interpretation of seismic records is the idea that each line-up on the record represents a single interface, to be plotted on a cross-section at a definite depth. There is a companion idea that individual line-ups should be correlated with some single sharp kick on the resistivity log. The records from the acoustic model present in a simple way the argument that reflections from closely spaced interfaces will interfere with each other to give a composite reflection, often to the confusion of the map maker and the map user.