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COMMENT ON "THE EXACT SEISMIC RESPONSE OF AN OCEAN AND A N-LAYER CONFIGURATION" BY G.G. DRIJKONINGEN AND J.T. FOKKEMA*

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In a recent paper, Drijkoningen and Fokkema (1987) calculated synthetic seismograms for an n-layer model with the aid of the Cagniard-de Hoop technique. They considered the three-layer problem as well as the more general case of a stack of n-fluid layers. In solving the boundary value problem, the space–time Green's functions are first computed and then convolution with a known source wavelet is performed. They also correctly pointed out the advantages and accuracy of the Cagniard-de Hoop approach in computing synthetic seismograms.

Due to the increased interest in 'exact' forward modelling techniques in exploration seismology, I would like to draw attention to some previous work related to the Cagniard approach for computing 'exact' synthetic seismograms. This work has already shown the ability of the Cagniard approach to compute 'exact' synthetics and its applicability in exploration seismology. Unfortunately, Drijkoningen and Fokkema (1987) did not mention this earlier work.

The problem of an explosive source in two half-spaces was considered by Cagniard (1939). Similar work was also done by Pekeris (1940). A modification of Cagniard's method was presented by de Hoop (1960). In the Cagniard–Pekeris–de Hoop (C-P-dH) approach the solution is expressed as a finite sum of simple integrals over finite intervals. An important characteristic of the method is its strong connection with the physical picture of rays propagating through the considered medium. Thus, to use the C-P-dH method the solution has to be written so that its various terms may be identified with physical rays. This identification is not a mere coincidence. By applying a standard asymptotic expansion to these terms we obtain the usual geometric rays; at a higher order of expansion we get the head waves, provided the physical conditions for their existence are satisfied. The terms into which the solution is split are called generalized rays (Spencer 1960). To complete the discussion of the C-P-dH technique, the work of Abramovici (1978) must be mentioned. Abramovici (1978) presented an extension of the C-P-dH method which is applicable to more general cases of various sources such as shear dislocations, vertical and horizontal point forces.

Finally, I consider the computation of 'exact' seismograms for an n-layer case, based on the C-P-dH method without neglecting any of the rays. The simplest case

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of a homogeneous layer over a homogeneous half-space for an SH-torque pulse was first presented by Pekeris, Alterman and Abramovici (1963). The problem of an explosive source for the same configuration was solved by Pekeris, Alterman, Abramovici and Jarosh (1965) and Abramovici (1970). Exact synthetic seismograms for the model of a layer over a half-space were computed for a point force (Vibrator) by Abramovici and Gal-Ezer (1978) and for a horizontal force (Shear Vibrator) by Abramovici, Kanasewich and Kelamis (1982). The horizontal force problem is three-dimensional and, therefore, complete three-component seismograms are computed. Abramovici *et al.* (1982) also presented some interesting properties of generalized rays. The applicability of synthetic seismograms computed with the C-P-dH approach in crustal and exploration studies was presented by Kelamis, Kanasewich and Abramovici (1982a, 1982b, 1983) and Kanasewich, Kelamis and Abramovici (1983). The simple model of a layer over a half-space was used for a weathered layer as well as a simplistic 'thick' sedimentary basin. An ad hoc method of attenuation in the synthetics was also introduced. I emphasize that in all the above the model under consideration is very simple (a single homogeneous layer over a homogeneous half-space). Abramovici (1984) presented the 'exact' solution of an n-layer flat earth model for an SH pulse using the C-P-dH method as extended by Abramovici (1978). This solution corresponds to the acoustic case for an n-layer configuration presented by Drijkoningen and Fokkema (1987). Furthermore, Abramovici (1984) considered any source and receiver configuration (VSP modelling can be done) and included all combinations of physically realizable rays.

Although the authors take a different approach to the same forward modelling problem, I feel that the above discussion is essential to fully expose the C-P-dH approach to the seismic exploration community.

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