FUNDAMENTAL RESEARCH IN REFLECTION SEISMOLOGY

I. Introduction

This proposal is concerned with doing fundamental research into techniques for solving the seismic wave equation in inhomogeneous media. The reason for this proposal is our belief that the correct understanding and solution of many problems in reflection seismology depend on the more rigorous and exact analysis that can be obtained by faithfully solving the wave equation. In addition, the time is appropriate for investigation of wave equation techniques since the present and easily forseeable computing power of the oil industry will make such data processing concepts practical. Because of the fundamental nature of this research, we are looking for a broad base of support from the oil industry, with the funding coming from a group of at least ten companies.

Our approach to waveform analysis is a synthesis of the disciplines of stochastic systems theory, physical optics, and finite difference numerical techniques. Despite the fact that problems of reflection seismology involve a good measure of each of these disciplines, rarely have they all been applied simultaneously. The kinds of opportunities and applications which arise from this combined approach are illustrated in an article in the October 1972 issue of GEOPHYSICS (see appendix). The article explains a method for waveform migration in velocity inhomogeneous media, using finite difference solutions to the wave equations. The method is illustrated by numerous synthetic examples and two marine sections.

Two important sub-areas of reflection seismology are now ripe both in terms of national need and in terms of the ability of technology to produce a functional solution. First, the growing difficulty of locating significant structural petroleum prospects in the continental U.S. has demonstrated the need for developing techniques for resolving subtle stratigraphic traps. Second, offshore prospecting has revealed an unexpectedly severe masking problem with the deep water multiple reflections. In both cases the primary need is more accurate simulation of seismic waveforms observed in realistically complex geologic structures. Wave equation processing techniques have already been applied to these two problems and the research done at Stanford (discussed in the next two sections of this proposal) gives promise of being able to understand and solve these problems.

The research so far has been restricted to processing techniques for conventional 2D data. The same fundamental techniques can be extended to process 3D data. However, since the computer memory requirements are much larger for 3D problems than for 2D problems, the initial investigation of 3D problems would probably be done in the frequency domain instead of the time domain.

Our fundamental studies will include theoretical work, computer testing of synthetic cases, and occasional tests with field data. Although the basic theme of this proposal is fundamental research, the wave equation techniques will be applied to real world problems. This will not only enhance the communication of ideas between the sponsors and the investigators, but will also allow realistic evaluation and direction of the research.