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GEOPHYSICAL MONOGRAPH SERIES

David V. Fitterman, Series Editor

William H. Dragoset Jr., Volume Editor

NUMBER 7

A HANDBOOK FOR SEISMIC DATA ACQUISITION IN EXPLORATION

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SOCIETY OF EXPLORATION GEOPHYSICISTS

included several technical innovations that furthered the development of seismic data acquisition equipment and the interpretation of seismic data.

Beginning in the early 1930s seismic exploration activity in the United States surged for 20 years as related technology was being developed and refined (Figure 2). For the next 20 years, seismic activity, as measured by the U.S. crew count, declined. During this period, however, the so-called digital revolution ushered in what some historians now are calling the Information Age. This had a tremendous impact on the seismic exploration industry. The ability to record digitized seismic data on magnetic tape, then process that data in a computer, not only greatly improved the productivity of seismic crews but also greatly improved the fidelity with which the processed data imaged earth structure. Modern seismic data acquisition as we know it could not have evolved without the digital computer.

During the past 20 years, the degree of seismic exploration activity has become related to the price of a barrel of oil, both in the United States (Figure 3) and worldwide. In 1990, US$2.195 billion was spent worldwide in geophysical exploration activity (Goodfellow, 1991). More than 96% of this (US$2.110 billion) was spent on petroleum exploration.

Despite the recent decline in the seismic crew count, innovation has continued. The late 1970s saw the development of the 3-D seismic survey, in which the data imaged not just a vertical cross-section of earth but an entire volume of earth. The technology improved during the 1980s, leading to more

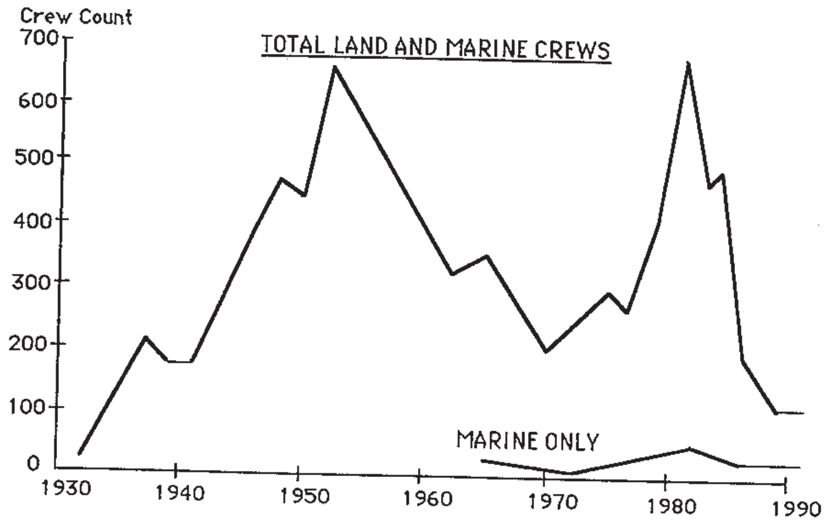

Fig. 2. U.S. seismic crew count (Goodfellow, 1991).

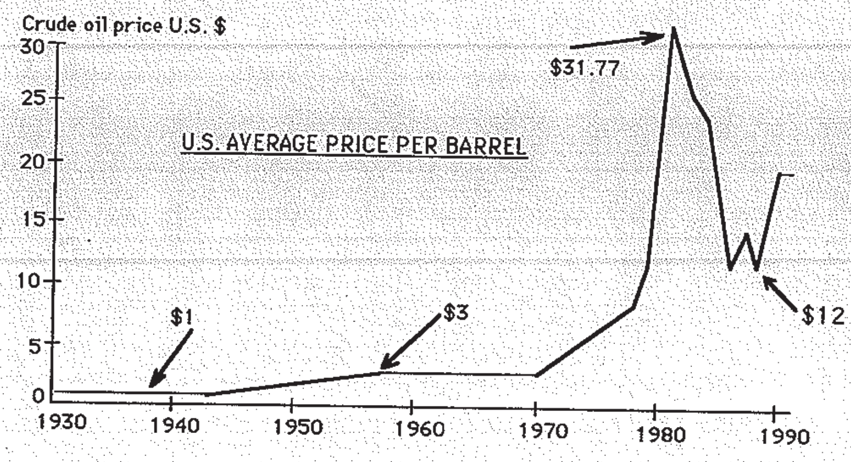

Fig. 3. U.S. price per barrel (courtesy U.S. Bureau of Mines, API).

accurate and realistic imaging of earth. This was partly responsible for the increased use of seismic data by the production arm of the oil industry.

1.2.2 Modern Data Acquisition

Because subsurface geologic structures containing hydrocarbons are found beneath either land or sea, there is a land data-acquisition method and a marine data-acquisition method. The two methods have a common goal—imaging the earth. But because the environments differ so, each requires unique technology and terminology.

In this section, simple examples of both methods are described in a presentation of the basic concepts of seismic data acquisition. Also, a hybrid of the two methods, called *transition-zone recording*, is described briefly.

Consider the simple land acquisition diagram shown in Figure 4. A seismic wave is generated by exploding an energy source near the surface to cause a shock wave to pass downward toward the underlying rock strata. Some of the shock wave's energy is reflected from the rocks back to the surface. The geophones vibrate as the reflected seismic wave arrives, and each generates an electrical signal. This signal is passed along cables to a recording truck, where it is digitized and recorded on magnetic tape or disk. The recorded information is taken to a computer center for processing. The seismic recording technique often is referred to as seismic surveying, so the words "recording" and "surveying" are interchangeable.

The positions at which the energy sources are detonated are called *shotpoints*. The energy-receiving geophones—"phones" for short—are placed cally monitored by radio navigation so that shots (or "pops") can be fired at the desired locations.

Just as with land records, marine shot records also are recorded and displayed in time (Figure 7). Instead of traces showing stations versus time, they are referred to as *channels* versus time. The shot records in Figure 7 have the ship and energy-source position to the left of the streamer. Seismic events such as A arrive first at channels on the left which are nearest to the source, then spread to the right in a curved manner. Event B is the direct arrival. The area of a marine shot record of greatest interest to the geophysicist is windowed on the right-hand record. A comparison of the land shot record (Figure 5) with the marine records shows that the marine events appear more continuous across the record. Although some reflection events are visible on the land record, most of that record is obscured by surface-generated noise. The marine record—being relatively noise free—is said to have a high signal-to-noise ratio, while the land record has a low signal-to-noise ratio. Reasons for this are discussed in greater detail in Chapter 3.

Consider again the land and marine acquisition schemes (Figures 4 and 6). After each land shot, the line of receivers may be moved along to another appropriate location and the shot fired again. This is the so-called *roll-along method* of seismic recording, the parameters of the roll-along being governed by both the geology and how the data are to be processed. Alternatively, the geophones may be left in place while the shot position is moved several times. To record an extensive number of lines on land is clearly time consuming because of the need to reposition the geophones manually. In marine

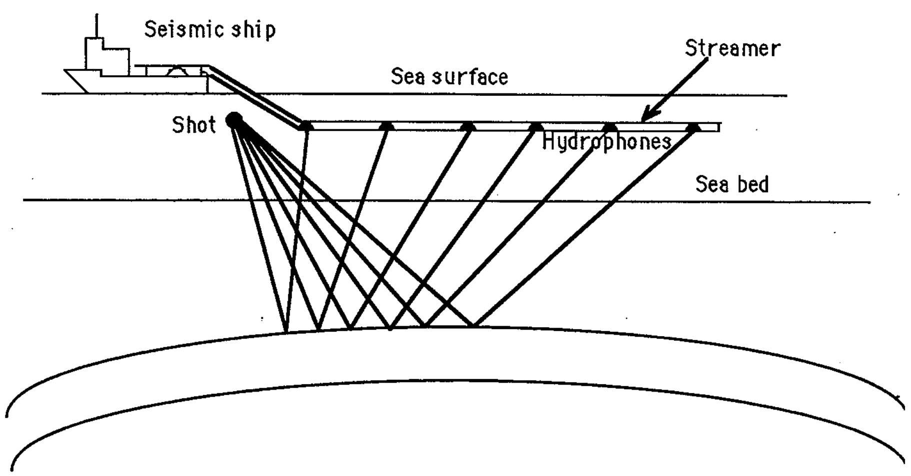

Fig. 6. Marine recording technique.

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