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Application Of Reflection Seismic Prospecting To Outlining Of Oil-Bearing Geological Structures

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transparent. Initially colored samples become more transparent and they deepen in shade. It is supposed that liberation of oxygen causes decrease in transparency. This clouding up of the material is avoided when an originally colored sample is treated because the color-giving impurity can remove oxygen, producing an increase in shade and a slight increase rather than a decrease in transparency.

APPLICATION OF REFLECTION SEISMIC PROSPECTING TO OUTLINING OF OIL-BEARING GEOLOGICAL STRUCTURES

ABSTRACT

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Seismic prospecting as it exists today had its beginning between 1920 and 1925. While it has many successful applications in the field of civil engineering such as in the determination of underground conditions in dam construction, in highway work, and in similar problems, nevertheless, because of the large financial resources controlled by the petroleum industry, its most extensive application has been in that field. While other applications are of great interest this discussion is limited to reflection surveying as applied to the discovery of oil.

To understand how the reflection method works we must know something about the geology involved. Before oil can accumulate it is necessary that there exist certain geological conditions favorable to this accumulation. Since oil is lighter than water, if there is a portion of a porous horizon which is higher in elevation than the neighboring points of that horizon, oil may accumulate in this region. Such a formation or structure is called an anticline. Similarly if a porous horizon is sealed off by a fault or by an unconformity there may likewise be a deposit of oil. In seismic prospecting we do not attempt to find oil directly but rather indirectly by outlining the structure and thereby determining whether or not the geological conditions are such that oil might have accumulated.

The method employed is simply to measure very accurately the time required for a sound wave produced by an explosion to travel from a given point in the ground to another point, the sound waves in general taking a variety of paths in going from the first point to the second. The physical fact which allows us to determine the underground structure is that the velocity of the sound depends upon the formation through which the sound is travelling. The velocity of sound in air is about 1,100 feet per second. The velocity of sound in sandstone varies with the degree

of consolidation, moisture content, cementation, etc., and may be from 3 to 12 times this value, whereas the velocity in limestone may be as high as twenty times the velocity in air.

The accompanying diagram (Fig. 1) illustrates reflection and refraction of seismic waves from a limestone bed. The wave travelling along path A from the shot point where the explosion takes place is reflected and refracted at the interface between the sandstone and limestone and then travels along the two paths B and C. For a wave such as G, which arrives at a critical angle such that no wave is transmitted into the limestone, the refracted wave travels along the interface, and at a point E both reflected and refracted waves may be observed, although the refracted wave is the first in arriving. At a point such as F, on the other hand, only reflected waves from the interface are observed.

As is shown in the diagram, the dynamite is placed at a considerable distance below the surface of the ground. This is done so that the energy of the explosion will not be dissipated into the air or into the weathered zone, but rather will be directed

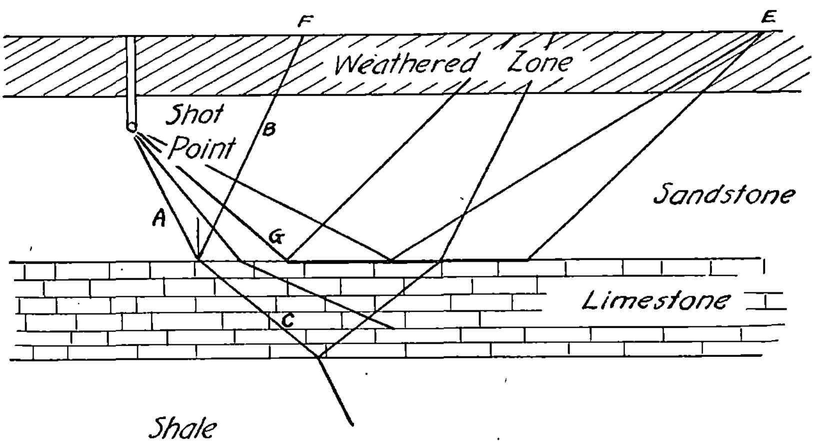

FIGURE 1. Diagram illustrating reflection and refraction of Seismic waves.

into the ground. In practice the depth of the shot is about fifty feet but in some cases may be as much as several hundred feet. The hole is drilled with a rotary drilling rig capable of drilling a four-inch hole at the rate of about 100 feet per hour in unconsolidated materials.

The dynamite is lowered into the hole by means of a sectioned pole, and is tamped by means of water run into the hole. The average size of the charge is about five pounds but may vary from a fraction of a pound to several tens of pounds.

The recording truck is the most vital part of the seismic equipment. It is located about a quarter of a mile from the shooting truck and is connected to it by telephone. There are connections from geophones, or pickups, placed in the ground, to the recording truck. The geophones are electrical devices which are sensitive to the motions of the earth and which send to the recording truck electrical impulses corresponding to these motions. An electrical impulse is sent to the recording truck at the instant the shot is fired.

The geophones are connected through amplifiers, to oscillographs. The electrical impulses cause a light beam to swing back and forth and a record results on a piece of moving photographic paper. Times lines, spaced ten one-thousandth seconds or in some cases five one-thousandth seconds apart, are also photographed on the light-sensitive paper.

The result is a reflection record showing the motion of the earth at the positions of the pickups as a function of time, and also the time at which the shot takes place is indicated by a break in one of the records.

Since we know the time required for the sound to go down to the various horizons and back and since we can determine the average velocity of the sound, we are able to calculate the depths of the various horizons as the length of the path taken by the sound is equal to the average velocity multiplied by the time. In making these calculations it is necessary to apply various corrections such as weathering corrections and elevation corrections.

The survey is carried out over an entire region and the results are correlated with each other and with geological evidence which may be available from well logs, etc. When this has been done, we are then able to draw some conclusions as to the underground structure. At this point in the interpretation there must be close cooperation between the geologist and the geophysicist.

This method of prospecting has been applied very successfully. It has a number of advantages over other geophysical methods and these advantages have been important factors in its widespread application. There are about 100 field parties working in the United States and the oil industry spends annually about $20,000,000 on this type of surveying. It is one of the most important geophysical methods and the prospects are that it will maintain this status for some years to come.

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