ber of samples. At the time of the animal injection, a duplicate sample of the colloid is prepared in water and serves as the standard for all subsequent measurements.

In case considerable skin is present, a small lump of hair will remain which may be filtered on cheesecloth and warmed with formamid; this procedure serves to extract any activity present. Since formamid is a good fat solvent, the presence of lipids does not present any problem. Only in the case of large bony structures is it necessary to resort to the much more cumbersome and hazardous HNO_3 digestion.

The method has been found to give values showing a strictly linear relation with respect to activity present. Standard deviations from average calculated values were ± 2.2 percent for P^{32}, ± 1.9 percent for Y^{90} and ± 3.1 percent for Au^{198}.

A complete description of the method will appear in *Nucleonics.*

D. L. TABERN
T. N. LAHR

Abbott Laboratories, North Chicago, Illinois

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Mapping Shallow Horizons with the Reflection Seismograph

The reflection seismograph has long been the standard in geophysical exploration for oil, because some types of geologic structure can be mapped with this instrument with rather high precision. Until recently, however, the seismic reflection method has not been used in shallow structural and depth-to-bedrock investigations, partly because of instrumental difficulties and partly because the petroleum industry, which has provided the stimulus for improvement in seismic exploration, has been interested primarily in finding deep structures and stratigraphic traps. For shallower studies, in the depth range from the surface down to about 1000 ft, core drilling, the refraction seismograph, and electric-resistivity methods have been widely employed.

Reflection seismic instruments, specially constructed for the U.S. Geological Survey, have recently been successfully tested in two areas in Oklahoma and Kansas. Near Ponca City, Okla., in Osage County, the Neva limestone has been successfully mapped at a depth of about 200 ft. Near Lyons, in Rice County, Kan., the Stone Corral dolomite has been mapped at depths of 150 to 200 ft. In addition, the base of the overburden at a depth of less than 100 ft has been mapped in some places in the Kansas test area. Reflection times as small as 30 msec have been measured. In the Oklahoma test area, reflecting horizons have been mapped continuously from 200 ft to depths as great as 4000 ft. [For an example of shallow-reflection mapping at somewhat greater depths, see C. F. Allen, L. V. Lombardi, and W. M. Wells, *Geophysics* **17**, 859 (1952)].

The instruments, designed by the Midwestern Geophysical Laboratory in close consultation with Survey geophysicists, are not radically different from conventional reflection seismic equipment. They have the following characteristics:

1) The frequency range of the 12 amplifiers is from 75 to 300 cy/sec (usually it is from 20 to 100 cy/sec).

2) The automatic volume-control time constant has been reduced to about a third of its usual value, and a variable presuppression control has been installed to permit a sharp reduction of the first energy arrivals.

3) The oscillograph paper speed has been increased from about 12 to 25 in./sec; high-frequency galvanometers have been installed, and the timing-line interval has been reduced from 10 to 2 msec.

The instruments can be used with or without automatic volume control and presuppression, and they are fully convertible to conventional operations by a simple amplifier exchange and a few oscillograph modifications. Reflected energy can be recorded almost immediately after the first arrivals.

In the Oklahoma test area, spread distances from the shot point of 100 to 210 ft between the first and twelfth geophones were used, and shots averaging 2 oz of dynamite were fired from shot holes drilled to the base of the "weathered" layer. A few single air shots were fired, but the record character was inferior to that for the hole shots. In the Kansas test area, spreads of from 20 to 130 ft were used with drilled shot holes and 2-oz charges (plus a few air shots in which the same disadvantage was displayed). No serious operational difficulties were encountered, although obtaining uniform amplitudes on each trace is less simple, because the travel distance for the first and last geophone positions is not as nearly identical as it is in conventional deep reflection work. Charge sizes are substantially smaller, and in some instances, with the automatic volume control and presuppression removed, a single blasting cap sufficed. The frequencies of recorded reflections averaged about 125 cy/sec.

Many of the limitations and ambiguities encountered in refraction work are absent in shallow-reflection mapping. The common refraction bugaboo of velocity inversion (the inability to detect low-velocity layers under high-velocity layers) is absent in the reflection method. Shallow-reflection work is much less expensive than core drilling, although some drilling for velocity and geologic control will always be necessary.

The shallow-reflection seismograph is expected to find wide application in ground-water and engineering investigations, mining investigations where stratigraphic and structural control of ore deposition is important, and in solving some of the near-surface problems in oil exploration. Both overburden-thickness problems and shallow structural problems in wide variety may be successfully solved by this new method.

L. C. PAKISER
D. R. MABEY

U.S. Geological Survey
Washington 25, D.C., and
Salt Lake City, Utah

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