they must be recovered, complicating the handling. (5) Data recording in an OBS is not affected by sea state while even moderate seas can severely degrade radio transmissions from buoys. (6) Radio transmission restrictions limit the available dynamic range of many buoys. The data acquisition system of an OBS is limited only by the onboard electronics. The range from transmitting buoy to receiving ship also tends to be limited to line of sight while no such restriction applies to the OBS. (7) A suitably designed OBS unit can be used in deep water with no difference in handling while tethered buoy handling problems increase with water depth.

Offshore Seismic Investigations of Sedimentary Basins with a Newly Developed Ocean Bottom Seismograph S15.7

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In order to explore deeply located geologic targets in offshore areas, where normal incidence reflection seismics have poor penetration, one can deploy ocean bottom seismographs (OBS) to record seismic shots fired at regular intervals along the OBS-line. Steep and wide-angle reflections, refracted and diving waves, as well as *PS* and *SP* converted waves, may be recorded on magnetic tape, digitally processed and plotted into traveltime sections. The sections are subsequently evaluated using a delay-time method, ray tracing and by computing theoretical seismograms. Seismic models developed by this technique are fairly reliable since they have to satisfy a large number of seismic sections, equidistantly distributed along the seismic line. The OBS instruments record for 100 hours continuously four seismic channels (3 geophones and 1 hydrophone) and 1 time signal. They may be operated in water depth to 4500 m and are marked at the surface by small sonobuoys and flashlights for easy retrieval. This system was tested on a fairly complicated structure in offshore western Greece, where vertical incidence reflection seismics had failed to penetrate. It was shown that the island of Paxos is part of the West Hellenic Nape-system which has overthrust soft marine sediments.

A Practical, High Resolution Geophone S15.8

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Advancements of the geophone, the first link in the data chain, have not kept pace with the many developments and improvements both to seismic recording systems and to data processing techniques. To obtain better resolution, higher frequencies are necessary and this highlights the problems of earth filtering and geophone-ground coupling. Geophone characteristics can be designed to partially compensate for earth filtering; better ground coupling is possible by geophone weight reduction.

High frequency data obtained from shallow interfaces is often useless since ground roll signals cause large mass excursions in conventional geophones resulting in considerable nonlinearities. An electronic, acceleration-sensitive geophone, by Klaassen and van Peppen (1982), overcame these problems by reducing weight and by changing frequency and phase characteristics. This device utilized a feed back principle which effectively locked the mass to the geophone frame, thus eliminating suspension nonlinearities. This geophone, which was subsequently developed for production, is sensitive to axial signals only and can operate in any orientation. For normal seismic survey application it was essential to ensure output only when the geophone is planted. Conventional external pulse test methods are not applicable because of the construction and an internally generated characterization pulse system compatible with existing test systems was required. Spectral analyses of field trials records confirmed the positive 6 dB per octave characteristic. Geophone characteristics indicate potential for (a) shallow (high resolution) surveys, (b) coal "in-seam" investigations, and (c) rock burst detection.

Seismic 16—3-D Seismic Case Histories

Three-Dimensional Seismic Monitoring of an Enhanced Oil Recovery Project S16.1

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The 3-D seismic survey technique has been used to monitor the progress of an enhanced oil recovery project in which production is stimulated by in-situ combustion driven by injected gas. A baseline 3-D data volume was recorded previous to the initiation of the combustion program. After combustion had been allowed to proceed for some time, the 3-D survey was repeated. Since the basis for tracking the effects of the combustion process is comparison, great care was taken to duplicate field geometry, recording parameters, and data processing. VSP data were also recorded to locate precisely the target sand reflection time and character.

Previous to the analysis of the 3-D data, synthetic traces were generated from well log data modified in several ways to simulate the effects of the combustion process. The target sand is characterized seismically by an impedance contrast due to low density. The predicted changes in reflection character are primarily due to changes in density caused by increased gas saturation. Complex trace attributes were computed to examine amplitude and other waveform changes. Comparison of preburn to postburn data shows differences that can be explained by increased gas saturation.