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Land streamer for shallow seismic data acquisition: Evaluation of gimbal-mounted geophones

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ABSTRACT

To increase the speed and efficiency of shallow seismic data recording and thereby decrease acquisition costs, the concept of a towed land streamer containing self-orienting, gimbal-mounted geophones is being evaluated. Our initial experiments at two locations within Switzerland demonstrate that good coupling with the ground may be achieved when the gimbal-mounted vertical geophones are contained in heavy (∼1 kg) casings and pulled along a very shallow (2–3 cm deep) furrow. Such a furrow may be created by mounting a heavy wheel on the towing vehicle. Placing the geophones in even heavier casings may provide the necessary good coupling with the ground, negating the need for the furrow. Shot gathers and stacked sections recorded with the gimbal-mounted geophones are practically indistinguishable from those recorded with conventional spike geophones. The principal advantage of this approach is that significantly fewer field personnel (only two or three) are required than for conventional shallow seismic surveying. When fully operational, the new acquisition system should be faster and less expensive for a wide variety of engineering and environmental applications.

INTRODUCTION

High-resolution seismic reflection techniques are powerful tools for mapping shallow geological structures (Steeples and Miller, 1990; Lanz et al., 1996; Büker et al., 1998a). New technological developments, such as the introduction of inexpensive 24-bit recording systems with large channel capacity, together with an improved understanding of the various waveforms recorded during typical shallow surveys (e.g., Robertsson et al., 1996a,b), have led to substantial improvements in the quality and reliability of high-resolution seismic reflection data. In addition to increasing our ability to record highfold and densely spaced data, the new technologies have also increased markedly the logistical complexity of a typical shallow seismic survey. For the same length of survey line, many more geophones must now be planted and many more source points used (Büker et al., 1998b). Accurate surveying of receiver and source locations and the manual planting of geophones are time consuming and costly aspects of shallow seismic data acquisition.

In light of this, we have initiated a project aimed at increasing the efficiency of high-resolution seismic reflection techniques, with the principal goal of decreasing the number of field personnel, time, and costs involved in conducting shallow surveys. To achieve these goals, we are adapting the concept of a snow streamer (Eiken et al., 1989) for use in engineering-scale land surveys.

TOWED LAND STREAMER

A new type of multichannel seismic cable has been designed and manufactured specially for efficient shallow data acquisition on land. It consists of 96 takeouts at fixed 1-m intervals. Each takeout is attached to a single self-orienting, gimbal-mounted vertical geophone. The seismic cable, or land streamer (Figure 1), is to be towed behind an all-terrain vehicle. A kevlar outer casing increases significantly the strength of the cable and helps prevent it from being damaged as it is pulled across rugged ground. The experiments reported here were conducted with a provisional set of six self-orienting, gimbal-mounted test geophones. Long recording spreads were simulated by moving the six-geophone spread and multiple firing of shots at the same locations.

The gimbal-mounted vertical geophones are key elements of this new system (Figure 2). Each geophone consists of a self-orienting velocity sensor mounted in a heavy cylindrical outer casing. To damp the motion of the sensor around its rotational axis, the inside of the casing is filled with viscous oil. Technical specifications of the geophones are given in Table 1.

GEOPHONE-TO-GROUND COUPLING TESTS

A critical issue of the land streamer concept is the geophone-to-ground coupling. In seismic reflection surveys,

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