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The usefulness of geophone ground-coupling experiments to seismic data

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ABSTRACT

Ground-coupling devices measure local conditions around a geophone and are therefore useful for geophone design. For purposes of gathering seismic data, the data from local ground-coupling experiments must be related to seismic data. In particular, the geophysicist wants to know whether a local measurement could help in detecting a ground-coupling problem or in correcting the seismic data for it. Two sets of field experiments have been carried out to investigate these effects. Our experimental data of coupling-measurement devices show that the behavior of well-planted spiked geophones is determined by shear along the spike, while the behavior of poorly planted geophones is determined by its weight. However, when a link is established between the data from a coupling-measurement device to seismic data, it becomes clear that the usefulness of this device for predicting problematic ground-coupling phenomena in seismic data is very limited.

INTRODUCTION

Ground coupling of geophones is still not a well-understood problem. Increased interest in single-sensor technology, three-component technology, four-component ocean-bottom sensors, and high-resolution seismics requires a better understanding of geophone-coupling problems. In this paper, experimental aspects of geophone coupling are investigated further, continuing from reports in the literature. A paper by Krohn (1984) is the most important in this area. The goal of this study was to investigate whether and how local ground-coupling measurements could help in detecting and/or correcting seismic data for ground-coupling problems. To answer these questions, some basic aspects of coupling required careful reinvestigation.

A clear distinction is made in this paper between so-called spike-shear coupling and weight coupling. The former term refers to the assumed way a spiked geophone is coupled to the ground and is important for geophone design. In weight coupling, it is purely the weight of the detecting device that furnishes the coupling between the geophone and the ground. This distinction between the two ways of coupling has become clear after the introduction of a spike in theoretical models by Tan (1987) and by Rademakers et al. (1996). In this paper, the focus will be mainly on the distinction between spike-shear and weight coupling of geophones. This is a common problem that the practicing geophysicist encounters when a geophone is not "well" coupled to the ground.

The paper by Krohn (1984) about experiments on ground coupling clearly describes the different laboratory and field techniques used to determine such coupling. Here, only field techniques are described briefly and used, with a focus on how to relate these measurements to seismic data. Measurements have been carried out in different soils, using two types of coupling-measurement devices. In addition, seismic-shot records were taken at the same locations. These results have been analyzed and conclusions have been drawn about the usefulness of such measurements to seismic data.

CONCEPTS OF GROUND COUPLING

The first issue in ground coupling is to define what geophone ground coupling means. In the past, some confusion has arisen because theoretical models did not explain experimental results about spiked geophones (see, for example, Krohn, 1984). Thus, theoreticians seemed to have a different meaning for ground coupling than that used by the practicing geophysicist. The definition of geophone ground coupling used in theoretical models (see, for example, Tan, 1987) is as follows: Geophone ground coupling is the difference between the velocity measured by the geophone and the velocity of the ground without the geophone. This definition is useful for the design of geophones so that optimal characteristics can be found. However,

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