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AUTOMATING SHALLOW SEISMIC IMAGING

Principal Investigator: Dr. Don W. Steeples
Institution: University of Kansas
Lawrence, KS 66045-2124

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Mr. Chester Miller, Office of Risk Policy, Office of Environmental Management
EMSP Program Manager: Mr. Jose Elizondo, Office of Research and Development

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TABLE OF CONTENTS

RESEARCH OBJECTIVE

Our current EMSP project continues an effort begun in 1997 to develop ultrashallow seismic imaging as a cost-effective method applicable to DOE facilities. The objective of the present research is to refine and demonstrate the use of an automated method of conducting shallow seismic surveys--an approach that represents a significant departure from conventional seismic-survey field procedures. Recent tests involving a second-generation mechanical geophone-planting device have shown that large numbers of geophones can be placed quickly and automatically and can acquire good data. In some easy-access environments, this device is expected to make shallow seismic surveying considerably more efficient and less expensive.

Another element of our research plan involves monitoring the cone of depression of a pumping well that serves as a proxy location for fluid-flow at a contaminated site. In May 2001, we collected data from a well site at which drawdown equilibrium had been reached. That information is being interpreted and evaluated.

The development of noninvasive, in-situ methods such as placing geophones automatically and using near-surface seismic methods alone or in concert with ground-penetrating radar to identify and characterize the hydrologic flow regimes at contaminated sites supports the prospect of developing effective, cost-conscious cleanup strategies for DOE and others.

RESEARCH PROGRESS AND IMPLICATIONS

As of June 2002, we have been able to acquire shallow seismic data using an automated geophone-planting device provisionally dubbed the "Autojuggie" (this appellation derives from two archaic slang terms referring to geophones and to the members of a seismic-acquisition crew responsible for laying out cables, planting geophones to acquire data, and retrieving the equipment after surveying). We have obtained accurate two-dimensional common-midpoint (CMP) data using rigidly interconnected geophones attached to pieces of channel iron. We have shown that large numbers of geophones can be placed automatically using a mechanical device, which could make the application of shallow seismic reflection (SSR) methods considerably faster and cheaper (Spikes et al., 2001; Schmeissner et al., 2001; Spikes, 2002).

Our progress has been attributable mainly to refinements in the design of the autojuggie and to an improved ability to measure the near-source wavefield. In several experiments, we collected data using single, 100-Hz geophones placed at intervals of 5 cm. In contrast, typical seismic surveys that are referred to as being "shallow" often use geophone intervals of 1 m or more. Because we increased the spatial density of the geophones by a factor of about 20, our ability to delineate and improve the coherence of the ultrashallow reflections over other interfering phases was enhanced. Seismic-source energy was provided by a single shot from a .22-caliber rifle using subsonic, solid-point, short ammunition. We found that the larger, more powerful shallow seismic exploration sources tested at the site (i. e., commercial seisguns and sledgehammers) generated near-field nonlinear soil deformation strong enough to prevent the detection of ultrashallow reflection information (Baker et al., 2000).

Additionally, we have had encouraging results in our attempts to demonstrate the use of an automated method of conducting shallow seismic surveys. Building on previous work indicating that a mechanical device could be used to place geophones automatically and simultaneously (Steeples et al., 1999), we performed further experiments to show that good seismic information can be recorded when interconnected geophones are mounted on a rigid medium (Fig. 1).

Fig.1. Automatic geophone-planting device set up for CMP data acquisition. The control line is on the left, the test line on the right. (Spikes, 2002).

We also have recorded high-quality, near-surface, 2-D CMP seismic data using this method (Spikes, 2002). Standard processing techniques were used to stack the recorded reflection data acquired from a conventionally planted geophone line and from a line of geophones mounted on a rigid medium. The stacked sections from the coincident CMP surveys at one of our field sites (Field Site 1) show that results for the control line and the test line were very similar (Figs. 2, 3).

Overall, our experiments indicate that the imaging results obtained using automated seismic methods compare favorably with those obtained using classical seismic techniques. Moreover, an automated geophone-planting device of the type under development would not necessarily be limited to the use of shallow seismic reflection methods. To pursue this possibility, we have begun testing data-collection procedures for both seismic-refraction and surface-wave studies.

Summaries of the significant results stemming from our EMSP funding to date can be found in the refereed scientific papers appended to this report. These documents also cover in greater detail the procedures we have used to achieve seismic imaging at ultrashallow depths.

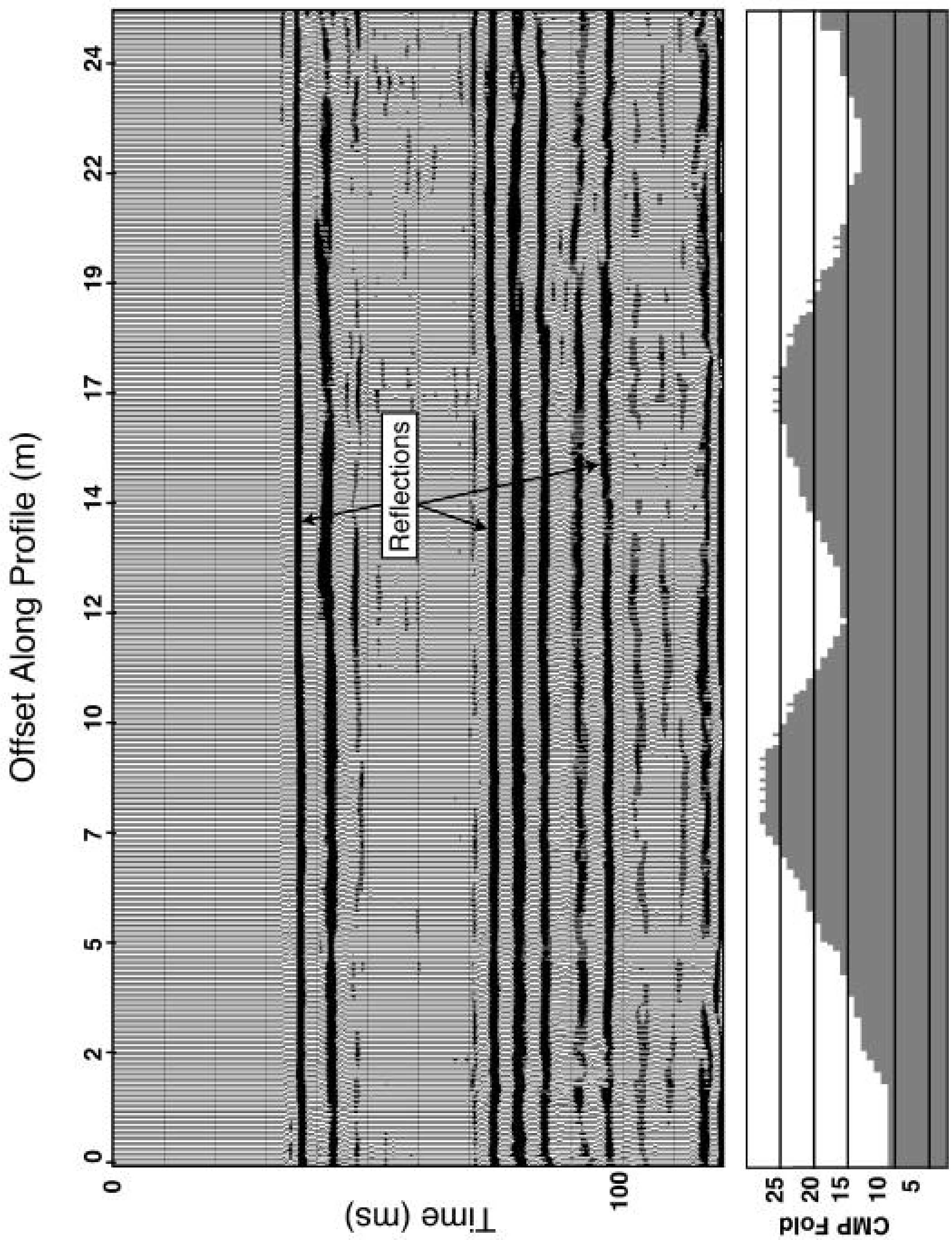

Fig. 2. Stacked section and fold diagram from the control line at Field Site 1, showing three prominent reflections at this locale. The fold diagram differs from the fold diagram in Fig. 3 because of differences in trace- and record editing.

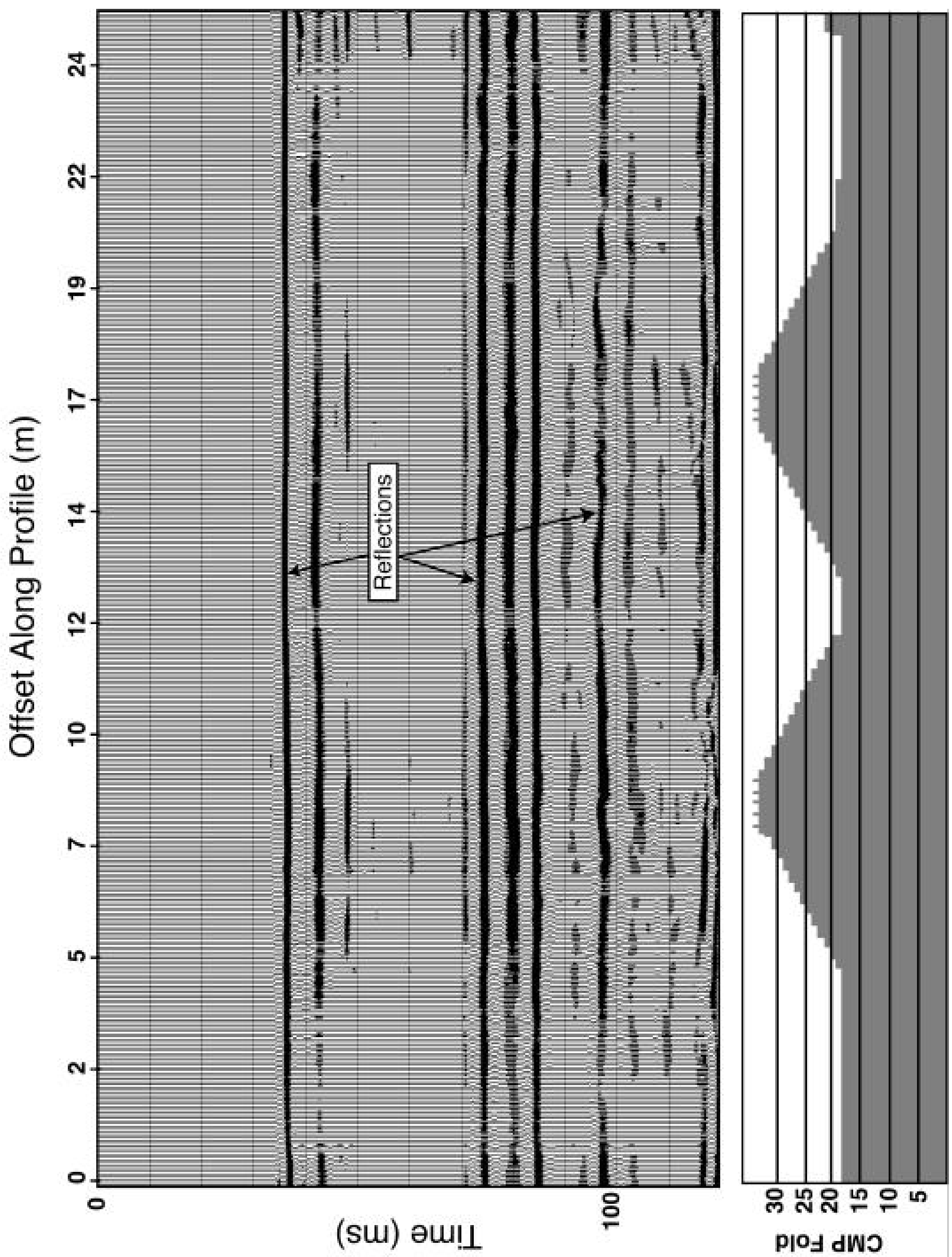

Fig. 3. Test-line stacked section from Field Site 1. This stack and the corresponding control-line stack (Fig. 2) are fundamentally the same, except for slight differences in phase and amplitude.

In summary, our results (Spikes, 2002) show that large numbers of interconnected, rigidly attached geophones can be placed automatically using a mechanical device, which will make the application of shallow and ultrashallow seismic research methods more attractive in easy-access localities.

For additional information about past work, we refer the reader to "Obtaining CMP Seismic Data using Interconnected Geophones," presented at the DOE 2001 Atlanta Workshop, and "Coincident Seismic and Ground-Penetrating Radar Images," presented in Atlanta in 2000.

PLANNED ACTIVITIES

The focus of our research during the remaining award period is to continue to test and refine the automated, cost-effective, ultrashallow seismic imaging method under investigation. This device is expected to be applicable to DOE facilities and potentially to other near-surface environmental, engineering, and geological problems as well. We have begun testing data-collection procedures for both seismic-refraction and surface-wave studies. In addition, we are interpreting and evaluating data acquired from the cone of depression of a pumping well that serves as a proxy location for fluid-flow at a contaminated site.

In the final year of our research, we will perform demonstration surveys using the automated device at one or more DOE facilities.

INFORMATION ACCESS

Refereed Papers Submitted, in Review, or In Press

2002

Baker, G. S., D. W. Steeples, and C. Schmeissner, 2002, Shallow underground reflection feasibility (SURF) diagrams: *Environmental and Engineering Geoscience,* in press.

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