High Resolution Seismic Source Characteristics on a Sand Bar along the Kansas River in Wabaunsee County, Kansas

Introduction

Results from a properly designed and executed high resolution seismic source comparison and noise survey on a sand bar along the Kansas River could provide valuable insight for optimizing seismic survey designs in areas with a relatively thick, sandy near-surface material and shallow water table. Data from this near-surface analog used in conjunction with site-specific geologic information could dramatically reduce on-site testing. Access and operational limitations, narrow operational time windows, and expensive mobilization and standby time for a full commercial seismic crew while testing dramatically impact the feasibility (economy) of seismic source and receiver array testing in many challenging data areas. Design evaluation and equipment testing were tasks routinely undertaken by research seismic reflection crews operated by the major oil companies. Advancements in and enhancements to seismic exploration technology has always required empirical research, concept evaluation (proof of concept), and seismic site response studies. This applied research project will field test and evaluate selected seismic sources under field conditions that closely simulate an area of exploration interest to Mobil Technology Company (MTC).

This seismic study will focus on several aspects of source energy, array design, and environmental impact. Key areas of interest include: 1) relative source energy (S/N), 2) access limitations (mobility, floatation, etc.), 3) resolution potential (frequency content as a function of depth), 4) 3-D characteristics of patch design, 5) near-surface variability and its effect on recorded data, 6) near-surface static effects, 7) seismic waveforms, 8) source footprint, 9) environmental impact (noise, size, waste, etc.), and 10) repeatability. Testing procedures will allow selection of the optimum source, source configuration, effectiveness of patch, and operational considerations (Miller et al., 1986; Miller et al., 1992; Miller et al., 1994; Doll et al., 1998). All data will be acquired consistent with MTC's source test plan.

The project will require about two field days and at least one day of local data evaluation. Preliminary reconnaissance has narrowed the list of possible sites to two: one site is located just north and east of Lawrence, Kansas, and a second is a few miles south and east of the town of Wabaunsee, Kansas. The Wabaunsee site possesses the best overall potential of achieving most of the goals and objectives of both MTC and the Kansas Geological Survey (KGS). Criteria used to select feasible test sites include: 1) at least 1000 m long and 200 m wide, 2) approximately 1000 m of consolidated sediments over igneous basement rocks, 3) around 20 m of unconsolidated sands and gravels, 4) shallow water table (<2 m), 5) close proximity to Lawrence, Kansas, 6) easy access from a public road, 7) void of noise sources (dredge, power lines, highways, industrial facilities, etc.), 8) State of Kansas property (between the high water lines, bank to bank on navigable rivers), and 9) it must be a sand bar. Vehicle access to the site is mandatory. It is anticipated that a shot hole drilling rig, IVI Minivib, 4 x 4 truck-mounted Bolt Air Gun (LSS-6), truck-mounted accelerated weight drop, cable/phone ATV, and seismograph mounted ATV will be used on site. The first day of field testing will involve the recording of most of the test data. A day will be spent in Lawrence at the KGS analyzing the data with ProMax on an SGI Octane computer. The second day of field testing will be used to evaluate and expand on various aspects of the primary comparison data and insure the data set is complete.

Outline of Proposed Program

1) Deployment of a 140 station patch using five 30 Hz geophones at each station. Station intervals will be 15 m along two parallel lines separated by 200 m. The geophones will be grouped and dug in to a depth of around 15 cm. This 1000 m long and 200 m wide patch will be recorded on a 240-channel Geometric StrataView seismograph. Twelve unique shot locations will be recorded at shot stations located between the receiver lines.

2) Shot gathers will be recorded using an IVI Minivib, Bolt Land Air Gun, Accelerated Weight Drop (provided by GSS on contract from MTC), dynamite, and 8-gauge Auger Gun. Sweeps used for the Minivib will be selected by MTC and will be generated using an IVI controller. The IVI controller records both baseplate and mass accelerometers, ground force, and filtered ground force. MTC will select the size of the gun chamber used by the Bolt Air Gun from the four available at the KGS. Dynamite charges (500 g and 1000 g of MTC's preferred type and brand) will be buried (2 holes, 3 m deep for the 500 g and 1 hole, 6 m deep for the 1000 g) and detonated with seismic blasting caps at each of the 12 shot stations. The 8-gauge Auger Gun will be fired at each station using 350 grain black powder loads.

3) The patch will be deployed as uniformly symmetric as possible. The two receiver lines will be separated by 200 m at both ends with equivalent receivers on both lines as nearly adjacent as possible. Shot locations will be equal distance from both receiver lines. From the center of the patch, shot stations will be located at -525, -465, -405, -345, -285, -225, 225, 285, 345, 405, 465, 525. Explosive holes will be drilled on site during the test once all other sources have been tested. This source ordering is designed to avoid unfairly impacting the performance of a surface source by the disturbed near-surface left from borehole detonation of high explosives.

4) Data recorded after the first day of test will be downloaded from the seismographs, copied to a CD, and transferred to the SGI for analysis by MTC at the KGS. The ProMax software will be available to MTC on the SGI computer. This "on-site" analysis will permit

modifications or enhancements to be made to the testing program while the patch is still deployed.

4) The final day of testing will be designed based on the previous days' analysis. All sources under the control of the KGS will be available for continued testing on the second day. A shot hole drilling rig will be available, permitting placement of high explosives in any configuration MTC chooses to test.

Table 1–Summary of Proposed Survey

1) Seismic system to be used – 240-channel R60 StrataView from Geometrics

2) Equipment and Sources Available from KGS
   - 30 Hz L28A Mark Products Geophones (5 phones per string, 140 strings)
   - 40 Hz L28E Mark Products Geophones (3 phones per string, 210 strings)
   - dynamite (quantity and type specified by MTC)
   - Bolt Land Air Gun (LSS-6)
   - IVI Minivib (15 to 450 Hz, ~300 lb reaction mass, 8,000 lb hold down)
   - 8-gauge auger gun
   - RAWD (Rubber band Assisted Weight Drop)
   - CME-55 drill rig (shot hole)
   - Cable and phone ATVs
   - 15 m takeout cable

3) Planned Field Schedule:

	Approx. Dates
Site selection, site clearing, permitting, bedrock drill confirmation	Feb. 1-15
Site layout and geophone deployment	Feb. 16-17
Day #1 source testing	Feb. 18
Data analysis at KGS	Feb. 19
Day #2 source testing	Feb. 20
Site clean-up (remove geophones/cables)	Feb. 21

4) Data gathered into 240 channel records and written to CD after acquisition of each day's source testing.
   Safety Report completed and delivered to MTC by March 15, 1999.

Quality Control (QC)

QC is critical and will be continuous throughout testing. Near-surface inconsistencies, vehicle noise, and difficult receiver coupling will require strict compliance with QC guidelines and meticulous monitoring of data. The seismograph CRT displays real-time noise levels permitting instantaneous monitoring of cultural, air traffic, vehicle traffic noise, cable-to-ground leakage, and geophone plant quality. A threshold noise level will be selected and no shot will be recorded when any trace exceeds the background noise limits. Around 0.05 mV peak to peak is a reasonable maximum background noise for this test. Each geophone will be tested to insure a cable-to-ground resistance greater than 1000K ohms, with individual geophone continuity within 5% of nominal string impedance (including consideration for cable offset). As well, each geophone will undergo a modified tap and twist test. The seismograph's real-time noise monitor and the roll-switch's earth leakage and continuity meters will be used to insure geophone plant quality and fitness as well as equality of background noise for each shot.

Walkaway Testing

Walkaway noise testing will be designed and executed to allow evaluation of acoustic signature, optimum acquisition parameters, variability of near-surface velocity structure, trace-to-trace consistency in reflection character, general resolution potential, signal-to-noise ratio, and impact on environment. It is the intent of this test to provide data that will guide definitive selections of equipment and parameters and the general survey design for a 3-D production survey planned by MTC.

Final Products

The raw data will be transferred from the seismograph's hard drives to CD-ROM at the KGS's Lawrence, Kansas, facility. Data from a 240 channel Geometrics StrataView are stored as 4 60 channel files in the seismographs native format SEG-2. Each recorded field file will be appropriately grouped into a single 240-channel shot record and converted to a SEG-Y format. The 240 channel SEG-Y records will be burned to CD and made available to MTC for downloading onto the KGS SGI workstation running ProMax. All field notes (OB) will be scanned and transferred onto the CD with the raw data. It is the intent of the KGS to provide all data in this format the morning following the acquisition of each data set. If time does not permit data to be transferred to MTC in this fashion, the data will be overnight mailed to MTC no more than one full working day after collection.

Overall Project Goal

Provide MTC with data that permits the design of a 3-D seismic survey in an environmentally sensitive sandy area with a relatively shallow target depth. These data will also be studied in hopes of enhancing seismic survey design in a variety of areas significant to both the KGS and MTC. And finally, these data will help develop a better understanding of low impact, small footprint source coupling and characteristics of various types of sources in thick sandy, saturated near-surface conditions.

References

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