New multi-component acquisition equipment: An initial report

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ABSTRACT

Burial of seismic receivers promises to increase the recorded energy band. We have designed a three-component (3-C) geophone with a planting spike and retrieval cable that allows the geophone to be deployed in the near surface. In addition, we have used a 48-channel hydrophone cable in a vertical water well to record the near surface pressure field. These measurements were made as part of a high-resolution seismic survey conducted over the Blackfoot field in November, 1997. In addition to simplify the recording of 3-C seismic data, we have developed a cable with single plug (6-pin) connectors. This promises simplify the deployment of 3-C equipment and lessen the complication of recording of 3-C data. All of these developments are aimed at improving both conventional and multicomponent surface seismic.

INTRODUCTION

We have continued testing advanced acquisition techniques over the Blackfoot field, Alberta. The current survey was designed to test near-surface geophone and downhole hydrophone response, in attempt to improve signal bandwidth.

Downhole 3-component geophones.

Along the center kilometre (high resolution) part of the Blackfoot high-resolution seismic line, patterns of 3 holes each were drilled to depths of 6, 12 and 18 m. Modified 3-component geophones were planted at the bottom of these holes using modified loading poles to ensure orientation was defined.

Hydrophone cable

At the center of the Blackfoot high-resolution survey a 100 m hole was drilled and a Mark Products hydrophone cable consisting of 48 hydrophones at a spacing of 2 m was deployed vertically into it.

3-component geophone cable

Although this was not ready for this particular survey, this is an attempt to simplify field operations with 3-component geophones.

DOWNHOLE 3-COMPONENT GEOPHONES

After reviewing data from a number of 3-component seismic surveys, it is evident that there is considerable loss of shear wave energy somewhere between the surface and several hundred meters in depth. This detracts from signal quality by reduction of both spectral bandwidth and received amplitude. Another problem has been the determination of static corrections for converted-wave surveys, as the velocity of shear waves in the near surface can be very low.

In an attempt to quantify the effects on the entire wavefield of the near-surface sediments, the deployment of geophones at different depths as described above was used. This provided data from the surface, and at 6, 12 and 18m depths which can be directly compared both pre- and post-processing. Sufficient stations were recorded to provide a stacked section from the downhole geophones for all three axes.

The holes for these geophones were drilled using a standard shot-hole drilling rig, but because of the diameter of the geophones, a larger than normal bit was necessary. The first attempts were to plant the geophones in a standard size shot-hole (100mm), but this proved impossible. Larger holes were drilled using a 150mm bit.

The geophones used were Geospace GS-20DM 3-C which have a circular case with a square section on top. The square section was mated to a square metal cup installed on the end of a modified loading pole which provided orientation stability as the geophone was pushed down the hole. A 150mm sand spike was installed on the geophone to prevent it from tilting during installation and to ensure that the final positioning was within the specifications for this geophone (within 10 degrees of vertical). A picture of the modifications made to the geophones can be seen in Figure 1.

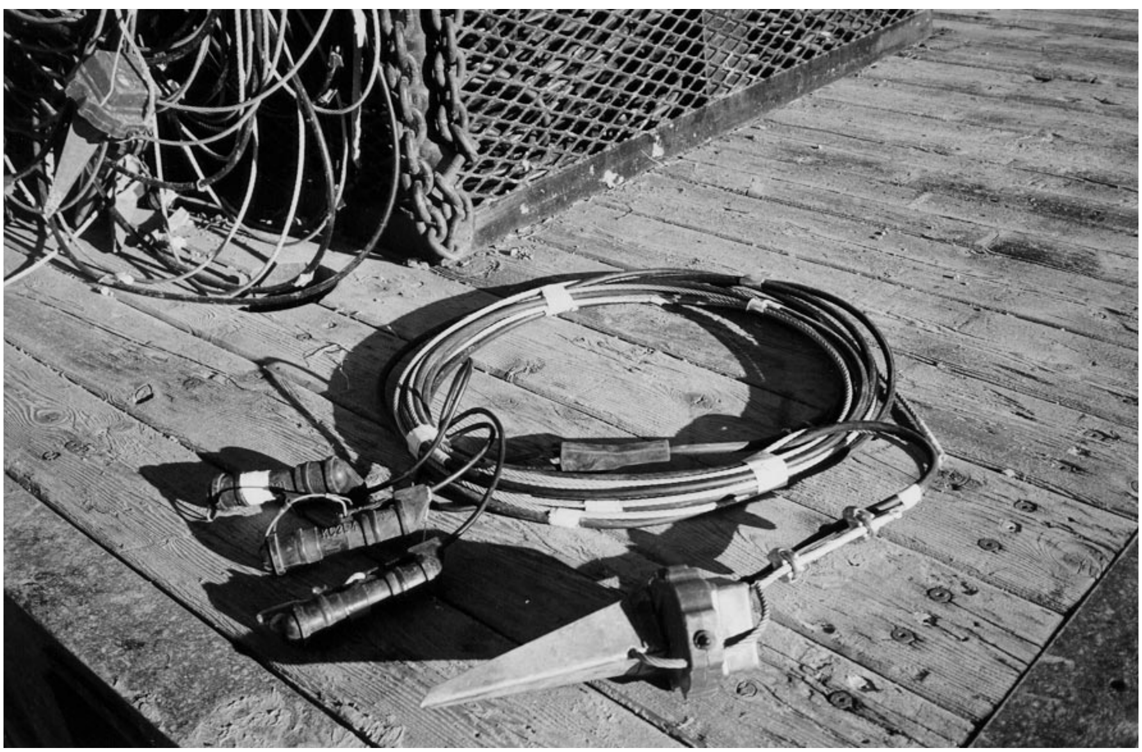

Fig. 1. The above picture shows the modifications made to the Geospace GS-20DM 3-C geophones. Note the sand spike and 3/16 inch aircraft cable.

Considerable force was required to get some of the geophones down the hole, as even when the planting was done immediately after drilling was completed, there were several points at which the hole was already collapsing. To make recovery possible after the completion of shooting, 3/16 inch 7x16 aircraft cable was attached to each geophone by drilling through the periphery of the case and top of the sand spike, then passing the cable around the geophone in a loop. This cable has a working strength of 4200 pounds, which was gratefully higher than needed! After the survey was completed, all the geophones were recovered.

HYDROPHONE CABLE

At the center point of the Blackfoot high-resolution survey, a 100 m hole was drilled and cased using a water well drilling rig. A hydrophone cable loaned to the CREWES Project by Noranda Technology Center was deployed in this hole. This cable consists of 48 Benthos AQ-4 hydrophones with attached AQ-302 pre-amps spaced at 2 m and is terminated in a single Amphib-122 connector. Connection of this cable to the geophone takeouts was accomplished through a set of 48 flying leads each with a geophone connector (KC-L2) attached and numbered to correspond with each separate hydrophone. Figure 2 shows the elements on the hydrophone cable and the adapter cable used to interface the recording instruments to the hydrophone cable.

Fig. 2 An adaptor cable (top) connects the hydrophone cable to the recording instruments. Note the hydrophone elements which appear as bulges in the thick hydrophone cable.

This cable was also used to try and sample the near surface effects in the same manner as the downhole 3-component geophones, but with more detail. Another purpose was to look at the feasibility of using vertical cable acquisition techniques on land. The results are sufficiently promising that the use of a cable with greater hydrophone spacing deployed in a much deeper hole is being discussed. A plot of a hydrophone receiver gather is displayed in Figure: 3.

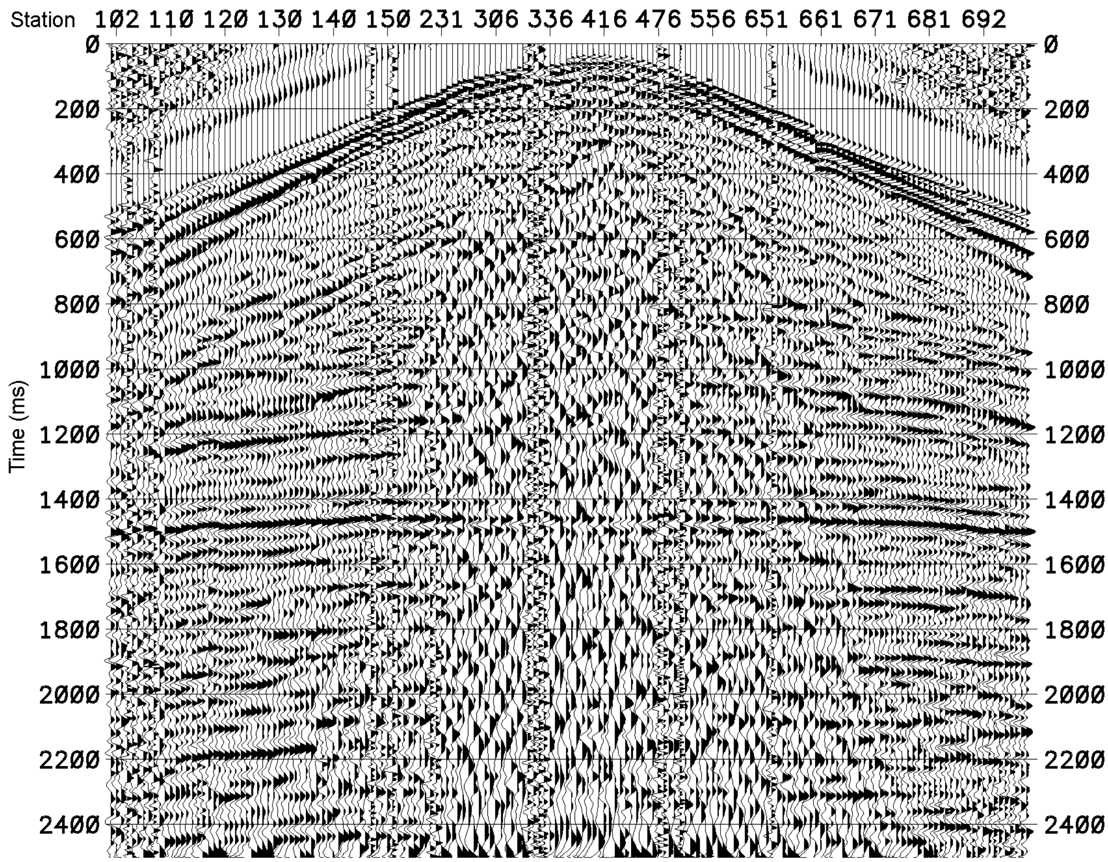

Fig. 3. A receiver gather of a hydrophone at a depth of 72m. A bandpass filter (5-10-100-150) and 300ms AGC have been applied

3-COMPONENT GEOPHONE CABLE

Use of 3-component geophones in the field, can be complicated. Because of the 3 connections required to each geophone there is a bulk of cable piled at each station, or multiple cables are used. There is a also a possibility that the connections of the three axes will not always be correct. These incorrect connections will not show up in the line-testing phase of the spread setup; consequently the first shot is required to check them.

Most surveys to date have used colored electrical tape to identify both the geophone axis and the corresponding cable take-out. This method is satisfactory as long as the crew is careful and well aware of possible problems e.g. picking a cable up for rollalong, then laying it out in the opposite orientation at the front of the spread, thereby reversing the color coding. It is essential that all shots are monitored by the observer to catch this sort of problem immediately.

The 3-component cable provides a single 6-pin connector (KCX-6) for each geophone, thus eliminating most of the problems outlined above. The connector is very similar to the standard 2-pin connector (KC-2L) now in common use. The type of pin (replaceable) and the material (molded polyurethane) are the same, but the diameter is slightly larger. Figure: 4 shows a comparison of the KC-2L and the KCX-6 connectors. These cables are designed to be analogous to standard cables with roll-through capability.

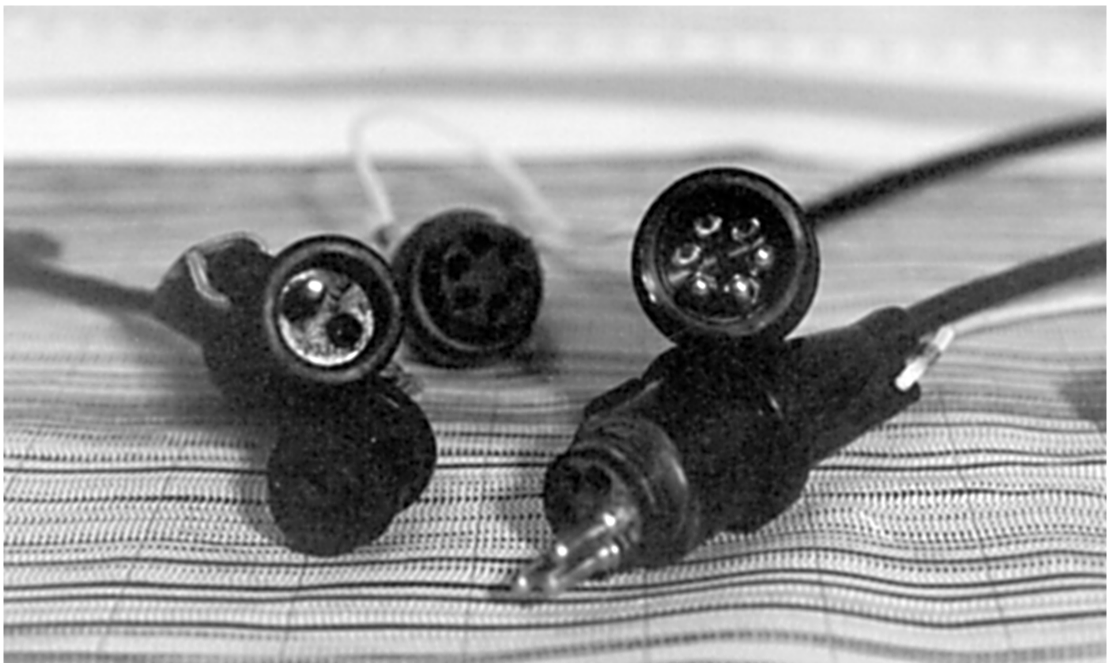

Fig. 4. Comparison of the KC-2L and KCX-6 connectors.

CONCLUSIONS

Downhole 3-component geophones

Using common receiver gathers to compare the results from the deeper geophones indicates that there are significant differences in some areas. The P-S events appear to be much better on the deeper buried (12,18m) geophones. The P-P events appear to be best on the mid-level (6,12m) geophones. However, it also appears that the geophone coupling is not always good. The results are discussed elsewhere in this report.

Hydrophone cable

The hydrophone cable appears to have recorded some excellent reflection data as seen in Figure 3. The events evident on the receiver gather correlate with those visible on the surface seismic sections. We are very encouraged by these data and think that this shows great promise for vertical land cable imagery.

3-component geophone cable

This is currently being manufactured and was not available for this survey. Discussions with field contractors and others have produced very favorable responses to the idea, including establishing a standard connection for 3-component geophones to provide simplicity in field operations and compatibility across different acquisition systems.

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