Recording seismic on geophones within ground screws II

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ABSTRACT

Seismic records were obtained from geophones installed within devices known as ground screws, normally used as bases for small buildings. The data were acquired along with other records at CREWES' Priddis test site in November/2014. Analysis is basically a comparison between the records and surface geophones at the same recording stations, and some ground screw records show clear advantages in signal to noise ratios. A patent on this type of recording is held by Ross Huntley.

INTRODUCTION

This report is partly a duplicate of an earlier report (Manning et al, 2014), but it has a more thorough description of the experiment, and contains a more complete analysis of the recorded results.

We have long been interested in methods to improve the acquisition of shear data at the earth's surface (Manning, 2012). The reason for our interest is the poor quality of most surface shear wave data compared with that obtained in boreholes (for an example, see Eisner et al 2009).

The idea of inserting geophones deeply into the ground inside an earth screw was developed and patented by Ross Huntley and informally presented to CREWES staff at the 2014 geophysics and geology conference in Calgary. Mr. Huntley then shipped a number of Krinner ground screws to CREWES in October so they might have geophone elements installed and tested as part of the larger test program at Priddis in early November/2014.

CREWES bought a set of SM7 geophone elements, 15 vertical and 30 horizontal, which were inserted into casings designed for spike geophones. These casings had to be trimmed in order to fit into the ground screws. The elements were soldered and wired into a small circuit board along with a shunt resistor, and then joined to the Cooter connectors. This was done within a very short time frame. A ground screw, a casing with elements, and a connector set is shown in Figure 1.

Initial fitting showed that the geophone casing would center the elements at about the top of the screw threads, and it appeared that a friction fit would provide sufficient coupling for the duration of the experiment. However, when most of the elements and casings had been installed, it was found that the casing depth within the screw sometimes ranged up to 6 centimetres above the usual position. This range was not considered a problem as far as recording depth was concerned, but there were concerns about the coupling.

The diagrams in Figure 2 show the usual positions of the screws in the ground, and the right screw shows the usual position of the casing and elements within the screw.

FIELD WORK

The ground screws were installed at 10 metre intervals along one of the receiver lines laid out for the main program. Figure 3 shows the top of a ground screw along with other geophones, including a conventional three-component geophone with the same SM7 elements (orange case)

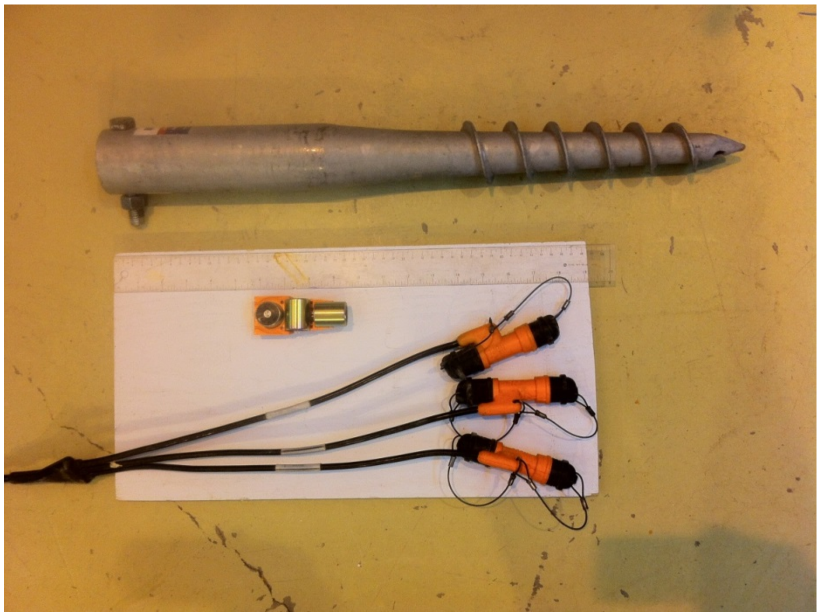

Figure 1: The Krinner ground screw is at the top, a set of three elements in an opened casing is on the paper, and the Cooter connectors are below. The transparent ruler is 20 inches long.

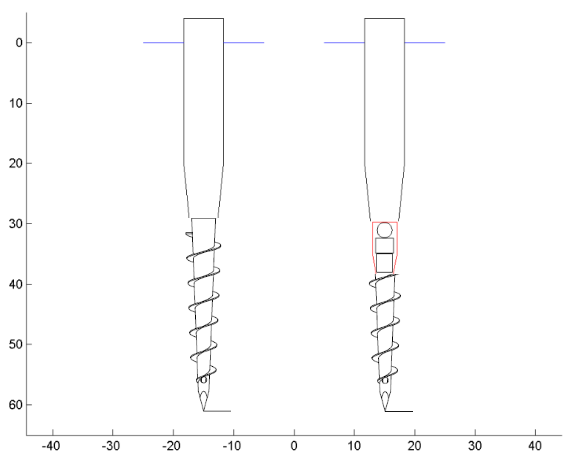

Figure 2: Diagrams of Krinner ground screws in place in the ground. The left axis shows the depth in centimetres below the ground level (in blue). Part of the right ground screw is cut away to show the usual position of the geophone elements within the casing. Note the ground screw is gradually enlarged above the threaded portion.

Figure 3: The sensors under test at station 165. The top of the ground screw appears slightly above and right of center. The comparable 3-component SM7 surface geophone is to the left in the orange case.

Pilot holes were drilled with a 5 cm. auger for each ground screw. Even with these holes it required considerable effort to insert a screw to depth.

The ground screws were driven with a fabricated wrench, which allowed two men to apply torque at a convenient working height. Slots in the wrench fit over the bolt in the screw, and a third slot allowed the geophone leads to emerge. Unfortunately the wrench, constructed of aluminum, failed after several plantings, and two versions had to be used.

The screws were quite readily reversed out of the ground at the end of the project.

DATA EXAMPLES

An examination of many of the 100 relevant records showed some errors in the wiring and possibly poor coupling between the ground screws and the sensor elements. Many of the wiring errors could be corrected in processing, but several traces were dead or ringing. The remaining ground screw traces showed less high frequency noise than conventional traces, especially from air-blast. An example of this is shown in the dynamite records in Figures 4 and 5.

Since the main advantage of using ground screws was expected to be when recording shear waves, the receivers were located on a line where some shots would be spaced to give longer offsets. This was in the hope of seeing shear waves converted from down-going pressure waves, where shear waves only arrive at longer offsets.

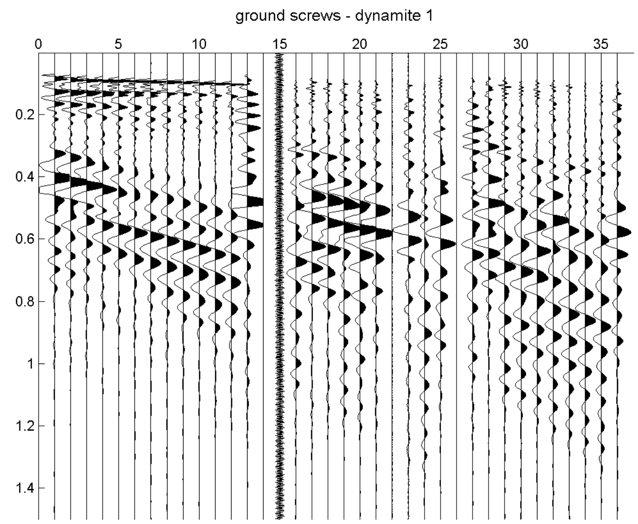

Figure 4:Dynamite data recorded from geophones installed in ground screws. There are 12 traces each of vertical data, in-line horizontal data, and cross-line horizontal data. There are several missing and noisy horizontal traces.

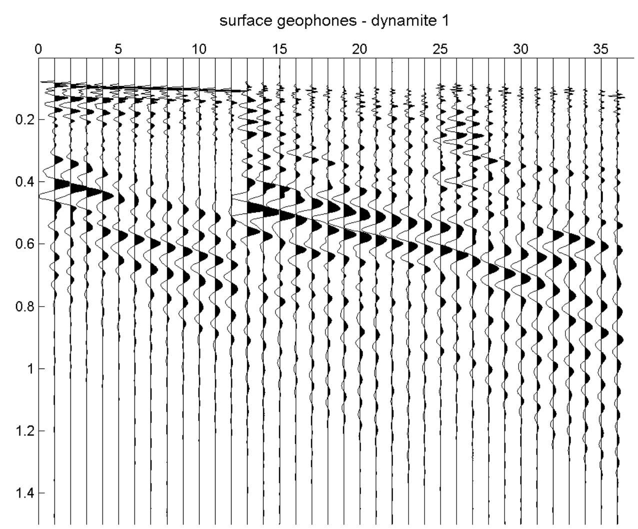

Figure 5: Dynamite data recorded from conventional surface three-component geophones with identical elements for comparison. The air-blast noise at 0.1 seconds is a little more obvious here.

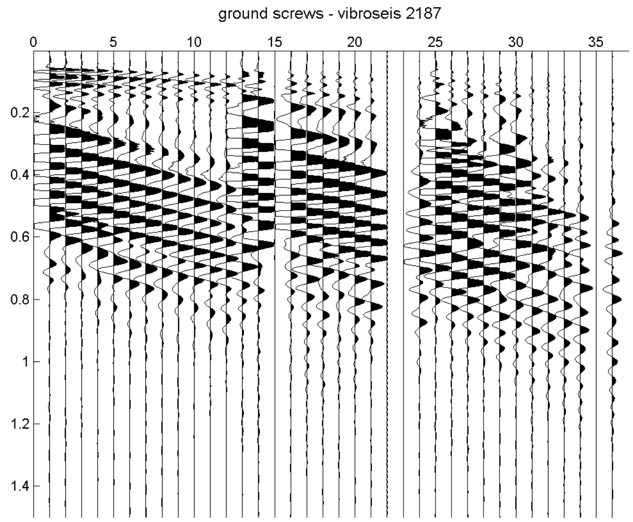

Figure 6: Vibroseis data sourced at station 187 and recorded from geophones installed in ground screws. The missing and noisy traces are obvious, but the high frequency air-blast noise is less than in the conventional record.

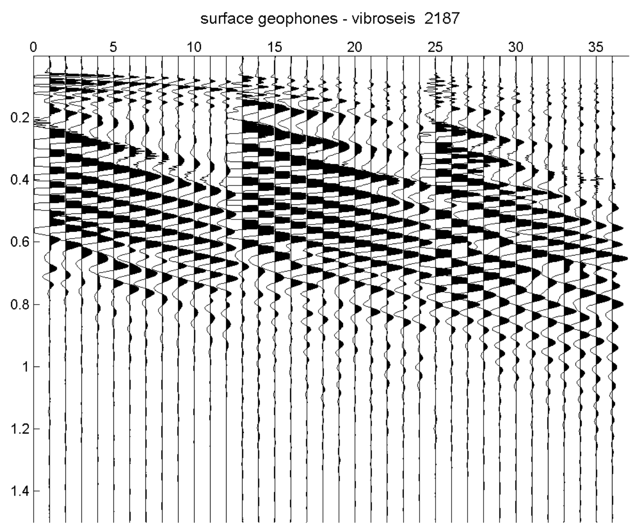

Figure 7: Vibroseis data recorded from conventional surface three-component geophones with identical elements for comparison.

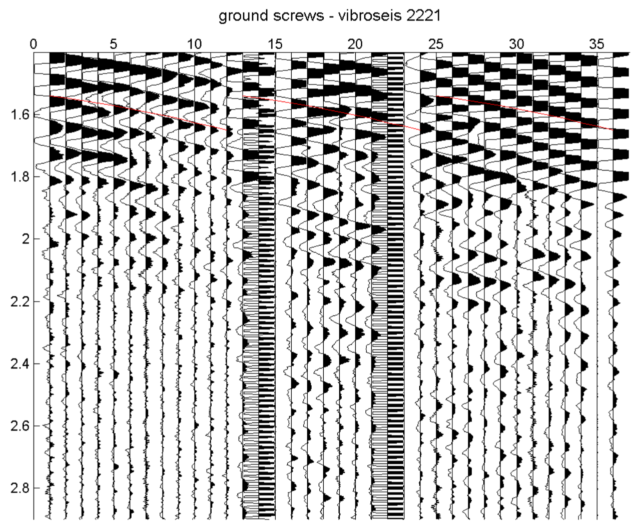

Figure 8: Vibroseis data from source point 221 and recorded from ground screws .This shows a deeper part of the record at much higher gain in hopes of finding converted waves at the longer offsets.

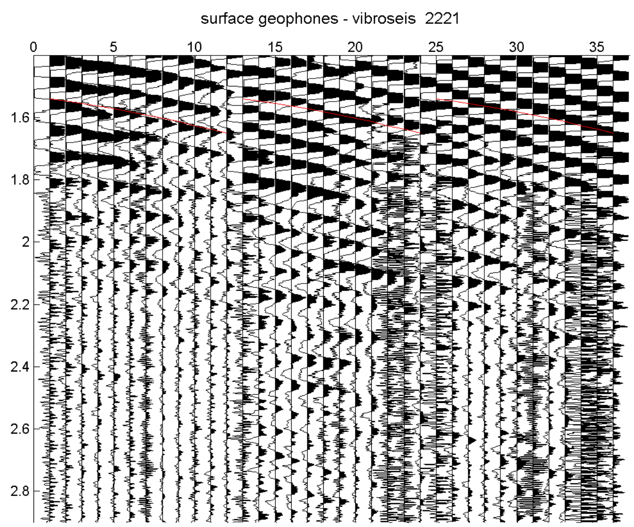

Figure 9: Vibroseis data recorded from conventional surface geophones and with the same gain to compare with Figure 8.

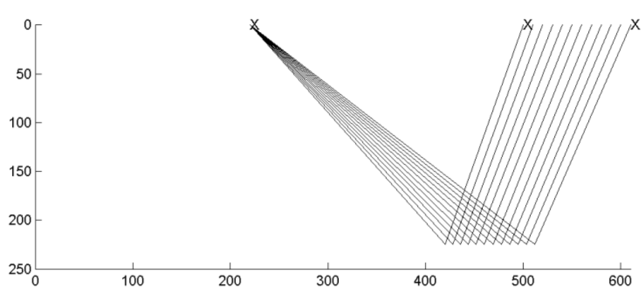

Figure 10: Possible converted raypaths from station 221 into the ground screw spread. The moveout curve associated with these raypaths is marked in red on the previous two figures.

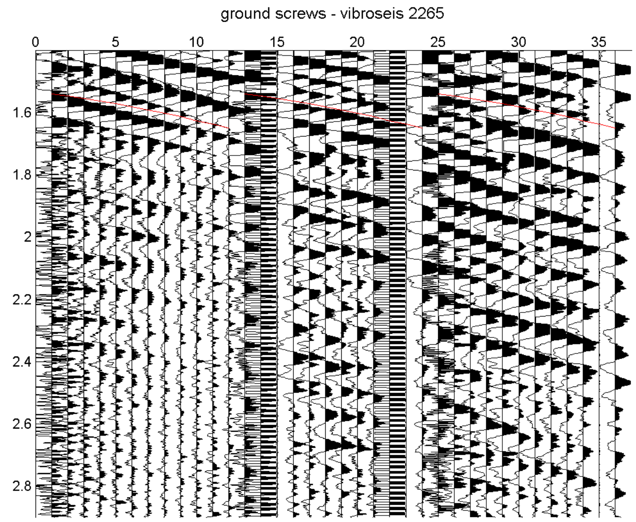

Figure 11: Vibroseis data from source point 265 and recorded from ground screws .This is a record similar to that in Figure 8, but with even longer offsets.

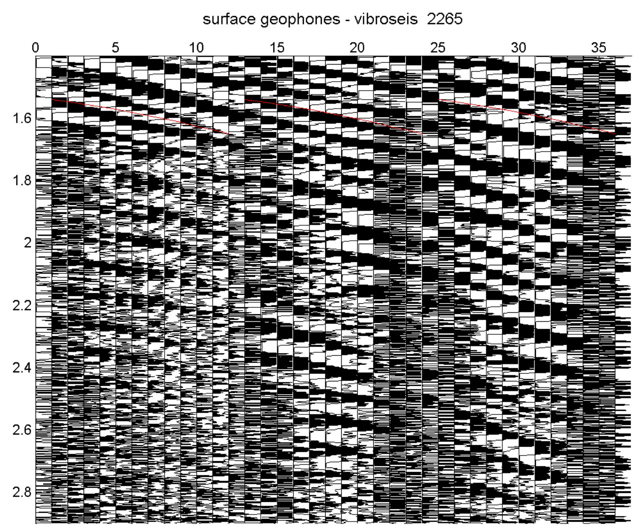

Figure 12: Vibroseis data recorded from conventional surface geophones and with the same gain to compare with Figure 11.

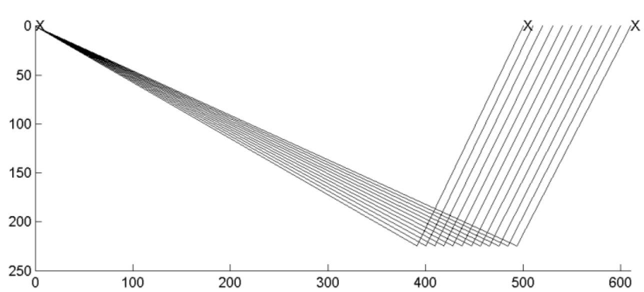

Figure 13: Possible converted raypaths from 265 into the spread. Again, the moveout curve associated with these raypaths is marked in red on the previous two figures.

DISCUSSION

These data show that in some cases, geophones planted inside ground screws have great potential for improving land seismic signal to noise ratios. The results shown here may not be representative, but alternatively they might also point the way toward even more improvements.

It appears that the signal to noise improvements shown here are mainly the result of the strong sensor to earth connection, although the actual depth of the sensors may be important.

Signal to noise improvements are essential to successful surface acquisition of shear wave data, but might also be useful for conventional pressure wave data when high frequencies are required.

Anyone who has done the hard work required to drive a ground screw into the ground will not be surprised that they provide a more solid connection with the earth. This contrasts with the usual geophone planting which can be easily dislodged. Ground screws cannot be easily moved, although they can be deliberately unscrewed, given a little time.

Ground screws have been developed to be rigid in the earth, to serve as foundation posts or fence post sockets. The ground screw used here compresses the earth in the vicinity of the uppermost threads, near where the geophone elements were inserted (see Figure 2). The bell of the screw compresses the earth downward, while the screw thread compresses the earth upward. The earth is also compressed in a lateral direction as the bell presses the earth outward.

CONCLUSIONS

The data recorded here give every indication that a more rigid connection of geophone elements to the earth will give superior signal to noise ratios. Ground screws may play a part in this connection.

Ground screws may be inserted into the ground quite readily to the depths used on this project. It may be significant that they were also easily extracted.

The coupling of the horizontal elements within the ground screw casing was not satisfactory. The reason is likely that the manufacturer had no reason to adhere to any design standards for the bottom taper of the cavity.

If ground screws of the type described here are used again, their interior will have to be carefully prepared, or have some kind of filler cast inside the cavity.

FUTURE WORK

Check out the bottom of the ground screw cavity, and correct the coupling problem.

Design an extension for the ground screw, and see what it takes to drive it deeper.

Repeat the testing, covering a significant range of planting depths.

Test with whole spreads of ground screws, and test in a micro-seismic setting.

Experiment with other models of ground screws, perhaps larger ones, or ones of different design.

ACKNOWLEDGEMENTS

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