Comparison of 3C data from two types of MEMS sensors

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Summary

Currently, two types of three-component (3C) sensors based on Micro-Electro Mechanical Systems (MEMS) technology are commercially available. We conducted a test comparing data from two types of MEMS sensors. Although the two sensor types employ different designs, they provide data with comparable quality.

Introduction

MEMS-based 3C receivers have led to an increase in multicomponent seismic acquisition on land. Employing a single sensor configuration with reduced sensitivity to tilt has greatly simplified field operations (Gibson et al., 2003). MEMS accelerometers record such low frequency data that we can use the gravity of the earth to calculate the tilt of each unit. These characteristics coupled with increased bandwidth result in improved data quality. There are currently two MEMS sensors available, the Sercel DSU3 (Farine et al., 2003) and Input/Output's VectorSeis® (Maxwell et al., 2001). The sensors employ different designs, the advantages of which have been debated at some length (Tessman and Maxwell, 2003; Gibson et al, 2004). Veritas conducted a field test of the sensors to determine if there were differences in data quality.

Field Acquisition Geometry

The comparison data were acquired on a 2D line in the heavy oil province of northern Alberta. Two hundred and seventy eight stations of each sensor type were planted at an interval of 7.5 meters in shallow drilled holes. One-eighth kilogram charges were placed at an interval of 22.5 meters and a depth of 15 meters. The maximum fold was approximately 80. Representatives from each manufacturer attended the test to ensure proper operation of their system. A preference to acquire the data concurrently had to be compromised in lieu of each manufacturers' requirement to keep their equipment proprietary from the other. To accommodate this two shot holes were drilled at every source location and the lines recorded on consecutive days. Due to the relatively small charge size it was judged that 4.5 meters was a sufficient distance to avoid any effect on the second shot by the first. Having the data acquired on separate days with different shots introduced a margin of error in the subsequent evaluation. However, the conditions were similar enough for one to be confident that any significant difference in data quality would be above the margin of error introduced in the field experiment.

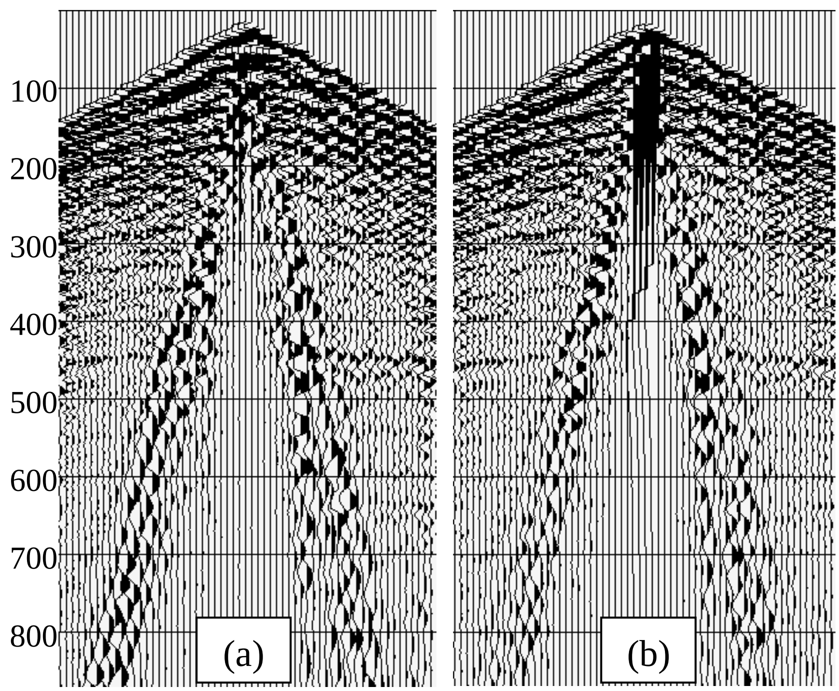
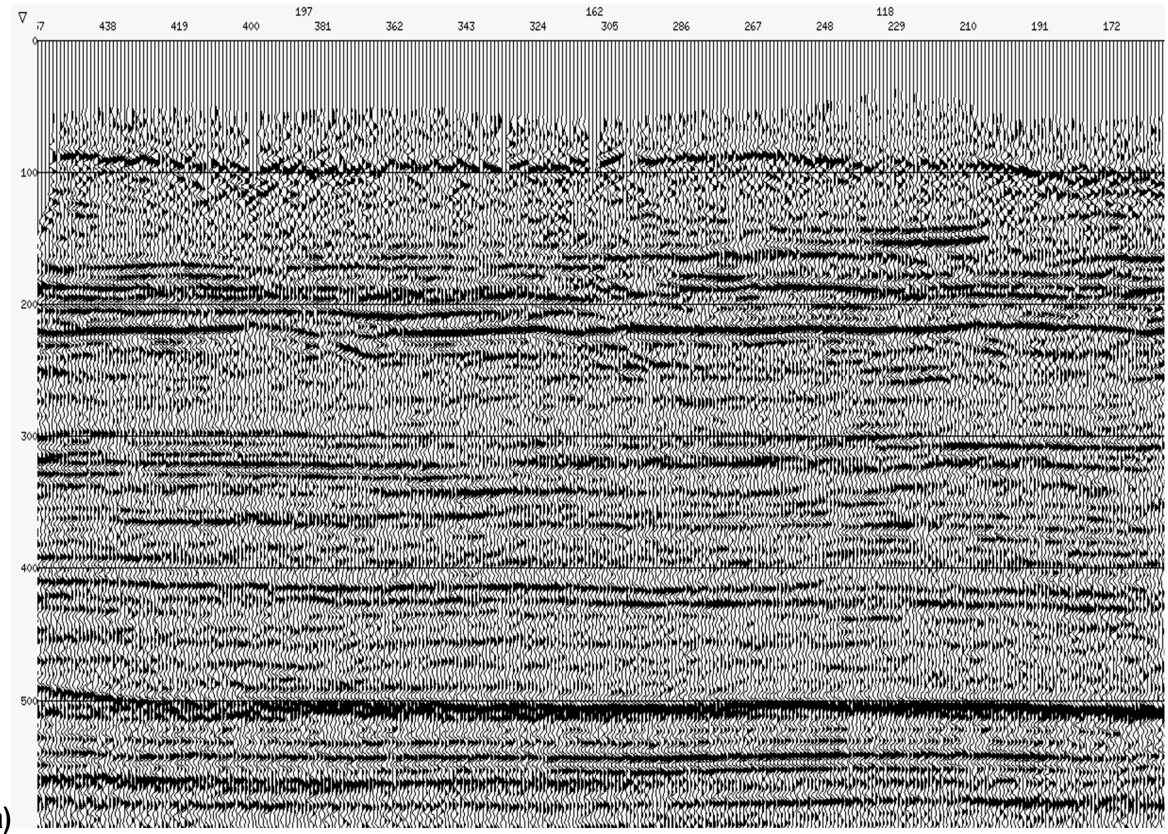


Figure 1. Prestack data comparison: (a) shot profile of DSU3 data. (b) VectorSeis® data of the same shot location. The full scale of MEMS (a) is about twice that of MEMS (b) and its recovery time from overdrive is much faster. As a result, overdrive is more apparent on (b).

Data Comparison

The most noticeable differences are seen on raw field data (Figure 1) and are a result of differing overdrive level and behavior of the sensors. Overdrive level refers to the point at which a sensor reaches full scale and overdrive behavior describes how quickly a sensor to recover from being overdriven. Since both MEMS sensors utilize accelerometers, it is natural to describe the overdrive



a)

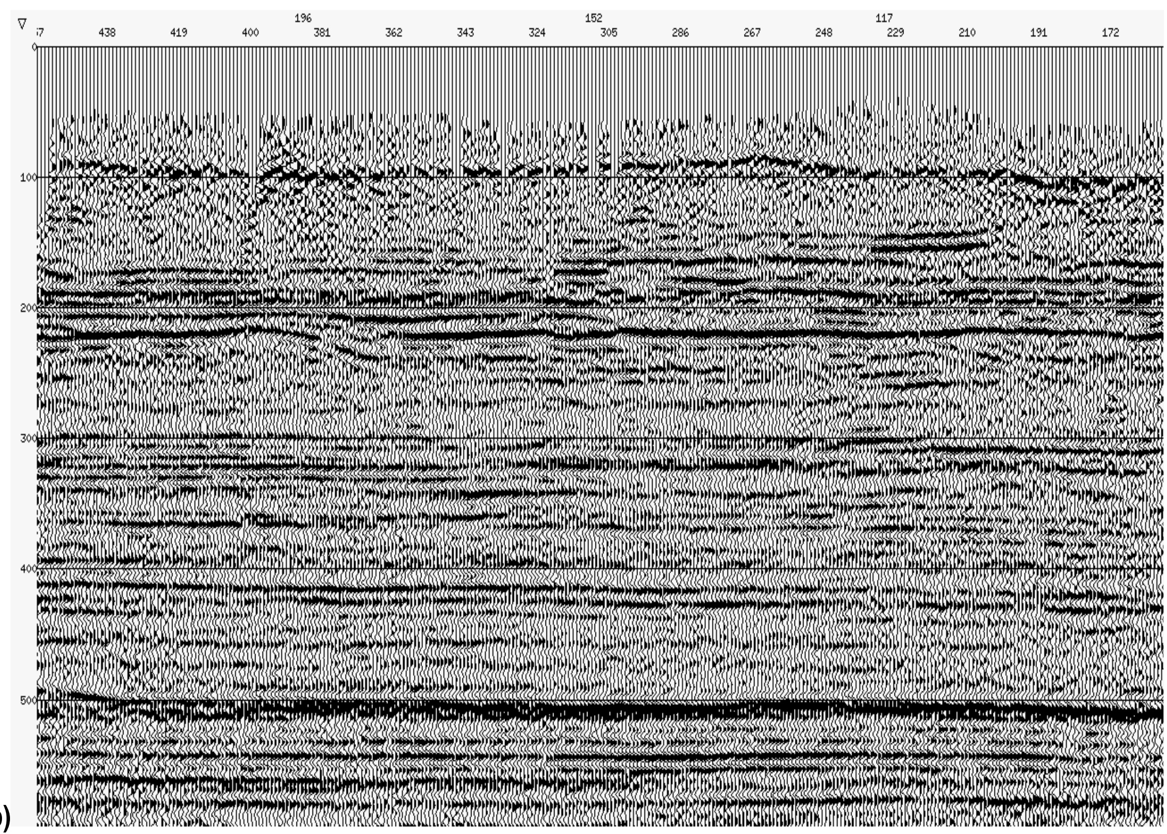


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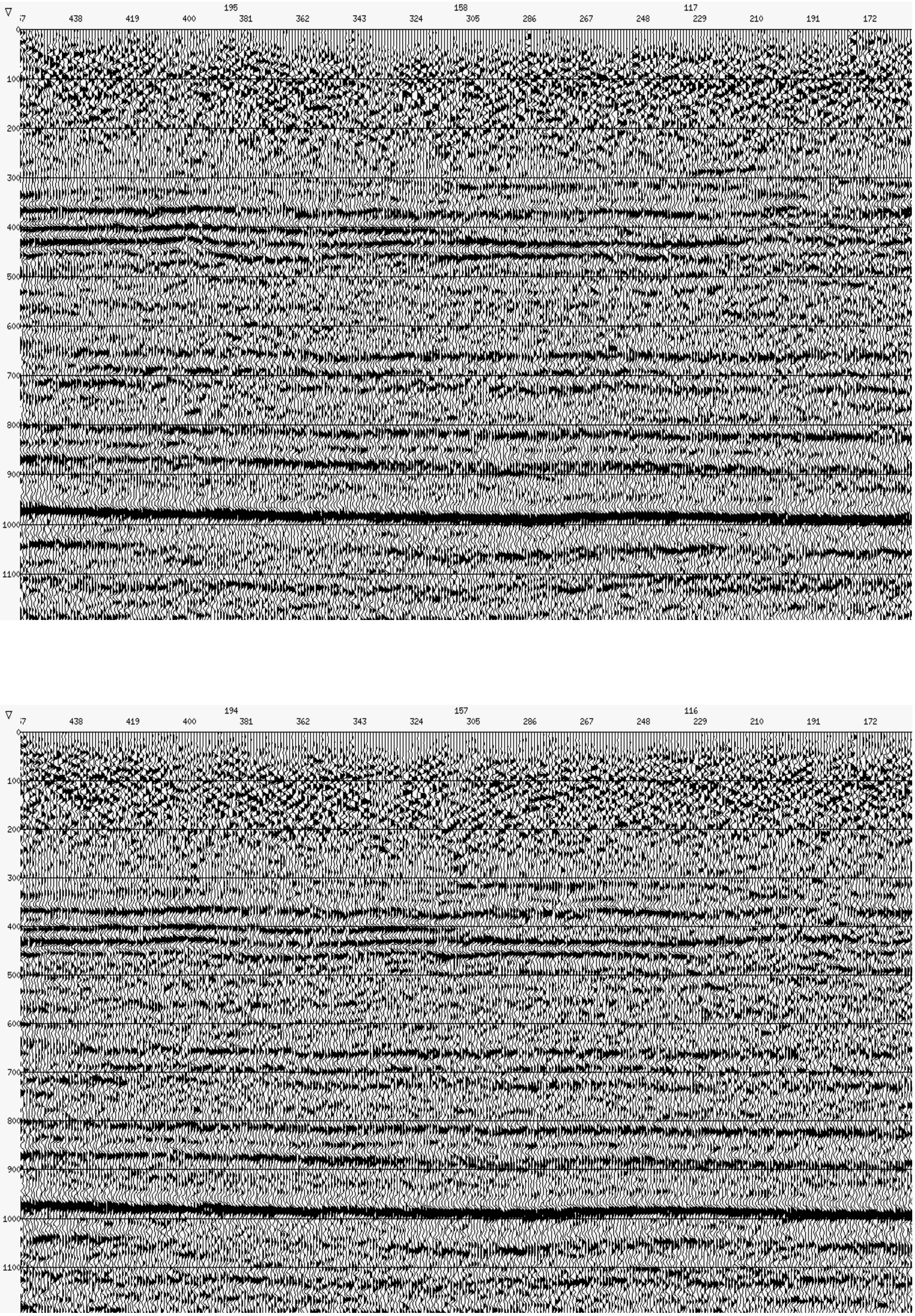
Figure 2. Vertical data stacked with PP velocity. (a) DSU3. (b) VectorSeis®.



a)

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Figure 3. Radial data stacked with PS velocity. (a) DSU3. (b) VectorSeis®.

levels relative to Earths gravity acceleration, g, (9.81 m/s^2). The overdrive levels that we observe are 0.459g on the DSU3 data and 0.225g on the VectorSeis® data. More important than the overdrive level is the recovery time. We observe that the VectorSeis® sensors require 650 ms to recover from overdrive while the DSU3 sensors recover almost immediately. This is apparent on the near offset traces in Figure 1 that are sufficiently close to the source to be overdriven.

Sensor overdrive is not a new phenomenon, but the long recovery time is a new problem. Might it have more significance for converted-wave recording? In the shallow heavy oil play of northern Alberta, there would be a significant near trace data loss when using VectorSeis® sensors. Converted-wave (PS) data typically have lower signal-to noise ratio than compressional-wave (PP) data and therefore use of larger charges and preserving every possible trace are desirable.

Figures 2 and 3 show comparisons of stacked PP and PS data. Sensor specification differences such as instrument noise level, dynamic range and overdrive behavior led to anticipation of larger variations in the data than were actually observed. Based on these figures it is not clear which sensor provides better stacked data. However, it is clear that the difference in data quality is small. Operationally, the DSU3's reduced power requirements and sensor testability provide a clear advantage.

Conclusion

Although the restriction of acquiring the comparative datasets on subsequent days and the lines 2D geometry made the experiment less than ideal, analysis of both the prestack and poststack PP and PS data indicate that the two sensor types provide data with comparable quality.

Acknowledgments

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References

Farine, M., Thorburn, N., and Mougenot, D., 2003. General Application of MEMS Sensors for Land Seismic Acquisition—Is it Time? Presented at the 2003 CSEG meeting in Calgary. http://www.cseg.ca/conferences/2003/2003abstracts/218S0130.pdf

Gibson, J., Watt, H., and Burnet, R., 2004. Dynamic Range vs. Sensor Tilt. Veritas Brochure. http://www.veritasdgc.com/bins/content_page.asp?cid=4-1502-2109-2113

Gibson, J., Watt, H., and Roche, S., 2003. Multi-component Seismic Data Acquisition… The Economics Revisited. The CSEG Recorder, October 2003. Page 17-21. http://www.cseg.ca/recorder/pdf/2003/10oct/oct03_04.pdf

Tessman, D.J., and P. Maxwell, 2003. Full-Wave Digital Seismic Recording and the Impact of Vector Fidelity on Improved P-Wave Data. The CSEG Recorder October 2003. Page 22-24. http://www.cseg.ca/recorder/pdf/2003/10oct/oct03_05.pdf

Maxwell, P., Tessman, D.J., and Reichart, B., 2001. Design through to production of a MEMS digital accelerometer for seismic acquisition. First Break, volume 19.03, 141-144.