Effects of Compression on Attributes

André Fabiano Steklain, Petrobras, Brazil
João Francisco Fernandes, Petrobras, Brazil
Livio Marques Pinto, Petrobras, Brazil
Raul Dias Damasceno, Petrobras, Brazil

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Abstract

In this work we calculate a series of attributes on seismic data with different degrees of compression and compare with the attributes calculated from the original data. We find that, although primary attributes are nearly unaffected by compression, secondary attributes, as Instantaneous Frequency, can be affected by a relatively low compression, say 90% of nominal fidelity, what can be a source of pitfalls on interpretation of the data.

Introduction

In the present seismic attributes have a leading role on prospection and development of oil fields. The main reason for using attributes is to highlight features that can not be seen in the original seismic data.

On the other hand, due to the improvement of the quality of the seismic and the new acquisitions, a increasing quantity of data must be handled and stored. A solution for this problem is data compression. Nevertheless, in this process there must be a commitment between the compression level one desire to achieve and the degree of fidelity between the compressed and the original data.

There are several different commercial compression systems. In this work we will employ one of these commercial compressed formats. This format possesses a nominal degree of fidelity that is defined as the ratio between the "noise" and the original data, where the "noise" is the difference between the original and the compressed data. This fidelity factor shows in a quantitative way how different are the data. However, this parameter does not provide information on how this difference can affect the interpretation of data.

In this work our intent is to demonstrate that when compressed data is used for the computation of attributes some features can appear different when compared with the attributes computed from the original data, even at low compression rates (90% of nominal fidelity). We employ the Instantaneous Phase, the Reflection Strength and the Instantaneous Frequency to discuss differences between original and compressed data.

Method

The compression format we will study uses a JPEG-like system (JPEG – Joint Photographic Experts Group) to perform the compression of seismic data [Hale, 1998]. Basically, the method (1) partition the seismic data into folded blocks of 8×8×8 samples, (2) make a discrete cosine on the data, (3) quantize and encode the transform coefficients. In this compression method, unlike JPEG system, the wavenumbers are all quantized equally, and no wavenumber-dependent errors are introduced. It does not mean, however, that the frequencies are not affected by the compression. A graphic showing the data size versus the fidelity factor of the compressions is shown in Figure 1. It can be seen that the data size suffers a great reduction until 90% of fidelity. For lower values of fidelity there are no significative reduction. Although lower values of fidelity are available, there are no practical reason for using them. We shall explore them only as an extrapolation.

In order to study this compression we use three instantaneous attributes: Instantaneous Phase, Reflection Strength and Instantaneous Frequency. Those attributes are derived from the complex trace [Taner et al, 1979]. Given the the (real) seismic trace, say *f(t)*, the complex component, say *g(t)* is given via Hilbert transform of *f(t)*. Considering the polar representation of complex numbers the Instantaneous Phase *θ(t)* and Reflection Strength *A(t)* are defined by the following:

$$\theta(t) = \arctan\left(\frac{g(t)}{f(t)}\right) \quad (1)$$

$$A(t) = \sqrt{f(t)^2 + g(t)^2} \quad (2)$$

The Instantaneous Frequency *F(t)* is simply the time derivative of the Instantaneous Phase:

$$F(t) = \frac{d\theta(t)}{dt} \quad (3)$$

In this work we use a seismic volume from Santos basin. This data has some interesting seismic features, like faults and on-laps structures, that can be highlighted using these instantaneous attributes. We compress the original file with nominal fidelities of 99%, 90%, 75% and 10%. In Figure 2, the same section is displayed for the original data and compressed at 10% fidelity and the difference between them. We can see that the data looks almost the same for the both cases, but differences are present.

We compute the Instantaneous Phase, Reflection Strength and Instantaneous Frequency for the original and the compressed data. We then track an horizon and extract these attributes as an average, using an 8ms time window around this horizon. We also compute the histogram of occurrences of the values of the attributes in this horizon. The results can be seen on Figures 3-8.

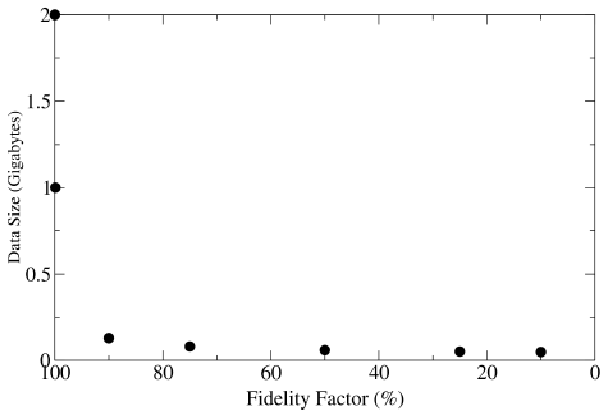

Figure 1. Data size versus fidelity factor. Fidelity factor 100% corresponds to the original data.

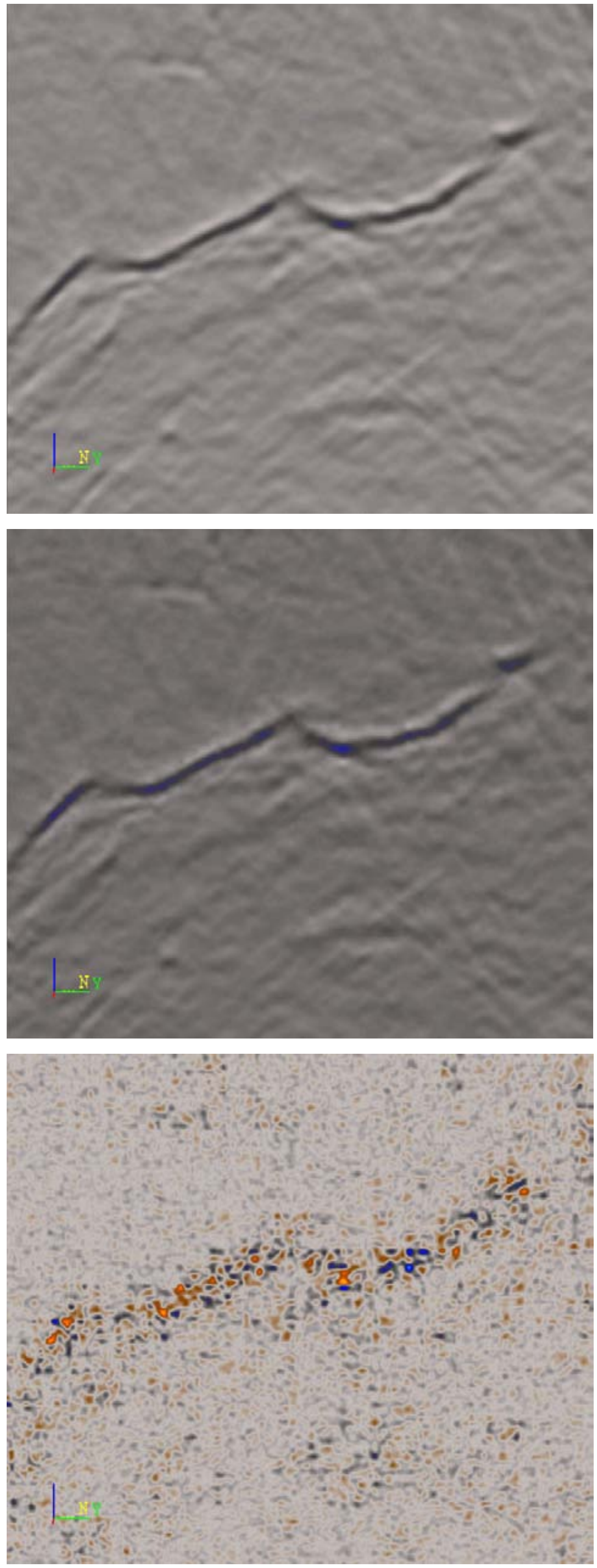

Figure 2. Section of the seismic data. Top: original seismic. Middle: data compressed at 10% of fidelity. Bottom: difference section between the two data. It can be seen that the differences are in general small.

Results

From Figure 2 it can be seen that even for low fidelity factors, like 10%, compressed data the seismic sections look the same. We only see the discrepancies between these data when we perform a difference section, where we subtract one volume from the other. The difference section can be seen at the bottom of Figure 2. The relative differences are mostly random noise. The appearance of structures in the difference section is due to the high amplitudes of the data, where the absolute differences are larger.

From Figure 3 we see the Instantaneous Phase for original data and different compressions. For lower compressions the display of this attribute is almost the same of the original data, although we can see the differences in the histogram obtained from the surface, in Figure 4. We see that there are some equally-spaced minima in the histograms of the compressed data. This artifact is due to the process of quantizing and encoding the coefficients of the cosine transform. For lower fidelity ratios the displays have significative changes.

From Figure 5 we see the Reflection Strength for original data and different compressions. The display of the Reflection Strength indicate that no visible changes occur for high fidelity compression. Even for 75% fidelity there are no significative changes in the display. In the histograms of Figure 6 we see a reverberation in the number of occurrences of the Reflection Strength. For 10% fidelity compression the histogram possesses significative changes, and the display changes.

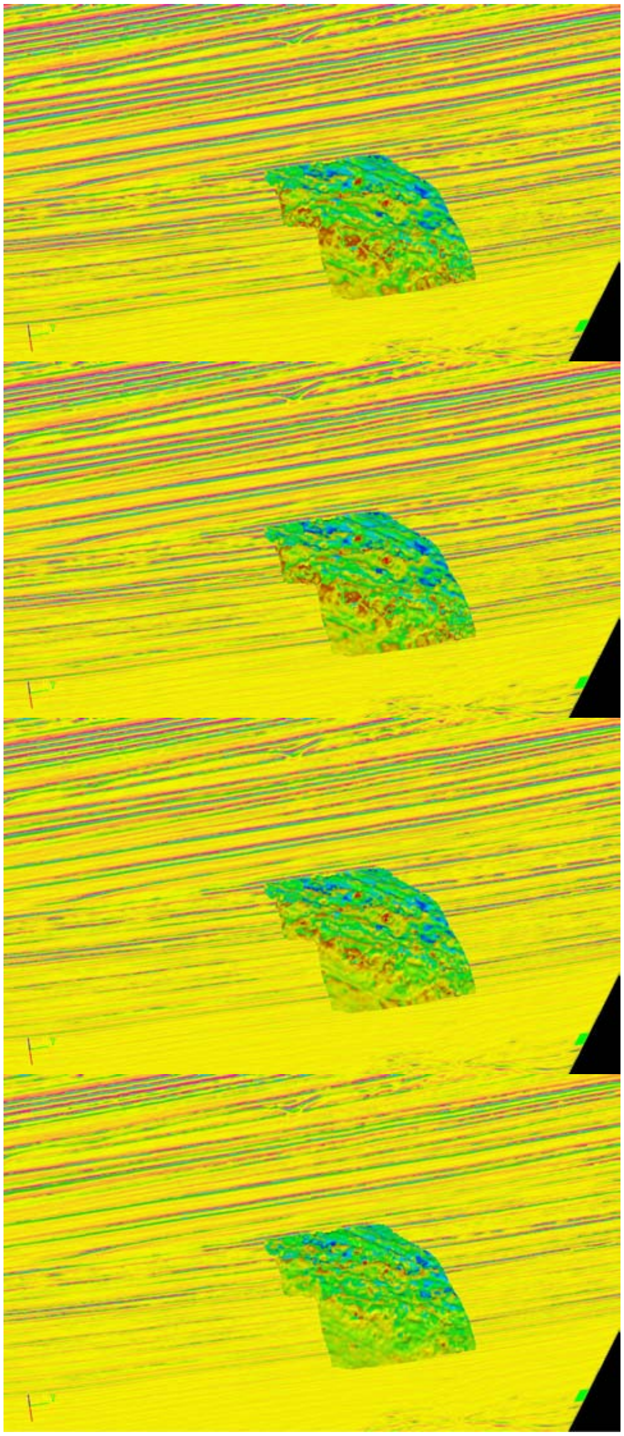

Figure 3. Instantaneous Phase on the seismic section and on a horizon. The respective color maps are illustrated in Figure 4 with the histograms. From top to bottom: the original data, compressed data at 90%, 75% and 10% respectively. The compression preserve the complex phase for high fidelity compression.

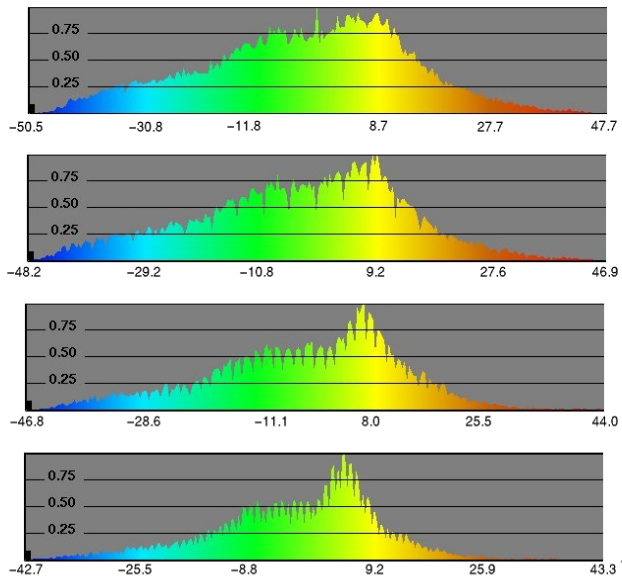

Figure 4. Histograms for occurrences of different values of the Instantaneous Phase in the horizon. From top to bottom: the original data, compressed data at 90%, 75% and 10% respectively. For compressed data there is a oscilation in the number of occurrences, and larger values vanish.

Finally, from Figure 7 we see the Instantaneous Frequency for original data and different compressions. Even for high fidelity compression (90%) some changes in display can be noticed. The histograms also present significative changes for high fidelity compressions. For 75% fidelity there some low frequencies are introduced, and for 10% fidelity it seems to be an inversion in the histogram.

Conclusions

In this work we analyze the effects of compression of data on attributes. We analyze two primary instantaneous attributes (Instantaneous Phase and Reflection Strength) and one derived instantaneous attribute (instantaneous frequency). We find that for the primary attributes high fidelity compression has little influence on the results. Given that the interpretation is made visually from these data, high fidelity compression offers little risk, and offers several advantages, as high fidelity compression can reduce the data size in 50%. However, for derived attributes, such Instantaneous Frequency, even high fidelity attributes can have considerable influence on the data, and must be used carefully.

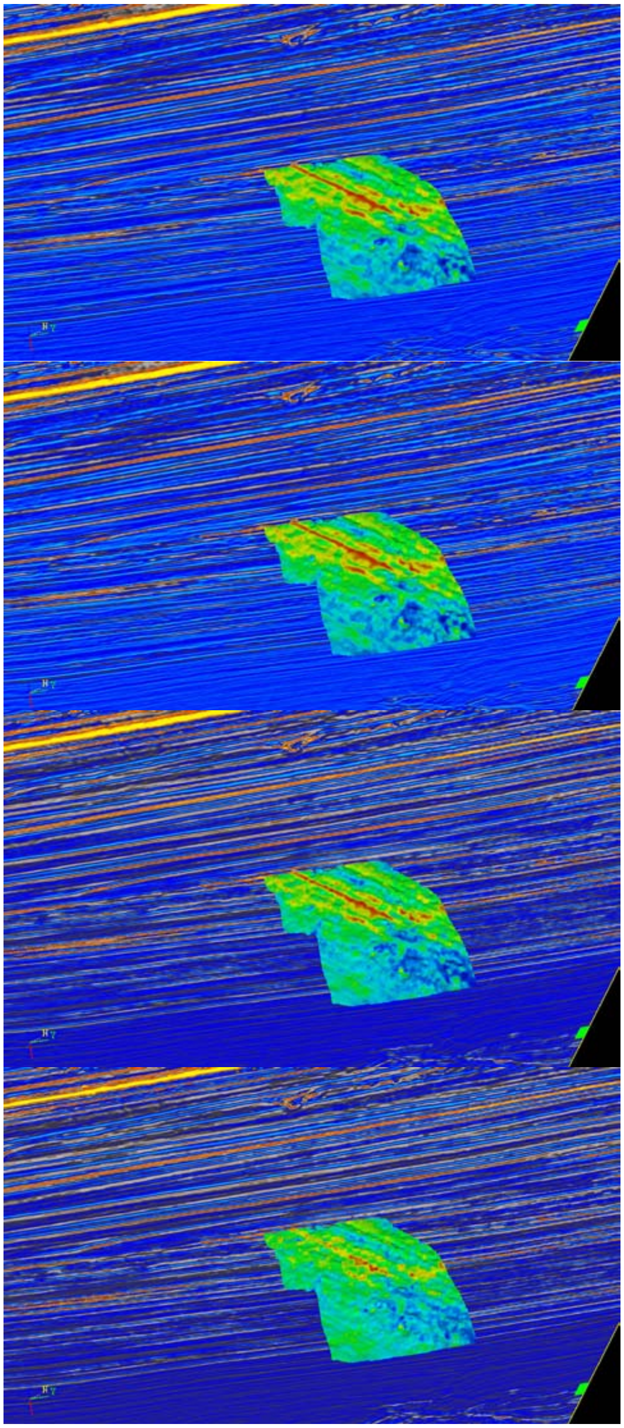

Figure 5. Reflection Strength on the seismic section and on a horizon. The respective color maps are illustrated in Figure 6 with the histograms. From top to bottom: the original data, compressed data at 90%, 75% and 10% respectively. The compression preserve the reflection strength for high fidelity compression.

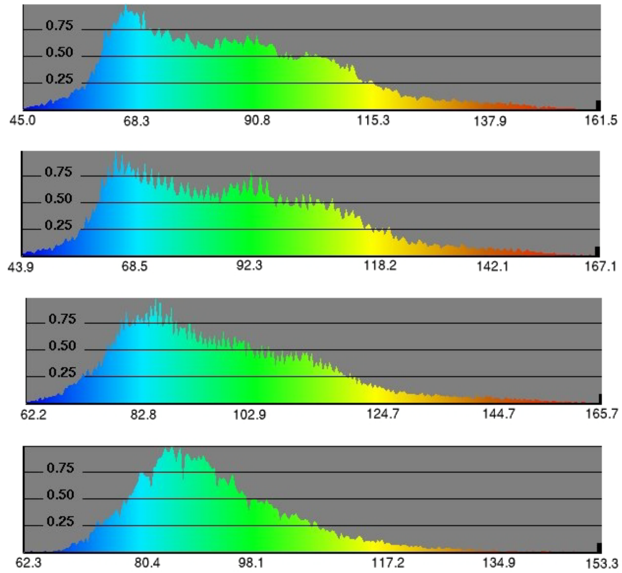

Figure 6. Histograms for occurrences of different values of the Reflection Strength in the horizon. From top to bottom: the original data, compressed data at 90%, 75% and 10% respectively. For compressed data, in general, there is a oscilation in the number of occurrences, and extreme values vanish.

Acknowledgments

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References

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[Taner et al, 1979] **Taner, M.T., Koehler, F., and Sheriff, R.E.**, 1979, Complex Seismic Trace Attributes, Geophysics, 44, 1041.

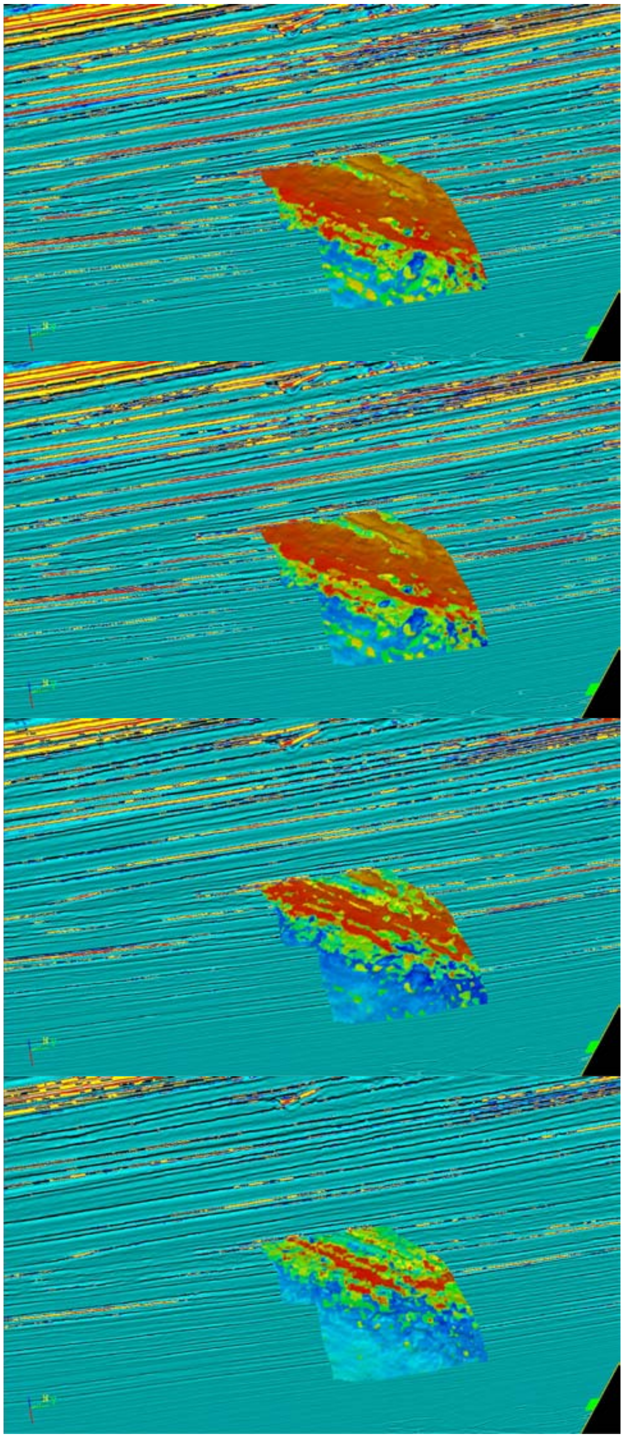

Figure 7. Instantaneous Frequency on the seismic section and on a horizon. The respective color maps are illustrated in Figure 8 with the histograms. From top to bottom: the original data, compressed data at 90%, 75% and 10% respectively. Even for high fidelity compression there are appreciable changes in the data display.

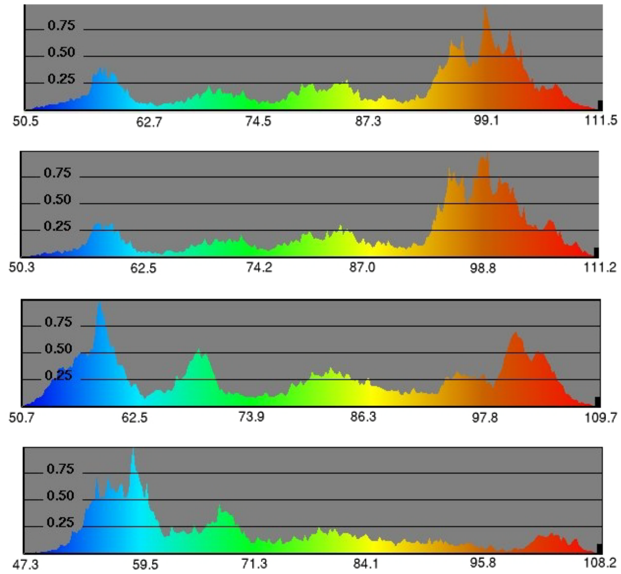

Figure 8. Histograms for occurrences of different values of the Instantaneous Frequency in the horizon. From top to bottom: the original data, compressed data at 90%, 75% and 10% respectively. For compressed data with lower fidelity factors there are noticeable changes.