EAGE

Reflections from the Hard Side: Seismic Data Examples from Colombia

J. Checa[1]

[1] SierraCol Energy

Summary

Summary is not available.

Introduction

Despite the enormous advancement of seismic acquisition technology worldwide in recent decades, the implementation of these new technologies in Colombia appears slow and not as aggressive as desired partially due to complex geography and low infrastructure. The most used design geometry is orthogonal but with relatively large separations between lines and stations, and a trace density that rarely exceeds 200,000 tr/km^2. The current use of vibratory sources is scarce, and there are no documented experiences of simultaneous vibration.

For many reasons, some of which are discussed in this article, terrestrial seismic acquisition in Colombia is an operation of unusual complexity. Frequently, technical decisions, even at the design stage, are heavily influenced by environmental aspects and the complexities of relationships with local communities.

In many of the most prospective areas of the country, before undertaking the acquisition of a seismic program, it is necessary to obtain approval from the local environmental authority for a detailed environmental management plan known as MMA. This plan includes the socio-environmental characterization of the area, the description of the logistics to be implemented, and the details of the acquisition geometry. The preparation of this management plan is a project in itself, requiring detailed fieldwork that can take several months, monitoring of environmental variables, characterization and evaluation of impacts, and formal processes of engagement with communities. This process, along with other related actions like land permitting and explosives purchase, must begin at least 18 months before the expected start of operations. The MMA is compulsory, leaving little room for real-time modifications during the execution phase.

In this context, discussions regarding the selection of a certain acquisition geometry, energy source, or other important elements must occur early and necessarily involve non-technical variables that the geophysicist must incorporate and resolve aiming to ensure the achievement of the exploratory objective. Likewise, it is important for social/environmental teams to have a basic understanding of the potential impact that certain real or self-imposed restrictions can have on data quality. Decision-making is then a complex multidisplinary operation with the project objectives at the center of the discussion.

For this reason, it is crucial to understand the specific geophysical response of the area to variations in the most important design elements. That is, while it is true that some general statements can be made, each area has a characteristic response, and any prior knowledge is of help to effectively address environmental challenges by allocating resources to those factors that have the greatest impact on quality and avoiding sacrificing those that are critical.

This article presents some comparisons with actual data from different areas of Colombia that illustrate these considerations. In some cases, these are published results, while others have been compiled by the author and remain unpublished.

Examples

Case 1. Comparison of geophone arrays vs. single geophone in the Putumayo foreland and in the Llanos foreland of Colombia.

Test data reported by Cortés (2015) from the Eastern Plains (Fig 1) shows that in this case there is a very subtle difference between the 6-geophone array and single geophone.

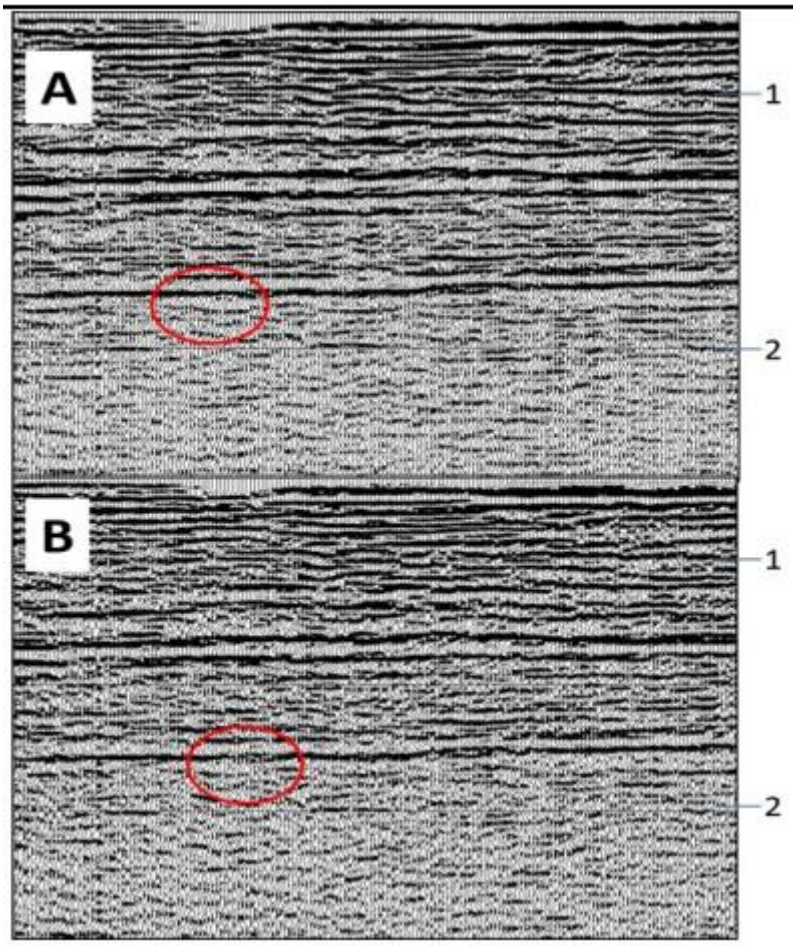

Figure 1. *Cortés (2015) reports a subtle difference between these two sections acquired with 6-element geophone array (left) and single sensor(right). The red circle indicates a slightly noisier result in the deeper part of the section. Depending on the target, this difference may or may not support the use of a single geophone.*

On other hand, in the Putumayo Basin, a similar exercise is depicted that does show more significant differences. (See Figure 2).

This information can be crucial when deciding whether to use arrays of geophones or single geophones while keeping the distance between stations fixed. The impact in time and cost can be very significant.

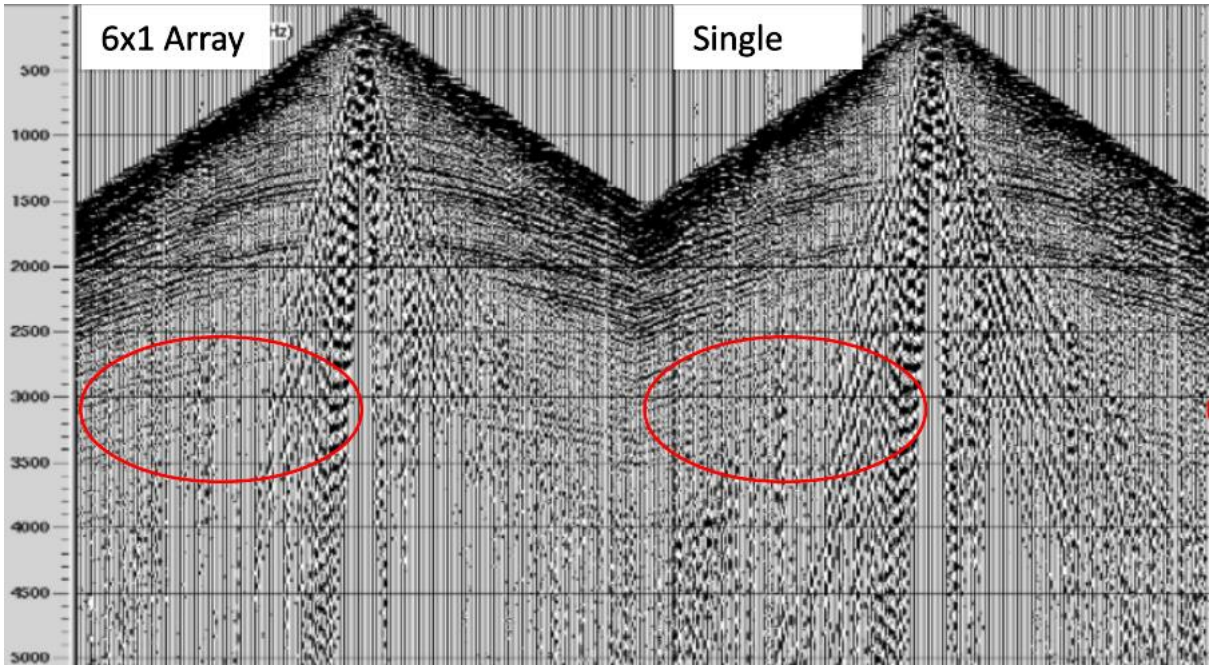

Figure 2. Comparison of two shot records acquired with a 6-element geophone array (left) and a single geophone pattern. As expected, the array shows a better S/N ratio which can also be observed at brute stack level.

Case 2. Charge and depth of hole in northern Colombia

A case in an area of La Guajira in northern Colombia shows the visible impact of making changes in the hole depth (5 m vs 10 m) and charge amount (450 g vs 900 g) of the explosive source pattern. In contrast, a test in the Sinu San Jacinto Basin compares loads of 6300, 9000 and 11700 g without resulting in consistent difference (Figure 3). In this case, it is evident that the size of the charge is not a determining factor in achieving a better signal/noise and that other different factors may be more influential and worthy of greater effort in the field.

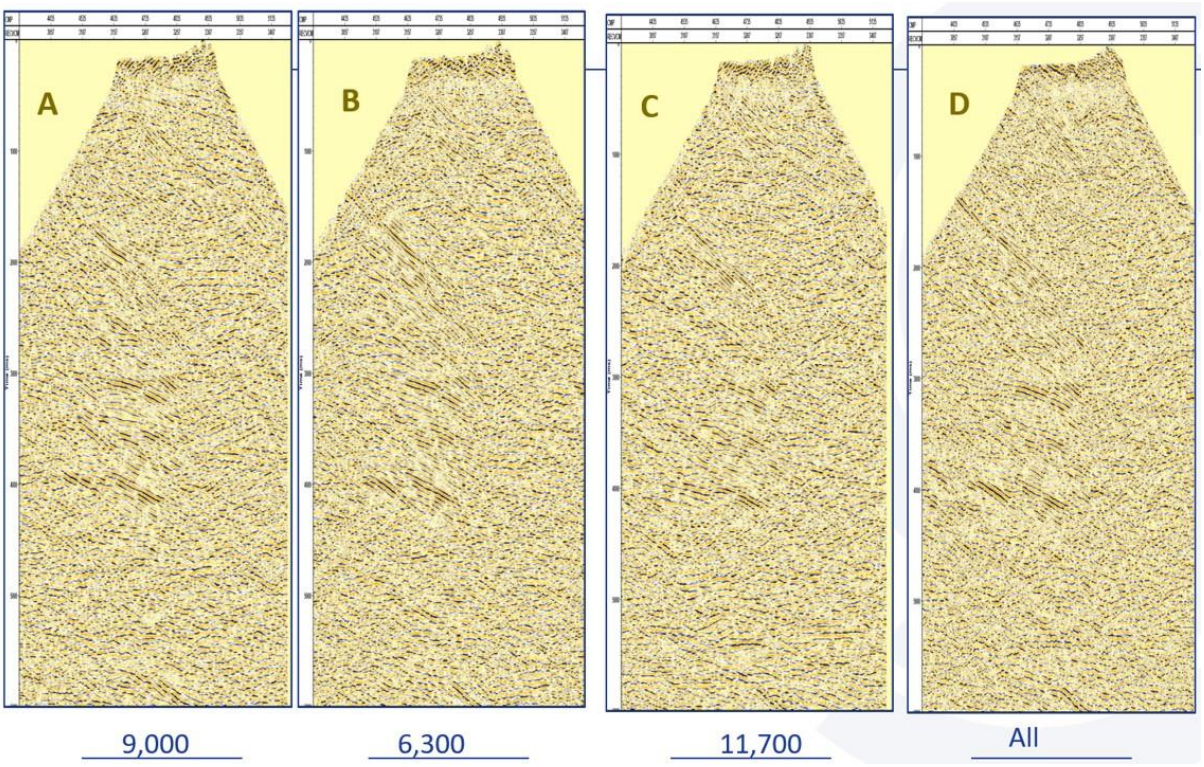

Figure 3. *Stacked versions of a test line in the Sinu San Jacinto area in Colombia acquired with different amounts of Sismigel at 10 m depth. No consistent quality change is observed related to charge size in this challenging area. In contrast, small variations in charge and depth in La Guajira area (not shown here) result in significant differences.*

Case 3. Acquisition with receiver carpet geometry.

An example is presented in a shallow target project in the Middle Magdalena Valley where the carpet geometry of receivers allowed the acquisition of 3D data in an area with extreme environmental restrictions in which the location of source points was almost impossible. This solution provided a much better understanding of the geometry of the structure. Within the very shallow structure (less than 800 m deep), at least 8 compartments separated by vertical faults that generally have two directions (NNE-SSW and NNW-SSE) were identified (Figure 4).
A 2D test was also acquired with Stryde nodal units with 4 m separation, which provided insight into spatial sampling impacts.

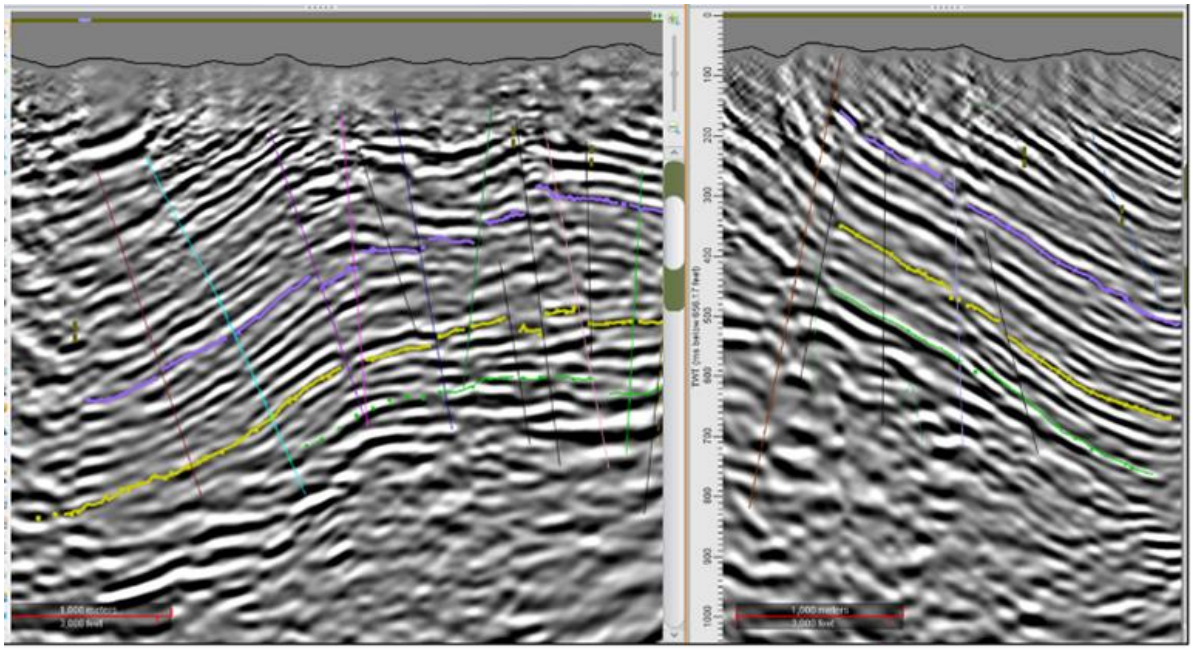

Figure 4. *Strike and dip seismic sections obtained with a 40m x 40m receiver carpet geometry in a complex area of the Middle Magdalena Valley where environmental restrictions made the location of source points almost impossible. Within the very shallow structure (less than 800 m deep), at least 8 compartments separated by vertical faults that generally have two directions (NNE-SSW and NNW-SSE) were identified The entire section of the 3D is contained within 1.0 seconds TWT.*

Conclusions

Understanding the seismic response at a local scale is extremely important to make informed decisions about the implementation of a seismic acquisition program, especially when faced with environmental/social situations that force the designer to sacrifice optimal parameters to a greater or lesser extent.

Conducting and documenting field tests on a regular basis is very important to understand the seismic response of an area. The design of the tests should be such that it allows the analysis of the results in stacked sections. Other aspects that would benefit from field testing could be tolerance to random noise, potential for subsampling via CS, trace density and source density among others.

While there are general rules and principles, the heterogeneous nature of the earth makes its response difficult to predict, which highlights the importance of conducting as many acquisition/processing tests and modeling and decimation studies as possible.

Acknowledgements

The author thanks SierraCol Energy and Ecopetrol for their permission to publish the results of Case 3.

References

Diana Marcela Cortes, Ecopetrol S.A., and Jack Caldwell*, (2015), "Single Geophone versus Geophone Array: A field study performed in Colombia," *SEG Technical Program Expanded Abstracts* : 1-5.