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Use of similarity maps to summarize seismic attributes: Two case histories

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Summary

The use of seismic attributes in two Venezuelan oil fields resulted in the generation of what we call similarity maps.. These maps summarize the analysis of all the independent attributes calculated from the seismic data available, providing the interpreters with a useful tool for the identification and delineation of prospective areas. The analysis of the data around certain calibration wells and their resemblance to the data in the rest of the study areas was used by the reservoir geologists and engineers to redefine their exploration and exploitation strategies in the fields studied. A simple statistical study was performed, allowing an estimation of the uncertainties in the use of these maps and a quantification of the errors involved.

Introduction

Seismic attributes analysis is generally performed as a systematic review of tens of maps, one for each attribute (Rijks and Jauffred, 1991; Bahorich and Bridges, 1992; Gallager and Hoover, 1994). Although some of the attributes seem to provide a different perspective of the properties of the study area, they also contain redundant information that makes the analysis awkward. No standard method had been developed to simplify the analysis of all this information.

We present in this paper a method to ease the interpreters task by summarizing all the attributes information in just one map. This map optimizes the use of the information contained in the seismic data by showing the resemblance of the seismic response in the whole area with respect to a selected location in the field.

The areas where the similarity technique was applied did not have statistically significant well control, which discouraged us to generate pseudo-properties maps, since the correlation between petrophysical and production parameters with attributes may be misleading in areas where scarce well control is available (Kalkomey, 1996).

Similarity maps

To correlate seismic attributes to interval reservoir properties and to avoid problems related to variations in layer thickness, attribute maps were calculated by averaging the attribute response around the zone of interest (Fig. 1). The attributes information was transformed into an orthogonal set of attributes by using the method of Gram-Smith orthogonalization. From these new, orthogonal attributes, only those with larger norm were kept for the analysis. After a calibration point was selected, we computed the mean and standard deviation of each attribute around such point and classified all points in the map with respect to their similarity to the mean around the calibration point. If the mean around a certain point is close to the mean around the calibration point (within the standard deviation) a high value, typically one, is assigned to that point. If not, a low value, typically zero, is assigned. These new maps are summed to produce a single map that summarizes the information of attribute similarity. The radii for these analysis is based on the dispersion of the data around the calibration point, the Fresnel zone for the depth of interest and a smoothing value related to gridding.

Similar rocks or similar reservoir conditions produce similar seismic response that independent attributes should capture. Although the opposite may not always be true for areas far from the calibration point, we expect areas close to the calibration point with similar seismic response to have similar rock properties by assuming that changes in the reservoir are gradual. If the calibration point is a producing well, the similarity map associated with it will be a map of possible prospective areas in its vicinity. If the calibration point is a dry well, the similarity map associated with it highlights the zones with lower priority in exploratory or infill drilling programs.

Two Venezuelan case histories

Similarity maps were calculated for two western Venezuela oil fields, aimed to integrate the results of seismic attributes for Cretaceous limestones. Venezuelan Cretaceous carbonate reservoirs production amounts 30% of total Venezuelan hydrocarbon production. A complete understanding of the mechanisms that control this production has not been established for most of them. Fracturing processes, diagenesis, compartmentalization, difficult seismic imaging, and considerable depth and structural complexity are all factors that have made difficult the development of fields which production potential is up to 4 000 barrels a day per well.

Lake Maracaibo. In western Venezuela, a large oil field located in central Lake Maracaibo was studied with the similarity approach (Capello *et al.*, 1997a, 1997b) (Fig. 2) with 12 attributes. The well control was scarce, so the calibration with petrophysical or production parameters was not possible. As part of an integrated approach, and maximizing the use of seismic information, the similarity maps approach led to conclusions about compartmentalization of the reservoirs and the extent of the prospective areas. The similarity map related to Well

A, 9.4 MMBO accumulated as June 1995, shows the extension of what was interpreted as a compartment (Fig. 3). The response of the seismic around well A is clearly separated from that of well B, another excellent producer well, with 14.8 MMBO accumulated as June 1995. These result is consistent with the hypothesis of reservoir compartmentalization proposed by Stiteler et *al.* (1996) in an integrated study of the area. The company that operates the field considered that the results opened a path for establishing new exploratory strategies for the field.

For the Lake Maracaibo area, the best parameters found for this procedure were gridding in a regular scheme of 40 by 40 m, and search radius of 80 m.

Barinas area. In Barinas, a similarity map referred to the only producer well in the area, well 1, was calculated. This map summarizes the response of ten attribute maps. Well 1 has an accumulated production of 0,4 MMBO (as July 1996, being a well drilled in 1994). The map shows a southwest-northeast trend, that was interpreted as a carbonate rim (Fig. 4). A consequence of the analysis of the spatial variation of the high similarity values near the producer well, resulted in the proposal of a re-entry from well 2, towards a nearby area with high similarity values that indicate rock properties probably similar to those of well 1. This drilling will validate the technique in a short term.

An example of the use of the similarity maps when the calibration point is a dry well is shown for this area (Fig. 5). Areas to be avoided in the re-exploration programs are those with high values in the similarity map related to well 3, because they represent the areas that are more similar to the vicinity of that dry well.

For the Barinas area, the smoothing was done by gridding the data in a 50 by 50 m regular grid, with a searching radius of 100 m. Besides the smoothing introduced by gridding, seismic attribute maps were additionally smoothed areally by the application of mean filters.

Conclusions

We presented a practical method to simplify the analysis of seismic attribute maps in exploratory areas, with examples of applications to seismic data from two Venezuelan fields. The procedure generates what we have called similarity maps, which we believe are a powerful tool to help exploration and developing plans.

Similarity maps optimize the use of seismic attributes and provide a simple visualization tool. The use of similarity maps related to producing wells indicate possible prospective areas. The similarity maps related to dry wells show the areas to be avoided.

Similarity maps were used in this study in exploratory areas with poor well control. More work needs to be done to understand the use of this technique in areas with more well and production information.

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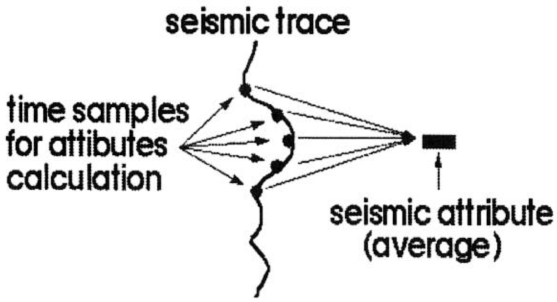

Figure 1. Seismic attributes calculation: An interval is considered.

Figure 2. Study areas: Lake Maracaibo and Barinas, both in western Venezuela.

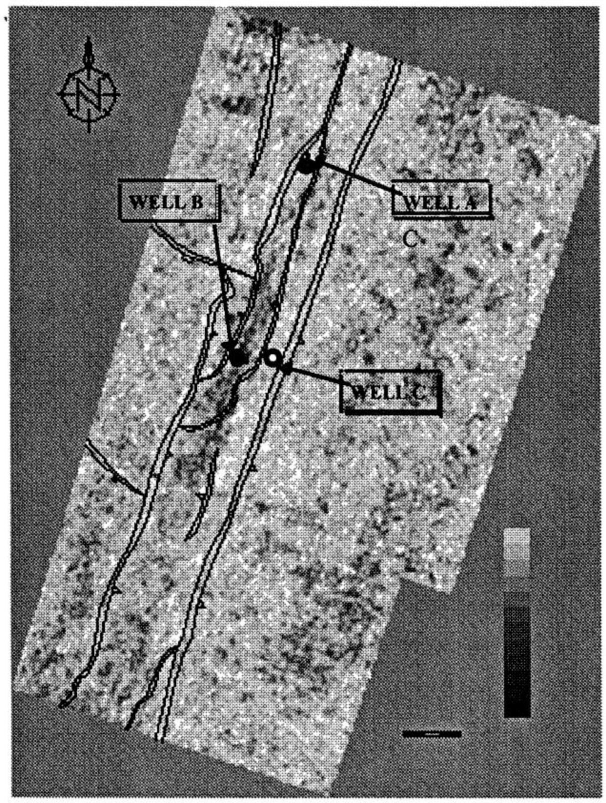

Figure 3. Similarity map for well B, Lake Maracaibo area. Dark areas around this well could be prospective areas. Note different similarity values for wells A and B, both producers.

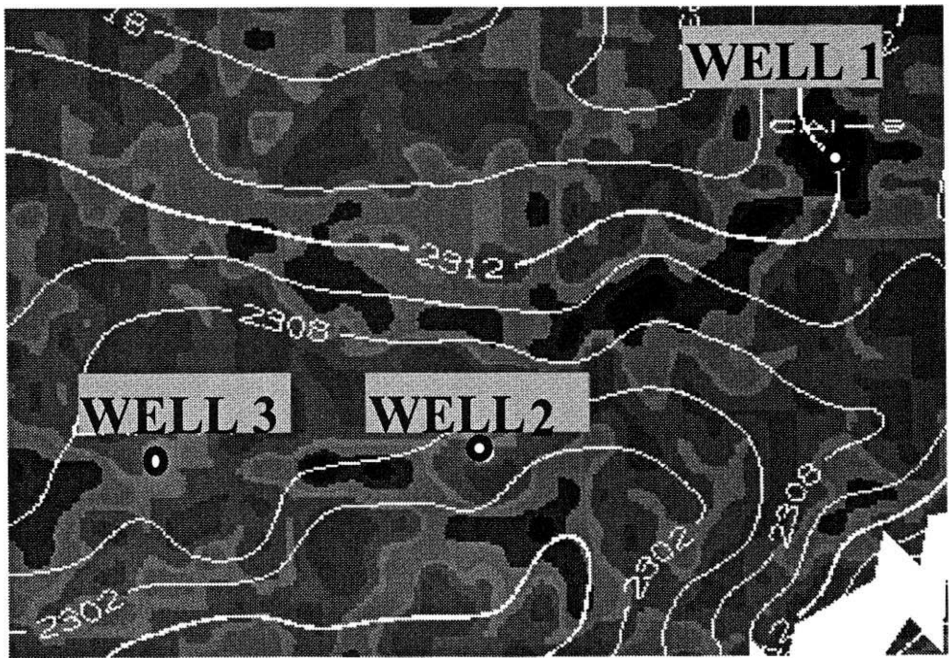

Figure 4. Similarity map for well 1, Barinas area. Well 1 is a producer, whereas wells 2 and 3 are dry. In dark areas, seismic attributes are identical to the attributes around well 1. A n-entry from well 2 to one of these areas was proposed.

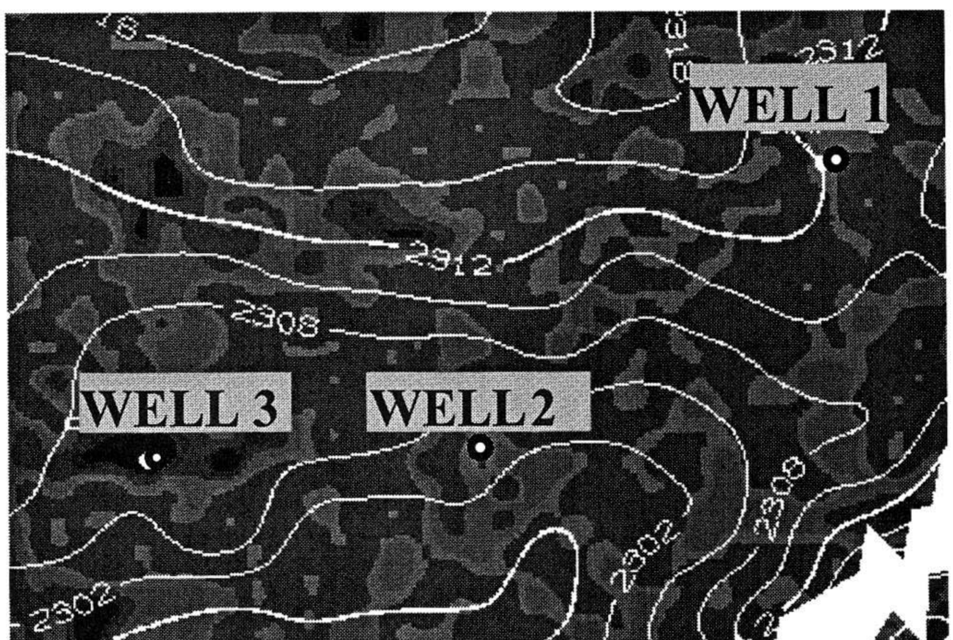

Figure 5. Similarity map for well 3, Barinas area. Well 3 is a dry well, so the high values (dark) in this map are interpreted as areas to be avoided in the exploration for further reserves.