The Libyan Journal of Science (An International Journal): Volume 22, 2019

Three Dimensional Seismic Attributes and RGB (Red, Green and Blue) Colour Blending to Enhance Faults in Sharara Field (NC-115), Murzuq Basin, SW Libya

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Abstract

Seismic Attributes are characteristics extracted from three-dimensional seismic data for highlighting particular geological parameters using color-blending process (Red-Green-Blue). In this process, a color is assigned to each attribute. For example, we assign the red color to the energy attribute, green color to the similarity feature, and a blue color of any other feature that gives a similar effect to all of these colors together. In the study area, the results display clearer reservoir boundaries as well as the neighboring faults. The ultimate goal is to illustrate how seismic attributes produce more accurate data and enable the development of the field through consistent convencing evidence and reduce exploration risks.

Keywords: Seismic; Attribute; RGB color Blending; Structural geology

المستخلــص

الصفـات والسمات السايزمية المتميزة، يمكن استخلاصها من المعلومات السايزمية ثلاثية الأبعـاد لإبراز خصائص جيولوجية معينـة، وذلك باستعمال مزيج من الألوان (أحمر، أخضر، أزرق) التي يتكون منها الخط السايزمي الملون. والخطوات المتبعة في هذه التقنية هي تخصيص كل لون لسمة معينة فعلى سبيل المثال يمكن تخصيص اللون الأحمر لسمة الطاقة، واللون الأخضر لسمة التماثل واللون الأزرق لأي صفة أو سمة أخرى والتي تعطي تأثير مشابه أو مماثل لكل الألوان مجتمعة. والنتـائج المستخلصة من هذه الورقة البحثية تظهر في منطقة الدراسة وضوح حدود المكمن النفطي وكذلك الصدوع المجاورة له. والهدف النهائي لبحثنا هذا هو لتوضيح كيف تلعب السمات السايزمية دوراً مهماً لإنتاج نتائج أكثر دقةً وتنسيقاً لأوضاع الحقل، وإعطاء أسباب جيدة ومقنعة للتطوير وخفظ المخاطرة.

Introduction

Three-dimension seismic interpretation is a form of seismic interpretation, which relies on the use of 3D surveys that provide visualizations of structures in three dimensions. Explorationists often use specialized software for this task, as 3D seismic interpretation requires a lot of calculation and careful construction. Interpretation of seismic data in geological terms is the objective and end product of seismic work.

Accepted for publication: 30/12/2019

The primary objective of a seismic survey for hydrocarbons usually is to locate structures; hydrocarbons traps. Records of explosions are generated and their reflections are read to generate data about what is going on underground (Telford et al, 1976).

With 3D seismic interpretation, this data is mapped on a three dimensional representation which allows explorationists to explore the data in a number of different ways, rather than visualizing a site in the form of a flat elevation map or cross-section. 3D seismic interpretation allows explorationists to manipulate the angle of view and to visualize a site as a whole (Bacon et. al, 2003). It can also provide information about the surrounding area, which may not be readily apparent with other mapping techniques. Seismic interpretation can be very complex, geologists are interested in the structure of the earth and in the components of the site they are studying. Seismic interpretation is designed to reveal not only the presence of underground formations, but also what is in those formations, and where are the transitions. Between different types of materials occurring, a geophysicist can play several scenarios. Modeling of scenarios on a map allows geophysicist and geologists to explore the possible results of various activities. For example, geophysicists may be concerned that oil field exploration could cause the collapse of a delicate formation, potentially putting people or the environment in danger. They may also believe that formations present on-site hold limited amount of useful resources, making investment in the site potentially unprofitable (Bacon et. al, 2003).

Seismic Data from current and past surveys can both be loaded into seismic softwares used in 3D seismic interpretation. However, it is not enough to map the top of the reservoir, to understand how structures were formed. It is usually necessary to map the range of marker horizons above and below the target. In most cases, mapping of several horizons above the target level is require. Interpretation is often the last hands-on step in seismic data gathering and analysis, the trend is to bring the interpreter closer to the processor and the acquisition contractor. It is an important fact that interpreters can be involved in all aspects of 3D seismic survey design, acquisition, and processing (Bacon, et al, 2003)

The basic principles of 2D seismic data interpretation provide the interpreter with the solid foundation necessary for 3D interpretation. Principles of 2D interpretation such as picking faults and horizons and loop tying of seismic lines are fundamental to all seismic interpretations. These principles are demonstrated with hands-on 2D and 3D seismic exercises involving picking faults and horizons in time and converting to depth, making time and depth maps for horizons and fault surfaces, and performing volumetric calculations (Telford et al, 1976).

True 3D display of a volumetric image is a difficult problem reviewed by the applicable technologies but all fall short of what the seismic interpreter needs. Most address very small volumes of data and also lack dynamic range, (Brown, 1986), personally experienced with holography and several seismic data holograms exist: However. The interpreter cannot interact with the image and dynamic range is inadequate for most purpose (Nelson, 1983).

Seismic Attributes and Color Blending

In reflection seismology, a seismic attribute is a quantity extracted or derived from seismic data that can be analyzed in order to enhance information that might be more subtle in a traditional seismic image, leading to a better geological or geophysical interpretation of the data. Examples of seismic attributes include measured time, amplitude, frequency and attenuation, in addition to the combinations of all these. Most seismic attributes are post-stack, but those that use CMP gather, such as amplitude versus offset (AVO), must be analyzed pre-stack. They can be measured along a single seismic trace or across multiple traces within a defined window (Bacon, 2003).

The first attributes developed were related to the 1D complex seismic trace and included: envelope amplitude, instantaneous phase, instantaneous frequency, and apparent polarity. Acoustic impedance obtained from seismic inversion can also be considered an attribute and was among the first developed. Other attributes commonly used include coherence, azimuth, dip, instantaneous amplitude, response amplitude, response phase, instantaneous bandwidth, AVO, and spectral decomposition. A seismic attribute that can indicate the presence or absence of hydrocarbons is known as a direct hydrocarbon indicator. The ultimate goal is to enable the geophysicist to produce a more accurate interpretation and reduce exploration risk and development of the reservoir (Nelson, 1983).

Color Blending

In colour Blending process (Red-Green-Blue) a color is assigned to each attribute. For example, we assign the red color to the energy attribute, the green color to the similarity feature, and the blue color of any other feature that gives a similar effect to all of these colors together. The result is that we will see the oil reservoir and its boundaries much clearer (Bacon, 2003).

Amplitude Attribute

Amplitude attributes are computed sample by sample to represent instantaneous variations of various parameters. The amplitude attribute increases the strength of high values and the small values fade.

Outputs of the instantaneous amplitude of the selected data volume at the sample location can be used as an effective discriminator for the following characteristics:

1. Mainly represents the acoustic impedance contrast, hence reflectivity,
2. Bright spots, possible gas accumulation,
3. Sequence boundaries,
4. Thin-bed tuning effects,
5. Major changes in the depositional environment,
6. Spatial correlation to porosity and other lithological variations. This indicates the group, rather than the phase component of the seismic wave propagation (Bacon, 2003).

Energy Attribute

The response attribute returns the energy of a trace segment. This attribute calculates the squared sum of the sample values in the specified *time-gate* divided by the number of samples in the gate. Energy is a measure of reflectivity in the specified *time-gate*. The higher the energy, the higher the amplitude. This attribute enhances, among others, lateral variations within seismic events, therefore useful for seismic object detection the response energy also characterizes acoustic rock properties and bed thickness (Bacon, 2003).

Similarity Attribute

The Similarity is a form of "coherency" that expresses how much two or more trace segments look alike. A similarity of 1 means the trace segments are completely identical in waveform and amplitude. A similarity of 0 means they are completely dis-similar (Bacon, 2003).

The main objective of this paper is to elaborate on how the techniques of the (RGB) color blending can make a difference in the interpretation of 3D seismic data in an area of complex structure including faults. In this particular area in the Murzug Basin, we will apply this technique to trace the trap of the reservoir and the faulted area behind it.

Study Area

Asharara oil, NC115 Field (Fig. 1) is located on the Murzuq Basin, Libya, which is a regional intecratonic basin in Southwest Libya. The Basin Lies between the structural highs of the Gargaf region to the North, the Tibesti Massif to the East and the Tassili to the west. It is contiguous with the Jado Basin to the South.

Geology of Murzuq Basin

Murzuq Basin covers an area of more than 350,000 km^2. It is one of several interatomic basins located in the North African platform. The present day borders of the basin are defined by tectonic uplifts, each of multi-phase generation. The present basin geometry bears little relation to the much broader North African sedimentary basin, which existed during the early Paleozoic. The eastern edge of the Murzuq-Djado Trough forms the western part of an early Palaeozoic horst striking from Mourizide NNW towards the western part of Gargaf Uplift (Tripoli-Tibesti Uplift) from about 14° 30' E and 24° N to about 12° 45' E and 27° 30' N (Klitzsch, 1970). Several generation of fault movement are recognized in the basin, but the resultant degree of deformation is relatively minor. The Basin contains a sedimentary fill that reaches a maximum thickness of about 4000m in its epicenter, which comprises a predominantly marine Paleozoic section and a continental Mesozoic (Goudarzi, 1967, 1981).

Silurian source rock remained within the oil generation window only in a limited area of the basin center. The basin including the Tiririne High separating the Al Awaynat and Awbari troughs and the Traghan High. The Present-day Murzuq Basin did not develop until the Mesozoic. Prior to that, the Paleozoic basin comprised a series of NW-SE directed highs and lows (Klitzsch, 2000). In general, fault density and structural complexity increase from the southern, more stable parts of the basin, towards the northeastern and Northwestern portions. The most complicated and intensively faulted areas are generally located over the Tiririne and Traghan high (Davidson et al., 2000; Echikh, and Sola, 2000).

The principle hydrocarbon play in the basin consists of a peri-glacial sandstone reservoir of Ordovician age sourced and sealed by overlying Silurian shale. This play has proved very successful and accounts for approximately 1500 million barrels of recoverable oil discovered to date. Oil generation may have taken place during the Cretaceous time, but further work is required to better define the timing of oil charge. Subsequent regional uplift and erosion have resulted in a cooling of the source rocks. There is no longer generated oil over large parts of the basin to the present day (Aziz, 2000).

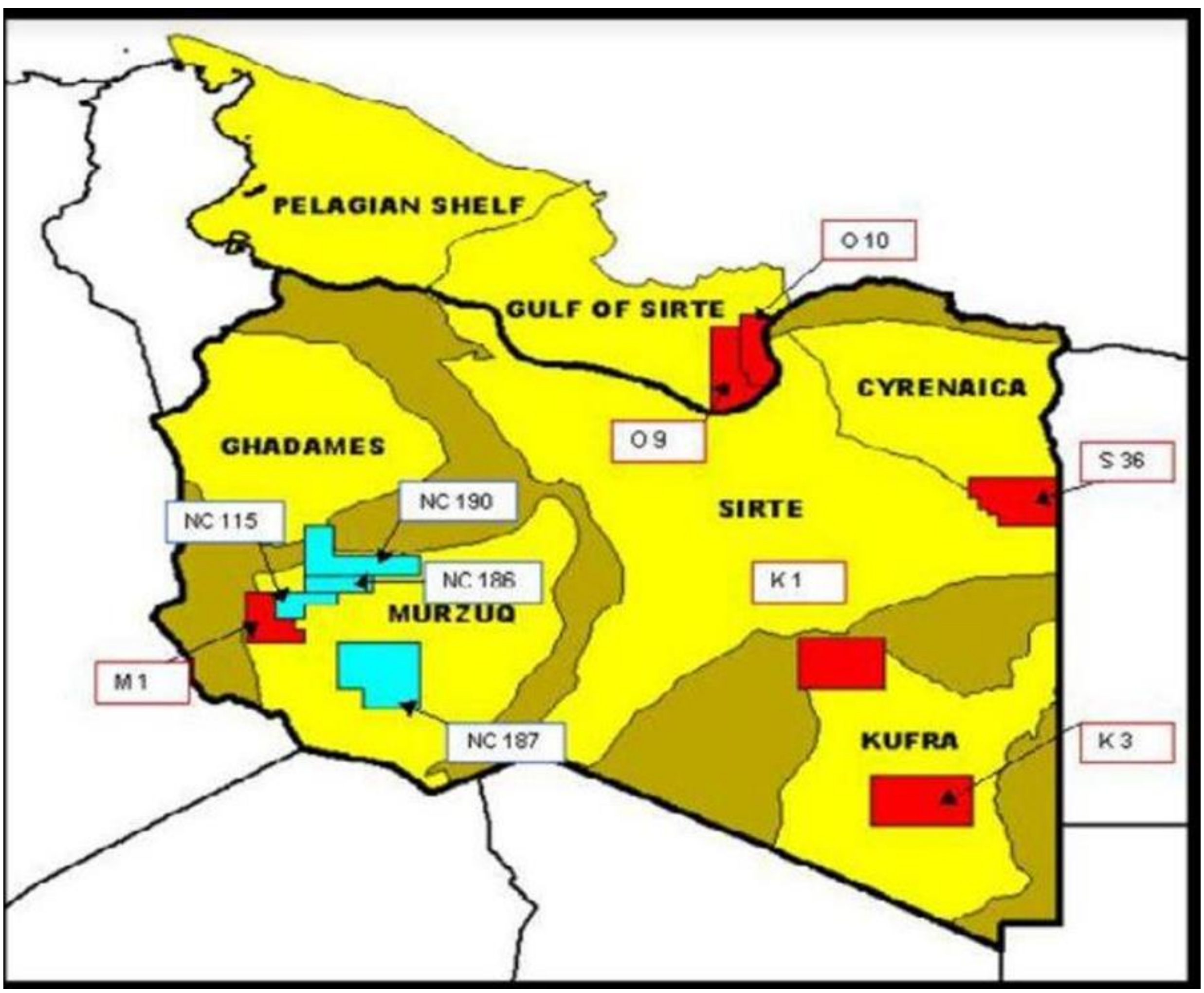

Fig. 1. The location map of Asharara Field, NC-115, Murzuq Basin, Libya.

Data Analysis and Discussion

The three dimension seismic interpreter works with a volume of data, normally done by studying some of each of three orthogonal slices through the volume. The interpreting of the structure needs to be judged using horizontal section and when to use vertical ones.

In Fig. 2, the blue area indicates very high amplitude, while, the red area represents lower amplitude. This indicates a fault zone, the event terminates clearly on the position shown in the section (Fig. 2). The picking of fault on a horizontal section provides a contour on the fault plane, thus picking a fault succession of suitably spaced horizontal sections constitute an easy approach to fault plane mapping. The fault evident in Fig.2 have been mapped in this way. In the horizontal section at 60 ms (Fig. 2), two fault show events of quite different widths. This is the effect of dip where the faults are mostly traced by sinuous events striking approximately north – south.

When we make an 3D data interpretation work after having previously mapped from 2D data over the same prospect, the most striking difference between maps is commonly the increased fault detail.

Similarity as shown in Fig. 3, Multi-trace attribute that returns trace-to-trace similarity properties expressing this attribute identify faults. Hence, the event will not terminate but will parallel the fault comparison and demonstrates that situation (Fig. 3). The difference in amplitude between the red area and the blue area is too high because of variation of properties caused by the fault.

We expect to detect faults from alignments of event terminations. Figure 3 shows a section of 3D data, which provide the event terminations clearly. Figure 4 also shows three faults system after using the similarity. In contrast, the horizontal section for the same data volume does not show clear event termination. Why the event termination is visible at the fault in Fig. 2 but not in Fig. 3? The answer lies simply in the relationship where the fault is between the structural strike and faults strike.

Any horizontal section alignment indicates the strike of the feature, if there is a significant angle between structure parallel or almost so. The events will terminate, if structural strike and fault strike, are parallel or almost, attribute on line the faults are much better.

The blue area in Fig. 5 shows that the amplitude attribute increases the strength of high values and the small values are faded, before and after applying amplitude attribute.

Figure 6 shows the energy in the red area, which is too high, while in the blue area it is very low. These variations in energy indicate that there is a fault in the area. The energy of a trace segment attribute calculates the squared sum of the sample values in the specified time-gate divided by the number of samples in the gate. However, Fig. 7 shows the effect of using the energy attribute. The difference in energy between the red area and the blue area is too high due to the properties variation indicating that there is a fault in the area.

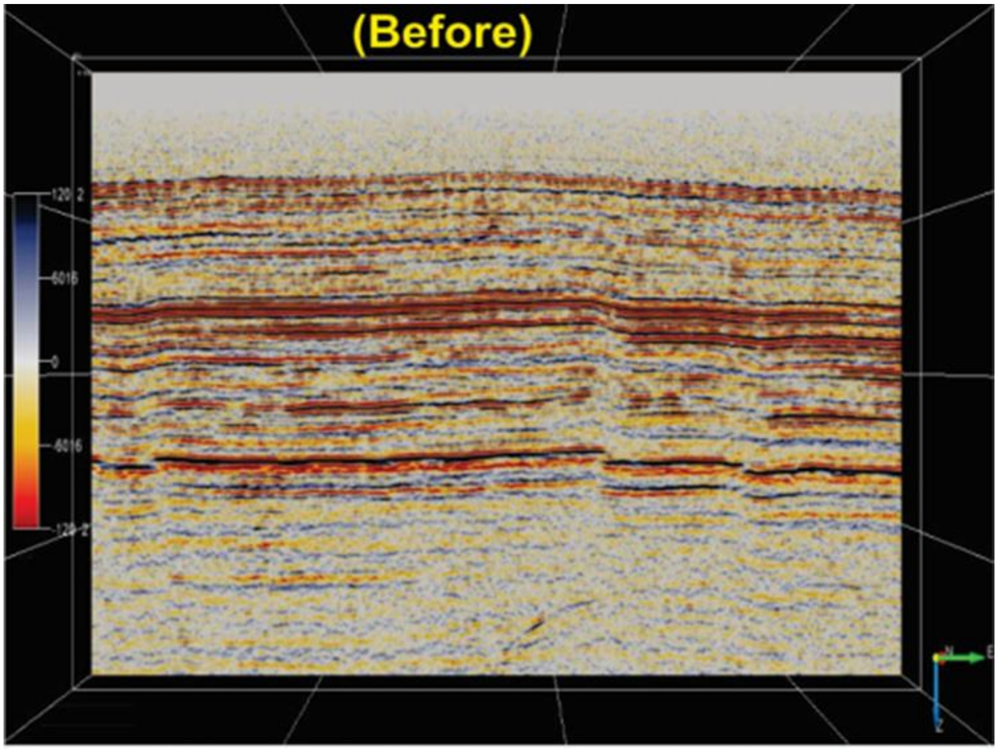

Fig. 2. 3D colored section in the area of study before using similarity.

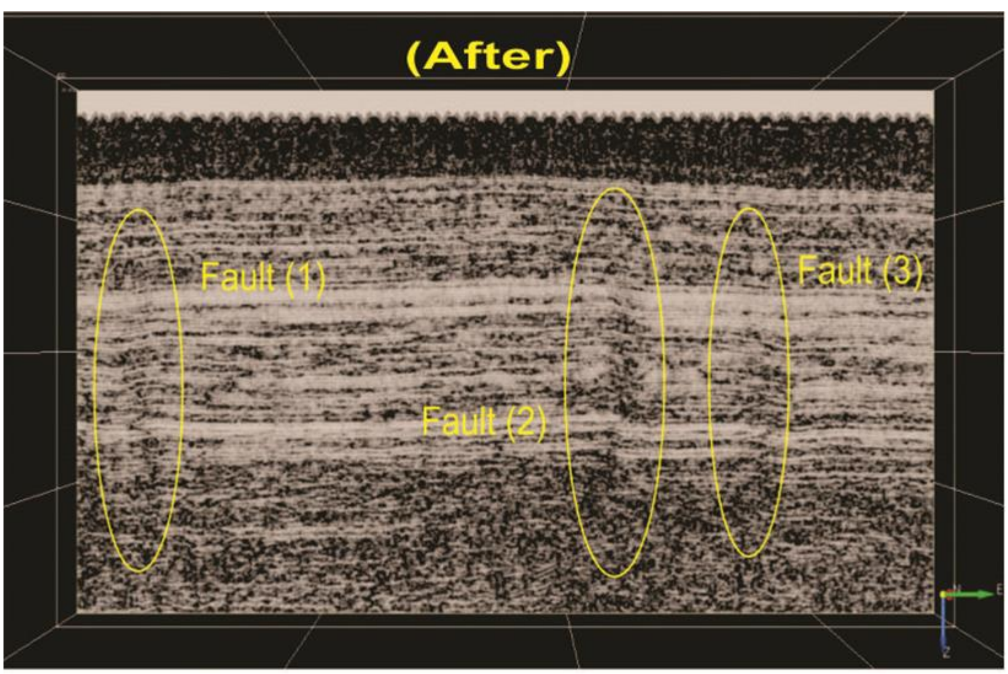

Fig. 3. Black and white seismic section data of Fig. 2, after using similarity.

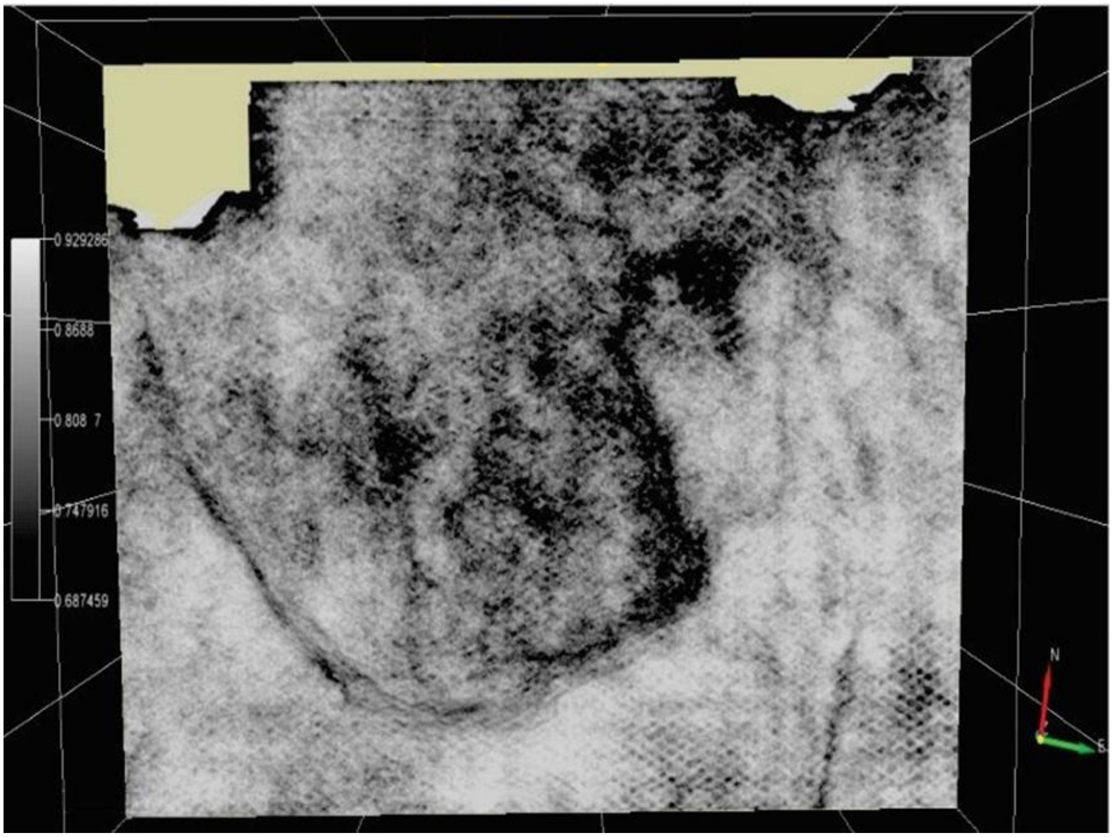

Fig. 4. Shows the similarity and how the traces are alike in black line.

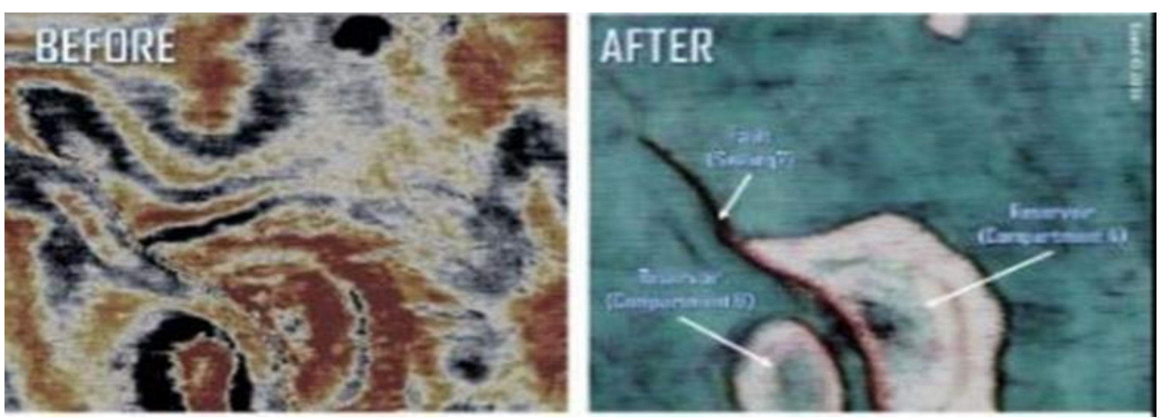

Fig. 5. The blue area marks too high amplitude while the red area marks too low indicating the presence of a fault.

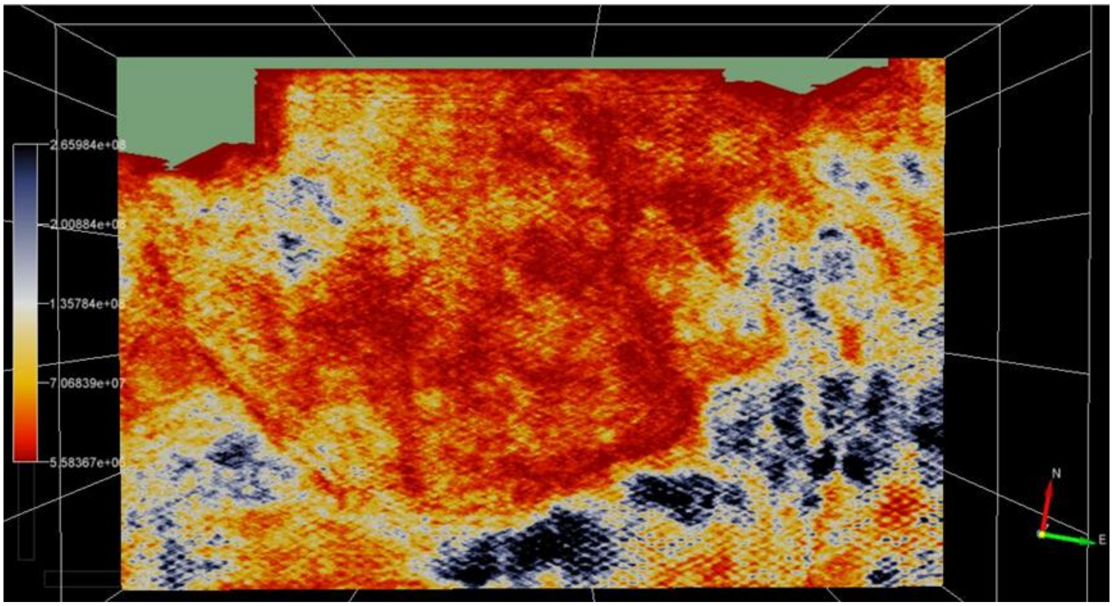

Fig. 6. The energy attribute.

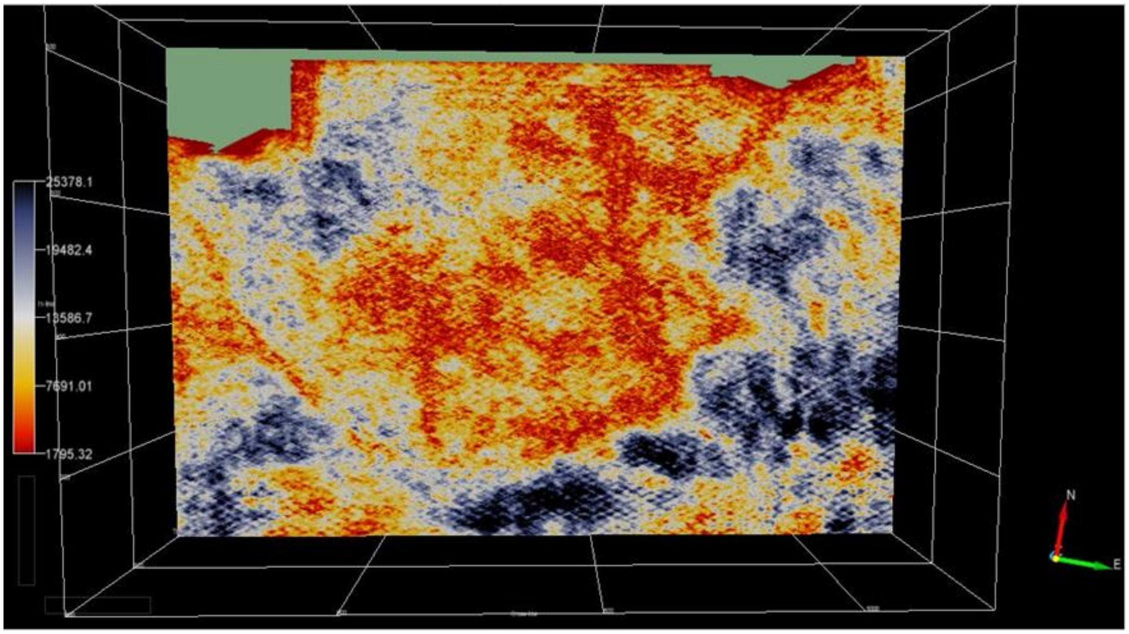

Fig. 7. After using energy attribute

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Conclusion

Apparently, colors are used in two fundamentally different ways, contrasting or gradational color schemes. A seismic section displayed in contrast colors is normally accompanied by a legend, so the interpreter can identify the value of the displayed attribute at any point. Also for more effective color display, it is important, to choose carefully the range of values associated with each color as the number of colors and their sequence are very important in order to show the contrast between adjacent colors and display scales. A color display must convey useful information and at the same time must be aesthetically pleasing. For a map such as shown earlier, it is desirable to perceive equal visual contrast between adjacent colors, so that no one boundary is more outstanding. The seismic attribute technique that has been applied in this area gives us the proof and assertion that faults exists in this area and can be detected and followed by applying this seismic attribute technique.

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