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What Lies Beyond the Rainbow

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Summary

As the 70's drew to a close two new technologies were injected into exploration, time migration and color amplitude displays. Migration was a boon to our ability to image the subsurface and it has been in constant development ever since. Color amplitude displays gave a similar boost to our ability to interpret seismic amplitude but unlike migration, the technology has remained stagnant and our ability to interpret amplitude is very much the same today as it was 40 years ago.

Technology, however, has changed and now we can display seismic amplitude directly rather than convert it to color. When we do, what will we see? What information lies beyond the Rainbow or any other palette?

Introduction

Migration has probably had more impact upon exploration and our ability to meet the world's ever-growing need for hydrocarbons than anything since. As strange as it may seem today, however, its initial introduction in the late 70's did not meet with universal approval. Many of the interpreters of the day complained about the "wormy" nature of migrated sections and given that most Alberta data at the time was flat and apparently featureless, they didn't see the need to migrate it.

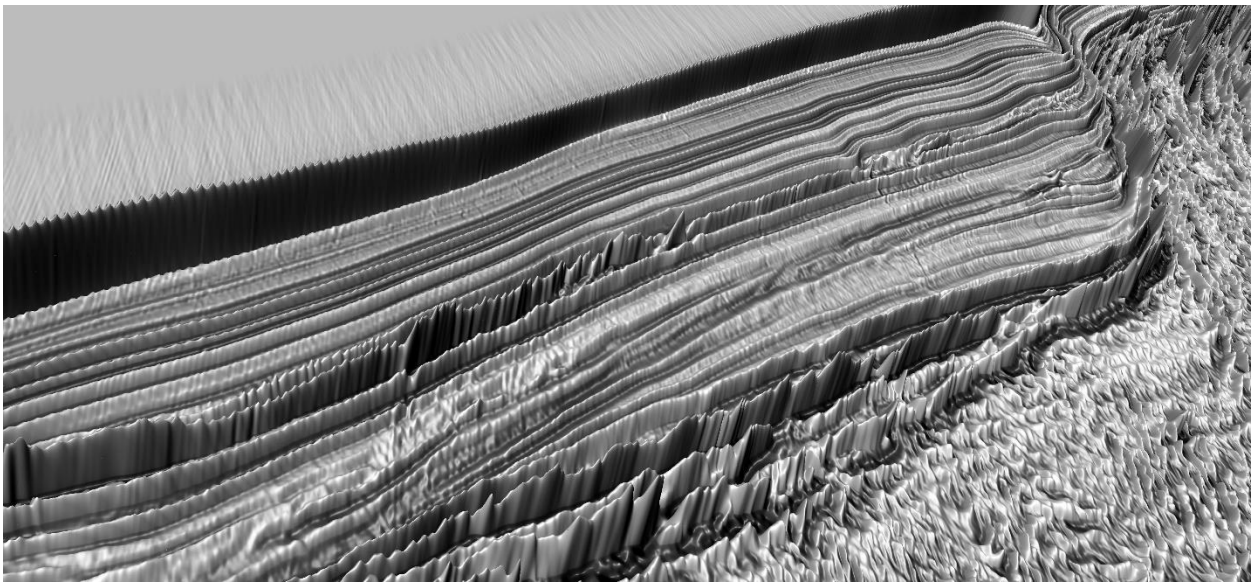

Figure 1: A Seismic Wavefield display, data from the Rockall Trough. A three-dimensional surface with x as the sample position, y as the time and z as the amplitude. Color, while visually engaging, would add little to our amplitude perception.

Everyone knew about the Fresnel zone and the theoretical benefits of collapsing it but, having never seen what happens when you do, they lacked motivation. Motivation was eventually supplied by corporate decree and when it was, what emerged from homogeneity were questions. Flat and featureless unmigrated events, when migrated, began to reveal channels, faults and structures that no one suspected were there. Questions were asked as to what these new features were; new plays were developed, and hydrocarbons were found where none were suspected.

The initial introduction of migration marked a watershed in our ability to image the subsurface and there has, in my opinion, been nothing like it since. Recent technological innovations, however, suggest the possibility that we are poised on the threshold of a new period of discovery, this time with amplitude.

Surprisingly, given its importance, we have never interpreted seismic amplitudes. What we interpret are patterns of color. We use color as a proxy for amplitude, but it is not amplitude. Despite the best efforts of many researchers, there exists no color palette that naturally associates with seismic. What is more, there is no biological organism, extant or extinct, whose color perception is good enough to detect even the gross nuances of seismic amplitudes or who can produce visual perceptions from pure color displays. Color is a poor substitute for the real thing and today, we don't need it anymore.

Today, we can display seismic in its natural form, as a three-dimensional surface. When we do, what we see, clearly and unambiguously, are seismic amplitudes. We see them for the first time and as with migration that preceded it by 40 years, what emerges are questions. What lies beyond the much-maligned rainbow color palette or any other color palette are questions.

A Step Beyond Color

Color is a ubiquitous technique for displaying complex surfaces, not only in exploration but in many other fields as well. We have used it to display seismic amplitudes for almost 40 years, so long that it is ingrained in us. There are, however, myriad problems associated with communicating amplitude information with color. There is the fact that we do not produce visual perceptions from color. When it comes to perception, color is entirely optional. There is the fact that primate color vision, although better than all other mammals, is still extremely limited. There is the fact that there is no natural association between amplitude and color and that the same image means different things to different viewers. All those problems, however, are irrelevant.

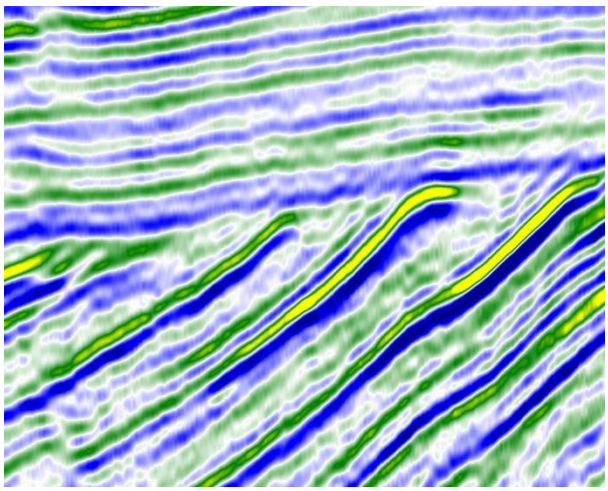

Figure 2: Color display of an unconformity from the Laurentian Sub-Basin.

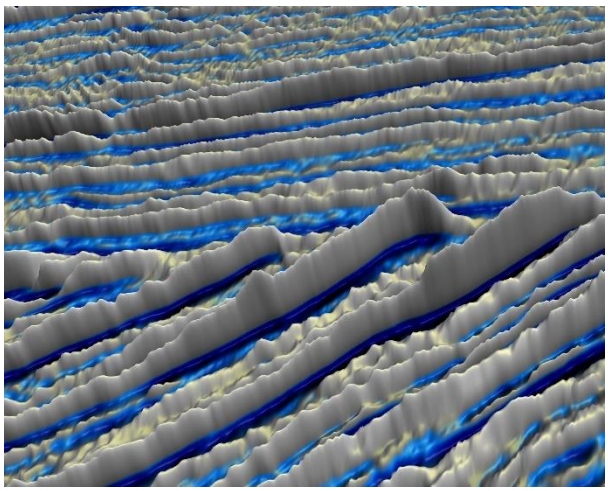

Figure 3: Seismic Amplitude display of the same data. Here, the seismic amplitude serves to provide the relief.

The transition from Figure 2 to Figure 3 marks an obvious step change in our ability to perceive seismic amplitude. When color displays were first introduced in the late 70's, they themselves were a similar step change. They replaced wiggle trace displays for amplitude analysis and in doing so, they made bright spot analysis possible. But as you can see, they were not the final step.

Seismic amplitude is always important and color displays were, in their time, a major advancement. But beyond color lies fascinating details that never having seen in the past, we are unaware of in the present. In that sense, today we are in the same position with amplitude that we were in with the Fresnel zone in the 70's. Never having seen the effect of migration, we were unaware of the details that existed beyond

our structure stacks. Today, never having worked directly with amplitude, we are, as an industry, unaware of the almost overwhelming amount of detail that they contain.

Understanding why color was not the final step may be scientifically fascinating but geophysically and geologically it is irrelevant. The only thing that is relevant is recognizing that another step exists, and our objective must be to learn how significant a step it is.

Examples

Color can be used to represent amplitudes but only to a point. Color has its limitations, including:

1. Color palettes are often set to highlight the highest amplitudes. Often, in these environments, amplitude changes along lower amplitude events become uninterpretable.
2. Amplitude changes above or below the clipping range of the palette are effectively invisible and yet, it is those changes that are often the most significant.
3. There is nothing inherent in a color display that clearly indicates scale. Color changes may be detected but the magnitude of the changes remains a mystery.
4. Color perception is subjective and the same display, when shown to different individuals, may produce ambiguous interpretations.

The following examples highlight these limitations, but their purpose is not to attack the use of color. Rather it is to focus attention on the fascinating amplitude details contained within every seismic line and to provide a window into the emerging world of true amplitude interpretation

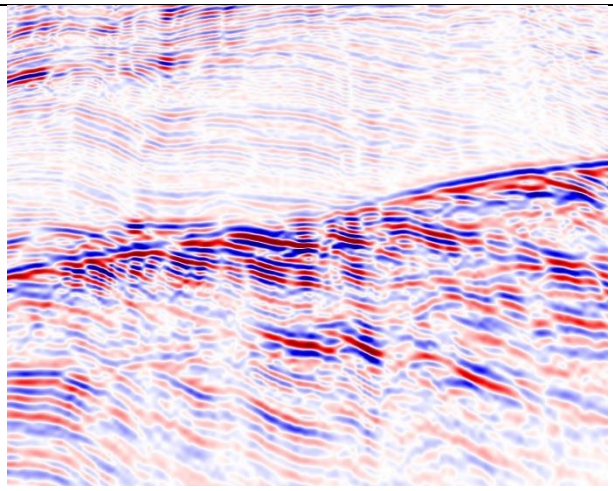

Figure 4: Blake Ridge Hydrates. The initial study of the hydrates was performed using this style of color palette.

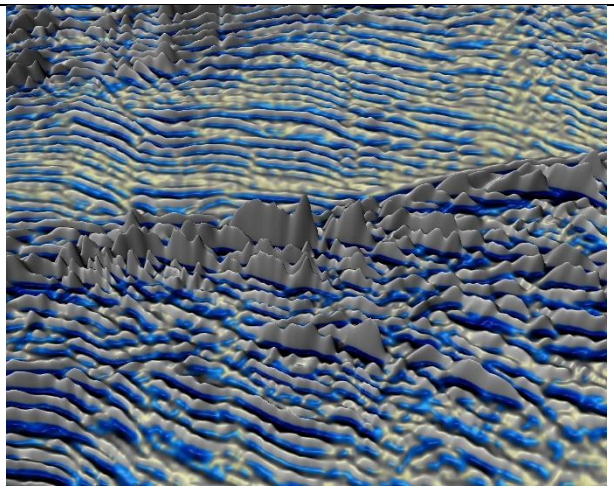

Figure 5: One feature of hydrates is that they produce complex, high amplitude reflections that are often visually clipped by conventional color palettes.

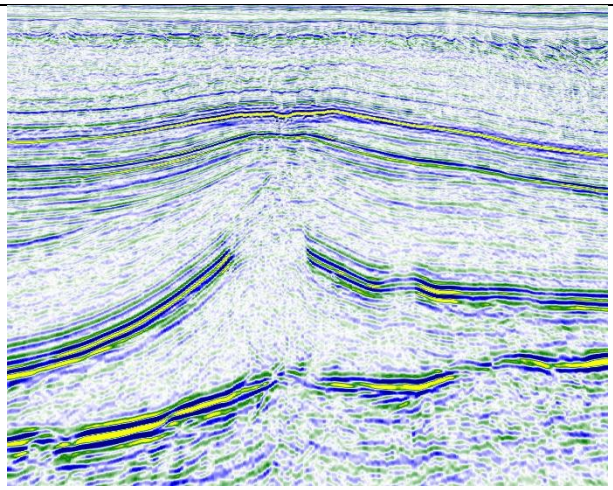

Figure 6: Mid North Sea High Salt Features. The color range of the display is severely affected by the high-amplitude lower event making subtle changes impossible to detect.

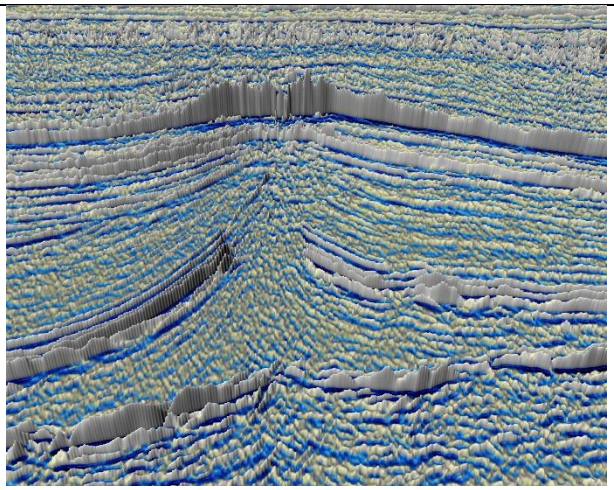

Figure 7: In salt environments, anomalously amplitudes can often indicate hydrocarbon migration. In this display, all amplitude ranges are equally interpretable.

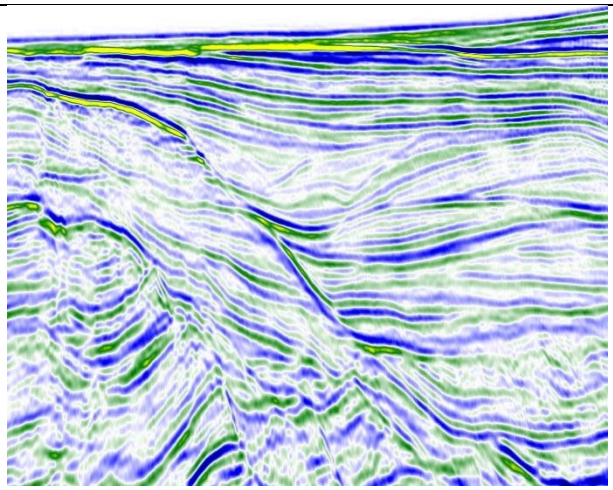

Figure 8: Basin edge, Trujillo area offshore Peru. Color cannot produce perception. Do you perceive amplitude here or do you have to make a conscious decision what is high and what is low? What decision would someone else make?

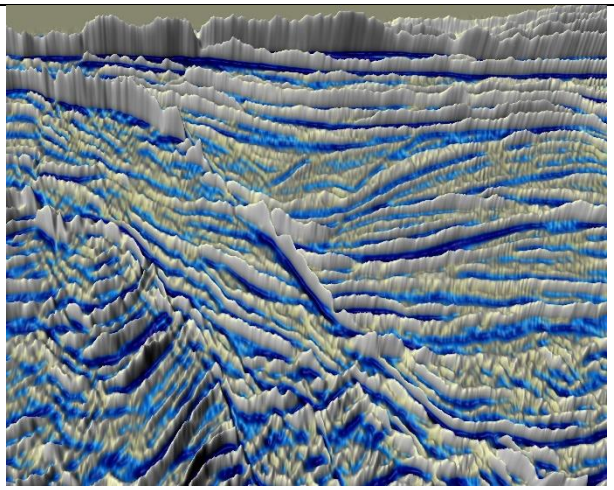

Figure 9: True amplitude displays are unambiguous. There is no question here of what it high and low and this display is equally interpretable and understandable to anyone who views it.

Conclusions

Exploration is built upon questions. New plays are often developed by explorationists observing something on seismic that they did not expect and do not understand. From questions comes a deeper understanding of geology and from a deeper undestanding of geology comes new exploration targets and new sources of hydrocarbons.

Our new found ability to display seismic amplitudes directly rather than use color proxies gifts us an entirely new source of questions. It makes every seismic survey ever acquired prospective again.

Acknowledgements

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