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Seismic window

Michael Micenko
Associate Editor for Petroleum
micenko@bigpond.com

Curvature, channels and compaction

Curvature is a measure of the amount of deformation of a surface such as a mapped seismic horizon. It is defined as the reciprocal of the radius of a circle that is tangent to the surface, and will be large for a tightly folded surface and zero for a planar surface. An anticlinal structure has a positive curvature and a synclinal shape has negative curvature. Commonly curvature is used to identify faults or channel edges, but it can also identify folds where there is no discontinuity. It is this characteristic that I want to pursue in this article.

Channels, canyons, incised valleys, regardless of what they are called, can be quite spectacular and produce artistic displays, but they may also host hydrocarbons if the channel fill has good reservoir properties. So, how can we identify a sand filled channel from one that is shale filled? Figure 1 is a vertical seismic section with two major incisions cutting into the sediments. The channel labelled A is interpreted to be shale filled while channel B has a sandy fill.

The horizon based similarity attribute displayed in Figure 2 shows that each incision is not formed by a single event, but by several events within a broad channel belt. The properties of the channels appear to be varying temporally and spatially. Shale filled channels have a concave shape because the deposited muds in the thickest section compact more than the thinner muds near the edges. On the other hand, sandstones have relatively low compaction compared to the surrounding shales and retain a positive relief. These differences in shape and intensity of deformation can be detected by an appropriate curvature attribute.

It should be possible to distinguish a convex up feature, such as the top of a sand filled channel, by displaying the positive curvature attribute, while shale filled channels should display a negative curvature – just calculate and display the positive curvature attribute to highlight all the convex up reflectors. This sounds simple and Figure 3 is an example of an early attempt. It's not as convincing as I'd hoped, but the sand filled channel seen in Figure 1 does have a positive curvature anomaly whilst the interpreted shale channel has no positive curvature (perhaps I need to apply a some kind of filter to enhance the areas of positive curvature).

Figure 3 is also an example of using colour blending to show multiple attributes in a single map. In this case I have assigned similarity to black, positive curvature to blue, curvedness to red and entropy to green, which results in sand prone channels having a purple hue (similarity highlights the channel edges and other discontinuities while entropy is a measure of chaos and highlights the channel belts).

While not perfect, this technique can be refined to allow rapid identification of sand prone areas within complex channel systems. Good hunting!

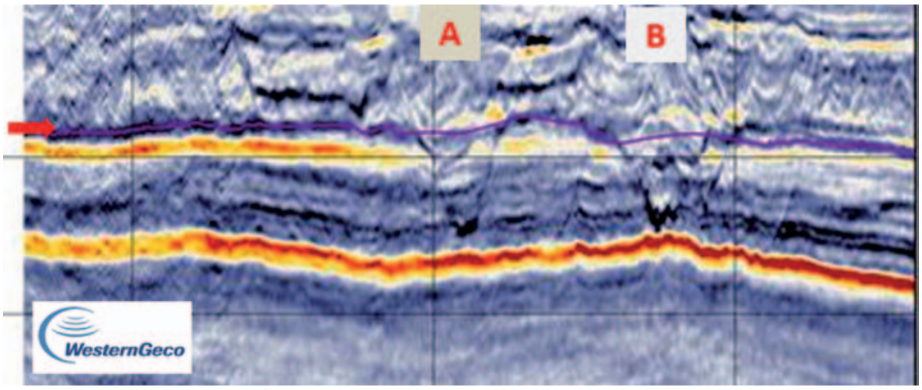

Figure 1. *Seismic line across an interpreted shale filled (A) and sand filled (B) channel. The reflectors above channel A are concave whereas those above channel B are convex. The display in Figure 2 is extracted just below the purple horizon. The red arrow indicates the level of the display in Figure 3. Data courtesy of WesternGeco Multiclient.*

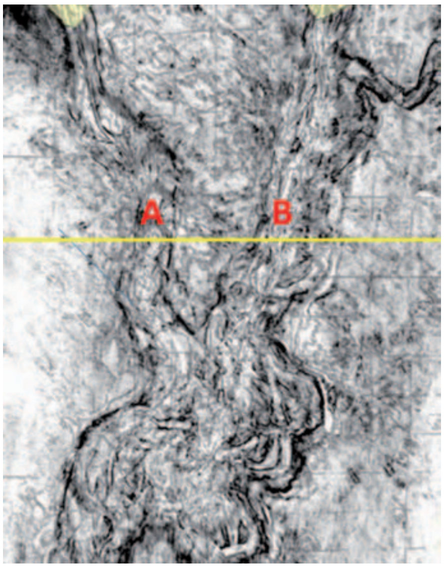

Figure 2. *Similarity attribute displayed along a horizon near the top of the channel system showing the location of channels A and B and the seismic line from Figure 1. Each channel belt consists of numerous meandering features that move spatially over time. Data courtesy of WesternGeco Multiclient.*

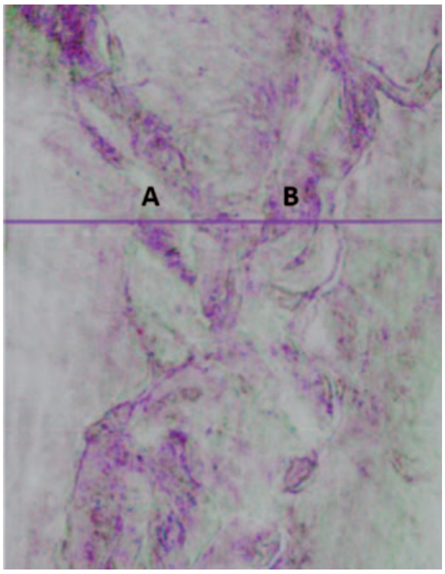

Figure 3. *Colour blend display along a horizon above the channelized section. Positive curvature is in blue and curvedness is in red (other channels are green – entropy, and black -similarity). Areas where there is drape over a sand fill have a positive curvature and appear purple such as location B. It appears the left hand channel at location A is more shale prone. Data courtesy of WesternGeco Multiclient.*