[GC]Shaded Relief Display of Seismic Images*

Arthur E. Barnes[1]

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[1]Landmark Graphics Corp., Highlands Ranch, Colorado (Barnes@halliburton.com)

General Statement

Seismic reflection data come alive when displayed with shaded relief. With shaded relief, time slices look like illuminated topography, and vertical sections look like rugged canyon walls; faults, domes, anticlines, synclines, channels and even gas clouds stand out boldly.

Shaded relief displays are ubiquitous in geology and geophysics. Elevations, bathymetry, gravity, magnetic and other kinds of map data are routinely displayed with shaded relief to make maps that look like photographs of apparent topography. Such maps are powerful aids to geologic intuition because apparent topography often suggests true underlying geology. Though contour maps offer the same information, shaded relief maps present the information in a way that is more natural – and so more readily comprehensible. also be effective in vertical view. (a) A highly faulted zone through the seismic data of Figure 1; (b) the seismic data blended with shaded relief. The yellow arrow indicates the direction of illumination. Faults appear sculpted into the side of the volume and tend to be clearer.

Method and Examples

Adding shaded relief to 3D seismic data is similar to adding shaded relief to maps, with the difference that shading is applied to all reflection surfaces in the seismic volume, not to a single horizon. Thus seismic shaded relief is inherently 3D, so that both time slices and vertical sections appear illuminated. The process of adding shaded relief to seismic data is simple: create a shaded relief seismic attribute and blend it with the seismic data (Figure 1).

A shaded relief seismic attribute quantifies the amount of light that seismic surfaces reflect when illuminated by a distant light source (Figure 2). This quantity – the shading – is a function of the angle of incidence of the illumination, which depends on reflection orientation and the position of the sun. Shading can be controlled by exaggerating reflection slopes to enhance contrasts, or by adjusting surfaces to appear dull like shale, shiny like water or moderately shiny like quartz sand. Because shaded relief depends on the sun position, it acts as a directional filter.

Features that trend perpendicular to the illumination direction are highlighted, while features that trend parallel are hidden. To capture all trends, it is necessary to create two shaded relief attribute volumes using orthogonal illumination directions. Blending seismic data with shaded relief complements blending data with a discontinuity attribute because shaded relief reveals different structural features than continuity, principally anticlines, synclines and domes (Figure 3).

Like discontinuity, shaded relief also reveals faults and channels (Figure 4), with the advantage that it can indicate the direction of throw on a fault and show the internal geometry of the channel. A shaded relief seismic attribute can have arbitrary resolution, but it tends to provide better results when it is fairly smooth and clean (as in the data examples presented here). Smoothed shaded relief highlights large features and trends that might otherwise be obscured by details in the data; it lets one see the forest for the trees. In this way shaded relief can serve as a useful tool for rapid reconnaissance of structure in a seismic volume. Of course, smoothing reduces the resolution of the shaded relief so that small features, such as narrow channels and minor faults, will not be seen. These features are often best imaged by discontinuity and curvature attributes.

Conclusion

Almost everything we do to prepare seismic data for conventional interpretation is designed to make images that look as much like geology – and as little like seismic waves – as we can. Seismic shaded relief is another small step in this direction. Can shaded relief aid our understanding of seismic data as much as it aids our understanding of geologic maps? Only time will tell.

Figures

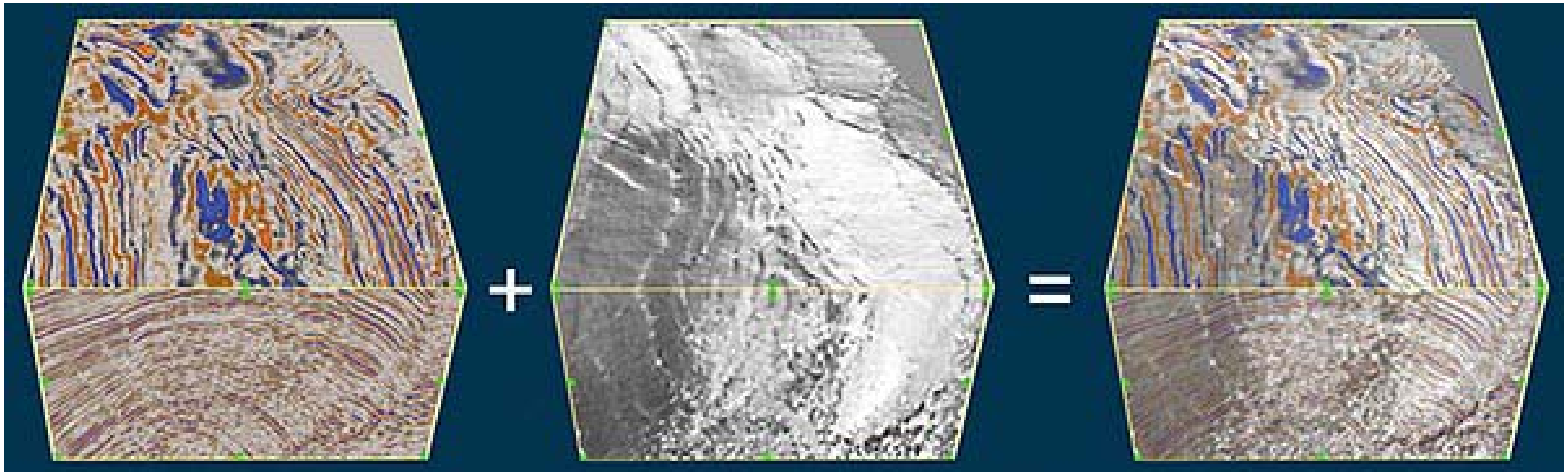

Figure 1. Seismic data + shaded relief attribute = illuminated seismic reflections.

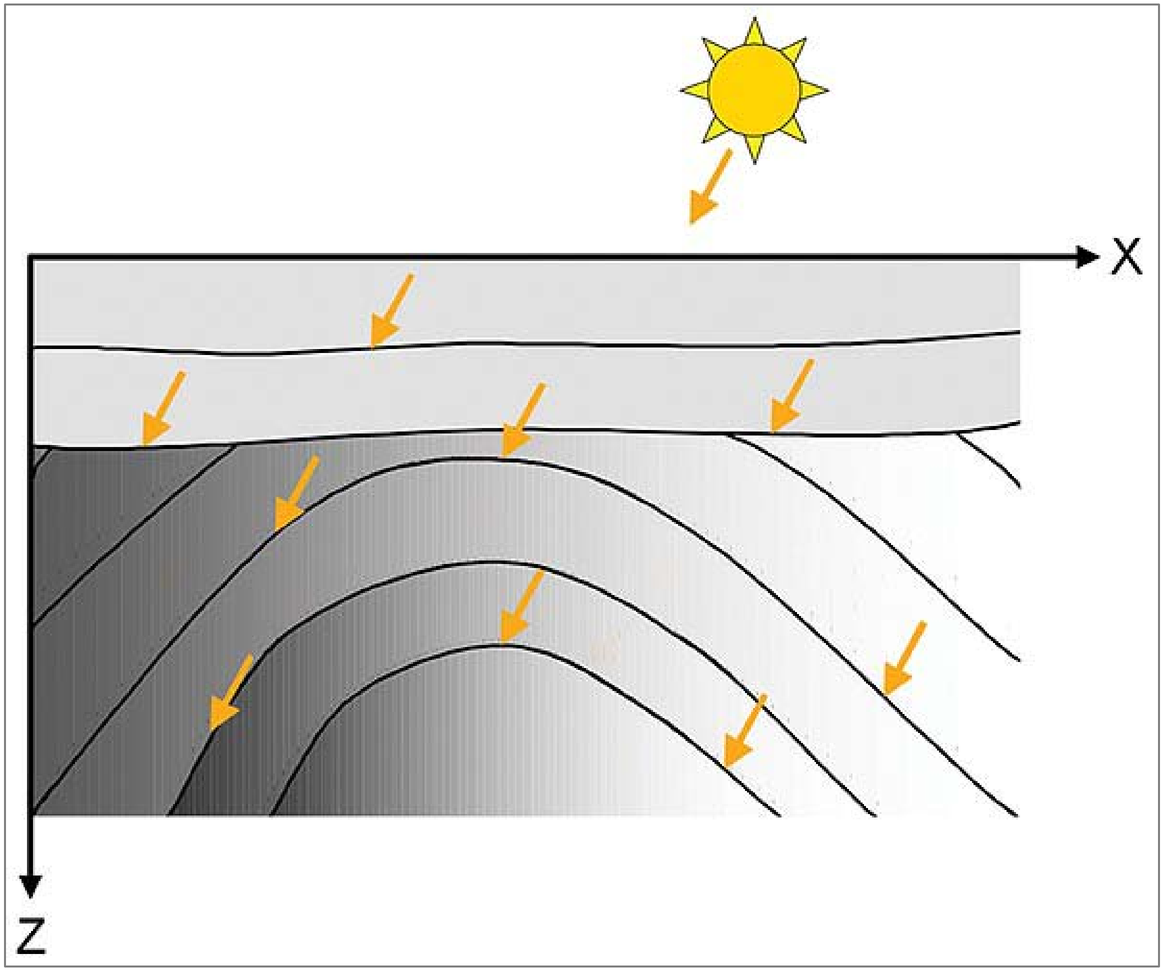

Figure 2. A cross-section as it would appear if imaged by seismic data and converted to seismic shaded relief. At any point on a reflection surface, the illumination is a function of the angle of incidence of the light upon the surface.

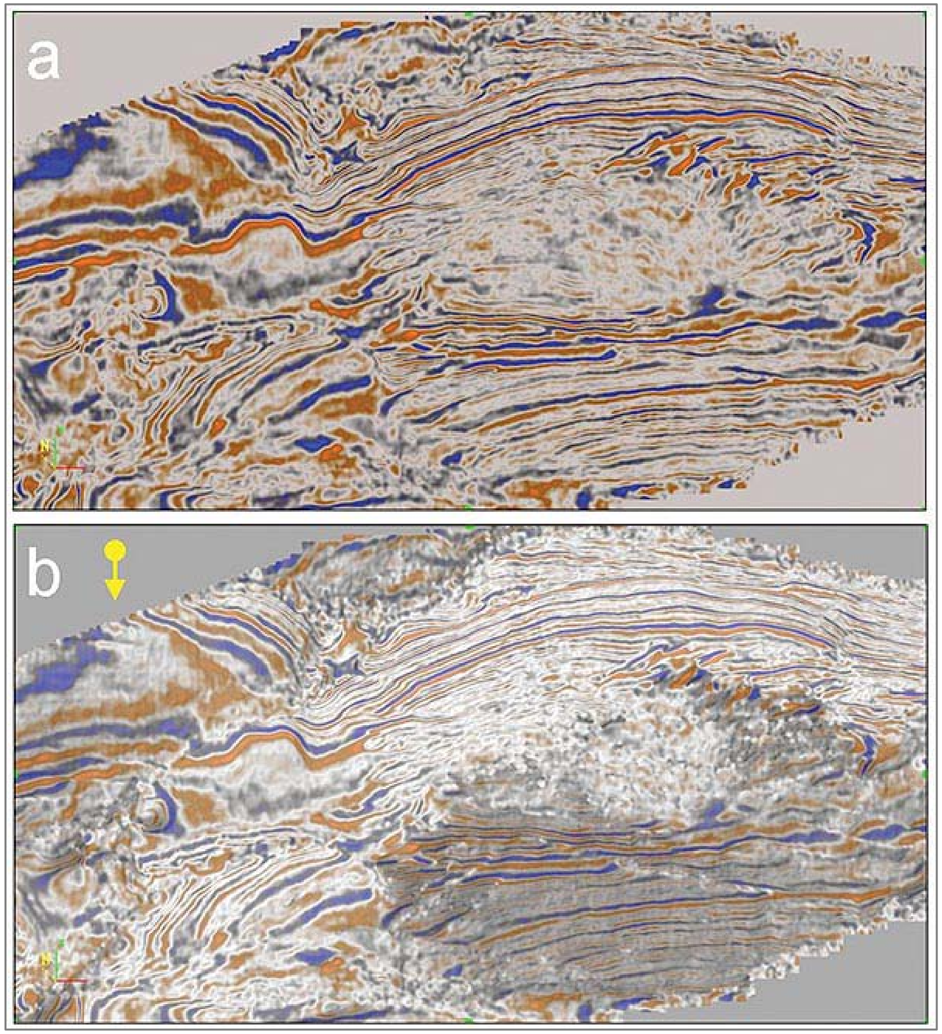

Figure 3. (a) Time slice through the seismic data volume of Figure 1; (b) the same time slice blended with shaded relief. The yellow arrow indicates the direction of illumination. The anticlinal structure stands out sharply, even though the crest is obscured by a gas cloud.

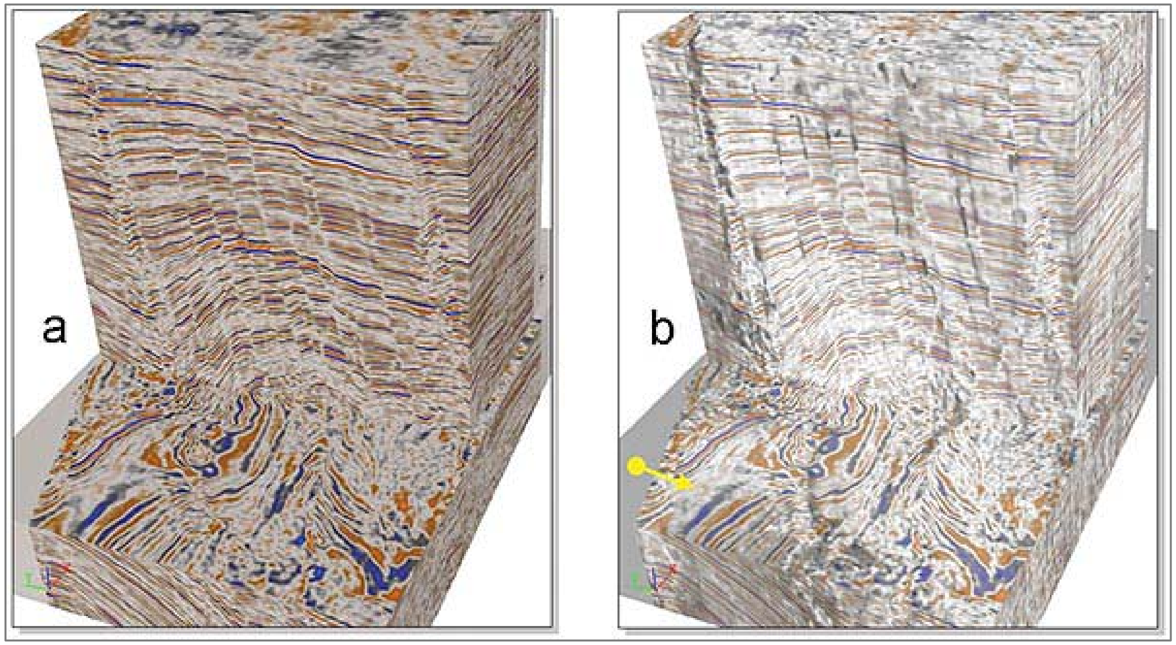

Figure 4. Seismic shaded relief is best viewed along time slices or horizons, but it can