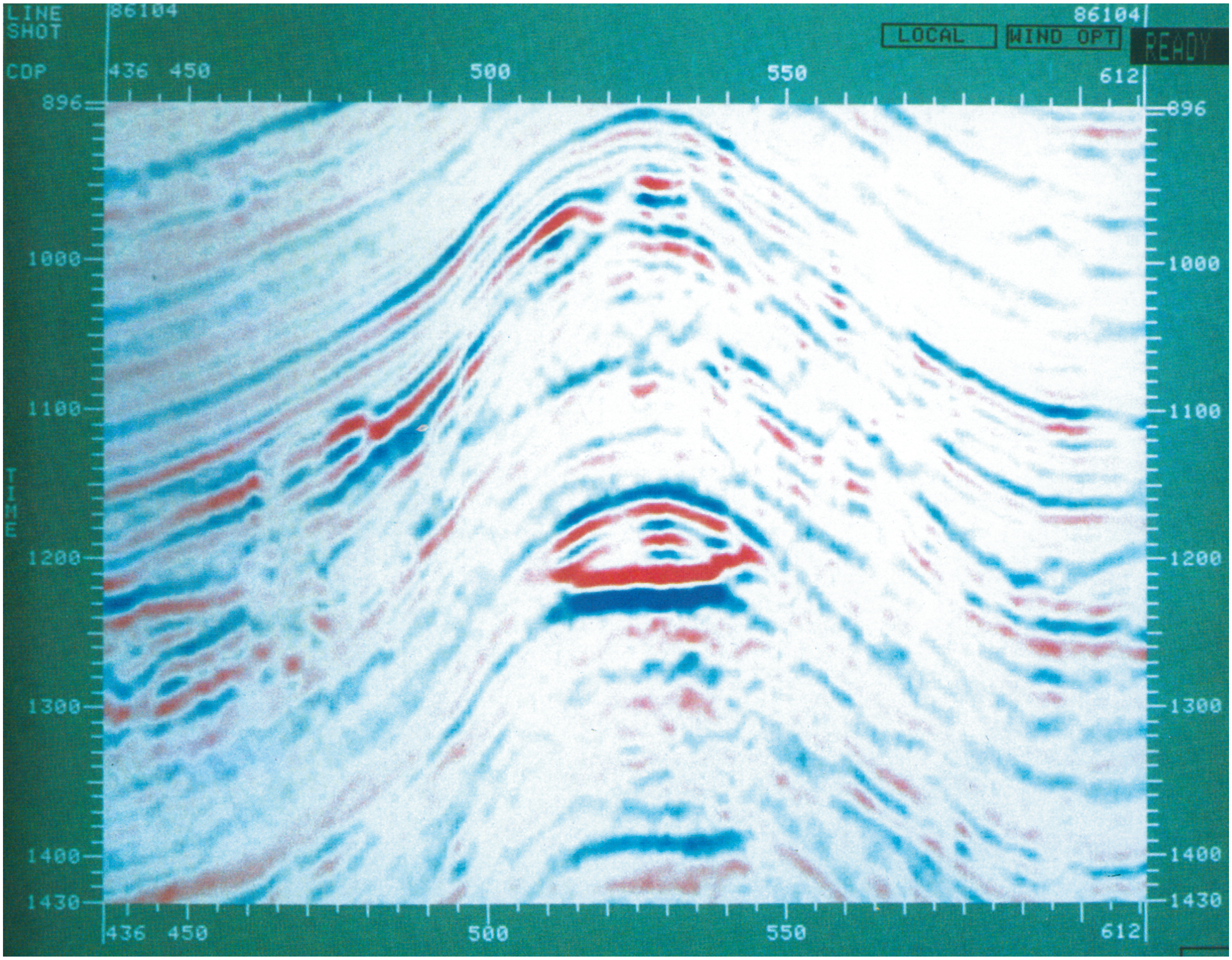

Fig. 2-25. Gulf of Mexico flat spot displaying a phase of approximately 90°. (Courtesy Geophysical Service Inc.)

The most common phase distortion confronting an interpreter is 90°, but it is also common to find the polarity opposite to what is normal for the region (European polarity data in America, for example). Figure 2-21 shows the four principal phase and polarity conditions to which the interpreter should be alert. They are illustrated for a low-impedance interval, such as a gas sand, and thus they correspond to the real data of Figure 2-20. All of these four conditions exist in all regions of the world. More detailed instructions for the interpretive assessment of phase and polarity appear in Appendix C.

The interpreter's ability to make this kind of assessment of phase and polarity depends critically on the display used. Figure 2-22 presents the same data panel in the same phase conditions for three different modes of display. Variable area/wiggle trace demonstrates how the visual imbalance between peaks and troughs makes the assessment of relative amplitudes impossible. Dual polarity variable area has corrected the visual imbalance but demonstrates the limited dynamic range of variable area. Gradational color demonstrates the visual balance between peaks and troughs and also the improved dynamic range. Relative amplitudes of peaks, troughs and side lobes can now be assessed with maximum available clarity for fairly high trace density. One disadvantage, however, of gradational color display is the stringency imposed on the reproduction process. The illustration that you, the reader, are studying is of

Fig. 2-27. Gulf of Mexico shallow gas reflections showing a phase of approximately 90°. (Courtesy Mobil Exploration & Producing U.S. Inc.)

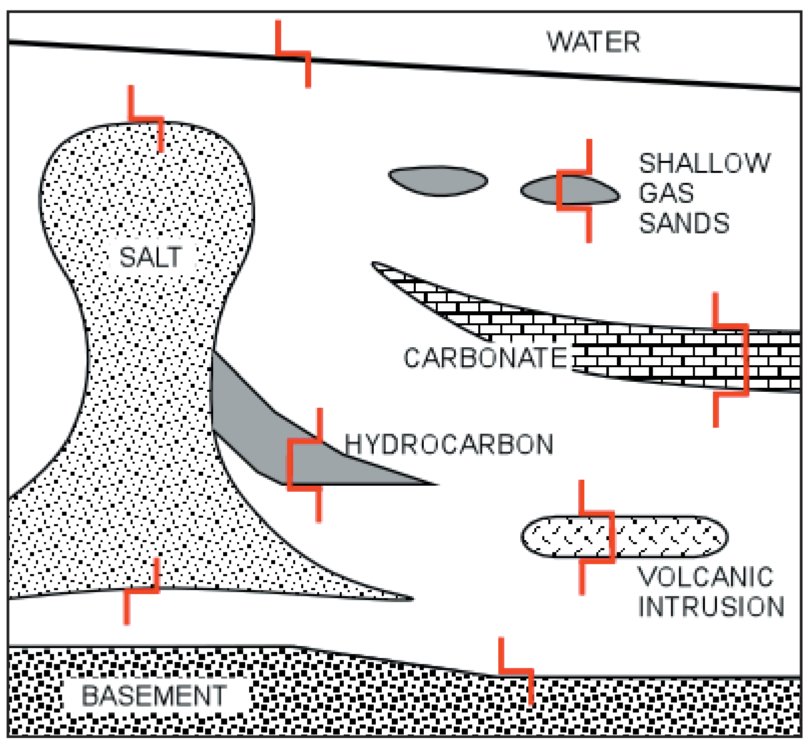

Fig. 2-26. Subsurface features which can generate sufficiently high amplitude reflections to be useful for interpretive assessment of phase and polarity. Probable impedance profiles are drawn.

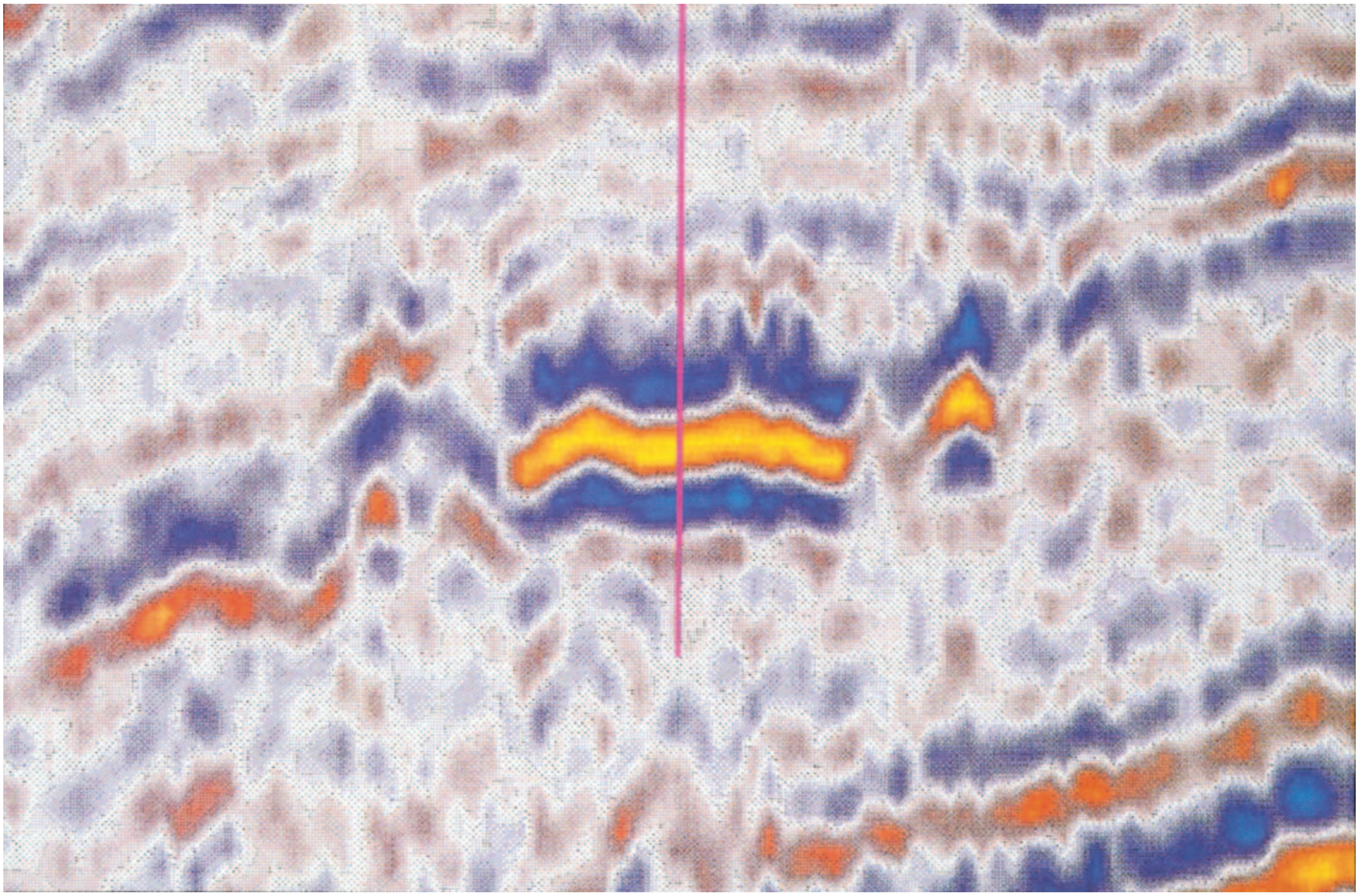

Fig. 2-28. Gulf of Mexico Miocene gas reservoir reflections showing a phase of approximately 90°. (Courtesy Conoco Inc. and Digicon Geophysical Corp.)

reduced quality compared to the screen image of the color monitor on which the original assessment was made.

If the phase of the data is unknown and cannot be assessed, reflection strength (also known as envelope amplitude; Taner and Sheriff, 1977) provides a display in which amplitude can be studied independent of phase. Figure 2-23 shows identical reflection strength sections corresponding to the four regular amplitude sections with different phases.

Any high-amplitude reflection which can be assumed to originate from a single interface is usable for assessing zero-phaseness when displayed in color. A fluid contact reflection, or flat spot, is normally an excellent candidate. If the structural horizons have moderate dip and the reservoir is fairly thick, the flat spot reflection will be well resolved and structurally unconformable. (The characteristics of fluid contact and other reservoir reflections are discussed more extensively in Chapter 5.) The flat spot in Figure 2-24 shows clearly one high-amplitude symmetrical red trough, indicating that the data are zero phase. A fluid contact is always an increase in impedance, so the observation that this flat spot is red indicates that the data are European polarity. The flat spot in Figure 2-25 shows a high-amplitude red-over-blue character, indicating an approximately 90° phase condition.

Figure 2-26 illustrates diagrammatically the sources of seismic reflections that often have a sufficient signal-to-noise ratio to be useful for interpretive phase assessment. Top of salt is good but may not be smooth enough and may be a gradational contact. The water bottom should be observed but it is often quite unreliable, presumably because it is not a single interface. Hydrocarbon reservoirs, shallow gas, and volcanic intrusions are all excellent.

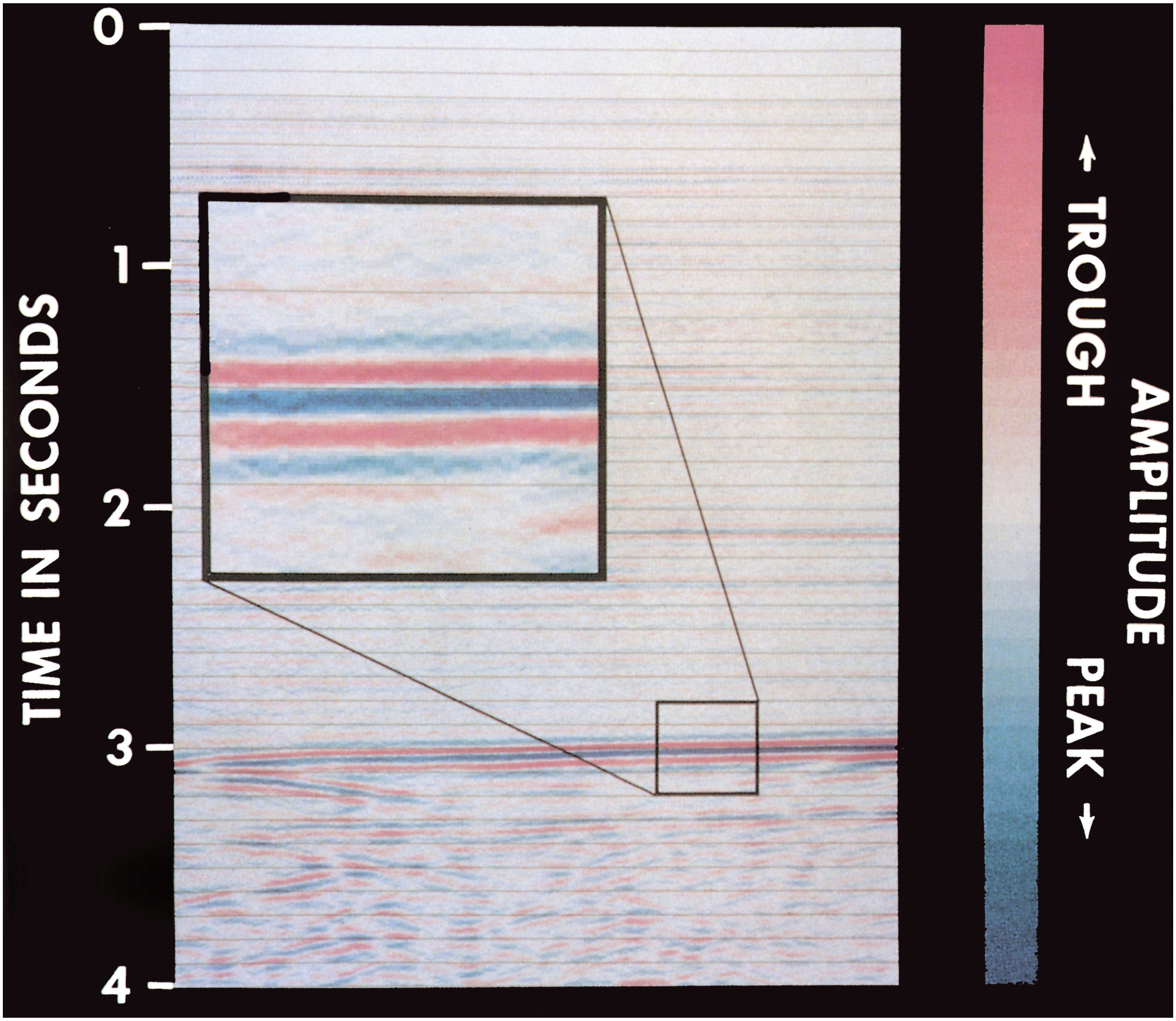

Fig. 2-29. Basement reflection displaying zero-phaseness. The central lobe is blue and the basement is hard; thus the data are American polarity. (Courtesy Geophysical Service Inc.)

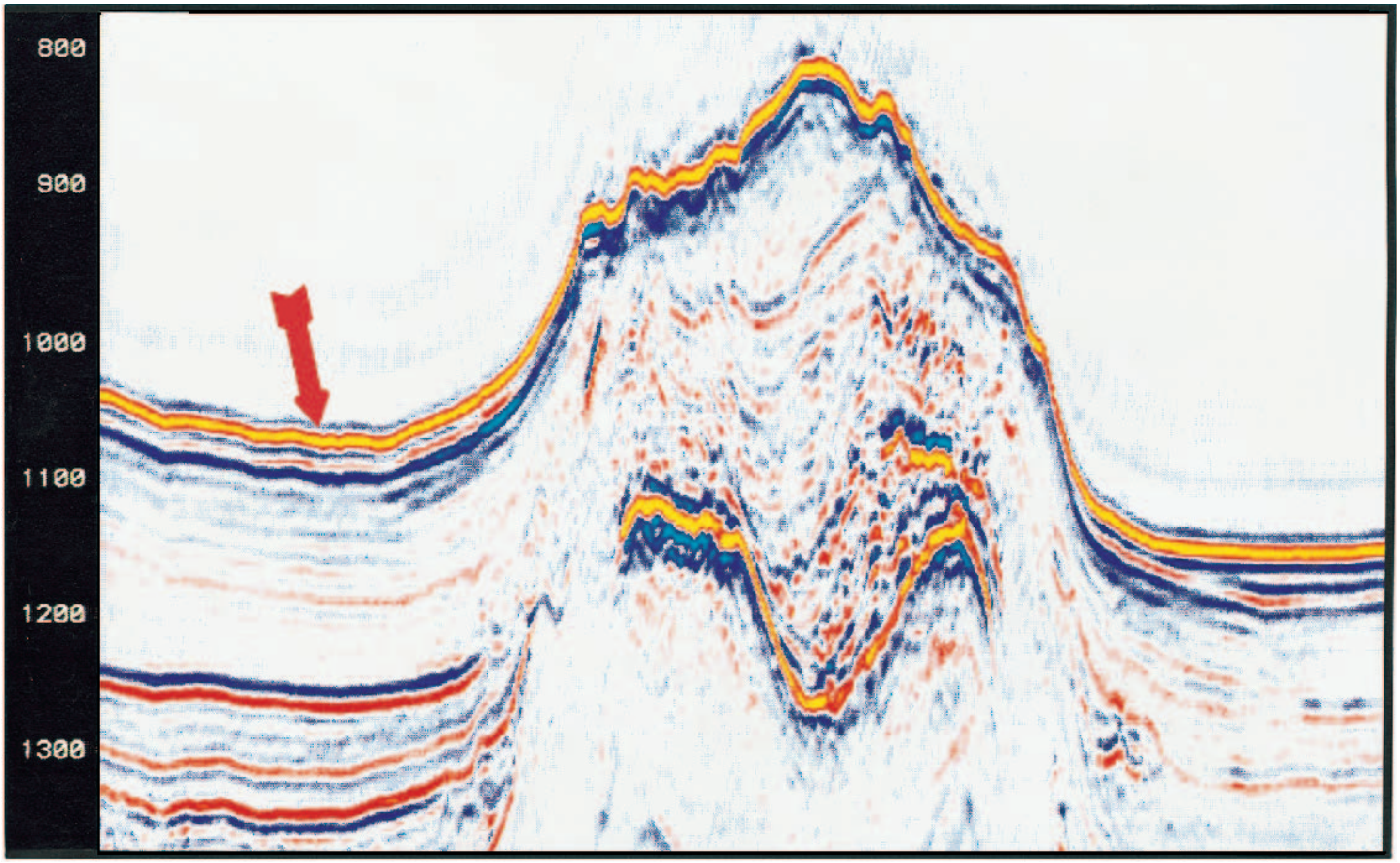

Fig. 2-30. Water bottom reflection in deep water displaying zero-phaseness and European polarity. (Courtesy Conoco Inc.)

Figure 2-27 shows reflections from the top and base of shallow gas. Both are double events indicating a phase of 90˚. Figure 2-28 shows strong reflections from a Miocene gas reservoir. Here the reservoir is thin so that the reflection from the top and the reflection from the bottom overlap each other, thus giving reinforcement of the red/yellow in the center. This again is an indication of 90˚ phase data, a remarkably common phenomenon.

Figure 2-29 shows an outstanding basement reflection which is probably from a single subsurface interface. The waveform of the reflection is clear, almost symmetrical, and spatially consistent. This indicates that the data are close to zero phase, at least around the time of 3 seconds (s). Figure 2-30 shows a strong water bottom reflection in deep water which is also a clear symmetrical waveform, again indicating zero-phaseness. On top of the seamount the phase assessment is ambiguous but at the red arrow the zero-phaseness is evident.

Time-variant phase distortion is possible but difficult to assess. Recently the author was able to determine that some Gulf of Mexico data were 90° at 2 s based on water bottom and shallow gas, and zero-phase European polarity at 4 s based on porous sand, gas sand, and top salt.

A further and very good discussion on phase and polarity and their impact on the interpreter is provided by Simm and White (2002).

Psychological Impact of Color

Studies on the psychological impact of color have shown that hues of yellow, orange and red are advancing and attracting, while hues of green and blue are cooler and receding. The interpreter can take advantage of this in communicating his results. It would seem logical to display the structural highs, the isopach thicks and the amplitude highs in advancing colors in order to promote their prospectivity. Figure 2-6 is a structure map which demonstrates this point.

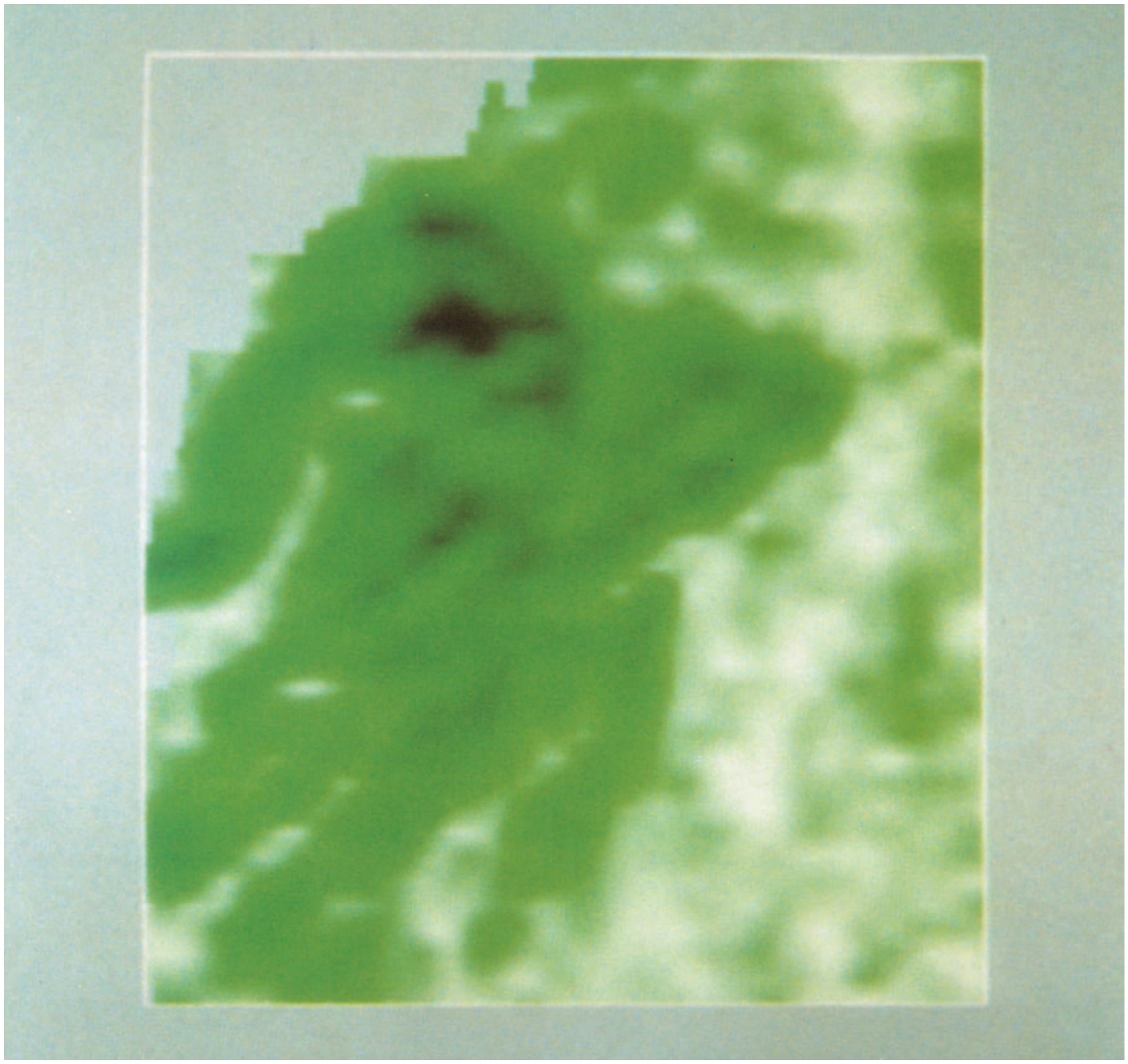

Fig. 2-31. Horizon slice displaying amplitude in gradational green to accentuate lineations due to faulting. (Courtesy Chevron U. S. A. Inc.)

Figures 2-31, 2-32 and 2-33 are the same horizon slice displaying reflection amplitude over a Gulf of Mexico reservoir, but presented with three different color schemes. In Figure 2-31 these data are represented in a green gradational scheme to accentuate the lineations due to faulting. The gradational colors accentuate these lineations by using the full dynamic range of color density and allow the eye to integrate all of the data quickly.

Figure 2-32 shows the same data displayed with a gradational color scheme using a wider range of hues. Now the relative strength of the amplitudes has much more impact on the eye; the advancing reds and yellows appear much more interesting than the cooler greens and blues. By using this scheme, the large anomaly near the top of the display draws considerable attention. A successful well was targeted and drilled, based on this display.

Yet another display of the same data (Figure 2-33) shows that a large area of high amplitude may be considered prospective. Here the low amplitude zones have been colored with fairly neutral grays. Further drilling potential can be considered on the basis of this display if amplitude strength is the key to developing this reservoir.

Thus one horizon slice was used for three different purposes by employing three different color schemes. The first drew attention to the faulting, the second to a particular anomaly, and the third to total drilling potential. Separate features of the data were enhanced differently by the different uses of color.

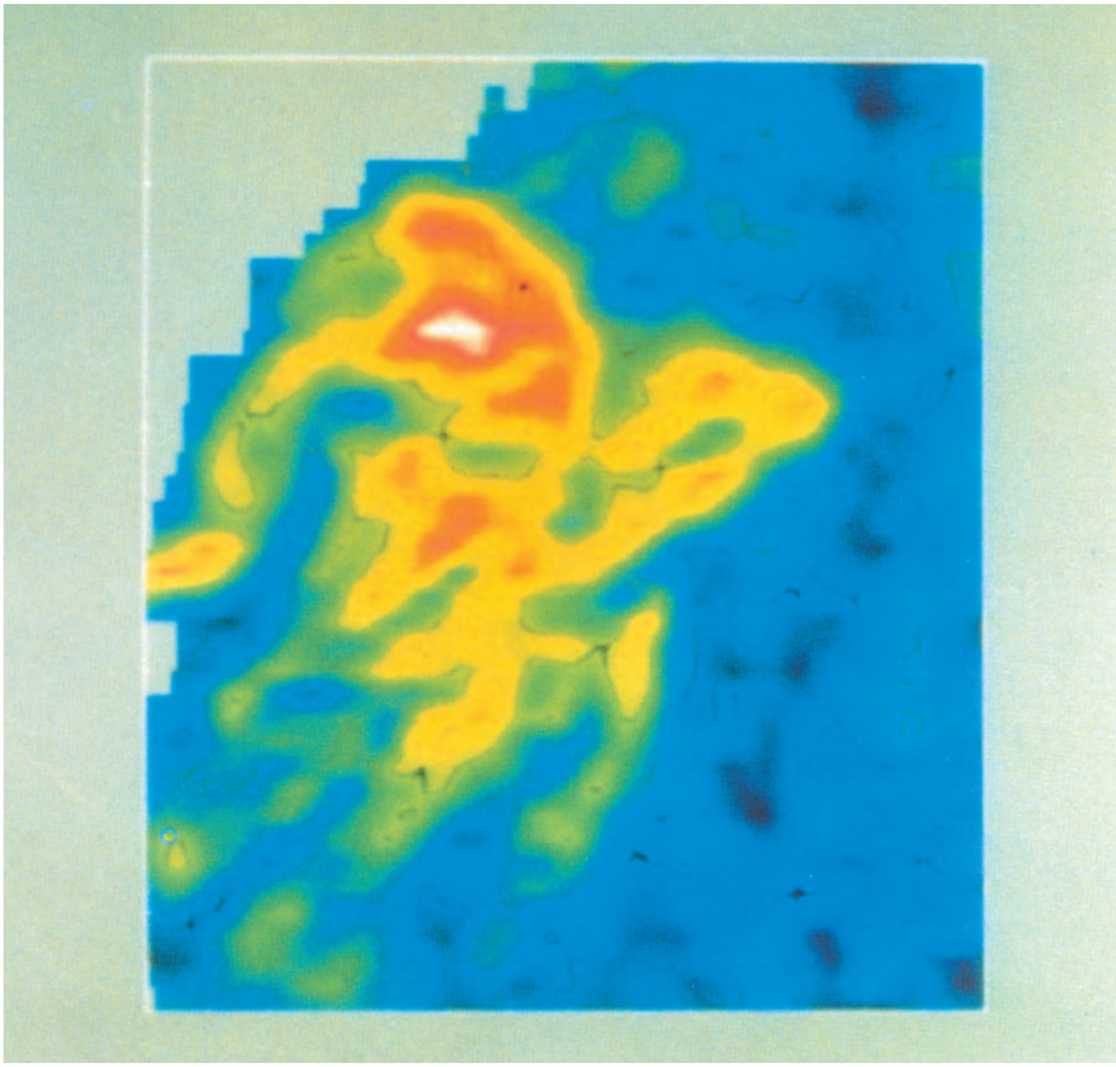

Fig. 2-32. Same horizon slice as in Figure 2-31 displayed in a wider range of hues to draw attention to the high amplitudes using advancing colors. (Courtesy Chevron U.S.A. Inc.)

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Fig. 2-33. Same horizon slice as in Figure 2-31 displayed in reds, yellows and grays to accentuate total drilling potential. (Courtesy Chevron U.S.A. Inc.)