Picking philosophy for 3-D stratigraphic interpretation

ALISTAIR R. BROWN, Consulting Reservoir Geophysicist, Dallas, Texas

As interpreters seek to extract more information out of seismic data, they must adapt to 3-D, to workstations, to color display, and to many tools and concepts of stratigraphic and reservoir interpretation. Undoubtedly more and more of our prospects are stratigraphic, and some of us are not adapting fast enough.

In this article my concern is picking philosophy. Approaches that are adequate — and well established — for structure mapping will often not work for stratigraphy. Let us consider an all-too-common procedure for horizon identification at the start of a project.

The interpreter prepares a synthetic seismogram, probably zero phase and with the polarity appropriate to his company or geographic area, and compares it with real data at the well location. The objective is to find the exact position of the geologic marker, say top reservoir, in time. It falls on the flank of the seismic waveform (Figure 1). Given that the reservoir is somewhat thin and there are other reflecting surfaces nearby, this should be no surprise. Also the interpreter wants the resultant map to tie the well. So this point is picked, on the flank of the waveform, over the area under study. Manual picking is, of course, the only tool available to do this. A map is thus made which is adequate for smooth structure.

We can criticize this approach on several counts. Were the phase and polarity of the data properly considered? Were the log data made into the synthetic seismogram of adequate quality? Should the interpreter not have used some form of machine autotracking for efficiency and precision? And finally, what use is an amplitude obtained from the waveform flank? I want to focus principally on this last question.

Although picking on the waveform flank may yield a useable structure map, the amplitude extracted from that point is less than optimum and is probably meaningless. Principles of seismic resolution tell us that all the reflecting interfaces within an interval equal to one-quarter wavelength will contribute to each reflection. Thus we should identify the relevant reflection and pick on the crest of it (Figure 1). The crest of the waveform is the correct point to pick for zero-phase data, and we need to make every effort to ensure that our data are zero phase. In simpler situations this is exactly what is required, the almost pure reflection from the desired geologic interface. In general this is still what is required, but understanding the seismic response is more complicated.

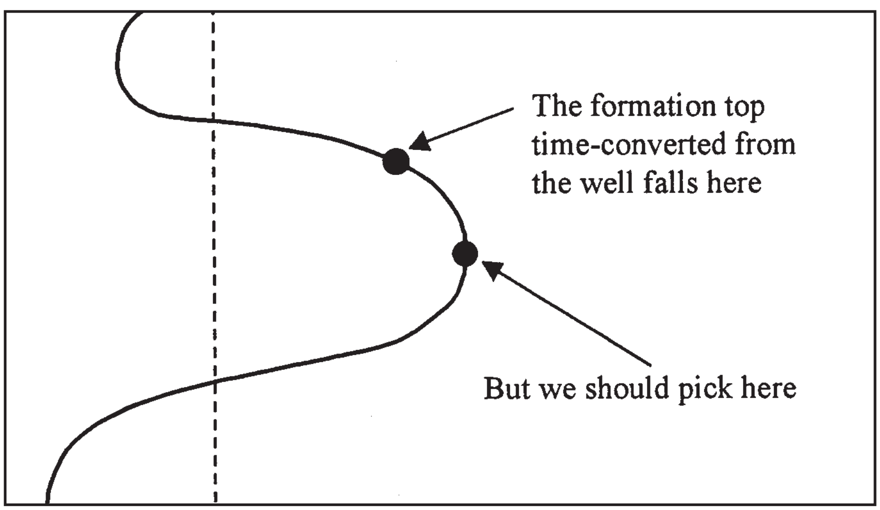

Figure 1. For stratigraphic and reservoir interpretation, the correct point to pick on the waveform is the crest.

For interpretation involving stratigraphic objectives, most projects today, I therefore believe we should identify the reflection from the top of the reservoir, for example, and pick on the crest of it. Thus we can use a machine autotracker for efficiency and precision, and, during the structural mapping phase, use time-derived horizon attributes for further structural information.

During the stratigraphic phase, however, the amplitude that we want is still the crestal amplitude, but we need to consider whether it is sufficiently pure for our purpose. If not, it may be necessary to try to "correct out" the undesired influences. These undesired, or contaminating, influences on seismic amplitude need to be determined in some other way, and wells are a possible answer. If many wells exist, it may be reasonable to assume that these influences vary smoothly between the wells and thus by interpolation these factors are determined everywhere and subtracted out.

Increasingly, I am asked how we may attempt to sort out different influences on amplitude in exploration or appraisal. Sometimes this can be done adequately, based on some reasonable geologic postulate and assisted by some workstation manipulations. Let's look at some examples.

I have long been a vociferous advocate of composite amplitude, defined as the absolute value summation of the top reflection amplitude and the base reflection amplitude. The benefit of composite amplitude is based on the following notion. The top amplitude and the base amplitude both contain information about the reservoir, so, by compositing them together, we emphasize the effect of the reservoir and deemphasize the effect of the embedding material. It's a kind of stacking, which is, of course, common in many seismic processes.

Compositing top and base amplitudes is usually accomplished by a simple arithmetical subtraction as the two amplitudes are normally of opposite sign. As an extension of this idea, the subtraction can be used to

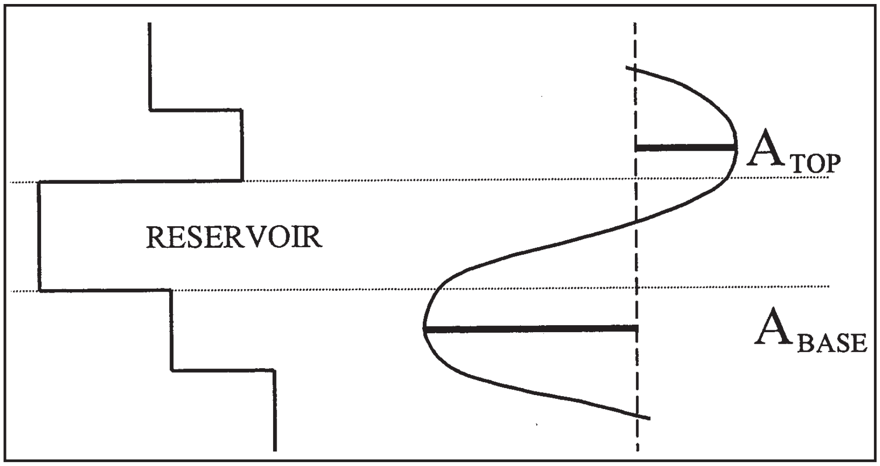

Figure 2. Reflections from the top and base of a reservoir. Each is contaminated by a significant adjacent acoustic contrast. Composite amplitude attempts to emphasize the effect of the reservoir and attenuate the effect of these other influences.

attenuate influences in the top and base amplitudes believed to have the same sign. For example, consider the simplified acoustic impedance profile in Figure 2 and its corresponding seismic response for zero phase and European / Australian normal polarity. The primary influence on the top reservoir reflection is the reduction in impedance at the top of the reservoir; the secondary influence is the increase in impedance slightly above; other influences are considered negligible. The primary influence on the base reservoir reflection is the increase in impedance at the base of the reservoir; the secondary influence is the additional increase slightly below; other influences are again considered negligible.

Composite amplitude for the situation described above would then be accomplished with the simple subtraction A_{TOP} - A_{BASE} (Figure 2). Each of these amplitudes is a horizon slice extracted along a high-precision autotracked horizon. The subtraction stacks in the effects of the top and base of the reservoir and stacks out, at least to some degree, the contaminating influences above and below. As long as this simplified impedance profile is generally applicable, the composite amplitude will have improved information content of the reservoir. For increasingly subtle stratigraphic objectives, we need all possible improvements in signal-to-noise.

Another related interpretation problem is in the preparation and display of horizon slices or amplitude maps. These are used widely to indicate the distribution of hydrocarbons or reservoir quality, and so they should be. However, I rarely see on the display an explicit description of how the display was prepared and how the tracking was accomplished. The interpretation of the amplitude patterns depends critically on these issues.

Let us consider some of the questions that may occur. Was the amplitude extracted exactly along a horizon or over a window? If along a horizon, what was the nature of the horizon: precision autotrack, smoothed autotrack, or manually drawn? If over a window, how large was the window and what type of amplitude (maximum positive, maximum negative, average absolute, average RMS, etc.) was extracted? Was the window large enough to allow in the target reflection but not too large to collect unwanted reflections?

I am sorry to say that in the course of recent stratigraphic interpretation discussions I have been shown horizon slices or amplitude maps where this information is not annotated, and furthermore it is sometimes not known. In communicating our results to management and to partners *it is important to be clear on the nature of the display and thus the basis of the conclusions and recommendations.*

By way of conclusion let me reiterate the main points:

• Thoroughly understand the seismic response of your objective; this includes an investigation of data polarity and phase. Get the data as close to zero phase as possible by making necessary corrections.

• Tie seismic data to well log data on *character*. Consider the principal acoustic contrasts in relation to the seismic character directly.

• Identify the reflections containing the top of the reservoir, and separately, the base.

• Track both top and base reflections on their waveform crest using machine autotracking whenever possible for precision and efficiency.

• Make horizon slices or amplitude maps which clearly explain the tracks on which they are based and the window parameters, if any, that were used.

• Composite the amplitudes of top and base reflections together in such a manner as to stack in the desired influences and stack out the undesired ones. The resultant amplitude should be the best for subsequent reservoir studies. **E**

Corresponding author: A. Brown, 1-972-385-0952