A FIXED TRANSIT TIME APPROACH TO SEISMIC INTERVAL VELOCITY†

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ABSTRACT

The interpretation of seismic velocity analyses is now a well established procedure among most goephysicists; however, the computation of interval velocity is highly dependent on these interpretations and can therefore vary significantly from one geophysicist to another, particularly where little or no stratigraphic data are available. The computation of "Dix" interval velocities over a window of fixed transit time helps to reduce interpretive differences. It is also an effective method of detecting and displaying velocity/stratigraphic variations in regional studies where large volumes of data are available and the interpreter must spend a minimum of his time on individual analyses.

The concept of seismic interval velocity has been well established since Dix published his work in 1955, and velocity data for stratigraphic study have been abundant since velocity analysis was applied to the digital computer in 1967. No major advances have been made since this time in either accuracy or method of interval velocity determination and the interpreter is still faced with the classical problem of extracting reliable and correlatable stratigraphic information from his velocity data, often devising his own interpretative methods for particular prospect areas.

One such method, presented here, has been of significant advantage in detecting anomalous velocities, regional markers, and facies or stratigraphic variations in areas where large volumes of seismic velocity data are available and where section of Tertiary age or younger is predominant. The method involves computation of interval velocity over a window of fixed two-way transit time determined by the interpreter. Computations are repeated at specified step intervals as the window shifts down the input r.m.s. or average velocity curve as shown in Figure 1. The results are plotted on a graph of interval velocity versus two-way time to show gradational changes in velocity through the section. This approach in fact measures changes in distance between two points separated by a fixed transit time along a normally incident ray path. Use of either the Dix equation or simple average velocity computations are acceptable since detection of lateral changes in velocity are the primary purpose of the procedure.

Preparation of data for this type of display is accomplished by picking all useable time-velocity data pairs from many consecutive velocity analyses with a minimum of regard to mapped events or geologic markers. Interpretation can, if necessary, be made on large quantities of data without the benefit of interpreted seismic sections. Data are then digitized and stored on tape for automatic computation and display of large numbers of curves in profile form as shown in Figure 2. This example is taken from a detailed prospect where seismic lines and velocity analyses were closely spaced. Velocity data were interpreted before structural mapping was complete in an effort to detect stratigraphic changes which might be included in the mapping program.

Most velocity interpretations are geared to the definition of an r.m.s. velocity at strong or easily mapped seismic events, and these events do not always enjoy the same quality when displayed on conventional velocity analyses, nor do maximum amplitudes or 'power peaks' always appear on the

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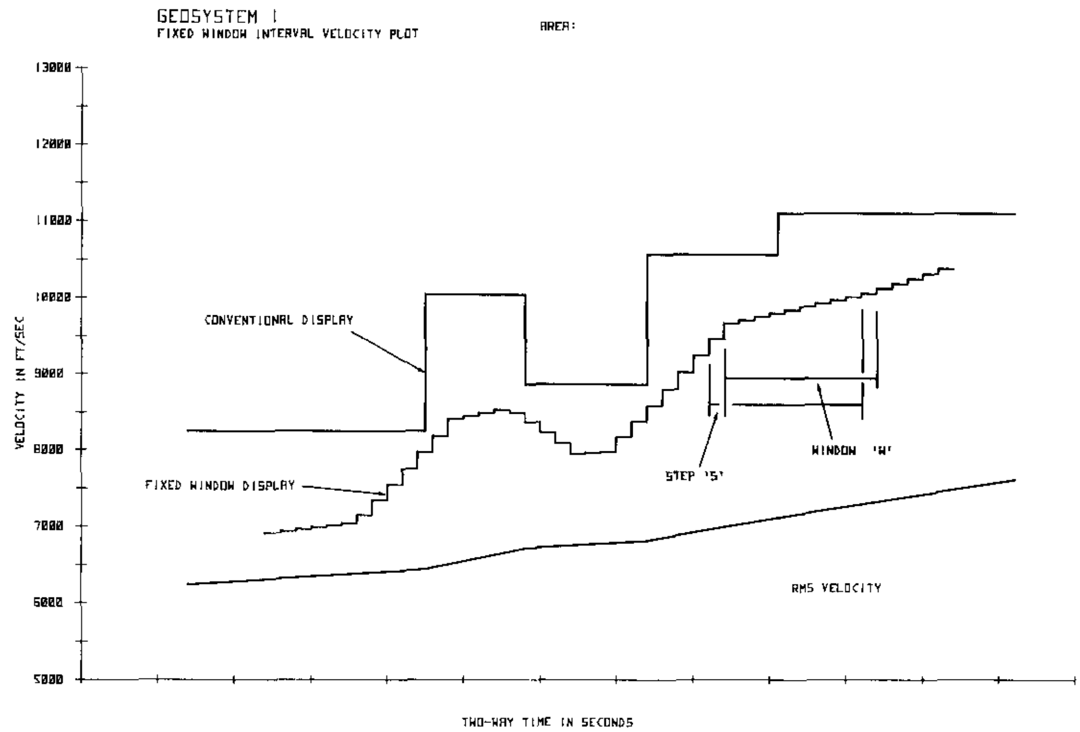
GEOSYSTEM I
FIXED WINDOW INTERVAL VELOCITY PLOT
AREA:
VELOCITY IN FT/SEC
13000
12000
11000
10000
9000
8000
7000
6000
5000
CONVENTIONAL DISPLAY
FIXED WINDOW DISPLAY
STEP 'S'
WINDOW 'W'
RMS VELOCITY
TWO-WAY TIME IN SECONDS

Fig. 1.

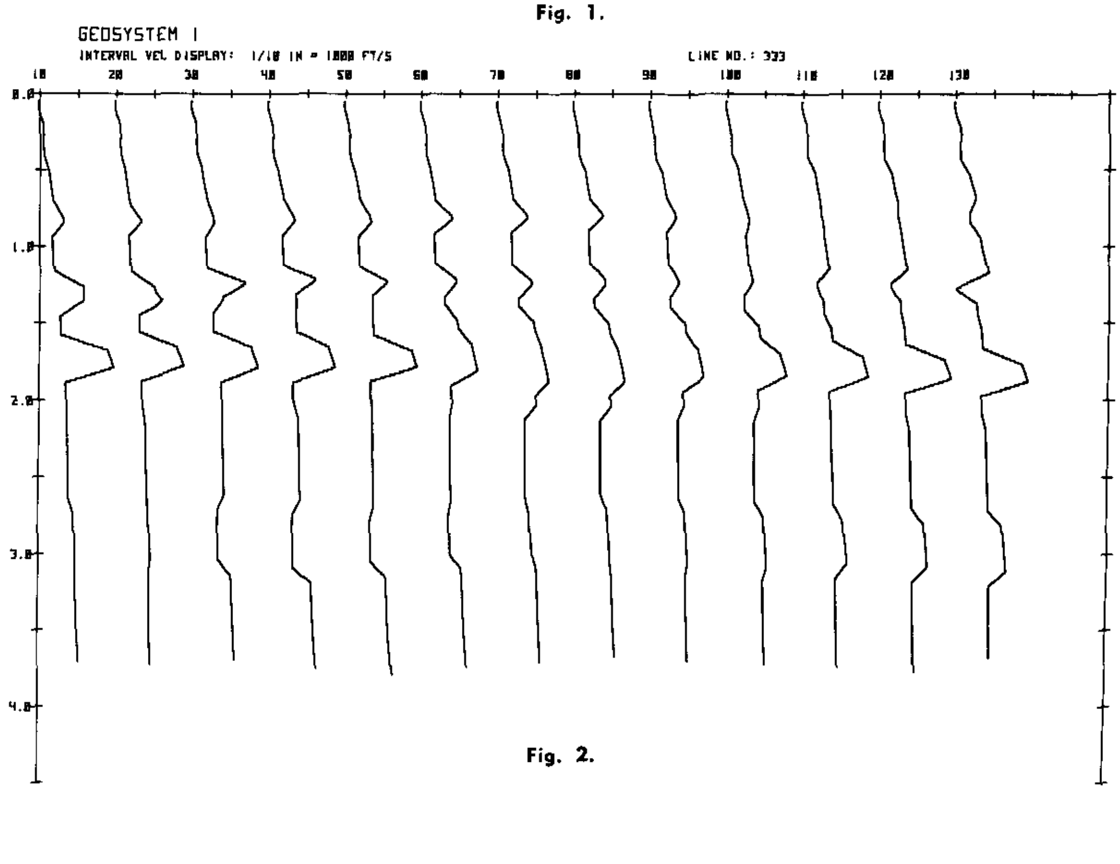
GEOSYSTEM I
INTERVAL VEL DISPLAY: 1/10 IN = 1000 FT/S
LINE NO.: 333
10
20
30
40
50
60
70
80
90
100
110
120
130
0.0
1.0
2.0
3.0
4.0

Fig. 2.

same leg as that carried by the structural interpretation. These problems of velocity and event correlation can be reduced by picking all velocity data available from an analysis without restriction to specific map levels and then taking advantage of the smoothing effect of interval velocity computation over a fixed window.

Most interpreters are aware that significant changes in interval velocity can occur from slight changes in the value of two-way time or r.m.s. velocity used in computation. Where some doubt or variation exists in the interpretation of velocity analyses the use of fixed transit time computations will reduce the significance of the location of each input data point. Long transit time windows also have a useful smoothing effect on poor quality data where velocity trends are important and individual values have only minimum significance. Most fixed transit time displays also demonstrate clearly that a linear increase in r.m.s. velocity between any two points in time requires a continually increasing interval velocity. Conventional plots do not display this phenomenon.

Use of the fixed transit time approach to interval velocity also requires the interpreter to make some judgment as to length of the window used in computation. This value is usually a function of data quality or distance between the events being considered. Where data quality is good and frequent variations of r.m.s. velocity can be detected a window of 100 ms might be used. Conversely, in an area where only a few control points can be taken from velocity analyses a window of 600ms to 800ms may be more appropriate. The step interval or frequency of computation does not affect the results. A very short interval of about 10 ms produces smooth transitions from one velocity to another but may be redundant in areas of sparse control where 40ms to 60ms would be adequate.

The use of conventional 'box' displays of interval velocity has no special interpretive significance and arises mainly from the useful habit of computing velocities between discrete interpreted or mapped events. The choice of events for computation is often dependent on reflection or map requirements and not necessarily on geologic significance. The definition of a sharp velocity break at the top or bottom of a geologic layer is also a matter of useful habit when we know that velocities, particularly in Tertiary section, are more likely to grade from one predominant value to another, or they may represent the averaged value of a series of thinly bedded stringers.

The fixed window approach to computation and display of velocity is a method devised to reduce some of the problems of conventional interval velocity interpretation and to allow the interpreter to visually absorb large quantities of data at a glance on several adjacent profiles. The method has been most successful in the Gulf Coast and North Sea areas when used with dense velocity control to help locate and follow stratigraphic anomalies of potential economic significance. Other interpreters may perhaps find further applications of the technique to different areas or problems.