DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

A Method for Determining Average Values of Wire-Line-Log Traces

By

James W. Schmoker[1]

U.S. Geological Survey Open-File Report 88-511

This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

[1]U.S. Geological Survey, MS 960, Box 25046, Denver Federal Center, Denver, CO 80225

1988

A METHOD FOR DETERMINING AVERAGE VALUES OF WIRE-LINE-LOG TRACES

By James W. Schmoker

INTRODUCTION

Interval-averaged physical-property measurements derived from wire-line logs are commonly used in subsurface studies of depositional environment, sedimentology, stratigraphy, and burial diagenesis. Log data measure relatively large volumes of rock and complement data obtained by methods such as scanning electron microscopy, thin-section study, sample and core examination, and geochemical analysis. This point is illustrated by examples such as Meissner (1978), Schmidt and McDonald (1979), Bornemann and Doveton (1983), Halley and Schmoker (1983), and Keith and Pittman (1983).

Average log values for a formation, member, or informal unit in a given well are usually obtained either by (1) estimating the average value of a log trace by eye, or (2) electronically digitizing a log trace and then averaging the digital data using a computer. The first approach is technologically simple but is subject to problems of accuracy and precision; the second approach is exact but requires a suitable computer system, specialized software, and a fairly high degree of computer literacy.

The method for averaging log traces described here is based on planimetry (the measurement of plane areas). Planimetry is a rigorous technique, yet involves a minimum of technological complexity. The area of a figure is measured by tracing a reference point around the figure's periphery. Mechanical or electronic planimeters are simple to operate and relatively inexpensive.

CONCEPT

The idea for determining the average value of a wire-line trace using planimetry is illustrated in Figure 1. The baseline can be on either the left (as shown) or the right, depending on the direction of increasing log value. The area (A) of the closed figure (shaded in Figure 1) formed by the log trace, the baseline, and the two horizontal lines marking the depth interval ($Z_B - Z_T$) is measured using a planimeter. The average value of the log trace above the level of the baseline ($\bar{T}$) is then given by:

$$\bar{T} = A/(Z_B - Z_T). \tag{1}$$

The derivation of equation (1) is shown in Figure 2. As ΔZ (Fig. 2) becomes small, the digital log-trace representation of Figure 2 approaches the analog representation of Figure 1. In practice, determining the average value of a wire-line-log trace by planimetry is essentially equivalent to averaging the digitized trace (Figs. 1, 2).

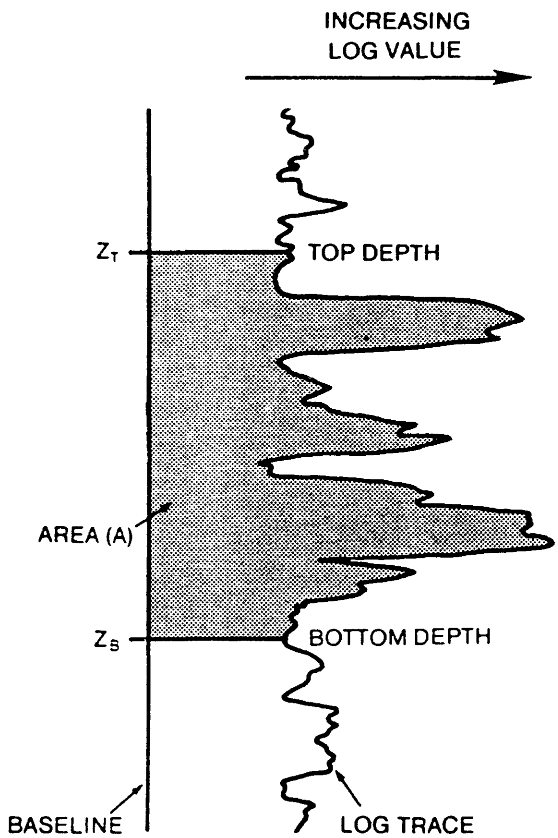
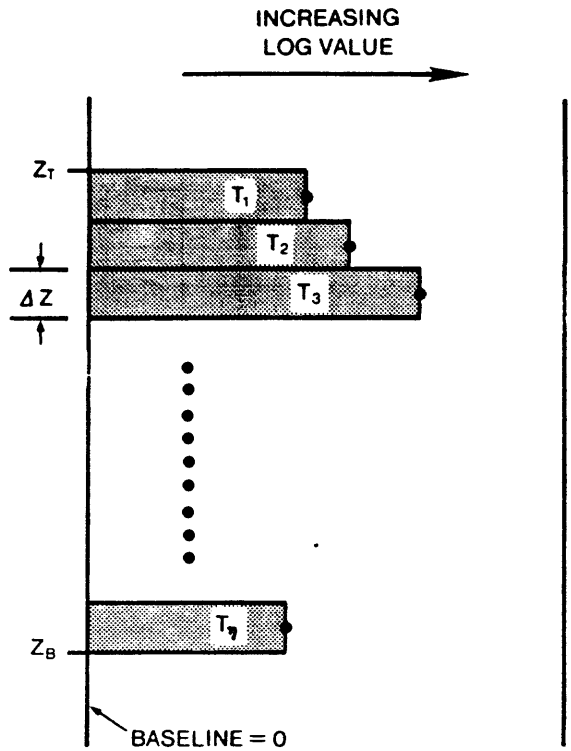


Figure 1.--Concept for determining average value of a wire-line-log trace by planimetry. (Measurement units are ignored to simplify illustration.) Area (A) of shaded region is measured using a planimeter. Average value ($\bar{T}$) of log trace between Z_T and Z_B is given by $\bar{T} = A/(Z_B - Z_T)$. This equation is derived in Figure 2. If baseline is not zero, $\bar{T}$ is average value above baseline.



DIGITIZED LOG TRACE

(LOG VALUES = $T_1, T_2, T_3 \cdots T_\eta$).

DIGITIZING INTERVAL $= \Delta Z$.

SHADED AREA(A) $= \Delta ZT_1 + \Delta ZT_2 + \Delta ZT_3 \cdots + \Delta ZT_\eta$

$$A = \Delta Z \sum_{k=1}^{\eta} Tk$$

$$A = \eta \Delta Z \left(\sum_{k=1}^{\eta} Tk \right) / \eta$$

BUT $Z_B - Z_T = \eta \Delta Z$

$$\text{AND } \bar{T} = \left(\sum_{k=1}^{\eta} Tk \right) / \eta$$

THUS $\underline{A = \bar{T}(Z_B - Z_T)}$

Figure 2.--Derivation of equation $\bar{T} = A/(Z_B - Z_T)$ (Fig. 1). (Measurement units are ignored to simplify illustration.) If baseline is not zero (e.g., baseline of density log is usually 2.0 g/cm^3), $\bar{T}$ is average value above baseline.

EXAMPLE

Figure 3 reproduces a portion of a sonic log from the upper part (Permian) of the Minnelusa Formation of the Powder River basin, Wyoming. The interval of interest represents an eolian-dune complex with a diagenetic history distinct from that of the underlying interdune deposits.

The area of the figure defined by the sonic-log trace, baseline, top depth (Z_T) and bottom depth (Z_B) (Fig. 3) was measured on the original log display using a mechanical planimeter and found to be 1.49 $in.^2$. The depth interval ($Z_B - Z_T$) is 58 ft. However, before using these values in equation 1, the area must be multiplied by a scaling factor to convert square inches to appropriate log units. The required scaling factor is the product of the vertical and horizontal log scales, which in this case (Fig. 3) are 40 ft/in. and 40 (μs/ft)/in., respectively. Thus, 1 $in.^2$ = (40 ft)(40 μs/ft) = 1,600 ft·μs/ft (the scaling factor), and A = (1.49)(1,600) = 2,384 ft·μs/ft. From equation 1, $\overline{T}$ = (2,384 ft·μs/ft)/58 ft = 41.1 μs/ft. Since the baseline is 40 μs/ft (Fig. 3), the average value of the sonic-log trace through the eolian dune complex is 81.1 μs/ft.

REFERENCES

Bornemann, E., and Doveton, J.H., 1983, Lithofacies mapping of Viola Limestone in south-central Kansas, based on wireline logs: American Association of Petroleum Geologists Bulletin, v. 67, no. 4, p. 609-623.

Halley, R.B., and Schmoker, J.W., 1983, High-porosity Cenozoic carbonate rocks of South Florida: progressive loss of porosity with depth: American Association of Petroleum Geologists Bulletin, v. 67, no. 2, p. 191-200.

Keith, B.D., and Pittman, E.D., 1983, Bimodal porosity in oolitic reservoir--effect on productivity and log response, Redessa Limestone (Lower Cretaceous), East Texas basin: American Association of Petroleum Geologists Bulletin, v. 67, no. 9, p. 1391-1399.

Meissner, F.F., 1978, Petroleum geology of the Bakken Formation, Williston basin, North Dakota and Montana, in The economic geology of the Williston basin: Montana Geological Society, 24th Annual Conference; 1978 Williston Basin Symposium, p. 207-227.

Schmidt, V., and McDonald, D.A., 1979, The role of secondary porosity in the course of sandstone diagenesis, in Scholle, P.A., and Schluger, P.R., eds., Aspects of diagenesis: SEPM Special Publication No. 26, p. 175-207.

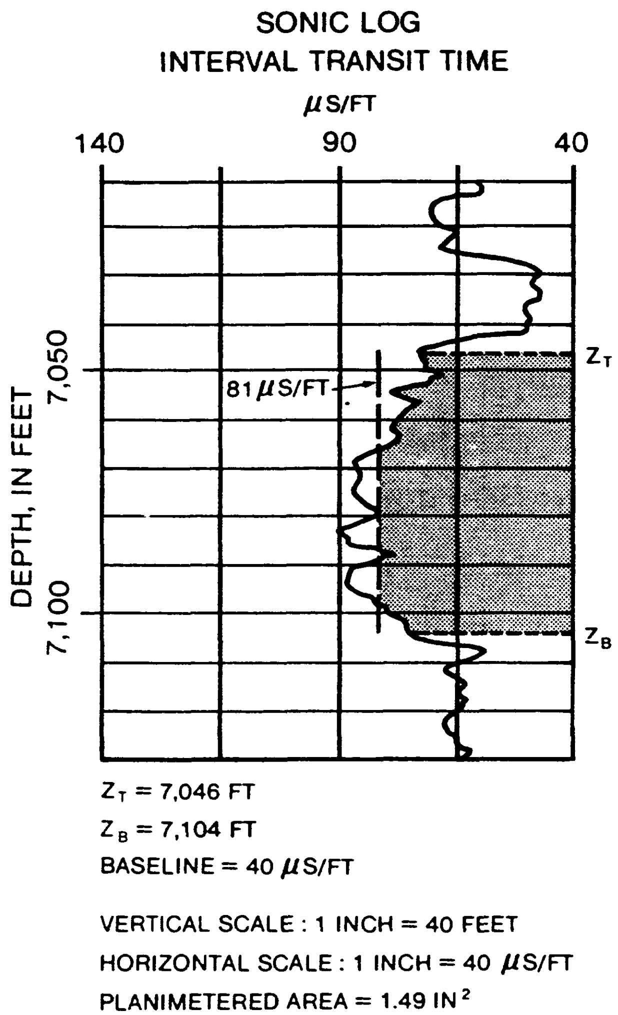


Figure 3.--Example illustrating measurement of average log value using planimetry. Scales and planimetered area refer to original log display. Average value of sonic-log trace between Z_T and Z_B is 81 μs/ft. Text gives details of calculation.