

## WELL LOGGING DIGITIZATION

*Ion Mălureanu, Ionuț Lambrescu, Doru Stoica*  
*Petroleum Gas University from Ploiești, Romania*

### INTRODUCTION

A geological formation comprises a sequence of layers of different thicknesses, different lithologies and petrophysical specific properties. In theory, each layer is distinguishing from the layers in the lower limit and upper limit by distinct petrophysical properties and presents a custom form on the geophysical diagraphy.

The way a layer appears on the diagraphy depends on many factors. These factors could be grouped as follows:

- a) – the thickness of the layers;
- b) – the type of log and the investigation device characteristics;
- c) – the contrast of physical properties between the analyzed layer and the adjacent ones;
- d) – what we could call the noise in the analyzed signal.

The data acquisition has changed during the time, from the graphical recording to the digital acquisition. The first measurements in wells have been done in stations, in 1931 one passes to continuous recording, and in 1936 one started recording on photosensitive film. The digital acquisition presents the advantage of processing and interpreting the data with the help of software, but also the possibility to swift transmission of the recorded data.

In many wells (especially old ones), the data had been recorded on film or photosensitive paper. These data have to be transferred on a digital format for the following reasons: the possibility of the automatic analysis, building a data base, the degradation in time of the physical support (film, paper). The digitization process, in principle is a simple problem but it is very important to accurately process the original diagraphy.

### DATA DENSITY

The quality of a digital diagram depends directly on the data density. In theory better the data density, more accurately a curve is reproduced. Following the sampling one gets a matrix in which, on a column is written the depth for a certain sampling step, and on the other column are written the values for the measured quantity that corresponds to the respective depth.

Setting the sampling step for the depth has to take into account the factors  $a, \dots, d$ , presented in Introduction, the shape of the curve and the vertical resolution of the investigation device. In principle, the sampling step has to be smaller than the vertical resolution of the device. The step will directly influence the data density and of course the quality of the sampled diagram.

### THE VERTICAL RESOLUTION OF THE INVESTIGATION METHODS

#### *Electrical methods*

For a layer with thickness  $h$ , with the resistivity  $\rho_R$  having in the lower limit and upper limit layers with resistivity  $\rho_{AD}$ , in the case of parallel plane separation limits and taking into account the influence of the well hole that goes through these layers, the response curves are presented in table 1. The vertical resolution for the potential and gradient devices depends on the length of the device, respectively on the distance between electrodes.

For a correct identification of the layers, the minimal distance taken into account is:  $AM(MA)/2$  for the potential devices and  $MN(AB)/2$  for the gradient devices (see figure 1). The characteristic points and these distances have to be observed on the sampled diagram,

and the minimal distances have to be measurable. These minimal distances are: for the standard electrical log and D.R.R. is 0.15 m and for special electrical log is 0.2 m.

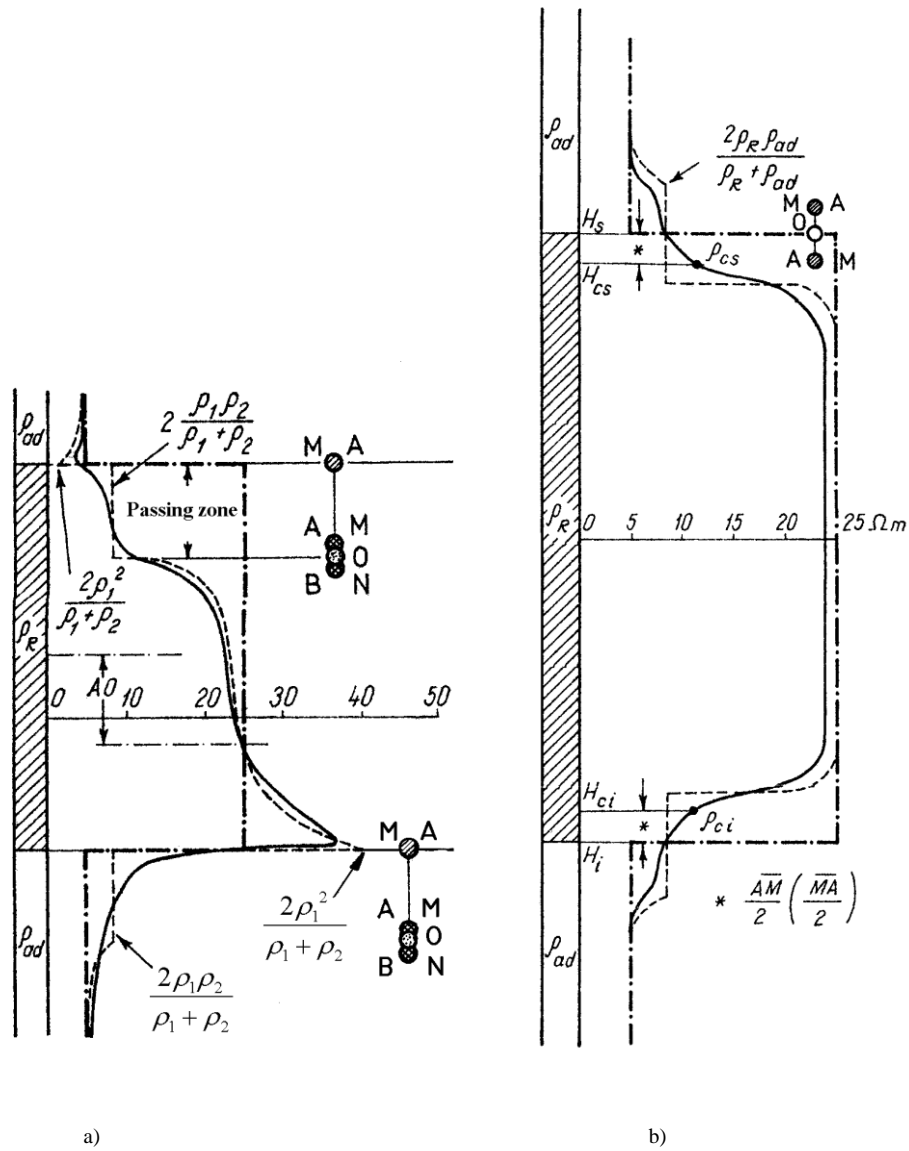


Figure 1 – Resistivity curves

The vertical resolutions for the focalized devices of type laterolog, for the inductive and micro devices are presented in table 2.

Table 2 - Vertical resolutions for the focalized devices of type laterolog, for the inductive and micro devices

focalized devices of type laterolog		Inductive devices		Micro devices	
Div. type	Vert. res(in)	Div. type	Vert. res(in)	Div. type	Vert. res(in)
LL7	32	5FF28	28	ML	4
LL3	12	6FF40	40	MLL(PL)	1,7
LL8	14	-	-	MSFL	8
DLL	24	-	-	-	-
SFL	30	-	-	-	-

### Radioactive Methods

For the radioactive methods, the vertical resolution depend on the geometrical elements (source-detector) but also on the source power, the layers radioactivity, the hydrogen content of the layers. For the usual methods, the vertical resolutions are presented in table 3.

Table 3 – Vertical resolution for the radioactive devices

Gamma natural log		Neutronic log		Density log	
Div. type	Vert. res.(in)	Div. type	Vert. res.(in)	Div. type	Vert. res.(in)
GR	The vertical resolution equals the investigation diameter and varies with the layers density and gamma radiation energy	GNAM	20-20	FDL	16
		GNT	15,5-19,5	FDC	10
		SNP	16	LDT	10
		CNL	10	-	-
		TDT	12	-	-

### Acoustic methods

The vertical resolution for the compensated acoustic log BHC equals the distance between the receptor pairs, in general 2 ft, but could be appreciated in the interval 2 to 6 ft.

## THE USE OF SAMPLED DIAGRAMS

A well is investigated depending on the established program with 2, 3 or more investigation methods. Each of these logs includes 2 or more curves. For a single well, or more precisely for the same interval, one has registered a sufficient number of curves. The use of these curves in an interpretation program imposes, on one hand, their sampling to the same sampling step, and on the other hand, arranging the data in an imposed format (ASCII, DLIS, LIS etc.).

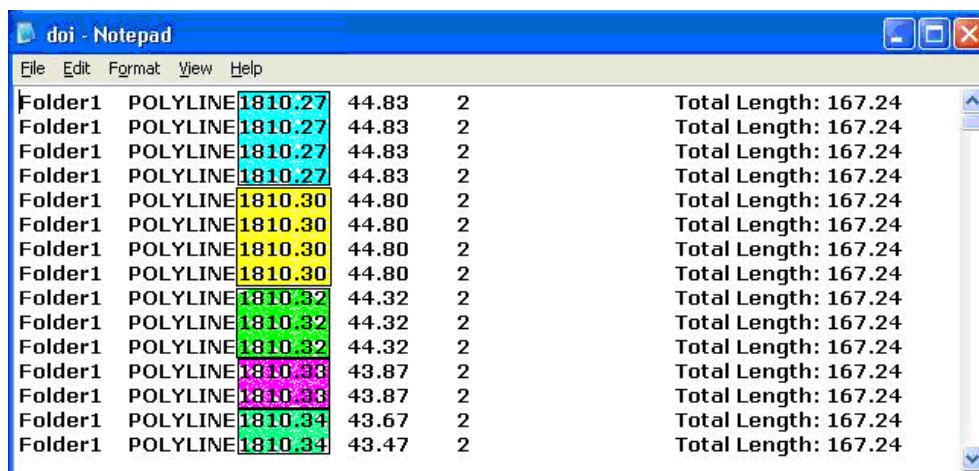
In the case of using curves with different sampling steps or originating from many producers one imposes the use of a software package to process the data in order to get the same sampling step for all the curves.

The same problem appears when the sampling software produces a certain number of points on a certain amount of time – it is the case of the software used in the geophysics laboratory in the Oil and Gas Engineering Faculty.

In order to bring the sampled data to a preset sampling step and to arrange data in ASCII format, the authors designed a computer program that will be exposed bellow.

## PROCESSING THE FILES RESULTED AFTER THE DIGITIZATION


After the sampling, for every analyzed curve one obtains an ASCII file with a structure similar with the one presented in figure 2. One can observe that the file includes along with the “useful” information (the values that follows the word POLYLINE, respectively the next column) “non-useful” information. The processing will have, on one hand, to retain only the “useful” information, but also to solve the problem of the identical values on the abscise (values highlighted in figure 2). These identical values, obtained as a result of the manual sampling of the curves will potentially produce problems during the interpolation process.



Folder1	POLYLINE	1810.27	44.83	2	Total Length: 167.24
Folder1	POLYLINE	1810.27	44.83	2	Total Length: 167.24
Folder1	POLYLINE	1810.27	44.83	2	Total Length: 167.24
Folder1	POLYLINE	1810.27	44.83	2	Total Length: 167.24
Folder1	POLYLINE	1810.30	44.80	2	Total Length: 167.24
Folder1	POLYLINE	1810.30	44.80	2	Total Length: 167.24
Folder1	POLYLINE	1810.30	44.80	2	Total Length: 167.24
Folder1	POLYLINE	1810.30	44.80	2	Total Length: 167.24
Folder1	POLYLINE	1810.32	44.32	2	Total Length: 167.24
Folder1	POLYLINE	1810.32	44.32	2	Total Length: 167.24
Folder1	POLYLINE	1810.32	44.32	2	Total Length: 167.24
Folder1	POLYLINE	1810.33	43.87	2	Total Length: 167.24
Folder1	POLYLINE	1810.33	43.87	2	Total Length: 167.24
Folder1	POLYLINE	1810.34	43.67	2	Total Length: 167.24
Folder1	POLYLINE	1810.34	43.47	2	Total Length: 167.24

Figure 2 – Structure of the unprocessed file (with identical values)

The goal of processing the original file is to obtain two columns of data (for every measured quantity), the first will play the abscissa role (representing measurement depths), and the second will comprise the measured quantity. The abscissas will have to be uniformly spaced (see figure 3 in which one can see the file after the first level of processing when the redundant abscissas are eliminated), the problem turning to an interpolation that will allow obtaining values for the measured quantity at uniformly spaced intervals.



1810.27	44.83
1810.30	44.80
1810.32	44.32
1810.33	43.87
1810.34	43.67
1810.36	42.75
1810.37	42.71
1810.39	42.47
1810.41	42.27
1810.43	42.19
1810.47	42.20
1810.51	42.12
1810.53	42.13
1810.56	42.09
1810.62	42.22

Figure 3 – The pre-processed file

In figure 4 one can see the principal window of the application. In order to ease the use of the application the main commands are available in the main menu and also in the toolbar area.

The figure presents the final situation, when in the area **Processed File** one can see the final state of the data file. One can observe that no equal values appear on the abscissa column.

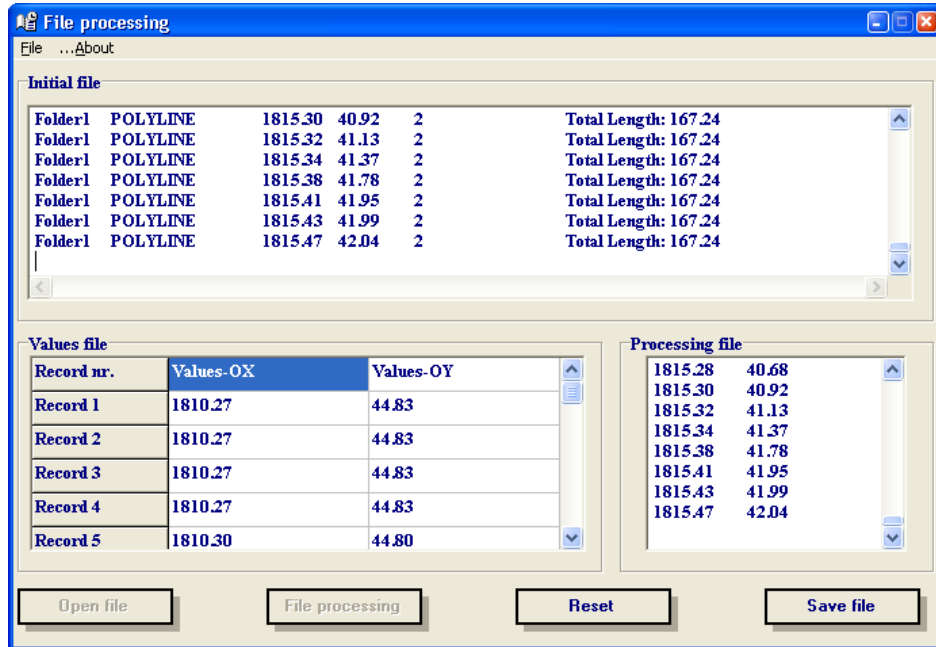


Figure 4 – Application window

Figure 5 reveals the application diagram.

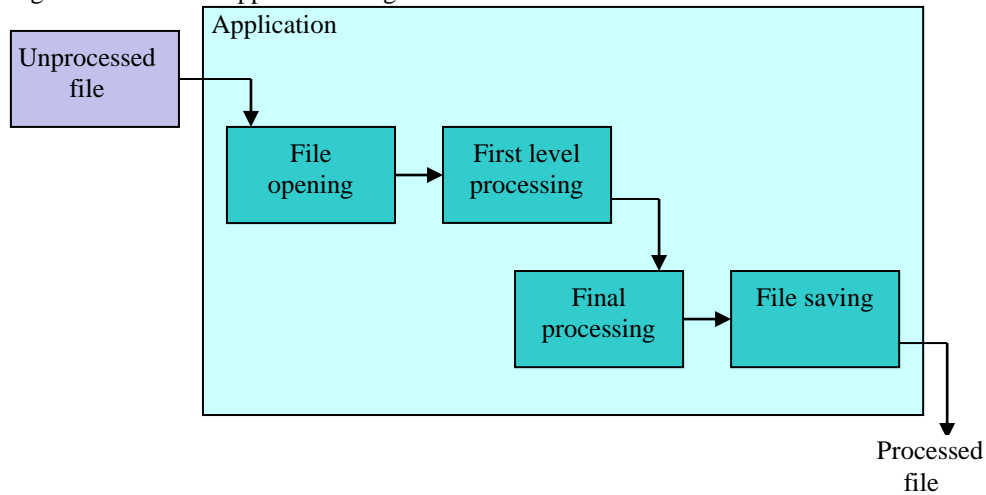
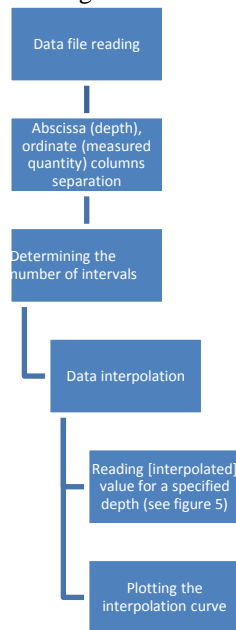


Figure 5 – Application diagram

The button **Initialize** brings the application in a state ready to process a new data file.

The second phase of the analysis will be performed within a Mathcad sheet. Here the file produced by the above mentioned application is read and further processed, in a manner that will be explained below – see also figure 6.



abscisa :=

ordonata = 40.18

Figure 6 – Mathcad document structure

The result will be two vectors, the first being the equally spaced abscissa and the second the corresponding quantity. In order to validate the algorithm, one obtained – as can be seen in figure 7 a X-Y plot. Figure 8 presents a zoomed area of the plot. One can appreciate the accuracy of the results.

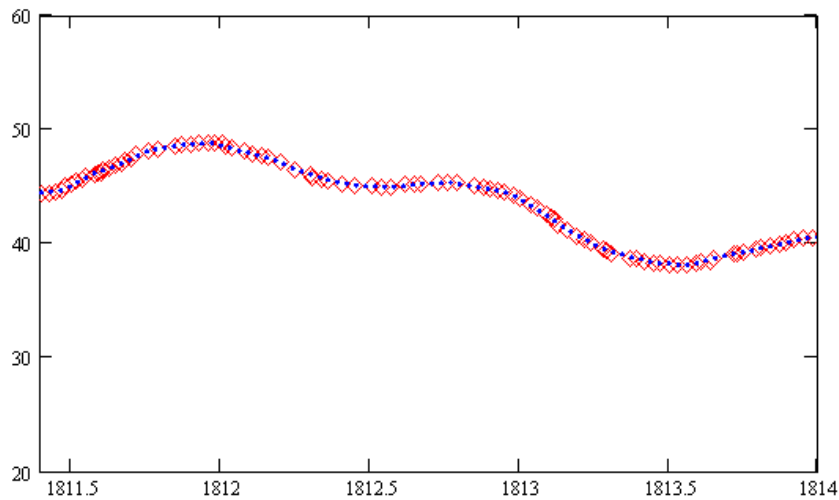


Figure 7 – Interpolated data plot

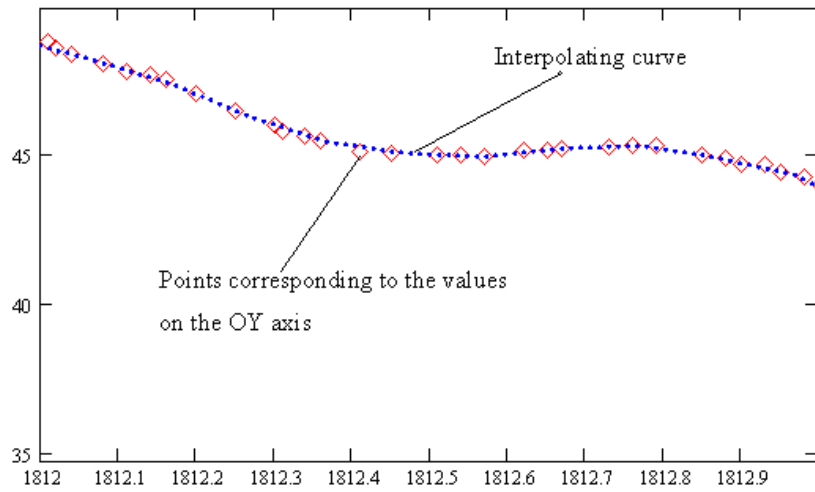


Figure 8 – Zoomed area in the interpolated data plot

Figure 9 presents a part of the final file, with the two columns used to obtain the above plot.

```

1810.27 44.83
1810.37 42.71
1810.47 42.2
1810.57 42.11
1810.67 42.33
1810.77 42.74
1810.87 43.19
1810.97 43.51
1811.07 43.71
1811.17 43.91
1811.27 44.11
1811.37 44.31

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1814.07 40.83
1814.17 40.96
1814.27 40.81
1814.37 40.16
1814.47 39.73
1814.57 38.62
1814.67 37.45
1814.77 35.84
1814.87 35.69
1814.97 36.15
1815.07 38.27
1815.17 39.64
1815.27 40.59
1815.37 41.67
1815.47 42.04

```

Figure 9 – The final form of the data file

## CONCLUSIONS

The paper dealt with the geophysics diaphragm sampling with sampling table.

The main conclusion is that one can appreciate that the sampling step has to be smaller than the vertical resolution of the investigation devices, constant and small for all of the diagrams.

If one considers the micro-devices, then the sampling step has to be around 0,05 m. This step cannot be read on a diagram at a 1:1000 scale and even 1:200, which would mean reading  $\frac{1}{4}$  mm.

In this case one can propose for diagrams recorded at a scale of 1:200 a sampling step of 0,1 m, which corresponds to 0,5 mm on the diagram and respects the condition that the step remains smaller than the vertical resolution of the investigation devices.

For diagrams recorder with a scale of 1:1000 the authors recommend the use of the software presented above.

The software proposed by the authors could also be used in cases of sampling step incompatibilities.

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