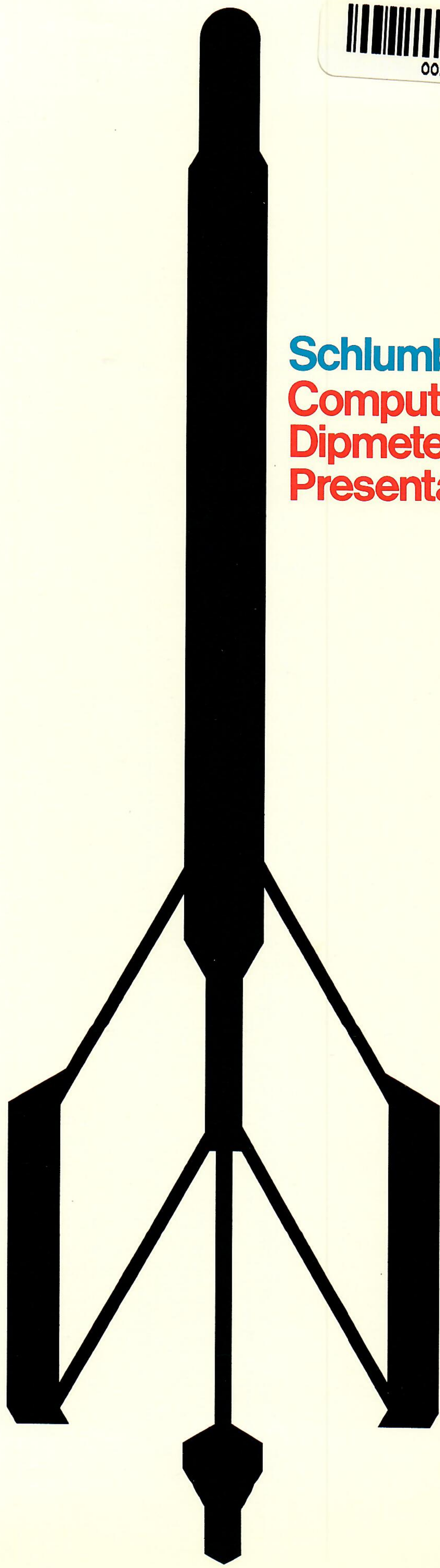


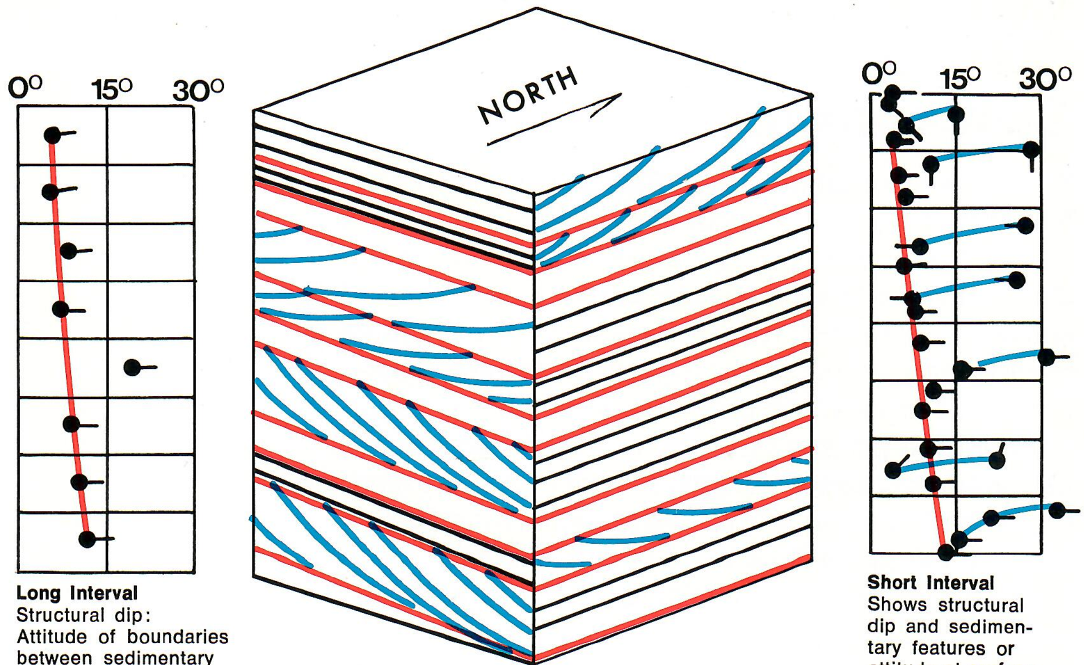
Schlumberger Computer-Processed Dipmeter Presentations

High Resolution Dipmeter Computation

The advanced telemetry of Schlumberger's High Resolution Dipmeter transmits borehole data uphole where it is digitally recorded on magnetic tape. Basic resistivity and orientation information is retrieved from the Dipmeter tape for computation tailored to particular geological problems. Resistivity and orientation data are processed within preselected parameters of correlation length, step distance and search angle. Results are displayed graphically and in tabular form. Nine different graphic presentations including a borehole geometry display and a tabular listing are available to facilitate interpretation of Dipmeter computations.

Dipmeter computation permits you to:

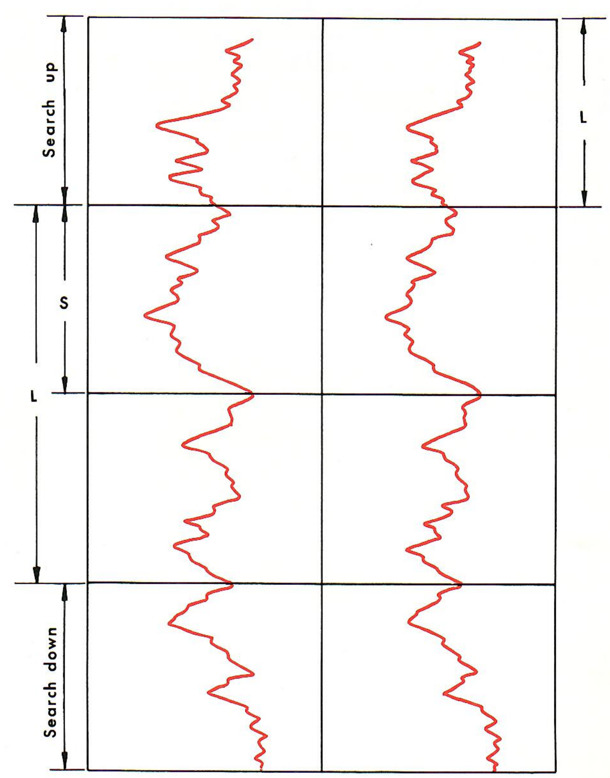
- Establish presence or absence of structure
- Evaluate the advisability of side tracking to establish or improve production
- Establish offset wells
- Evaluate reservoir true-bed thickness
- Facilitate contour mapping and cross section plotting
- Define environment at the time of deposition
- Define faults, unconformities, sand bars, channels, pinch outs, crossbedding, and depositional fronts.



Long Interval
Structural dip:
Attitude of boundaries between sedimentary units.

Short Interval
Shows structural dip and sedimentary features or attitude at surface.

Fig. 1. Correlation Length



L = Correlation length
S = Step distance

Fig. 2. Step Distance

Computation Options

After basic resistivity and orientation information is retrieved from the Dipmeter tape, the data are processed within preselected parameters based on the geological feature to be studied. The preselected parameters, correlation length, step distance and search angle are discussed below. Usually, a correlation length of four feet, a step distance of two feet and a search angle of 60 degrees are chosen to give dips reflecting both structural and stratigraphic features. For delineation of finer features, correlation lengths of one or two feet are sometimes required.

Correlation Length—The window-length through which the computer views the micro-resistivity curve data for automatic correlation (Figure 1 & 2).

Step Distance—Distance the window is moved for the next set of correlations. Usually the step distance is 50% of the correlation length (the window is moved half its length). One dip is computed per step (Figure 2).

Search Angle—Each resistivity curve is compared to the others in steps of one-tenth of an inch and a correlation coefficient computed for each position. This shifting is computed over an interval called the search interval (Figure 2). The maximum correlation coefficient is taken as the correct depth shift and displacement is determined. This search interval (converted to an angle) is preselected based upon the maximum magnitude of anticipated dips. A search angle of 70 degrees requires double the computations of a search angle of 45 degrees (Figure 3).

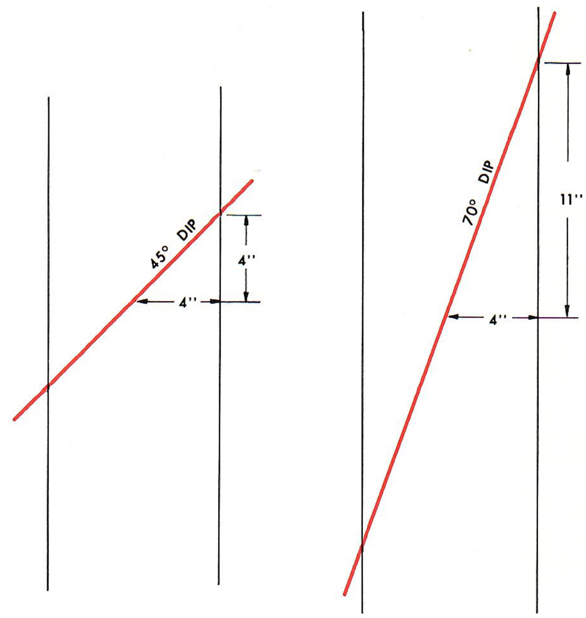


Fig. 3. Search Angle

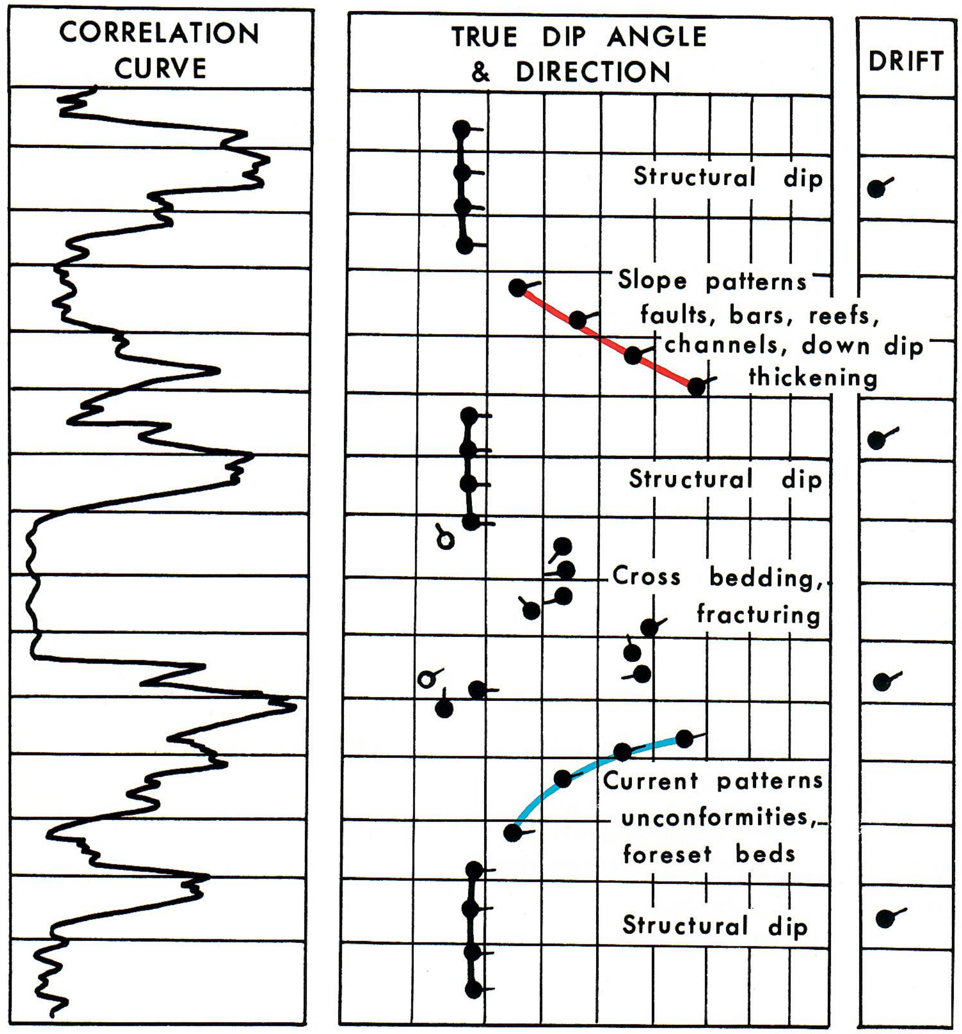


Fig. 4. Arrow Plot

Data Display and Presentation

Dipmeter computation data are displayed graphically and in tabular form. Nine different presentations including a borehole geometry display and a tabular listing are available to facilitate your interpretation of Dipmeter computations.

1. Arrow Plot—The Arrow Plot shown in Figure 4 gives the magnitude (scale at top) and direction (of the arrow with North at the top) of true dips. Arrow Plot information can be grouped into patterns: structural dip is indicated by constant dip magnitude and direction with increasing depth; slope patterns are indicated by increasing dip and constant azimuth with depth and define faults, bars, channels, reefs and down dip thickening; current patterns are dip groups which indicate unconformities and foreset beds by decreasing dip and constant azimuth with depth.

Two types of circles represent dip magnitude on the Arrow Plot. All quality rated computations are solid circles; open circles represent computations which are not quality rated. At the extreme right is the drift and direction of the sonde (hence the borehole). Any depth scale may be used, but a common one is 5″ = 100′ in order to correlate with other logs such as the I-ES. With Schlumberger's High Resolution Dipmeter, correlation is accomplished with a computed resistivity curve, obtained from one of the focused resistivity measurements. If a three-arm Dipmeter is run, the GR or SP can be displayed.

2. Cross Section Plot—The Cross Section Plot is a two-dimensional cross section at a preselected azimuth. The standard presentation is shown in Figure 5. The Cross Section Plot shows how each bedding plane would cross the borehole at a prespecified azimuth.

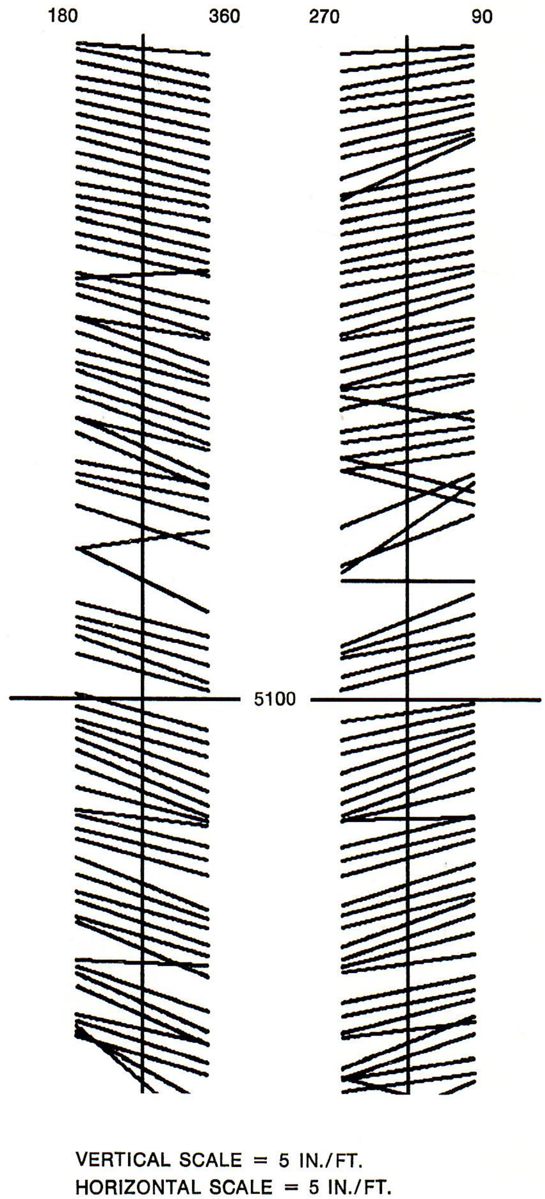


Fig. 5. Cross Section Plot

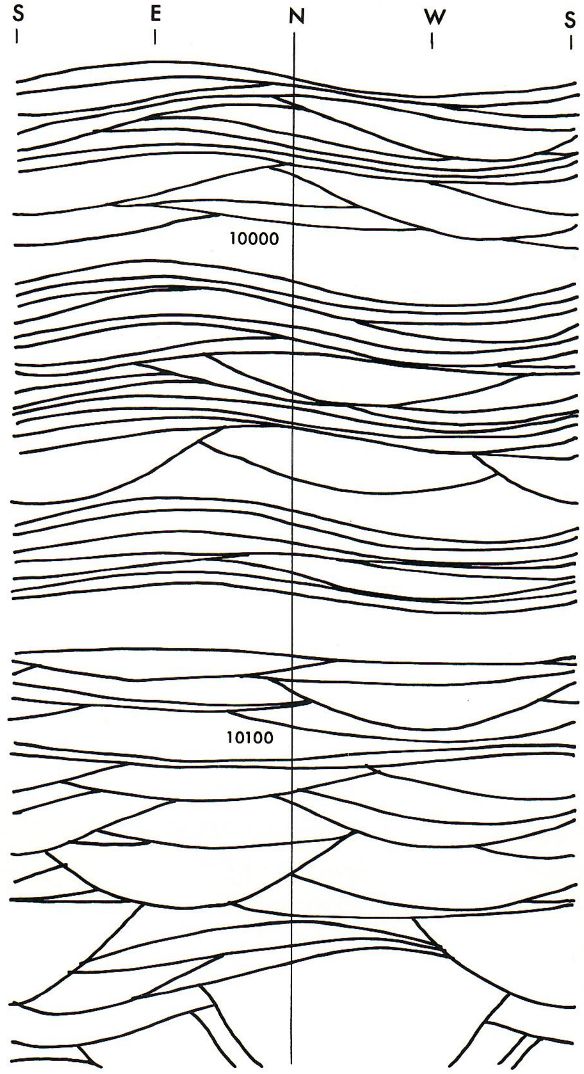
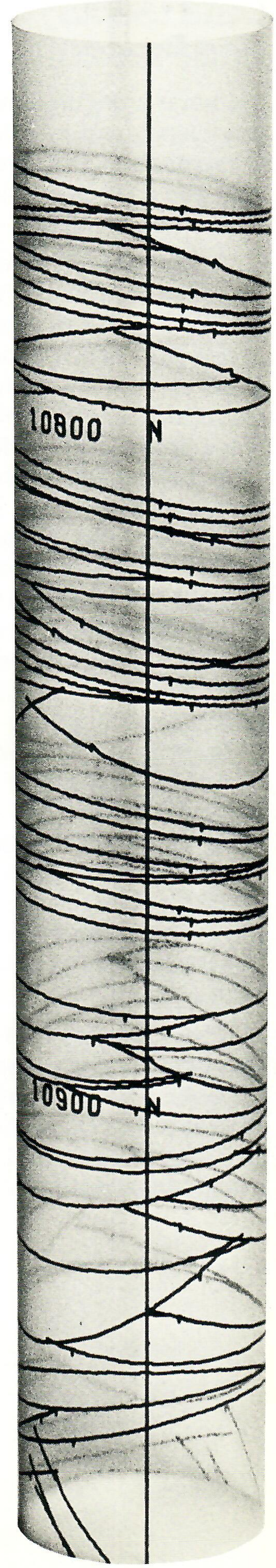


Fig. 6. FAST Plot



3. **FAST Plot**—This two-dimensional presentation has the appearance of the borehole split on the South axis. When this two-dimensional plot is placed in a transparent cylinder, the bedding plans appear as they would in an oriented core (Figure 6).

4. **Seria Plot**—The Seria Plot presents the same information as the Arrow Plot in a different form (Figure 7). This presentation separates dip and azimuth so that each can be separately evaluated.

5. **Modified Schmidt Plot (vertical dip at the center)**—The Modified Schmidt Diagram (Figure 8) is used to determine structural dip when it is hard to find from the Arrow Plot.

The paper is polar with North at the top. Dip magnitudes are represented by concentric circles. The plot is divided into cells of 10-degree magnitude and 10-degree azimuth; the dots are plotted for all dips computed. In some cells there may be no dots; in others, one dot; in still others, two or more dots. Contour lines connect the dots of each group. Structural dip is an elongated, contour hugging the outer rim of the plot and extending over a wide range of azimuths. The remaining dips (slope and current patterns) will plot in rough triangles with their apexes pointing toward the center of the plot. If structural dip is greater than three or four degrees, it can be vectorially subtracted from the dips by the computer, leaving the absolute current and slope pattern dips.

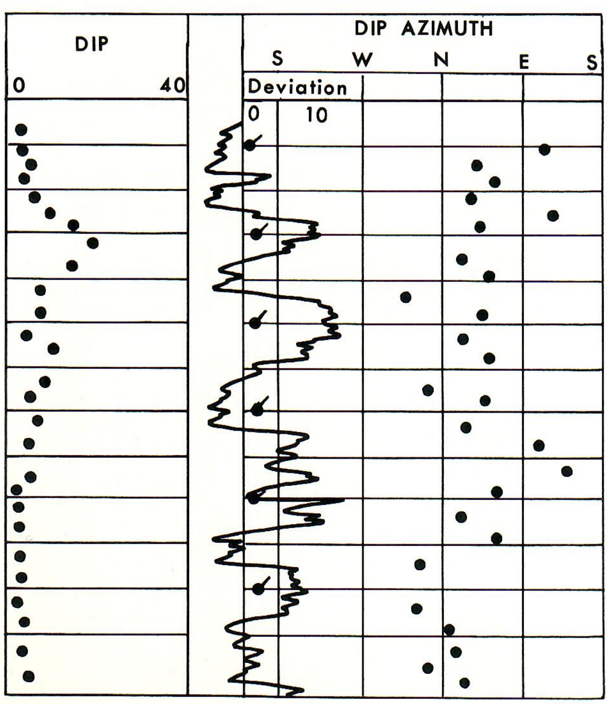
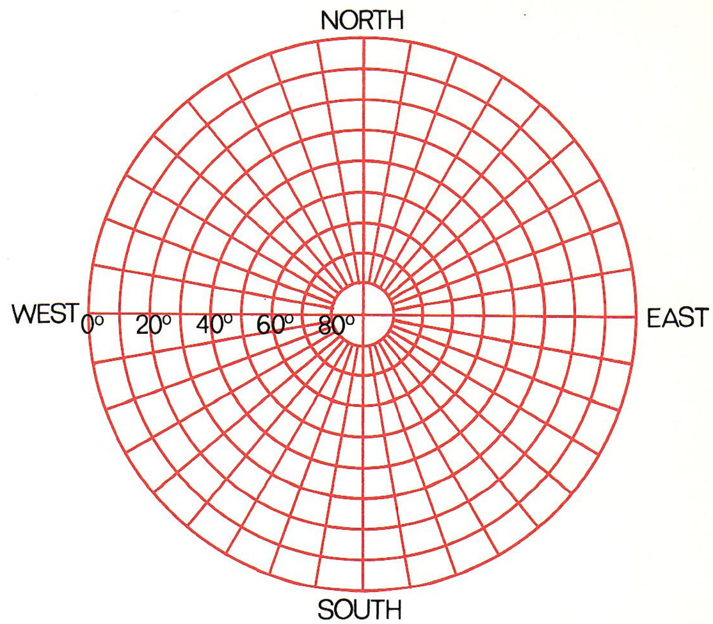


Fig. 7. Seria Plot



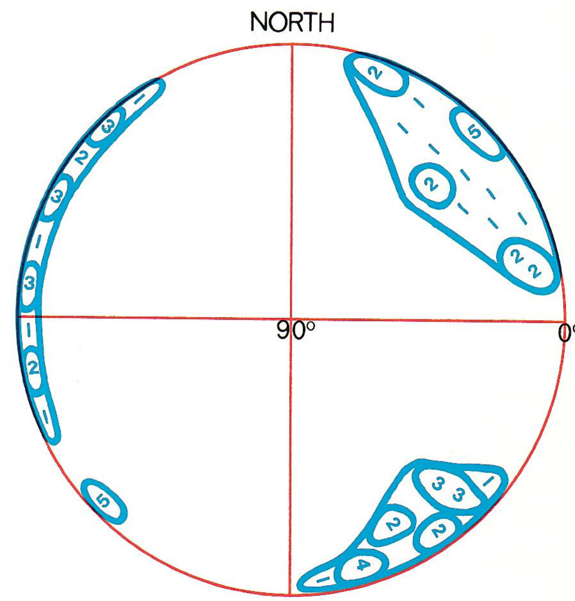


Fig. 8. Modified Schmidt Plot

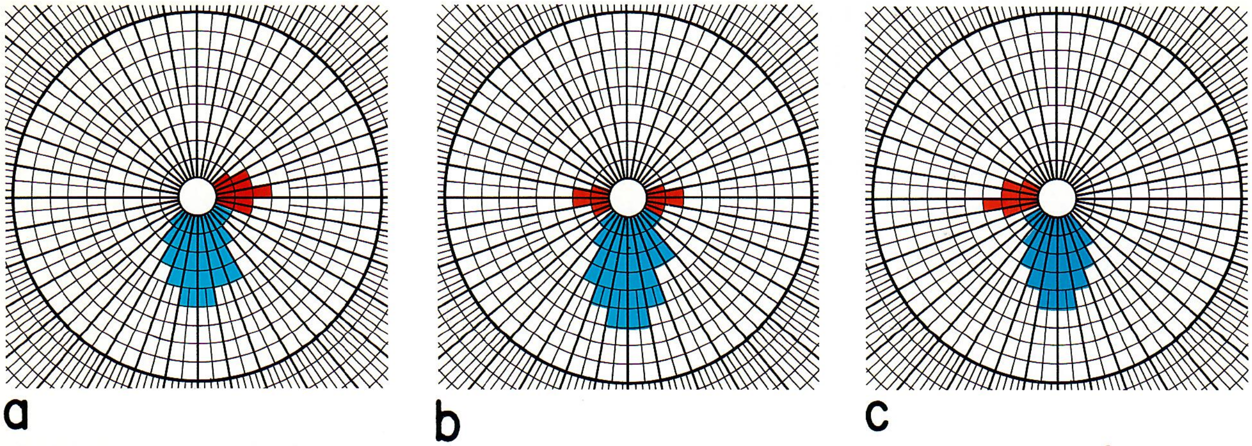
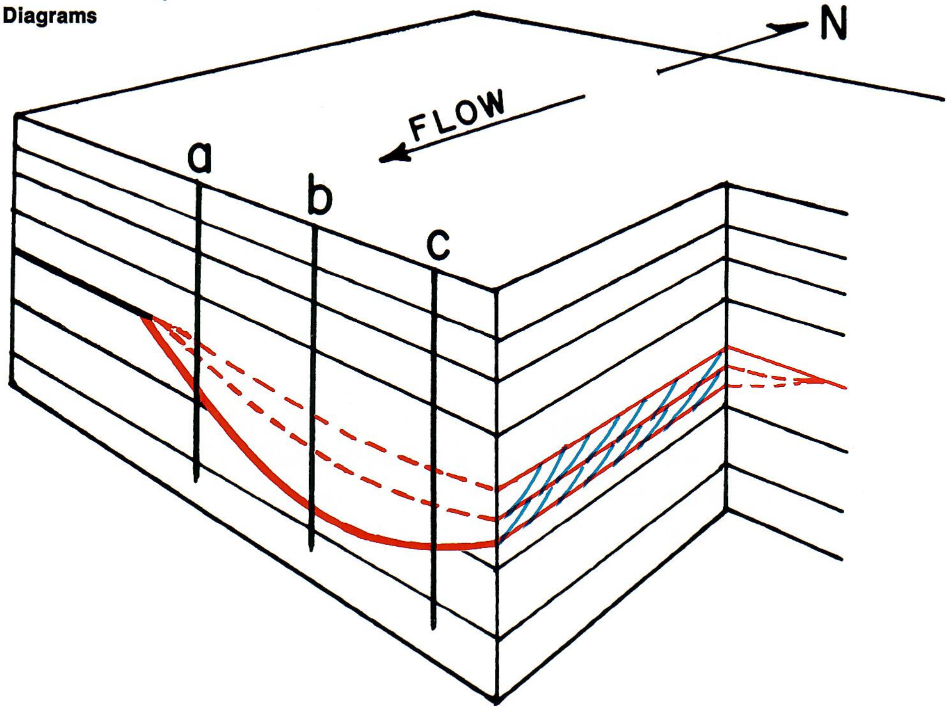


Fig. 9. Azimuth Frequency Diagrams



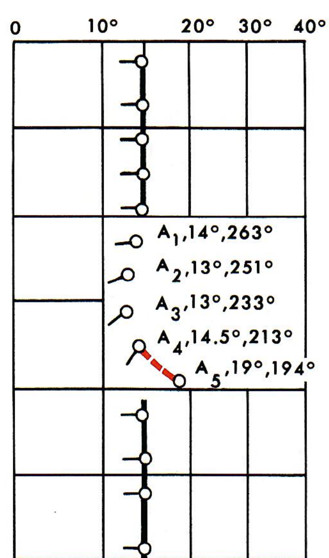


Fig. 10. Arrow Plot

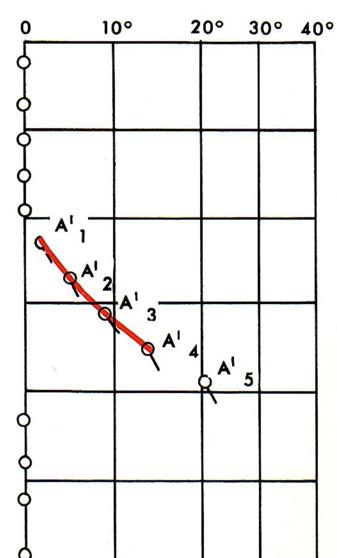


Fig. 11. Arrow Plot with structural dip removed

6. **Azimuth Frequency Diagram**—The Azimuth Frequency Diagram (Figure 9) is plotted on polar co-ordinate paper with North at the top and 10-degree azimuth increments. The length of each 10-degree segment is proportional to the number of dips in the interval having that azimuth range, with zero frequency at the center. The result will be little fans (originating at the center) which may be composed of slope or current patterns. Comparison with the Arrow Plot will differentiate current and slope patterns. Azimuth Frequency Diagrams are excellent tools for delineating bars, reefs, channels and troughs.

7. **Arrow Plot with structural dip removed**—To use slope or current patterns to best advantage, it is usually necessary to subtract by vector rotation structural dip greater than 5 degrees. The subtraction can be accomplished automatically by the computer. Figure 10 shows the plot of the interval with dip values computed (structural dip is 15 degrees W). A possible slope pattern is indicated by the dashes between A_4 and A_5. Figure 11 shows the plot of the interval with structural dip removed. The "absolute" slope pattern is clearly defined and can be used for stratigraphic or sedimentary study.

8. **Borehole Geometry Plot**—The High Resolution Dipmeter with four-arm sonde records two independent oriented caliper surveys. This information is presented graphically to show borehole geometry and direction of hole elongation. Figure 12 is an example of the available borehole geometry presentation.

9. **Listing**—All Dipmeter computation information can be presented in tabular or list form (See Figure 13, next page). A glossary of tabular listing data shown on the list follows the print-out.

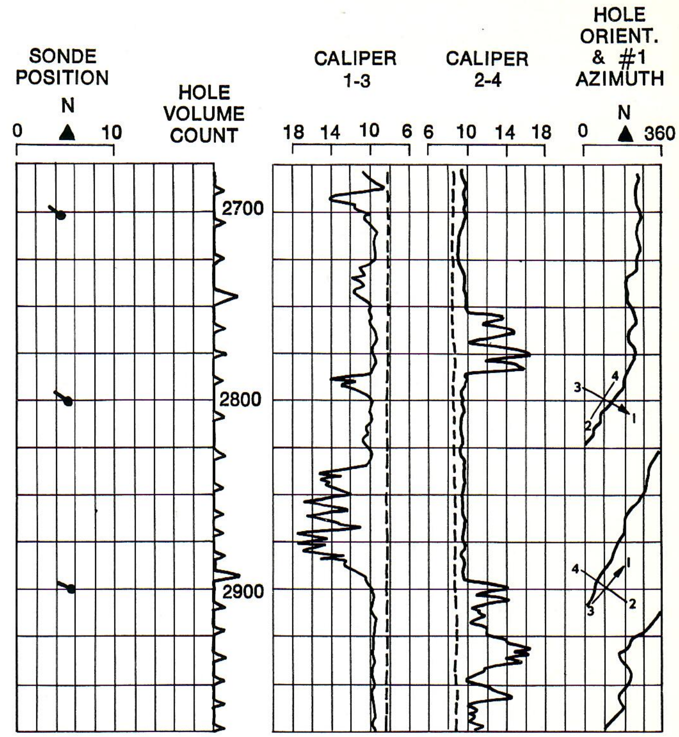


Fig. 12. Borehole Geometry

1	2	3	4	5	6	7	8	9	10	11	12
DEPTH	DIP	DIP AZM	DEV	DEV AZM	DIAM 1-3	DIAM 2-4	LO GI	Q	PLA	CLO	MAX
5896	3.0	205	1.9	246	8.7	9.8		B	0	100	50
5894	2.1	202	2.0	245	8.5	9.9		A	45	100	54
5892	3.2	155	2.0	243	8.5	10.0		A	100	100	59
5890	3.1	206	2.0	243	8.6	9.8		A	0	100	57
5888	2.6	230	2.0	243	8.6	9.9		A	0	100	57
5886	3.4	230	2.1	243	8.7	10.1	**	A	44	100	53
5884	2.4	215	2.1	243	8.8	10.0		A	100	100	74
5882	2.6	187	2.1	243	8.8	9.8		*	0	43	76
5880	5.2	259	2.0	245	9.0	9.7		C	0	100	35
5878	38.2	221	2.0	244	8.9	9.6	**	D	100	100	71
5876	4.0	235	2.0	244	8.8	9.8	**	C	100	100	86
5874	3.5	236	2.0	245	8.7	10.0	**	B	100	100	78
5872	2.8	228	2.0	245	8.8	10.1	**	C	100	100	73
5870	2.1	230	2.0	244	8.7	10.1	**	C	40	100	85
5866	5.2	228	2.2	245	8.8	10.6		B	0	100	91
5864	NO CORR		2.1	244	9.0	10.6					
5862	24.4	140	2.1	245	9.1	10.6		*	0	0	35
5860	30.7	24	2.1	244	8.8	10.6		*	0	0	6
5858	6.3	234	2.1	244	8.7	10.4		A	0	54	27
5856	24.3	319	2.2	245	8.7	10.5		*	0	20	23
5854	1.1	222	2.3	244	8.8	10.6		*	0	30	44
5852	18.7	306	2.4	243	8.7	10.5		B	0	100	37
5850	21.9	303	2.3	244	8.5	10.5		D	0	100	50
5848	1.8	114	2.3	244	8.5	10.5		B	0	100	73
5846	1.4	223	2.2	244	8.5	10.5	**	B	17	57	84
5844	2.1	186	2.1	244	8.4	10.5	**	A	100	100	73
5842	2.6	211	2.2	243	8.3	10.6	**	A	100	100	68
5840	3.9	232	2.3	243	8.3	10.6	**	C	100	68	58
5838	1.7	218	2.3	244	8.5	10.6		*	0	33	72
5836	3.6	132	2.2	245	8.5	10.7	**	C	10	100	61
5832	1.4	218	2.3	243	8.5	10.8	**	A	100	100	84
5830	1.6	221	2.3	243	8.4	10.9	**	A	100	100	82
5828	1.5	201	2.4	243	8.4	10.9	**	B	100	100	72
5826	1.7	107	2.4	244	8.4	10.9	**	B	11	100	84
5824	.7	193	2.4	244	8.3	10.9		C	0	100	90
5822	1.5	206	2.4	243	8.2	10.8		C	0	100	85
5820	2.5	260	2.4	242	8.2	11.0		*	0	10	42
5818	1.7	196	2.4	240	8.2	11.2	**	D	100	100	86
5816	.4	230	2.4	240	8.4	11.3	**	D	10	100	82
5814	1.3	189	2.4	238	8.4	11.4	**	A	33	100	59

1. Computation attempted unsuccessfully.
2. **Four-pad logic.
3. "Best-Fit" dip determination, good planarity.
4. *Quality not rated (coherence factor not computed).

Fig. 13. Listing

TABULAR LISTING DATA

Column 1
Depth in feet

Column 2
Dip angle in degrees

Column 3
Dip direction—in degrees clockwise from True North

Column 4
Sonde deviation in degrees from vertical

Column 5
Direction of sonde deviation in degrees clockwise from True North

Column 6
Borehole diameter from Dipmeter pads 1-3

Column 7
Borehole diameter from Dipmeter pads 2-4

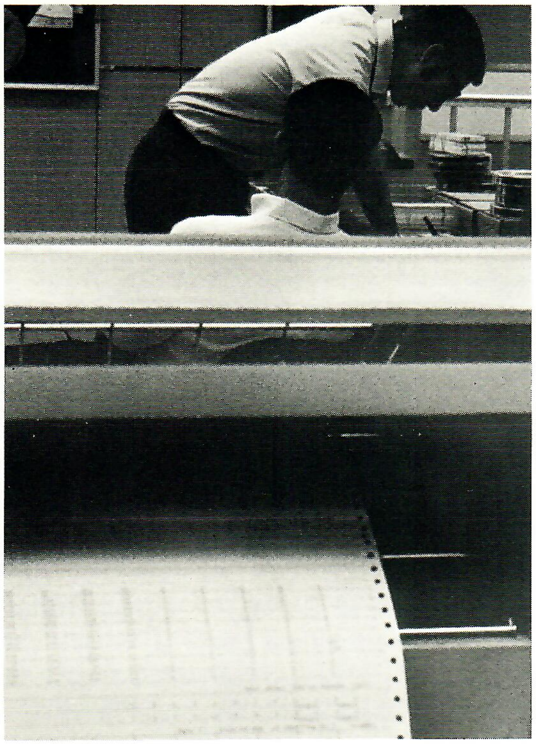
Column 8
LOGI—Logic used in the program—whether in 3-pad or 4-pad logic. Two asterisks are printed in the column when 4-pad logic is used. This column is blank when 3-pad logic is used, for example when only three of the four resistivity curves can be used for correlation or when a three-arm Dipmeter is being computed.

Column 9
Q—Quality. This coefficient rates from 100 to 1 each correlation between two curves. The lowest rating of the three or four correlations is listed in this column after translating its numerical value into A, B, C, or D values (from very good to possible) according to:
A—75 to 100 B—50 to 75 C—25 to 50 D—less than 25
Q is listed as an asterisk if the sonde speed correction could not be made and/or a diagonal correlation could not be made in a dip result derived from three pads.

Column 10
PLA—Planarity. The planarity coefficient indicates the degree of planarity of the four adjacent displacements. It varies from perfect (100) to poor (10). If one correlation is missing it is set to zero. When PLA is greater than 50 and the quality coefficient is good, dip is computed using the 4-pad best-fit technique. When PLA is less than 50 the best-fit 3-pad correlation is used.

Column 11
CLO—Closure. This coefficient checks the degree to which the correlations were made on homologous markers. It varies from perfect (100) to poor (10). The closure is zero when the check cannot be made.

Column 12
MAX—lowest correlogram maximum. The correlation between two curves is the result of a mathematical function, the graph of which is called a correlogram. At least four such correlograms are computed for each dip determination. Under MAX is listed the amplitude of the lowest of the maxima of the correlograms used in that dip determination. It varies from perfect correlation (MAX = 100) to no correlation (MAX = 0).



A total digital capability

Positive structural and stratigraphic information obtained from the computation of Dipmeter surveys can lead to successful exploration and development programs. Quality dip information depends upon the accuracy of both the recording and the computation of data. Schlumberger has developed a complete digital recording and computation system that will give you the positive data you need. Dipmeter data are digitally recorded in the field on magnetic tape and processed with advanced software in Schlumberger computer centers.