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**FACULTY OF HYDROCARBONS and CHEMSTRY**

GEOPHYSIQUE

# Manual for use by geologists, geophysicists and producers

# Interpretation of well imaging by electrical logging

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# Interpretation of well imaging by electrical logging

MINISTRY OF HIGHER EDUCATION AND

SCIENTIFIC RESEARCH

UNIVERSITY of BOUMERDES

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# Summary

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# Imagelog Interpretation Overview

Up to this point we have focused on the computation of formation dips from resistivity and acoustic images. Initially the primary use for the dipmeter tools focused on structural dip computation from one borehole rather than three boreholes .Dips are also used to define Sedimentologic features and this application became reality upon the advent of correlation techniques using computers in the early 1960's.
The advent of resistivity imaging tools in the late 1970's early 1980's produced data that provided a much more detailed picture of the borehole wall. Integration with cores and direct comparison became a realistic approach. The amount of information acquired in the borehole for dip and Imagelog Interpretation today allows the following categories of interpretation to be done:

- Structural Dip Interpretation: determine the following information from Structural Dip Analysis:
- ○ Dip Magnitude
- ○ Structural Type
- ○ Fracture orientation and type
- ○ Fault/Fracture Plunge
- ○ Stress Regime orientation
- ○ Sedimentologic Dip Interpretation: remove the structural dip to help determine the following information:
- ○ Sand Body Morphology
- ○ Paleocurrent inference
- ○ Depositional Environment
- ○ Thin Bed porosity/permeability characterisation
- ○ Clastic Environments: Imagelog Interpretation features in Clastic Environments
- ○ Carbonate Environments: Imagelog Interpretation features in Carbonate Environments
- ○ Thin Bed Analysis: High Resolution determination of petrophysical properties in conjunction with standard resolution logs
- ○ Reservoir Heterogeneity: Carbonate Rock Fabric properties
- ○ Borehole Mechanics: Sanding Analysis, Borehole breakout and stability

In order to usefully apply image data to the above problems, the interpretation involves use of techniques which involve auxiliary plots that can be generated from the dip data either manually picked or automatically generated. If manually picked data is used, the features picked can be distinguished based on lithology, dip magnitude, feature character and observed dip trends. When utilizing Petrolog we can generate the following useful graphics objects:

- Stereonets: Wulff, Schmidt and Walkout plots
- Stick Plots:
- Azimuth Rose:
- Breakout Plots
- Breakout Perspective
- Breakout Rose

These plots are designed to present spatial information in 2 dimensions and in a format that allows relationships to be readily determined and related to the geologic environment.

# Imagelog Interpretation: Structural Dip Interpretation

Structural dip is defined as a regional dip trend which describes the attitude of a particular formation in the crust. It is generally represented by the dip in shales and is usually inferred from intervals of consistent dip that are of such a length that reasonably defines the regional trend. Before any Paleocurrent work can be undertaken, structural dip needs to be determined and removed. An example of structural dip is illustrated in the following figure 1

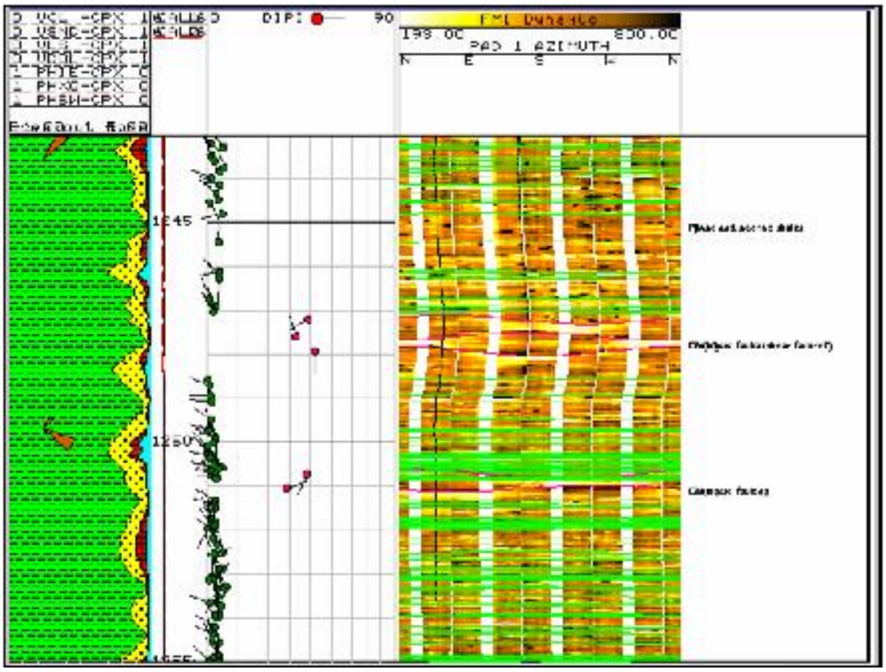

**Figure 1**

These structural dips can be plotted as stick plots and when plotted in time can give a realistic comparison with seismic. This has application in assessing accuracy of time to depth conversion. Velocity field estimation etc. An example of the comparison is illustrated in figure 2

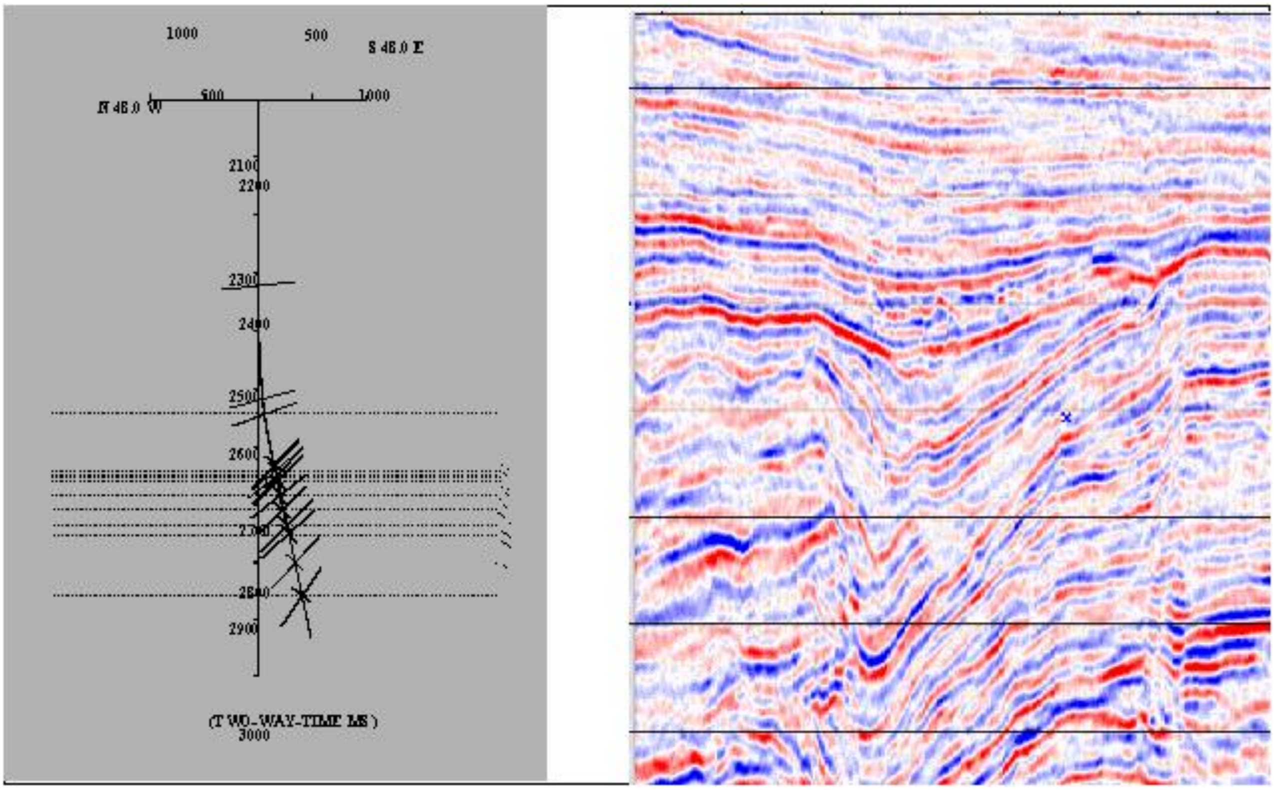

Figure 2

Figure 2 shows a stick plot presentation next to a seismic plot.

Faulting within an interval can be identified on an image as a discordant break or change in formation type. On single button dip resistivity data, the presence of a fault was inferred from deformation envelopes surrounding the actual fault or fault zone. A deformation envelope is local ductile deformation associated with the fault or fault drag. The fault drag usually presents itself as increasing then decreasing dip magnitude as illustrated in figure 3.

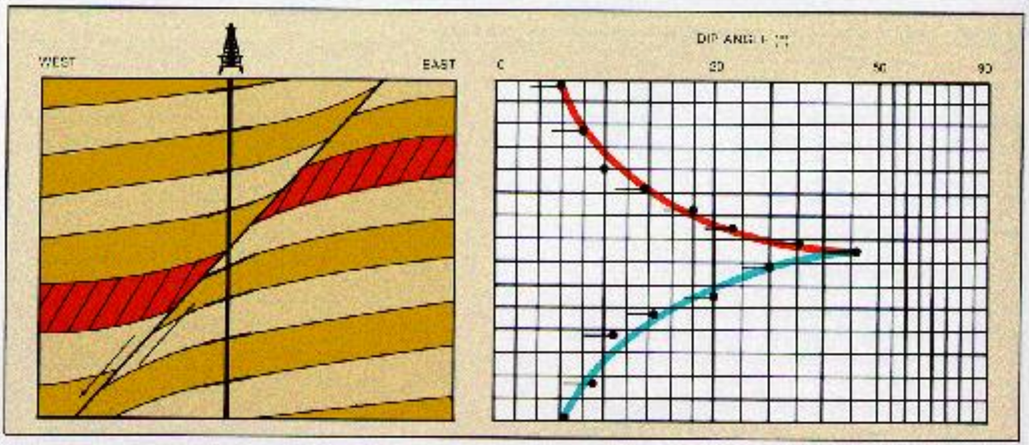

Fig. 5-19 — Drag often produces small concave folds in downthrown block and small convex folds in the upthrown block.

Figure 3

Figure 3 is a typical fault drag and the resultant dip pattern on the right. See Fundamentals of Dip Log Analysis Atlas Wireline Services Western Atlas (Bigelow, 1987)

If the pole to the plane of these dips is plotted on an equal area lower hemisphere stereonet they will describe a great circle. The pole to the plane of the great circle describes the plunge of the fold or the orientation of the fold.

The drag may be produced on either the foot wall or the hanging wall or both.

The amount of detail present in the images available today permits identification of faults that are down to the centimeter scale. The examples in figure 4 show faults that do not have a deformation envelope but have juxtaposed discordant bedding:

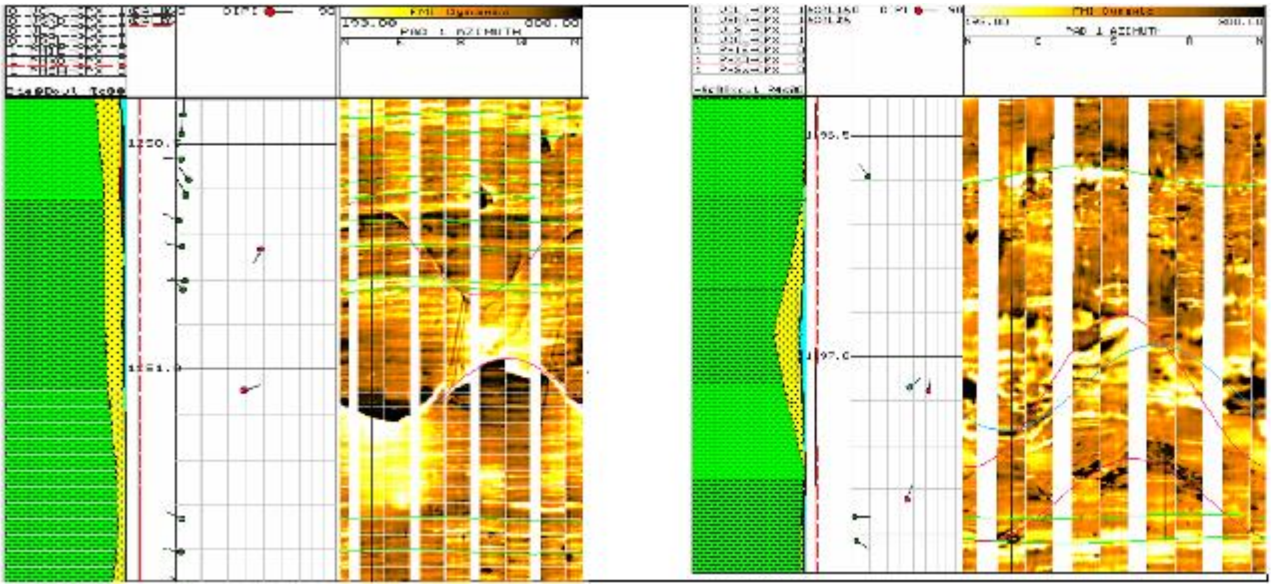

**Figure 4**

Figure 4 are Images showing small scale faulting (both images cover a 2 Meter Interval)

Fractures identification is also an important part of structural analysis and can define important structural trends related to porosity and the structural style of the field. By identifying fracture frequency and the average dip, the true spacing can be determined. The distribution of fractures can have a marked affect on the productibility and the ultimate recovery of a reservoir. The orientation of fractures in space can assist in describing the structural style of a particular reservoir. The example illustrated in Figure 5 shows fractures (blue and green picks) occurring at or near what could be considered to be a fault zone. A distinct conjugate set is defined by these fractures with a Northwest and Southeast dip direction orientation.

These fractures can be used to define the true fracture spacing not the fracture spacing as illustrated on the plot. The methodology for doing this is illustrated in figure 6.

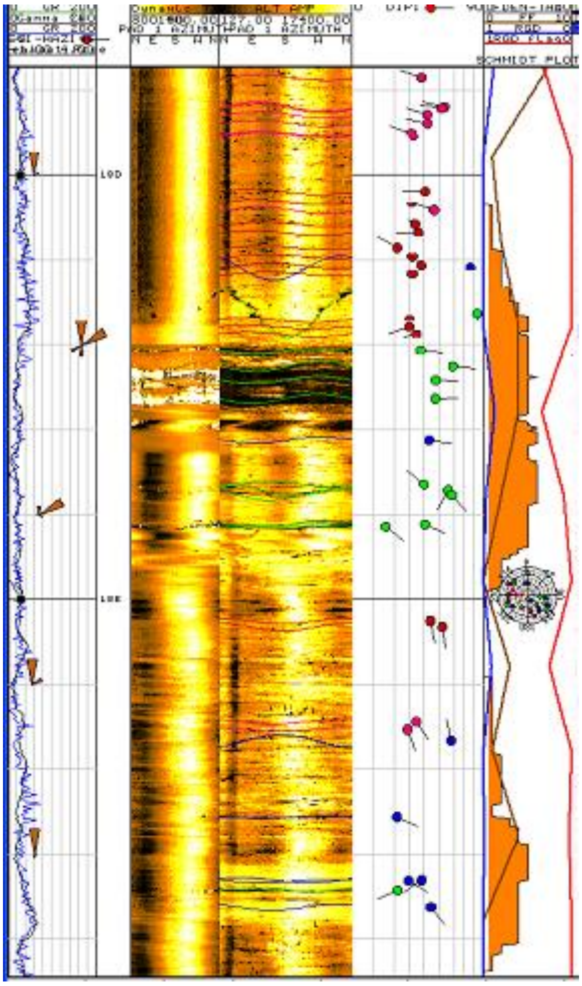

**Figure 5**

Figure 5 shows fractures illustrating a conjugate set.

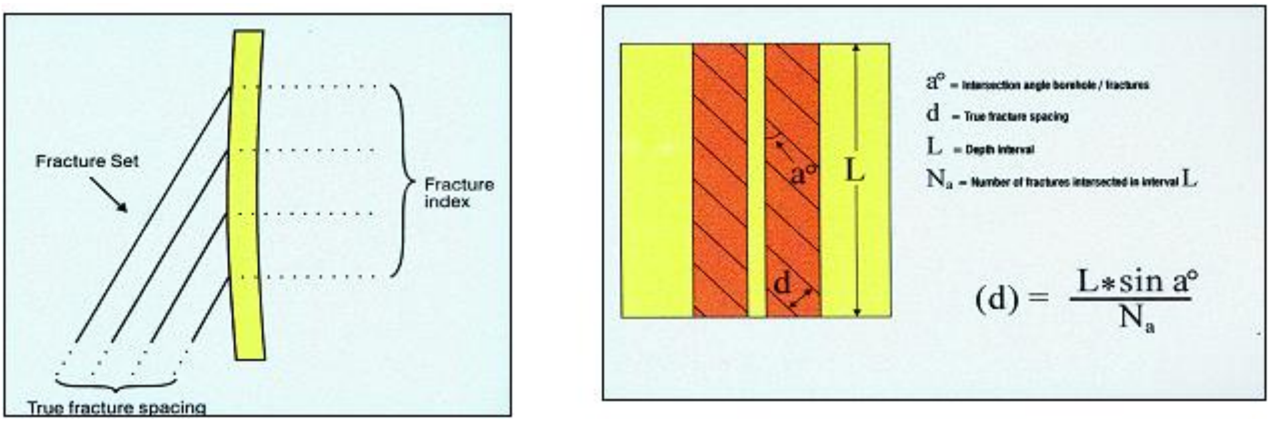

Figure 6

Figure 6 gives the equation used in the determination of true fracture spacing

The deformation associated with faults and also with folds can be used to define the fold. By plotting the dips on a equal area lower hemisphere stereonet as poles to plane of the dips permits the use of the spherical geometric properties of the stereonet to identify fold axis and plunge. These fold geometries are illustrated in figure 7.

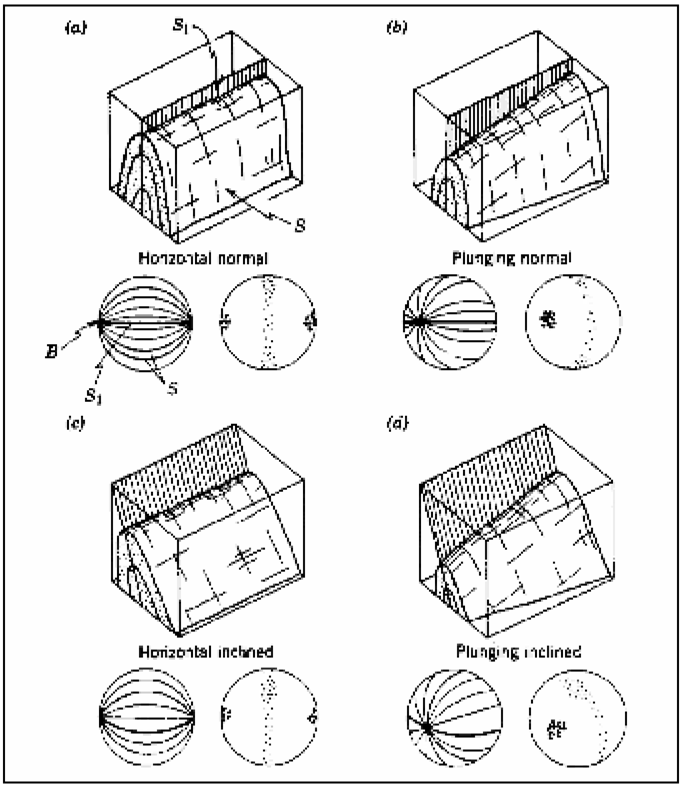

**Figure 7**

**Figure 7 illustrates fold identification from an unknown reference.**

Geometrically, a fold should have a dip arrangement that creates great circles that intersect at the plunge. Because this is confusing, the approach usually taken is to plot the poles and see if the dips create a shape that represents a great circle. Various examples are shown in the above stereonets.

Bengston (1981) introduced a statistical technique that is now abbreviated SCAT. It essentially takes the dips and constructs transverse and longitudinal sections oriented along structure and down dip from structure. The transverse section is oriented in the dip direction where the greatest cluster of dip magnitude exists. His figures on the next pages illustrate how the dips are presented.

Rather than just computing the apparent dip, the technique relies on computation of the variance of the dip from the longitudinal and transverse directions. The fold or fault type can be distinguished through different patterns. These patterns also permit the definition of anticline, syncline and throw orientation on the fault.

A great circle is constructed on a stereonet as follows. Rotate the stereonet so that the strike (dip direction -90 Deg) of the dip is at 0 degrees or North point. The dip magnitude is counted in from the edge on the right hand (East) side of the Stereonet. The pole is plotted as a point 90 degrees away. That is you count out from the centre on the west side of the plot the dip magnitude whilst keeping the net in this orientation.

Ref Bengston., Statistical Curvature Analysis Techniques for Structural Interpretation of Dipmeter Data, AAPG Bulletin, V. 65, 1981,PP 312-332

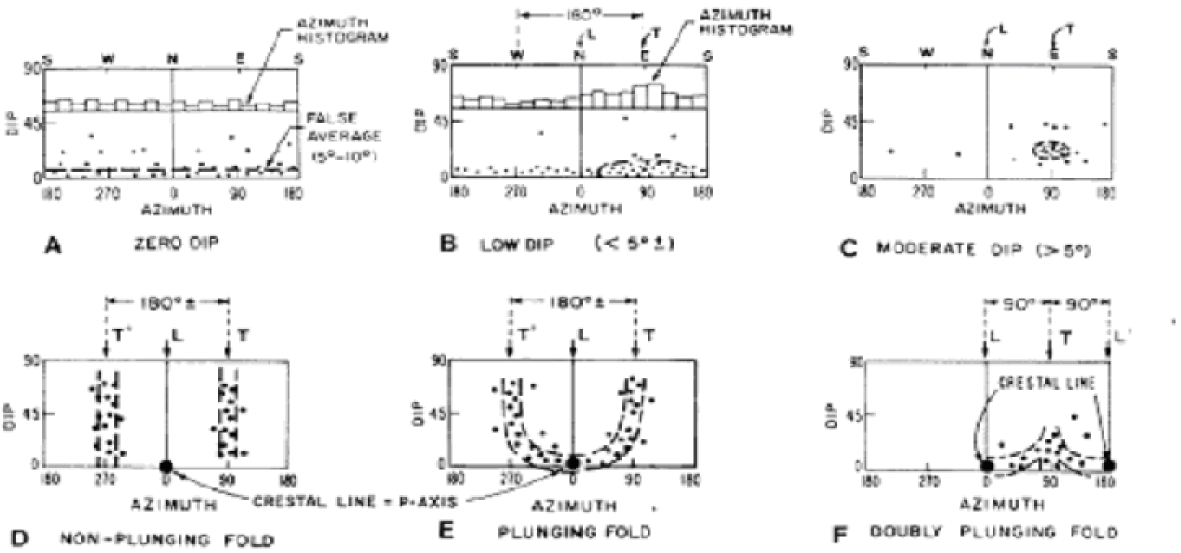

FIG. 2—Six basic dip versus azimuth patterns corresponding to bulk-curvature categories of Figure 1.

**Figure 8**

Figure 8 shows the different scatter patterns for different tectonic settings.

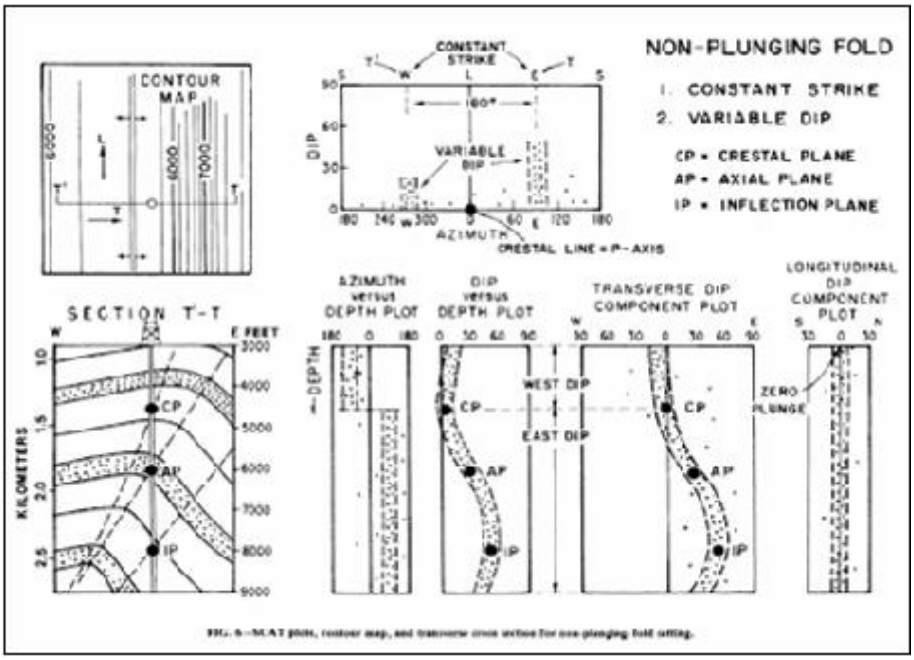

**Figure 9**

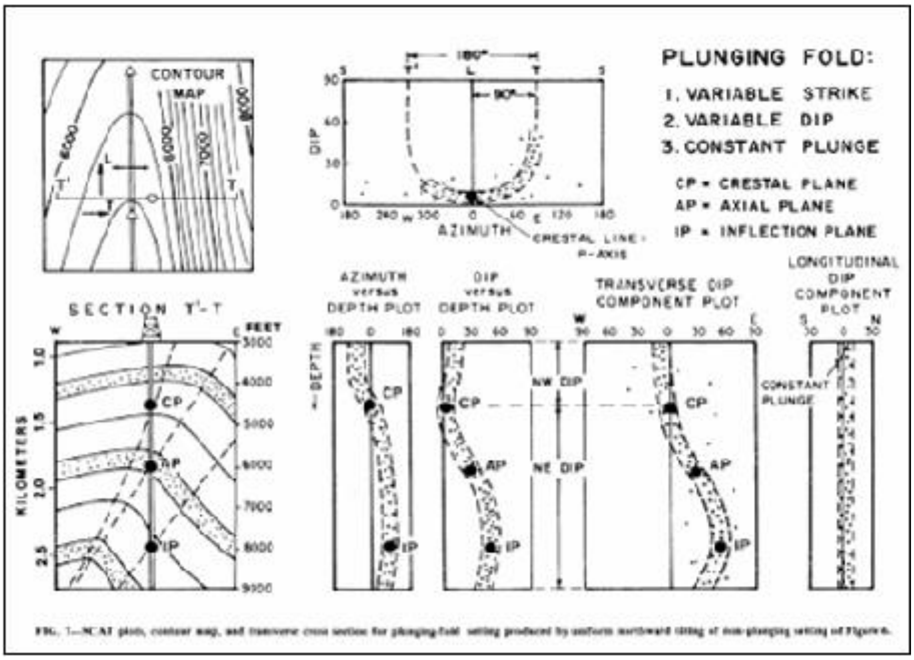

**Figure 10**

Figure 9 and 10: Bengston (1981) Scatter patterns for different tectonic settings.