

## **APPENDIX H**



Magellan Petroleum

Palm Valley 10 & 10a

FMS Interpretation Report

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## SUMMARY

Fracture analysis was carried out on the FMS image data acquired from the Palm Valley-10 well over the interval 2138-1451m, and Palm Valley-10a well over the interval 2334m-1451m.

A total of 201 fractures was identified within the Palm Valley-10 section but only 72 fractures from the Palm Valley-10a section. This disparity in fracture density reflects the poor data quality in the Palm Valley-10a well and not geology.

Most of these fractures are interpreted to be partly open. The next most common fracture type are those interpreted to be closed. About one dozen open fractures are interpreted for each well.

Overall the fractures within the Palm Valley-10 well have a mean dip magnitude of  $88^{\circ}$  towards an azimuth of  $166^{\circ}$ . Those in the Palm Valley-10a well show have a mean dip magnitude of  $76^{\circ}$  towards an azimuth of  $186^{\circ}$ . The open fractures in both wells show a mean dip magnitude of  $82^{\circ}$  towards an azimuth of  $174^{\circ}$ .

The mean fracture aperture for both wells computes to be 0.043mm.

## 1. INTRODUCTION

The Formation MicroScanner Tool was run in the Magellan Petroleum Palm Valley-10 well over the interval 2138-1451m on the 31st of December 1994, and, in the Palm Valley-10a well over the interval 2334m-1451m on the 4th of February 1995.

This report summarizes the location, orientation and aperture of the various types of fractures intersected by the two wells, based on the FMS images. The main findings of an interpretation of the Palm Valley-10 well by Roestenburg dated 2 January 1995 are also incorporated in this report.

The FMS is a 4 pad micro-resistivity sonde, each pad carrying a dense, 16-electrode array. In operation the 4 pads are pushed against the borehole wall as the tool is pulled up the hole and the electrode array is used to record a resistivity map of the borehole wall. When the FMS resistivity data is appropriately scaled, coloured and coupled with the inclinometry data, oriented resistivity images of borehole wall can be generated with a resolution of approximately 5 mm.

In the Palm Valley-10 & 10A wells, the FMS data was processed to provide STATIC NORMALISED, DYNAMIC NORMALISED and FMSCAL borehole images suitable for interactive interpretation using the Image Examiner workstation.

FMS image processing options are described in detail by Serra (1989). For this study, the DYNAMIC images were used for a detailed characterization of the dip orientation and magnitude of the fractures in the logged interval. The STATIC images were used as a guide to the continuous vs. discontinuous nature of the fractures and the FMSCAL images were used to compute the apparent fracture aperture following the work of Luthi et al. (1990) and Cheung (1990).

## 2. FMS IMAGE ANALYSIS

Enclosure 1 shows the detailed FMS image interpretation of the Palm Valley-10 well at 1:40 scale. Images at left are the Static images and those on the right with the colour coded fracture sine wave overlay are the Dynamic images. Enclosure 2 details the interpretation of the Palm Valley-10a well in the same manner.

Numerous fractures recognized in these wells show a conductive (black) electrical signature all the way around the borehole wall, i.e. the fracture trace is black and evident on all four pads of the FMS tool. These fracture types were termed Continuous ( and conductive) fractures and colour coded red. It is thought that they reflect continuous, open fractures penetrated by the bit.

Most of the fractures in the wells are interpreted to be discontinuous around the borehole, i.e. the fracture trace is only evident on 2 or 3 of the FMS pads. These types of fractures were termed Discontinuous fractures and colour coded yellow. It is thought that they reflect discontinuous, or partly open fractures penetrated by the bit.

Resistive fractures (white fracture traces) together with minor, discontinuous fractures that were evident on only part of some pads were lumped together and colour coded cyan. It is thought these types of fractures are effectively closed at the borehole but may well have an open habit away from the borehole. Faults were not evident from these FMS images.

The FMS image quality for the Palm Valley-10 well is very good to excellent throughout most of the logged interval (2138-1451m). A total of 201 fractures were identified and their orientations are summarized as a whole and for their different types in Figure 1 (Wulff plots) and Figure 2 (Strike plots). Enclosure 3 displays the various fracture types in terms of tadpole with depth, Enclosure 4 shows the same data in terms of azimuth with depth and Enclosure 5 shows a dip and strike plot representation with depth.

The Palm Valley-10a FMS image quality has, for some large intervals, been adversely effected "sticky hole" conditions. Sticky hole results in erratic sonde speeds which tends to "blur" the borehole images. For the Palm Valley-10a data set, processing options that use various weighted combinations of cable speed and button-to-button correction were trialled in order to produce the best possible image data. Despite this, some intervals still remain un-interpretable. A total of 72 fractures were identified and their orientations are summarized as a whole and for their different types in Figure 3 (Wulff plots) and Figure 4 (Strike plots). Enclosure 6 displays the various fracture types in terms of tadpole with depth, Enclosure 7 shows the same data in terms of azimuth with depth and Enclosure 8 shows a dip and strike plot representation with depth.

### 3. FMS FRACTURE TRENDS

Figure 3 shows that the 201 fractures interpreted in the Palm Valley-10 well have a mean dip magnitude of  $88^\circ$  towards an azimuth of  $166^\circ$ .

Only 12 of these fractures were classified as being Continuous (red) and their mean dip magnitude is  $82^\circ$  towards an azimuth of  $174^\circ$ . The majority of the fractures (122) are classified as being Discontinuous (yellow) and their mean dip orientation dominates the overall trend. A substantial number (67) of resistive/minor fractures are evident and they show a mean dip magnitude of slightly less than  $90^\circ$ , again towards an azimuth of  $166^\circ$ . While the continuous fractures interpreted in this well statistically show a slightly flatter, more southerly dip trend, it is probable that there is only one fracture set is present in the logged interval.

Figure 3 shows that the 72 fractures interpreted in the Palm Valley-10a well have a mean dip magnitude of  $76^\circ$  towards an azimuth of  $186^\circ$ .

Ten of these fractures were classified as being Continuous and their mean dip magnitude is  $82^\circ$  towards an azimuth of  $174^\circ$ , i.e. exactly the same orientation as that of the Palm Valley-10 well. Again the majority of the fractures (44) in the logged interval are classified as being Discontinuous and their mean orientation is  $74^\circ$  towards  $189^\circ$ .

A total of 18 fractures were also classified as being resistive/minor fractures and they show a mean orientation of  $77^\circ$  towards  $190^\circ$ .

Generally, the fractures interpreted in the Palm Valley-10a well show more scatter in their orientation trends than those in the Palm Valley-10 well fractures. It is thought that most of this scatter reflects the differences in the data quality rather than some geological differentiation.

### 4. FMS FRACTURE APERTURE

As described by Cheung et. al. (1990) FracView uses the FMS conductivity response in an open fracture, along with the conductivity of the fluid filling that open fracture to compute the fracture aperture.

Enclosures 9 and 10 show the apparent fracture aperture computed from all interpreted fractures for the 2 wells. For both wells, the fracture aperture computes to be within the range 0.005-0.400mm, and have a mean of 0.043mm.

## **Bibliography**

Luthi, S., Souhaiti, P., "Fracture Aperture from Electrical Borehole Scans" Geophysics, 1990, vol 74, N0.7

Cheung, P.S.Y., "Workstation Based Fracture Evaluation Using Borehole Images": SPE 1990. N0. 20573.

Serra, O., "Fundamentals of Well Log Interpretation" : 1985 Elsevier

Serra, O., "Advanced Interpretation of Wireline logs" : 1986 Schlumberger ATL Marketing & Technique publication No. M - 090029



## FMS RESULTS

	<u>PV-10</u>	<u>PV-10A</u>
Image Quality	Very Good	*Generally Poor
Number of Fractures	201	72
Mean Dip/Azimuth (No.)		
- All Fractures	88°/166° (201)	76°/186° (72)
- Open	82°/174° (12)	82°/174° (10)
- Partly Open	88°/166° (122)	74°/189° (44)
- Closed	90°/166° (67)	77°/190° (18)

Aperture: for both wells computes within the range 0.005-0.4 mm, with a mean of 0.043 mm.

PV-10A Fracture orientations show more scatter. Considered this is reflection of data quality.

(\*Image Quality Adversely effected by erratic sonde speed in high angle hole, blurred images).





1862.0

PV-10  
P1 UNIT

1863.0

TD: 9/50  
TD: 8/36

TD: 15/13

1864.0

TD: 1/42

FIRST P1  
SANDSTONE

TD: 11/207

1865.0

1866.0

1867.0

1868.0

TD: 12/23

TD: 15/14

1869.0

MAIN UPPER  
P1 UNIT  
SANDSTONE

TD: 9/268  
TD: 78/128  
TD: 82/136

TD: 9/22  
TD: 69/146

1870.0

<0.06mm

↑

\*

0.4MMCFD

TD: 7/8

1871.0

TD: 12/51

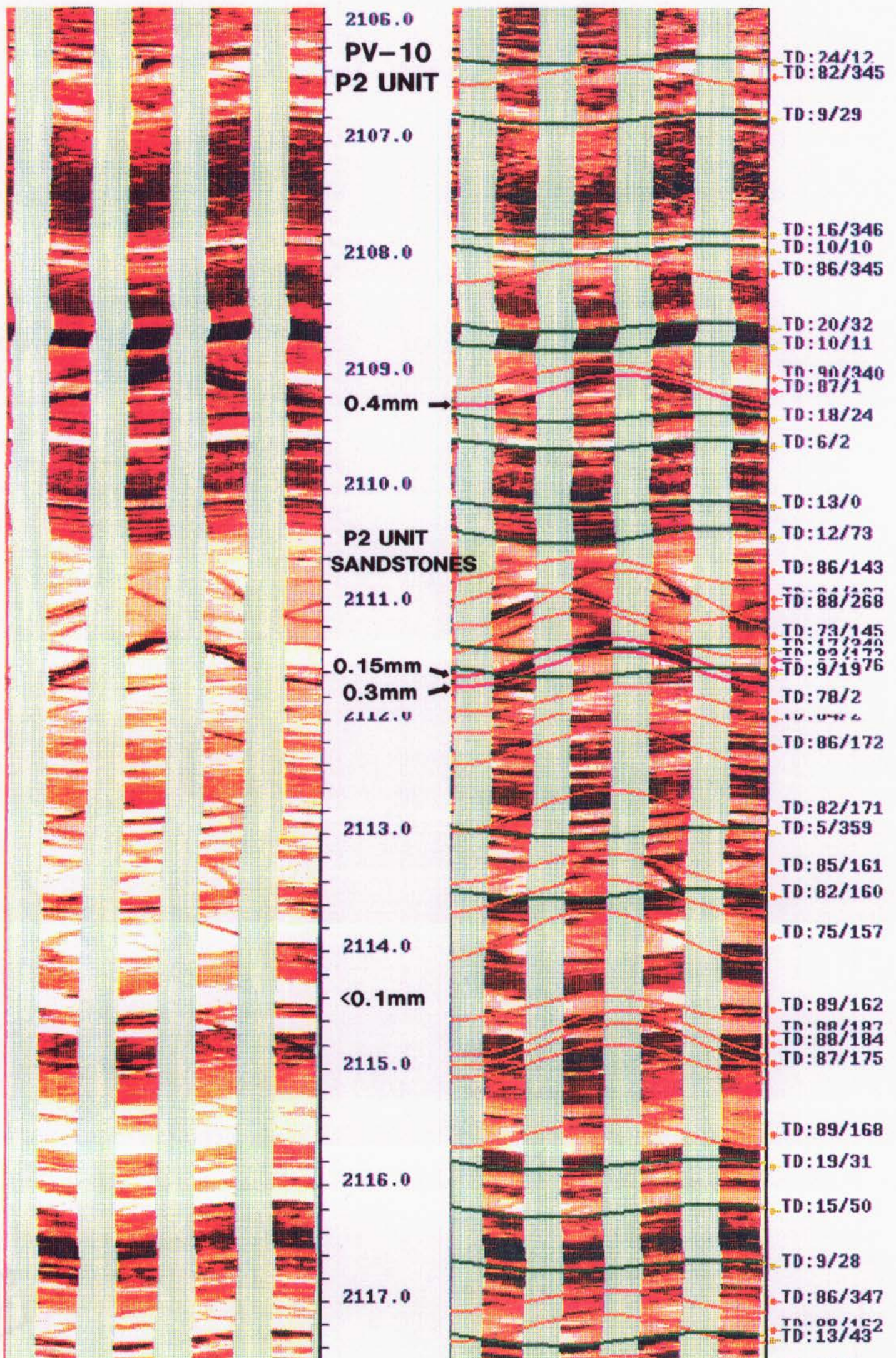
1872.0

TD: 7/14

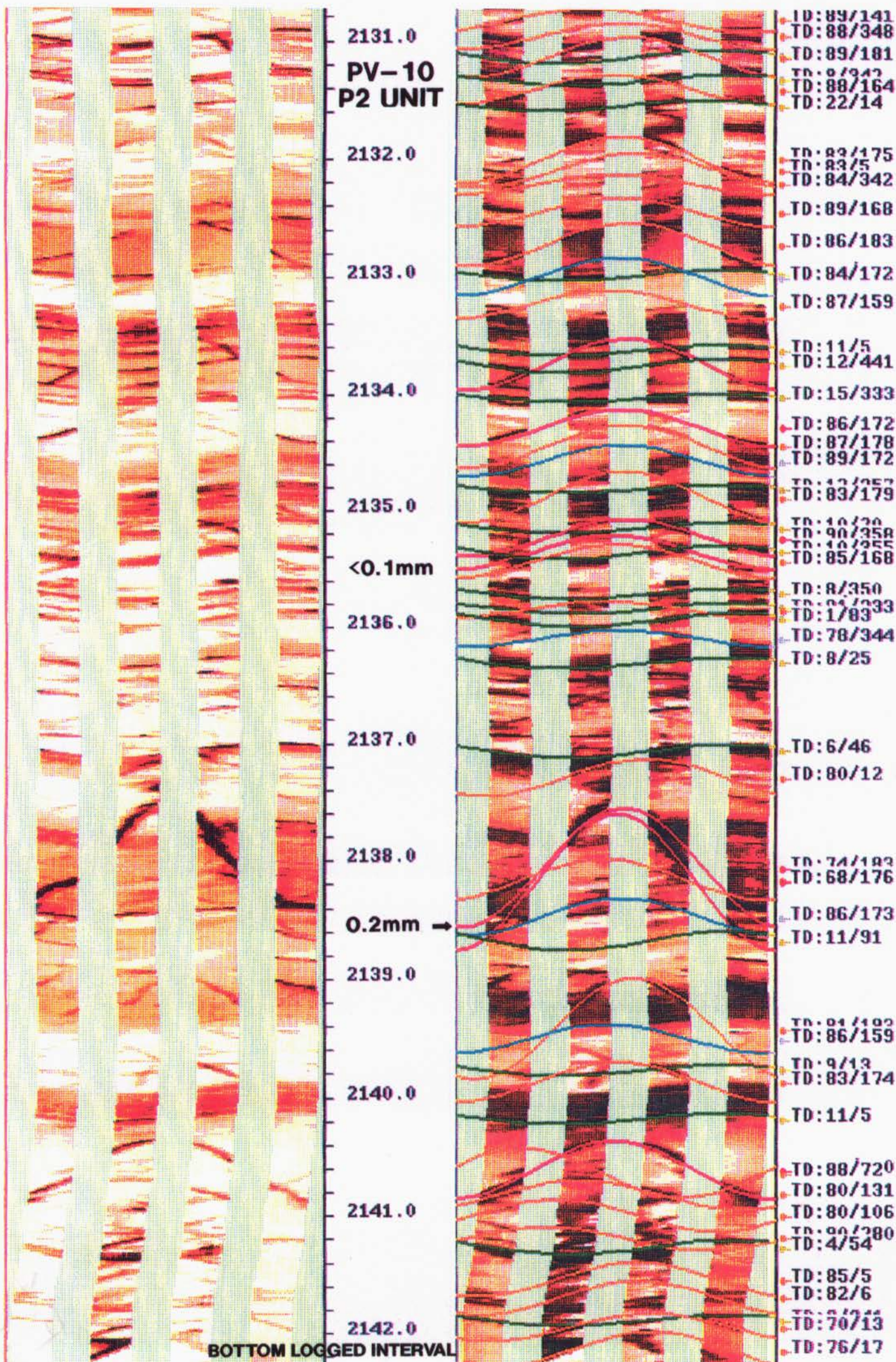
1873.0

TD: 5/353











1974.0  
PV-10A

FIRST P1  
SANDSTONE  
1975.0

≤ 0.02mm

1976.0

1977.0

1978.0

1979.0

1980.0

1981.0

1982.0  
MAIN UPPER  
P1 UNIT  
SANDSTONE

1983.0

≤ 0.02mm

1984.0

↑  
\*  
1.4 MMCFD

1985.0

TD:74/166

TD:72/168

TD:14/338

TD:58/200

TD:57/314

TD:88/277

TD:76/168

TD:71/218

TD:11/275



PV-10A  
P2 UNIT  
2301.0

1' BEDDED  
SANDSTONES  
2302.0  
AND  
SILTSTONES

2303.0

2304.0

<0.06mm

2305.0

2306.0

2307.0

2308.0

2309.0

2310.0

MINOR  
FORMATION  
WATER  
INFLUX

2311.0

2312.0

TD:5/0

TD:15/15

TD:79/184

TD:12/10

TD:90/177

TD:64/180

TD:12/11

TD:16/36

TD:82/186

TD:14/226

TD:86/350

TD:16/268



2323.0  
PV-10A  
P2 UNIT

2324.0

2325.0

2326.0

2327.0

<0.1mm

2328.0

2329.0

2330.0

2331.0

2332.0

2333.0

BOTTOM  
LOGGED  
INTERVAL

2334.0

TD:59/228

TD:61/226

TD:24/345

TD:81/343

TD:74/161

TD:4/339

TD:80/353

TD:80/167

TD:72/189

TD:21/7

TD:75/178

TD:84/167

TD:87/167

TD:97/180

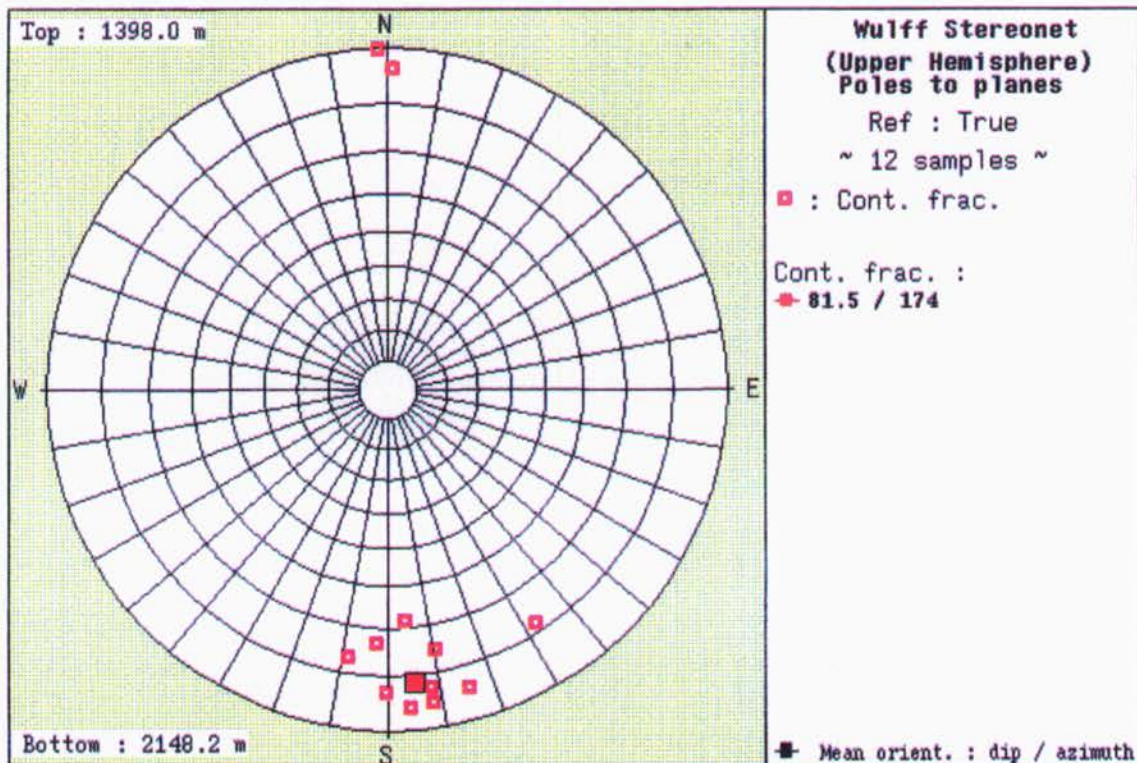
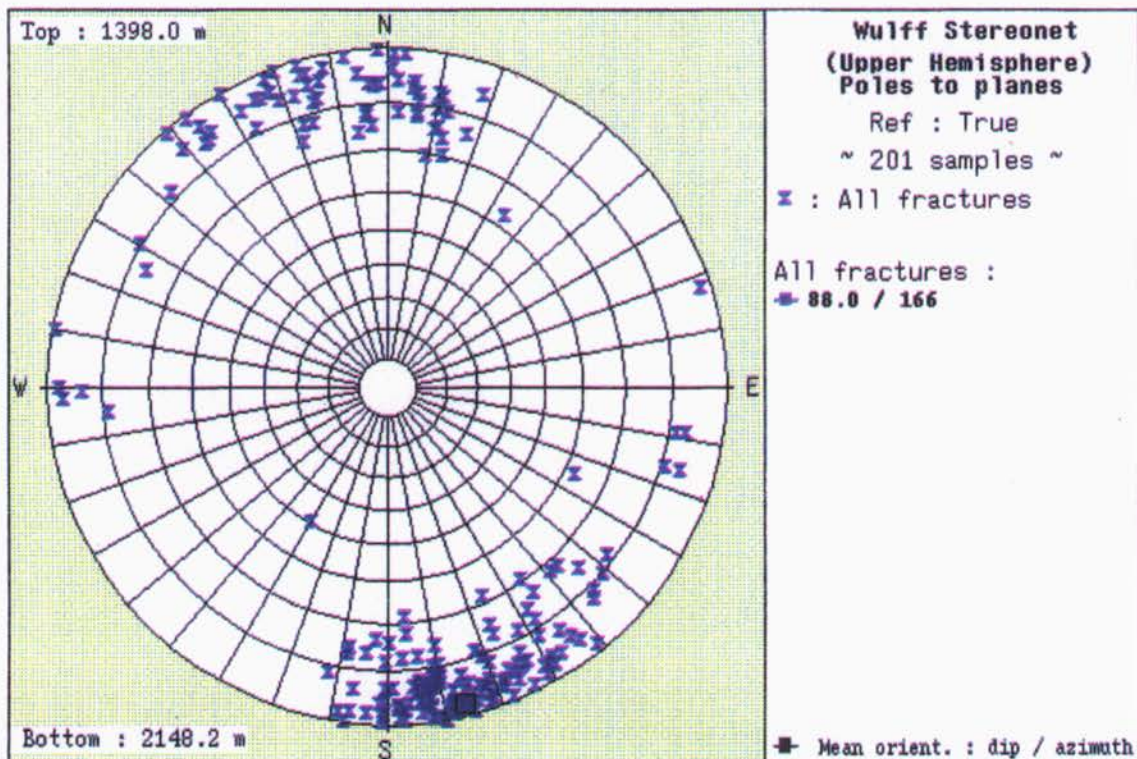


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FracView

Figure 1A

WELL : PALM VALLEY #10  
CLIENT : MAGELLAN PETROLEUM  
FIELD : PALM VALLEY  
DATE : Fri 17 Feb 1995 @ 15:48



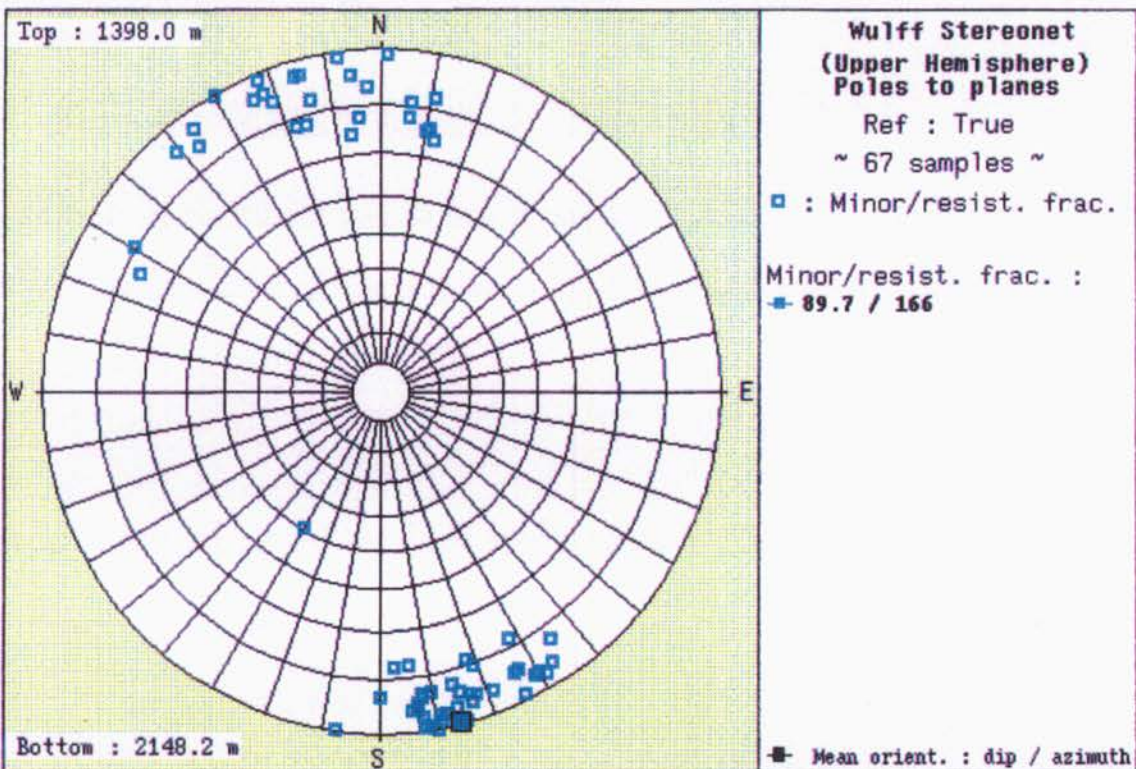
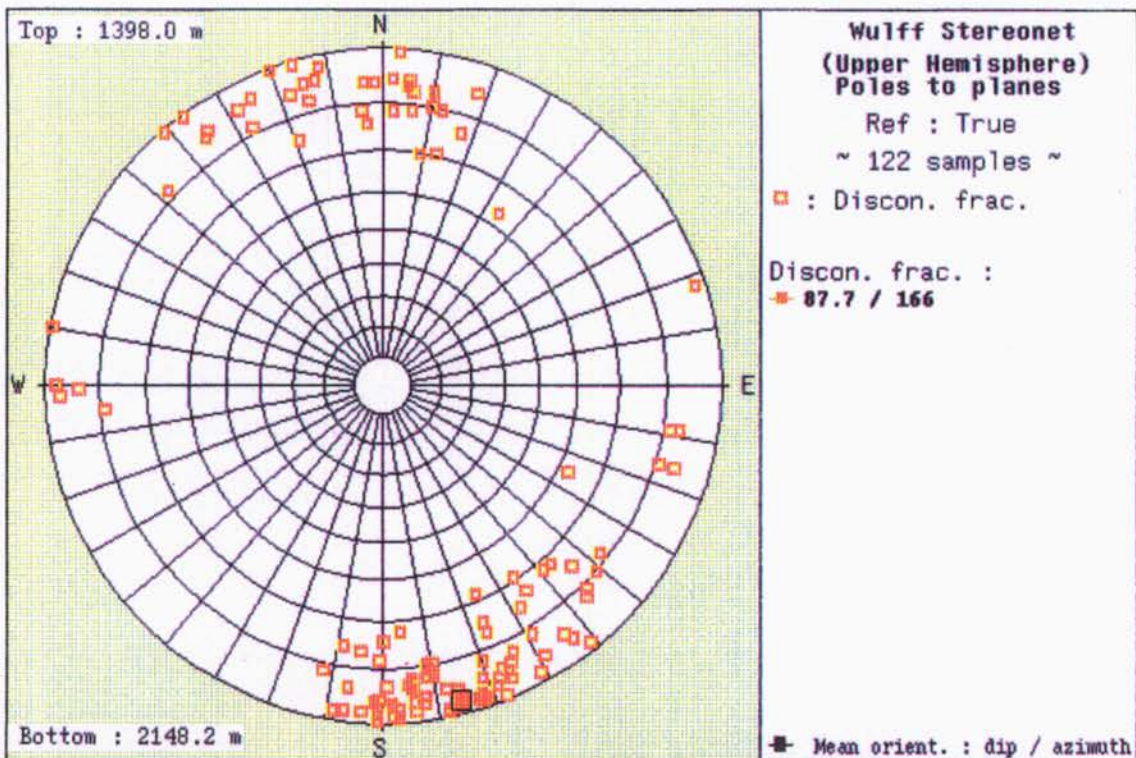


Schlumberger

FracView

Figure 1B

WELL : PALM VALLEY #10  
CLIENT : MAGELLAN PETROLEUM  
FIELD : PALM VALLEY  
DATE : Fri 17 Feb 1995 @ 15:48

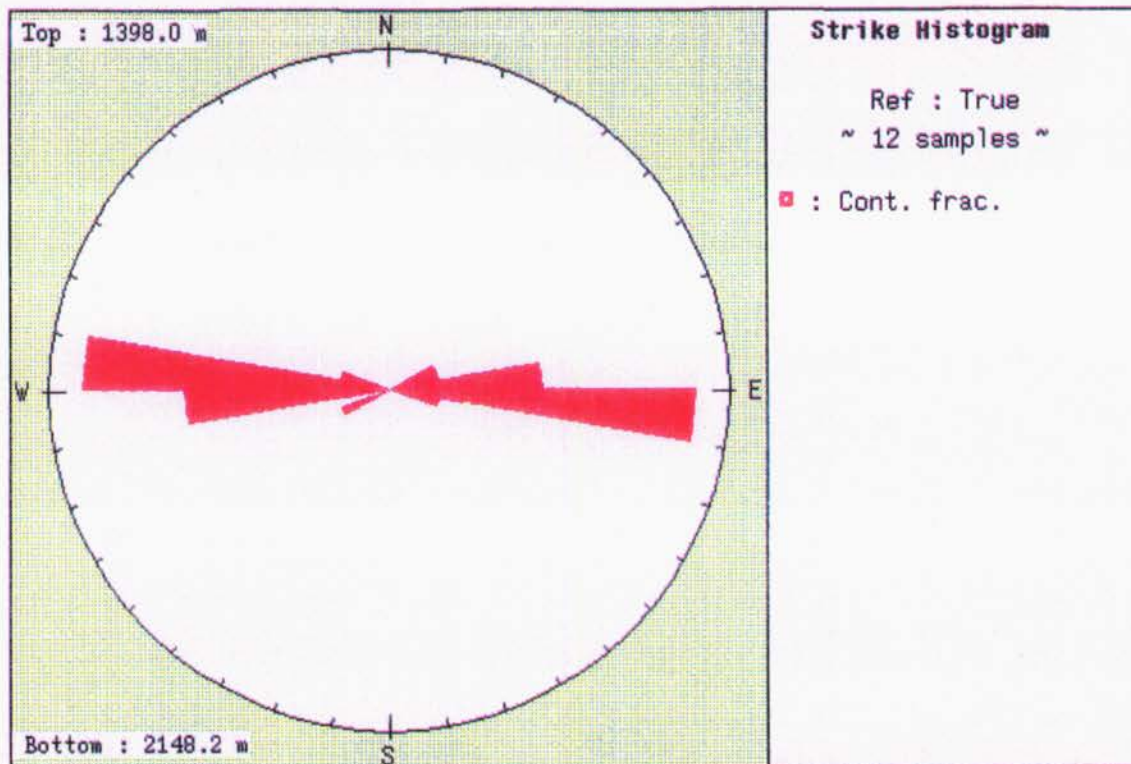
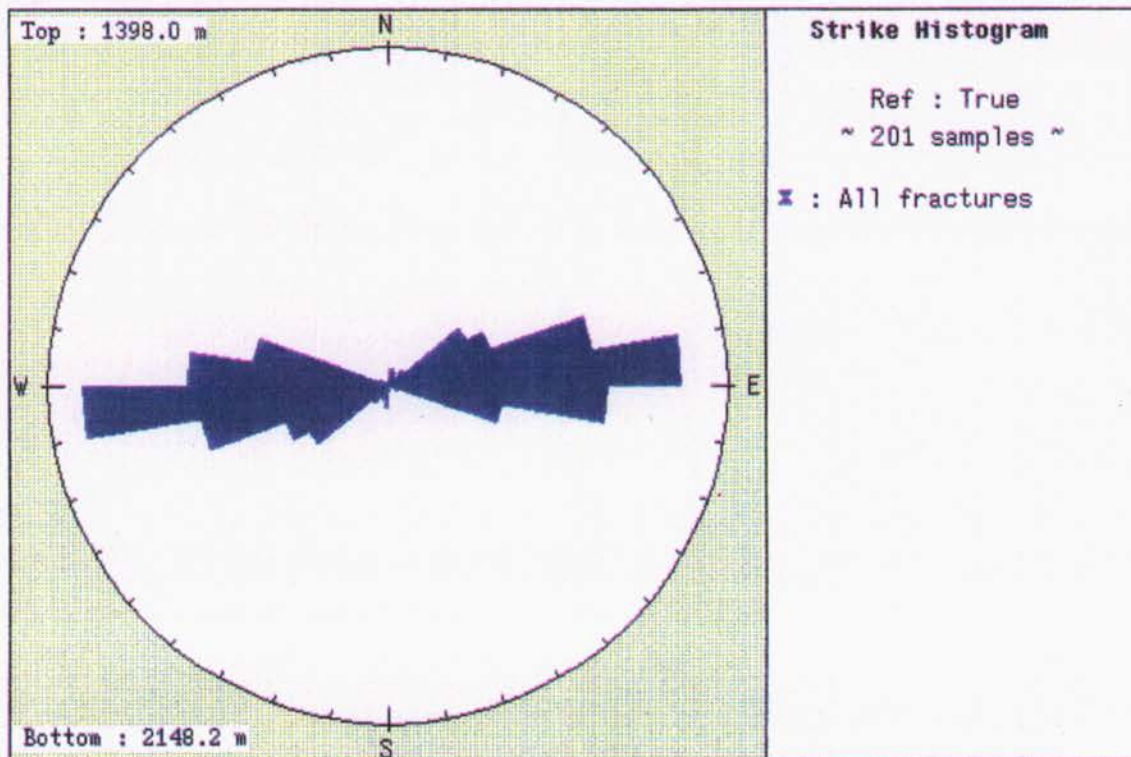


Schlumberger

FracView

Figure 2A

WELL : PALM VALLEY #10  
CLIENT : MAGELLAN PETROLEUM  
FIELD : PALM VALLEY  
DATE : Fri 17 Feb 1995 @ 15:52



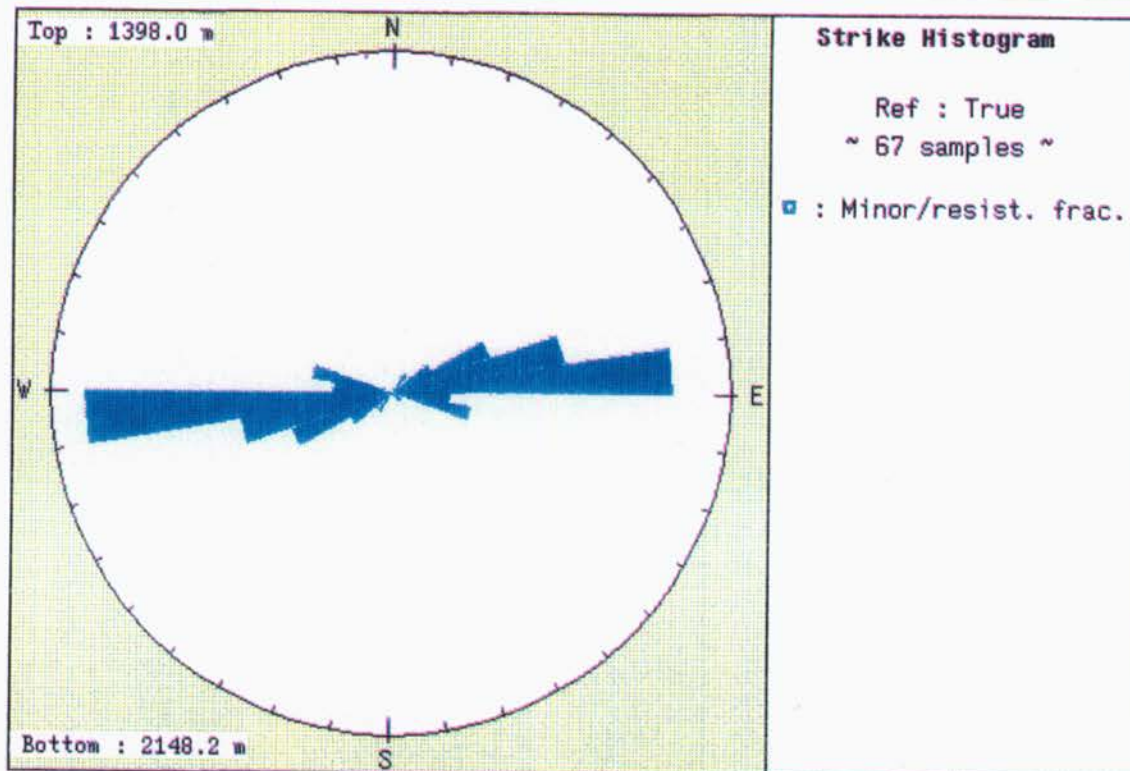
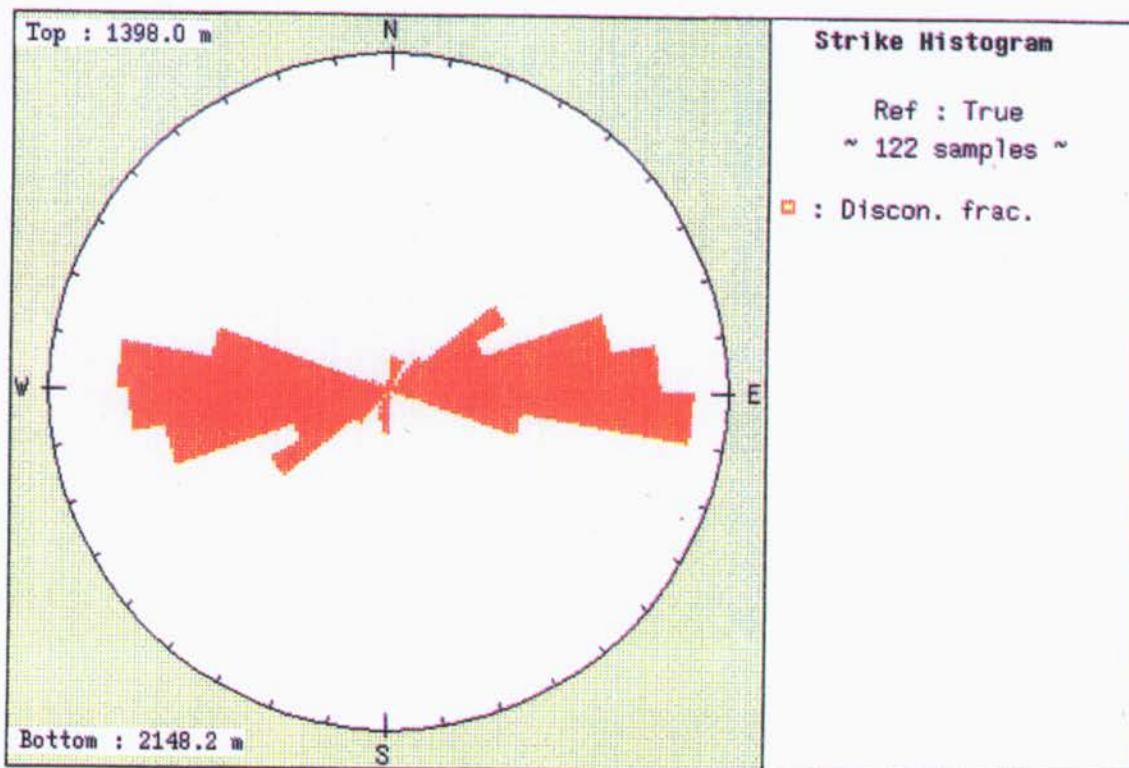


Schlumberger

FracView

Figure 2B

WELL : PALM VALLEY #10  
CLIENT : MAGELLAN PETROLEUM  
FIELD : PALM VALLEY  
DATE : Fri 17 Feb 1995 @ 15:52

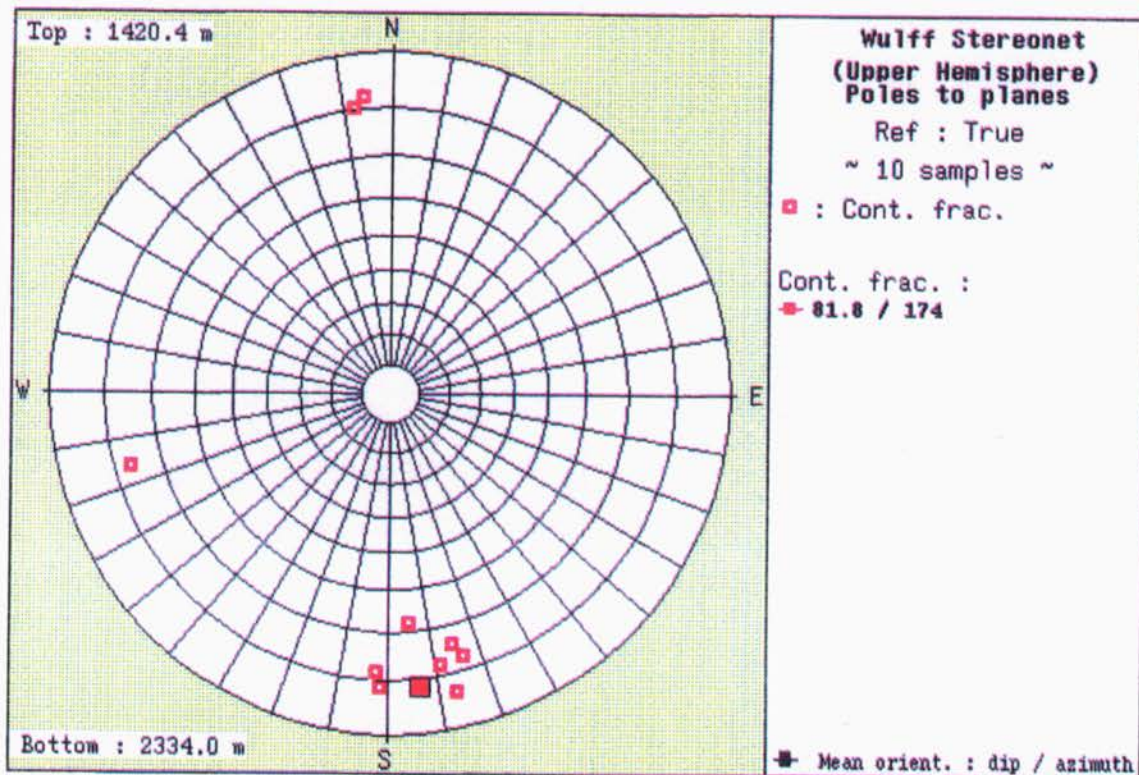
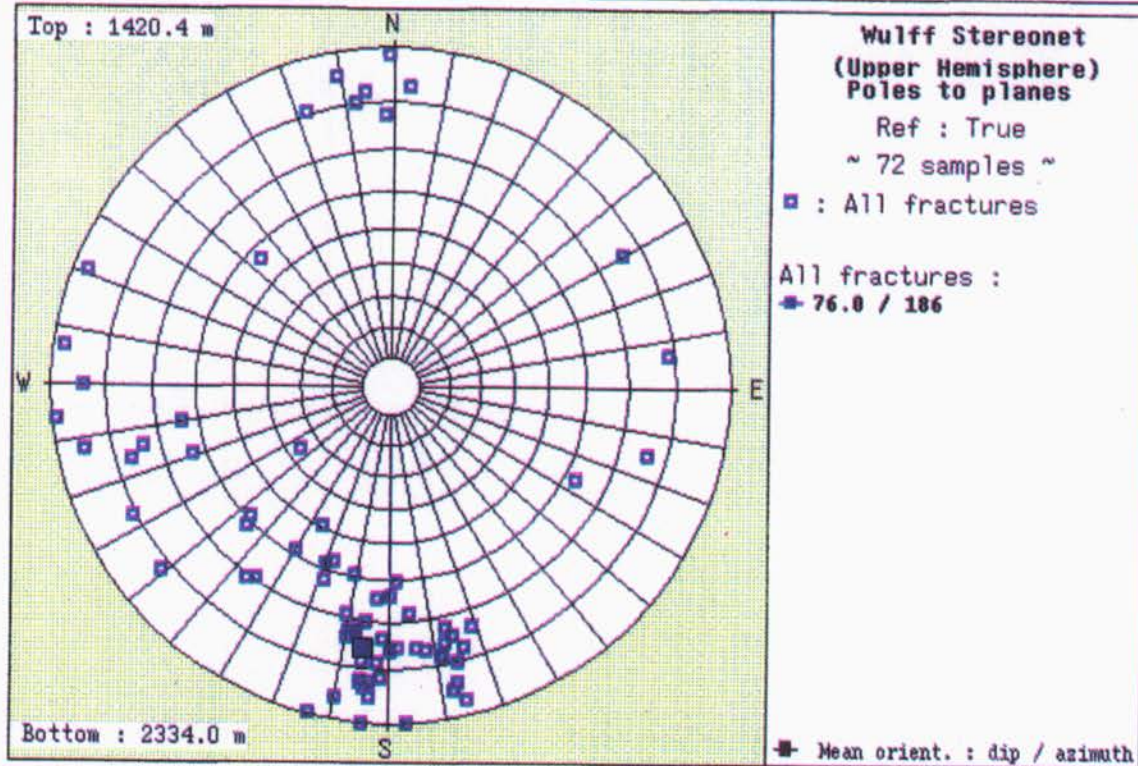


Schlumberger

FracView

Figure 3A

WELL : PALM VALLEY #10A  
CLIENT : MAGELLAN PETROLEUM  
FIELD : PALM VALLEY  
DATE : Fri 17 Feb 1995 @ 17:14



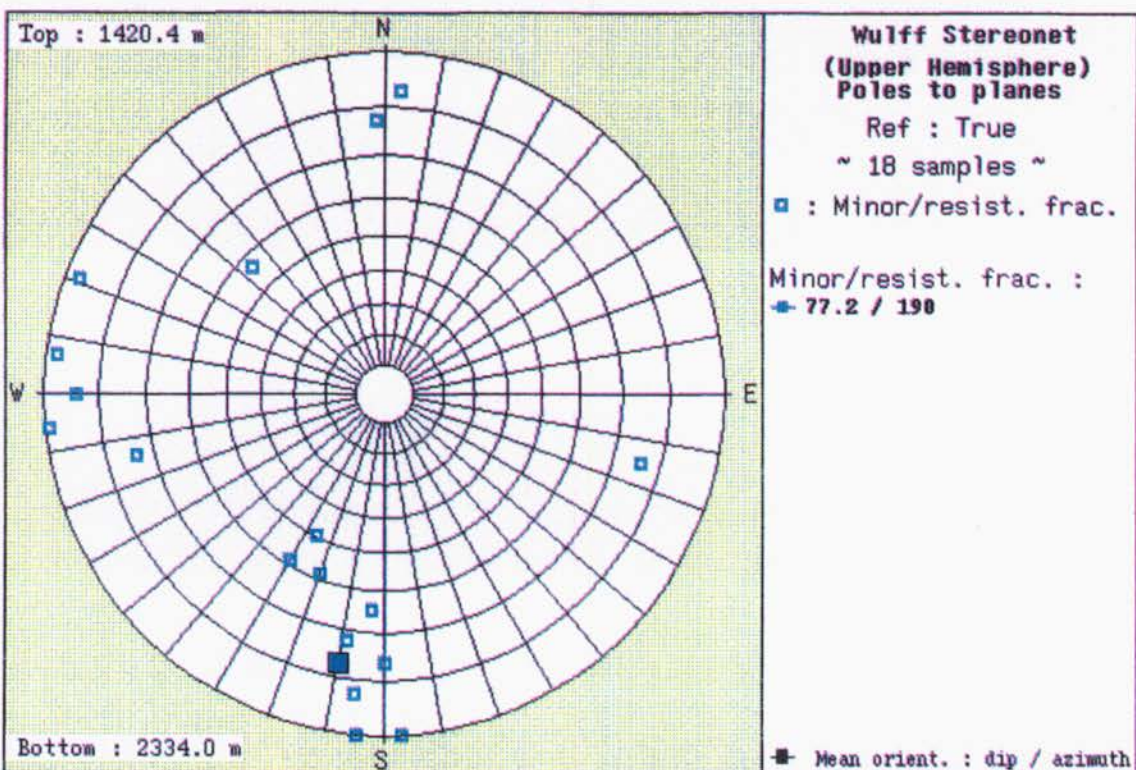
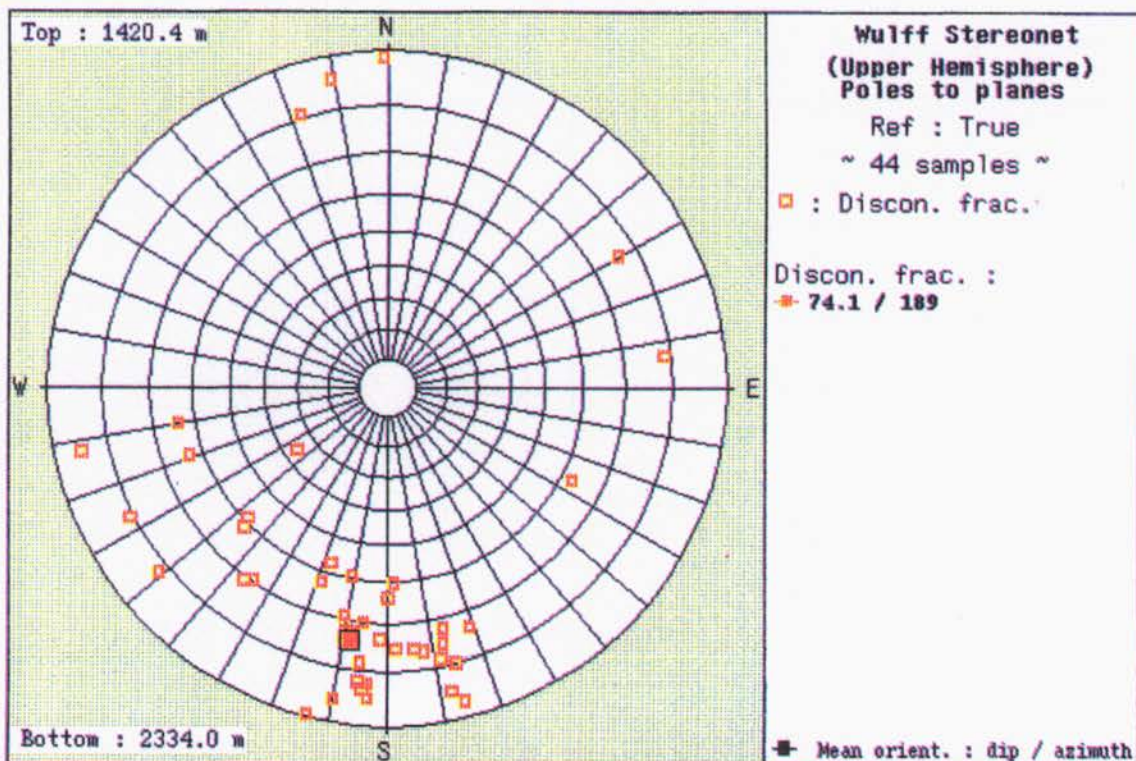


Schlumberger

FracView

Figure 3B

WELL : PALM VALLEY #10A  
CLIENT : MAGELLAN PETROLEUM  
FIELD : PALM VALLEY  
DATE : Fri 17 Feb 1995 @ 17:14



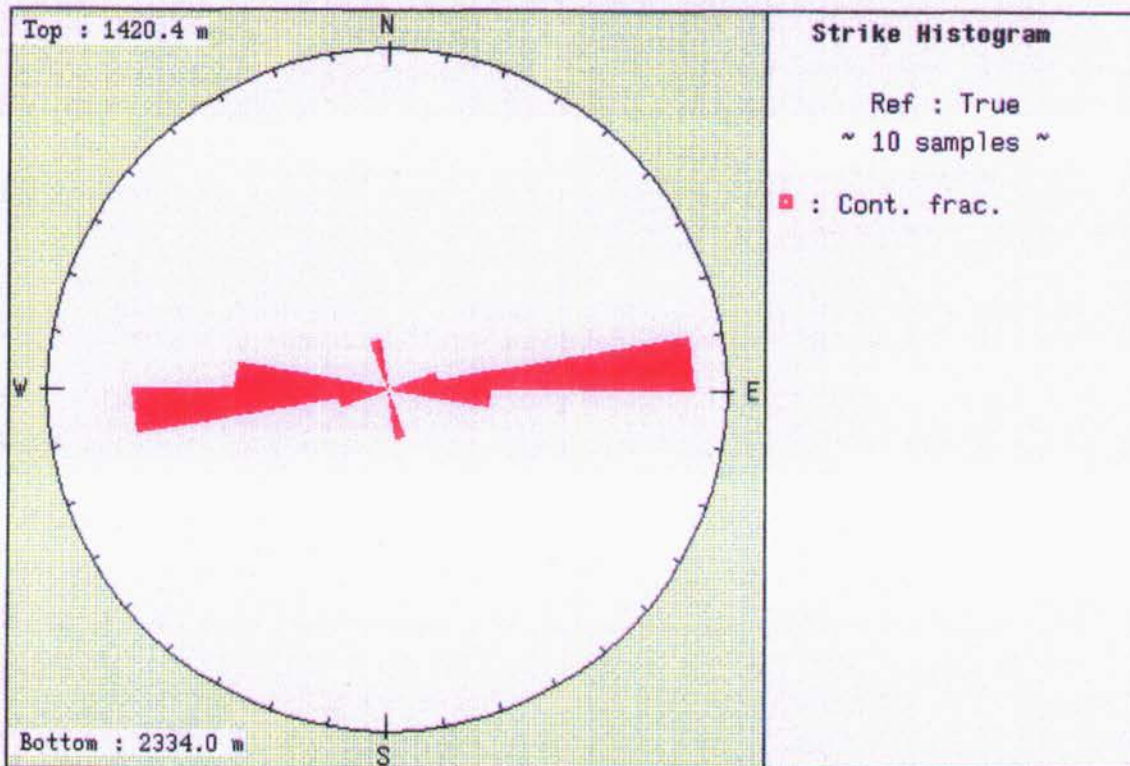
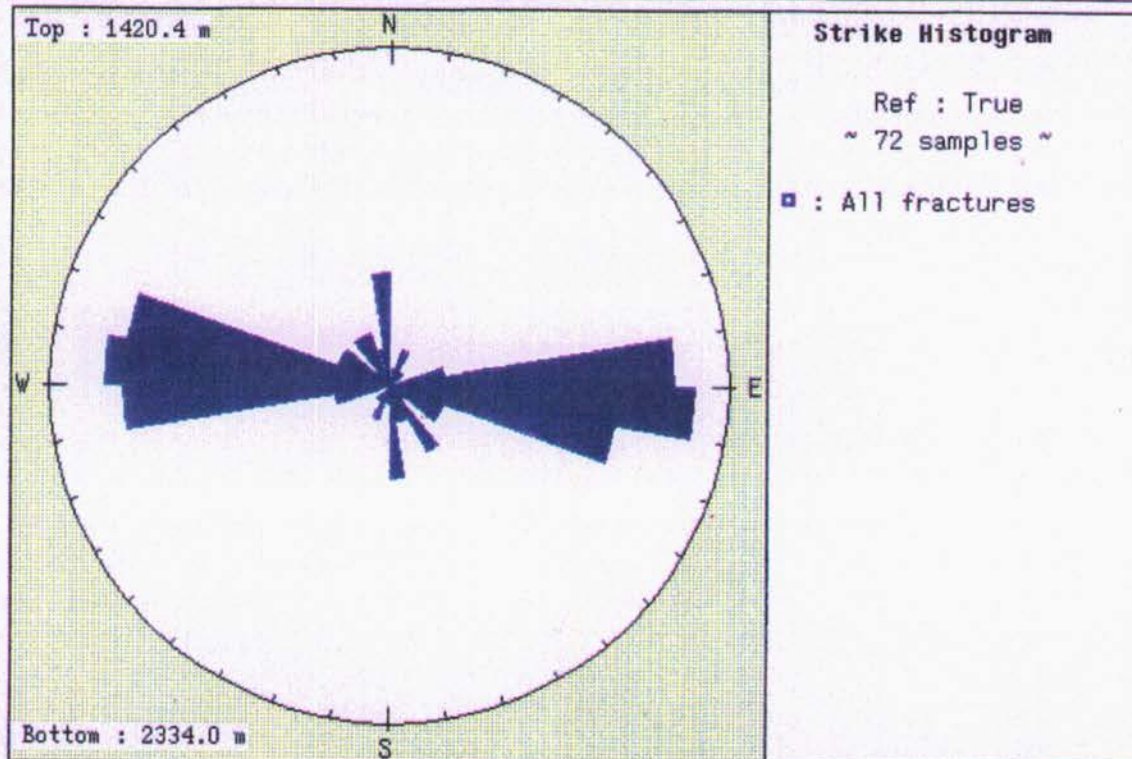


Schlumberger

# FracView

Figure 4A

WELL : PALM VALLEY #10A  
CLIENT : MAGELLAN PETROLEUM  
FIELD : PALM VALLEY  
DATE : Fri 17 Feb 1995 @ 17:17

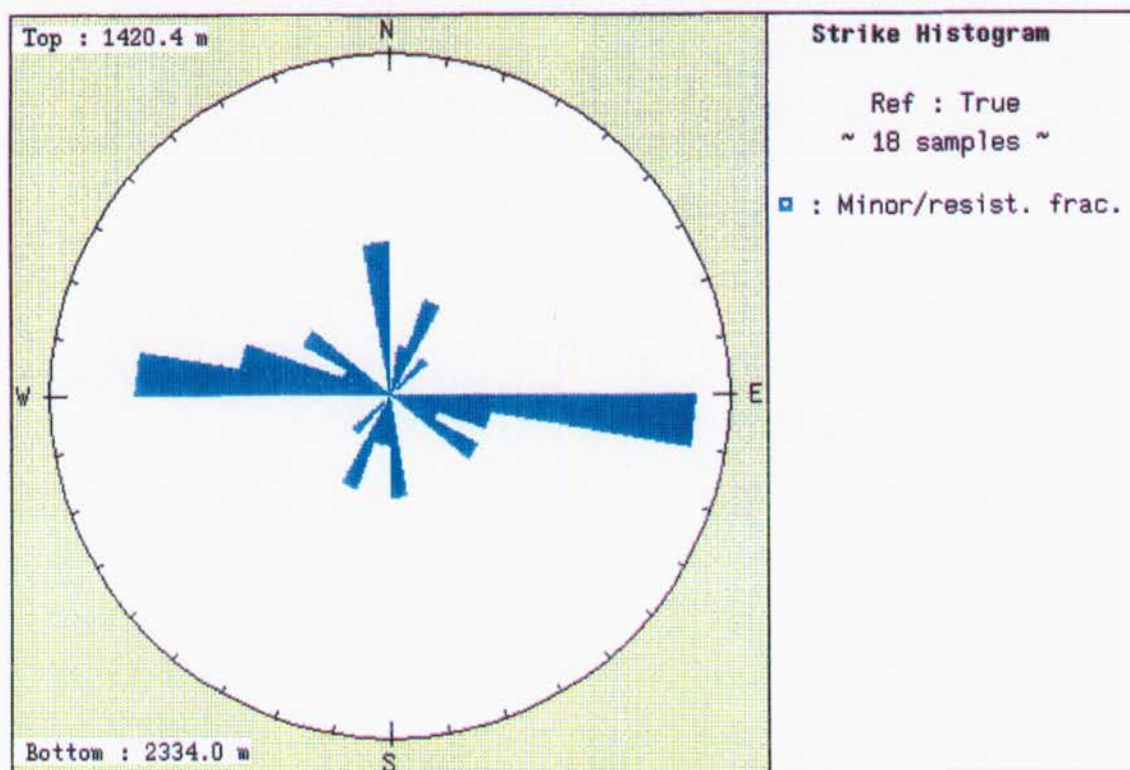
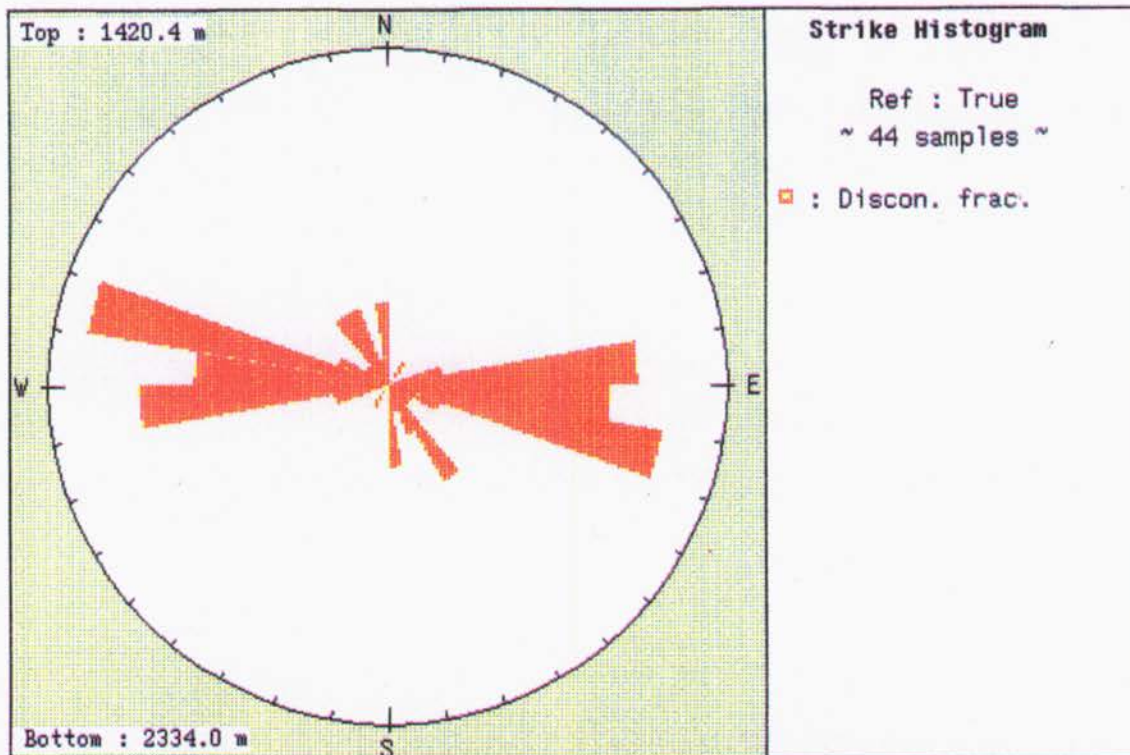


Schlumberger

# FracView

Figure 4B

WELL : PALM VALLEY #10A  
CLIENT : MAGELLAN PETROLEUM  
FIELD : PALM VALLEY  
DATE : Fri 17 Feb 1995 @ 17:17

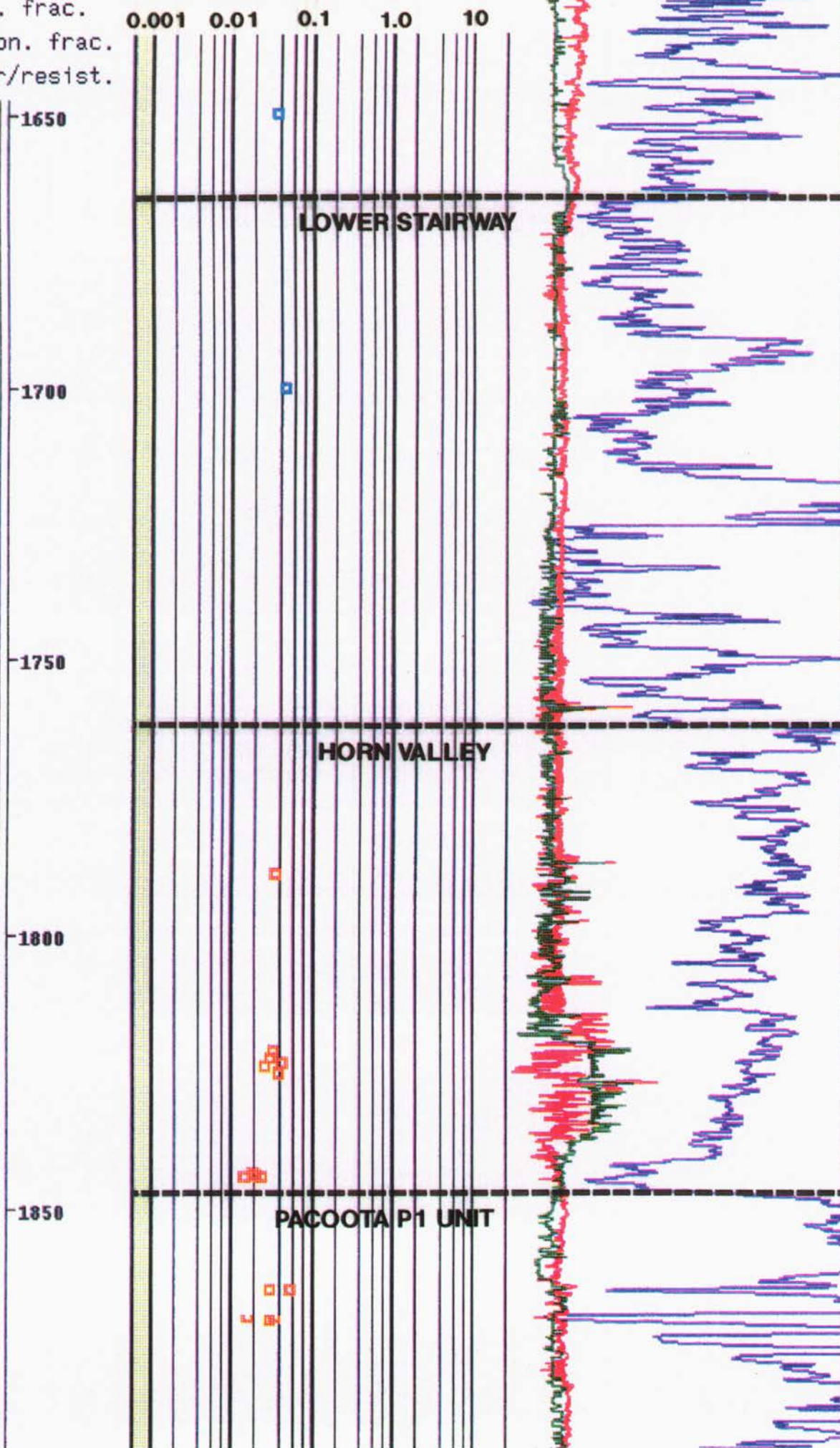




~ 72 samples ~

# PALM VALLEY-10

- : Cont. frac.
- : Discon. frac.
- : Minor/resist.

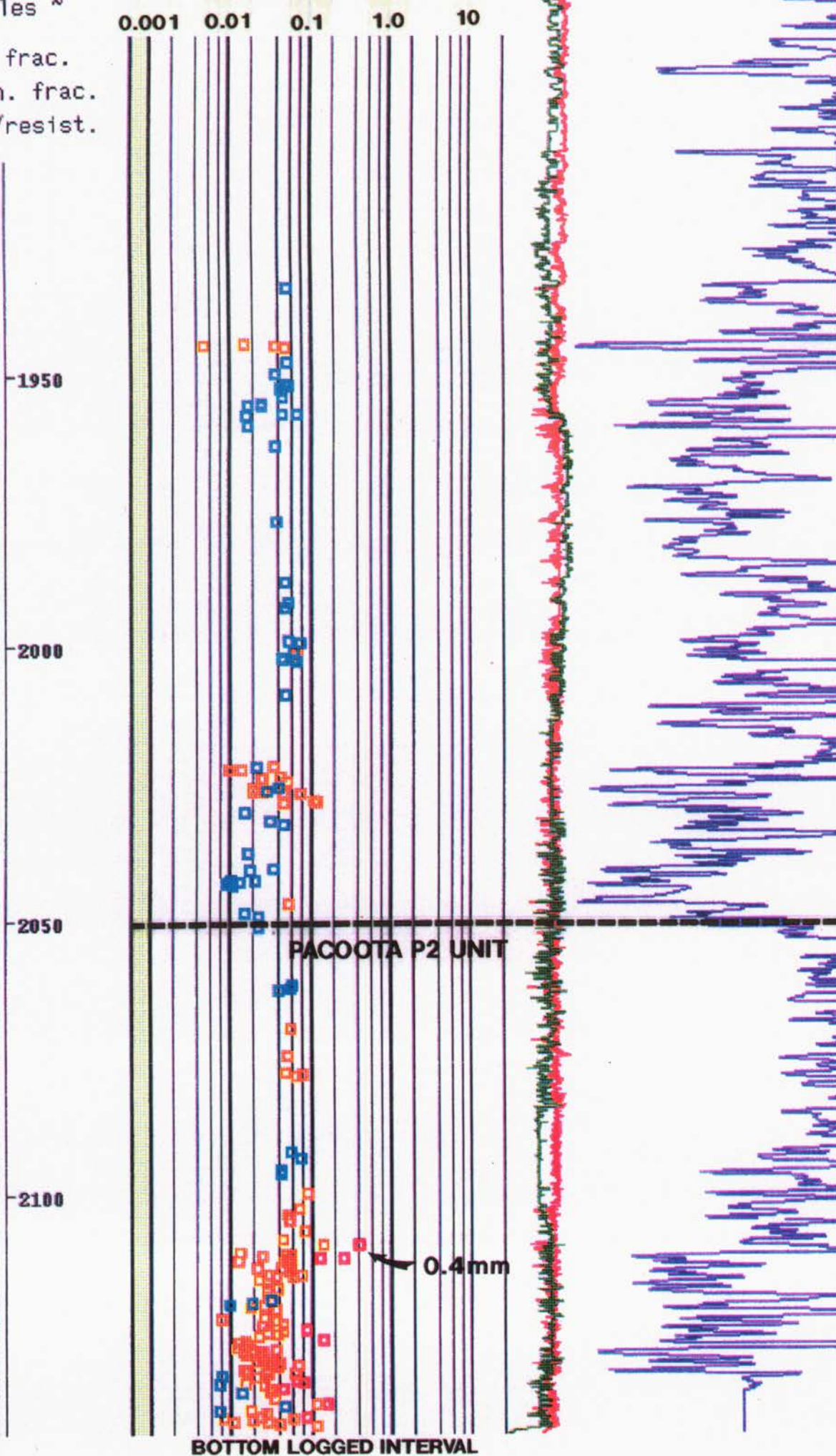




# PALM VALLEY-10

~ 72 samples ~

- : Cont. frac.
- : Discon. frac.
- : Minor/resist.



BOTTOM LOGGED INTERVAL



# PALM VALLEY-10A

~ 201 samples ~

- : Cont. frac.
- : Discon. frac.
- : Minor/resist.

0.001 0.01 0.1 1.0 10

HORN VALLEY

PACOOTTA P1 UNIT

1850

1900

1950

2000

2050

1900  
1950  
2000  
2050

~ 201 samples ~

# PALM VALLEY-10A

- : Cont. frac.
- : Discon. frac.
- : Minor/resist.

