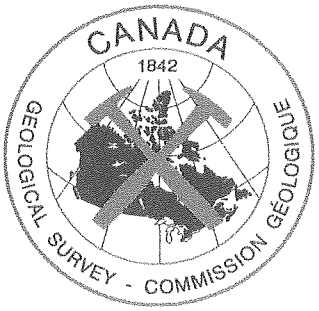

Geological Survey of Canada open file # 3998

Vitrinite reflectance (Ro) of dispersed organic matter from Husky/Bow Valley et al North Ben Nevis P-93

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Vitrinite reflectance (Ro) of dispersed organic matter from Husky/Bow Valley et al North Ben Nevis P-93

G.S.C. Locality No.: D265 **Unique Well ID:** 300 P93 46500 48150 **Location:** 46.713269°N, 48.475092°W

R.T. Elevation: 22m **Water Depth:** 99.3m **Total Depth:** 5282.2m

Sampled Interval: 920-5280m **Interval Studied:** 920-5280m

Depth Units: Meters referenced to R.T. **Rig Release Date:** November 1, 1985

Vitrinite reflectance has been determined on 30 rotary cuttings samples from Husky/Bow Valley et al North Ben Nevis P-93, which was classified as an exploratory well and is located on the Grand Banks approximately 330 km east northeast of St. John's, Newfoundland. Well status is Plugged and Abandoned.

Sample preparation followed the procedures listed in Appendix I. Data acquisition and manipulation for this report utilized the Zeiss Photometer III system with a custom interface to a microcomputer which provides data storage and statistical summaries.

Analysis of the well reveals thermal maturation intervals given in Table I. Specific maturation levels, as set out in this report, are based on those of Dow (1977) with modified terminology (Appendix II).

Table I
Inferred Thermal Maturation Levels*

Depth in meters	Vitrinite Reflectance (%Ro)**	Maturity for oil generation*
99	(0.21)	Sea floor
1490	0.3	immature
2540	0.4	immature approaching maturity
3350	0.5	marginally mature
4010	0.6	onset of significant oil generation
5060	0.8	peak of oil generation
5282	(0.85)	T.D. (within oil window)

* *Actual hydrocarbon products depend on type of organic matter present.*
** *( )'s indicate Ro's extrapolated from linear regression (0.119 log Ro/km).*

Remarks

Sample coverage for vitrinite reflectance analysis (Figure 1, Table II) was very complete over the section penetrated at North Ben Nevis P-93. The data were plotted on a log Ro vs. linear depth scale and a regression line was calculated and plotted through the data points (Figure 1). The 'error bars' displayed on the maturation profile indicate one standard deviation on either side of the mean and may be deceivingly small for samples with very few readings. The slope of the maturation line is 0.119 log Ro/km.

The histogram display plot shows the variability in the reflectance populations and represents the maturation of the sediments with depth (Figure 2). Plotting reflectance histograms on a log scale may help reveal any trends that may be present in the Ro data. It can also help to demonstrate the effects of cavings, geology, casing points and other influences on the vitrinite reflectance populations.

These vitrinite reflectance data provide evidence that the thermal regime of the lower section of North Ben Nevis P-93 is suitable to generate and preserve hydrocarbons within the drilled section, between 3350 and 5282m (T.D.), assuming potential source rocks and traps are present.

Discussion

The vitrinite reflectance maturity profile for this Grand Banks well shows a stepwise increase from an initial value of 0.21%Ro at 950m to 0.97%Ro at 5282 (T.D.). Similar stepwise or "kinky" profiles were reported as being related to paleopore pressure (Law, 1989). The extensive kerogen sample coverage available for North Ben Nevis P-93 provides a good view of this feature which is present in many wells. Other East Coast offshore wells show similar 'step' profiles. Some examples from Grand Banks are Hebron I-13 (Avery, 1993) and Trave E-87 (Avery, 1987) and from Scotian Shelf North Banquereau I-13 (Avery, 2000) and Glenelg J-48 (Avery, 1990).

The maturity trend for this well is slightly lower than that determined for Ben Nevis I-45 (approx.18km east southeast; unpublished report). The maturation trend for the Ben Nevis I-45 well was based on vitrinite reflectance measurements on coaly particles ('bark vitrain'), not kerogen. Vitrinite reflectance on such particles is considered prone to sample contamination from cavings, reworked sediments, mud additives, etc. This may account for the considerable scatter of the data points in the Ben Nevis I-45 profile (Figure 3).

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c.c. K.D. McAlpine, MResG, Dartmouth
A.E. Jackson, MResG, Dartmouth
MResG Files, Dartmouth
Central Technical Files, Ottawa
K. Osadetz, GSC (Calgary)
N. DeSilva, CNOPB, St. John's (3 copies)
C. Beaumont, Dalhousie Univ., Halifax

Table II

Summary of kerogen - based vitrinite reflectance

Sample Labels	Depths in meters	Mean Ro (SD) non-rotated	Number of Readings Total	Edited
K0882A	915-950	0.21 (±0.04)	9	9
K0882B	1090-1100	0.25 (±0.04)	11	11
K0882C	1240-1250	0.28 (±0.03)	10	10
K0882D	1390-1400	0.30 (±0.05)	9	9
K0883A	1565-1575	0.31 (±0.04)	6	6
K0883B	1695-1705	0.33 (±0.06)	10	10
K0883C	1845-1855	0.36 (±0.04)	11	11
K0883D	1995-2005	0.40 (±0.04)	6	6
K0884A	2145-2155	0.34 (±0.04)	11	11
K0884B	2300-2310	0.40 (±0.05)	11	11
K0884C	2420-2430	0.44 (±0.03)	6	6
K0884D	2600-2610	0.44 (±0.06)	8	8
K0885A	2750-2760	0.43 (±0.06)	16	16
K0885B	2890-2900	0.49 (±0.06)	16	16
K0885C	3065-3075	0.47 (±0.05)	12	12
K0885D	3180-3190	0.43 (±0.05)	19	19
K0886A	3375-3385	0.49 (±0.04)	16	16
K0886B	3495-3505	0.52 (±0.05)	20	20
K0886C	3585-3625	0.53 (±0.05)	21	21
K0886D	3735-3775	0.56 (±0.06)	22	22
K0887A	3905-3915	0.53 (±0.06)	15	15
K0887B	4055-4095	0.64 (±0.06)	9	9
K0887C	4235-4275	0.51 (±0.05)	6	6
K0887D	4415-4455	0.73 (±0.06)	17	13
K0888A	4595-4635	0.71 (±0.06)	20	19
K0888B	4745-4785	0.66 (±0.06)	14	10
K0888C	4925-4965	0.72 (±0.07)	16	11
K0888D	5015-5025	0.82 (±0.06)	5	5
K0889A	5125-5165	0.87 (±0.04)	16	13
K0889B	5245-5280	0.97 (±0.06)	8	6

Table III

Formation Tops (McAlpine, 1990)

Formation	Depth
Banquereau	in casing
(unconformity)	1923
South Mara Unit	1923
(unconformity)	2163
Dawson Canyon	2163
Petrel Mbr	2328-2365
Nautilus Shale	2380
(unconformity)	2542
(unconformity)	2735
Ben Nevis	2735
(unconformity)	3132
Avalon	3132
(unconformity)	3514
Eastern Shoals	3514
Whiterose Shale (upper)	3566
Catalina	4185
("B" Marker)	4480
Hibernia	4536
Hebron Well Mbr	4536-4904
Fortune Bay Shale	5262
Total Depth	5282

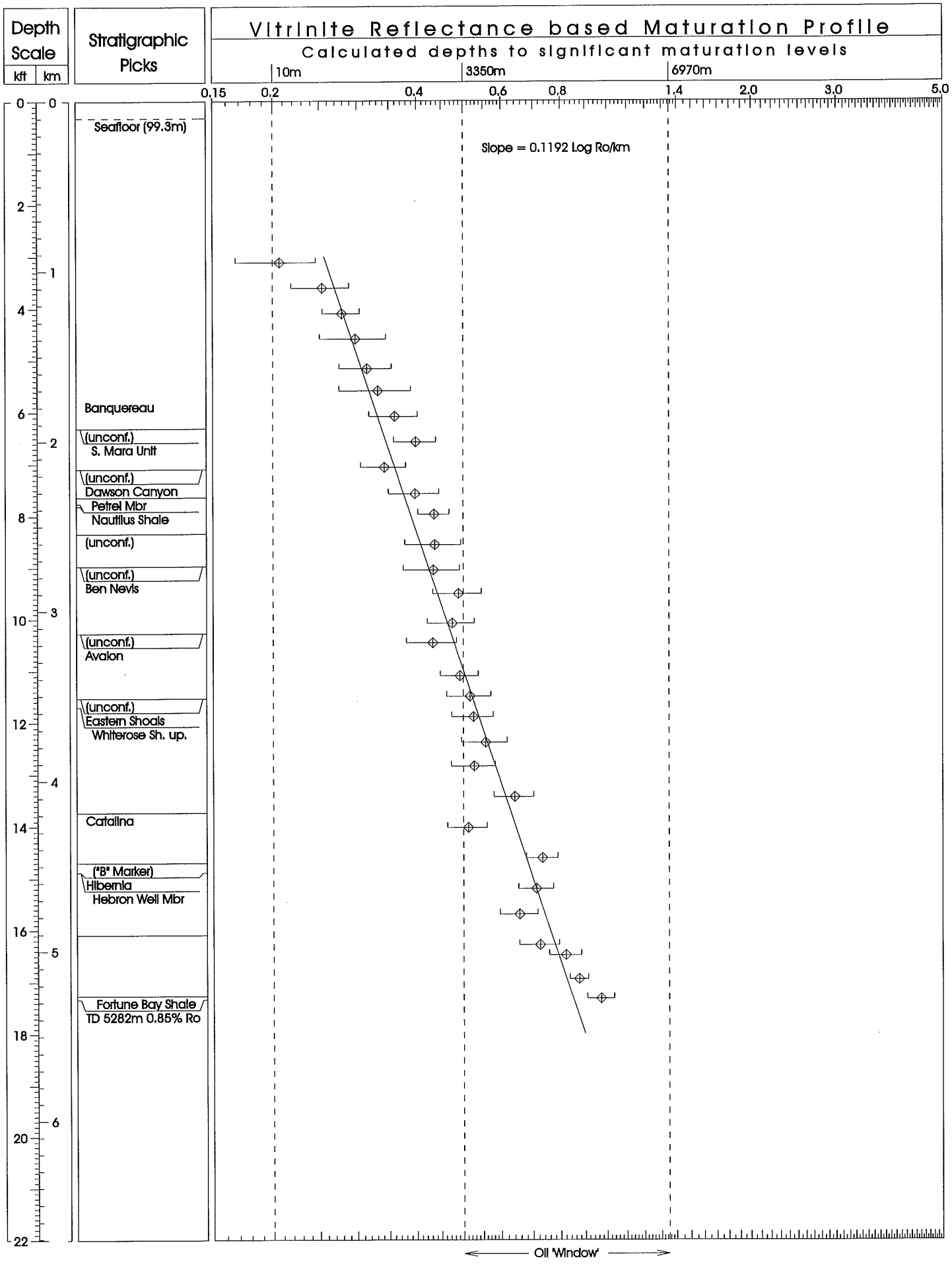


Fig. 1 NORTH BEN NEVIS P-93

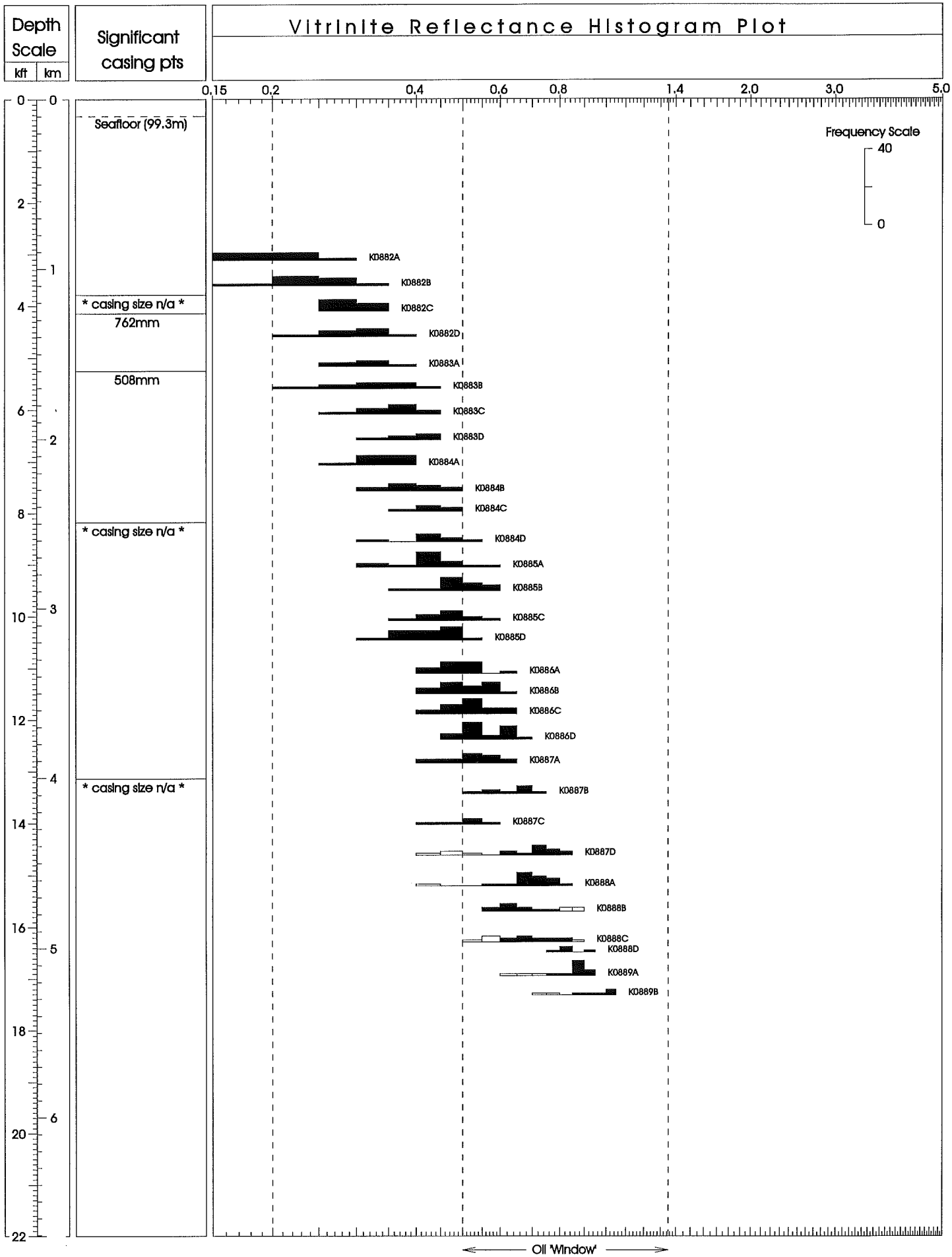


Fig. 2 NORTH BEN NEVIS P-93 <Histograms>

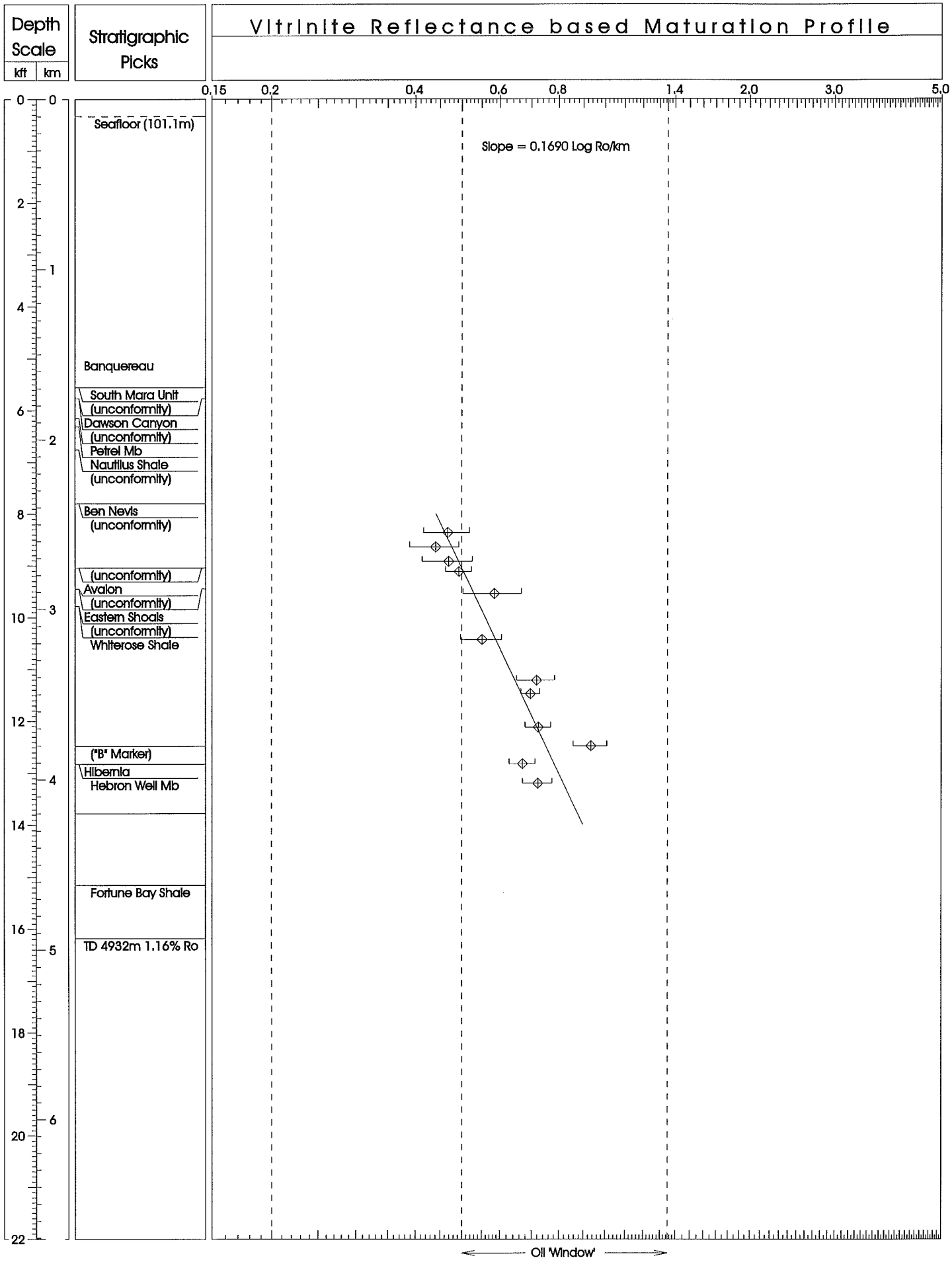


Fig. 3 BEN NEVIS I-45

Appendix I

Sample Preparation Method

Kerogen Concentrate

Preliminary wash (preparation for cuttings)

Dry samples in oven (25°C)

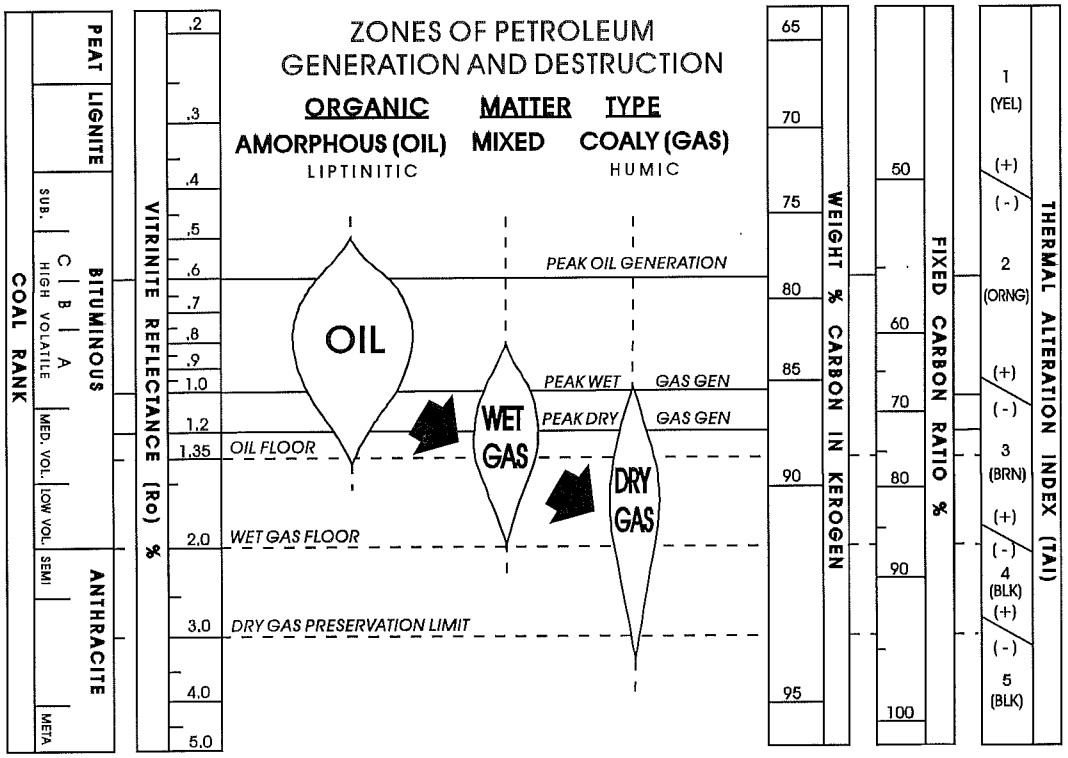
PALYNOLOGY Lab preparation

Place 20-30 grams 250 ml plastic beaker.
Add 10% HC1 till reaction ceases (removes carbonates).
Wash (rinsed) 3 times.
Conc. HF overnight (removes silicates).
Wash (rinsed) 3 times.
Heat (60-65°C) conc. HC1 (remove fluorides caused by HF).
Wash 3 times.
Transfer to 15 ml test tube with 4-5 ml 4% Alconox.
Differential centrifuge at 1500 rpm for 90 sec.
Decant.
Wash 3 times with centrifuging.
Float off organic fraction using 2.0 S.G. Znbr solution.
Centrifuge 1000 rpm, 8 min.
Float fraction into second test tube.
Wash 3 times with centrifuging.
Kerogen smear slide made.
Remaining kerogen material delivered to Organic Petrology Lab.

VITRINITE REFLECTANCE Lab preparation

Pipette off excess water and prepare as 1" dia. plastic stubs (to fit polisher).
Freeze dry and fix material for polishing with epoxy resin.
Polish with diamond based suspension to obtain low relief, scratch free surface.
Examine under oil lens, incident light at approximately 1000x magnification.

Appendix II (Dow, 1977)



Note: In this report, the terminology used to describe the various maturation levels has been modified. The 'peak' designation, as used in this figure, has been changed to 'onset of significant' and 0.8 %Ro is herein used as the 'peak of oil generation' (Table I, Figure 1).

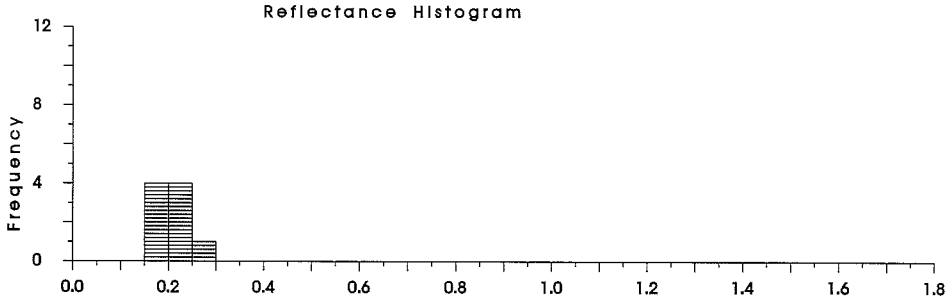
Appendix III

Reflectance Histograms

K0882A, 915-950m

Col >	1	2	3	4	5	6	7	8	9
Row	(0.24)	(0.18)	(0.22)	(0.29)	(0.21)	(0.18)	(0.20)	(0.17)	(0.17)

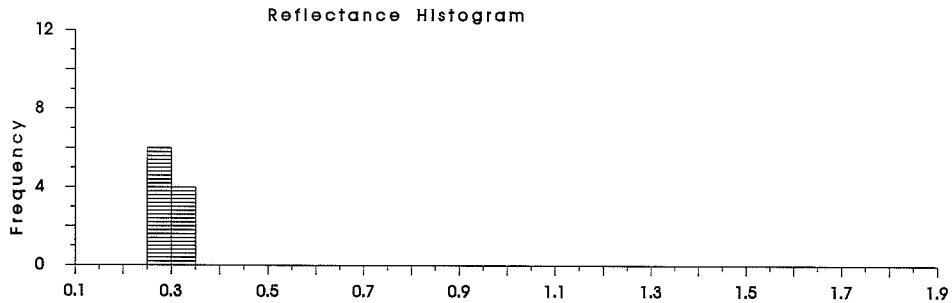
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.21	.04	9	.17	.29	1.86
(Edit)	.21	.04	9	.17	.29	1.86



K0882C, 1240-1250m

Col >	1	2	3	4	5	6	7	8	9	0
Row	(0.26)	(0.26)	(0.30)	(0.29)	(0.25)	(0.31)	(0.25)	(0.26)	(0.30)	(0.31)

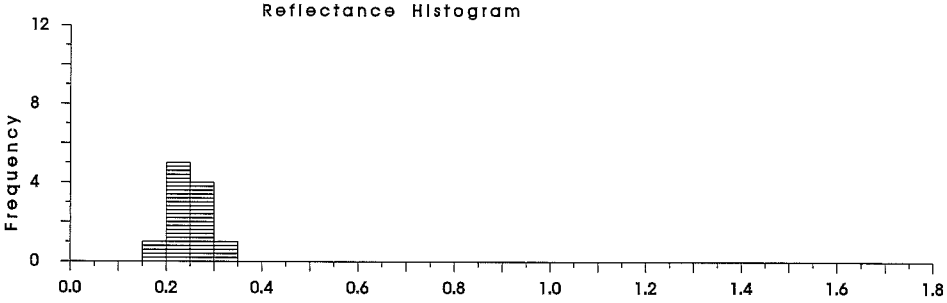
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.28	.03	10	.25	.31	2.79
(Edit)	.28	.03	10	.25	.31	2.79



K0882B, 1090-1100m

Col >	1	2	3	4	5	6	7	8	9	0
Row	(0.28)	(0.29)	(0.32)	(0.23)	(0.23)	(0.27)	(0.24)	(0.24)	(0.19)	(0.26)
1	(0.24)									

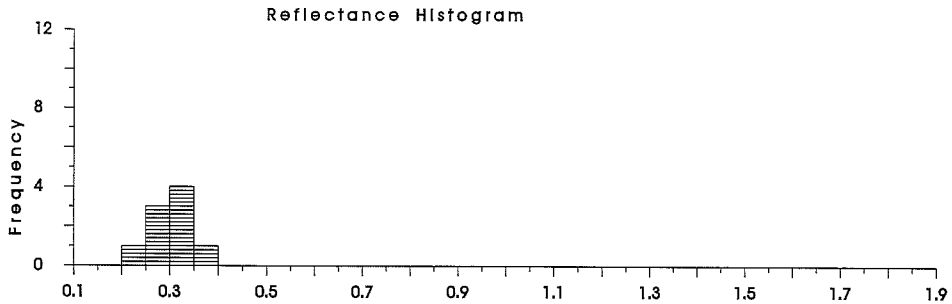
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.25	.04	11	.19	.32	2.79
(Edit)	.25	.04	11	.19	.32	2.79



K0882D, 1390-1400m

Col >	1	2	3	4	5	6	7	8	9
Row	(0.22)	(0.31)	(0.25)	(0.27)	(0.33)	(0.28)	(0.34)	(0.37)	(0.31)

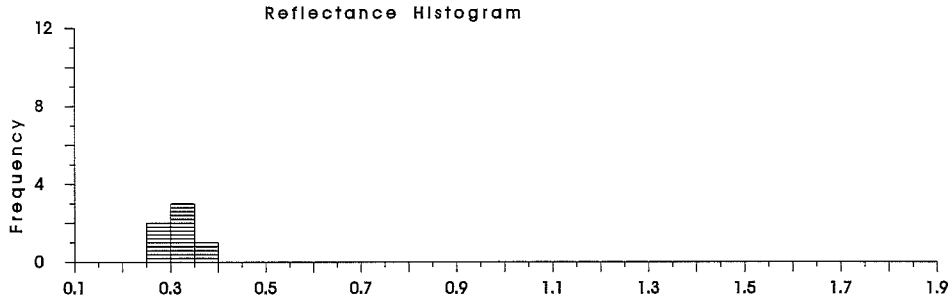
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.3	.05	9	.22	.37	2.68
(Edit)	.3	.05	9	.22	.37	2.68



K0883A, 1565-1575m

Col >	1	2	3	4	5	6
Row	(0.39)	(0.28)	(0.32)	(0.31)	(0.30)	(0.29)

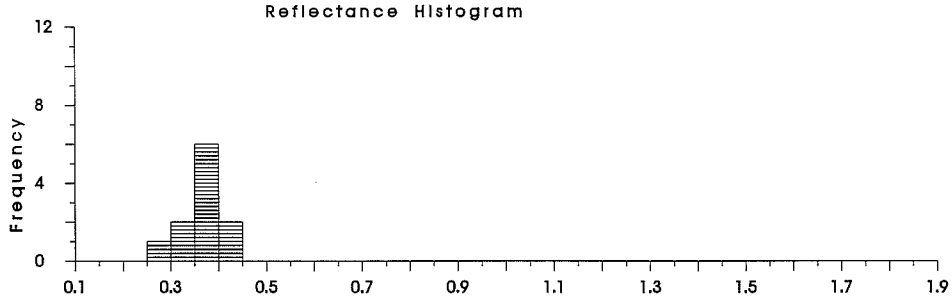
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.31	.04	6	.28	.39	1.89
(Edit)	.31	.04	6	.28	.39	1.89



K0883C, 1845-1855m

Col >	1	2	3	4	5	6	7	8	9	0
Row	(0.31)	(0.36)	(0.36)	(0.28)	(0.41)	(0.42)	(0.38)	(0.39)	(0.35)	(0.33)
1	(0.37)									

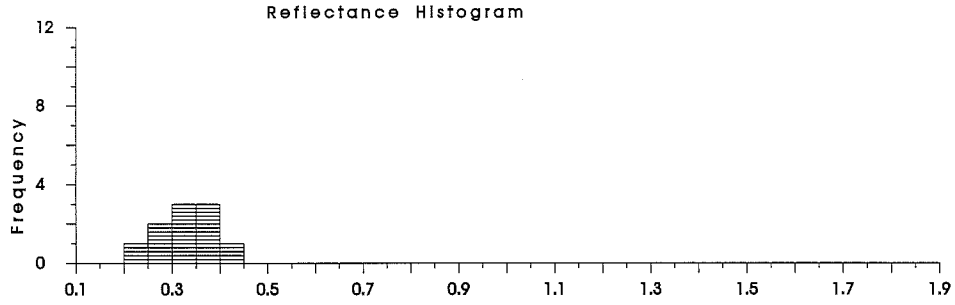
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.36	.04	11	.28	.42	3.96
(Edit)	.36	.04	11	.28	.42	3.96



K0883B, 1695-1705m

Col >	1	2	3	4	5	6	7	8	9	0
Row	(0.33)	(0.43)	(0.29)	(0.36)	(0.39)	(0.31)	(0.33)	(0.36)	(0.29)	(0.23)

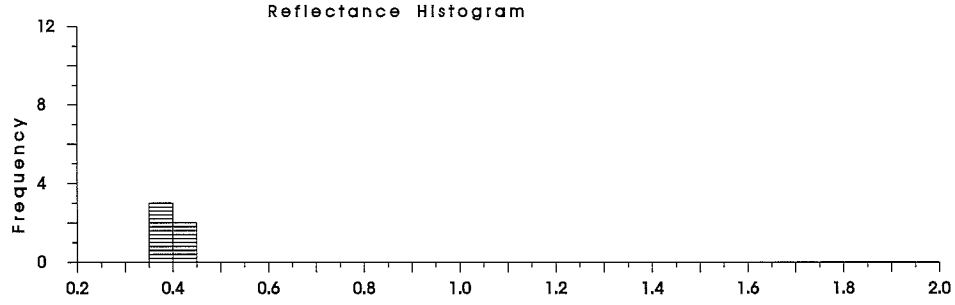
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.33	.06	10	.23	.43	3.32
(Edit)	.33	.06	10	.23	.43	3.32



K0883D, 1995-2005m

Col >	1	2	3	4	5	6
Row	(0.42)	(0.45)	(0.35)	(0.37)	(0.37)	(0.43)

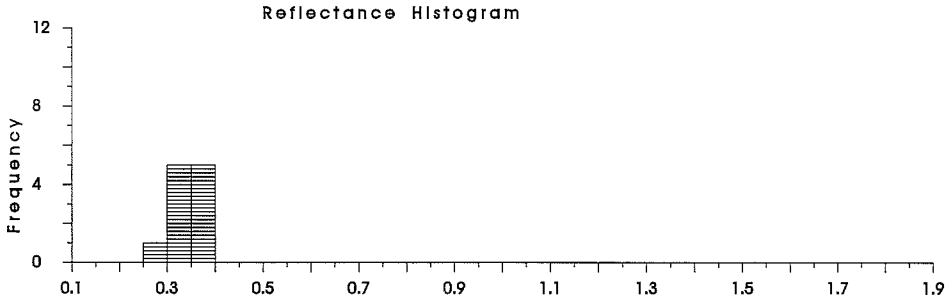
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.4	.04	6	.35	.45	2.39
(Edit)	.4	.04	6	.35	.45	2.39



K0884A, 2145-2155m

Col >	1	2	3	4	5	6	7	8	9	0
Row	(0.30)	(0.38)	(0.27)	(0.33)	(0.34)	(0.38)	(0.38)	(0.38)	(0.32)	(0.36)
1	(0.33)									

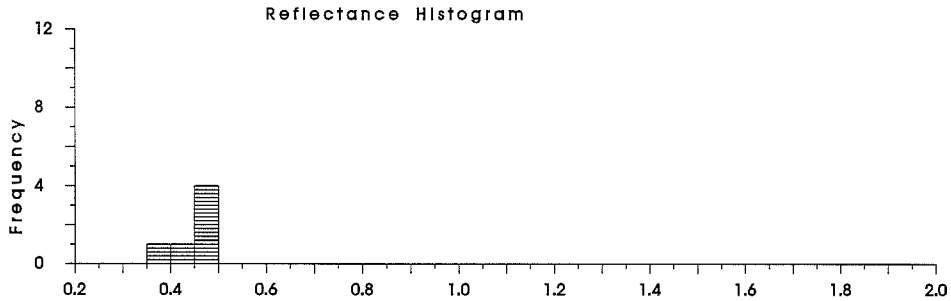
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.34	.04	11	.27	.38	3.77
(Edit)	.34	.04	11	.27	.38	3.77



K0884C, 2420-2430m

Col >	1	2	3	4	5	6
Row	(0.38)	(0.46)	(0.45)	(0.45)	(0.46)	(0.41)

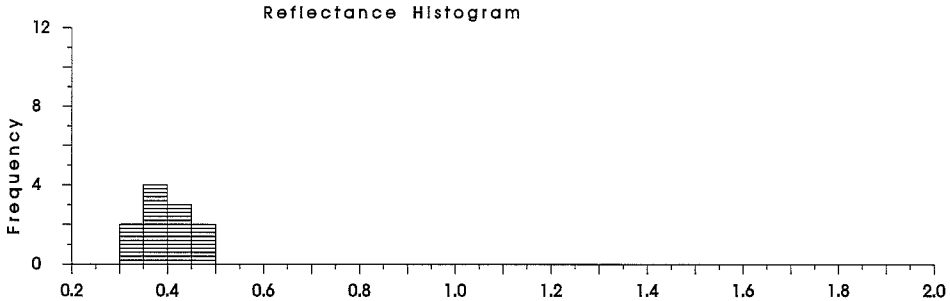
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.44	.03	6	.38	.46	2.61
(Edit)	.44	.03	6	.38	.46	2.61



K0884B, 2300-2310m

Col >	1	2	3	4	5	6	7	8	9	0
Row	(0.38)	(0.46)	(0.33)	(0.34)	(0.41)	(0.36)	(0.41)	(0.49)	(0.38)	(0.39)
1	(0.42)									

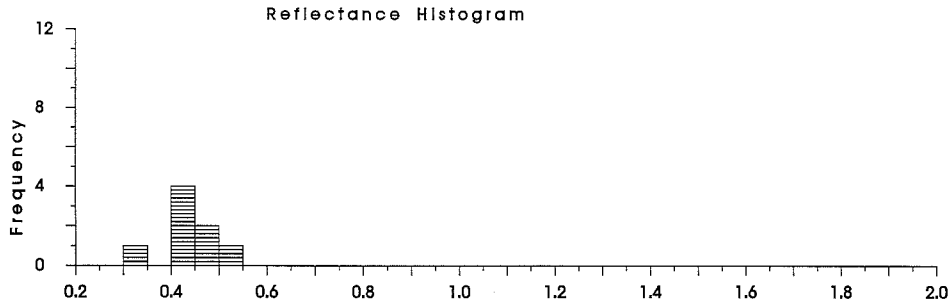
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.4	.05	11	.33	.49	4.37
(Edit)	.4	.05	11	.33	.49	4.37



K0884D, 2600-2610m

Col >	1	2	3	4	5	6	7	8
Row	(0.41)	(0.41)	(0.44)	(0.40)	(0.34)	(0.49)	(0.48)	(0.52)

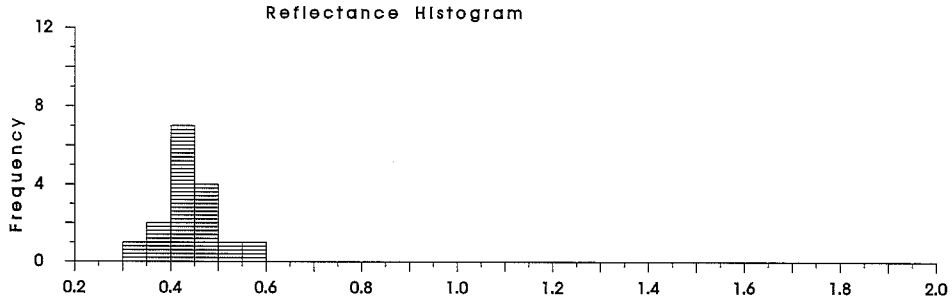
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.44	.06	8	.34	.52	3.49
(Edit)	.44	.06	8	.34	.52	3.49



K0885A, 2750-2760m

Col >	1	2	3	4	5	6	7	8	9	0
Row	(0.41)	(0.36)	(0.44)	(0.49)	(0.44)	(0.46)	(0.45)	(0.44)	(0.35)	(0.56)
1	(0.46)	(0.34)	(0.41)	(0.51)	(0.41)	(0.40)				

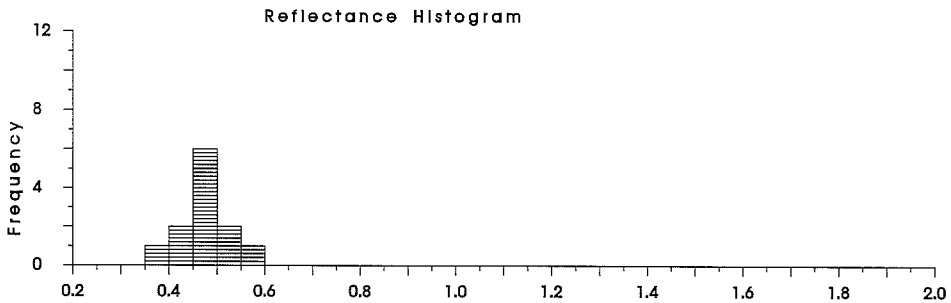
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.43	.06	16	.34	.56	6.93
(Edit)	.43	.06	16	.34	.56	6.93



K0885C, 3065-3075m

Col >	1	2	3	4	5	6	7	8	9	0
Row	(0.46)	(0.41)	(0.45)	(0.55)	(0.37)	(0.48)	(0.53)	(0.49)	(0.49)	(0.43)
1	(0.54)	(0.49)								

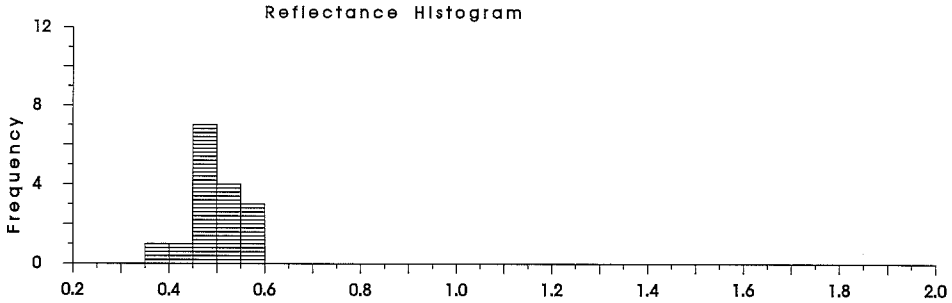
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.47	.05	12	.37	.55	5.69
(Edit)	.47	.05	12	.37	.55	5.69



K0885B, 2890-2900m

Col >	1	2	3	4	5	6	7	8	9	0
Row	(0.48)	(0.50)	(0.46)	(0.42)	(0.57)	(0.51)	(0.49)	(0.59)	(0.56)	(0.46)
1	(0.51)	(0.46)	(0.36)	(0.46)	(0.50)	(0.49)				

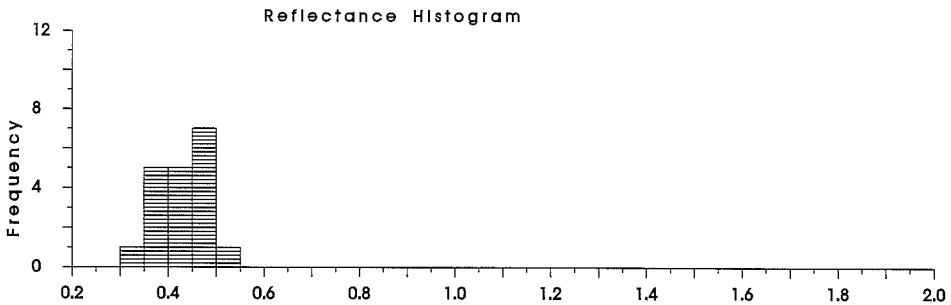
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.49	.06	16	.36	.59	7.82
(Edit)	.49	.06	16	.36	.59	7.82



K0885D, 3180-3190m

Col >	1	2	3	4	5	6	7	8	9	0
Row	(0.42)	(0.39)	(0.52)	(0.46)	(0.37)	(0.48)	(0.46)	(0.41)	(0.49)	(0.48)
1	(0.33)	(0.49)	(0.39)	(0.44)	(0.48)	(0.38)	(0.44)	(0.40)	(0.38)	

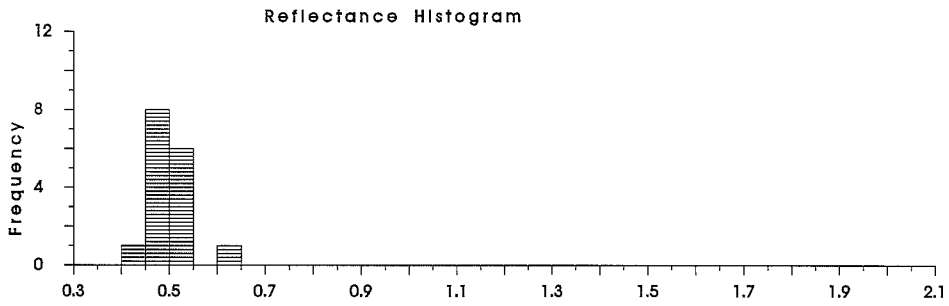
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.43	.05	19	.33	.52	8.21
(Edit)	.43	.05	19	.33	.52	8.21



K0886A, 3375-3385m

Col >	1	2	3	4	5	6	7	8	9	0
Row	(0.46)	(0.61)	(0.49)	(0.45)	(0.43)	(0.48)	(0.54)	(0.50)	(0.52)	(0.46)
1	(0.45)	(0.49)	(0.50)	(0.46)	(0.54)	(0.50)				

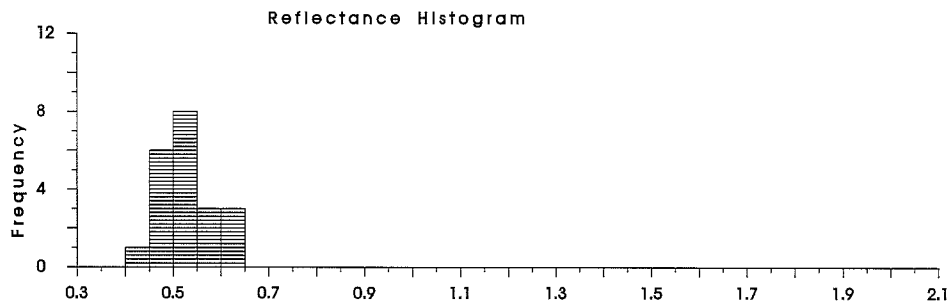
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.49	.04	16	.43	.61	7.88
(Edit)	.49	.04	16	.43	.61	7.88



K0886C, 3585-3625m

Col >	1	2	3	4	5	6	7	8	9	0
Row	(0.62)	(0.47)	(0.60)	(0.47)	(0.47)	(0.58)	(0.53)	(0.54)	(0.57)	(0.61)
1	(0.53)	(0.57)	(0.54)	(0.52)	(0.52)	(0.53)	(0.49)	(0.48)	(0.44)	(0.45)
2	(0.50)									

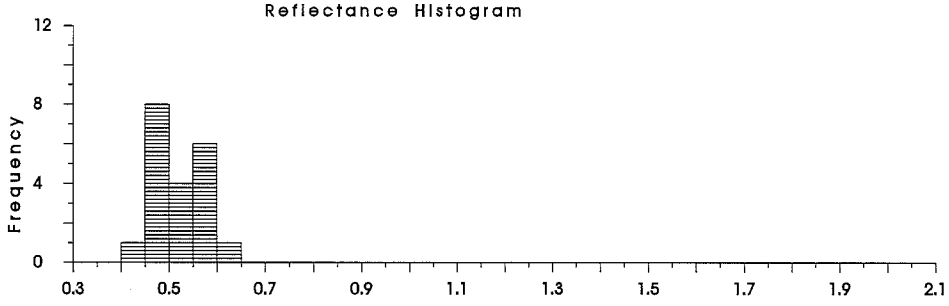
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.53	.05	21	.44	.62	11.03
(Edit)	.53	.05	21	.44	.62	11.03



K0886B, 3495-3505m

Col >	1	2	3	4	5	6	7	8	9	0
Row	(0.53)	(0.58)	(0.54)	(0.59)	(0.48)	(0.47)	(0.51)	(0.48)	(0.46)	(0.56)
1	(0.43)	(0.55)	(0.48)	(0.49)	(0.52)	(0.56)	(0.63)	(0.45)	(0.57)	(0.45)

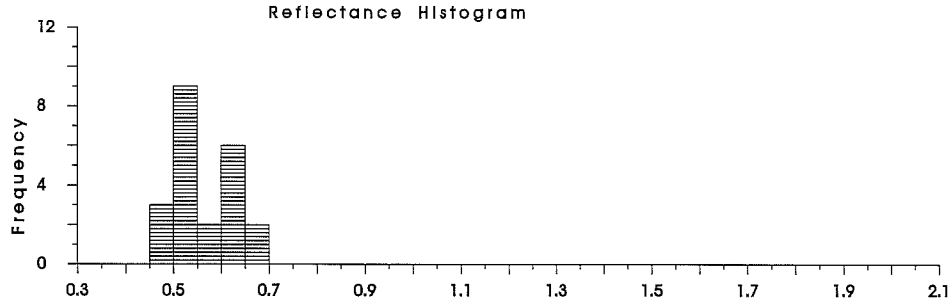
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.52	.05	20	.43	.63	10.33
(Edit)	.52	.05	20	.43	.63	10.33



K0886D, 3735-3775m

Col >	1	2	3	4	5	6	7	8	9	0
Row	(0.63)	(0.50)	(0.67)	(0.55)	(0.64)	(0.53)	(0.52)	(0.51)	(0.61)	(0.65)
1	(0.60)	(0.60)	(0.61)	(0.54)	(0.58)	(0.50)	(0.48)	(0.53)	(0.54)	(0.51)
2	(0.46)	(0.49)								

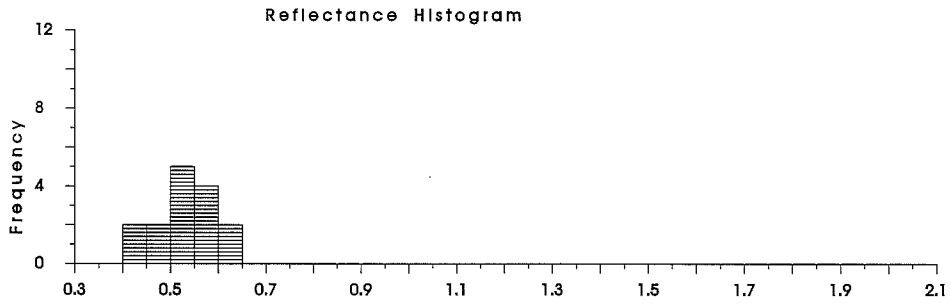
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.56	.06	22	.46	.67	12.25
(Edit)	.56	.06	22	.46	.67	12.25



K0887A, 3905-3915m

Col >	1	2	3	4	5	6	7	8	9	0
Row	(0.51)	(0.48)	(0.44)	(0.44)	(0.49)	(0.50)	(0.56)	(0.61)	(0.56)	(0.53)
1	(0.53)	(0.63)	(0.50)	(0.58)	(0.55)					

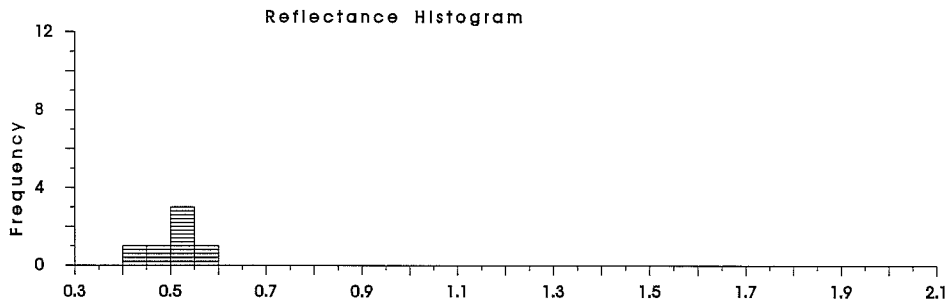
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.53	.06	15	.44	.63	7.91
(Edit)	.53	.06	15	.44	.63	7.91



K0887C, 4235-4275m

Col >	1	2	3	4	5	6
Row	(0.51)	(0.52)	(0.58)	(0.44)	(0.48)	(0.54)

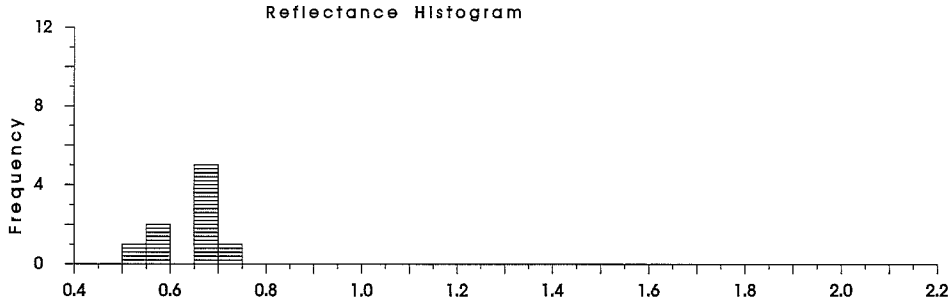
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.51	.05	6	.44	.58	3.07
(Edit)	.51	.05	6	.44	.58	3.07



K0887B, 4055-4095m

Col >	1	2	3	4	5	6	7	8	9
Row	(0.74)	(0.68)	(0.66)	(0.65)	(0.53)	(0.59)	(0.67)	(0.59)	(0.66)

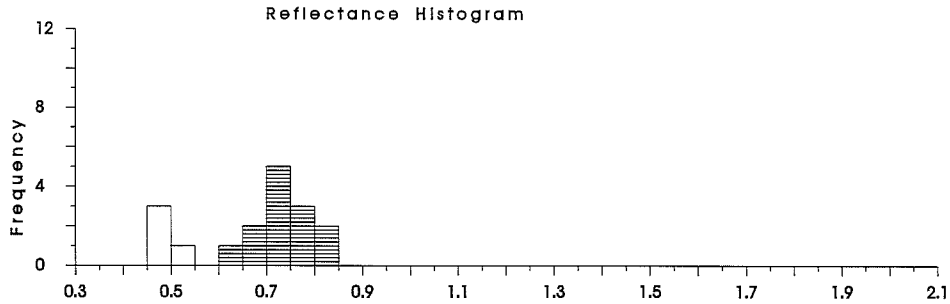
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.64	.06	9	.53	.74	5.77
(Edit)	.64	.06	9	.53	.74	5.77



K0887D, 4415-4455m

Col >	1	2	3	4	5	6	7	8	9	0
Row	0.54	(0.74)	0.49	(0.74)	(0.73)	(0.81)	(0.65)	(0.78)	0.49	(0.71)
1	(0.69)	(0.74)	(0.81)	(0.76)	0.45	(0.62)	(0.75)			

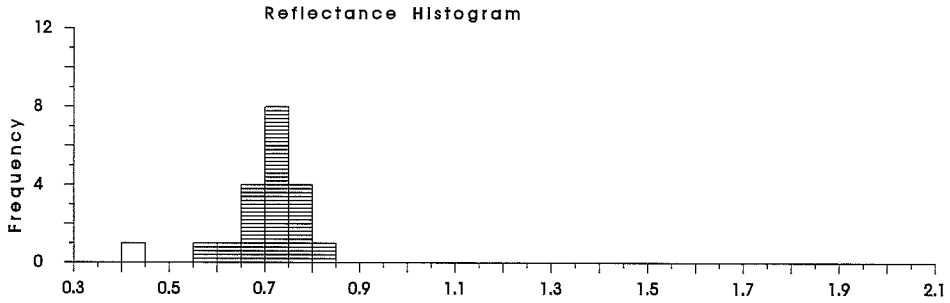
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.68	.12	17	.45	.81	11.5
(Edit)	.73	.06	13	.62	.81	9.53



K0888A, 4595-4635m

Col >	1	2	3	4	5	6	7	8	9	0
Row 1	(0.70) (0.68)	0.42 (0.75)	(0.78) (0.70)	(0.79) (0.68)	(0.57) (0.73)	(0.61) (0.82)	(0.70) (0.73)	(0.66) (0.73)	(0.77) (0.71)	(0.69) (0.73)

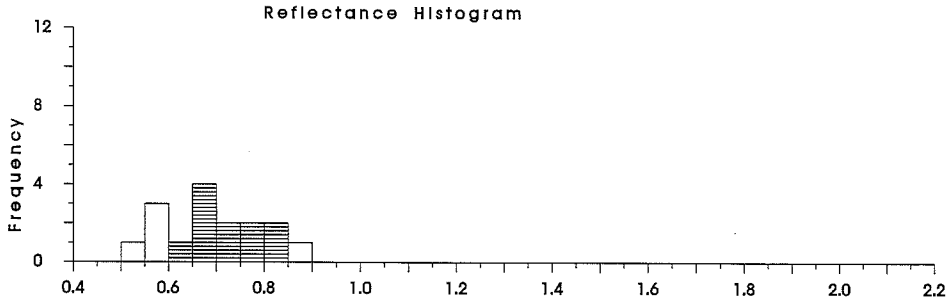
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.7	.09	20	.42	.82	13.95
(Edit)	.71	.06	19	.57	.82	13.53



K0888C, 4925-4965m

Col >	1	2	3	4	5	6	7	8	9	0
Row 1	(0.78) (0.82)	(0.75) (0.65)	(0.74) (0.69)	0.56 (0.67)	(0.73) 0.88	(0.67) 0.58	(0.84)	0.54	0.59	(0.63)

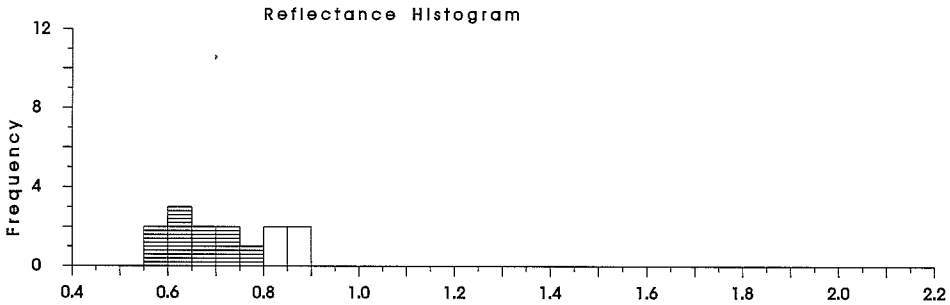
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.69	.1	16	.54	.88	11.12
(Edit)	.72	.07	11	.63	.84	7.97



K0888B, 4745-4785m

Col >	1	2	3	4	5	6	7	8	9	0
Row 1	(0.73) (0.65)	(0.64) 0.88	0.83 (0.70)	0.81 (0.58)	(0.61)	(0.58)	(0.69)	(0.63)	(0.75)	0.88

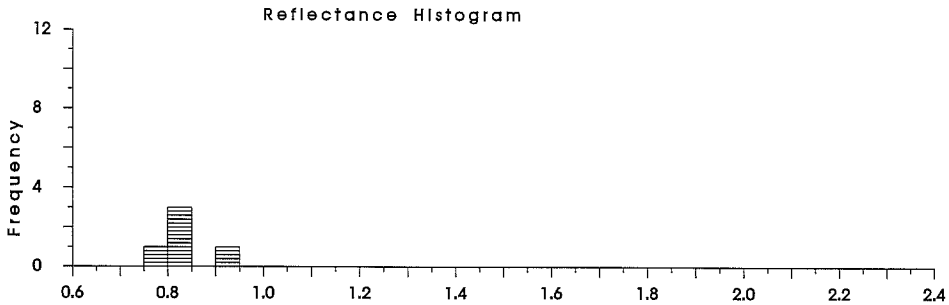
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.71	.11	14	.58	.88	9.96
(Edit)	.66	.06	10	.58	.75	6.56



K0888D, 5015-5025m

Col >	1	2	3	4	5
Row 1	(0.75)	(0.80)	(0.92)	(0.80)	(0.83)

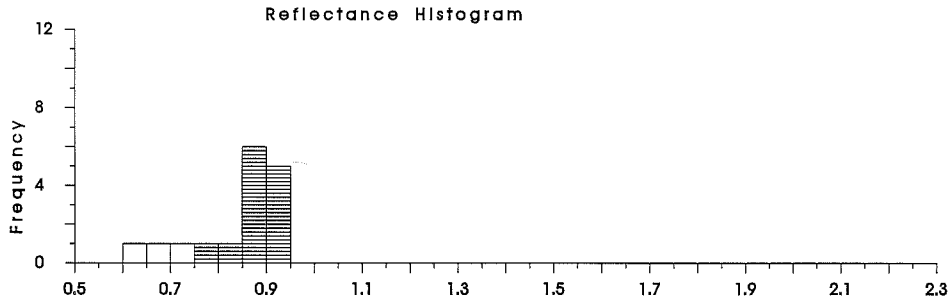
	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.82	.06	5	.75	.92	4.1
(Edit)	.82	.06	5	.75	.92	4.1



K0889A, 5125-5165m

Col >	1	2	3	4	5	6	7	8	9	0
Row	0.73	0.61	(0.91)	(0.87)	(0.85)	0.67	(0.79)	(0.90)	(0.88)	(0.92)
1	(0.90)	(0.84)	(0.93)	(0.85)	(0.87)	(0.85)				

	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.84	.09	16	.61	.93	13.37
(Edit)	.87	.04	13	.79	.93	11.36



K0889B, 5245-5280m

Col >	1	2	3	4	5	6	7	8
Row	(0.88)	(1.03)	0.71	(1.03)	(0.98)	0.79	(1.00)	(0.91)

	Mean	Stand Dev	Pts	Min	Max	Sum
Total	.92	.12	8	.71	1.03	7.33
(Edit)	.97	.06	6	.88	1.03	5.83