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**HYDROCARBON-SOURCE RELATIONSHIPS,
JEANNE D'ARC AND AVALON BASINS,
OFFSHORE NEWFOUNDLAND**

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Abstract

A mature, rich, petroleum source rock has been identified in the Avalon Basin. It is of Upper Jurassic age and contains up to 9.0% organic carbon and the organic matter is Type II. The source rock is mature under the Hibernia field. Hydrocarbons discovered to date in the Avalon Basin belong to a general genetic family but differ in the level of maturity at which they were generated. This is understandable in terms of the geology of the area. The fields flank a major depocentre under which the source rock has achieved various levels of maturation. Hydrocarbons generated at different maturity levels have migrated to the edge of the depocentre where they are now trapped. Gasoline-range analyses have enabled an oil to source correlation to be made between the Hibernia oils and the Upper Jurassic source rock underlying the Hibernia field.

Introduction

The discovery of a major oil field in Lower Cretaceous reservoirs at Hibernia (Fig. 1) (Arther *et al.*, 1982) is of particular interest from the geochemical point of view because geochemical studies on other areas of the East Coast (Scotian Shelf - Powell, 1982; Labrador Shelf - Rashid *et al.*, 1980; Powell, 1979) and drilling results (Purcell *et al.*, 1980; McMillan, 1982) had shown them to be gas-prone. However, geochemical work by Swift and Williams (1980) had indicated the potential for oil generation in the Jeanne D'Arc Basin. They identified an immature oil source rock in the southern part of the Avalon Basin and their maturation studies suggested it became more mature to the north. The discovery of a small amount of oil in the Adolphus structure in 1973 had also suggested the presence of mature oil source beds.

This paper is concerned with the hydrocarbon-source relationships in the Jeanne D'Arc and Avalon Basins with emphasis on the Hibernia area. It is based on the results of analyses conducted on samples obtained from the Hibernia P-15 discovery well and subsequent wells combined with results obtained by other authors from the older wells. This latter work consists of the organic petrographic data of Bujak *et al.* (1977a and b) and Barss *et al.* (1980), the cuttings gas and organic carbon data of Hardy and Jackson (1980), the study by Rashid (1978) on the Adolphus structure, and

the synthesis of maturation and source rock data for the Grand Banks area by Swift and Williams (1980).

Samples and Methods

Samples

Table 1 lists the wells used for establishing maturation trends and the sources of data. Single well studies were carried out on the Hibernia P-15 and O-35 wells and part of the K-18 well; and on the Ben Nevis I-45 and South Tempest G-88 wells.

A variety of types of analyses were obtained. Screening studies were carried out at ISPG on the Hibernia P-15 well using cuttings gas and organic carbon analysis and subsequently reflectance data (W. Kalkreuth, ISPG¹); gasoline range data, extract data and kerogen data were obtained. In order to confirm the results of the study on the P-15 well, gasoline range, organic carbon, RockEval, reflectance and extract data were obtained for the deeper portions of the Hibernia O-35 and K-18 wells. Independent organic petrographic studies by P. Hacquebard (vitrinite reflectance) and J. Bujak (TAI) at AGC² confirmed the interpretations made at ISPG concerning the maturation levels in the Hibernia area. Individual well studies involving cuttings gas and carbon analyses, RockEval data, extract data and gasoline-range analyses were conducted on the Ben Nevis I-45 and South Tempest G-88 wells.

Forty-four oil and condensate samples were analysed from the Jeanne D'Arc Sub-basin including 29 samples from the Hibernia field (Table 3, Appendix).

¹ ISPG = Institute of Sedimentary and Petroleum Geology, Calgary, Alberta.

² AGC = Atlantic Geoscience Centre, Dartmouth, Nova Scotia.

Methods

The procedure for cuttings gas analysis, organic carbon analysis, extraction and fractionation of hydrocarbons, kerogen isolation, elemental analysis and vitrinite reflectance measurements were essentially those used by Powell (1978) and modified as described by Powell (1982). Gas chromatographic procedures for analysis of saturate fractions were those described by Powell (1982). Pyrolysis data (S1, S2, and Tmax - Espitalie *et al.*,) were obtained using a RockEval II (Girdel, France).

Analytical procedures for analysis of gasoline range components in oils and rocks were those described by Snowdon and Powell (1982). The gasoline range components identified were as follows: (1) isopentane, (2) n-pentane, (3) 2,2-dimethylbutane, (4) cyclopentane, (5) 2,3-dimethylbutane, (6) 2-methylpentane, (7) 3-methylpentane, (8) n-hexane, (9) methylcyclopentane, (10), benzene, (11) cyclohexane, (12) 2-methylhexane, (13) 1,1-dimethylcyclopentane, (14) 2,3-dimethylpentane, (15) 3-methylhexane, (16) 1c3-dimethylcyclopentane, (17) 1t3-dimethylcyclopentane, (18) 1t2-dimethylcyclopentane, (19) n-heptane, (20) 1c2-dimethylcyclopentane, (21) methylcyclohexane, (22) 2,5-dimethylhexane, (23) 2,4-dimethylhexane, (24) 2,2,3-trimethylpentane, and (25) toluene.

The paraffin indices of Thompson (1979) were calculated from the relative concentration of these components as follows: Paraffin Index I = Isoheptane value = (2-methylhexane + 3-methylhexane)/(dimethylcyclopentane isomers: 1c3+1t3+1t2); and Paraffin Index II = Heptane value = % heptane in compounds eluting between cyclohexane and methylcyclohexane.

Analytical procedures for the distillation of oils, fractionation of hydrocarbon fractions and analysis by gas chromatography were those described by Snowdon and Powell (1979) and modified by Powell (1982).

To facilitate comparison of a large number of variables in a larger number of samples, the gasoline range data were subjected to cluster and factor analysis to determine if significant groupings or correlations could be made. The computer programs used in this study were those published and discussed by Davis (1973) and modified by K.N. Nairn (ISPG) to run on available hardware.

Maturation

Table 1 lists the pertinent maturation data available for the study area and the depths at which critical changes occur for the various maturation parameters. These maturation indicators have been variously calibrated to the processes of oil and gas generation, but the relationship between the indicators used in this study is given in Table 2 and is basically the same as that established by Powell (1982) for the Scotian Shelf. Three zones of maturation are defined: an immature zone where no hydrocarbon generation has occurred; a marginally mature zone where hydrocarbon generation has begun and where waxy terrestrial organic matter has not generated any liquid hydrocarbons; and a mature zone representing the peak stage of hydrocarbon generation for both terrestrial and marine organic matter. It must be noted that marine organic matter and resinite rich terrestrial organic matter can produce liquid hydrocarbons in the marginally mature zone (Powell and Snowdon, 1983).

As has been indicated previously (Bujak *et al.*, 1977a and b; Swift and Williams, 1980), large parts of the Tertiary and Mesozoic section in the study area are immature or at best marginally mature. In the Hibernia area, the mature zone is reached only below about 4200 m, whereas it occurs at a somewhat shallower depth in the eastern wells in the basin (<3500 m in Ben Nevis I-45 and South Tempest G-88) (Table 1). The Adolphus structure is an exception. Here, a heat anomaly is associated with the piercement salt diapir and the maturation level of the rock immediately enclosing the salt diapir is enhanced (Rashid, 1978).

The relationship of the stratigraphy to the maturation zones is illustrated for the southwestern pool of the Jeanne D'Arc Basin in Figure 2. Only the Jurassic in the Hibernia area is mature, the Cretaceous rocks which contain the Hibernia reservoirs fall in the marginally mature zone. However, to the east of the Hibernia area and in the depocentre of the basin, Lower Cretaceous rocks probably enter the mature zone, and in the deepest pool of the depocentre both the basal Lower Cretaceous and the Jurassic will probably be overmature because of the great thickness of Lower Cretaceous rocks (Fig. 3).

Source Rocks

Organic rich rocks occur at three broad stratigraphic intervals in the Hibernia area (Fig. 4). These are in the immature Tertiary rocks which are characteristically organic rich throughout the East Coast Offshore (Powell *et al.*, 1979; Rashid *et al.*, 1980). In the Lower Cretaceous in the Hibernia O-35 well, high organic carbon values are due to coals. In the Hibernia P-15 and K-18 wells, exceptionally rich rocks (up to 9% organic carbon) were encountered in the Jurassic (Fig. 4). This interval corresponds to the immature potential source rock identified in the Egret K-36 well by Swift and Williams (1980) (Fig. 2) and to an organic rich interval in the Flying Foam I-13 (Hardy and Jackson, 1980) and South Tempest G-88 wells. In the Hibernia area this interval falls in the mature zone (Fig. 2).

The hydrocarbon yields from selected samples from the Hibernia wells are also shown in Figure 4. As expected from maturity considerations, only the Jurassic organic rich intervals show high hydrocarbon yields which are indicative of excellent source potential or staining. The yields from the Jurassic interval in the P-15 well are somewhat lower than in the K-18 well, indicating a lower level of maturity. This is indicated in the gas chromatograms where the saturates from the P-15 well still show a slight odd to even predominance, whereas those from the K-18 well show a more mature, smooth distribution of hydrocarbons (Fig. 5).

RockEval analyses show that the kerogen from the organic rich interval in the K-18 well is Type II and oil prone, whereas the RockEval data from the Ben Nevis I-45 well show that all the younger immature sediments are of Type III (Fig. 6). The source zone is in the order of 300 m thick at Hibernia.

Characteristics of Oils and Condensates

Gross Composition

The oils and condensates were distilled to remove the fraction boiling below 210°C to facilitate fractionation of the heavy fraction into various compound types. As expected in a population of oils and condensates there is a wide variation in gross composition (Table 3). Condensates contain

amounts of gasoline range hydrocarbons (up to 83% $>210^{\circ}\text{C}$), high contents of saturates (up to 73%) and small amounts of ONS compounds ($\sim 6\%$). The majority of the oils have gasoline contents in the range of 18% to 40% ($<210^{\circ}\text{C}$ fraction); saturated and aromatic hydrocarbons are in roughly equal proportion (40% each $\pm 10\%$); and ONS contents are between 10 and 20%. Three samples from Hebron I-13 (DST 9, 10, 11) are depleted in gasoline range components ($\sim 11\%$). In general these features reflect the physical conditions in the reservoir and conditions of collection and do not relate to genetic differences.

Gasoline Range

To facilitate comparison of the concentration of the 25 compounds in 35 samples, cluster and factor analyses were run on the gasoline range data. The cluster analysis dendrogram is shown in Figure 7. There are 3 main clusters, A, B and C, and the Adolphus sample is somewhat separate from cluster C. The distribution of samples within the clusters has no relationship to geographic or stratigraphic position. Thus, samples from the Hebron zone from the Hibernia O-35 well occur in clusters A, B and C and samples from the Hibernia zone from the Hibernia K-18 well occur in clusters A and C. Likewise, samples from the Hebron I-13 well are distributed between clusters A and C. Examination of the factor analyses data shows that much variance between samples can be accounted for by the relative amount of lower molecular weight hydrocarbons ($\text{C}_5\text{-C}_6$) compared with heavier components ($\text{C}_7\text{-C}_8$). This difference is attributed to variations in comparative loss and conditions of collection but is not genetic in origin. In order to overcome this problem only the compounds eluding from the gas chromatographic column after and including cyclohexane (C_6H_{12}) will be considered (see methods for compound list).

The normalized composition of C_7 compounds is illustrated in a ternary diagram in Figure 8. The majority of the samples fall in a tight knit but elliptical group and include samples from all the Hibernia wells, Ben Nevis, Hebron and South Tempest. The Adolphus sample (#1) is richer in normal and branched paraffins compared with this group whereas samples 2, 11 and 12 are enriched in cyclic components compared with this group. This suggests that maturation is the primary control

on the compositional variations. Thompson (1979) has defined two Paraffin Indices (see Methods) which change systematically with maturation. In his studies, Paraffin Index I (Isoheptane Value) and Paraffin Index II (Heptane Value) have ranges of about 0.75 to 6.0 and about 5 to 30 respectively between the immature and overmature zones. The paraffin indices for the Jeanne D'Arc Basin oils are illustrated in Figure 9. The Adolphus sample stands out as being unique with its very high paraffin indices and it is interpreted to be a very mature oil. There is however a wide range in the the paraffin indices in the remainder. In the Hibernia field Isoheptane Values range from as low as 0.9 (P-15, DST 2) to as high as 1.9 (P-15, DST 8) and the corresponding Heptane Values range from 16 to 34. A similar variation is seen in the Hebron I-13 well. These variations are not attributed to biodegradation since biodegradation causes deviations from the diagonal which is largely defined by maturation (Snowdon and Powell, 1982). These results suggest that the oils were generated over a wide range of maturation levels and were emplaced in the reservoir at different times.

Saturated and Aromatic Hydrocarbons

The saturate fraction gas chromatograms are generally very similar. The only differences that arise are in the proportion of waxy n-alkanes (C_{22}) compared with the higher boiling components and slight variations in pristane to phytane ratio (Fig. 10). Some samples show a higher proportion of waxes with a slight odd to even predominance in the higher molecular weight range. Pristane to phytane ratios of samples from the Hibernia field and Hebron wells are very similar ranging from 0.60 to 1.10 (Table 3). These low values reflect the reducing conditions of the marine source environment. Samples from the Ben Nevis and South Tempest wells have slightly higher pristane to phytane ratios suggesting that the source on the eastern side of the basin was somewhat less anoxic (Table 3).

Oil-Source Relationships

Gasoline range data can be used to determine the maturation level of an accumulated oil in relation to the immediately surrounding rocks and to correlate to a proposed source (Thompson's

(1979) paraffin indices; Snowdon and Powell, 1982). By determining the composition of gasoline-range compounds in both shales and reservoirs, it becomes possible to ascertain whether the reservoir hydrocarbons were generated at the maturation level observed in that section or have migrated from a more mature zone at greater depth.

Three wells in the Hibernia field were analysed for gasoline range hydrocarbons. The variations in Isoheptane value with depth in these wells are summarized in Figure 11. With the exception of oil in the Jurassic sand in the P-15 well, the reservoir oils have higher values than the sediments either above or below the reservoir zones. The sediments immediately above the reservoir zones show values in between that of the oil in the reservoir and the overlying rocks. These sediments are thought to be stained by leakage or diffusion of light-hydrocarbons from the immediately adjacent reservoir. Similarly, the sediments immediately below the reservoir show a similar effect. This could be attributed to diffusion, staining or partly to caving or cuttings from the reservoir zone. It is interesting to note that there is an increase in Isoheptane Value through the C-zone in the P-15 well even though this interval is water bearing in this well (Benteau and Sheppard, 1982). This indicates that some oil has either passed through this zone or that oil is beginning to accumulate in it.

The oil in the Jurassic sand in the P-15 well is less mature than other oils in the Hibernia field. Its Isoheptane and Heptane Values are similar to the values in the immediately underlying Jurassic shales which have been shown to be somewhat less mature than in the K-18 well (Figs. 9 and 11). This oil is correlated to the Jurassic section in the P-15 well. The paraffin indices in the rich source section in the K-18 well cover the range for the higher values in the Hibernia reservoirs and clearly correlate with the oils in the Hibernia reservoirs (Fig. 11).

The variation in maturation level of the oils in the various fields (e.g. Hibernia and Hebron, Fig. 9) is readily explainable in terms of the geometry of the basin. It has already been shown that there is a maturation difference between the source kerogen in the Hibernia P-15 well and the more basinward K-18 well. The fields discovered to date skirt the main Lower Cretaceous depocentre (Figs. 1 and 3). The underlying Jurassic source rock would therefore have passed through successive stages of maturation as it became progressively buried by Lower Cretaceous rocks in the depocentre. As

burial progressed, hydrocarbons of successively increasing degrees of maturity would therefore have been available for migration to the flanks of the basin. These maturation variations are evidently preserved in the complex block faulted fields and could also explain the high proportion of gas in the B-08 block (Benteau and Sheppard, 1982). This scenario could also explain the occurrence of oil in deep Jurassic sands below the immature Jurassic source in the South Tempest G-88 well. The oil would be derived from this source but at deeper structural levels in the basin. Because of the great thickness of Lower Cretaceous rocks in the depocentre, oil generation in Jurassic rocks would have started as early as Lower Cretaceous, the potential for loss of hydrocarbons from the basin during the period of the Avalon unconformity (Figs. 1 to 3) is therefore considerable. The oils currently in reservoirs beneath the Avalon unconformity were emplaced relatively late since there is no evidence of extensive biodegradation. For example, the oils in the Hebron well occurring in the Avalon sand immediately beneath the Avalon unconformity have a full suite of n-alkanes although they are depleted in gasoline range components (see section on Character of Oils). The depletion of gasoline range components may indicate that the Avalon unconformity is a major fluid conduit. A similar depletion has been observed in oils adjacent to the pre-Cretaceous unconformity in Alberta (Deroo and Powell, 1978).

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Table 1: Summary of maturation data.

Table 2: Criteria for definition of maturity zones, Jeanne D'Arc and Avalon Basins.

Table 3: Organic geochemical properties of oil samples from the Avalon Basin.

Figure 1: Location map, stratigraphy and cross section of Hibernia field; lines of section are those in Figures 2 and 3.

Figure 2: Schematic cross-section A-A' (Fig. 1) showing maturation and stratigraphic relationships, Jeanne D'Arc and Avalon Basins.

Figure 3: Schematic cross-section B-B' (Fig. 1) showing position of Hibernia field relative to depocentre (redrawn from Barbeau and Sheppard, 1982).

Figure 4: Organic carbon logs and hydrocarbon yields of selected samples from Hibernia P-15, O-35 and K-18 wells. Lettered samples refer to gas chromatograms in Figure 5.

Figure 5: Selected saturate fraction gas chromatograms of samples from Hibernia area. Sample positions are given in Figure 4.

Figure 6: Classification of organic matter types based on RockEval analyses: A) 4500 m interval, Hibernia K-18 well; B) Tertiary and Cretaceous samples, Ben Nevis I-45 well. Scatter in Oxygen Indices is due to varying contributions from mineral matter. Note differences in Hydrogen Indices.

Figure 7: Cluster analysis dendrogram of gasoline range data from oils and condensates. Numbered samples refer to Table 3.

Figure 8: Ternary diagram of normalized composition of C₇ compounds from oils and condensates. Numbered samples refer to Table 3.

Figure 9: Paraffin indices for oils and condensates and selected shales from Hibernia P-15 and K-18 wells.

Figure 10: Saturate fraction gas chromatograms of selected oils. Figure 11: Variation in Isoheptane Values in oils and sediments in Hibernia wells.

Fig. 1

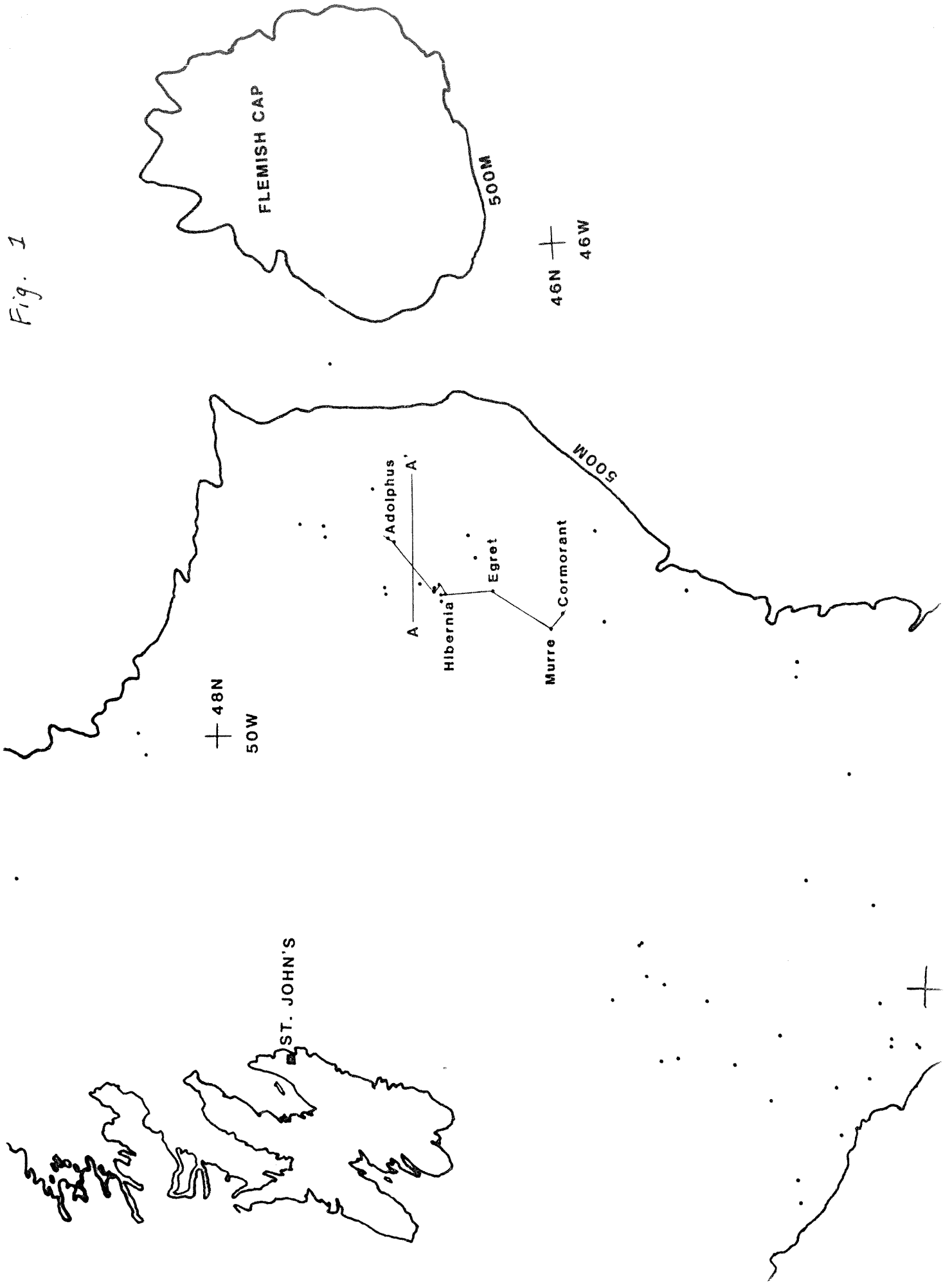
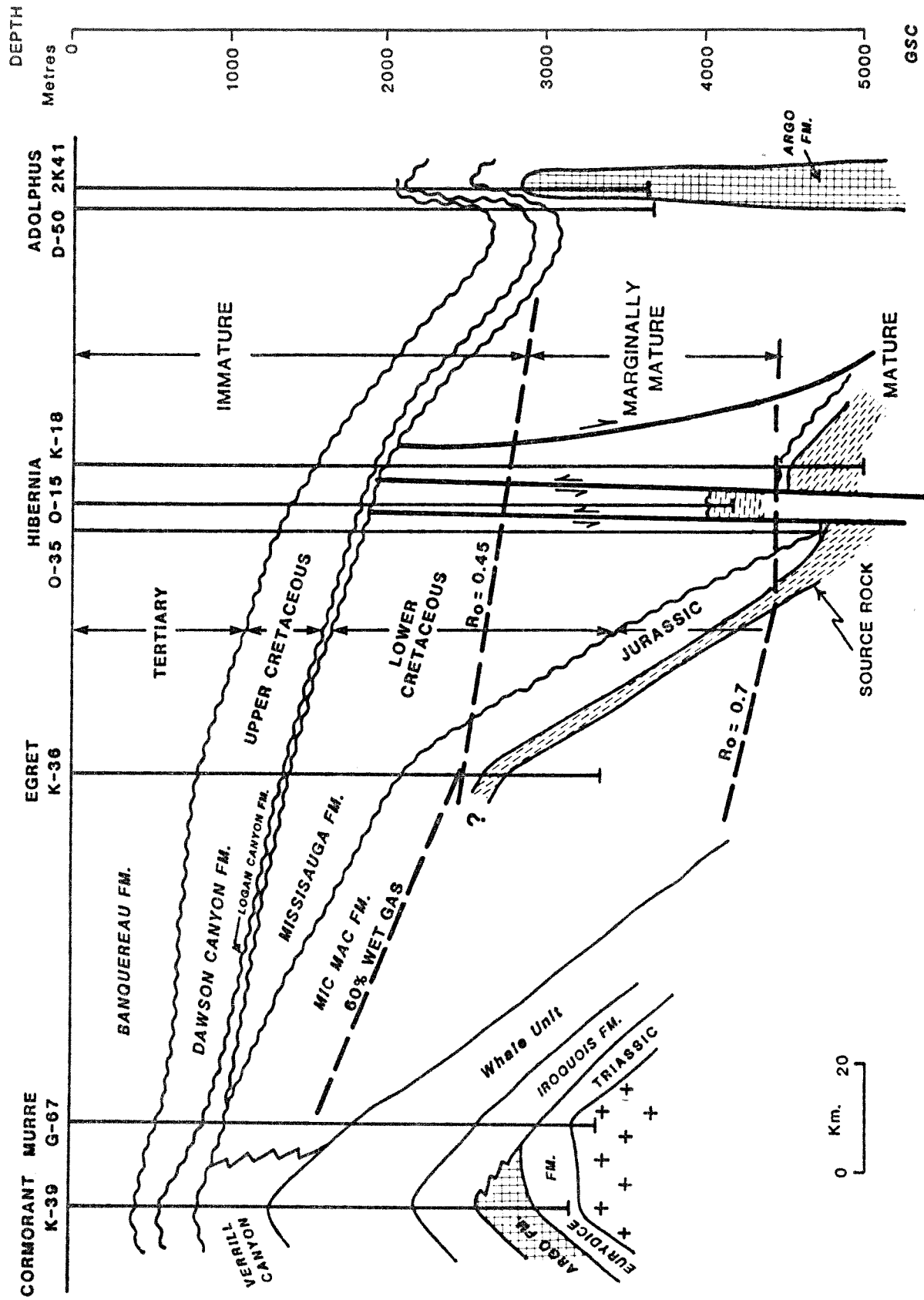
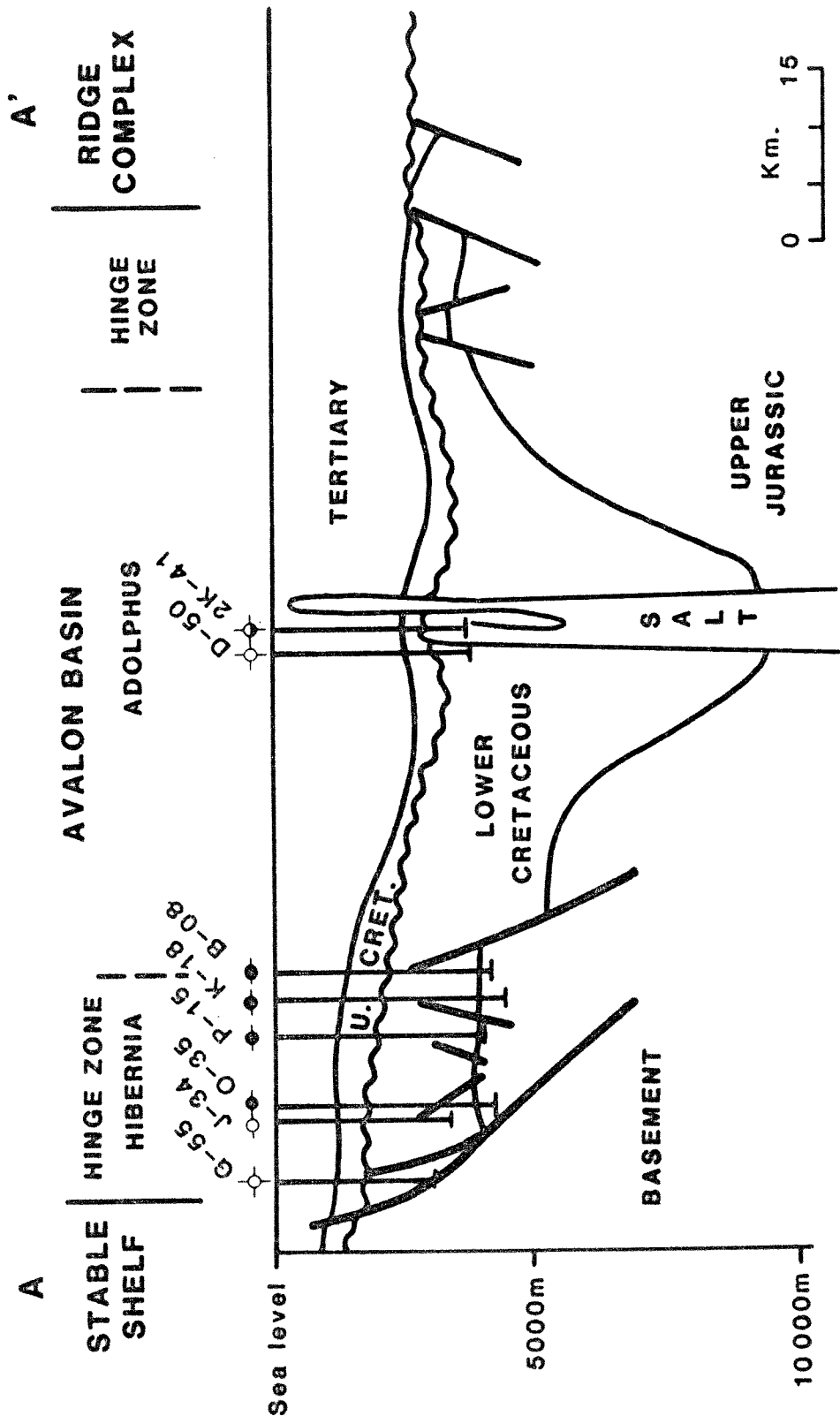


Fig. 2



SCHEMATIC CROSS-SECTION SHOWING MATURATION AND STRATIGRAPHIC RELATIONSHIPS

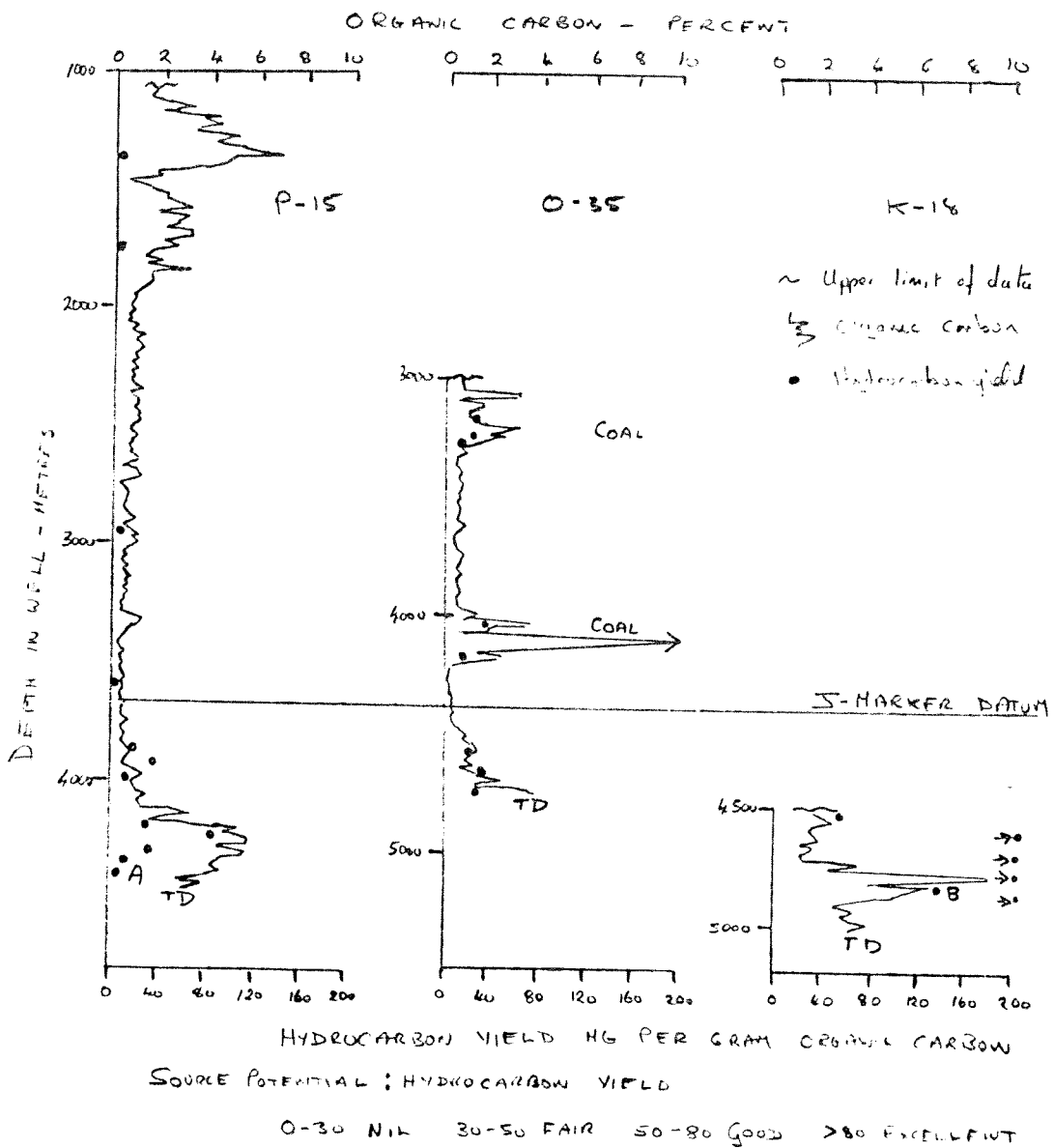
Fig. 3

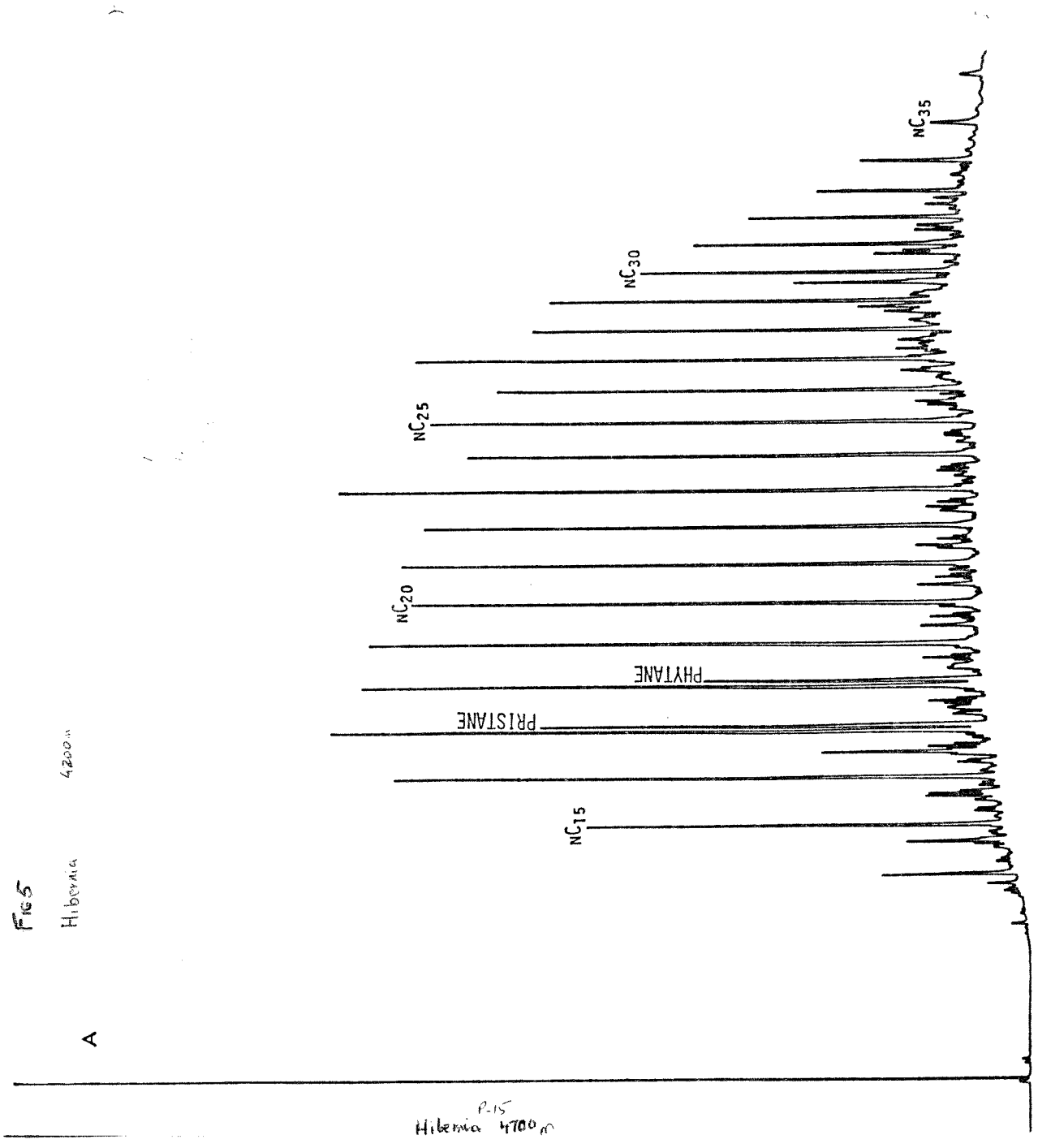


SCHEMATIC CROSS-SECTION ACROSS AVALON BASIN

GSC

Fig 4

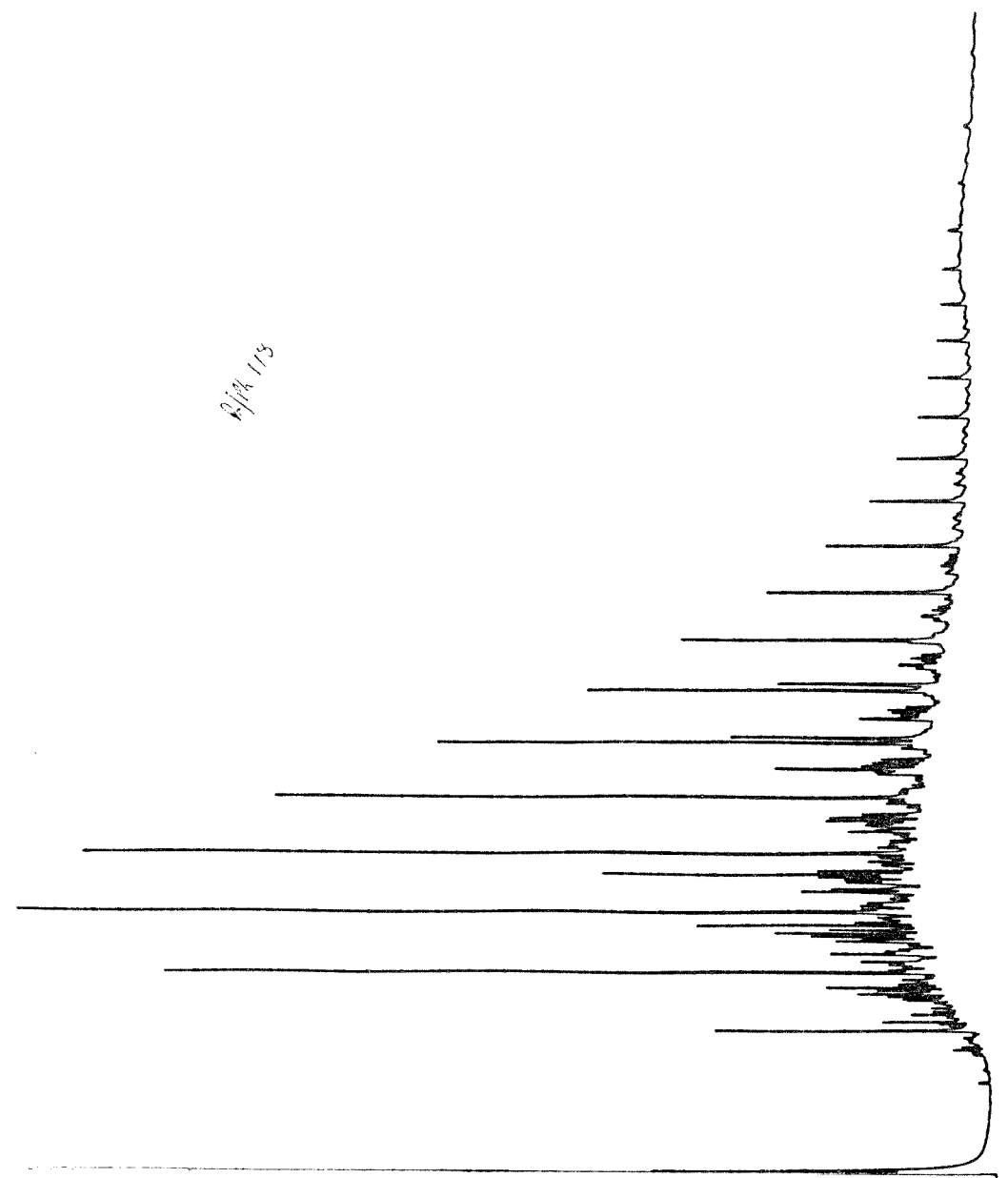






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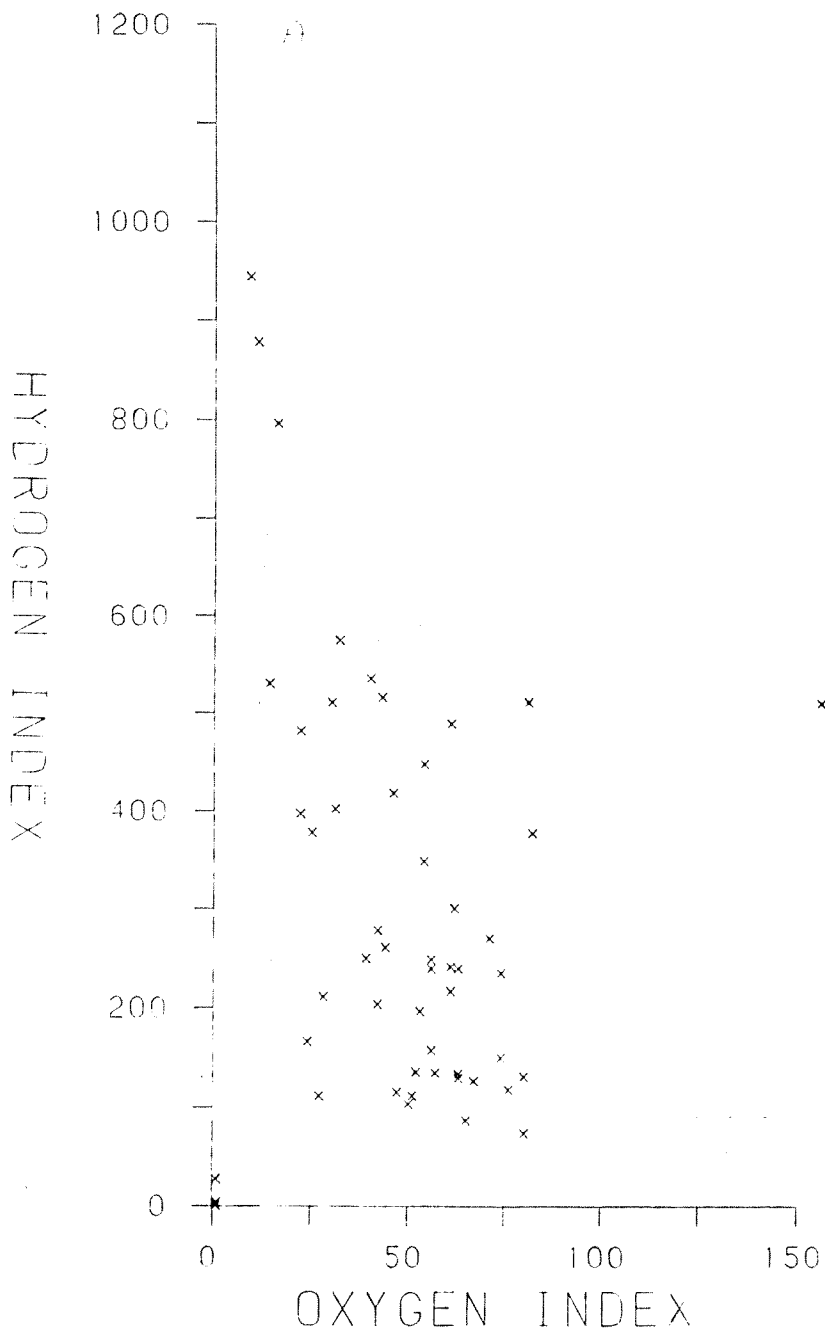
Fig 5 B



10394 Hibernia K-13 4840m Saturates

MAR 31 1983

Fig 6



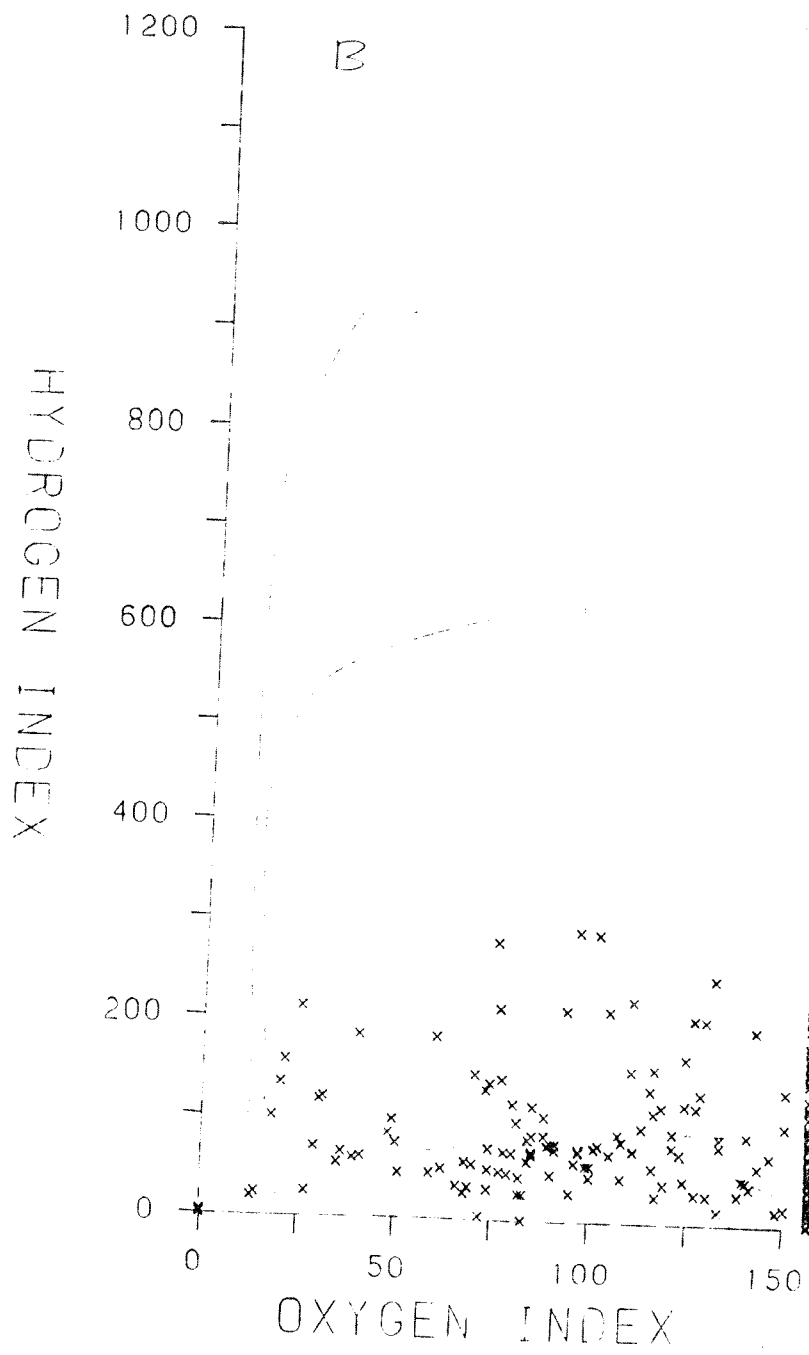


Fig 7.

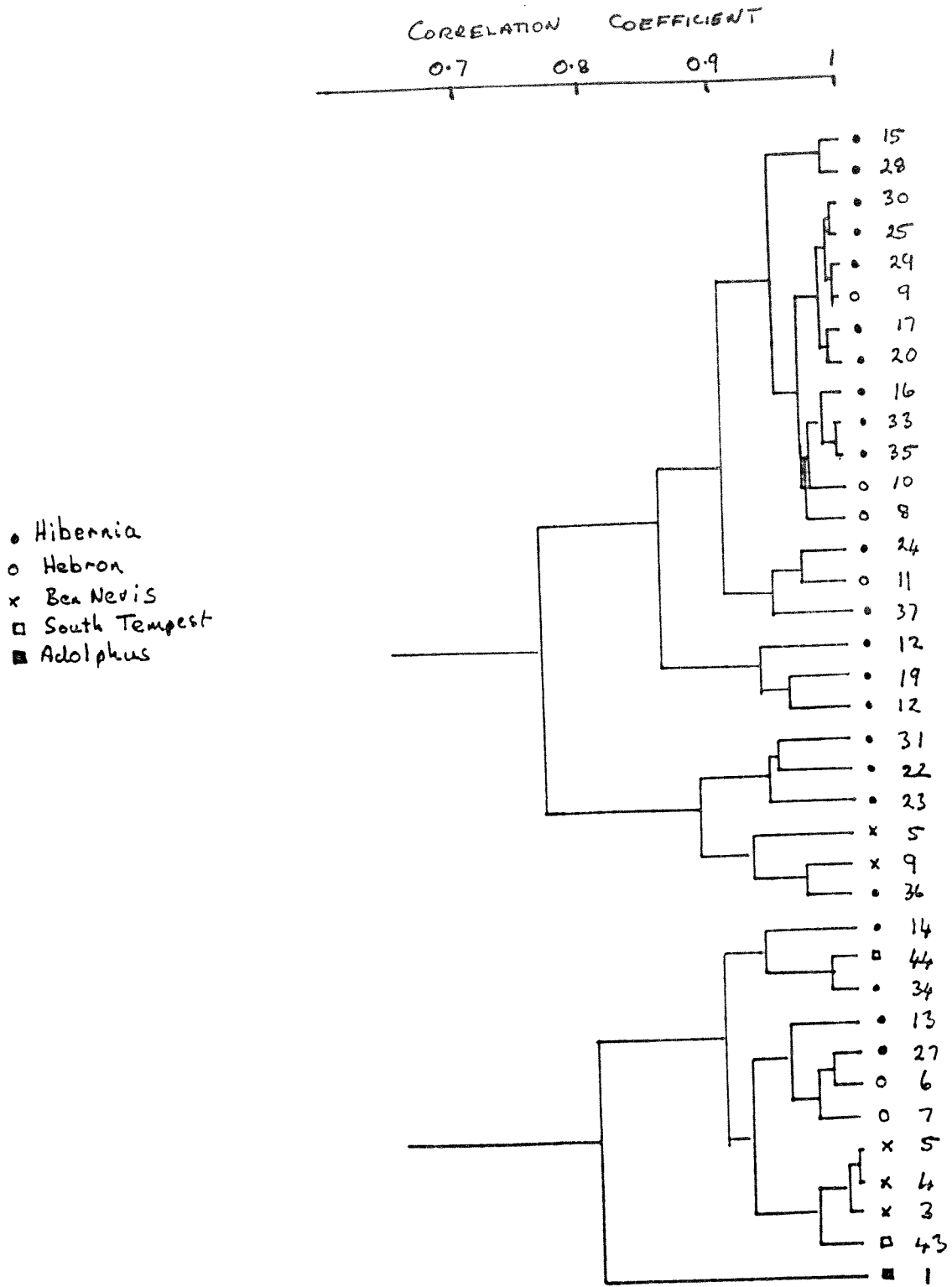


Fig 8.

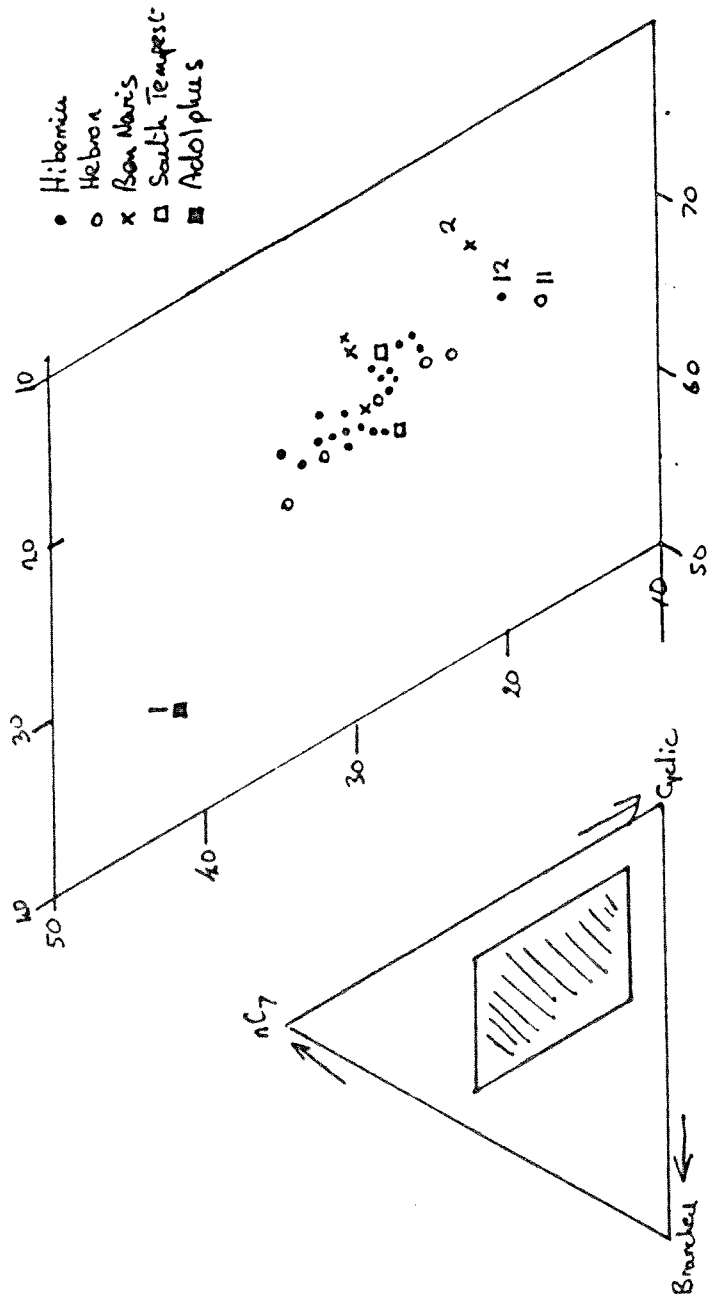


Fig. 9.

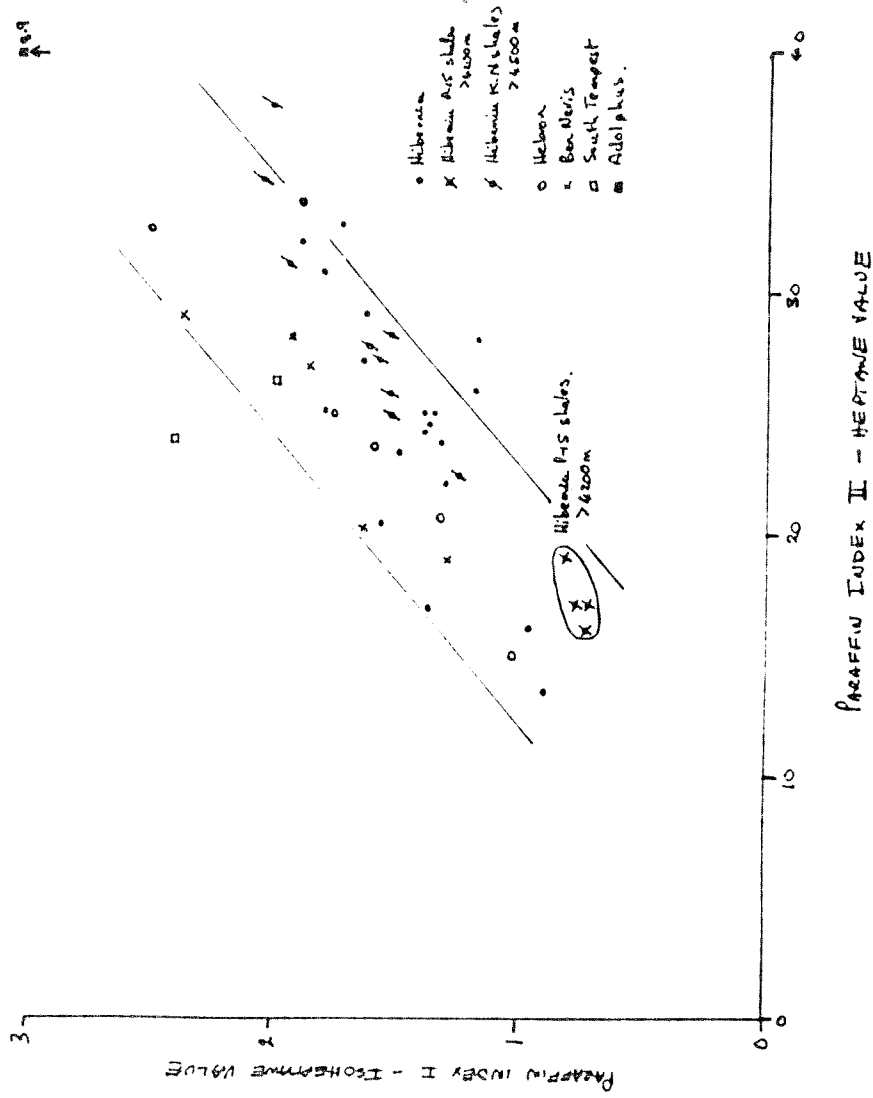
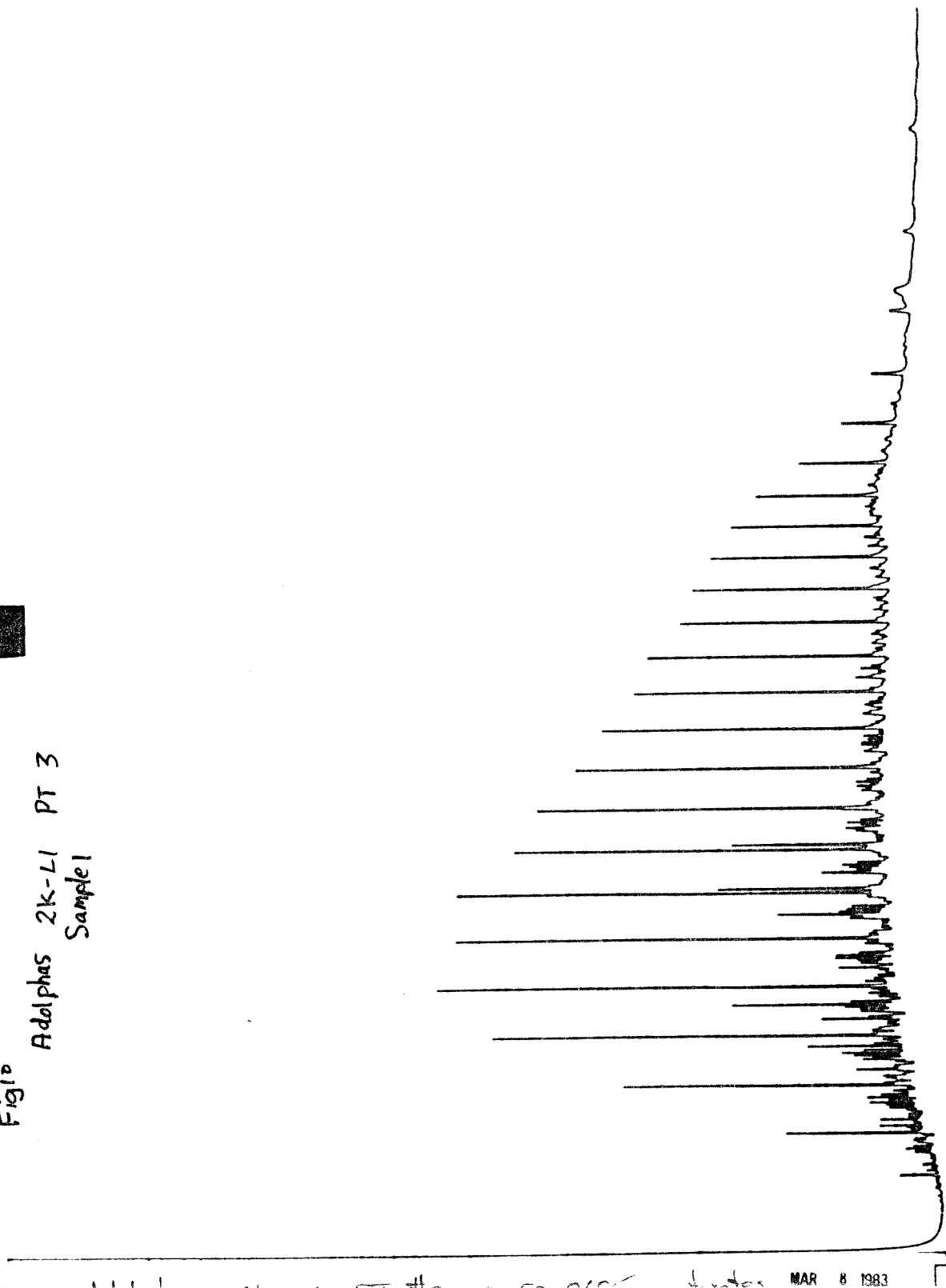
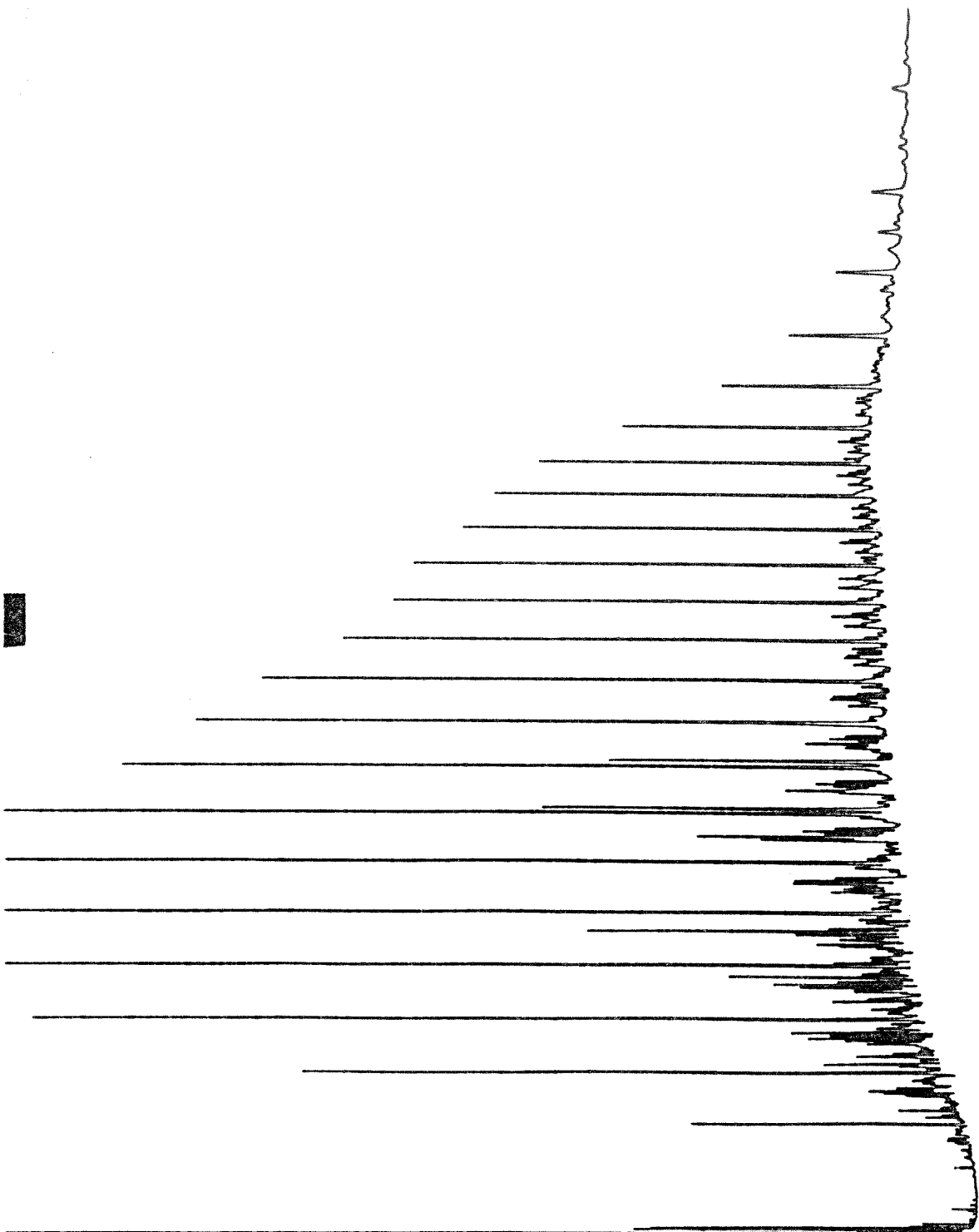




Fig 10
Adolphus 2k-L1 PT 3
Sample 1

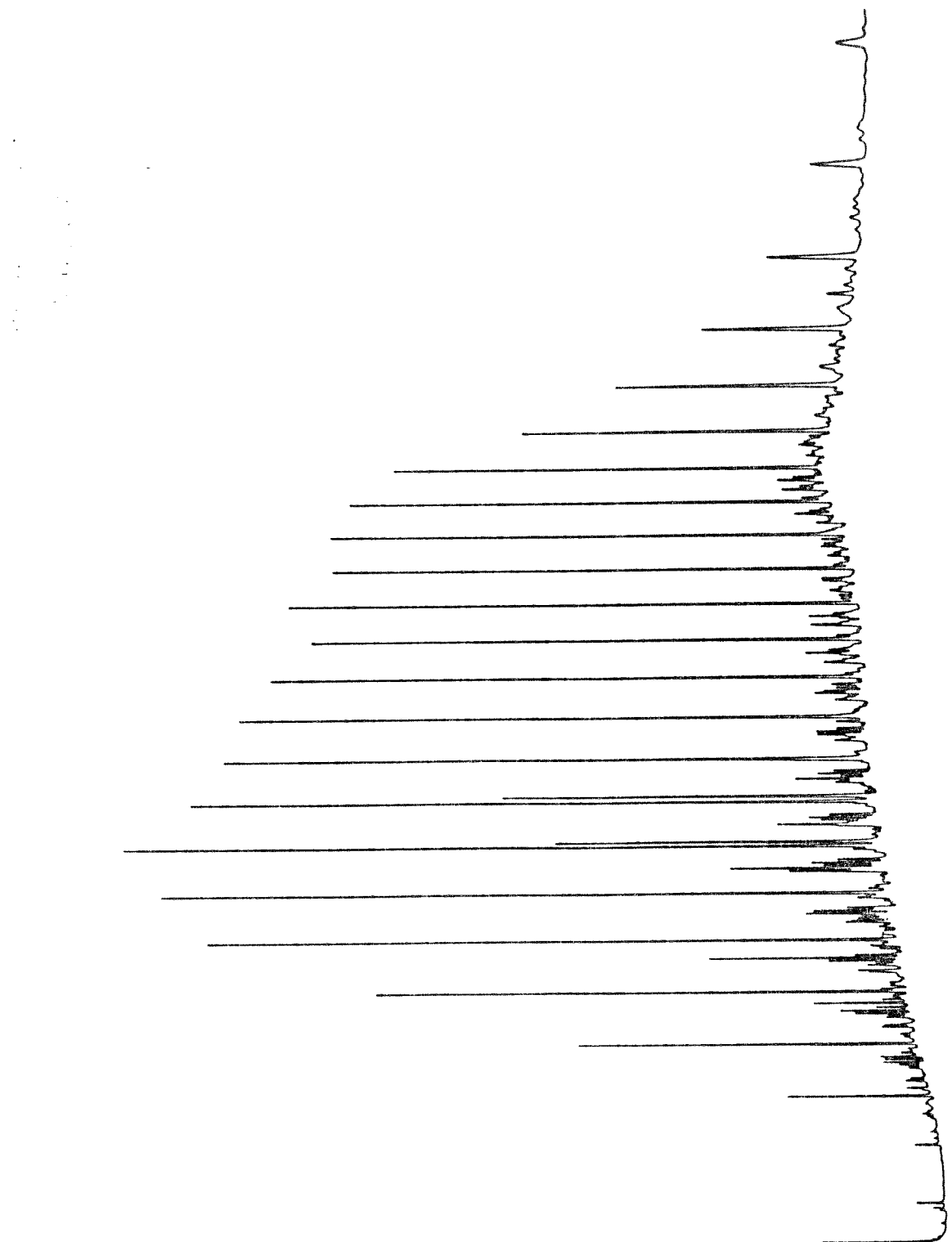




183 BEN NEVIS I-45 DST#11
2420 → 2432m Sats

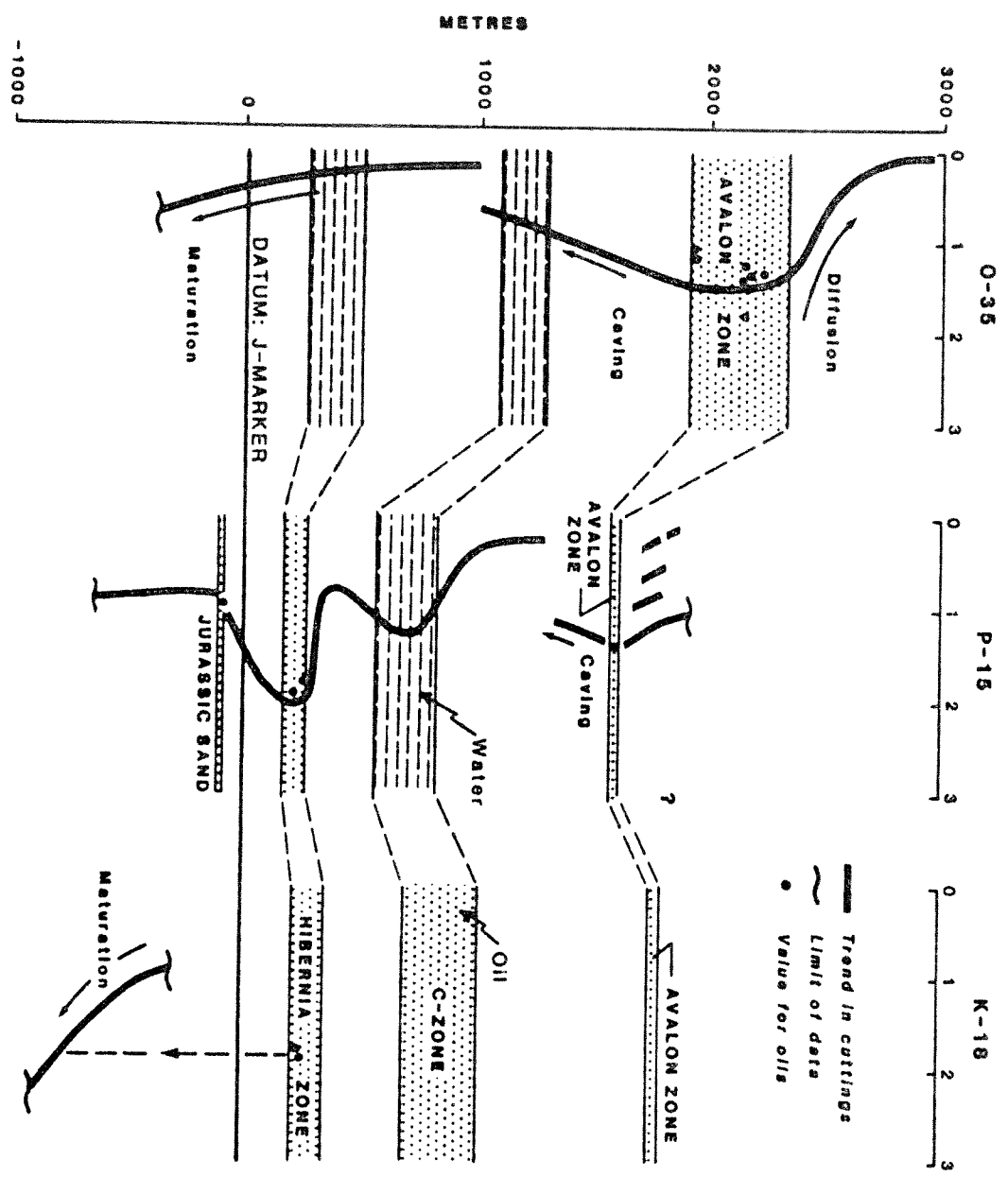
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266 Hibernia K:18 DST. # 11 Zone # 8 2313 → 2330 m

Fig 11



VARIATIONS IN PARAFFIN INDEX I HIBERNIA WELLS

TABLE 1: Summary of maturation data

	Light Hydrocarbons Ref 1, 2 >60% Wet Gas	Gasoline Ref 1 Range	Thermal Alteration Index Ref 3	Reflectance Ref 1+4 %Ro	Tmax Ref 1 °C	Extract Ref 1	Depth to Top
Bonnetion H-32	2700	1460	1+2 ⁻ 2 ⁻ 2 ⁻ , 2 ⁻	2 2, 2+ 0.5 0.6 0.7	425 435	445	Jurassic
Egret K-36	2200	2040	3000 3200	3000			2369
Egret N-46	1900	2100	2900 3200				2236
Ben Nevis I-45	2300			2800 3250 3750 2500 4000			
Hibernia P-15	3100	3100	1600 1900	3600 3300 4100			4095
Hibernia O-35	3900	2220	3520	2400 4000			4738
Hibernia K-18	<4500				<4500 4850	<4500	4511
Flying Foam I-13	2050	3300					3083
Adolphus D-50	1450	1800	2900 3250 3400				np
Dominion O-23	2133	3660	4000				np
S. Tempest G-88	3000				3500		3173

Sources of Data: Ref 1 - this paper; 2 - Hardy and Jackson (1980); 3 - Barss et al. (1980); 4 - Hacquebard (unpublished results)

TABLE 2: Criteria for definition of maturity zones

	% Wet Gas	Light Hydrocarbons iC_4/nC_4 iC_5/nC_5	Hydrocarbons Isoheptane Value	Heptane Value	Thermal Alteration Index	Vitrinite Reflectance %Ro	%Hydrocarbons in extract	Extract Data Odd/Even Predominance n-alkanes	Pr+Ph $nC_{17}+nC_{18}$	Tmax °C
Immature	<60	>1	<0.6	<10	<1+,2 ⁻	<0.45	<25	High (>2)	>1	<425
Marginally Mature	>60	<1	>0.6	>10	1+,2 ⁻ to 2	0.45-0.65	25-40	intermediate	<1	425-435
Mature		Not diagnostic			>2	>0.65	>40	=1	<1	>435

TABLE 3: Oil Samples and Analytical Data

Sample	Well	DST/PT	Depth (m)	Distillation %>210°C	% Composition >210°C			Saturate Fraction		Gasoline Range	
					Sats	Arom	Ons	Pr Ph	Pr+Ph nC ₁₇ +nC ₁₈	PI-1	PI-2
1	Adolphus 2K-41	3	2606-2647	17.6	54.7	34.4	9.7			8.93	39.6
2	Ben Nevis I-45	3	4427-4438	27.5	60.9	33.4	4.2	2.02	0.33	1.29	18.4
3		9	2890-2894	60.6	71.0	23.6	2.4	1.40	0.39	2.38	28.5
4		10	2440.5-2445.5	13.3	45.4	36.0	16.2	1.40	0.42	1.87	26.8
5		11	2420-2432	18.0	50.1	36.3	12.3	1.06	0.50	1.93	28.1
6	Hebron I-13	1	4368-4381	37.6	61.1	33.1	5.4	1.13	0.36	2.50	32.4
7		5	3842-3845	24.6	43.5	44.5	11.6	0.83	0.57	1.89	33.8
8		6	2974.8-2985.8	39.9	40.4	40.2	18.3	nd	nd	1.59	23.5
9		7	2923-2940	10.7	42.1	44.2	13.1	0.89	0.44	1.11	11.3?
10		9	1905-1915	7.1	36.3	45.1	18.6	0.92	0.66	1.31	20.5
11		10	1863-1876	10.7	42.1	44.2	13.1	0.91	0.37	1.02	2.6
12	Hibernia P-15	2	4113-4129	nd	52.7	35.1	9.3	0.92	0.76	0.95	16
13		8	3805-3822	26.9	53.4	37.8	7.8	1.00	0.51	1.90	32.1
14		10	3742-3746	21.9	51.6	39.9	8.1	1.10	0.39	1.80	30.8
15		11	2422-2443	18.1	48.0	38.2	12.7	0.84	0.59	1.39	25.1
16	Hibernia B-06	3	3705-3715	24.7	52.5	35.8	10.4	1.20	0.36	1.64	27.1
17		6	3604-3613	32.3	61.9	32.2	5.6	1.21	0.38	1.49	22.7
18		7		41.5	57.7	34.1	5.6	0.95	0.44		
19		9		62.0	71.3	25.6	2.4	1.01	0.47	1.38	16.8
20		11		62.1	72.5	24.3	1.9	1.07	0.45	1.78	25.5
21		12		35.2	72.8	24.0	1.6	1.06	0.43	1.17	28.0
22		16	3018-3033	81.8	70.7	26.4	2.0	0.45	0.62	1.63	29.1
23		17	2954-2963	82.8	75.4	23.3	1.7	0.99	0.69	1.30	22.0
24		18	2648-2661	28.4	53.1	34.8	10.6			1.57	20.4
25	Hibernia O-35	2	2476-2467	25.8	39.5	47.3	13.2	0.79	0.52	1.19	24.9
26		3	2430.7-2440.3	33.4	39.5	45.2	14.0	0.66	0.64	1.05	?
27		4	2349-2342	34.6	48.3	41.1	10.5	0.81	0.48	1.73	32.4
28		5	2305.4-2292	28.3	47.1	41.1	9.4	0.88	0.50	1.32	23.7
29		6	2218.7-2226.3	31.1	41.3	43.8	12.7	0.76	0.58	1.38	24.5
30		7	2195.5-2184.5	35.3	47.4	41.5	7.8	0.31	0.45	1.38	24.5
31		8	2055-2066	41.4	46.7	42.3	9.2	0.66	0.58	1.34	25.0
32	Hibernia K-18	1	3850-3895	28.3	46.1	40.1	12.9	0.84	0.45	nd	nd
33		2	3831-3843	37.5	43.5	42.6	13.0	0.72	0.46	1.74	25.7
34		3	3831-3843	24.9	46.2	39.7	13.4	0.85	0.46	1.86	28.4
35		4	3804-3812	31.4	41.6	43.4	15.0	0.84	0.45	1.78	26.6
36		5	3783-3788	27.7	51.8	39.8	8.4	0.96	0.45	nd	nd
37		6	3735-3740	26.3	51.0	40.9	8.0	0.68	0.51	nd	nd
38		7	3210-3217	26.2	39.7	45.9	14.2	0.72	0.62	nd	nd
39		8	3120-3135	25.4	44.8	42.9	12.1	0.81	0.61	nd	nd
40		11	2313-2330	28.8	41.1	46.5	12.2	0.79	0.61	nd	nd
41		12	2313-2330	32.0	41.1	46.3	12.6	0.84	0.62	nd	nd
42		13	2285-2294	25.7	43.2	44.3	12.5	0.83	0.62	nd	nd
43	South Tempest G-88	RFT	4043	nd	68.6	28.4	2.9	nd	nd	2.00	26.2
44		RFT	4113.5	nd	67.2	30.2	2.4	1.52	0.66	2.41	23.9

Sats = Saturates; Arom = Aromatics; ONS = Oxygen, nitrogen and sulphur compounds; PI-1 = Paraffin Index I; PI-2 = Paraffin Index II; Pr = Pristane; Ph = Phytane; nd = not determined