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# ORGANIC PETROGRAPHY AND KINETICS OF JURASSIC/CRETACEOUS SHALES AND GEOCHEMISTRY OF SELECTED LIQUID HYDROCARBONS, SCOTIAN BASIN

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## 1.0. SUMMARY

In this report, geochemical analysis and basin modelling using multicomponent kinetics resolved some of the intriguing problems of generation, expulsion, and entrapment of the Scotian Basin petroleums. The report establishes more understanding of the following aspects: (a) hydrocarbon potential of additional composite shale samples, (b) oil-oil and oil-source rock correlation have been reevaluated using additional analysis of aromatic biomarkers and fingerprinting the geochemical nature of additional oil asphaltenes, (c) multicomponent kinetic studies of Kerogen Type IIA-IIB and IIB for two samples using Pyromat II, and (d) amount and timing of generated and expelled hydrocarbon fractions (methane; $C_2$-$C_5$; $C_6$-$C_{15}$; and $C_{15}$+) using n-component kinetics in the BasinMod™ program.

### *Source Rock Characterization*

Except for a few samples from the Merigomish C-52 and Thebaud I-93 wells, most of the analyzed rocks contain abundant terrestrial oxidized organic matter forming Kerogen Type III (Tables 1 and 2). Most analyzed source rocks are mature for petroleum generation (Table 1). Statistically, 4.8% of the analyzed rocks can generate oil and condensate (Type IIA-IIB); 28.6% are capable of generating condensate and gas (Kerogen Type IIB); 61.8% are gas-prone (Kerogen Type III) and 4.8% are nonsource for commercial petroleum.

### *Oil-Oil and Oil-Source Rock Correlation*

Using methylphenanthrene index (MPI), the maturity of all oil and condensate samples analyzed for the last four years were reevaluated. The calculated vitrinite reflectance from most of the oil and condensate samples from Alma, Arcadia, Glenelg, S. Venture, Uniacke, and Venture fields are greater than 0.9% $R_c$ (S. Venture oils have the highest maturity: >1.1 $R_c$; Fig. 2A). Most of the Cohasset, Panuke, and Balmoral oils have less than 0.9% $R_c$ and are generally between 0.7 and 0.8% $R_c$.

Based on twenty-two maturity insensitive aromatic biomarkers (derived from GC/MS and Py-GC/MS), three distinctly different oil families could be recognized (Figs. 2B, 3, and 4; Tables 4a, 4b, 5, and 6). Group I represents most of the high maturity condensates from the Venture and other fields which are derived from a terrestrial source. Group 2 represents the majority of the

petroleum from the Cohasset-Panuke-Balmoral fields which are derived from an algal source. The Group 3 represents oils from the Sable Island wells (sourced from mixed organic matter). A few samples from Cohasset D-42 and Panuke J-99 do not correlate with any group possibly suggesting geochemical alteration of oil within the reservoir. According to oil-oil correlation of various reservoirs, most of the Cohasset-Panuke-Balmoral oils are genetically connected ($r^2$ >0.80) (Figs. 5a, 5b, and 5c).

### *N-Component Reaction Kinetics*

The multicomponent (methane, ethane, and propane) kinetics suggest that the generation of ethane from both kerogen (primary cracking) and $C_{15}$+ (secondary cracking) have the lowest activation energy distributions and $T_{max}$ values (derived from Pyromat II) (Table 7; Figs. 6 through 6d). The generation of methane from $C_{15}$+ required the highest activation energy distributions and $T_{max}$.

### *Amount and Timing of Methane Expulsion*

Preliminary evaluation on the generation and expulsion of n-components using BasinMod and analyzed n-component kinetics showed that they differ in various stratigraphic units and are dependant on the variation of their maturity and depth. The amount of methane expulsion from sixteen stratigraphic units from wells N. Truimph G-43/B-52 and fifteen units from the well S. Desbarres O-76 has been critically reviewed. In general, N. Truimph has generated and expelled almost double the amount of various n-components compared to the S. Desbarres O-76 well. This is because N. Truimph contains abundant Kerogen Type IIB source rock intervals and the sediments were buried deeper in the geological past. The amount of methane expelled from Kerogen Type IIB varies between ~7 (at 3665m) to 70 (at 10800m) mg/g TOC in the N. Truimph well and ~8 (3670m) and ~50 (5550m) mg/gTOC in S. Desbarres. The amount of methane expulsion varied widely for various stratigraphic units in both wells when Kerogen Type III source rock intervals are compared using the measured IIB and default III kinetics.

Similarly, the timing of methane expulsion in various units are dependant on their age, depth and maturity. As an example, in unit TJ2 (Kerogen Type IIB) of the N. Truimph G-43, the expulsion started around 130 mybp and reached its peak around 20 mybp (Table 9a). At the present time, this unit has reduced its capability for major gas expulsion. On the contrary, in well S. Desbarres O-76, the similar (Begin_Age) unit (MicMac, Kerogen Type IIB) started expelling around 90 mybp and reached its peak in the last 10 mybp (Table 9b). This suggests that the hydrocarbon system in the Scotian Basin is a highly dynamic system and the reservoirs are replenishing with hydrocarbons expelled from the younger horizons.

## 2.0. INTRODUCTION

### *2.1. Administrative Aspect*

This research proposal was requested by Supply and Services Canada, Dartmouth, Nova Scotia at the initiation of the Basin Analysis Subdivision of the Geological Survey of Canada Atlantic, Bedford Institute of Oceanography. Global Geoenergy Research Ltd. of Halifax, Nova Scotia, submitted a financial and work schedule for the research proposal. The proposal was accepted and the research work was started on July 11, 1994. Canada-Nova Scotia Offshore Petroleum Board (C-NSOPB), Halifax, Nova Scotia, on our request, permitted us to collect two condensates, four core samples, and forty-two unwashed cuttings from selected Scotian Shelf wells at the C-NSOPB Repository, Dartmouth, Nova Scotia.

According to the contract, Rock-Eval pyrolysis of 40 samples was done at the Geochemistry Laboratory at GSC Calgary. This laboratory also did liquid chromatography of eleven oil samples and bitumen extractions for four source rocks. According to the contract, kerogen isolation, smear slide preparation, kerogen plug preparation, and vitrinite reflectance measurement were done at the palynology laboratory (Bernard Crilley) and coal laboratory (Mike Avery) at the GSC Atlantic.

The analytical work for gas-chromatography mass spectrometry and pyrolysis-gas chromatography/mass spectrometry of aromatic biomarkers was subcontracted to Dr. Michael Kruge of the Southern Illinois University, Carbondale, U.S.A., who successfully completed earlier subcontracts on Scotian Shelf samples (Mukhopadhyay, 1991, 1993, 1994). The use of multicomponent kinetics for oil and gas generation is at present in an experimental stage. Only two commercial laboratories (Lab Instruments [Dr. Alain Samoun] and Humble Geochemical Services [Dan Jarvie]) in North America can do those analysis. Our earlier studies indicated that oil and condensate in the Scotian Basin were generated from multiple source rocks. The use of multicomponent kinetics would be useful in partitioning the generation and expulsion of gas and condensate as normal crude oil is extremely rare in the basin. This work was subcontracted to Alain Samoun of Lab Instruments, Kenwood, California. Dr. Simoun was previously involved with this type of multicomponent kinetics studies in association with the Lawrence Livermore Group who formulated n-component reaction kinetics in the latest version of the BasinMod$^{TM}$ (1994) Program.

### *2.2. Scientific Aspect*

Between 1970 and 1990, significant gas and associated condensate or light oil were discovered in the Jurassic-Cretaceous reservoirs around the Sable Subbasin of the Scotian Basin. Since 1988, Basin Analysis Subdivision of Geological Survey of Canada, Atlantic at Dartmouth, Nova Scotia initiated systematic research projects to resolve problems related to the characterization of the source rocks and reservoired petroleum. Those studies (as done by Global Geoenergy Research Ltd.) characterized some of the source rocks in various stratigraphic intervals; characterized the geochemical properties of some selected oils and condensates; and determined some possible oil-oil and source rock-oil correlation (Mukhopadhyay and Birk, 1989; Mukhopadhyay, 1989; Mukhopadhyay and Wade, 1990; Mukhopadhyay, 1990a; Mukhopadhyay, 1990b; Mukhopadhyay, 1991, Mukhopadhyay, 1993; Mukhopadhyay, 1994a and b; Mukhopadhyay et al., 1995).

Mukhopadhyay (1991, 1993, 1994), from extensive organic petrographic analyses and Rock-Eval pyrolysis, established the distribution of various organic facies present in the basin and the proportion of oil-, condensate-, and gas-prone source rocks in the various stratigraphic sequences. Mukhopadhyay (1991, 1993, 1994), from the study of the aromatic biomarkers and bitumen/oil isotope analyses, characterized possible correlation of oil-oil and oil-source rock pairs which indicated that various crude oils or condensates may have been derived from three types of source rocks.

Isotopic composition of kerogen, using stable carbon isotope, may provide information on the nature of depositional environment and type of organic matter. Mukhopadhyay (1994b) studied the isotopic composition (-22.72 to -26.41°/oo) of ten kerogen samples which suggests that none of them were formed in a restricted, anoxic basin. However, some shale and limestone samples (in N. Truimph and Abenaki wells) may have some influence of marine phytoplankton as compared to the shale samples from Venture area. The isotopic composition also shows the difference in maturity among various kerogens.

Kinetic analysis is performed on known source rocks to determine the energy required to decompose organic matter to form petroleum. Application of these data in a quantitative basin modeling program permits a more accurate determination of the timing of oil generation. The *BasinMod* program utilizes those chemically derived kinetic models to accurately predict the onset and peak oil/gas zones and timing/amount of hydrocarbon generation and migration (Platt River Associates, 1992). In our previous studies, kinetic analysis of selected source rocks showed wide variations in the distribution of activation energies and Arrhenius Factors (Mukhopadhyay, 1993, 1994a; Mukhopadhyay et al., 1995). Some Kerogen Type IIA-IIB can generate and expel hydrocarbons earlier in the maturation history of a source rock (<0.8% $R_o$) with about 60% of activation energies below 48 kcal/mole, whereas other Kerogen Type IIA-IIB source rocks behave similar to Kerogen Type II of Tissot and Welte (1984) having 60% activation energies between 49 and 52 kcal/mole. The reaction rate of the second form of Kerogen Type IIA-IIB is considered as medium compared to the first one (Mukhopadhyay, 1993, 1994a, 1994b). The reaction rate of some Kerogen Type IIB is slower compared to both forms of Kerogen Type IIA-IIB source rock. The kinetic analysis, acquired through various contracts, already enhanced our capability to achieve an understanding about the timing of petroleum generation and migration using the BasinMod program.

However, those studies were found to be inadequate to define precisely the generation and expulsion of various hydrocarbon fractions, and the volume of reservoired petroleum in the basin because (a) the kinetics of gas generation using primary and secondary cracking was not evaluated, (b) lack of analysis of an adequate number of composite source rock intervals, and (c) the absence of adequate oil-oil correlation within the reservoired petroleum in the Cohasset-Panuke-Balmoral area. The present work attempts to solve some of those existing problems.

### *2.3. Objectives*

The objectives of this research are:

(a) To define the organic facies, kerogen type, and hydrocarbon potential of additional 40 composite shale source rock intervals.

(b) To use aromatic biomarkers and asphaltene pyrolyzates for oil-oil and possible oil-source rock correlation and differences using crude oils from the various reservoir within the Cohasset-Panuke-Balmoral and Venture fields.

(c) To evaluate the primary and secondary cracking of kerogen and $C_{15}$+ hydrocarbons for gas and condensate generation from some selected Kerogen Type IIB and IIA-IIB source rocks to determine the timing and an approximate amount of gas generation. Two types of gas generating kinetics will be studied: (i) direct cracking of the kerogen macromolecule to form methane and other gases, and (ii) cracking of the generated crude oil within the organic matter which were not expelled earlier from the organic matter network.

## 3.0. ANALYTICAL PROCEDURES

### *3.1. Samples*

Forty-two composite shale samples (unwashed cuttings), four core samples, and seven oil/condensate samples were analyzed (Fig. 1 and Tables 1 and 3). All rock samples were analyzed for organic petrography (organic facies and vitrinite reflectance) (Table 1). Those forty-two composite shale samples from the Logan Canyon, Missisauga, Verrill Canyon and Mic Mac Formations were chosen from the following wells:Bluenose 2G-47 (between 4730-5797m), Citadel H-52 (5500-5620m), Eagle D-21 (10800-15900'), Intrepid L-80 (9280-12940'), Merogomish C-52 (2515-3950m), Onondaga B-96 (8100-13085'), Sable Island C-67 (9090-15100'), S. Venture O-59 (4340-6175m), Thebaud I-93 (3835-5000m), Venture D-23 (2700-2750m), Wenonah J-75 (8230-12040'). Forty rock samples were analyzed for Rock-Eval pyrolysis (Table 2). The samples used in the study for oil-oil and oil-source rock correlation are presented in Table 3. In Table 3a, the seven new samples are distinguished by the prefix "NS94" in their SIU (Southern Illinois University, Kruge, 1991, 1992, 1993) numbers. They include Balmoral M-32 (test 1), Cohasset A-52 (test 1), Cohasset D-52 (test 3), S. Venture O-59 (test 11), Venture B-13 (tests 6 and 4), and W. Venture C-62 (test 3). The asphaltenes analyzed are from the latter two samples. All four core samples (S. Desbarres O-76, 3801.88m; S. Sable B-44, 3938.3m; W. Chebucto K-20, 4043.1m; and N. Truimph B-52, 3773.5m) were analyzed for Rock-Eval pyrolysis and bitumen extraction. Based on those data, two samples (two extracted rocks and two bitumen extracts) were selected for kinetic analysis (Table 7a through 7d).

### *3.2. Methods*

The methods adopted for organic facies, vitrinite reflectance, and Rock-Eval pyrolysis, were discussed in our earlier reports (Mukhopadhyay, 1991, 1993).

3.2.1. Aromatics Biomarkers and Pyrolysis-GC/MS of Oil Asphaltenes: Most of the analytical and statistical methods have been described in detail previously by Kruge 1990; 1991; 1992; 1993. One difference in the current round of analyses is that asphaltenes were analyzed by pyrolysis-GC/MS, rather than py-GC-FID as was done previously. So that the data for the new samples would be compatible with the old, the five original asphaltenes were reanalyzed by py-GC/MS. The three rock extract asphaltenes were deasphaltened again by the method of Kruge (1992) in an attempt to remove contaminants previously noted. For pyrolysis-GC/MS, a CDS 120 Pyroprobe was coupled to an HP 5890A GC and an HP 5970B Mass Selective Detector. The GC was equipped with a 50 m HP-1 column (0.2 mm i.d., 0.33 µm film thickness), initially held at 40°C for 5 min., then raised to 300° at 5°/min., then held for 20 min. The mass spectrometer scanned from 50 to 450 Da, with an ionizing voltage of 70 eV. The Pyroprobe heated the sample at 610°C for 20 sec. The molecular ions of the compounds of interest were used for quantitation, except in the case of *n*-alkanes and *n*-alk-1-enes, for which the base peaks were used (m/z 57 and 55, respectively). Another difference is that the aromatic fractions were analyzed using a 50 m HP-1 column, rather than the 25 m column previously employed. The new temperature program was from 100 to 300°C at 3°/min., holding at 300° for 15 min. The aromatic data were collected in SIM mode, as described previously (Kruge, 1990; 1991; 1993), except that m/z 212 was omitted. This means that there are no data for dimethyldibenzothiophenes for the current group of samples.

Statistical processing of the quantitated, normalized and scaled aromatic GC/MS data was attempted two ways — 1) as described by Kruge (1990; 1991) and Mukhopadhyay and others (1995) and 2) by the method of Kruge (1993). The former method was found to yield results most compatible with the stratigraphic, petrologic and pyrolysis data and is presented in this report. In brief, the raw data were normalized according to compound class, scaled logarithmically, stripped of components which were sensitive to maturation and subjected to a multiple linear regression. The regression results were summarized by cluster analysis using the "single linkage" method. Refer to Kruge (1991) for a full explanation. The only difference in the method used in present report is the above-mentioned absence of dimethyldibenzothiophenes, as well as the absence of one dimethylbiphenyl peak due to a coelution problem on the 50 m column.

3.2.2. Pyrolysis-MS Kinetic Analysis: Pre-extracted rock and oil (bitumen) extract from two core samples (well: N. Truimph B-52, 3773.5m [no. 8355 in Tables 7a and 7b] and S. Desbarres O-76, 3801.88m [no. 8358 in Tables 7c and 7d]) were analyzed on a PYROMAT II MS micropyrolyzer. The temperature programme for the analysis was as follows: 10 minutes at 250°C and then pyrolyzed up to 750°C with three heating rates (50, 15, and 5°C/minute). The sample weight varies between 10 and 100 mg. In order to determine multicomponent kinetics, the following three mass fragment ions were monitored: (1) m15 - methane; (b) m29 - ethane; and (c) m43 - propane.

Hydrocarbon pyrograms are in good agreement with previous results (Burnham et al., 1987; Braun and Burnham, 1991). The two rock and two oil (bitumen) samples produced kinetic factors relatively close to each other or quite different depending on the monitored mass number.

3.2.3. Modelling of Hydrocarbon Generation Using *BASINMOD*$^{TM}$: In the BASIN-MOD program, geohistory/burial history constructs a geological model of stratigraphy versus time utilizing a wide range of parameters such as lithology, water depth, surface temperature, compaction, permeability, conductivity, subsidence, thermal history using either rifting heat flow or present day geothermal gradient. The model calculates the thermal conductivities automatically when the lithology or a mixture of lithologies is chosen. Compaction corrections have a significant impact on thermal history which, in turn, affects the timing of source rock maturity, petroleum generation and expulsion. For the modeling, the default compaction correction was used according to Sclater and Christie (Platt River Associates, 1992). The permeability factor considers the fluid flow (single phase) through porous media using Darcy's Law. For the modeling, Kozeny-Carmen/modified Kozeny Carmen default values were used.

BasinMod accepts one surface heat flow value which represents the total of all heat sources at the surface. For the modeling, Steady State Heat Flow was considered which is based on the simple relationship between heat flow and thermal conductivity. Rifting heat flow was taken as major heat source which usually decreases with time. One requirement for the calculation of rifting heat flow in BASIN-MOD is a $\beta$ factor. Usually the default value for $\beta$ is 2 in the BASIN-MOD Program. For this report, $\beta$ was taken as 3 for the analyzed wells.

BMOD-BSM provides a n-component kinetic model which considers a parallel reaction model and is based upon the method developed at Lawrence Livermore National Laboratory (1989, 1992, 1994). The kinetic approach considers the diversity of composition and distribution of the original kerogen. It calculates the multiple parallel reactions that occur as organic matter undergoes transformation to hydrocarbons (Burnham et al., 1987; Espitalie et al., 1987; Braun and Burnham, 1987, 1991). Each reaction has its own kinetic parameters such as percentage of kerogen with a specific activation energy and Arrhenius constant or Frequency factor (frequency with which certain reaction takes place). The kinetic approach considers the various HC potential for different kerogens. BMOD-KIM converts kerogens to oil and gas (4-component model). The oil can undergo secondary cracking to gas and residue. The expulsion efficiency in the n-component reaction is calculated on a "Saturation Method". In the saturation method, expulsion efficiency is controlled by a porosity saturation threshold. This suggests that hydrocarbons saturated beyond that threshold are expelled. The default saturation value is 0.20 (20% saturation). Analyzed organic facies data suggest that Kerogen Type IIB and IIA-IIB source rocks occur mostly as thin units (Mukhopadhyay, 1991, 1993, 1994a). Accordingly, the lithostratigraphic units were further subdivided into thin Kerogen Type IIB or IIA-IIB and thick Kerogen Type III units. Tables 8a and 8b illustrate the revised lithostratigraphic units for the wells N. Truimph G-43 and S. Desbarres O-76, respectively.

In the BasinMod program, three wells (S. Desbarres O-76, N. Truimph B-52, and Venture B-52) were selected to estimate the generation and migration of various hydrocarbon components (methane, $C_2$-$C_5$ gases, $C_6$-$C_{15}$ condensates, and $C_{15}$+) from selected source rocks. Accordingly, the analyzed muliticomponent kinetics data were utilized within "Reaction Networks" of BasinMod. The kinetics of ethane generation (m29) is used for $C_2$-$C_5$ hydrocarbons and the kinetics for propane (m43) generation was used for $C_6$-$C_{15}$ (condensate range).

In the "Reaction Networks", three stages of data input are required: (a) network structure; (b) reaction constants; and (c) product properties. In the *network structure,* the proportion of primary cracking (kerogen to $C_{15}$+, methane, $C_2$-$C_5$, $C_6$-$C_{15}$ and residue) and secondary cracking ($C_{15}$+ to methane, $C_2$-$C_5$, $C_6$-$C_{15}$, and residue) are arbitrarily chosen. In the *reaction constants*, the actual distribution of activation energies in relation to percentages of hydrocarbon conversion for the n-components (1. kerogen to $C_{15}$+, methane, $C_2$-$C_5$, and $C_6$-$C_{15}$; 2. $C_{15}$+ to methane, $C_2$-$C_5$, and $C_6$-$C_{15}$) were inserted. The third input requires the actual density and expulsion criteria of each n-components. For those input data, three Kerogen Types (IIA-IIB, IIB, and III) were used. The n-component kinetics for Kerogen Type IIA-IIB and IIB were determined in this report. For Kerogen Type III, the default n-component kinetics of Brent coal was used (Platt River Associates, 1994). The following input data for density were used: $C_{15}$+ = 0.81-0.84; $C_6$-$C_{15}$ = 0.73 to 0.78; $C_2$-$C_5$ gases = 0.1; methane = 0.007 to 0.01. In this report, 1-D modelling of two wells (N. Truimph B-52/G-43 and S. Desbarres O-76) was reported to show the amount of generated and expelled n-components (methane, $C_2$-$C_5$, $C_6$-$C_{15}$, and $C_{15}$+) through time from various source rock intervals.

## 4.0. RESULTS AND DISCUSSIONS

### *4.1. Organic Facies*

Except for the Merigomish C-52 samples , the majority of the composite shale samples analyzed for this report, have abundant vitrinite and inertinite group of macerals indicating predominance of terrestrial organic matter and oxidation during tranport and at the depositional interface (Table 1). Those samples also contain oxidized liptinites such as sporinite and resinite as revealed by the transparency and fluorescence colour (example: samples from Onondaga B-96). All analyzed samples from Merigomish C-52, except one, contain algal derived organic matter (telalginite, lamalginite, exinite [algal spore], AOM 2). The sample at 3730m in Merigomish, contains more than 50% AOM 2 derived from degradation products of algal and terrestrial liptinite. Based on organic facies (having fluorescent lamalginite and AOM 2), all analyzed samples from the Logan Canyon Formation in Merigomish C-52 can be considered as Kerogen Type IIA-IIB and IIB. On the other hand, composite shale samples from the same formation, as well as underlying formations in Wenonah J-75, 18 kms to the east show abundant oxidation forming mainly Kerogen Type III and III-IV. Except for a sample from 4860m, most samples from Thebaud I-93 are contaminated with drilling mud additives (example: lignosulfonate) in spite of thoroughly cleaning and handpicking the sample.

### *4.2. Rock-Eval Pyrolysis*

Table 2 illustrates the data of various Rock-Eval pyrolysis parameters ($S_1$, $S_2$, $S_1$+$S_2$, $S_3$, PI, HI, OI, $T_{max}$, and TOC) from the 40 composite shale samples. The total organic carbon content of the whole rock samples varies between 0.56 (S. Venture O-59, 4475-4610m) to 5.12% (Bluenose 2G-47, 5260-5500m)).

Considering the depth and total organic carbon content of the samples, the amount of $S_1$ (thermal extraction below 300°C) fraction is considered as extremely high (Table 1A)(Tissot and Welte, 1984). Anomalously high $S_1$ content may be caused by: (a)contamination from drilling mud additives, especially hydrocarbons; (b) early generation of hydrocarbons; and (c) soaking of allochthonous bitumen or migrated petroleum. At this stage, it is difficult to predict the cause of the $S_1$ anomaly. Petrological evaluation of those samples (except samples from wells Thebaud I-93 and S. Venture O-59) ruled out the possibility of contamination by drilling mud additives.

Except for samples from Merigomish C-52, the $S_2$ fraction of most samples have <1 mg HC/g of rock suggesting extremely low potential for crude oil (Table 2). The low $S_2$ can also be caused by the retention of liquid hydrocarbons (derived from cracking of kerogen) within the mineral matrix (Espitalie et al., 1985; Mukhopadhyay, 1989 and references therein).

Except for the Thebaud and S. Venture wells, $T_{max}$ (maturation parameter) values in composite shale samples increase with depth. The suppression of $T_{max}$ in some wells may be caused by the anomalously high $S_1$ (free hydrocarbons) content of the samples or the presence of lignite contamination.

### *4.3. Maturation and Source Rock Potential*

Vitrinite reflectance data (Table 1) of all samples (except one sample from Merigomish C-52) are considered as mature (between 0.5 to 1.3% $R_o$) to overmature (>1.4% $R_o$). In most cases, vitrinite reflectance values increase with the depth of the sediment. The vitrinite reflectance values in the deeper sediments, in most cases, do not correlate with the $T_{max}$ values which are possibly caused by bitumen absorption within the whole rock matrix or due to lignite contamination. Merigomish C-52 shows a sharp increase in vitrinite reflectance between 2515m (0.48% $R_o$) and 3950m (0.99% $R_o$) possibly due to normal faulting. The presence of exhausted AOM 2 corresponds with the higher reflectance at 3950m. The lowest reflectance is observed at 2515m in Merigomish C-52 and the highest reflectance was observed at 6175m in S. Venture O-59.

Statistically, 4.8% of the 42 analyzed samples are oil- and condensate-prone Kerogen

Type IIA-IIB; 28.6% are condensate- and gas-prone Kerogen Type IIB; 61.8% are gas-prone Kerogen Type III; and 4.8% are interpreted as Kerogen Type III-IV which is considered as nonsource rock for major liquid hydrocarbons and gas. This interpretation is based mainly on organic facies analysis as Rock-Eval pyrolysis data are influenced by maturation and contamination. Most analyzed source rocks are mature for oil and gas generation.

### *4.4. Aromatic Biomarkers*

As part of an ongoing organic petrological and geochemical study in the Scotian Basin (Mukhopadhyay et al., 1995), the aromatic fractions of 21 petroleums and 18 rock extracts had been evaluated by gas chromatography/mass spectrometry (GC/MS) (Kruge, 1990; 1991; 1993) (Tables 3a and 3b). The thermal maturity levels were determined for each sample and two statistical approaches to oil classification and oil-source rock correlation were attempted, as described in detail in the above reports. Asphaltenes from two oils and three rock extracts were analyzed by pyrolysis-gas chromatography, providing additional evidence (Kruge, 1992). This report documents the results of the analysis of 7 additional petroleum aromatic fractions and two additional petroleum asphaltenes.

4.4.1. Maturity Determination From Polyaromatic Hydrocarbon Distributions: Polyaromatic hydrocarbons (PAH) have been shown to be very sensitive to levels of thermal maturation, as was discussed previously in detail (Kruge, 1990; 1991; 1993). As was done before, the initial maturity assessment was made using the methylphenanthrene index (MPI), cast in the form "$R_c$", which is an estimate of the percent reflectance of vitrinite. The new samples may be seen in their maturity context in Table 4 and Figure 2A. The new Cohasset, S. Venture and Balmoral oils show maturity levels compatible with the early to early middle oil window. The Venture and W. Venture oils appear to be in the upper oil window, with Venture B-13 (test 4) being the most mature of the group.

4.4.2. Oil Classification and Oil-Source Rock Correlation: The statistical results discussed in this report represent both 1) an incorporation of the new PAH data into the preexisting matrix and 2) a revision of last year's study (Kruge, 1993). It is a return to the methods employed in the first reports (Kruge, 1990; 1991; Mukhopadhyay et al., 1995), which appear to be more compatible with other information available (see methods section). It must be remembered that a very high coefficient of determination is required for a good match, since the single linkage method was employed in the cluster analysis. The full correlation matrix is presented in Table 5 and the dendrogram (Figure 2B) summarizes the genetic relationships between the samples.

The Venture and W. Venture petroleums match well with the previously recognized "Group 1" oils. The S. Venture and Cohasset A-52 oils have only limited similarities with this main oil group. The new Balmoral and Cohasset D-42 petroleums do not correlate well with any other samples, including the old samples from the same wells.

Although no new source rock extracts were analyzed, it is interesting to reexamine the data in light of the revised statistics. Samples from the Middle and Lower Missisauga Fm., undifferentiated Logan Canyon Fm., the Penobscot Limestone of the Mic Mac Fm. and the Baccaro Mbr. of the Abenaki Fm. are all reasonably compatible with the Group 1 oils. In contrast, the samples from the Naskapi Mbr. (Logan Canyon Fm.), Misaine Mbr. (Abenaki Fm.) and Verrill Canyon Fm. show no correlation with any of the oils. However, not all of the Missisauga and Mic Mac samples match the Group 1 oils. In particular, those labeled "undifferentiated" (Table 3b) correlate poorly. None of the rock samples seem to match the non-Group 1 oils, including the Cohasset petroleums. This does not eliminate the possibility of multiple sourcing.

### *4.5. Pyrolysis-GC/MS of Oil Asphaltenes and Oil-Oil/Oil-Source Rock Correlation*

The samples of Venture B-13 (DST 4) and W. Venture C-62 (DST 3) received for asphaltene pyrolysis were less than satisfactory, as they were in fact polar fractions. An attempt was made to separate asphaltenes from them, but yields were less than 1 mg in both cases. Judging by the total ion current traces (Figure 3), the samples are heavily contaminated with silanes, carboxylic acids, phthalates, etc. Styrenes are also present, which may either be contaminants or true pyrolysis products of the samples. Nevertheless, the mass spectrometer permits the confident recognition and quantitation of aromatic hydrocarbons, including benzenes, naphthalenes, indenes, phenanthrenes, anthracenes, and pyrenes. Fluorenes are unusually strong in both samples. Normal alkanes and alkenes are weak; thiophenes are barely detectable. Phenols are significant components, particularly in the W. Venture sample (Figures 3 and 4). Comparison of Figures 4A and 4B indicates that the samples are similar, confirming the correlation based on PAH (Figure 2B). A mid to late oil window maturity level is indicated by the MPR and TRMN ratios (Table 6), confirming assessments based on the aromatic fraction data (Table 4).

The presence of phenols and lack of thiophenes in the Venture and W. Venture samples indicate a strong terrestrial influence on the organic matter that formed the petroleum. Since these oils belong to the "Group 1" family (Figure 2B), it seems likely that a terrestrial kerogen type is responsible for the bulk of these petroleums. Lower Missisauga samples, such as those from S. Desbarres O-76 and Venture B-52, are candidate source rocks based on their aromatic fractions (Figure 2B). Their asphaltene pyrolyzates, although still contaminated even after repeated deasphaltening, show good correspondence with the two oils (Figure 4 and Table 4), particularly in their high aromaticity. The differences in phenol content may be ascribed to variations in maturity, as the S. Desbarres sample is less mature and the Venture B-52 sample is more mature than the two oils (Tables 4 and 6). The phenol content in terrestrially derived samples will be high initially, dropping off as peak oil generation is reached (Kruge and Bensley, 1994).

Among the other two oil asphaltenes, the Cohasset A-52 sample is very rich in aliphatic components (Figure 4 and Table 6), although the predominance of alkanes over alkenes suggests that deasphaltening was not complete (Kruge, 1992). The Naskapi rock asphaltene, from N. Truimph G-43, is extremely rich in aliphatics, suggesting a predominance of algal material, perhaps lacustrine, since the thiophene content is low. Oil from the Sable Island discovery has an intermediate aromaticity. These oils may originate from multiple source horizons containing different organic matter types in varying proportions, whereas "Group 1" oils may have been derived for the most part from terrestrial kerogens.

Using aromatic biomarkers in GCMS and pyrolysis-MS of asphaltenes of oils, an attempt was made at oil-oil correlation of various reservoirs in the Cohasset-Panuke-Balmoral fields. Figure 5a shows the reservoir stratigraphy of Cohasset, Panuke, Balmoral fields characterizing the number of tested and analyzed reservoirs as well as nonavailable reservoir samples. A comparison of all analytical data of 1991, 1993, and 1995 showed some salient variations in reservoir properties (Fig. 5b). This is possibly due to the change in the number of maturity-sensitive aromatic biomarkers used in different years. Based on this oil-oil correlation, Balmoral

M-32, DST #1 & #3, Cohasset D-42, DST #7, Panuke B-90, DST #1, Penobscot L-30, DST #5 showed strong correlation among each other ($r^2$ >0.85; Fig. 5c). Cohasset A-52, DST #5 and #11 also show fairly high correlation ($r^2 > 0.8$) with the main cluster. Only two oils (Panuke PP3 J-99, DST #1 and Cohasset D-42, DST #3) show poor correlation. This variation in correlation within various reservoirs may be related to reservoir properties such as temperature, pore pressure, water chemistry, etc., rather than type and maturity of the source rocks from which they are generated and migrated.

### *4.6. Multicomponent Kinetics*

The multicomponent (methane, ethane, and propane) kinetics of both extracted rock (kerogen part) and bitumen extract (generated oil part) show wide variation of activation energy distribution and Arrhenius Factors (Table 7a through 7d and Figures 6a through 6d). For methane generation from Kerogen Type IIA-IIB (N. Truimph B-52/G-43) higher (between 48 and 53 kcal/mole) activation energy is required compared to Kerogen Type IIB (S. Desbarres O-76) (between 45 and 50 kcal/mole) (Tables 7a and 7c). In general, cracking of both kerogen and $C_{15}$+ to ethane requires less energy compared to generation of methane and propane. The lowest $T_{max}$ values (454-422-398°C) were observed on cracking of $C_{15}$+ to ethane in Kerogen Type IIA-IIB for all temperatures of pyrolysis. Generally, the highest $T_{max}$ value is recorded during the generation of methane cracked from both kerogen and oil. It is interesting to note that cracking of $C_{15}$+ to methane in Kerogen Type IIB requires the highest activation energy distribution and Arrhenius Factor compared to any sample (Table 7a through 7d).

### *4.7. Modelling of Hydrocarbon Generation and Expulsion for N-Components*

A preliminary assessment of generation and expulsion of various hydrocarbon components (methane, $C_2$-$C_5$, $C_6$-$C_{15}$, and $C_{15}$+) was made for selected stratigraphic intervals from both the N. Truimph G-43/B-52 and S. Desbarres O-76 wells [Figs. 7a through 7r(ii) and 8a through 8q]. Because the 1-D modelling using n-component kinetics is extremely complex, more work is needed to assess the hydrocarbon mass balance in the Sable Island area. At this stage, only comparable generation and expulsion of various n-components from similar lithostratigraphic units and different kerogen types from the two wells were evaluated (all Figs 7 and 8).

Accordingly, the expulsion of methane from various stratigraphic intervals was compared (Table 9). Moreover, a comparable assesment was made on methane expulsion from selected intervals where both default Type III (Brent Coal) and analyzed IIB kinetics were used for Kerogen Type III rock intervals (Table 10).

Figues 7a and 8a showed the generation and expulsion of n-components from various Kerogen Type IIB (genetic potential 175 mg/g TOC) and Figues 7b and 8b for Kerogen Type III (genetic potential 90 mg/g TOC) stratigraphic intervals from both wells. The data implied higher generation and expulsion of various n-components for Kerogen Type IIB intervals compared to Kerogen Type III intervals and $C_{15}$+ hydrocarbons are cracked to methane in the deeper part of the section. The data also suggest that N. Truimph G-43/B-52 well has generated and expelled almost double the amount of various n-components, compared to the S. Desbarres O-76 well, because of the abundance of Kerogen Type IIB source rock units in the N. Truimph well.

In this report, only the expulsion of methane from various stratigraphic intervals was studied. In N. Truimph G-43/B-52, 16 intervals were evaluated (Table 9a). In intervals having Kerogen Type IIB, the methane expulsion increased from ~7 mg/g TOC (Mississauga 1 at 3665m) to 70 mg/g TOC (MM6 at 10,800m). Using the comparable kinetics (analyzed IIB and default III) for various Kerogen Type III intervals showed that (1) up to a depth of 6850 m, methane expulsion is higher for analyzed kinetics compared to the default kinetics (Units TJ1 and TJ3), and (2) beyond 6850m, default Type III kinetics expelled higher methane (Units MM1, MM3, MM5, and MM7) compared to the analyzed Type IIB kinetics.

In the S. Desbarres O-76 well, for various Kerogen Type IIB intervals, the methane expulsion varies between ~8 (unit TJ2) to 50 (unit J2a) mg/g TOC. However, the comparable kinetics between analyzed type IIB and default III showed a reverse trend compared to N. Truimph. In the younger horizon (unit TJ3), default III kinetics expelled more methane compared to measured IIB kinetics. On the other hand, the deeper interval (unit J2b) showed the reverse trend. This anomolous relationship could not be resolved by comparing the lithological variation in those units.

The timing of methane expulsion in various units differs depending on the variation of their maturity or depth. For stratigraphic unit MM5 in N. Truimph B-52 (Begin_Age: 191.5;

Kerogen Type III), the methane expulsion started around 190 mybp and reached its peak around 120 mybp. The methane expulsion in the unit MM5 of S. Desbarres (Begin Age: 174.5; Kerogen Type III) started around 115 mybp and reached its peak in the last 50 mybp. In unit Mississauga 3 of N. Truimph well (Kerogen Type IIB), migration of methane started around 105 mybp (million year before present) and reached its peak around last 5 my. In unit TJ2 (Kerogen Type IIB) of the same well, the expulsion started around 130 mybp and reached its peak around 20 mybp (Table 9a). At the present time, this unit has reduced its capability for major gas expulsion. On the contrary, in S. Desbarres O-76, the similar (Begin_Age) unit (MicMac, Kerogen Type IIB) started expelling around 90 mybp and reached its peak in the last 10 mybp (Table 9b). This suggests that expulsion of methane is active in the Scotian Shelf in the present time.

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7. BasinMod Project: well N. Truimph G-43/B-52.

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N-Component generation and expulsion (in mg/g TOC)
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j. Unit TJ2: kerogen - IIB; kinetics -IIB.
k (i). Unit TJ3: kerogen - III; kinetics - IIB
k (ii). Unit TJ3: kerogen - III; kinetics - III
l (i). Unit MM1: kerogen - III; kinetics - IIB
l (ii). Unit MM1: kerogen - III; kinetics - III
m. Unit Mic Mac: kerogen - IIB; kinetics - IIB
n. Unit MM2: kerogen - IIB; kinetics - IIB
o (i). Unit MM3: kerogen - III; kinetics - IIB
o (ii). Unit MM3: kerogen - III; kinetics -III
p (i). Unit MM5: kerogen - III; kinetics - IIB
p (ii). Unit MM5: kerogen - III; kinetics -IIB
q. Unit MM6: kerogen - IIB; kinetics - IIB
r (i). Unit MM7: kerogen - III; kinetics - IIB
r (ii). Unit MM7: kerogen - III; kinetics - III

8. BasinMod Project: well S. Desbarres O-76, 3801.88m.

a. N-component generation and migration of all units having kerogen type IIB and using IIB kinetics, well: S. Desbarres O- 76.

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N-Component generation and expulsion (in mg/g TOC)

c. Unit Top Jurassic: kerogen - IIA/IIB; kinetics IIA-IIB.
d. Unit TJ1: kerogen - III; kinetics - IIB
e. Unit TJ2: kerogen - IIB; kinetics -IIB.
f (i). Unit TJ3: kerogen - III; kinetics - IIB
f (ii). Unit TJ3: kerogen - III; kinetics - III
g. Unit Mic Mac: kerogen - IIB; kinetics - IIB
h. Unit MM1: kerogen - III; kinetics - IIB
i. Unit MM3: kerogen - IIB; kinetics - IIB
j. Unit MM3: kerogen - III; kinetics - IIB
k. Unit MM4: kerogen - IIB; kinetics - IIB
l (i). Unit MM5: kerogen - III; kinetics - IIB
l (ii). Unit MM5: kerogen - III; kinetics -IIB
m. Unit J1: kerogen - IIB; kinetics - IIB
n. Unit J2: kerogen - III; kinetics - III
o. Unit J2a: kerogen - IIB; kinetics - III

p (i). Unit J2b: kerogen - III; kinetics - IIB
p (ii). Unit J2b: kerogen - III; kinetics - III
q. Unit Mohican: kerogen - III; kinetics - IIB

TABLE 1: Maceral Composition in volume percent (organic facies), $R_o$, kerogen type, and oil/gas potential of composite shale samples

| Borehole No. | Depth (ft/m) | Fm/ Member | $R_o$ | Vit | Int | Exe | Res | Lam | Tel | Ltd | aom 2 | aom 3 | Bit | Rank Int | Kerogen Type | Oil/Gas Potent. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bluenose2G-47 | 4730-4830m | lr.Miss | 1.09 | 37 | 50 | 7 |  | 1 |  |  |  |  |  | 5 | III | Gas |
|  | 5050-5225m | MicMac | 1.39 | 25 | 60 | 5 |  | 1 |  |  |  |  |  | 9 | III | Gas |
|  | 5260-5500m | MicMac | 1.38 | 25 | 40 | 9 |  | 1 |  |  | 11 | 1 |  | 10 | IIB | Cond/Gas |
|  | 5695-5797m | MicMac | 1.52 | 35 | 42 | 7 | 1 | 1 | 1 |  | 10 |  |  | 3 | IIB | Cond/Gas |
| Citadel H-52 | 5500-5620m | MicMac | 1.81 | 51 | 28 | 10 |  | 1 |  | 1 | 2 |  |  | 3 | III | Gas |
| Eagle D-21 | 10800-11670' | Naskapi | 0.58 | 45 | 30 | 18 | 1 |  |  | 1 | 3 |  |  |  | III | Gas |
|  | 11800-12600' | up.Miss | 0.70 | 51 | 32 | 14 | 2 |  |  |  |  | 1 |  |  | III | Gas |
|  | 13400-14400' | up.Miss | 0.76 | 35 | 53 | 8 |  |  |  |  | 2 |  |  | 2 | III | Gas |
|  | 14550-15290' | lr.Miss | 0.81 | 42 | 41 | 12 |  |  | 1 | 1 | 2 |  |  | 1 | III | Gas |
| Intrepid L-80 | 9280-9680' | Naskapi | 0.58 | 44 | 34 | 13 | 1 | 1 | 1 | 1 | 3 |  | 1 | 1 | IIB | Cond/Gas |
|  | 10750-11250' | m.Miss | 0.63 | 41 | 45 | 11 |  |  |  |  | 2 |  |  | 1 | III | Gas |
|  | 11575-12400' | m.Miss | 0.68 | 33 | 54 | 11 | 1 |  |  |  | 1 |  |  |  | III | Gas |
|  | 12400-12940' | m.Miss | 0.72 | 39 | 37 | 11 | 1 | 1 |  |  | 1 |  | 2 | 8 | IIB | Cond/Gas |
| Merigomish C-52 | 2515-2690m | Cree | 0.48 | 26 | 36 | 26 | 2 | 4 | 1 | 1 | 4 |  |  |  | IIB | Cond/Gas |
|  | 2740-2895m | Cree | 0.60 | 22 | 30 | 20 | 1 | 2 | 1 |  | 19 | 5 |  |  | IIB | Cond/Gas |
|  | 3000-3200m | Cree | 0.69 | 25 | 35 | 30 | 1 | 1 | 1 |  | 3 | 1 | 2 | 1 | IIB | Cond/Gas |
|  | 3250-3500m | Cree | 0.79 | 28 | 37 | 15 | 1 | 5 |  |  | 11 | 1 | 2 |  | IIB | Cond/Gas |
|  | 3525-3700m | Cree | 0.82 | 23 | 29 | 5 | 1 | 3 | 1 |  | 30 | 1 | 1 | 7 | IIB | Cond/Gas |
|  | 3730-3950m | Naskapi | 0.99 | 13 | 28 | 1 | 1 |  |  |  | 56 |  | 1 |  | IIA-IIB | Oil/Cond |

TABLE 1 (continued): Maceral Composition in volume percent, $R_o$, kerogen type, and oil/gas potential of composite shale samples

| Borehole No. | Depth (ft/m) | Fm/ Member | $R_o$ | Vit | Int | Exe | Res | Lam | Tel | Ltd | aom 2 | aom 3 | Bit | Rank Int | Kerogen Type | Oil/Gas Potent. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Onondaga B-96 | 8100-8700' | Naskapi | 0.50 | 42 | 28 | 25 | 3 | 1 | 1 |  | 1 |  |  |  | III | Gas |
|  | 9200-9750' | up.Miss | 0.50 | 32 | 30 | 30 | 6 | 1 |  |  | 1 |  |  |  | IIB | Cond/Gas |
|  | 11890-12000' | m.Miss | 0.67 | 27 | 50 | 17 | 5 | 1 |  | 1 |  |  |  |  | III | Gas |
|  | 12000-12328' | m.Miss | 0.71 | 29 | 47 | 18 | 4 | 2 |  |  |  |  |  |  | III | Gas |
| Sable Island C-67 | 9090-9700' | Naskapi up.Miss | 0.51 | 34 | 36 | 26* | 2 | 1 |  |  |  | 1 |  |  | III | Gas |
|  | 11050-11800' | m.Miss | 0.61 | 26 | 43 | 27 | 2 | 1 |  |  |  |  | 1 |  | III | Gas |
|  | 13100-13600' | lr.Miss | 0.65 | 19 | 52 | 25 | 2 | 1 |  |  |  |  | 1 |  | III | Gas |
|  | 14000-15100' | lr.Miss | 0.82 | 20 | 43 | 32 |  | 1 | 1 |  |  | 1 | 2 |  | III | Gas |
| S. Venture O-59 | 4340-4475m | lr.Miss | 0.78 | 25 | 40 | 33 | 1 |  |  |  |  |  | 1 |  | III | Gas |
|  | 4475-4610m | lr.Miss | 0.84 | 24 | 37 | 35 | 1 | 1 |  |  | 1 |  | 1 |  | III | Gas |
|  | 4895-5035m | lr.Miss | 1.13 | 39 | 35 | 12 |  | 1 |  |  | 8 | 3 | 2 |  | III | Gas |
|  | 5865-6175m | MicMac | 1.97 | 31 | 45 | 2 |  |  |  |  | 2 |  | 2 | 20 | IIB (over-mature) | Cond/Gas |
| Thebaud I-93 | 3835-3915m | lr.Miss | 0.68 | 46 | 32 | 20 | 1 |  |  |  | 1 |  |  |  | III | Gas |
|  | 4115-4310m | lr.Miss | 0.81 | 45 | 41 | 11 | 1 |  |  |  | 1 |  | 1 |  | III (high lignite contamina-ton | Gas (?) |
|  | 4410-4625m | lr.Miss | 0.96 | 40 | 50 | 7 |  |  |  |  | 1 |  | 2 |  | Same as above | Gas (?) |
|  | 4665-4850m | lr.Miss | 1.04 | 46 | 35 | 13 |  |  |  |  | 4 |  |  |  | III (minor contamina-tion | Gas (?) |
|  | 4860-5000m | lr.Miss | 1.49 | 22 | 28 | 4 | 4 |  |  |  | 36 | 4 |  | 2 | Depleted IIA-IIB | Oil/Cond |

TABLE 1: Maceral Composition in volume percent (organic facies), $R_o$, kerogen type, and oil/gas potential of composite shale samples

| Borehole No. | Depth (ft/m) | Fm. or Member | $R_o$ | Vit | Int | Exe | Res | Lam | Tel | Ltd | aom 2 | aom 3 | Bit | Rank Int | Kerogen Type | Oil/Gas Potent. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Venture D-23 | 2700-2750m | Cree | 0.45 | 23 | 46 | 23 | 6 | 1 | | | 1 | | | | IIB | Cond/Gas |
| | | | | | | | | | | | | | | | | |
| Wenonah J-75 | 8230-8630' | Cree | 0.56 | 32 | 56 | 8 | 2 | 1 | | | 1 | | | | III-IV | Minor Gas |
| | 8630-9060' | Cree | 0.67 | 30 | 56 | 11 | 2 | 1 | | | | | | | III-IV | Minor Gas |
| | 9200-10000' | Naskapi up.Miss | 0.72 | 39 | 49 | 9 | 2 | | | | 1 | | | | III | Gas |
| | 10600-11400' | up.Miss VerrCan | 0.77 | 38 | 49 | 11 | | | | | 2 | | | | III | Gas |
| | 11400-12040' | VerrCan Argo | 0.82 | 37 | 51 | 11 | 1 | | | | | | | | III | Gas |

LEGEND:Fm = Formation; $R_o$ = mean random vitrinite reflectance; Vit = vitrinite; Int = Inertinite; Exe = Exenite; Res = Resinite; Lam = Lamalginite; Tel = telalginite Ltd = liptodetrinite; aom 2 = amorphous organic matter 2 (oil and condensate); aom 3 = amorphous organic matter 3 (gas); Bit = solid bitumen; Rank Int = rank inertinite or oxidized liptinite; Oil/gas potent. = oil and gas potential; * = oxidized phytoclasts; Nonsour. = nonsource rock; Cree = Cree Member, Logan Canyon Formation; Naskapi= Naskapi Member, Logan Canyon Formation; up.Miss= upper member, Mississauga Formation; m.Miss= middle member Mississauga Formation; lr.Miss= lower member, Missisauga Formation; VerrCan= Verrill Canyon Formation.

Table 2: Rock–Eval pyrolysis data

| depth | qty | tmax | s1 | s2 | s3 | p i | s2/s3 | pc | toc | hi | oi |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BLUENOSE 2G–47 | | | | | | | | | | | |
| 4730–4830m | | | | | | | | | | | |
| 4730 | 100.0 | 435 | 0.52 | 1.36 | 3.64 | 0.28 | 0.37 | 0.15 | 3.45 | 39 | 105 |
| 4730 | 100.3 | 436 | 0.50 | 1.42 | 3.50 | 0.26 | 0.40 | 0.16 | 3.47 | 40 | 100 |
| 5050–5225m | | | | | | | | | | | |
| 5050 | 100.6 | 313 | 1.85 | 3.71 | 6.83 | 0.33 | 0.54 | 0.46 | 5.02 | 73 | 136 |
| 5050 | 100.5 | 314 | 1.75 | 3.62 | 7.16 | 0.33 | 0.50 | 0.44 | 5.00 | 72 | 143 |
| 5260–5500m | | | | | | | | | | | |
| 5260 | 100.6 | 422 | 1.14 | 2.81 | 6.28 | 0.29 | 0.44 | 0.32 | 5.12 | 54 | 122 |
| 5260 | 100.7 | 422 | 1.11 | 2.70 | 6.19 | 0.29 | 0.43 | 0.31 | 5.08 | 53 | 121 |
| 5695m–TD | | | | | | | | | | | |
| 5695 | 100.5 | 421 | 0.84 | 1.87 | 3.26 | 0.31 | 0.57 | 0.22 | 3.32 | 56 | 98 |
| 5695 | 100.8 | 421 | 0.85 | 1.83 | 3.21 | 0.32 | 0.57 | 0.22 | 3.38 | 54 | 94 |
| CITADEL H–52 | | | | | | | | | | | |
| 5500–5620m | | | | | | | | | | | |
| 5500 | 100.3 | 418 | 0.51 | 0.66 | 2.51 | 0.44 | 0.26 | 0.09 | 1.43 | 46 | 175 |
| 5500 | 100.2 | 418 | 0.49 | 0.56 | 2.47 | 0.47 | 0.22 | 0.08 | 1.47 | 38 | 168 |
| EAGLE D–21 | | | | | | | | | | | |
| 10800–11670' | | | | | | | | | | | |
| 10800 | 99.8 | 435 | 0.07 | 0.60 | 0.91 | 0.11 | 0.65 | 0.05 | 1.35 | 44 | 67 |
| 10800 | 100.5 | 435 | 0.07 | 0.61 | 0.88 | 0.10 | 0.69 | 0.05 | 1.35 | 45 | 65 |
| 11800–12600' | | | | | | | | | | | |
| 11800 | 100.1 | 436 | 0.09 | 0.66 | 0.51 | 0.12 | 1.29 | 0.06 | 1.28 | 51 | 39 |
| 11800 | 100.6 | 437 | 0.09 | 0.66 | 0.49 | 0.12 | 1.34 | 0.06 | 1.31 | 50 | 37 |
| 13400–14400' | | | | | | | | | | | |
| 13400 | 100.6 | 442 | 0.06 | 0.43 | 0.59 | 0.12 | 0.72 | 0.04 | 0.79 | 54 | 74 |
| 13400 | 100.7 | 442 | 0.06 | 0.40 | 0.57 | 0.13 | 0.70 | 0.03 | 0.81 | 49 | 70 |
| 14550–TD | | | | | | | | | | | |
| 14550 | 100.1 | 446 | 0.14 | 0.44 | 0.51 | 0.24 | 0.86 | 0.04 | 0.83 | 53 | 61 |
| 14550 | 99.9 | 446 | 0.16 | 0.47 | 0.48 | 0.26 | 0.97 | 0.05 | 0.83 | 56 | 57 |
| 14550 | 100.4 | 445 | 0.13 | 0.41 | 0.50 | 0.24 | 0.82 | 0.04 | 0.83 | 49 | 60 |
| INTREPID L–80 | | | | | | | | | | | |
| 9280–9680' | | | | | | | | | | | |
| 9280 | 99.9 | 434 | 0.15 | 0.46 | 0.87 | 0.25 | 0.52 | 0.05 | 0.99 | 46 | 87 |
| 9280 | 100.0 | 433 | 0.15 | 0.41 | 0.96 | 0.27 | 0.42 | 0.04 | 1.00 | 41 | 96 |
| 10750–11250' | | | | | | | | | | | |
| 10750 | 100.5 | 436 | 0.15 | 0.73 | 0.65 | 0.17 | 1.12 | 0.07 | 1.16 | 62 | 56 |
| 10750 | 100.9 | 435 | 0.15 | 0.79 | 0.69 | 0.16 | 1.14 | 0.07 | 1.18 | 66 | 58 |
| 11575–12400' | | | | | | | | | | | |
| 11575 | 100.4 | 438 | 0.08 | 0.56 | 0.40 | 0.12 | 1.40 | 0.05 | 0.87 | 64 | 45 |
| 11575 | 100.3 | 438 | 0.08 | 0.60 | 0.37 | 0.12 | 1.62 | 0.05 | 0.88 | 68 | 42 |
| 12400–12940' | | | | | | | | | | | |
| 12400 | 100.0 | 442 | 0.09 | 0.53 | 0.27 | 0.15 | 1.96 | 0.05 | 1.00 | 53 | 27 |
| 12400 | 100.0 | 442 | 0.10 | 0.56 | 0.30 | 0.15 | 1.86 | 0.05 | 1.02 | 54 | 29 |

**Table 2**

```
:DEPTH: QTY :TMAX: S 1  : S 2  : S 3  : P I  :S2/S3 : P C  : TOC  : H I  : O I :
:-----:-----:----:------:------:------:------:------:------:------:------:-----:
MERIGOMISH C-52
: 2515-2590m
: 2515:100.0: 431:  3.66:  2.61:  0.77:  0.58:  3.38:  0.52:  1.70:  153 :   45:
: 2515:100.5: 431:  3.66:  2.74:  0.81:  0.57:  3.38:  0.53:  1.68:  163 :   48:
: 3000-3200m
: 3000:100.1: 431:  2.61:  3.16:  0.89:  0.45:  3.55:  0.48:  1.91:  165 :   46:
: 3000:100.2: 431:  2.60:  3.21:  0.87:  0.45:  3.68:  0.48:  1.87:  171 :   46:
: 3250-3500m
: 3250: 99.8: 435:  5.12:  6.55:  1.42:  0.44:  4.61:  0.97:  3.51:  186 :   40:
: 3250:100.5: 434:  5.17:  6.68:  1.55:  0.44:  4.30:  0.98:  3.52:  189 :   44:
: 3525-3700m
: 3525: 99.8: 438:  6.06:  4.92:  1.25:  0.55:  3.93:  0.91:  4.07:  120 :   30:
: 3525:100.2: 439:  5.96:  4.97:  1.22:  0.55:  4.07:  0.91:  3.99:  124 :   30:
: 3730-3950m
: 3730:100.5: 438:  5.16:  5.33:  1.29:  0:49:  4.13:  0.87:  3.80:  140 :   33:
: 3730:100.7: 436:  5.19:  5.11:  1.29:  0.50:  3.96:  0.85:  3.78:  135 :   34:

ONONDAGA B-96
: 8100-8700'
: 8100:100.1: 430:  0.44:  1.30:  1.39:  0.25:  0.93:  0.14:  1.89:   68 :   73
: 8100:100.4: 428:  0.45:  1.27:  1.43:  0.26:  0.88:  0.14:  1.88:   67 :   76:
: 9200-9750'
: 9200:100.8: 427:  0.49:  1.14:  0.63:  0.30:  1.80:  0.13:  1.08:  105 :   58
: 9200:100.5: 426:  0.48:  1.17:  0.60:  0.29:  1.95:  0.13:  1.10:  106 :   54
:11890-12000'
:11890:100.7: 438:  0.23:  0.68:  0.37:  0.26:  1.83:  0.07:  1.07:   63 :   34:
:11890:100.2: 437:  0.23:  0.68:  0.39:  0.26:  1.74:  0.07:  1.05:   64 :   37:
:12000-TD
:12000:100.4: 440:  0.28:  0.61:  0.54:  0.32:  1.12:  0.07:  1.03:   59 :   52:
:12000:100.6: 438:  0.28:  0.64:  0.53:  0.30:  1.20:  0.07:  1.03:   62 :   51:

: SABLE ISLAND C-67
: 9090-9700'
: 9090:100.3: 429:  0.11:  0.28:  0.63:  0.29:  0.44:  0.03:  0.75:   37 :   84:
: 9090:100.5: 429:  0.11:  0.32:  0.59:  0.26:  0.54:  0.03:  0.74:   43 :   79:
:11050-11800'
:11050:100.1: 435:  0.11:  0.80:  0.48:  0.12:  1.66:  0.07:  1.34:   59 :   35:
:11050:100.4: 438:  0.11:  0.82:  0.48:  0.12:  1.70:  0.07:  1.38:   59 :   34:
:13100-13600'
:13100:100.1: 440:  0.32:  0.59:  0.25:  0.36:  2.36:  0.07:  0.62:   95 :   40:
:13100:100.2: 436:  0.35:  0.61:  0.26:  0.36:  2.34:  0.08:  0.63:   96 :   41:
:14000'-TD
:14000:100.4: 444:  0.30:  0.76:  0.38:  0.28:  2.00:  0.08:  0.87:   87 :   43:
:14000: 99.8: 444:  0.31:  0.74:  0.38:  0.30:  1.94:  0.08:  0.86:   86 :   44:

: SOUTH VENTURE O-59
: 4340-4475m
: 4340:100.4: 445:  0.07:  0.53:  0.56:  0.12:  0.94:  0.05:  0.80:   66 :   70:
: 4340:100.0: 442:  0.09:  0.49:  0.51:  0.16:  0.96:  0.04:  0.77:   63 :   66:
: 4475-4610m
: 4475:100.2: 451:  0.10:  0.39:  0.39:  0.21:  1.00:  0.04:  0.56:   69 :   69:
: 4475:100.7: 448:  0.09:  0.43:  0.38:  0.17:  1.13:  0.04:  0.59:   72 :   64:
```

**Table 2**

```
:DEPTH: QTY :TMAX: S 1  : S 2  : S 3  : P I  :S2/S3 : P C  : TOC  : H I  : O I :
:-----:-----:----:------:------:------:------:------:------:------:------:-----:
S. VENTURE O-59 (Continued)
: 4895-5035m
: 4895:100.0: 431:  0.53:  0.37:  1.02:  0.59:  0.36:  0.07:  0.98:   37 :  104:
: 4895:100.0: 430:  0.56:  0.36:  1.03:  0.61:  0.34:  0.07:  0.96:   37 :  107:
: 5865m-TD
: 5865:100.1: 426:  1.22:  1.67:  3.27:  0.42:  0.51:  0.24:  4.83:   34 :   67:
: 5865: 99.7: 427:  1.27:  1.66:  3.24:  0.43:  0.51:  0.24:  5.05:   32 :   64:

: THEBAUD I-93
: 3835-3915m
: 3835:100.9: 438:  0.18:  0.40:  0.59:  0.31:  0.67:  0.04:  0.61:   65 :   96:
: 3835:100.8: 438:  0.17:  0.41:  0.58:  0.29:  0.70:  0.04:  0.62:   66 :   93:
: 4115-4310m
: 4115: 99.6: 443:  0.36:  0.43:  2.26:  0.46:  0.19:  0.06:  1.11:   38 :  203:
: 4115:100.4: 443:  0.35:  0.42:  2.27:  0.46:  0.18:  0.06:  1.10:   38 :  206:
: 4410-4625m
: 4410:100.1: 451:  0.38:  0.39:  1.95:  0.50:  0.20:  0.06:  1.12:   34 :  174:
: 4410:100.2: 448:  0.38:  0.44:  1.99:  0.46:  0.22:  0.06:  1.13:   38 :  176:
: 4665-4850m
: 4665:100.4: 443:  0.61:  0.69:  2.41:  0.47:  0.28:  0.10:  1.94:   35 :  124:
: 4665:100.1: 443:  0.63:  0.69:  2.35:  0.48:  0.29:  0.11:  1.94:   35 :  121:
: 4860-5000m
: 4860: 99.9: 429:  0.98:  1.19:  4.88:  0.45:  0.24:  0.18:  3.73:   31 :  130:
: 4860: 99.6: 428:  0.99:  1.24:  4.97:  0.45:  0.24:  0.18:  3.77:   32 :  131:

: WENONAH J-75
: 8230-8630'
: 8230: 99.7: 432:  0.29:  0.67:  1.16:  0.30:  0.57:  0.08:  1.20:   55 :   96:
: 8230:100.0: 431:  0.31:  0.76:  1.14:  0.29:  0.66:  0.08:  1.22:   62 :   93:
: 8630-9060'
: 8630: 99.8: 430:  0.25:  0.47:  0.81:  0.35:  0.58:  0.06:  0.90:   52 :   90:
: 8630:100.0: 433:  0.25:  0.55:  0.81:  0.31:  0.67:  0.06:  0.94:   58 :   86:
: 9200-10000'
: 9200:100.8: 435:  0.37:  0.85:  0.72:  0.30:  1.18:  0.10:  1.50:   56 :   48:
: 9200:100.9: 433:  0.35:  0.88:  0.76:  0.29:  1.15:  0.10:  1.48:   59 :   51:
:10600-11400'
:10600:100.4: 439:  0.57:  1.52:  0.63:  0.27:  2.41:  0.17:  2.13:   71 :   29:
:10600:100.8: 436:  0.60:  1.61:  0.66:  0.27:  2.43:  0.18:  2.12:   75 :   31:
:11400'-TD
:11400:100.9: 440:  0.63:  1.41:  0.75:  0.31:  1.88:  0.17:  2.28:   61 :   32:
:11400:100.8: 440:  0.63:  1.47:  0.76:  0.30:  1.93:  0.17:  2.28:   64 :   33:
:-----:-----:----:------:------:------:------:------:------:------:------:-----:
:DEPTH: QTY :TMAX: S 1  : S 2  : S 3  : P I  :S2/S3 : P C  : TOC  : H I  : O I :
:-----:-----:----:------:------:------:------:------:------:------:------:-----:
```

Oil samples

| Well | SIU No. | DST/RFT | Depth (m) | Formation | Member | Code |
|---|---|---|---|---|---|---|
| Arcadia J–16 | NS9116 | 5 | 5156–5175 | Missisauga | Lower | ARCADJ–5O |
| Balmoral M–32 | NS9302 | 3 | 1954–1958 |  |  | BALMOM–3O |
| Balmoral M–32 | NS9405 | 1 |  |  |  | BALMOM–1O |
| Banquereau C–21 | NS9113 | 1 | 3585–3596 | Missisauga | Lower | BANQUC–1O |
| Bluenose 2G–47 | NS9115 | 8 | 4577–4590 | Mic Mac |  | BLUENG–8O |
| Chebucto K–90 | NS9001 | 4 | 4227–4238 | Missisauga | Upper | CHEBUK–4O |
| Citnalta I–59 | NS9112 | 3 | 3777–3781 | Missisauga | Lower | CITNAI–3O |
| Cohasset A–52 | NS9004 | 5 | 1888–1891 | Logan Canyon | Cree | COHASA–5O |
| Cohasset A–52 | NS9407 | 11 |  |  |  | COHASA–1O |
| Cohasset D–42 | NS9002 | 7 | 1861–1865 | Logan Canyon | Cree | COHASD–7O |
| Cohasset D–42 | NS9406 | 3 |  |  |  | COHASD–3O |
| Glenelg J–48 | NS9010 | 8 | 3491–3495 | Missisauga | Upper | GLENEJ–8O |
| N. Triumph B–52 | NS9006 | 4 | 3771–3777 | Missisauga | Upper | NTRIUB–4O |
| Olympia A–12 | NS9007 | 5 | 4664–4678 | Missisauga | Lower | OLYMPA–5O |
| Panuke B–90 | NS9003 | 1 | 2293–2299 | Missisauga | Upper | PANUKB–1O |
| Panuke PP3 J–99 | NS9301 | 1 | 2572–2580 |  |  | PANUKJ–1O |
| Penobscot L–30 | NS9114 | 5 | 2642 | Missisauga | Upper | PENOBL–5O |
| S. Venture O–59 | NS9008 | 5 | 5035–5050 | Missisauga | Lower | SVENTO–5O |
| S. Venture O–59 | NS9009 | 10 | 4255–4267 | Missisauga | Lower | SVENTO–0O |
| S. Venture O–59 | NS9404 | 11 |  |  |  | SVENTO–1O |
| Sable Island 3H–58 | NS9005 | 5 | 1435–1436 | Logan Canyon | Mamora | SABLEH–5O |
| Thebaud C–74 | NS9118 | 9 | 3865–3888 | Missisauga | Lower | THEBAC–9O |
| Uniacke G–72 | NS9303 | 6 | 5191–5199 | Mic Mac |  | UNIACG–6O |
| Venture B–13 | NS9401 | 4 | 4882–4888 |  |  | VENTUB–4O |
| Venture B–13 | NS9403 | 6 |  |  |  | VENTUB–6O |
| Venture H–22 | NS9117 | 5 | 5021–5025 | Mic Mac |  | VENTUH–5O |
| Venture H–22 | NS9304 | 7 | 4957–4962 | Mic Mac |  | VENTUH–7O |
| W. Venture C–62 | NS9402 | 3 | 4741–4743 |  |  | WVENTC–3O |

**Table 3a**

Rock Extract Samples

| Well | SIU No. | Depth (m) | Formation | Member | Code |
|---|---|---|---|---|---|
| Abenaki J-56 | NS9305 | 3080 | Missisauga | Lower | ABENAJ-3R |
| Alma F-67 | NS9013 | 4500 | Verrill Canyon |  | ALMAF-4R |
| Alma F-67 | NS9108 | 5045 | Verrill Canyon |  | ALMAF-5R |
| Cohasset A-52 | NS9011 | 2036 | Logan Canyon | Cree | COHASA-2R |
| Cohasset D-42 | NS9012 | 4426 | Abenaki | Misaine | COHASD-4R |
| Demascota G-43 | NS9306 | 3615 | Abenaki | Baccaro | DEMASG-3R |
| Migrant N-20 | NS9101 | 3587 | Missisauga | Lower | MIGRAN-3R |
| N. Triumph G-43 | NS9103 | 4845 | Missisauga | undif. | NTRIUG-4R |
| N. Triumph G-43 | NS9109 | 3695 | Logan Canyon | Naskapi | NTRIUG-3R |
| Penobscot L-30 | NS9105 | 2118 | Logan Canyon | undif. | PENOBL-2R |
| Penobscot L-30 | NS9307 | 4214 | Mic Mac | Penobscot | PENOBL-4R |
| S. Desberres O-76 | NS9107 | 3861 | Missisauga | Lower | SDESBO-3R |
| S. Sable B-44 | NS9111 | 3938 | Missisauga | Middle | SSABLB-3R |
| S. Venture O-59 | NS9014 | 6115 | Mic Mac | undif. | SVENTO-6R |
| Thebaud C-74 | NS9110 | 3911 | Missisauga | Lower | THEBAC-3R |
| Venture B-52 | NS9102 | 5121 | Missisauga | Lower | VENTUB-5R |
| W. Chebucto K-20 | NS9104 | 5210 | Missisauga | undif. | WCHEBK-5R |
| Whycocomagh N-30 | NS9106 | 3360 | Missisauga | undif. | WHYCON-3R |

**Table 3b**

Table 4a: Maturity parameters for Scotian Basin petroleums

| Sample Code | MPI | Rc | DMP | TrMN | TeMN |
|---|---|---|---|---|---|
| ARCADJ-5O | 1.12 | 1.07 | 0.71 | 0.71 | 0.80 |
| BALMOM-1O | 0.66 | 0.79 | 0.48 | 0.51 | 0.37 |
| BALMOM-3O | 0.61 | 0.76 | 0.49 | 0.53 | 0.40 |
| BANQUC-1O | 0.79 | 0.88 | 0.60 | 0.55 | 0.43 |
| BLUENG-8O | 0.85 | 0.91 | 0.61 | 0.70 | 0.85 |
| CHEBUK-4O | 0.76 | 0.86 | 0.60 | 0.68 | 0.62 |
| CITNAI-3O | 0.62 | 0.77 | 0.53 | 0.45 | 0.27 |
| COHASA-1O | 0.46 | 0.67 | 0.47 | 0.49 | 0.30 |
| COHASA-5O | 0.57 | 0.74 | 0.52 | 0.51 | 0.37 |
| COHASD-3O | 0.60 | 0.76 | 0.48 | 0.51 | 0.36 |
| COHASD-7O | 0.76 | 0.86 | 0.50 | 0.54 | 0.38 |
| GLENEJ-8O | 0.87 | 0.92 | 0.61 | 0.61 | 0.50 |
| NTRIUB-4O | 0.78 | 0.87 | 0.60 | 0.64 | 0.55 |
| OLYMPA-5O | 0.77 | 0.86 | 0.59 | 0.67 | 0.64 |
| PANUKB-1O | 0.73 | 0.84 | 0.53 | 0.52 | 0.38 |
| PANUKJ-1O | 0.63 | 0.78 | 0.48 | 0.54 | 0.37 |
| PENOBL-5O | 0.69 | 0.82 | 0.57 | 0.57 | 0.38 |
| SABLEH-5O | 0.80 | 0.88 | 0.64 | 0.44 | 0.42 |
| SVENTO-0O | 0.76 | 0.85 | 0.48 | 0.63 | 0.57 |
| SVENTO-1O | 0.62 | 0.77 | 0.46 | 0.54 | 0.43 |
| SVENTO-5O | 1.25 | 1.15 | 0.75 | 0.74 | 0.71 |
| THEBAC-9O | 0.85 | 0.91 | 0.59 | 0.63 | 0.56 |
| UNIACG-6O | 0.96 | 0.98 | 0.72 | 0.71 | 0.67 |
| VENTUB-4O | 0.93 | 0.96 | 0.64 | 0.74 | 0.71 |
| VENTUB-6O | 0.76 | 0.85 | 0.63 | 0.68 | 0.62 |
| VENTUH-5O | 1.00 | 1.00 | 0.71 | 0.71 | 0.81 |
| VENTUH-7O | 0.90 | 0.94 | 0.65 | 0.74 | 0.73 |
| WVENTC-3O | 0.77 | 0.86 | 0.65 | 0.69 | 0.60 |

**Table 4a**

Table 4b: Maturity parameters for Scotian Basin rock extracts

| Sample Code | MPI | Rc | DMP | TrMN | TeMN |
|---|---|---|---|---|---|
| ABENAJ-3R | 0.39 | 0.64 | 0.36 | 0.48 | 0.18 |
| ALMAF-4R | 0.86 | 0.91 | 0.61 | 0.58 | 0.47 |
| ALMAF-5R | 0.83 | 0.90 | 0.54 | 0.57 | 0.49 |
| COHASA-2R | 0.46 | 0.68 | 0.40 | 0.44 | 0.28 |
| COHASD-4R | 0.84 | 0.90 | 0.59 | 0.54 | 0.51 |
| DEMASG-3R | 0.57 | 0.74 | 0.45 | 0.66 | 0.49 |
| MIGRAN-3R | 0.57 | 0.74 | 0.46 | 0.46 | 0.29 |
| NTRIUG-3R | 0.75 | 0.85 | 0.58 | 0.57 | 0.47 |
| NTRIUG-4R | 0.84 | 0.90 | 0.60 | 0.59 | 0.53 |
| PENOBL-2R | 0.48 | 0.69 | 0.49 | 0.54 | 0.42 |
| PENOBL-4R | 0.55 | 0.73 | 0.48 | 0.68 | 0.53 |
| SDESBO-3R | 0.55 | 0.73 | 0.51 | 0.46 | 0.22 |
| SSABLB-3R | 0.58 | 0.75 | 0.37 | 0.39 | 0.26 |
| SVENTO-6R | 1.08 | 1.05 | 0.68 | 0.63 | 0.66 |
| THEBAC-3R | 0.74 | 0.85 | 0.50 | 0.63 | 0.56 |
| VENTUB-5R | 1.08 | 1.05 | 0.71 | 0.76 | 0.75 |
| WCHEBK-5R | 0.68 | 0.81 | 0.56 | 0.50 | 0.63 |
| WHYCON-3R | 0.61 | 0.76 | 0.48 | 0.47 | 0.31 |

**Table 4b**

| Sample | CHEBUK-4O | COHASD-7O | PANUKB-1O | COHASA-5O | SABLEH-5O | NTRIUB-4O | OLYMPA-5O | SVENTO-5O | SVENTO-0O | GLENEJ-8O | COHASA-2R |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CHEBUK-4O | 1.000 | | | | | | | | | | |
| COHASD-7O | 0.747 | 1.000 | | | | | | | | | |
| PANUKB-1O | 0.836 | 0.927 | 1.000 | | | | | | | | |
| COHASA-5O | 0.623 | 0.796 | 0.831 | 1.000 | | | | | | | |
| SABLEH-5O | 0.688 | 0.831 | 0.802 | 0.754 | 1.000 | | | | | | |
| NTRIUB-4O | 0.976 | 0.794 | 0.866 | 0.680 | 0.737 | 1.000 | | | | | |
| OLYMPA-5O | 0.906 | 0.846 | 0.863 | 0.684 | 0.837 | 0.902 | 1.000 | | | | |
| SVENTO-5O | 0.937 | 0.786 | 0.843 | 0.693 | 0.725 | 0.933 | 0.910 | 1.000 | | | |
| SVENTO-0O | 0.904 | 0.825 | 0.812 | 0.599 | 0.771 | 0.895 | 0.961 | 0.889 | 1.000 | | |
| GLENEJ-8O | 0.955 | 0.817 | 0.866 | 0.700 | 0.753 | 0.985 | 0.914 | 0.948 | 0.899 | 1.000 | |
| COHASA-2R | 0.805 | 0.537 | 0.621 | 0.543 | 0.583 | 0.766 | 0.627 | 0.698 | 0.645 | 0.713 | 1.000 |
| COHASD-4R | 0.558 | 0.416 | 0.515 | 0.481 | 0.571 | 0.560 | 0.474 | 0.488 | 0.466 | 0.499 | 0.736 |
| ALMAF-4R | 0.677 | 0.404 | 0.493 | 0.438 | 0.490 | 0.682 | 0.492 | 0.577 | 0.523 | 0.613 | 0.848 |
| SVENTO-6R | 0.685 | 0.428 | 0.529 | 0.414 | 0.427 | 0.674 | 0.464 | 0.574 | 0.489 | 0.596 | 0.841 |
| MIGRAN-3R | 0.923 | 0.648 | 0.731 | 0.562 | 0.658 | 0.923 | 0.797 | 0.823 | 0.822 | 0.883 | 0.847 |
| VENTUB-5R | 0.869 | 0.563 | 0.618 | 0.499 | 0.620 | 0.866 | 0.751 | 0.857 | 0.797 | 0.849 | 0.811 |
| NTRIUG-4R | 0.581 | 0.308 | 0.402 | 0.387 | 0.391 | 0.582 | 0.404 | 0.493 | 0.428 | 0.548 | 0.735 |
| WCHEBK-5R | 0.687 | 0.436 | 0.497 | 0.319 | 0.424 | 0.684 | 0.491 | 0.543 | 0.500 | 0.625 | 0.722 |
| PENOBL-2R | 0.850 | 0.545 | 0.611 | 0.498 | 0.550 | 0.829 | 0.674 | 0.721 | 0.710 | 0.778 | 0.899 |
| WHYCON-3R | 0.734 | 0.401 | 0.471 | 0.322 | 0.401 | 0.716 | 0.505 | 0.581 | 0.545 | 0.653 | 0.813 |
| SDESBO-3R | 0.906 | 0.573 | 0.675 | 0.512 | 0.588 | 0.912 | 0.746 | 0.806 | 0.746 | 0.879 | 0.799 |
| ALMAF-5R | 0.635 | 0.385 | 0.460 | 0.408 | 0.426 | 0.630 | 0.444 | 0.539 | 0.491 | 0.571 | 0.815 |
| NTRIUG-3R | 0.458 | 0.203 | 0.283 | 0.278 | 0.254 | 0.465 | 0.280 | 0.373 | 0.302 | 0.441 | 0.595 |
| THEBAC-3R | 0.823 | 0.645 | 0.655 | 0.512 | 0.682 | 0.815 | 0.799 | 0.774 | 0.883 | 0.793 | 0.734 |
| SSABLB-3R | 0.754 | 0.427 | 0.495 | 0.388 | 0.433 | 0.730 | 0.551 | 0.660 | 0.631 | 0.678 | 0.842 |
| CITNAI-3O | 0.848 | 0.754 | 0.867 | 0.573 | 0.643 | 0.837 | 0.824 | 0.789 | 0.772 | 0.822 | 0.574 |
| BANQUC-1O | 0.856 | 0.693 | 0.847 | 0.582 | 0.621 | 0.826 | 0.784 | 0.782 | 0.748 | 0.803 | 0.657 |
| PENOBL-5O | 0.849 | 0.881 | 0.856 | 0.685 | 0.860 | 0.888 | 0.925 | 0.854 | 0.869 | 0.918 | 0.606 |
| BLUENG-8O | 0.945 | 0.835 | 0.865 | 0.686 | 0.807 | 0.953 | 0.967 | 0.930 | 0.943 | 0.954 | 0.717 |
| ARCADJ-5O | 0.933 | 0.771 | 0.834 | 0.702 | 0.755 | 0.945 | 0.900 | 0.970 | 0.882 | 0.946 | 0.751 |
| VENTUH-5O | 0.959 | 0.826 | 0.870 | 0.664 | 0.764 | 0.961 | 0.950 | 0.962 | 0.921 | 0.960 | 0.706 |
| THEBAC-9O | 0.844 | 0.868 | 0.838 | 0.631 | 0.854 | 0.863 | 0.924 | 0.812 | 0.918 | 0.859 | 0.655 |
| PANUKJ-1O | 0.573 | 0.448 | 0.576 | 0.391 | 0.354 | 0.580 | 0.380 | 0.448 | 0.392 | 0.505 | 0.629 |
| BALMOM-3O | 0.787 | 0.946 | 0.882 | 0.735 | 0.793 | 0.825 | 0.818 | 0.777 | 0.808 | 0.846 | 0.626 |
| UNIACG-6O | 0.702 | 0.364 | 0.511 | 0.494 | 0.416 | 0.701 | 0.513 | 0.659 | 0.508 | 0.680 | 0.735 |
| VENTUH-7O | 0.970 | 0.686 | 0.772 | 0.611 | 0.684 | 0.965 | 0.858 | 0.934 | 0.863 | 0.947 | 0.833 |
| ABENAJ-3R | 0.852 | 0.512 | 0.615 | 0.487 | 0.559 | 0.847 | 0.660 | 0.709 | 0.680 | 0.791 | 0.897 |
| DEMASG-3R | 0.803 | 0.406 | 0.496 | 0.374 | 0.443 | 0.766 | 0.596 | 0.681 | 0.652 | 0.718 | 0.858 |
| PENOBL-4R | 0.697 | 0.292 | 0.409 | 0.346 | 0.335 | 0.662 | 0.466 | 0.576 | 0.505 | 0.612 | 0.813 |
| VENTUB-4O | 0.930 | 0.747 | 0.789 | 0.645 | 0.756 | 0.929 | 0.932 | 0.949 | 0.929 | 0.944 | 0.726 |
| WVENTC-3O | 0.972 | 0.720 | 0.810 | 0.637 | 0.707 | 0.963 | 0.913 | 0.934 | 0.904 | 0.957 | 0.762 |
| VENTUB-6O | 0.962 | 0.760 | 0.861 | 0.698 | 0.798 | 0.958 | 0.930 | 0.915 | 0.891 | 0.940 | 0.791 |
| SVENTO-1O | 0.872 | 0.890 | 0.899 | 0.660 | 0.794 | 0.877 | 0.934 | 0.848 | 0.912 | 0.869 | 0.620 |
| BALMOM-1O | 0.731 | 0.823 | 0.805 | 0.624 | 0.713 | 0.744 | 0.787 | 0.723 | 0.788 | 0.779 | 0.516 |
| COHASD-3O | 0.373 | 0.608 | 0.526 | 0.523 | 0.544 | 0.393 | 0.484 | 0.346 | 0.455 | 0.424 | 0.261 |
| COHASA-1O | 0.862 | 0.742 | 0.782 | 0.599 | 0.787 | 0.859 | 0.894 | 0.786 | 0.864 | 0.846 | 0.680 |

**Table 5**

| Sample | COHASD-4R | ALMAF-4R | SVENTO-6R | MIGRAN-3R | VENTUB-5R | NTRIUG-4R | WCHEBK-5R | PENOBL-2R | WHYCON-3R | SDESBO-3R | ALMAF-5R |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CHEBUK-4O | | | | | | | | | | | |
| COHASD-7O | | | | | | | | | | | |
| PANUKB-1O | | | | | | | | | | | |
| COHASA-5O | | | | | | | | | | | |
| SABLEH-5O | | | | | | | | | | | |
| NTRIUB-4O | | | | | | | | | | | |
| OLYMPA-5O | | | | | | | | | | | |
| SVENTO-5O | | | | | | | | | | | |
| SVENTO-0O | | | | | | | | | | | |
| GLENEJ-8O | | | | | | | | | | | |
| COHASA-2R | | | | | | | | | | | |
| COHASD-4R | 1.000 | | | | | | | | | | |
| ALMAF-4R | 0.809 | 1.000 | | | | | | | | | |
| SVENTO-6R | 0.727 | 0.912 | 1.000 | | | | | | | | |
| MIGRAN-3R | 0.576 | 0.787 | 0.742 | 1.000 | | | | | | | |
| VENTUB-5R | 0.589 | 0.787 | 0.693 | 0.906 | 1.000 | | | | | | |
| NTRIUG-4R | 0.614 | 0.800 | 0.679 | 0.705 | 0.715 | 1.000 | | | | | |
| WCHEBK-5R | 0.589 | 0.766 | 0.805 | 0.723 | 0.628 | 0.659 | 1.000 | | | | |
| PENOBL-2R | 0.544 | 0.809 | 0.773 | 0.954 | 0.865 | 0.744 | 0.724 | 1.000 | | | |
| WHYCON-3R | 0.571 | 0.856 | 0.854 | 0.832 | 0.753 | 0.766 | 0.931 | 0.871 | 1.000 | | |
| SDESBO-3R | 0.479 | 0.726 | 0.708 | 0.952 | 0.868 | 0.655 | 0.719 | 0.922 | 0.821 | 1.000 | |
| ALMAF-5R | 0.720 | 0.954 | 0.903 | 0.747 | 0.738 | 0.805 | 0.762 | 0.786 | 0.870 | 0.677 | 1.000 |
| NTRIUG-3R | 0.461 | 0.661 | 0.557 | 0.577 | 0.583 | 0.957 | 0.608 | 0.628 | 0.703 | 0.562 | 0.693 |
| THEBAC-3R | 0.542 | 0.692 | 0.583 | 0.892 | 0.893 | 0.628 | 0.523 | 0.832 | 0.655 | 0.770 | 0.672 |
| SSABLB-3R | 0.544 | 0.824 | 0.738 | 0.873 | 0.888 | 0.793 | 0.640 | 0.918 | 0.813 | 0.818 | 0.789 |
| CITNAI-3O | 0.354 | 0.435 | 0.503 | 0.778 | 0.596 | 0.360 | 0.542 | 0.655 | 0.536 | 0.764 | 0.398 |
| BANQUC-1O | 0.439 | 0.525 | 0.591 | 0.801 | 0.644 | 0.449 | 0.536 | 0.697 | 0.565 | 0.776 | 0.483 |
| PENOBL-5O | 0.420 | 0.479 | 0.475 | 0.775 | 0.701 | 0.395 | 0.552 | 0.667 | 0.533 | 0.762 | 0.440 |
| BLUENG-8O | 0.489 | 0.575 | 0.566 | 0.889 | 0.819 | 0.480 | 0.579 | 0.783 | 0.617 | 0.850 | 0.533 |
| ARCADJ-5O | 0.517 | 0.648 | 0.621 | 0.892 | 0.897 | 0.563 | 0.569 | 0.798 | 0.633 | 0.863 | 0.603 |
| VENTUH-5O | 0.493 | 0.573 | 0.586 | 0.857 | 0.818 | 0.473 | 0.620 | 0.751 | 0.630 | 0.841 | 0.530 |
| THEBAC-9O | 0.492 | 0.519 | 0.519 | 0.809 | 0.706 | 0.401 | 0.553 | 0.696 | 0.553 | 0.731 | 0.479 |
| PANUKJ-1O | 0.424 | 0.564 | 0.733 | 0.598 | 0.419 | 0.442 | 0.652 | 0.601 | 0.639 | 0.620 | 0.555 |
| BALMOM-3O | 0.428 | 0.470 | 0.483 | 0.737 | 0.631 | 0.429 | 0.554 | 0.660 | 0.525 | 0.662 | 0.456 |
| UNIACG-6O | 0.511 | 0.704 | 0.619 | 0.761 | 0.781 | 0.882 | 0.575 | 0.764 | 0.695 | 0.780 | 0.686 |
| VENTUH-7O | 0.586 | 0.742 | 0.710 | 0.943 | 0.942 | 0.650 | 0.691 | 0.877 | 0.768 | 0.935 | 0.696 |
| ABENAJ-3R | 0.687 | 0.887 | 0.839 | 0.936 | 0.858 | 0.801 | 0.831 | 0.932 | 0.923 | 0.915 | 0.851 |
| DEMASG-3R | 0.553 | 0.831 | 0.764 | 0.914 | 0.899 | 0.801 | 0.701 | 0.941 | 0.876 | 0.883 | 0.814 |
| PENOBL-4R | 0.535 | 0.799 | 0.726 | 0.819 | 0.807 | 0.873 | 0.640 | 0.870 | 0.821 | 0.801 | 0.794 |
| VENTUB-4O | 0.520 | 0.601 | 0.549 | 0.858 | 0.891 | 0.502 | 0.511 | 0.758 | 0.581 | 0.826 | 0.551 |
| WVENTC-3O | 0.513 | 0.647 | 0.600 | 0.927 | 0.885 | 0.567 | 0.605 | 0.837 | 0.682 | 0.913 | 0.603 |
| VENTUB-6O | 0.650 | 0.696 | 0.657 | 0.905 | 0.844 | 0.587 | 0.663 | 0.803 | 0.690 | 0.870 | 0.637 |
| SVENTO-1O | 0.528 | 0.486 | 0.509 | 0.755 | 0.664 | 0.352 | 0.548 | 0.620 | 0.508 | 0.676 | 0.433 |
| BALMOM-1O | 0.385 | 0.398 | 0.366 | 0.663 | 0.586 | 0.498 | 0.498 | 0.562 | 0.470 | 0.575 | 0.405 |
| COHASD-3O | 0.164 | 0.146 | 0.118 | 0.370 | 0.220 | 0.139 | 0.188 | 0.323 | 0.186 | 0.308 | 0.141 |
| COHASA-1O | 0.513 | 0.587 | 0.500 | 0.866 | 0.741 | 0.514 | 0.623 | 0.768 | 0.643 | 0.794 | 0.535 |

**Table 5**

| Sample | NTRIUG-3R | THEBAC-3R | SSABLB-3R | CITNAI-3O | BANQUC-1O | PENOBL-5O | BLUENG-8O | ARCADJ-5O | VENTUH-5O | THEBAC-9O | PANUKJ-1O |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CHEBUK-4O | | | | | | | | | | | |
| COHASD-7O | | | | | | | | | | | |
| PANUKB-1O | | | | | | | | | | | |
| COHASA-5O | | | | | | | | | | | |
| SABLEH-5O | | | | | | | | | | | |
| NTRIUB-4O | | | | | | | | | | | |
| OLYMPA-5O | | | | | | | | | | | |
| SVENTO-5O | | | | | | | | | | | |
| SVENTO-0O | | | | | | | | | | | |
| GLENEJ-8O | | | | | | | | | | | |
| COHASA-2R | | | | | | | | | | | |
| COHASD-4R | | | | | | | | | | | |
| ALMAF-4R | | | | | | | | | | | |
| SVENTO-6R | | | | | | | | | | | |
| MIGRAN-3R | | | | | | | | | | | |
| VENTUB-5R | | | | | | | | | | | |
| NTRIUG-4R | | | | | | | | | | | |
| WCHEBK-5R | | | | | | | | | | | |
| PENOBL-2R | | | | | | | | | | | |
| WHYCON-3R | | | | | | | | | | | |
| SDESBO-3R | | | | | | | | | | | |
| ALMAF-5R | | | | | | | | | | | |
| NTRIUG-3R | 1.000 | | | | | | | | | | |
| THEBAC-3R | 0.476 | 1.000 | | | | | | | | | |
| SSABLB-3R | 0.672 | 0.831 | 1.000 | | | | | | | | |
| CITNAI-3O | 0.262 | 0.621 | 0.511 | 1.000 | | | | | | | |
| BANQUC-1O | 0.326 | 0.660 | 0.599 | 0.955 | 1.000 | | | | | | |
| PENOBL-5O | 0.292 | 0.704 | 0.505 | 0.820 | 0.747 | 1.000 | | | | | |
| BLUENG-8O | 0.358 | 0.828 | 0.645 | 0.860 | 0.822 | 0.940 | 1.000 | | | | |
| ARCADJ-5O | 0.431 | 0.835 | 0.735 | 0.798 | 0.805 | 0.867 | 0.951 | 1.000 | | | |
| VENTUH-5O | 0.361 | 0.774 | 0.634 | 0.857 | 0.811 | 0.925 | 0.978 | 0.953 | 1.000 | | |
| THEBAC-9O | 0.280 | 0.791 | 0.550 | 0.816 | 0.762 | 0.929 | 0.947 | 0.850 | 0.906 | 1.000 | |
| PANUKJ-1O | 0.373 | 0.386 | 0.530 | 0.622 | 0.676 | 0.426 | 0.480 | 0.491 | 0.501 | 0.468 | 1.000 |
| BALMOM-3O | 0.321 | 0.695 | 0.543 | 0.769 | 0.719 | 0.886 | 0.840 | 0.783 | 0.824 | 0.853 | 0.499 |
| UNIACG-6O | 0.838 | 0.632 | 0.796 | 0.492 | 0.580 | 0.478 | 0.596 | 0.715 | 0.606 | 0.445 | 0.485 |
| VENTUH-7O | 0.527 | 0.849 | 0.819 | 0.765 | 0.786 | 0.819 | 0.923 | 0.958 | 0.934 | 0.806 | 0.544 |
| ABENAJ-3R | 0.694 | 0.779 | 0.867 | 0.636 | 0.691 | 0.655 | 0.760 | 0.778 | 0.748 | 0.680 | 0.630 |
| DEMASG-3R | 0.695 | 0.822 | 0.951 | 0.561 | 0.641 | 0.552 | 0.699 | 0.756 | 0.679 | 0.588 | 0.522 |
| PENOBL-4R | 0.804 | 0.702 | 0.905 | 0.452 | 0.554 | 0.415 | 0.569 | 0.652 | 0.553 | 0.441 | 0.496 |
| VENTUB-4O | 0.372 | 0.849 | 0.683 | 0.743 | 0.749 | 0.868 | 0.951 | 0.953 | 0.938 | 0.856 | 0.378 |
| WVENTC-3O | 0.446 | 0.850 | 0.745 | 0.821 | 0.823 | 0.850 | 0.949 | 0.947 | 0.940 | 0.830 | 0.487 |
| VENTUB-6O | 0.451 | 0.817 | 0.690 | 0.828 | 0.834 | 0.871 | 0.949 | 0.928 | 0.945 | 0.872 | 0.528 |
| SVENTO-1O | 0.234 | 0.721 | 0.504 | 0.841 | 0.790 | 0.883 | 0.919 | 0.831 | 0.919 | 0.935 | 0.471 |
| BALMOM-1O | 0.418 | 0.680 | 0.487 | 0.716 | 0.673 | 0.792 | 0.766 | 0.710 | 0.760 | 0.775 | 0.378 |
| COHASD-3O | 0.093 | 0.356 | 0.176 | 0.463 | 0.374 | 0.535 | 0.468 | 0.339 | 0.405 | 0.523 | 0.178 |
| COHASA-1O | 0.390 | 0.811 | 0.630 | 0.809 | 0.759 | 0.859 | 0.899 | 0.820 | 0.860 | 0.870 | 0.426 |

**Table 5**

| Sample | BALMOM-3O | UNIACG-6O | VENTUH-7O | ABENAJ-3R | DEMASG-3R | PENOBL-4R | VENTUB-4O | WVENTC-3O | VENTUB-6O | SVENTO-1O | BALMOM-1O | COHASD-3O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CHEBUK-4O | | | | | | | | | | | | |
| COHASD-7O | | | | | | | | | | | | |
| PANUKB-1O | | | | | | | | | | | | |
| COHASA-5O | | | | | | | | | | | | |
| SABLEH-5O | | | | | | | | | | | | |
| NTRIUB-4O | | | | | | | | | | | | |
| OLYMPA-5O | | | | | | | | | | | | |
| SVENTO-5O | | | | | | | | | | | | |
| SVENTO-0O | | | | | | | | | | | | |
| GLENEJ-8O | | | | | | | | | | | | |
| COHASA-2R | | | | | | | | | | | | |
| COHASD-4R | | | | | | | | | | | | |
| ALMAF-4R | | | | | | | | | | | | |
| SVENTO-6R | | | | | | | | | | | | |
| MIGRAN-3R | | | | | | | | | | | | |
| VENTUB-5R | | | | | | | | | | | | |
| NTRIUG-4R | | | | | | | | | | | | |
| WCHEBK-5R | | | | | | | | | | | | |
| PENOBL-2R | | | | | | | | | | | | |
| WHYCON-3R | | | | | | | | | | | | |
| SDESBO-3R | | | | | | | | | | | | |
| ALMAF-5R | | | | | | | | | | | | |
| NTRIUG-3R | | | | | | | | | | | | |
| THEBAC-3R | | | | | | | | | | | | |
| SSABLB-3R | | | | | | | | | | | | |
| CITNAI-3O | | | | | | | | | | | | |
| BANQUC-1O | | | | | | | | | | | | |
| PENOBL-5O | | | | | | | | | | | | |
| BLUENG-8O | | | | | | | | | | | | |
| ARCADJ-5O | | | | | | | | | | | | |
| VENTUH-5O | | | | | | | | | | | | |
| THEBAC-9O | | | | | | | | | | | | |
| PANUKJ-1O | | | | | | | | | | | | |
| BALMOM-3O | 1.000 | | | | | | | | | | | |
| UNIACG-6O | 0.461 | 1.000 | | | | | | | | | | |
| VENTUH-7O | 0.739 | 0.778 | 1.000 | | | | | | | | | |
| ABENAJ-3R | 0.618 | 0.802 | 0.894 | 1.000 | | | | | | | | |
| DEMASG-3R | 0.523 | 0.819 | 0.865 | 0.937 | 1.000 | | | | | | | |
| PENOBL-4R | 0.408 | 0.896 | 0.768 | 0.887 | 0.954 | 1.000 | | | | | | |
| VENTUB-4O | 0.747 | 0.638 | 0.940 | 0.750 | 0.729 | 0.609 | 1.000 | | | | | |
| WVENTC-3O | 0.757 | 0.719 | 0.969 | 0.831 | 0.800 | 0.695 | 0.960 | 1.000 | | | | |
| VENTUB-6O | 0.777 | 0.694 | 0.948 | 0.847 | 0.754 | 0.656 | 0.931 | 0.962 | 1.000 | | | |
| SVENTO-1O | 0.857 | 0.425 | 0.802 | 0.643 | 0.533 | 0.403 | 0.844 | 0.831 | 0.887 | 1.000 | | |
| BALMOM-1O | 0.869 | 0.508 | 0.668 | 0.548 | 0.479 | 0.400 | 0.694 | 0.713 | 0.735 | 0.774 | 1.000 | |
| COHASD-3O | 0.609 | 0.145 | 0.305 | 0.259 | 0.179 | 0.116 | 0.370 | 0.401 | 0.421 | 0.482 | 0.570 | 1.000 |
| COHASA-1O | 0.798 | 0.558 | 0.829 | 0.755 | 0.677 | 0.551 | 0.831 | 0.891 | 0.908 | 0.839 | 0.787 | 0.570 |

**Table 5**

Ratios computed from py-GC/MS quantitation results.

| | Aromatics/ Aliphatics | Benzenes/ ∑Aromatics | Naphths/ ∑Aromatics | Phenan+Antl ∑Aromatics | Phenols/ Benzenes | Thiophenes/ Benzenes | Anthracene Phenanthrene | MPR | TRMN |
|---|---|---|---|---|---|---|---|---|---|
| **Oils** | | | | | | | | | |
| Venture B-13 DST 4 | 4.46 | 0.27 | 0.36 | 0.23 | 0.31 | 0.01 | 0.32 | 0.43 | 0.65 |
| W. Venture C-62 DST 3 | 3.24 | 0.35 | 0.35 | 0.22 | 0.71 | 0.01 | 0.34 | 0.41 | 0.61 |
| Sable Is 3H-58 PT4 | 1.39 | 0.43 | 0.33 | 0.17 | 0.40 | 0.05 | 1.67 | 0.23 | 0.47 |
| Cohasset A-52, DST5 | 0.52 | 0.49 | 0.30 | 0.10 | 0.49 | 0.04 | 1.26 | 0.28 | 0.44 |
| **Rock Extracts** | | | | | | | | | |
| S. Desbarres O-76 (L. Missisauga) | 2.09 | 0.43 | 0.32 | 0.15 | 0.78 | 0.01 | 0.62 | 0.42 | 0.49 |
| Venture B-52 (L. Missisauga) | 3.29 | 0.53 | 0.27 | 0.15 | 0.13 | 0.01 | 0.20 | 0.60 | 0.71 |
| N. Triumph G-43 (Naskapi) | 0.23 | 0.60 | 0.22 | 0.08 | 0.23 | 0.02 | 0.42 | 0.41 | 0.50 |

Benzenes: C0-C3 (m/z 78, 92, 106, 120)
Naphthalenes: C0-C3 (m/z 128, 142, 156, 170)
Phenanthrenes and Anthracenes: C0-C2 (m/z 178, 192, 206)
Indenes: C0-C2 (m/z 116, 130, 144)
Phenols: C0-C2 (m/z 94, 108, 122)
Thiophenes: C0-C3 (m/z 84, 98, 112, 136)
Aliphatics: C5-C13 n-Alkanes (m/z 57) and n-Alk-1-enes (m/z 55)
MPR: (2-MP + 3-MP)/(1-MP + 9-MP + 2-MP + 3-MP), where MP=methylphenanthrene
TRMN: (1,3,6-TMN + 2,3,6-TMN)/(1,4,6-TMN + 1,3,5-TMN + 1,2,5-TMN + 1,3,6-TMN + 2,3,6-TMN)
where TMN = trimethylnaphthalene

**Table 6**

# Table 7a: Multicomponent kinetics data

## Sample: N. Truimph B–52, 3773.5m

Extracted Rock, No. 8355

| Methane(m15) | | | Ethane(m29) | | | Propane(m43) | | |
|---|---|---|---|---|---|---|---|---|
| Activation Energy Distribution | % of Conv. | Arrhenies Constant | Activation Energy Distribution | % of Conv. | Arrhenius Constant | Activation Energy Distribution | % of Conv. | Arrhenius Constant |
| 35 | 0.67 | 3.5455e+11/sec | 35 | 0.00 | 4.2118e+11/sec | 35 | | 6.4073e+11/sec |
| 36 | 0.00 | or | 36 | 0.00 | or | 36 | | or |
| 37 | 0.73 | 0.1118e+26/my | 37 | 1.28 | 0.1328e+26/my | 37 | | 0.2021e+26/my |
| 38 | 0.31 | | 38 | 0.12 | | 38 | 3.49 | |
| 39 | 0.91 | | 39 | 3.92 | | 39 | 0.00 | |
| 40 | 0.13 | | 40 | 1.12 | | 40 | 1.65 | |
| 41 | 1.33 | | 41 | 5.92 | | 41 | 1.60 | |
| 42 | 0.34 | | 42 | 4.03 | | 42 | 0.91 | |
| 43 | 0.00 | | 43 | 0.00 | | 43 | 1.16 | |
| 44 | 1.10 | | 44 | 0.00 | | 44 | 1.69 | |
| 45 | 0.00 | | 45 | 5.56 | | 45 | 0.00 | |
| 46 | 6.82 | | 46 | 12.72 | | 46 | 7.47 | |
| 47 | 3.69 | | 47 | 30.97 | | 47 | 19.66 | |
| 48 | 13.08 | | 48 | 6.54 | | 48 | 17.42 | |
| 49 | 7.98 | | 49 | 14.83 | | 49 | 8.63 | |
| 50 | 6.08 | | 50 | 2.05 | | 50 | 0.00 | |
| 51 | 12.30 | | 51 | 0.00 | | 51 | 0.78 | |
| 52 | 1.04 | | 52 | 3.80 | | 52 | 2.02 | |
| 53 | 13.54 | | 53 | 1.51 | | 53 | 0.00 | |
| 54 | 0.00 | | 54 | 0.00 | | 54 | 10.03 | |
| 55 | 9.90 | | 55 | 0.00 | | 55 | 6.06 | |
| 56 | 7.02 | | 56 | 5.65 | | 56 | 1.73 | |
| 57 | 0.00 | | 57 | | | 57 | 0.00 | |
| 58 | 0.00 | | 58 | | | 58 | 0.00 | |
| 59 | 13.04 | | 59 | | | 60 | 15.69 | |
| 60 | | | 60 | | | 60 | | |

**Table 7a**

| SAMPLE | TMAX OF MASS 15 | TMAX OF MASS 29 | TMAX OF MASS 43 |
|---|---|---|---|
| | 50 - 15 - 5 Deg.C./Min | 50 - 15 - 5 Deg.C./Min | 50 - 15 - 5 Deg.C./Min |
| 8355 Rock | 549 - 521 - 496 | 511.5 - 481 - 459 | 508 - 478 - 457 |
| 8355 Oil | 551 - 528 - 500.6 | 454 - 422 - 398 | 482.6 - 461 - 460 |
| 8358 Rock | 552 - 516.8 497.6 | 491 - 469 - 460 | 510 - 480.5 -458.6 |
| 8358 Oil | 551.4 - 524.8 - 501.65 | 491 - 469 - 460 | 501 - 471 - 458 |

## Table 7b: Multicomponent kinetics data

## Sample: N. Truimph B–52, 3773.5m

Total Bitumen (Oil) Extract, No. 8355

| Methane(m15) | | | Ethane(m29) | | | Propane(m43) | | |
|---|---|---|---|---|---|---|---|---|
| Activation Energy Distribution | % of Conv. | Arrhenies Constant | Activation Energy Distribution | % of Conv. | Arrhenius Constant | Activation Energy Distribution | % of Conv. | Arrhenius Constant |
| 35 | | 1.4447e+12/sec | 35 | 0.65 | 1.7200e+12/sec | 35 | | 1.7200e+12/sec |
| 36 | | or | 36 | 0.20 | or | 36 | | or |
| 37 | | 0.4556e+26/my | 37 | 0.77 | 0.5424e+26/my | 37 | 0.00 | 0.5424e+26/my |
| 38 | | | 38 | 0.93 | | 38 | 0.06 | |
| 39 | 1.25 | | 39 | 1.02 | | 39 | 0.67 | |
| 40 | 0.00 | | 40 | 1.41 | | 40 | 0.00 | |
| 41 | 0.71 | | 41 | 2.47 | | 41 | 1.91 | |
| 42 | 0.00 | | 42 | 0.00 | | 42 | 0.00 | |
| 43 | 0.99 | | 43 | 0.61 | | 43 | 0.00 | |
| 44 | 7.97 | | 44 | 21.32 | | 44 | 13.11 | |
| 45 | 0.00 | | 45 | 3.88 | | 45 | 6.51 | |
| 46 | 4.56 | | 46 | 10.76 | | 46 | 8.04 | |
| 47 | 4.16 | | 47 | 6.12 | | 47 | 8.64 | |
| 48 | 3.158 | | 48 | 9.02 | | 48 | 9.42 | |
| 49 | 6.62 | | 49 | 10.07 | | 49 | 14.58 | |
| 50 | 6.84 | | 50 | 13.40 | | 50 | 15.02 | |
| 51 | 8.92 | | 51 | 1.71 | | 51 | 0.88 | |
| 52 | 5.43 | | 52 | 4.39 | | 52 | 5.62 | |
| 53 | 11.01 | | 53 | 2.48 | | 53 | 0.50 | |
| 54 | 3.84 | | 54 | 0.00 | | 54 | 3.40 | |
| 55 | 7.47 | | 55 | 3.49 | | 55 | 0.31 | |
| 56 | 4.97 | | 56 | 0.30 | | 56 | 1.72 | |
| 57 | 6.08 | | 57 | 0.00 | | 57 | 3.10 | |
| 58 | 1.39 | | 58 | 0.00 | | 58 | 0.00 | |
| 59 | 5.30 | | 59 | 4.98 | | 59 | 0.00 | |
| 60 | 3.67 | | 60 | | | 60 | 0.00 | |
| 61 | 0.00 | | 61 | | | 61 | 6.50 | |
| 62 | 0.00 | | | | | | | |
| 63 | 5.65 | | | | | | | |

**Table 7b**

# Table 7c: Multicomponent kinetics data

## Sample: S. Desbarres O–76, 3801.88m

Extracted Rock sample, No. 8358

| Methane(m15) | | | Ethane(m29) | | | Propane(m43) | | |
|---|---|---|---|---|---|---|---|---|
| Activation Energy Distribution | % of Conv. | Arrhenies Constant | Activation Energy Distribution | % of Conv. | Arrhenius Constant | Activation Energy Distribution | % of Conv. | Arrhenius Constant |
| 34 | 0.24 | | 34 | 0.96 | | | | |
| 35 | 0.24 | 8.9683e+10/sec | 35 | 1.02 | 4.8407e+10/sec | 35 | | 8.0902e+11/sec |
| 36 | 0.31 | or | 36 | 1.44 | or | 36 | | or |
| 37 | 0.41 | 0.2828e+25/my | 37 | 2.15 | 0.1527e+25/my | 37 | 0.00 | 0.2555e+26/my |
| 38 | 0.44 | | 38 | 2.98 | | 38 | 1.46 | |
| 39 | 0.44 | | 39 | 2.20 | | 39 | 0.00 | |
| 40 | 0.46 | | 40 | 0.00 | | 40 | 1.30 | |
| 41 | 0.00 | | 41 | 0.00 | | 41 | 0.75 | |
| 42 | 0.58 | | 42 | 10.61 | | 42 | 0.00 | |
| 43 | 3.79 | | 43 | 13.58 | | 43 | 0.96 | |
| 44 | 2.13 | | 44 | 31.99 | | 44 | 1.78 | |
| 45 | 11.16 | | 45 | 9.28 | | 45 | 1.01 | |
| 46 | 4.32 | | 46 | 14.89 | | 46 | 6.89 | |
| 47 | 19.38 | | 47 | 0.00 | | 47 | 8.34 | |
| 48 | 2.78 | | 48 | 3.99 | | 48 | 27.55 | |
| 49 | 9.45 | | 49 | 1.90 | | 49 | 0.00 | |
| 50 | 9.65 | | 50 | 0.00 | | 50 | 14.68 | |
| 51 | 2.81 | | 51 | 0.00 | | 51 | 0.43 | |
| 52 | 9.11 | | 52 | 3.01 | | 52 | 0.00 | |
| 53 | 5.21 | | 53 | 2.48 | | 53 | 0.00 | |
| 54 | 2.20 | | 54 | 0.00 | | 54 | 3.92 | |
| 55 | 7.41 | | 55 | 3.49 | | 55 | 2.03 | |
| 56 | 0.00 | | 56 | 0.30 | | 56 | 6.90 | |
| 57 | 0.00 | | 57 | 0.00 | | 57 | 4.67 | |
| 58 | 7.45 | | 58 | 0.00 | | 58 | 0.00 | |
| 59 | | | 59 | 4.98 | | 59 | 0.00 | |
| 60 | | | 60 | | | 60 | 0.00 | |
| 61 | | | 61 | | | 61 | 17.35 | |
| 62 | 0.00 | | | | | | | |
| 63 | 5.65 | | | | | | | |

**Table 7c**

# Table 7d: Multicomponent kinetics data

## Sample: S. Desbarres O–76, 3801.88m

Total Bitumen (Oil) Extract, No. 8358

| Methane(m15) | | | Ethane(m29) | | | Propane(m43) | | |
|---|---|---|---|---|---|---|---|---|
| Activation Energy Distribution | % of Conv. | Arrhenies Constant | Activation Energy Distribution | % of Conv. | Arrhenius Constant | Activation Energy Distribution | % of Conv. | Arrhenius Constant |
| | | | | | | 33 | 0.19 | |
| | | | 34 | 0.81 | | 34 | 0.00 | |
| 35 | | 4.3261e+12/sec | 35 | 0.76 | 2.0770e+11/sec | 35 | 0.34 | 2.0744e+11/sec |
| 36 | | or | 36 | 0.65 | or | 36 | 0.72 | or |
| 37 | | 0.1364e+27/my | 37 | 1.37 | 0.6550e+25/my | 37 | 0.26 | 0.6542e+25/my |
| 38 | | | 38 | 2.58 | | 38 | 2.71 | |
| 39 | | | 39 | 0.00 | | 39 | 0.00 | |
| 40 | | | 40 | 0.00 | | 40 | 0.00 | |
| 41 | | | 41 | 7.24 | | 41 | 4.57 | |
| 42 | 1.48 | | 42 | 13.66 | | 42 | 10.67 | |
| 43 | 0.00 | | 43 | 0.00 | | 43 | 0.00 | |
| 44 | 0.00 | | 44 | 17.85 | | 44 | 17.06 | |
| 45 | 2.68 | | 45 | 0.00 | | 45 | 1.48 | |
| 46 | 3.19 | | 46 | 21.40 | | 46 | 21.92 | |
| 47 | 0.00 | | 47 | 9.27 | | 47 | 11.69 | |
| 48 | 6.14 | | 48 | 8.02 | | 48 | 5.32 | |
| 49 | 0.85 | | 49 | 2.60 | | 49 | 2.05 | |
| 50 | 7.81 | | 50 | 3.69 | | 50 | 5.36 | |
| 51 | 4.39 | | 51 | 0.72 | | 51 | 0.00 | |
| 52 | 11.63 | | 52 | 2.27 | | 52 | 4.10 | |
| 53 | 4.74 | | 53 | 1.51 | | 53 | 0.72 | |
| 54 | 15.33 | | 54 | 0.00 | | 54 | 2.10 | |
| 55 | 2.80 | | 55 | 0.00 | | 55 | 2.64 | |
| 56 | 11.41 | | 56 | 5.59 | | 56 | 0.00 | |
| 57 | 2.35 | | 57 | | | 57 | 6.10 | |
| 58 | 7.97 | | 58 | | | 58 | 0.00 | |
| 59 | 1.76 | | 59 | | | 59 | 0.00 | |
| 60 | 5.64 | | 60 | | | 60 | 0.00 | |
| 61 | 0.93 | | 61 | | | 61 | 6.50 | |
| 62 | 2.79 | | | | | | | |
| 63 | 2.76 | | | | | | | |
| 64 | 0.00 | | | | | | | |
| 65 | 0.00 | | | | | | | |

Table 8a: Lithostratigraphy data of North Truimph G-43 well in BasinMod

| FM_NAME | BEGIN_AGE | TOP_DEPTH | THICKNESS | LITHOLOGY | KEROGEN_NAME | TOC |
|---|---|---|---|---|---|---|
| Quaternary | 1.6 | ¯74 | ¯176 | Sandstone | | |
| Unconformity1 | 3 | | | | | |
| Pliocene | 5.0 | ¯250 | ¯500 | 30/70/0 | | |
| Unconformity2 | 10.5 | | | | | |
| L. Miocene | 20 | ¯750 | ¯265 | Shale | | |
| Unconformity3 | 30 | | | | | |
| E. Oligocene | 49.5 | ¯1015 | ¯415 | 10/80/10 | | |
| Unconformity4 | 58.5 | | | | | |
| L. Paleocene | 62 | ¯1430 | ¯170 | 0/90/10 | | |
| Unconformity5 | 70 | | | | | |
| E. Maastrichtian | 74.5 | ¯1600 | ¯28 | 0/60/40 | | |
| Wyandot | 85 | ¯1628 | ¯80 | 0/90/10 | Type II | 1.0 |
| Dawson Canyon | 92 | ¯1708 | ¯154 | 40/60/0 | III | 1.5 |
| Logan Canyon | 98.5 | ¯1862 | ¯524 | 60/40/0 | III | 1.5 |
| Sable | 101 | ¯2386 | ¯135 | 50/50/0 | IIB | 2.0 |
| Cree | 117 | ¯2521 | ¯880 | 60/40/0 | IIB | 2.7 |
| Naskapi | 120 | ¯3401 | ¯259 | 30/70/0 | III | 3.0 |
| Naskapi A | 120.2 | ¯3660 | ¯5 | 30/70/0 | IIA–IIB | 3.0 |
| Missisauga1 | 120.8 | ¯3665 | ¯100 | 70/30/0 | IIB | 3.0 |
| Missisauga2 | 129.3 | ¯3765 | ¯1000 | 50/50/0 | IIB | 3.0 |
| Missisauga3 | 131 | ¯4765 | ¯200 | 30/70/0 | IIB | 3.0 |
| Missisauga4 | 144 | ¯4965 | ¯1535 | 50/50/0 | IIB | 3.0 |
| Top Jurassic | 152 | ¯6500 | ¯100 | 20/80/0 | IIB | 2.0 |
| TJ 1 | 157 | ¯6600 | ¯200 | 20/80/0 | III | 1.5 |
| TJ 2 | 167 | ¯6800 | ¯50 | 20/80/0 | IIB | 2.0 |
| TJ 3 | 170 | ¯6850 | ¯150 | 20/80/0 | III | 1.5 |
| Mic Mac | 181 | ¯7000 | ¯100 | 20/70/10 | IIB | 1.5 |
| MM 1 | 182 | ¯7100 | ¯500 | 20/70/10 | III | 1.5 |
| MM 2 | 185 | ¯7600 | ¯100 | 20/70/10 | IIB | 1.5 |
| MM 3 | 185.5 | ¯7700 | ¯1000 | 20/70/10 | III | 1.5 |
| MM 4 | 191 | ¯8700 | ¯100 | 20/70/10 | IIB | 1.5 |
| MM 5 | 191.5 | ¯8800 | ¯2000 | 20/70/10 | III | 1.5 |
| MM 6 | 198 | ¯10800 | ¯100 | 20/70/10 | IIB | 1.5 |
| MM 7 | 198.5 | ¯10900 | ¯700 | 20/70/10 | III | 1.5 |
| Mohican | 200 | ¯11600 | ¯3000 | 20/70/10 | III | 1.0 |
| Breakup Unc. | 201 | | | | | |
| Argo | 204 | ¯14600 | ¯2000 | 0/10/90 | III | 0.2 |
| Eurydice | 235 | ¯16600 | ¯1500 | 30/60/10 | III | 0.2 |

Table 8a

# Table 8b: Lithostratigraphy data of S. Desbarres O–76 well in BasinMod

| FM_NAME | BEGIN_AGE | TOP_DEPTH | THICKNESS | LITHOLOGY | KEROGEN_NAME | TOC |
|---|---|---|---|---|---|---|
| Quaternary | 1.6 | ¯50 | ¯50 | 45/55/0 | | |
| up. Banquereau | 15.0 | ¯100 | ¯573 | 70/30/0 | III | 1.0 |
| Unconformity | 55 | | | | | |
| E. Eocene | 60 | 673 | ¯215 | 90/10/0 | III | 1.5 |
| Unconformity2 | 64 | | | | | |
| E. Paleocene | 66.4 | 888 | ¯90 | Shale | III | 1.0 |
| Maastrichtian | 75.0 | 978 | ¯130 | Shale | IIB | 1.5 |
| Wyandot | 87.5 | 1108 | ¯42 | 0/30/70 | IIA–IIB | 2.0 |
| Coniacian | 88.5 | 1150 | ¯14 | 10/80/10 | | |
| Dawson Canyon | 91 | 1164 | ¯107 | Shale | | |
| Cenomanian | 94 | 1271 | ¯117 | 10/80/10 | | |
| Logan Canyon | 97.5 | 1388 | ¯157 | 50/50/0 | | |
| Albian | 99.2 | 1545 | ¯75 | 30/70/0 | | |
| Sable | 101.3 | 1620 | ¯93 | 30/70/0 | | |
| Cree | 113 | 1713 | ¯427 | 60/40/0 | | |
| Aptian | 116 | 2140 | ¯245 | 60/40/0 | | |
| Naskapi | 119 | 2385 | ¯123 | 40/60/0 | | |
| Missisauga | 124 | 2508 | ¯323 | 70/20/10 | | |
| O Marker | 144 | 2831 | ¯839 | 80/20/0 | | |
| Top Jurassic | 152 | 3670 | ¯10 | 20/70/10 | IIA–IIB | 2.5 |
| TJ 1 | 153 | ¯3680 | ¯50 | 70/20/10 | III | 1.5 |
| TJ 2 | 154 | ¯3730 | ¯10 | 20/70/10 | IIB | 2.0 |
| TJ 3 | 155 | ¯3740 | ¯120 | 70/20/10 | III | 1.5 |
| Mic Mac | 163 | 3860 | ¯10 | 20/70/10 | IIB | 2.0 |
| MM1 | 164 | ¯3870 | ¯500 | 20/40/40 | III | 1.5 |
| MM2 | 169 | ¯4370 | ¯10 | 20/70/10 | IIB | 2.0 |
| MM3 | 169.5 | ¯4380 | ¯500 | 20/40/40 | III | 1.5 |
| MM4 | 174 | ¯4880 | ¯10 | 20/70/10 | IIB | 2.0 |
| MM5 | 174.5 | ¯4890 | ¯210 | 20/40/40 | III | 1.5 |
| J1 | 176 | ¯5100 | ¯150 | 20/80/0 | IIB | 1.6 |
| J2 | 177 | ¯5250 | ¯300 | 20/70/10 | III | 1.5 |
| J2a | 179 | ¯5550 | ¯30 | 20/80/0 | IIB | 2.5 |
| J2b | 179.5 | ¯5580 | ¯520 | 20/70/10 | III | 2.0 |
| J3 | 181 | ¯6100 | ¯960 | 20/70/10 | III | 1.5 |
| Mohican | 200 | 7060 | ¯3740 | 45/40/15 | III | 0.5 |
| Breakup Unc. | 201 | | | | | |
| Argo | 204 | 10800 | ¯1000 | 0/10/90 | III | 0.2 |
| Eurydice | 225 | 11800 | ¯1000 | 40/50/5/5 | III | 0.2 |

**Table 8b**

Table 9a. Methane expulsion (mg/g TOC) in various stratigraphic units in N. Truimph B-52/G-43 well using multicomponent kinetics

N. Truimph G-43/B-52

| Fm_Name | Top_Depth (m) | Thickness (m) | Kerogen Type | TOC (mg/g TOC) | Kinetic Type | Methane Expulsion (mg/g TOC) |
|---|---|---|---|---|---|---|
| Naskapi | 3401 | 259 | III | 3.0 | IIB | ~2 |
| Mississauga1 | 3665 | 100 | IIB | 3.0 | IIB | ~7 |
| Mississauga2 | 3765 | 1000 | IIB | 3.0 | IIB | ~29 |
| Mississauga3 | 4765 | 200 | IIB | 3.0 | IIB | ~33 |
| Mississauga4 | 4965 | 1535 | IIB | 3.0 | IIB | ~53 |
| Top Jurassic | 6500 | 100 | IIB | 2.0 | IIB | ~55 |
| TJ1* | 6600 | 200 | III | 1.5 | IIB | ~30 |
| TJ1* | Same | Same | III | Same | III | ~23 |
| TJ2 | 6800 | 50 | IIB | 2.0 | IIB | ~58 |
| TJ3* | 6850 | 150 | III | 1.5 | IIB | ~30 |
| TJ3* | Same | Same | III | Same | III | ~27 |
| MicMac | 7000 | 100 | IIB | 1.5 | IIB | ~60 |
| MM1* | 7100 | 500 | III | 1.5 | IIB | ~33 |
| MM1* | Same | Same | III | Same | III | ~38 |
| MM2 | 7600 | 100 | IIB | 1.5 | IIB | ~63 |
| MM3* | 7700 | 1000 | III | 1.5 | IIB | ~36 |
| MM3* | Same | Same | III | Same | III | ~53 |
| MM5* | 8800 | 2000 | III | 1.5 | IIB | ~37 |
| MM5* | Same | Same | III | Same | III | ~61 |
| MM6 | 10800 | 100 | IIB | 1.5 | IIB | ~70 |
| MM7* | 10900 | 700 | III | 1.5 | IIB | ~38 |
| MM7* | Same | Same | III | Same | III | ~63 |

**Table 9a**

Table 9b. Mthane expulsion (mg/g TOC) in various stratigraphic units in S. Desbarres O–76 using multicomponent kinetics

S. Desbarres O–76

| Fm_Name | Top_Depth (m) | Thickness (m) | Kerogen Type | TOC (mg/g TOC) | Kinetic Type | Methane Expulsion (mg/g TOC) |
|---|---|---|---|---|---|---|
| Naskapi | 2385 | 123 | | | | |
| Mississauga1 | | | | | | |
| Mississauga2 | | | | | | |
| Mississauga3 | | | | | | |
| Mississauga4 | | | | | | |
| Top Jurassic | 3670 | 10 | IIA–IIB | 2.5 | IIA–IIB | ~8 |
| TJ1* | 3680 | 50 | III | 1.5 | IIB | No |
| TJ2 | 3730 | 10 | IIB | 2.0 | IIB | ~8 |
| TJ3* | 3740 | 120 | III | 1.5 | IIB | ~35 |
| TJ3* | same | same | same | same | III | ~51 |
| MicMac | 3860 | 10 | IIB | 2.0 | IIB | ~11 |
| MM1* | 3870 | 500 | III | 1.5 | IIB | ~6 |
| MM2 | 4370 | 10 | IIB | 2.0 | IIB | ~21 |
| MM3* | 4380 | 500 | III | 1.5 | IIB | ~13 |
| MM4 | 4880 | 10 | IIB | 2.0 | IIB | ~35 |
| MM5* | 4890 | 210 | III | 1.5 | IIB | ~17 |
| MM5* | same | same | same | same | III | ~2 |
| J1 | 5100 | 150 | IIB | 1.6 | IIB | ~42 |
| J2 | 5250 | 300 | III | 1.5 | IIB | ~24 |
| J2a | 5550 | 30 | IIB | 2.0 | IIB | ~50 |
| J2b* | 5580 | 520 | III | 2.0 | IIB | ~29 |
| J2b* | same | same | same | same | III | ~23 |
| J3 | 6100 | 960 | | | | |
| Mohican | 7060 | 3740 | III | 0.5 | IIB | ~38 |

**Table 9b**

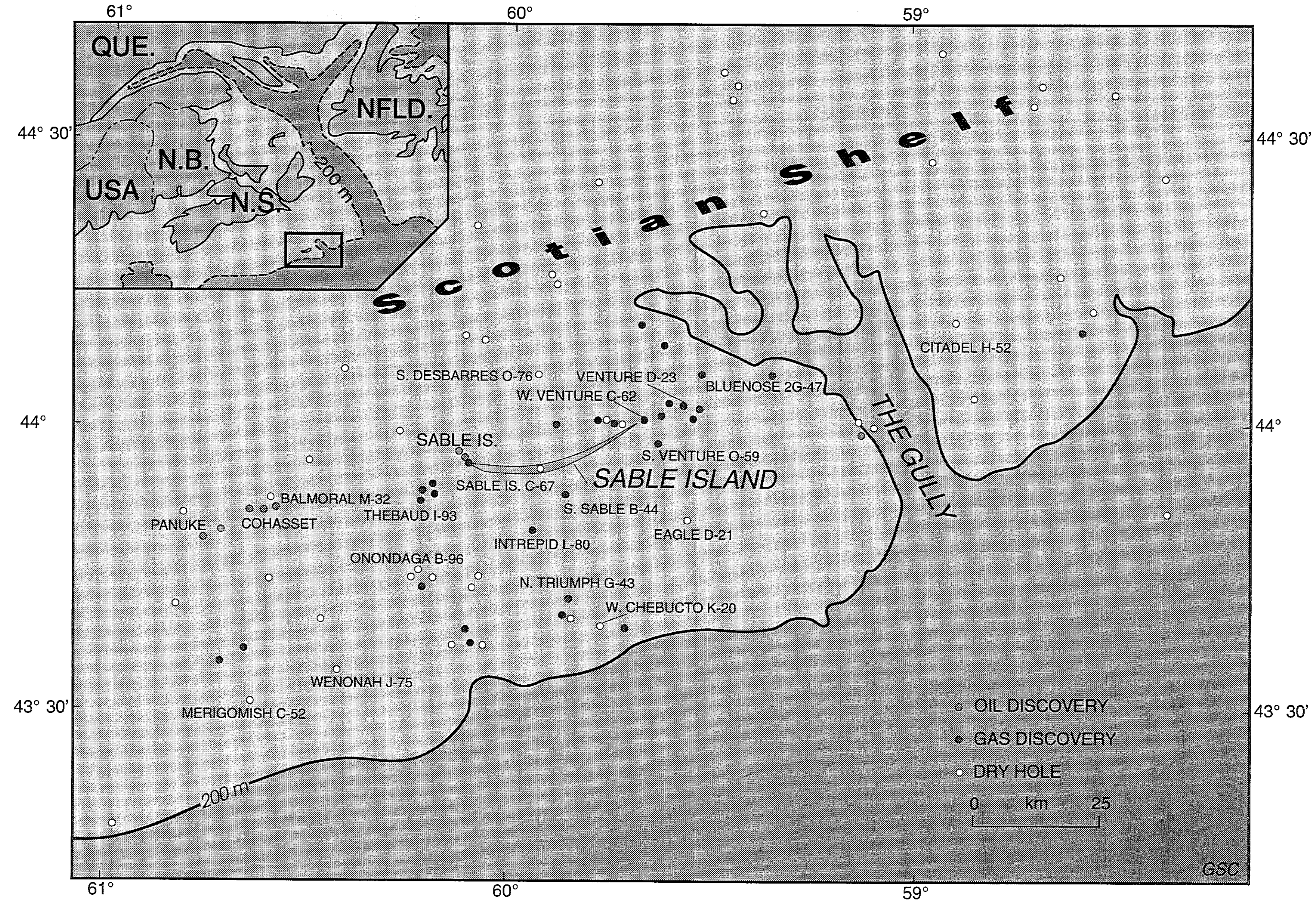


FIGURE 1. Index map of wells analysed in this report.

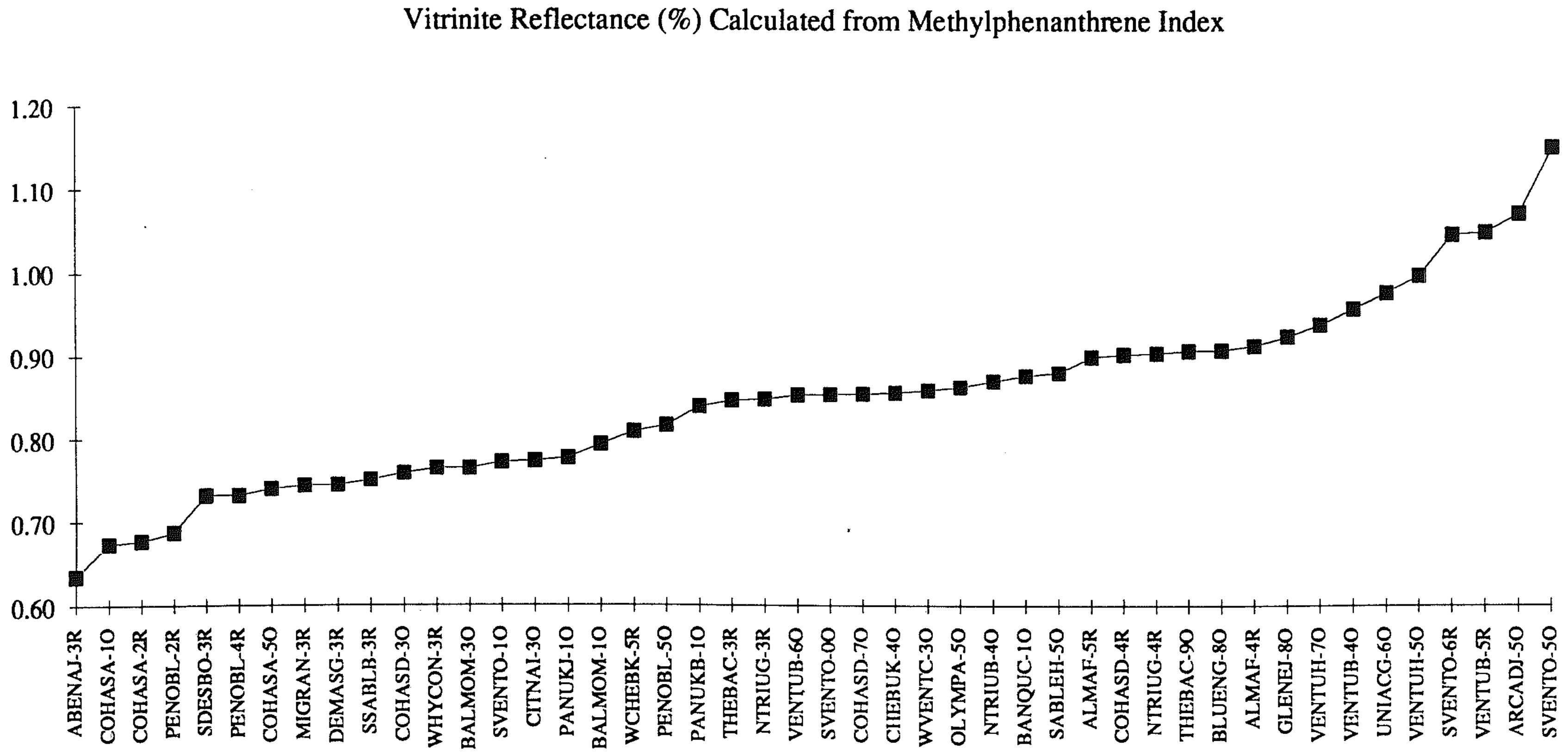
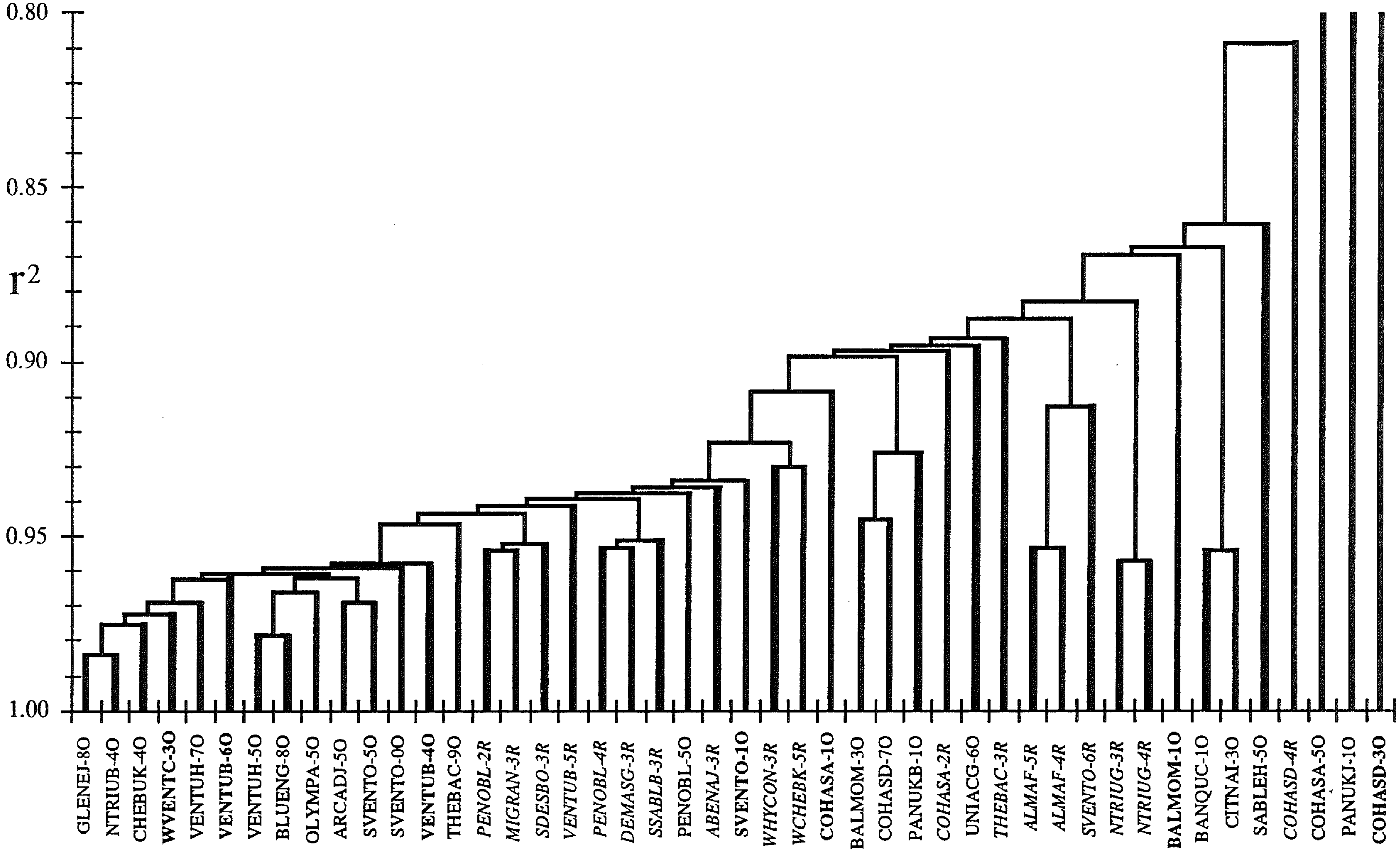
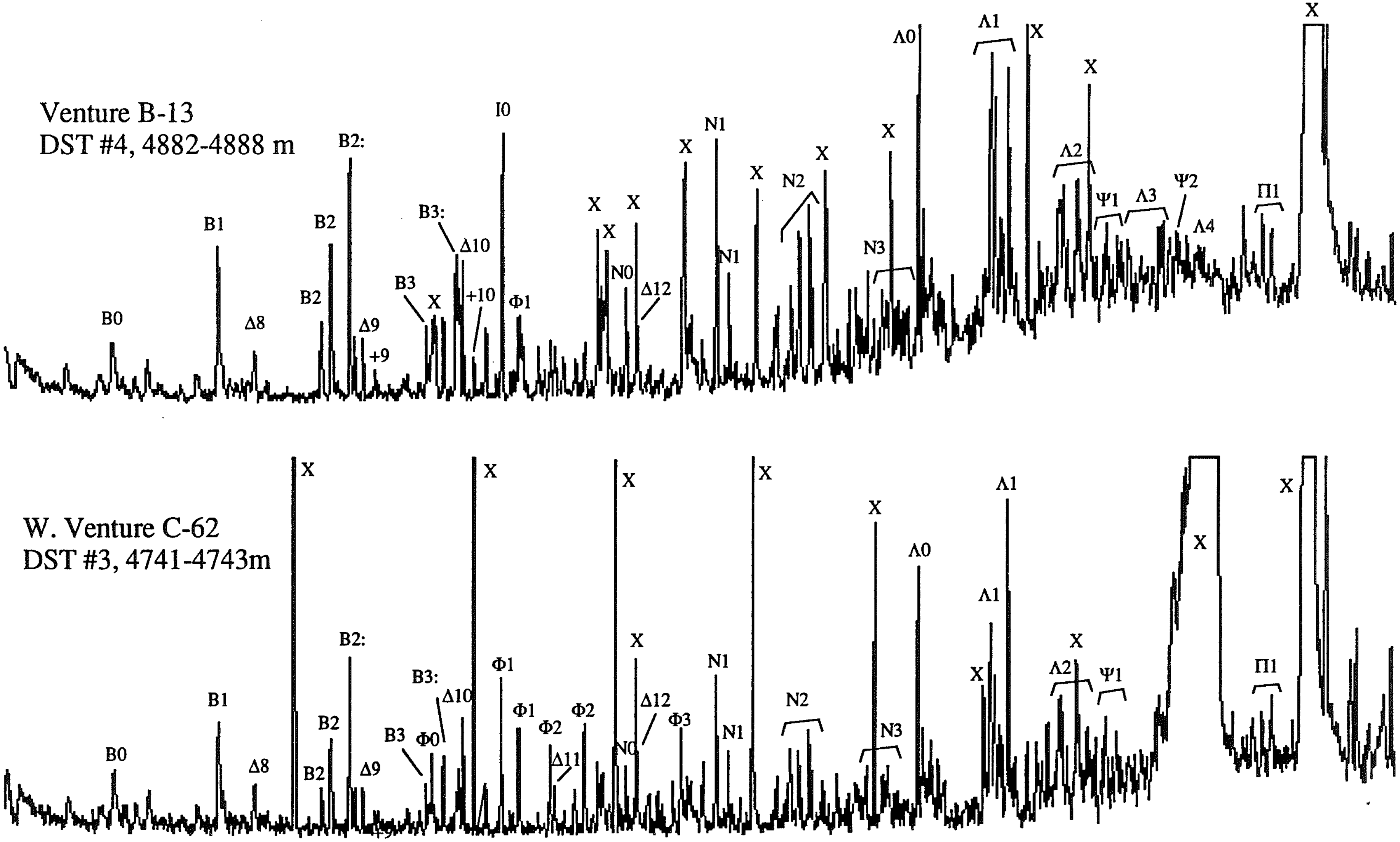

Vitrinite Reflectance (%) Calculated from Methylphenanthrene Index
1.20
1.10
1.00
0.90
0.80
0.70
0.60
ABENAJ-3R
COHASA-1O
COHASA-2R
PENOBL-2R
SDESBO-3R
PENOBL-4R
COHASA-5O
MIGRAN-3R
DEMASG-3R
SSABLB-3R
COHASD-3O
WHYCON-3R
BALMOM-3O
SVENTO-1O
CITNAI-3O
PANUKJ-1O
BALMOM-1O
WCHEBK-5R
PENOBL-5O
PANUKB-1O
THEBAC-3R
NTRIUG-3R
VENTUB-6O
SVENTO-0O
COHASD-7O
CHEBUK-4O
WVENTC-3O
OLYMPA-5O
NTRIUB-4O
BANQUC-1O
SABLEH-5O
ALMAF-5R
COHASD-4R
NTRIUG-4R
THEBAC-9O
BLUENG-8O
ALMAF-4R
GLENEJ-8O
VENTUH-7O
VENTUB-4O
UNIACG-6O
VENTUH-5O
SVENTO-6R
VENTUB-5R
ARCADJ-5O
SVENTO-5O

Figure 2A



Dendrogram of Scotian Basin oils and rock extracts formed by the single linkage method (Massart and Kaufman, 1983), using coefficients of determination from the multiple linear regression of 22 maturation insensitive polyaromatic compounds quantitated in each sample. **1994 samples in bold face.** *Rock samples in italics.*

**Figure 2B**

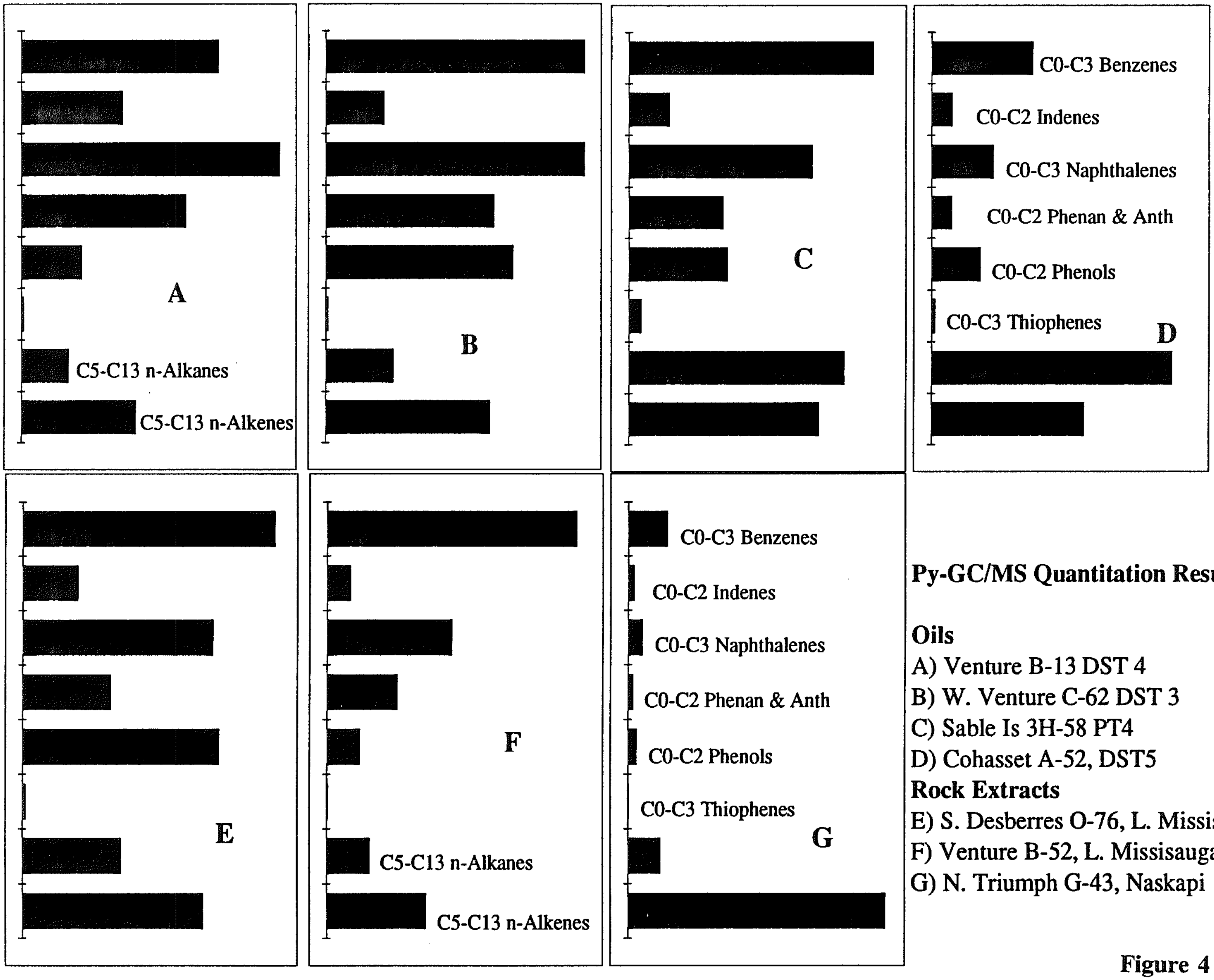


Venture B-13
DST #4, 4882-4888 m

W. Venture C-62
DST #3, 4741-4743m

Flash pyrolysis-GC/MS total ion current traces of asphaltenes isolated from two Scotian Shelf petroleum samples.

Figure 3



**Py-GC/MS Quantitation Results**

**Oils**
A) Venture B-13 DST 4
B) W. Venture C-62 DST 3
C) Sable Is 3H-58 PT4
D) Cohasset A-52, DST5
**Rock Extracts**
E) S. Desberres O-76, L. Missisauga
F) Venture B-52, L. Missisauga
G) N. Triumph G-43, Naskapi

Figure 4

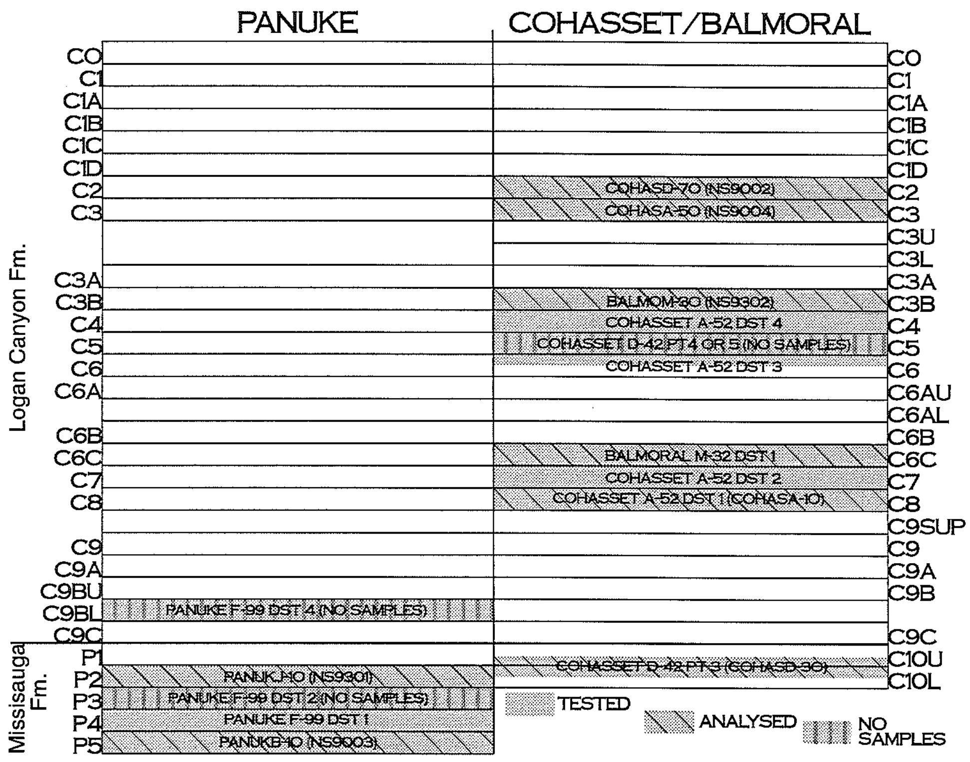


FIGURE 5a. Reservoir stratigraphy for Cohasset and Panuke fields showing location of analysed oils. (Stratigraphy from C-NSOPB)

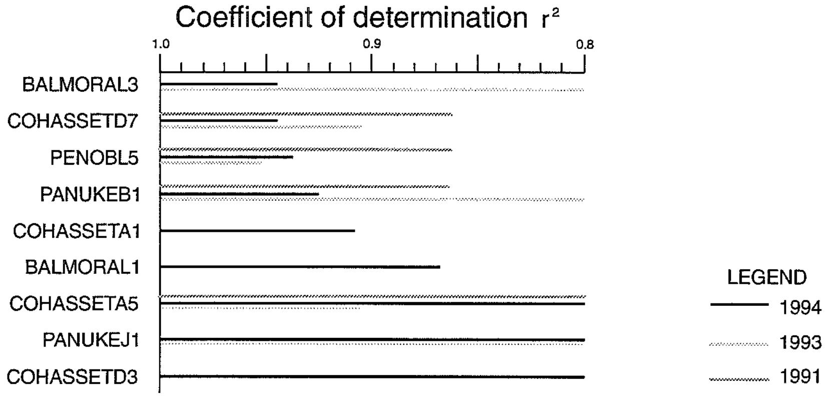


FIGURE 5b. Variations in dendrogram correlations of Cohasset/Panuke oils. Data from Kruge, 1991, 1993, 1994.

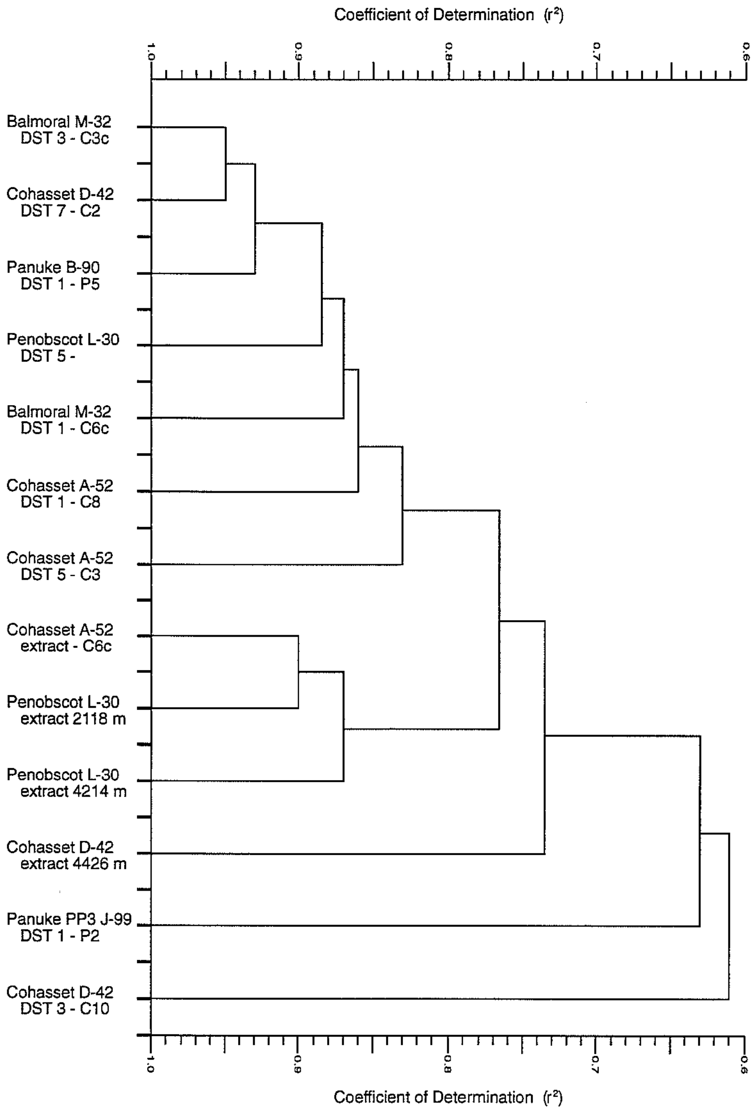
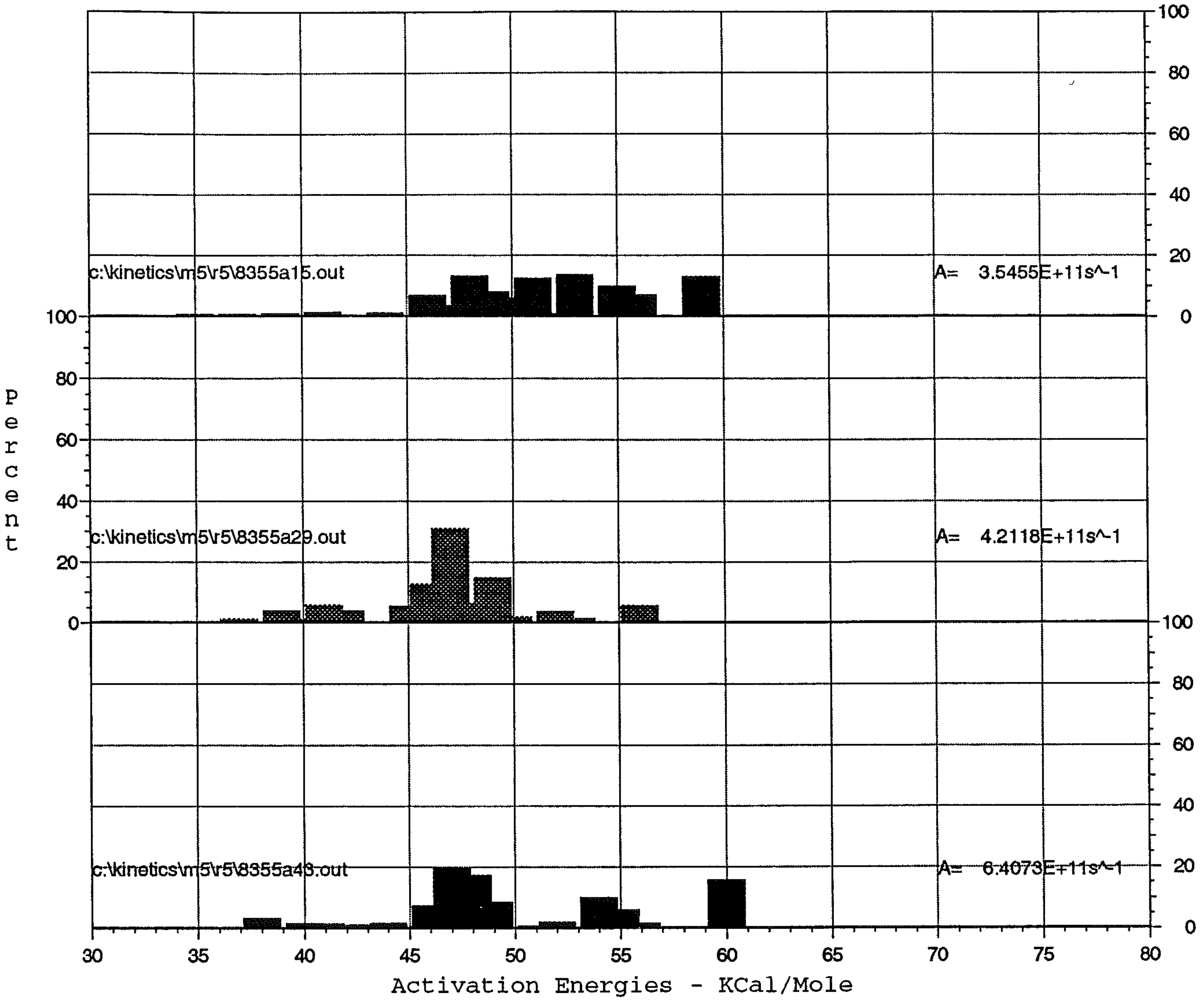


FIGURE 5c. Dendrogram of Cohasset/Panuke oils and rock extracts formed by the single linkage method (Massart and Kaufman, 1983), using coeffients of determination from the multiple linear regression of 22 maturation insensitive polyaromatic compounds quantitated in each sample.

**Figures 5a, 5b, and 5c**

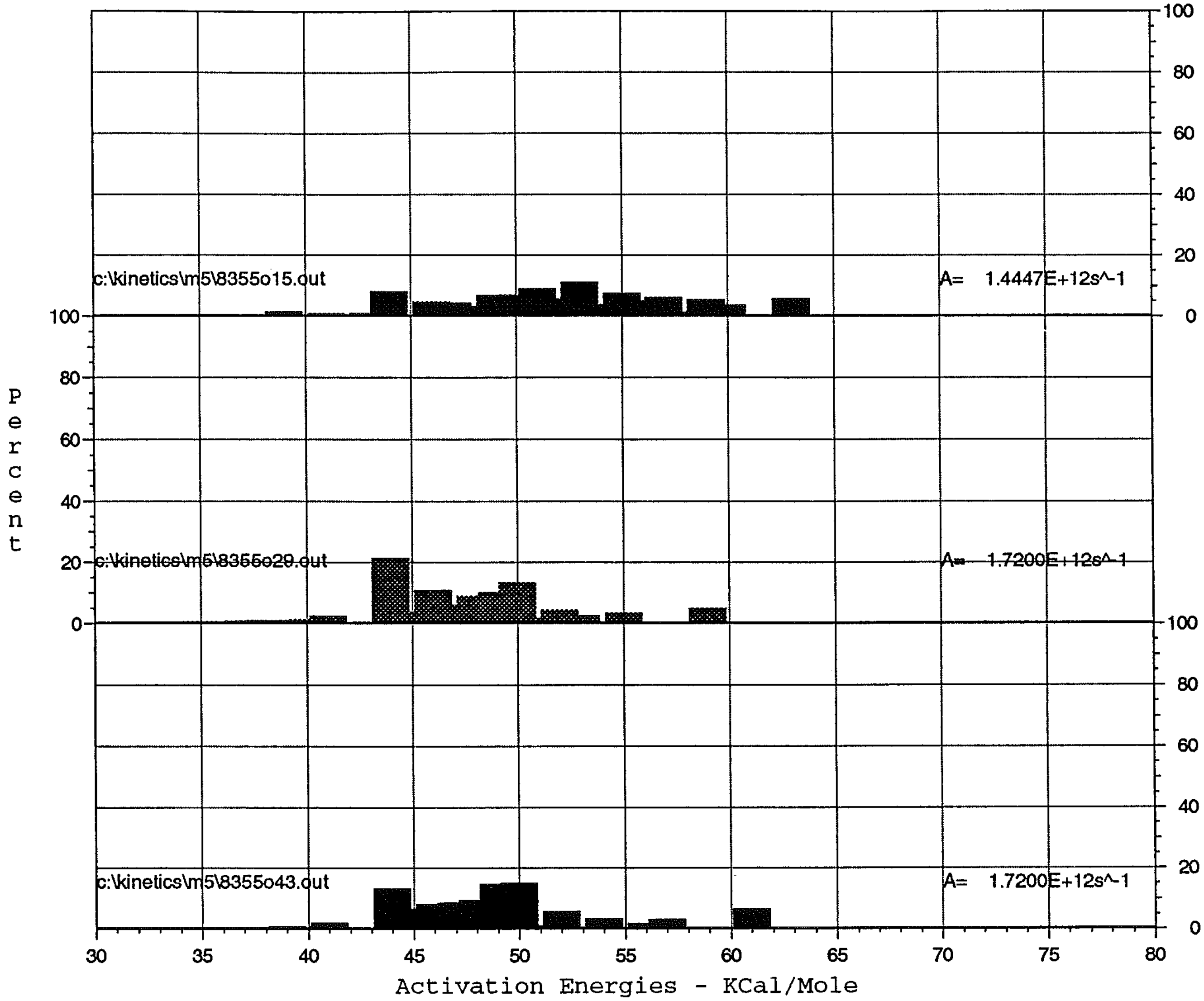
ACTIVATION ENERGIES HISTOGRAMS



N. Truimph B-52, Extracted Whole Rock

Figure 6a

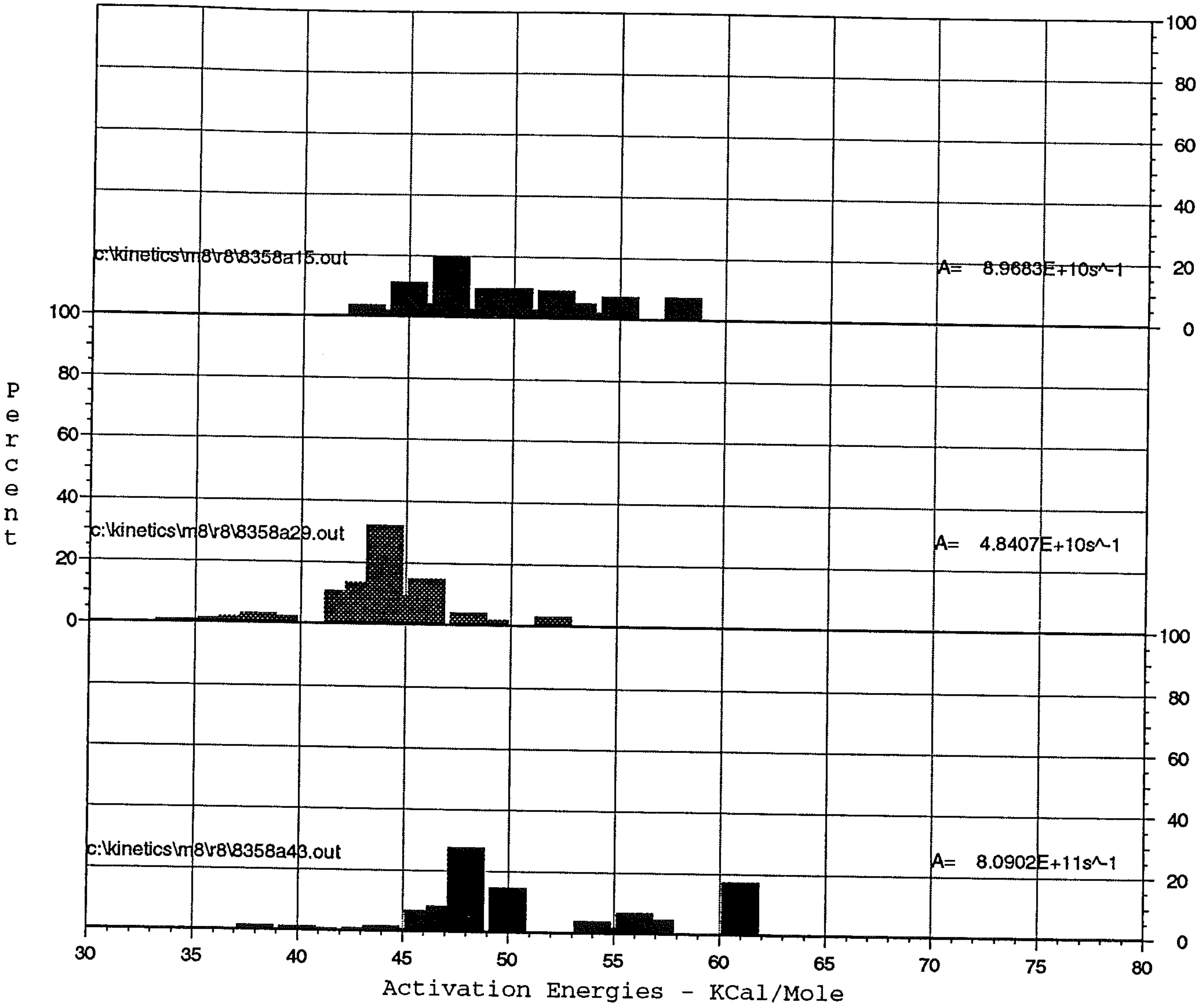
# ACTIVATION ENERGIES HISTOGRAMS



N. Truimph B-52, Bitumen (Oil)

Figure 6b

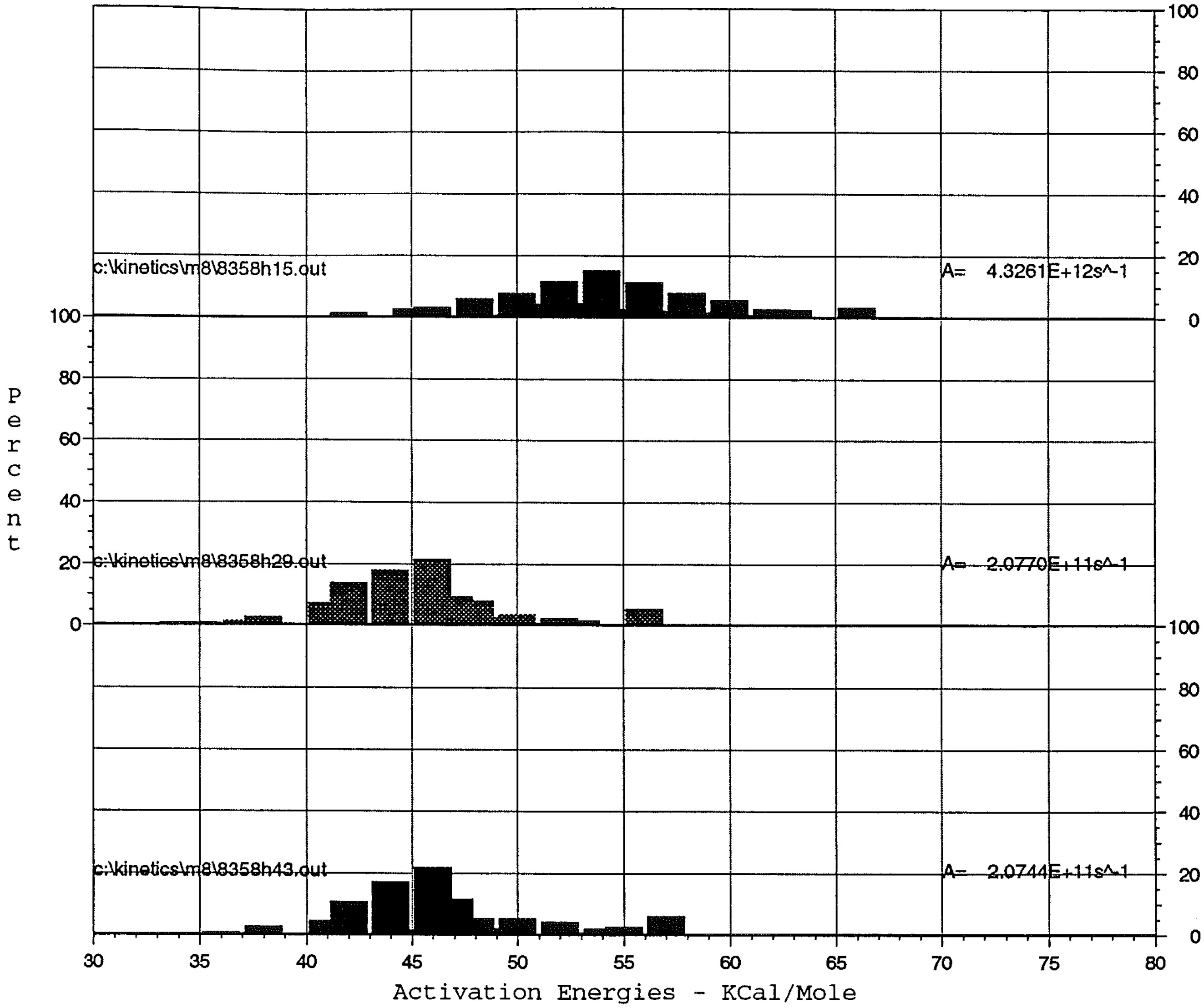
# ACTIVATION ENERGIES HISTOGRAMS



S. Desbarres O-76, Extracted Whole Rock

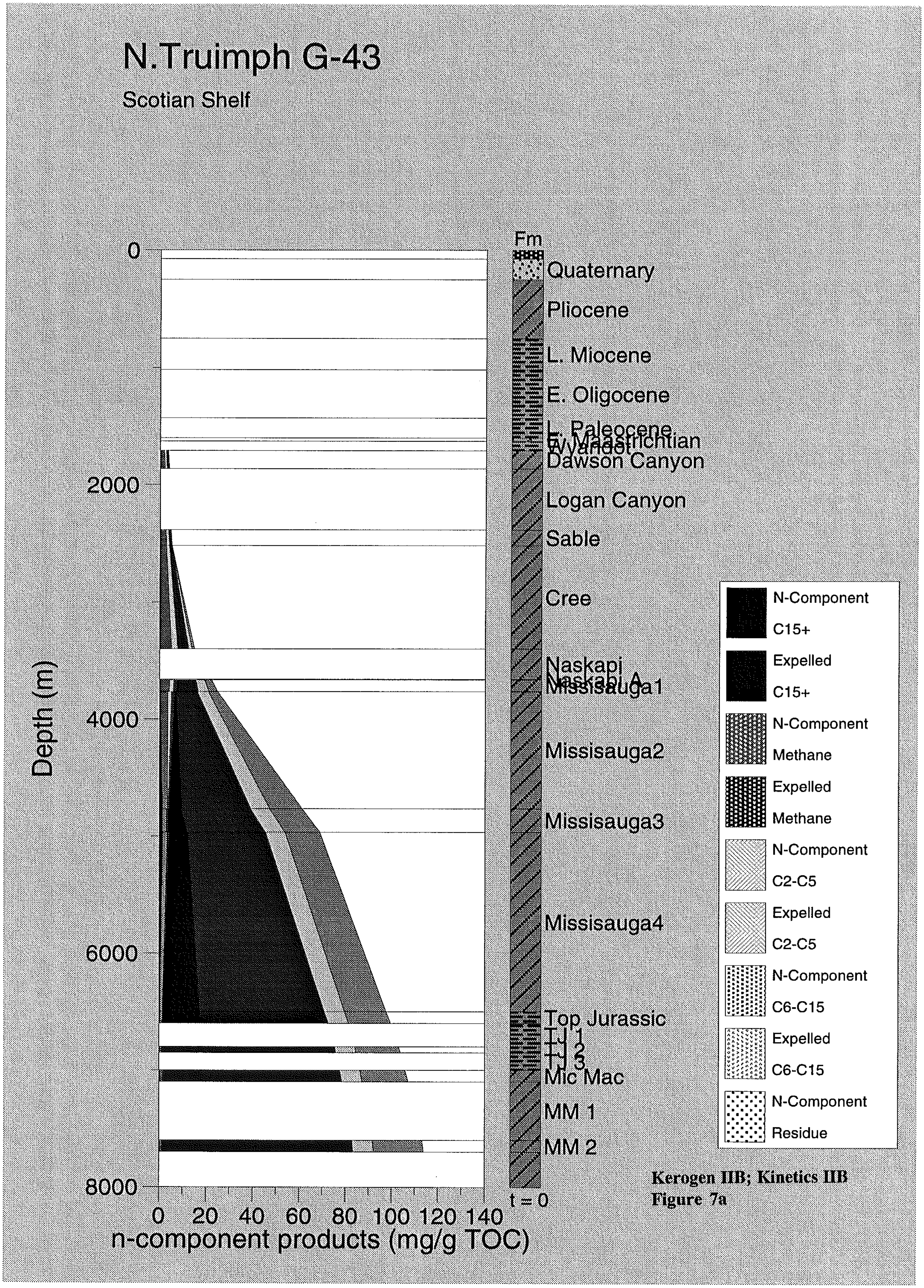
Figure 6c

ACTIVATION ENERGIES HISTOGRAMS

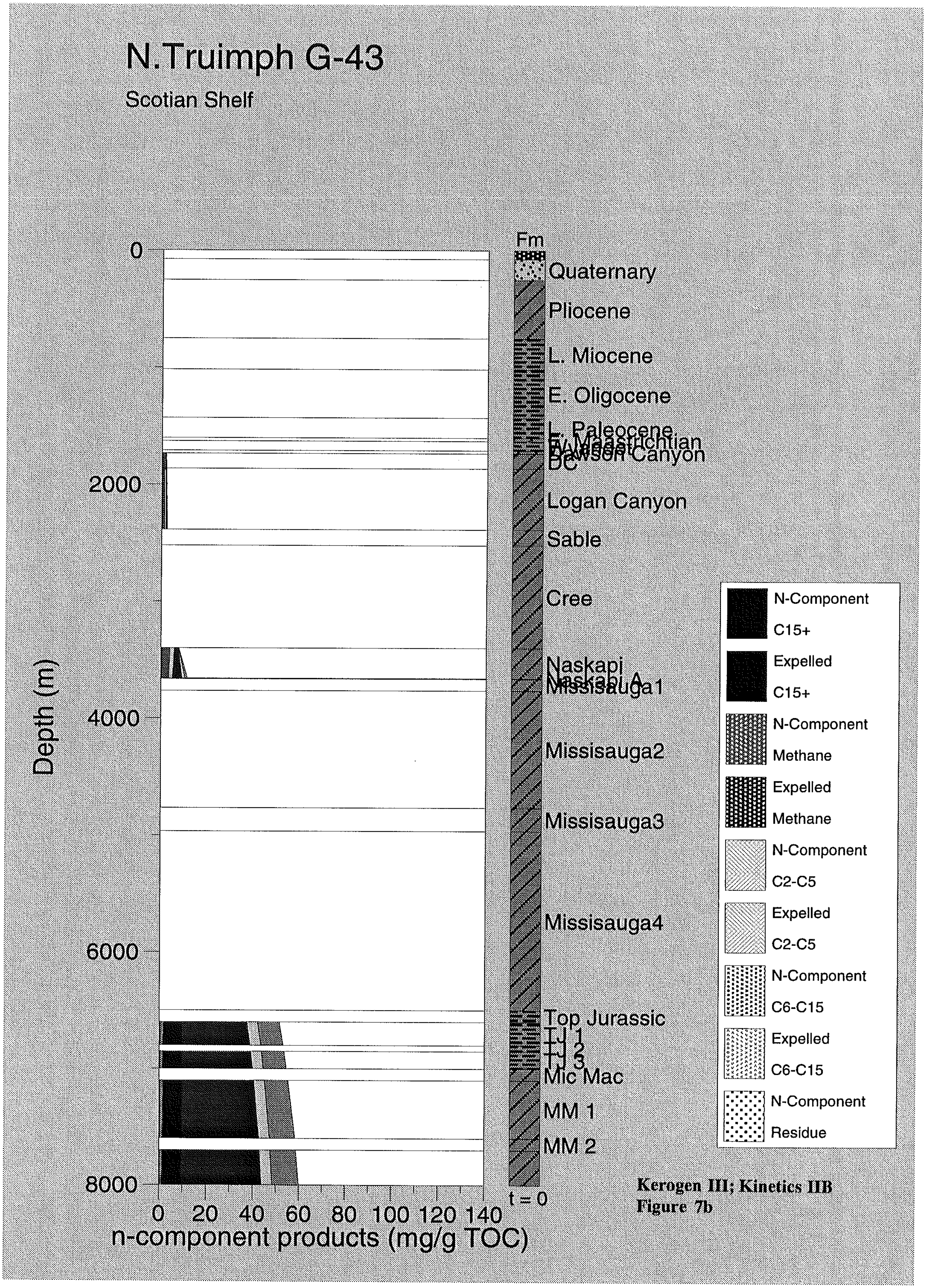


**S. Desbarres O-76, Bitumen**

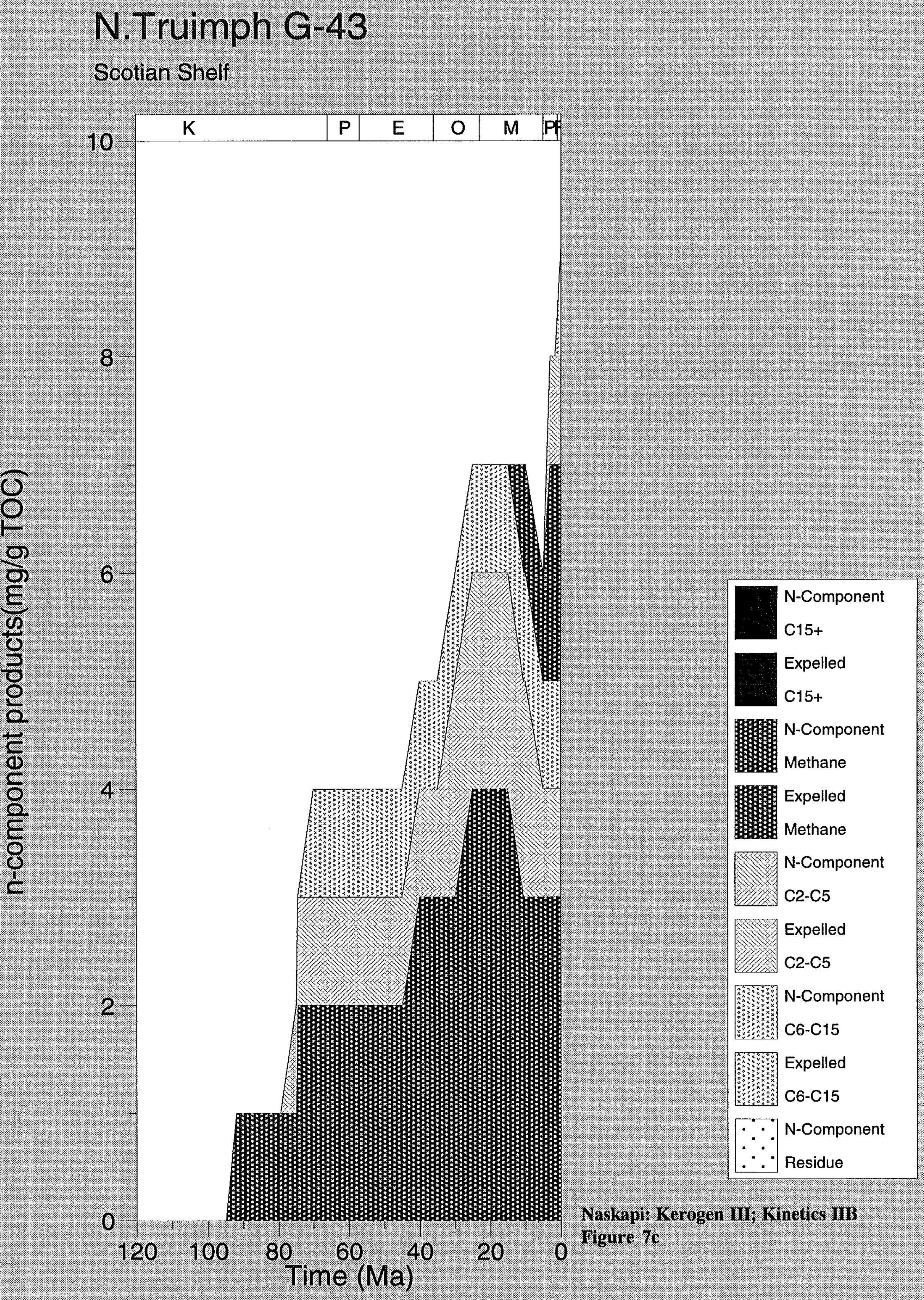
**Figure 6d**



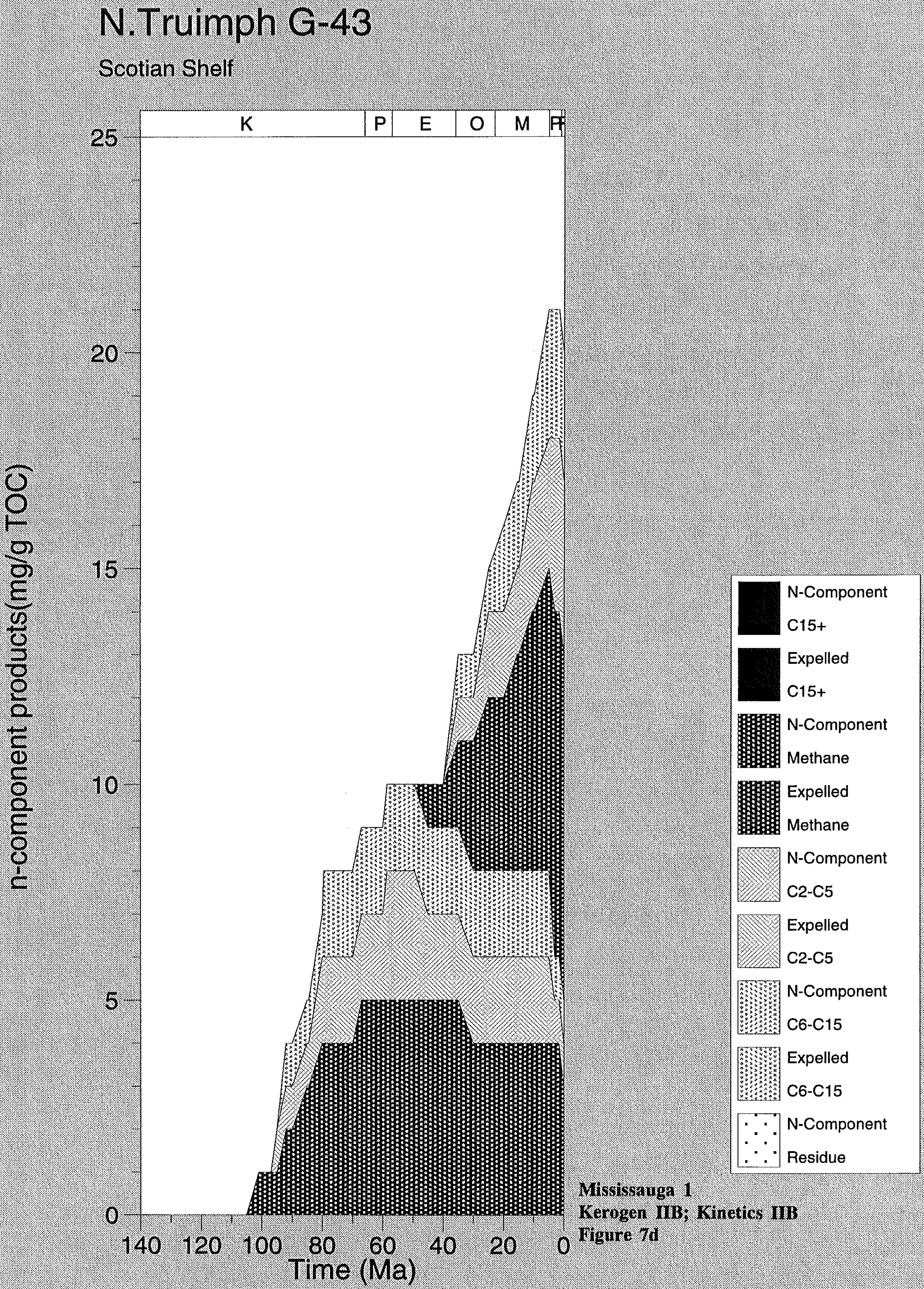
**Kerogen IIB; Kinetics IIB**
**Figure 7a**



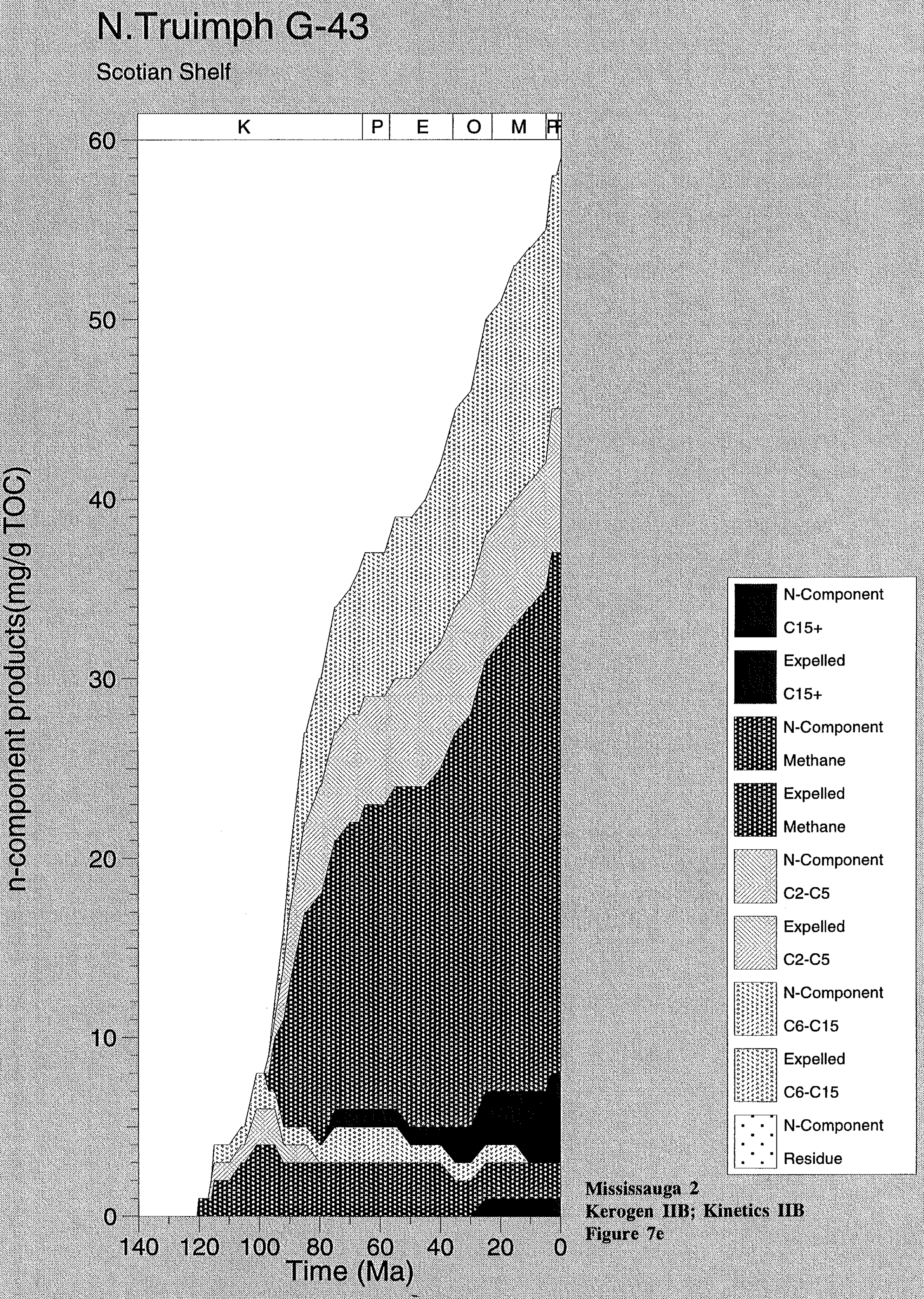
**Kerogen III; Kinetics IIB**
**Figure 7b**



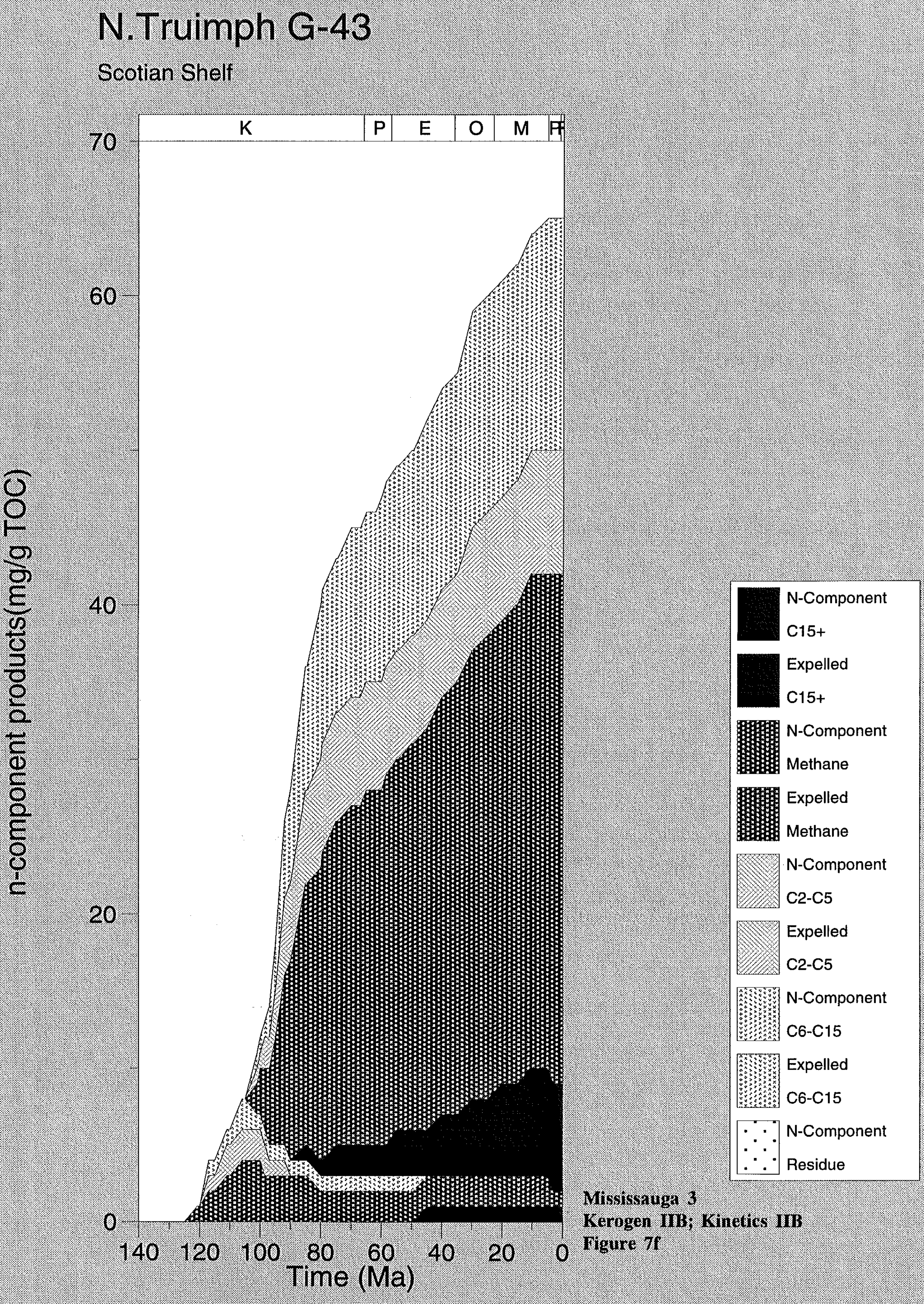
**Naskapi: Kerogen III; Kinetics IIB**
**Figure 7c**



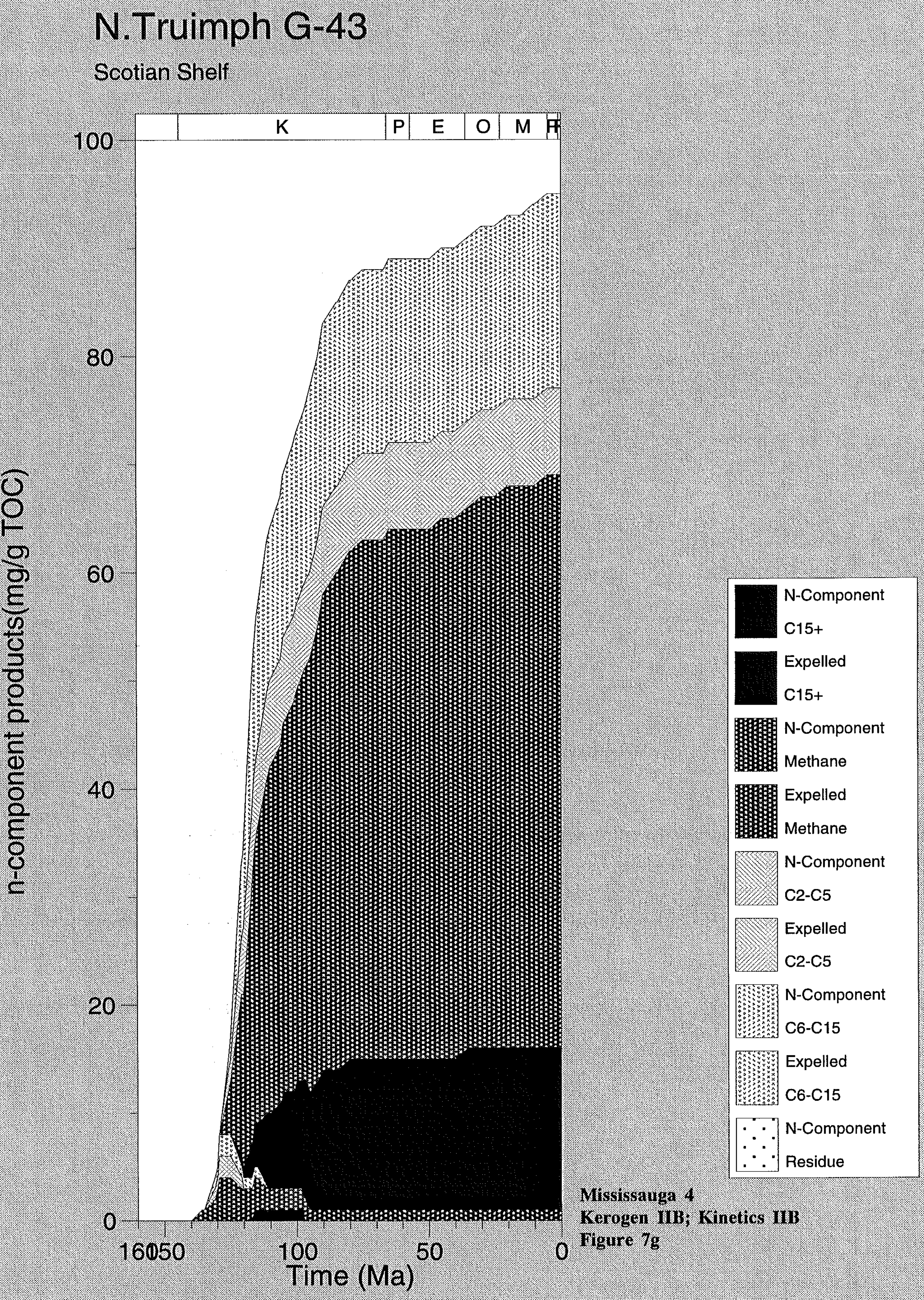
**Mississauga 1**
**Kerogen IIB; Kinetics IIB**
**Figure 7d**



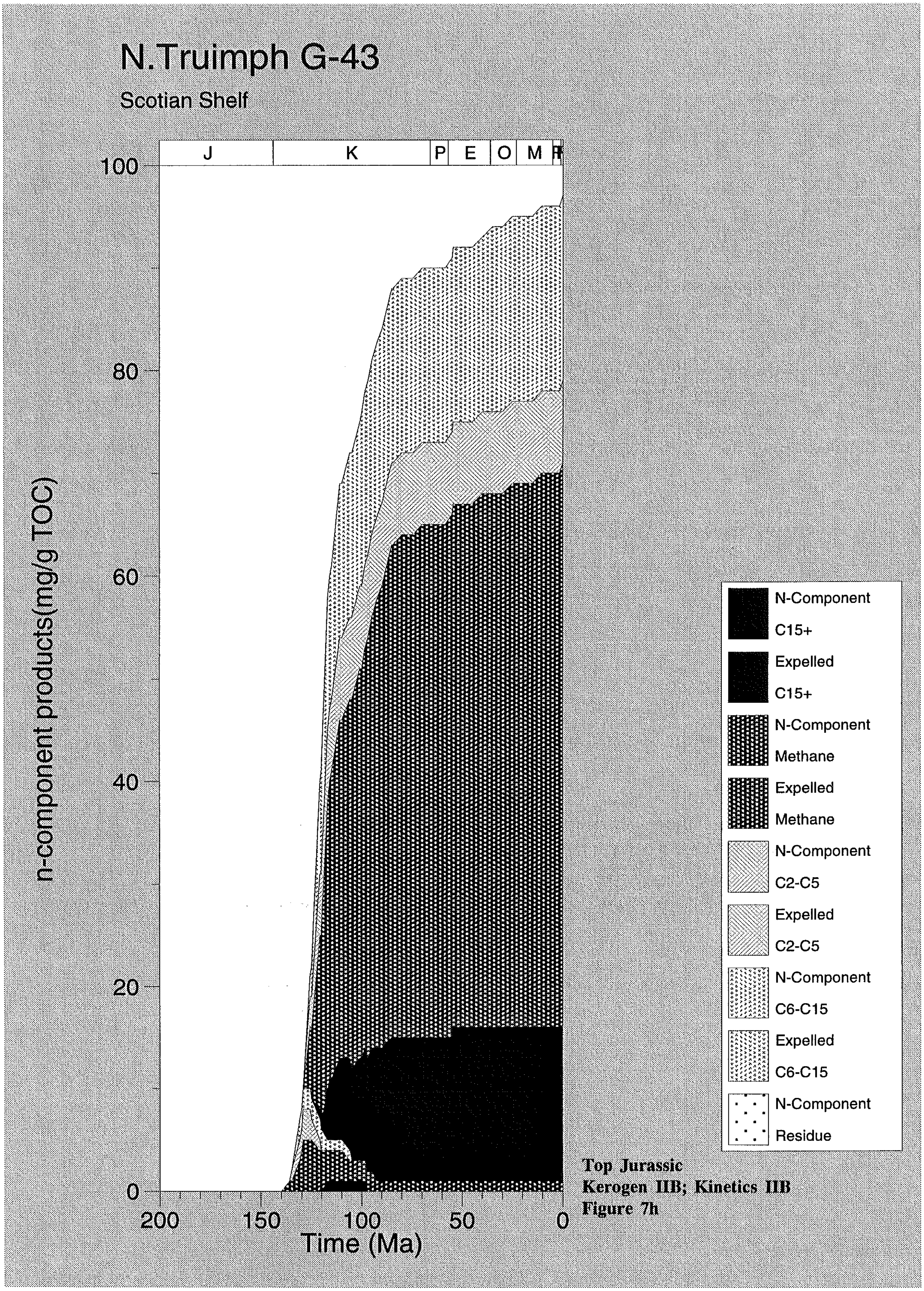
**Mississauga 2**
**Kerogen IIB; Kinetics IIB**
**Figure 7e**



**Mississauga 3**
**Kerogen IIB; Kinetics IIB**
**Figure 7f**

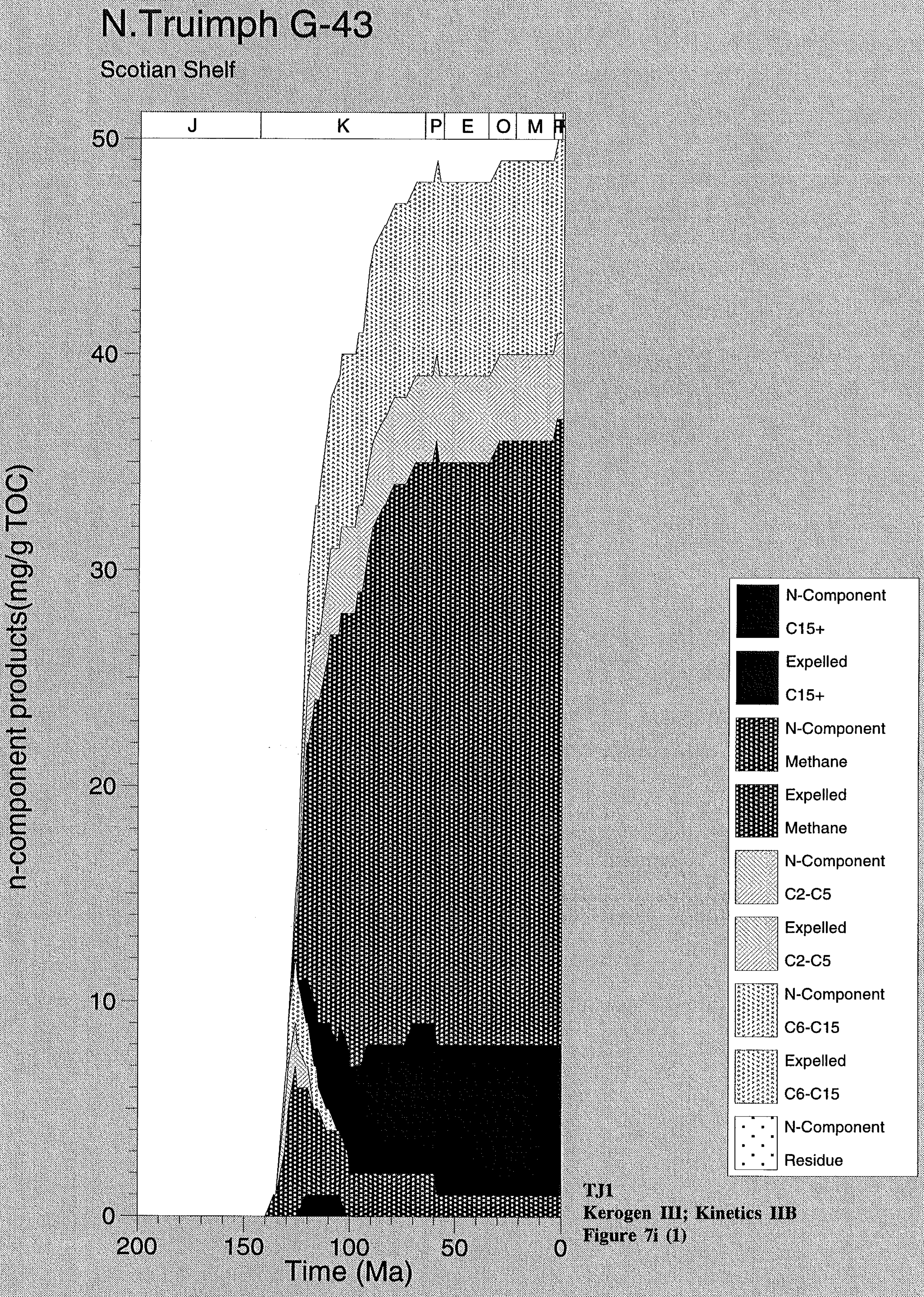


**Mississauga 4**
**Kerogen IIB; Kinetics IIB**
**Figure 7g**

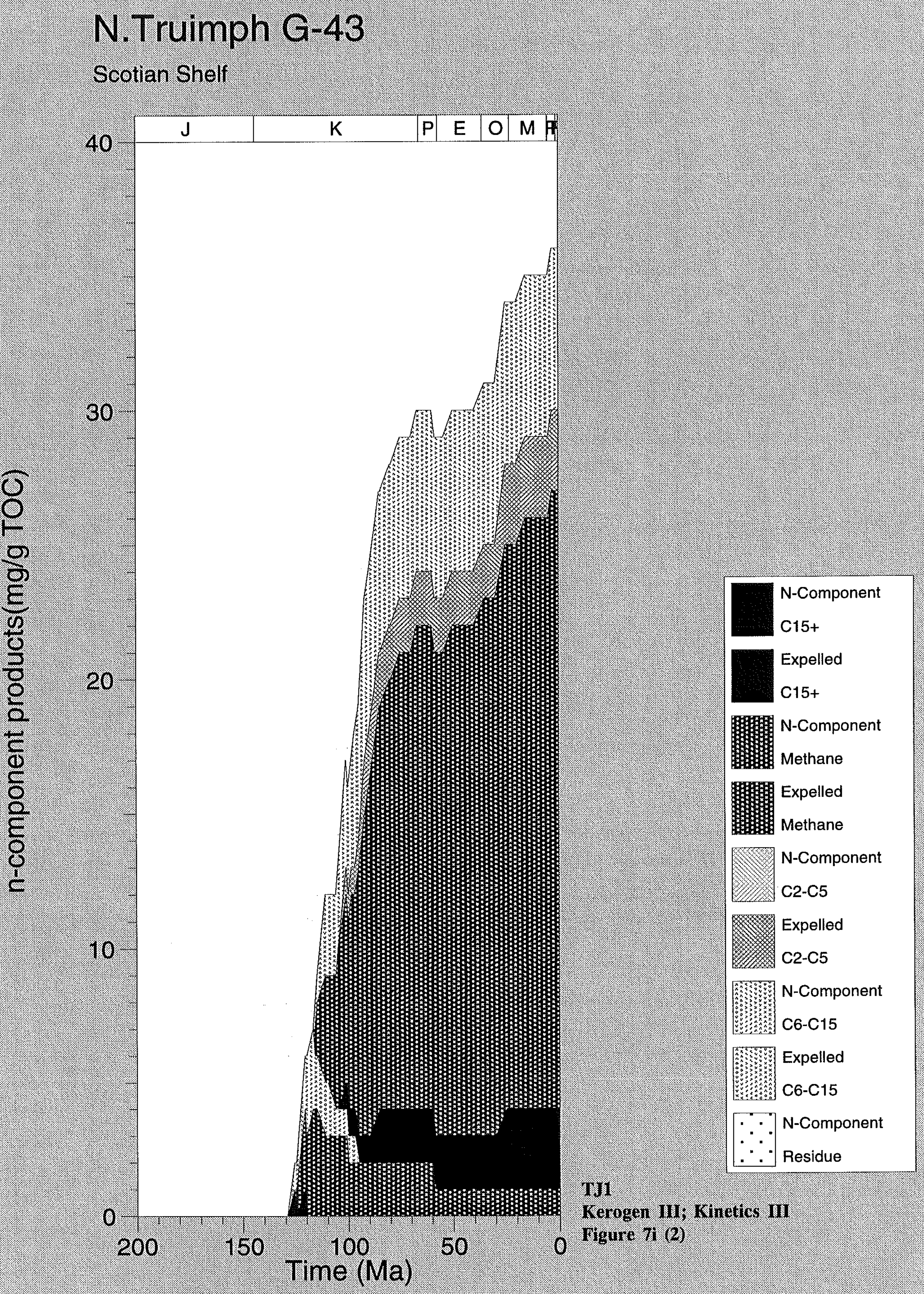


**Top Jurassic**
**Kerogen IIB; Kinetics IIB**
**Figure 7h**

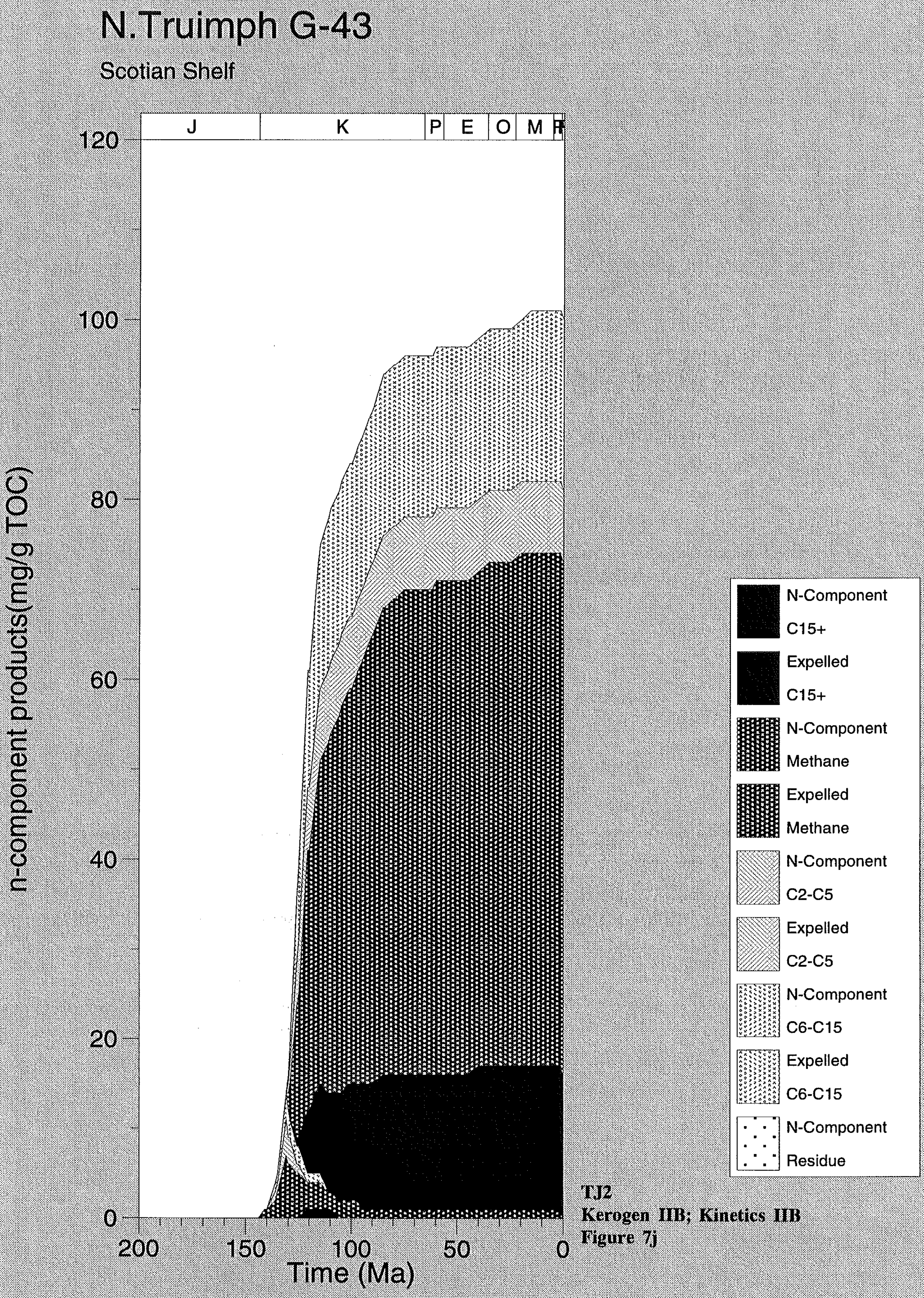
30



**TJ1**
**Kerogen III; Kinetics IIB**
**Figure 7i (1)**



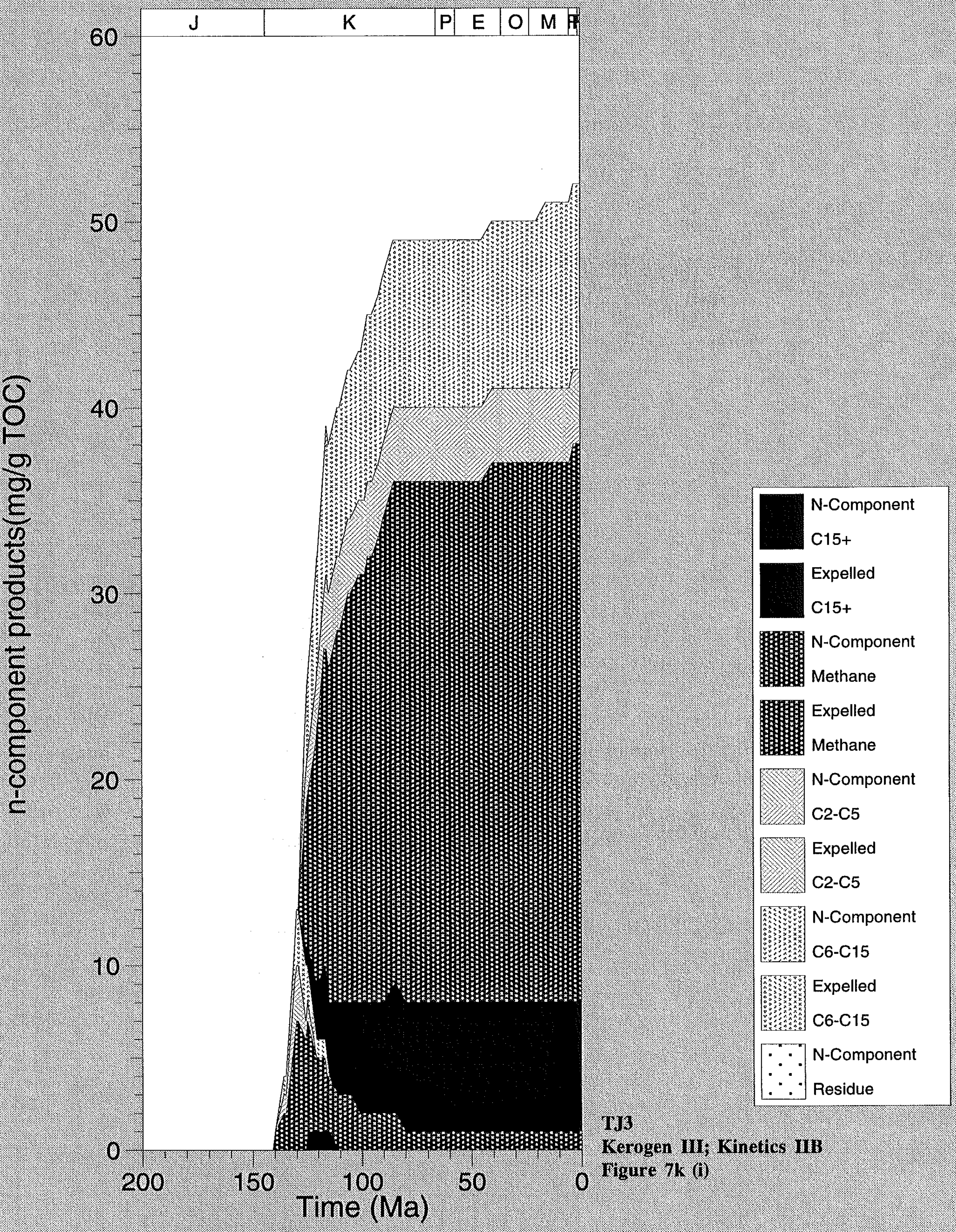
**TJ1**
**Kerogen III; Kinetics III**
**Figure 7i (2)**



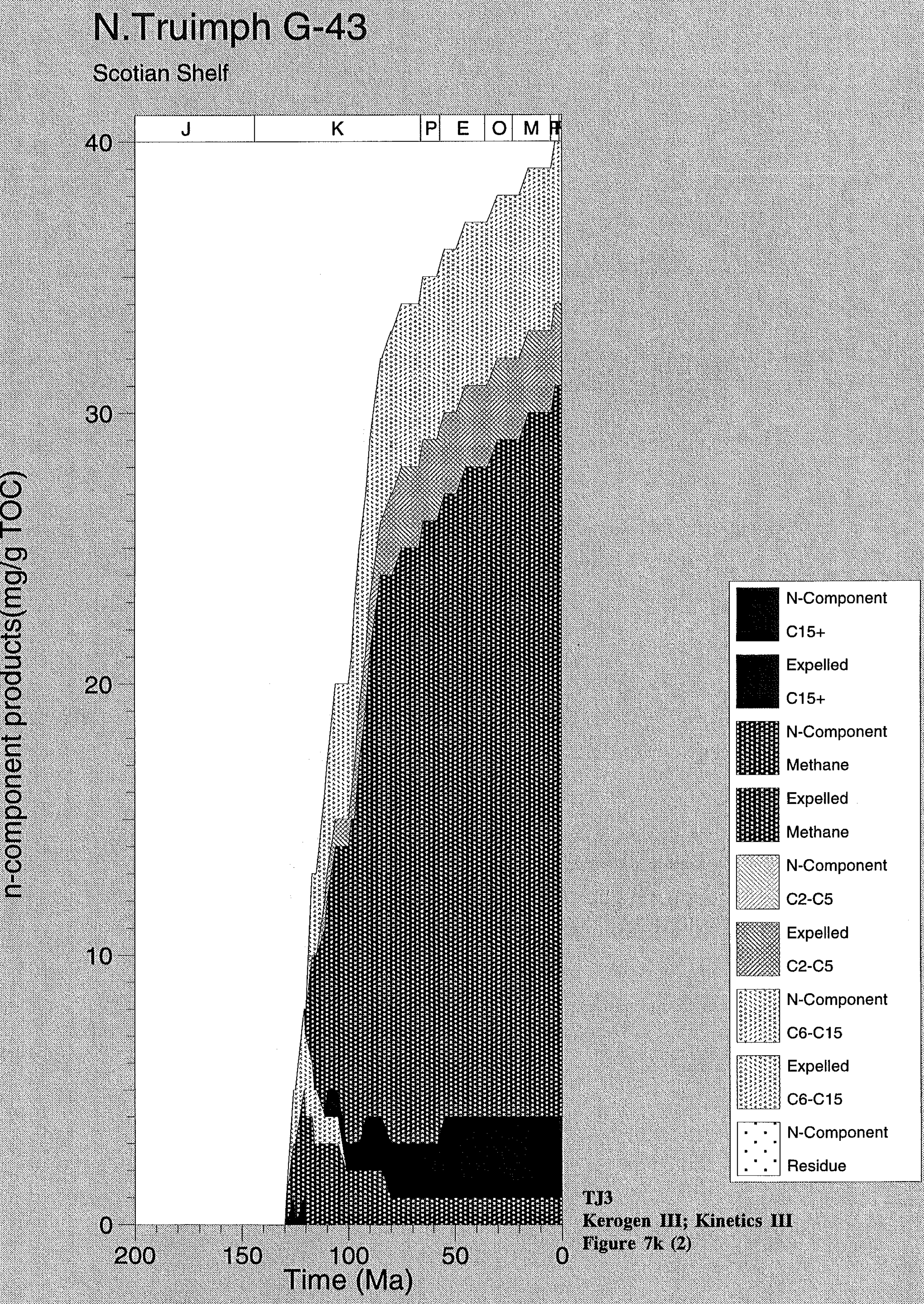
**TJ2**
**Kerogen IIB; Kinetics IIB**
**Figure 7j**

N.Truimph G-43

Scotian Shelf



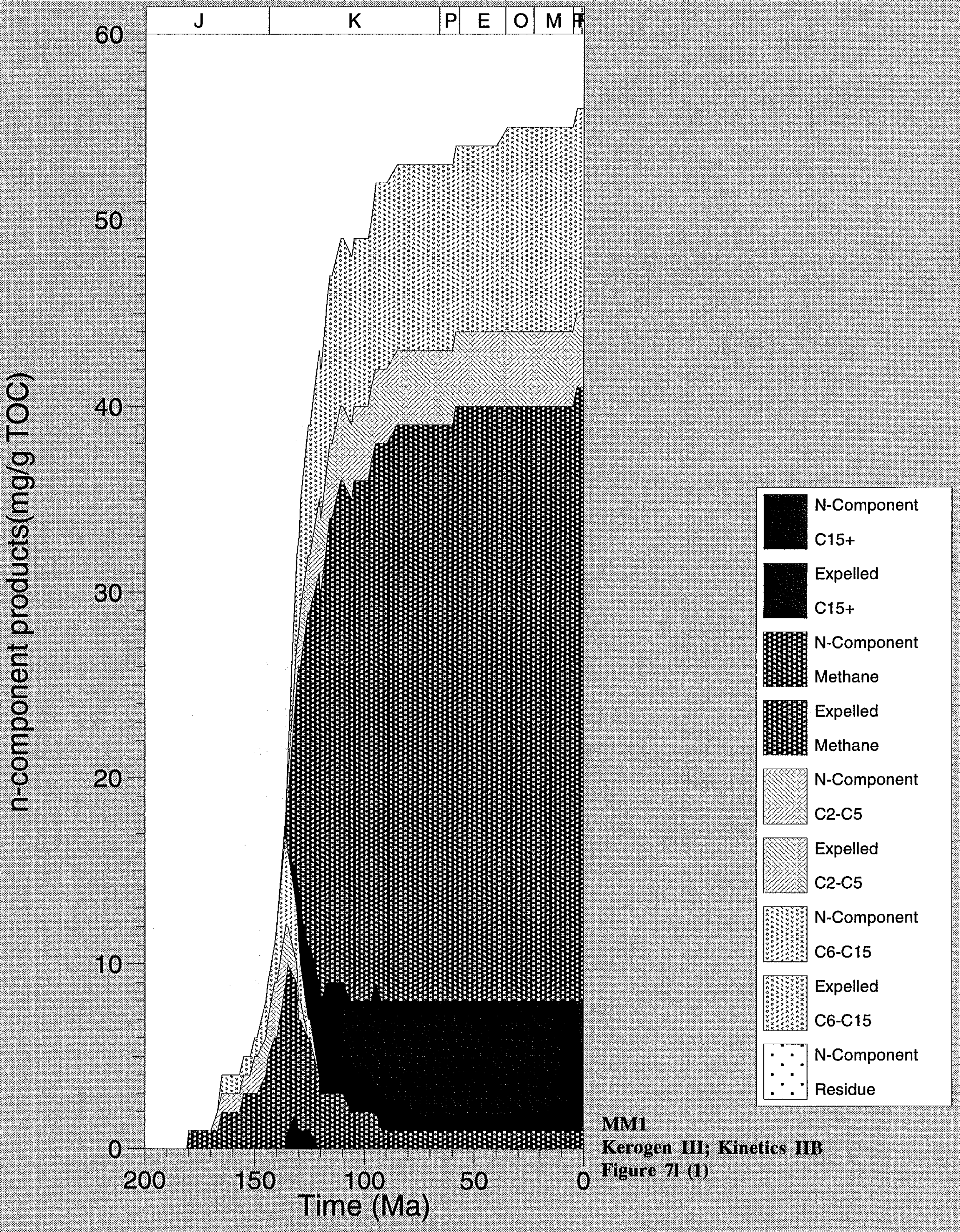
**TJ3**
**Kerogen III; Kinetics IIB**
**Figure 7k (i)**



**TJ3**
**Kerogen III; Kinetics III**
**Figure 7k (2)**

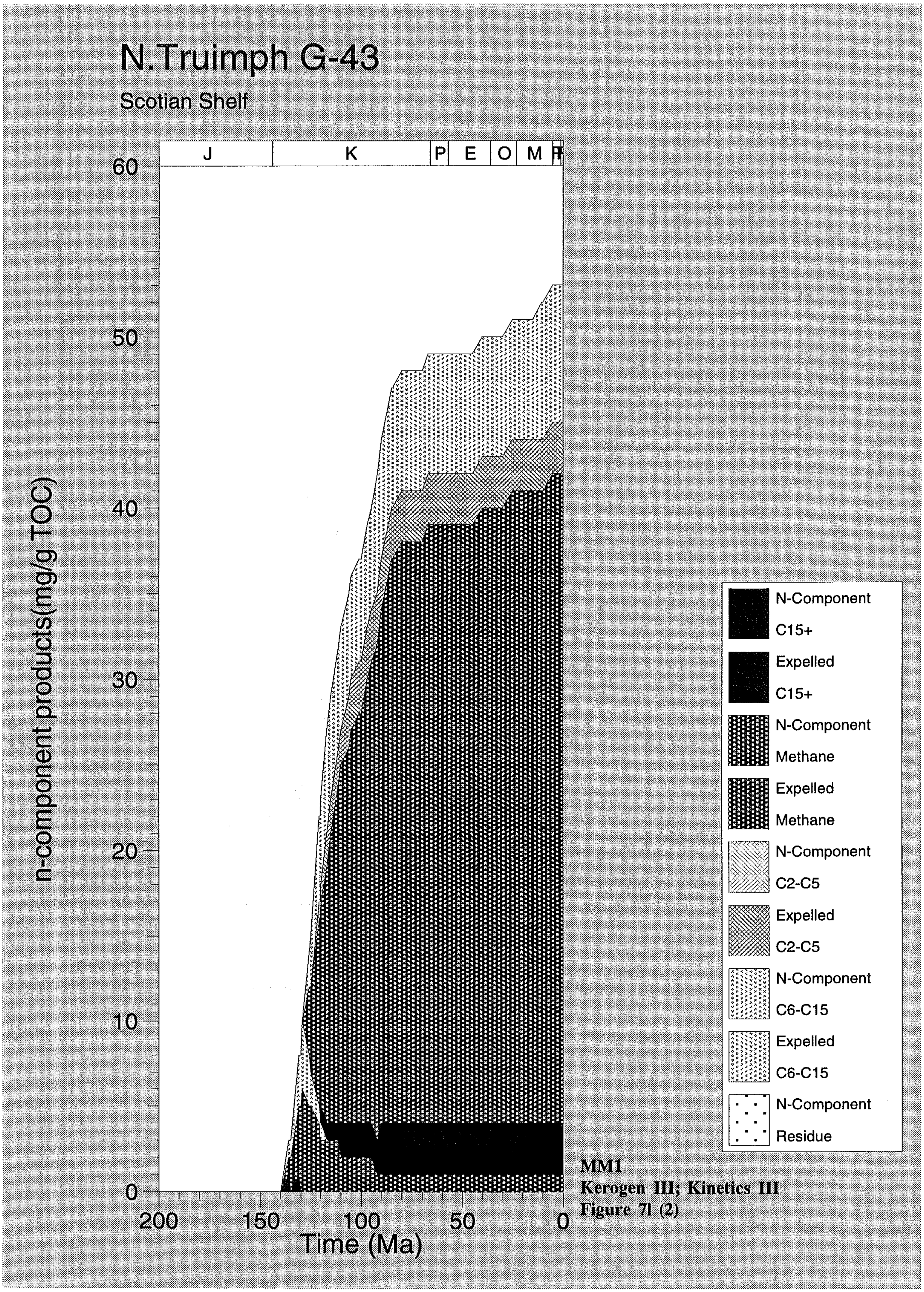
# N.Truimph G-43

Scotian Shelf

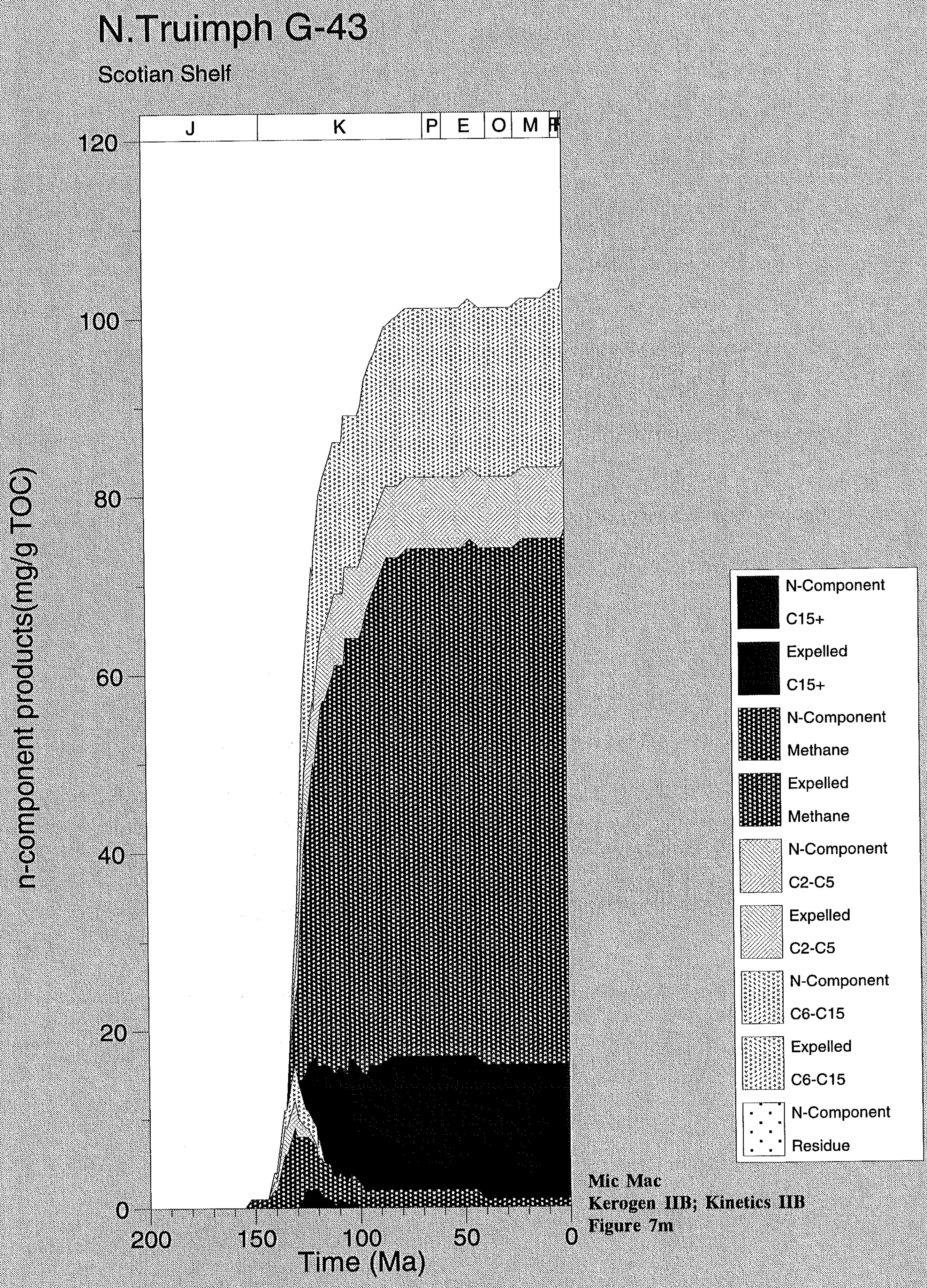


**MM1**
**Kerogen III; Kinetics IIB**
**Figure 7l (1)**

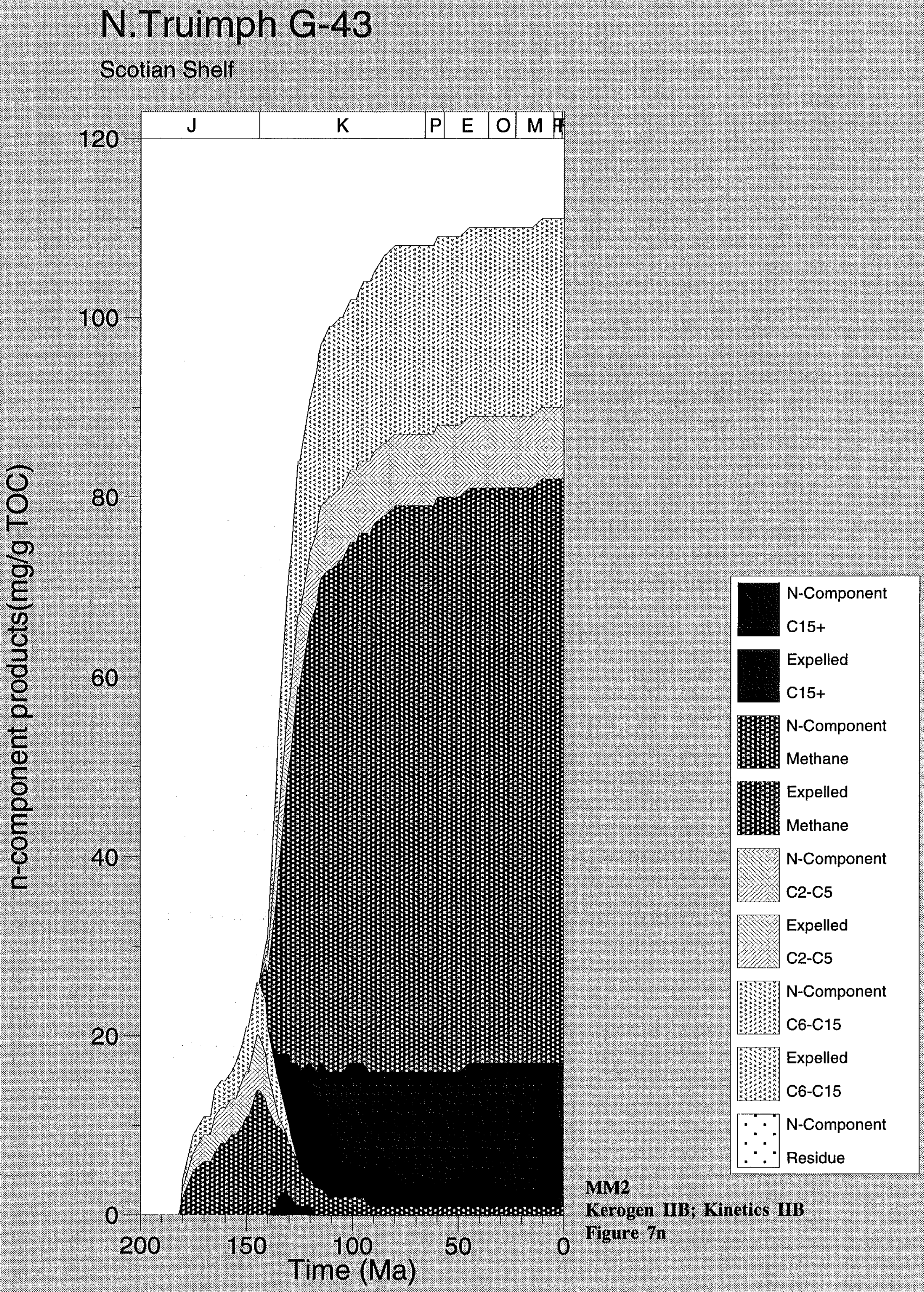
38



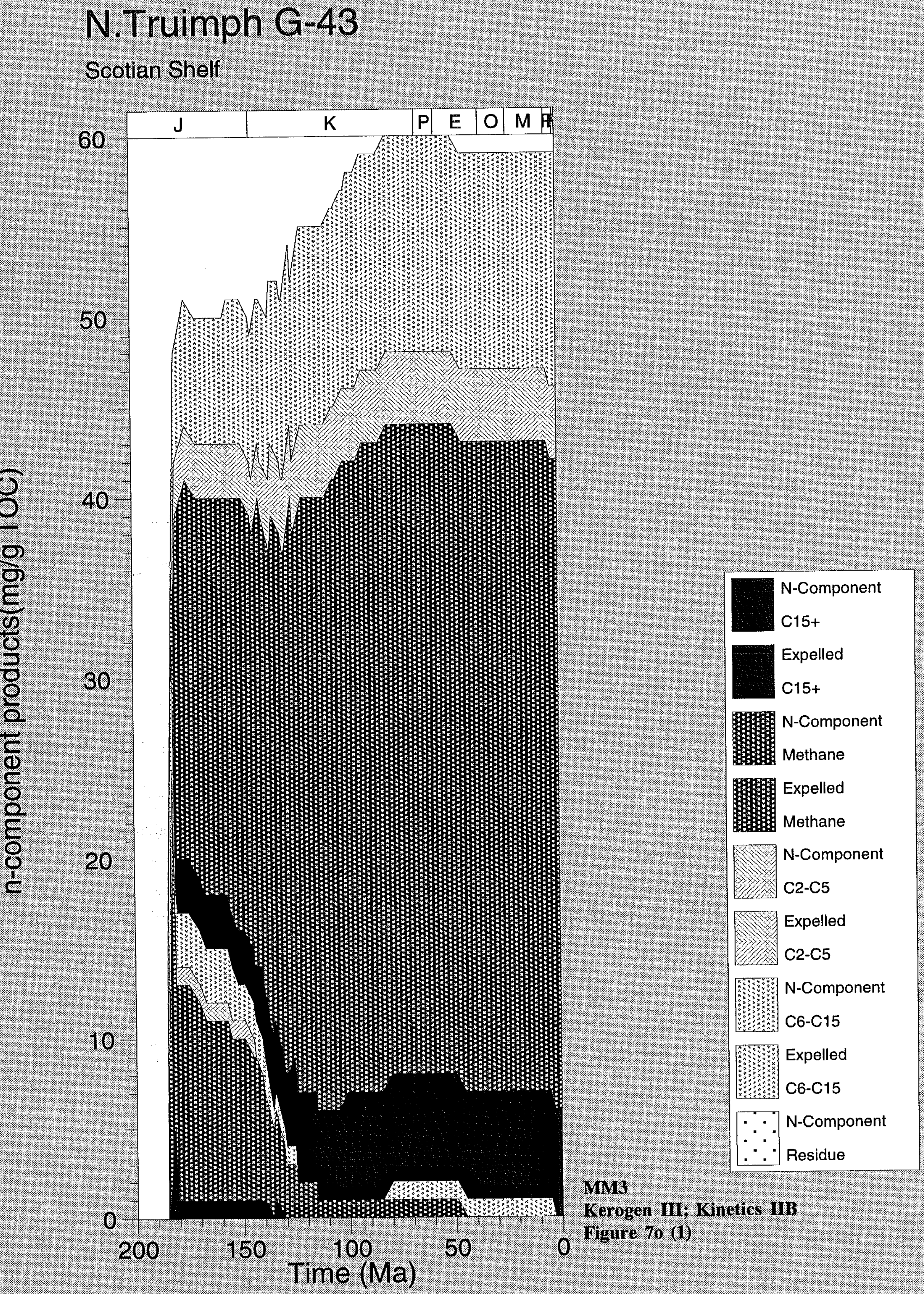
**MM1**
**Kerogen III; Kinetics III**
**Figure 7l (2)**



**Mic Mac**
**Kerogen IIB; Kinetics IIB**
**Figure 7m**



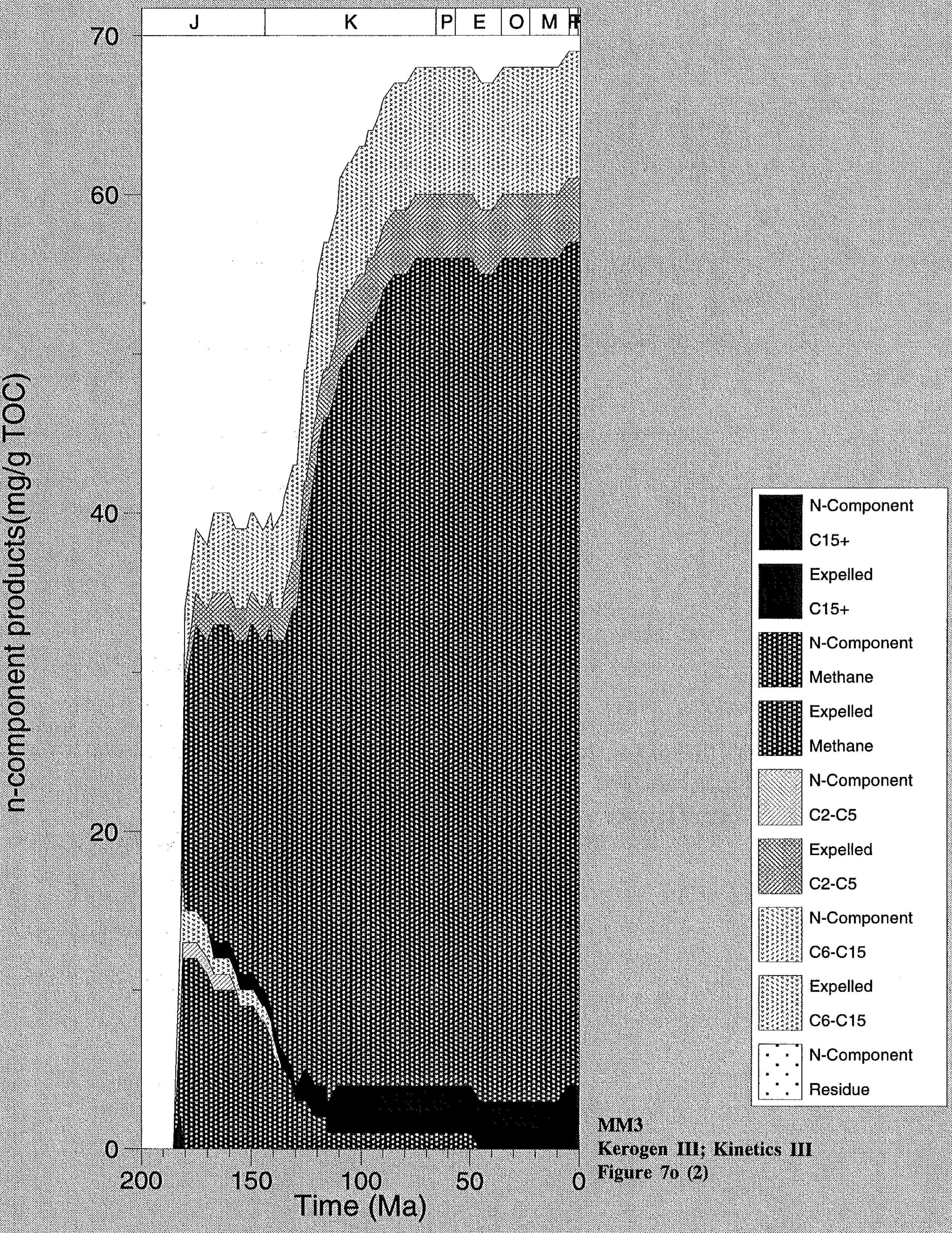
**MM2**
**Kerogen IIB; Kinetics IIB**
**Figure 7n**



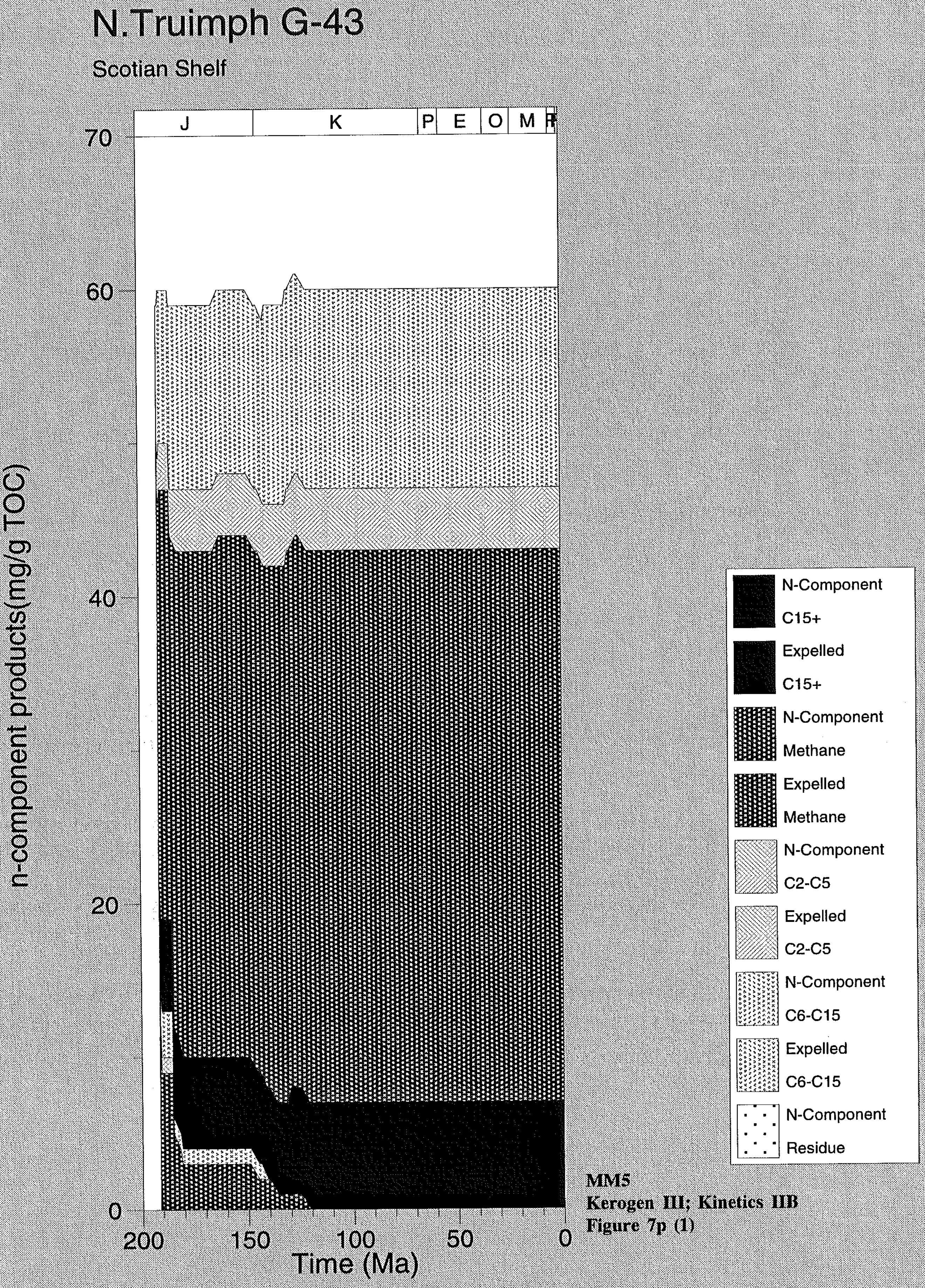
**MM3**
**Kerogen III; Kinetics IIB**
**Figure 7o (1)**

# N.Truimph G-43

Scotian Shelf



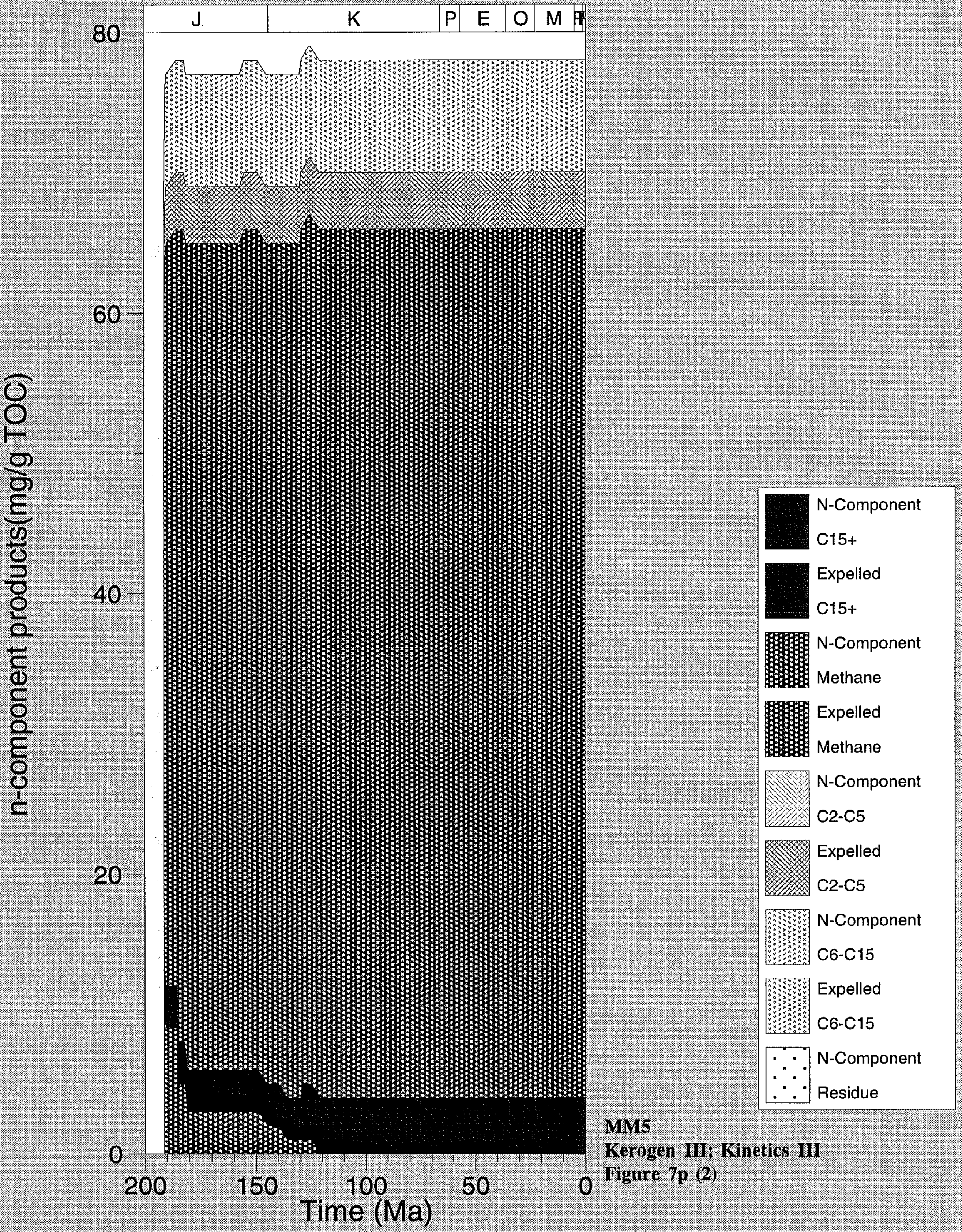
**MM3**
**Kerogen III; Kinetics III**
**Figure 7o (2)**



**MM5**
**Kerogen III; Kinetics IIB**
**Figure 7p (1)**

# N.Truimph G-43

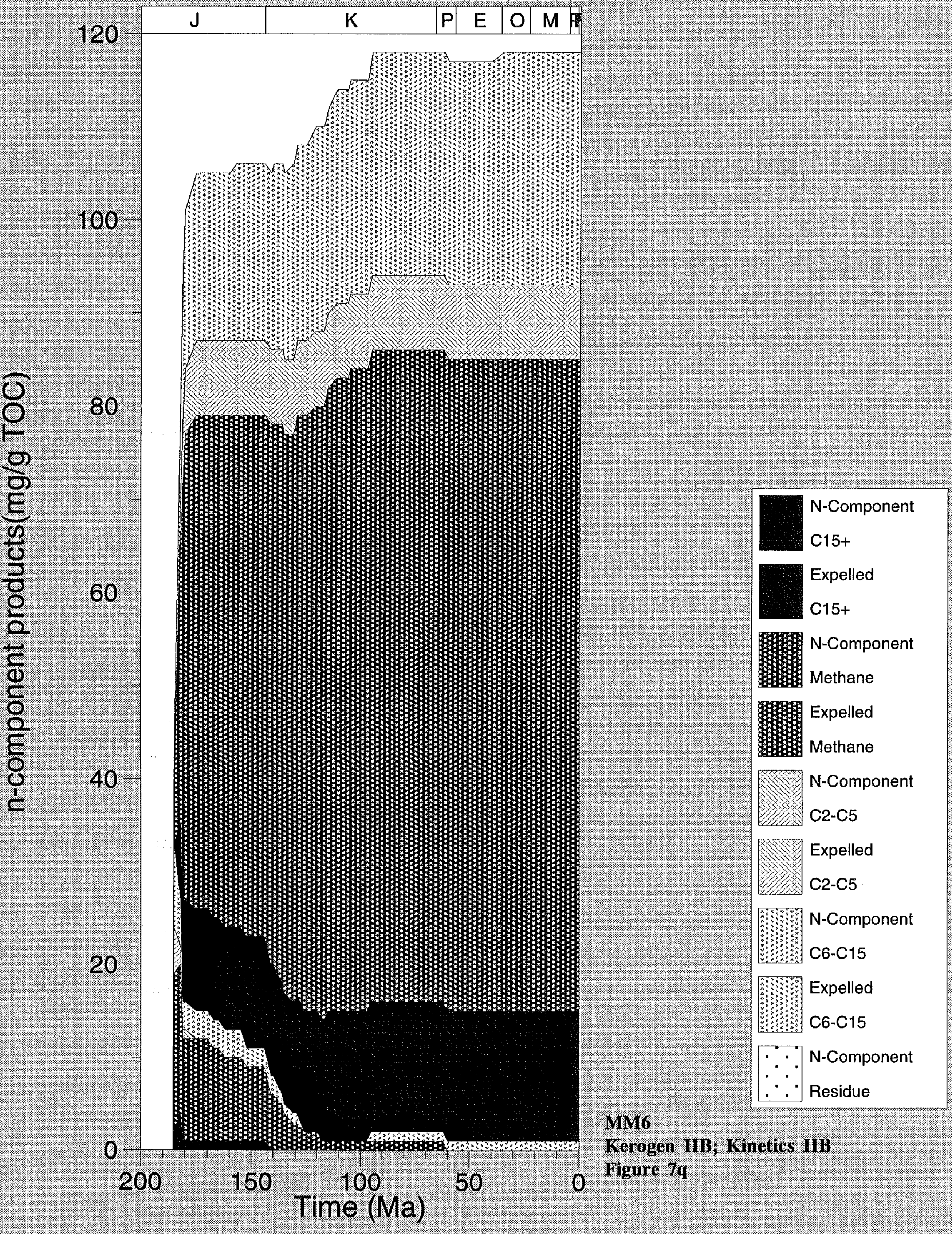
## Scotian Shelf



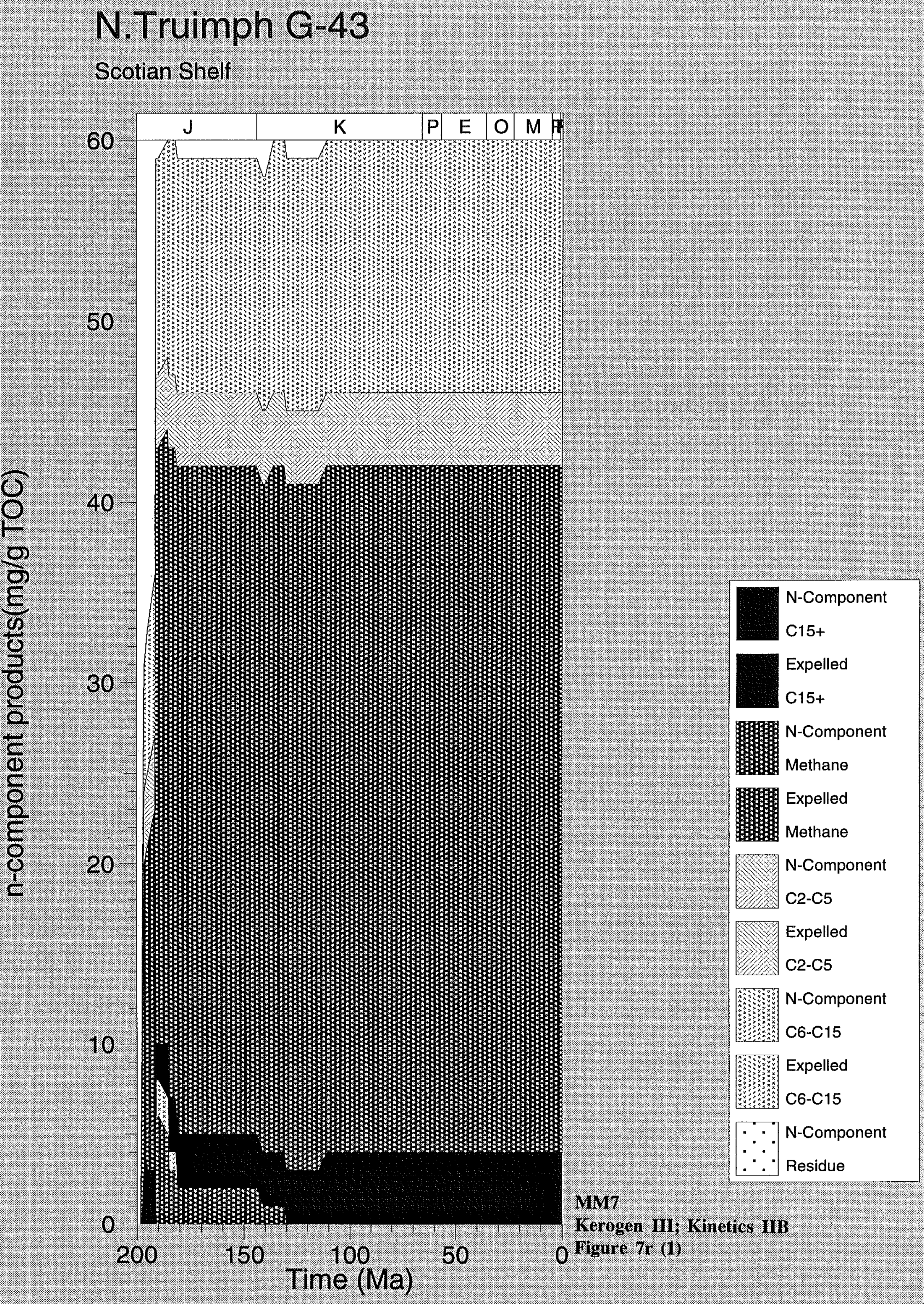
**MM5**
**Kerogen III; Kinetics III**
**Figure 7p (2)**

# N.Truimph G-43

Scotian Shelf

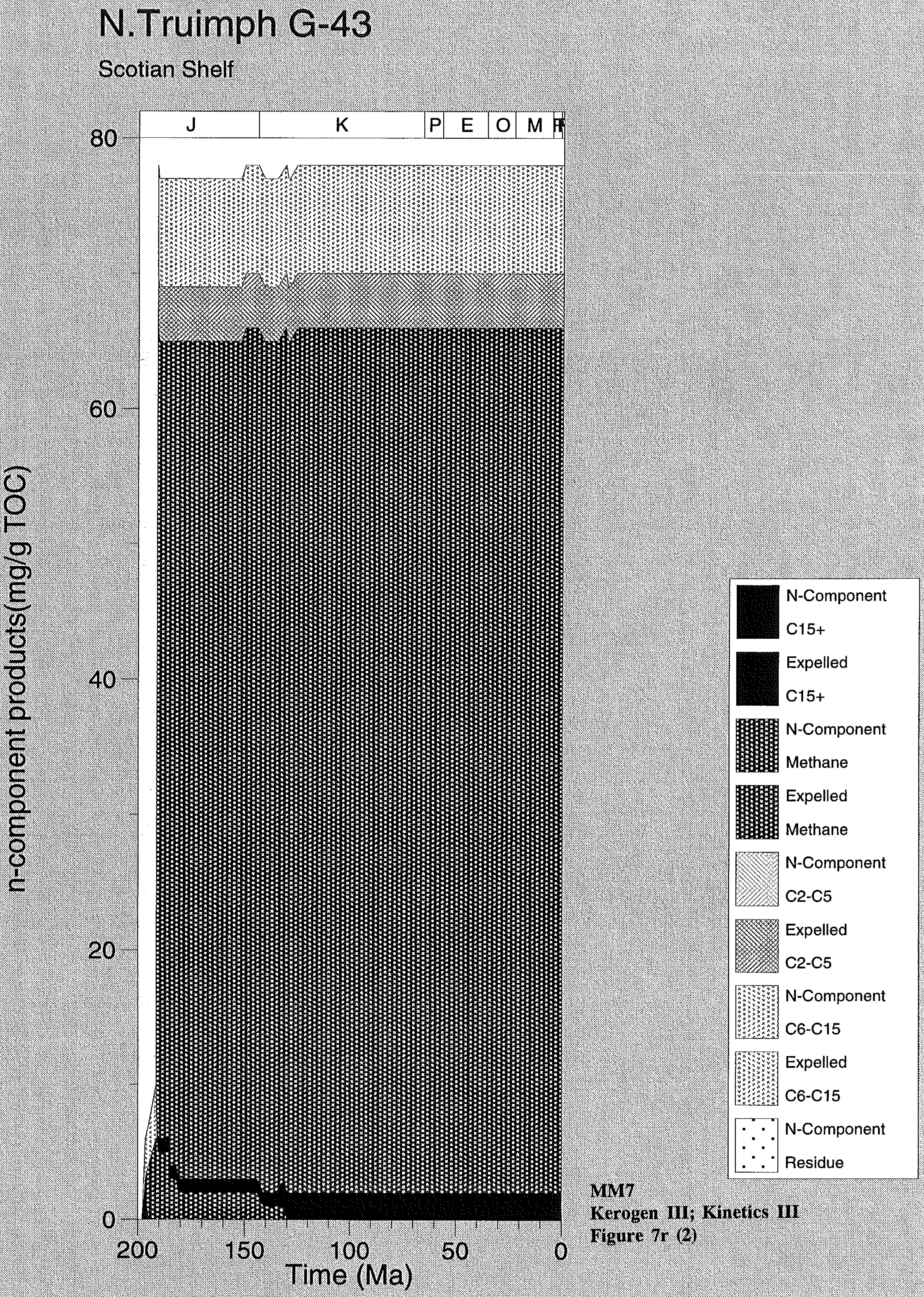


**MM6**
**Kerogen IIB; Kinetics IIB**
**Figure 7q**

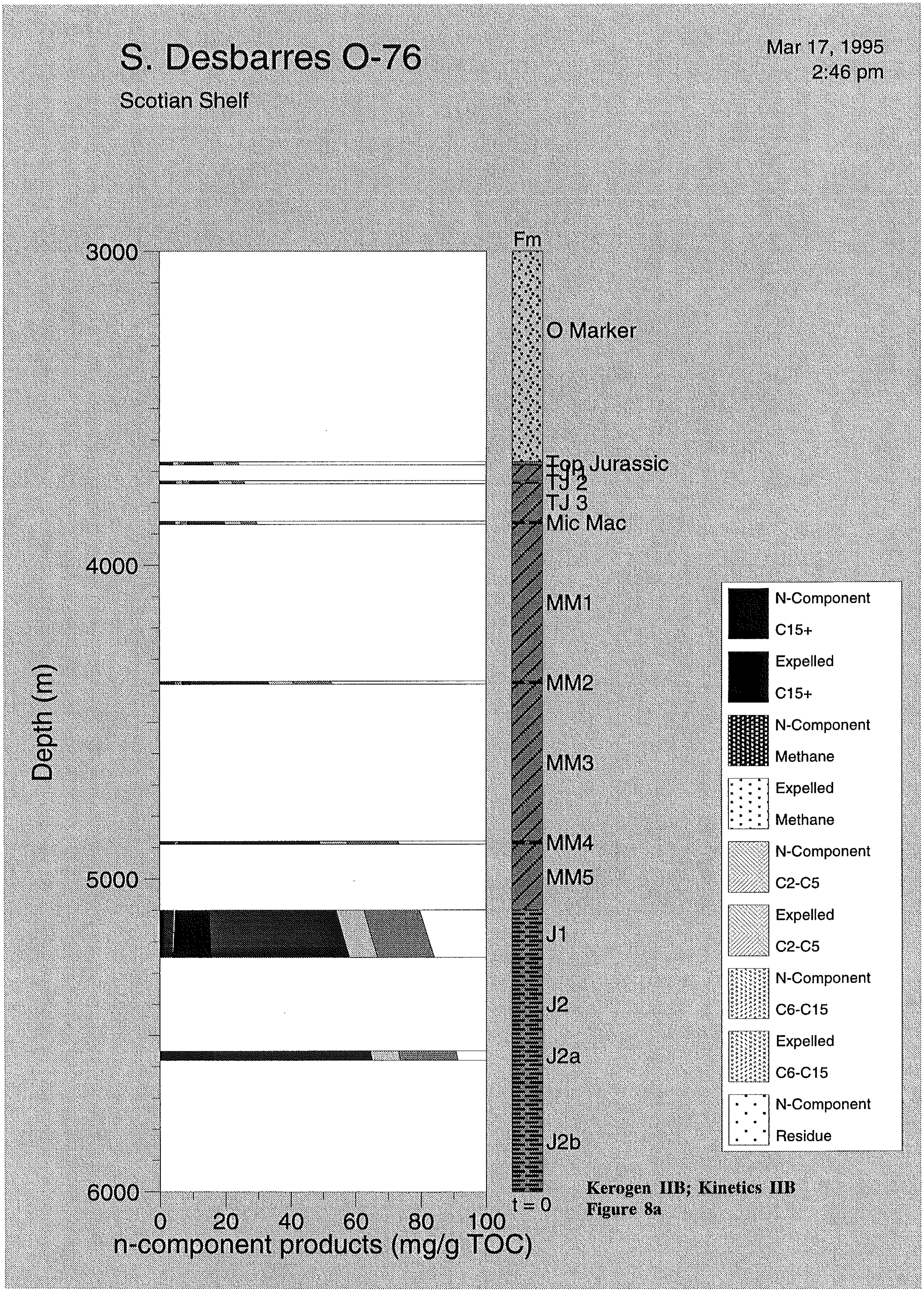


**MM7**
**Kerogen III; Kinetics IIB**
**Figure 7r (1)**

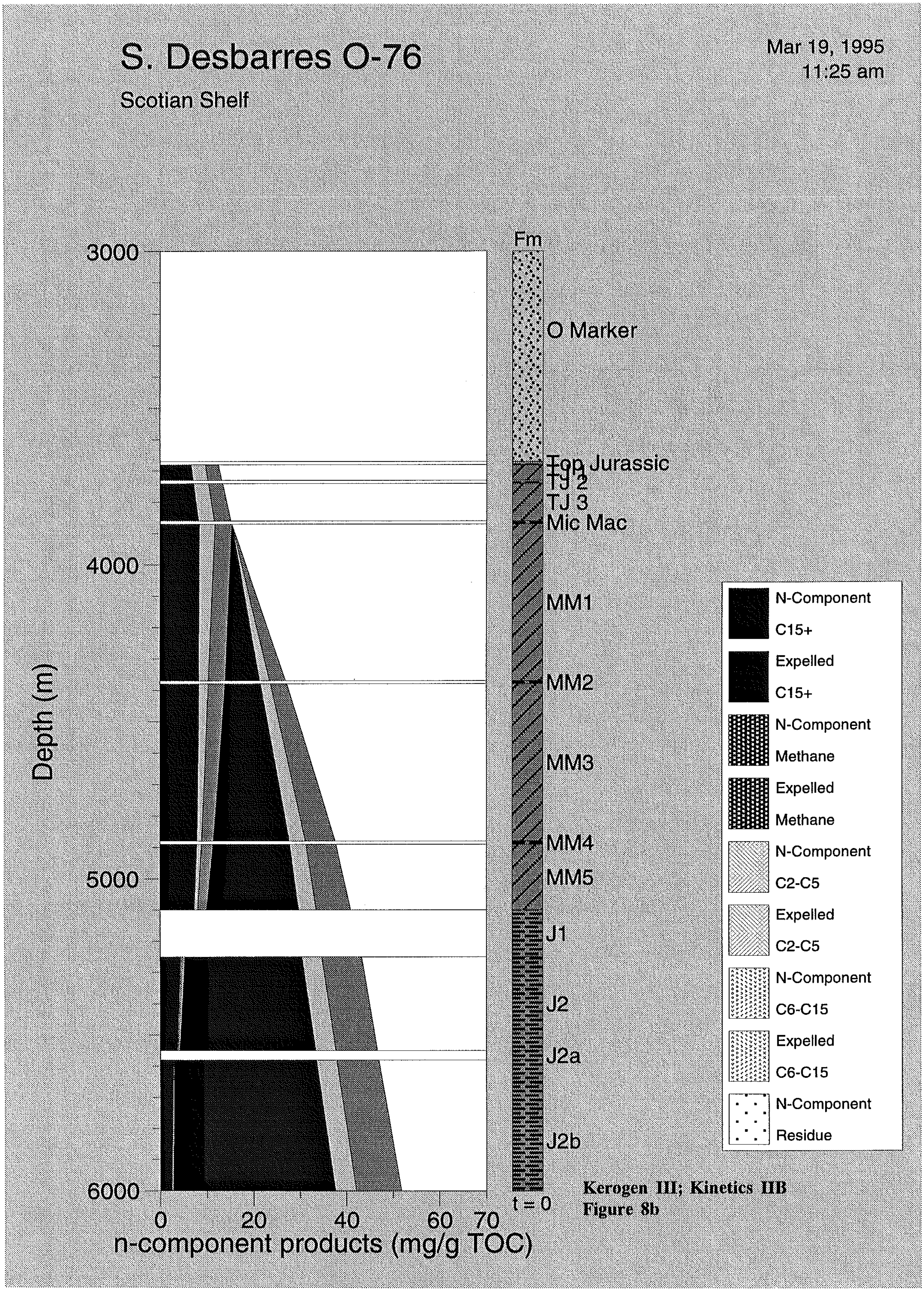
63



**MM7**
**Kerogen III; Kinetics III**
**Figure 7r (2)**



**Kerogen IIB; Kinetics IIB**
**Figure 8a**



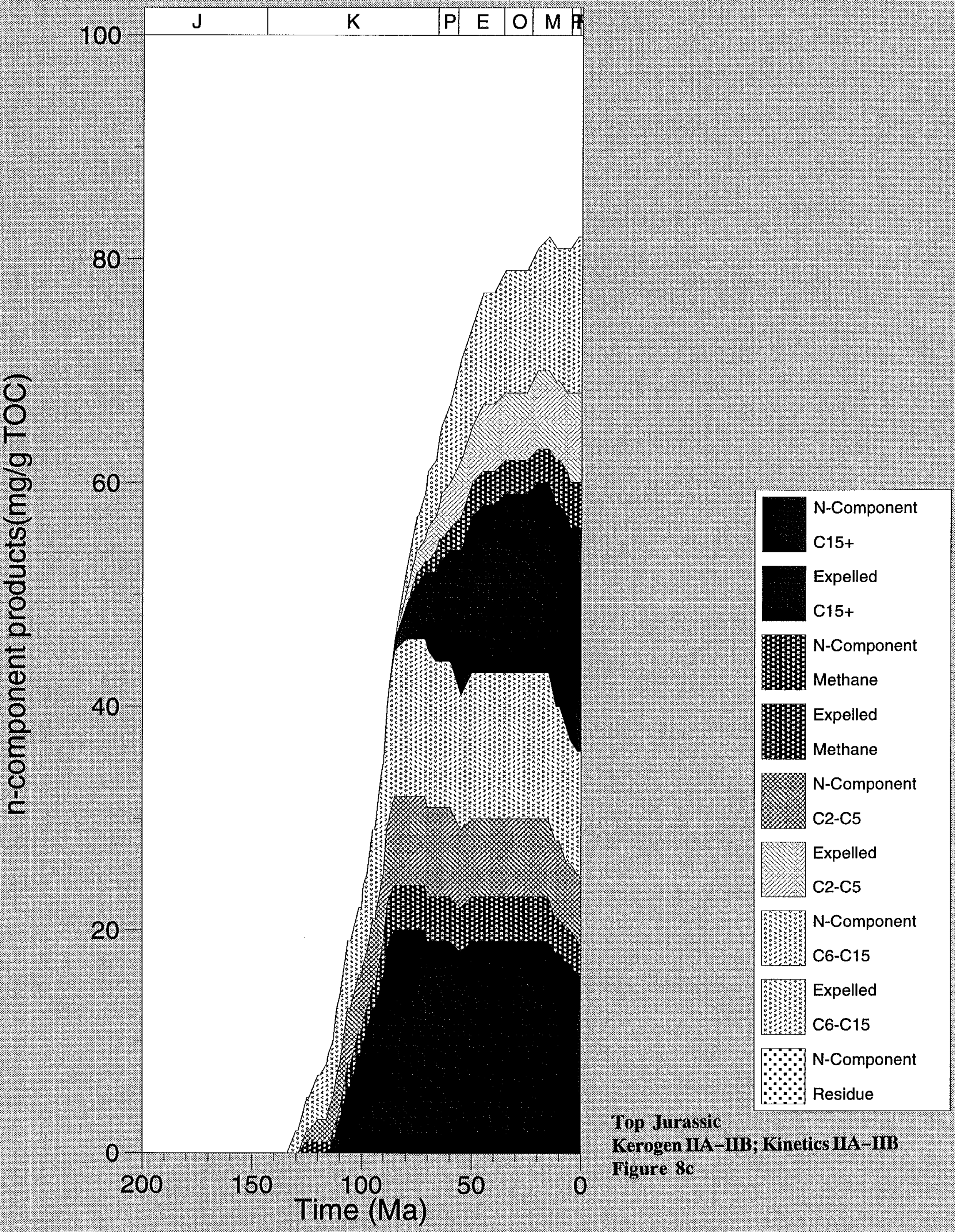
**Kerogen III; Kinetics IIB**
**Figure 8b**

S. Desbarres O-76

Scotian Shelf

Mar 18, 1995
12:54 pm

20 mg oil
8 mg Gas

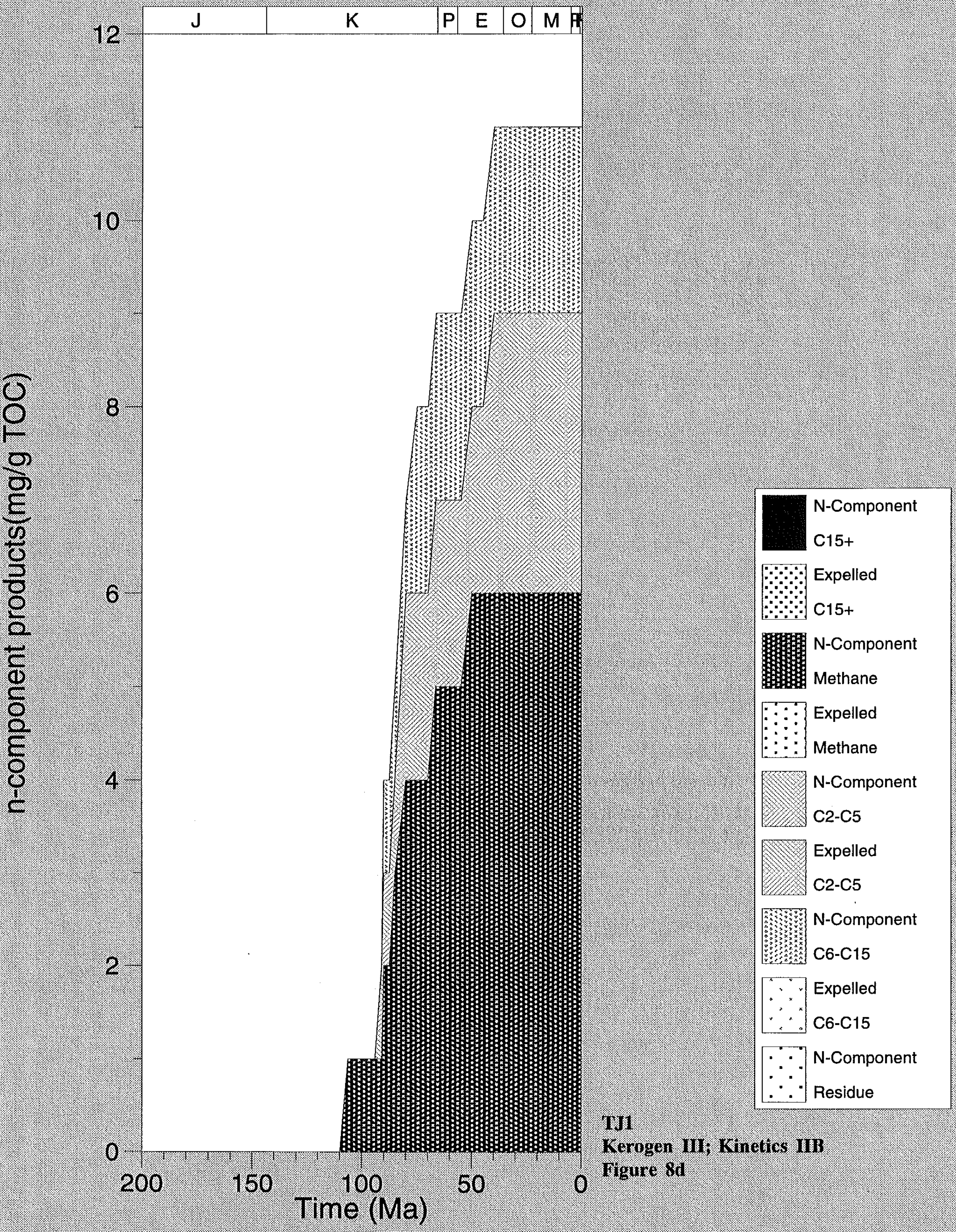


**Top Jurassic**
**Kerogen IIA-IIB; Kinetics IIA-IIB**
**Figure 8c**

# S. Desbarres O-76

Scotian Shelf

Mar 18, 1995
1:22 pm

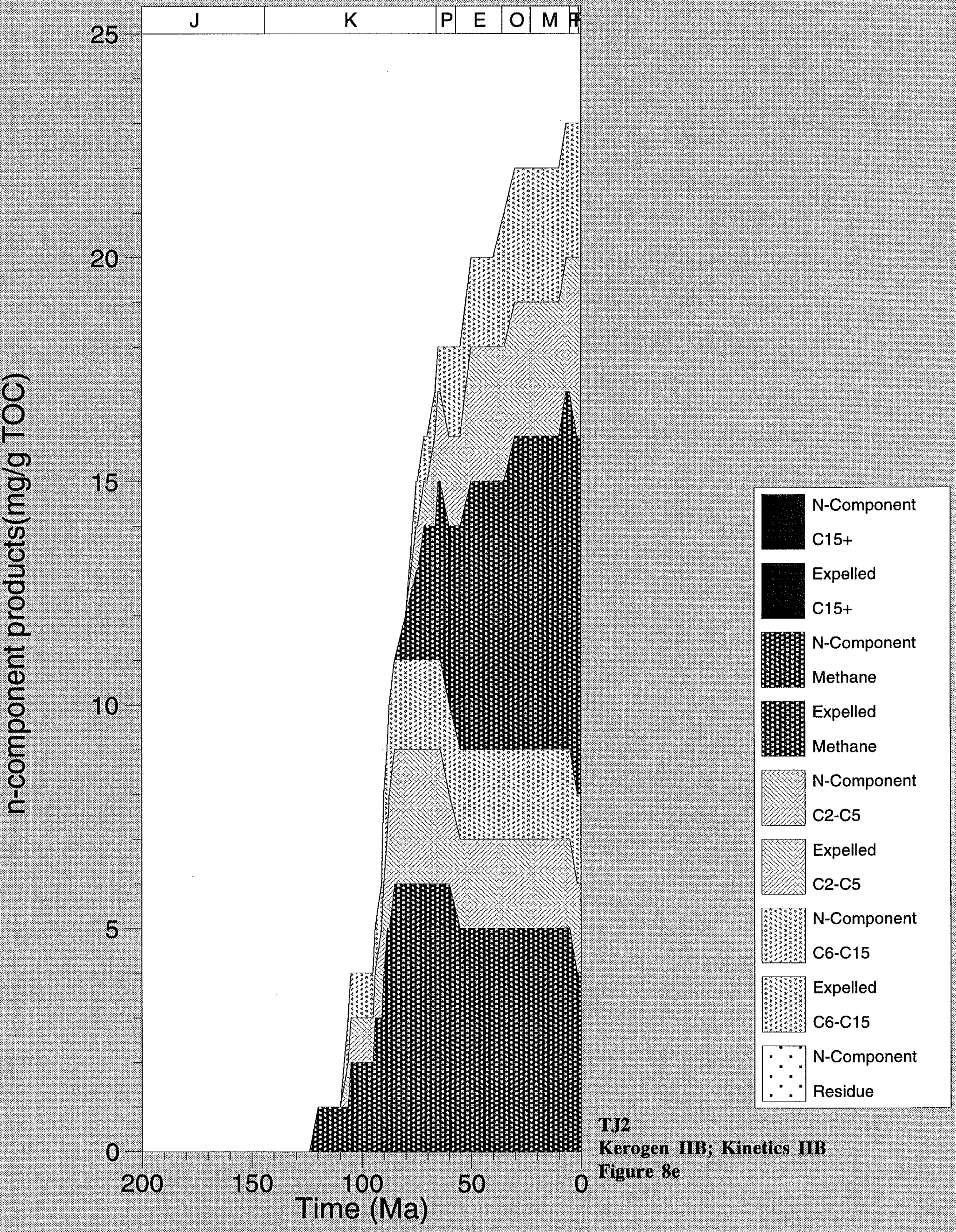


**TJ1**
**Kerogen III; Kinetics IIB**
**Figure 8d**

## S. Desbarres O-76

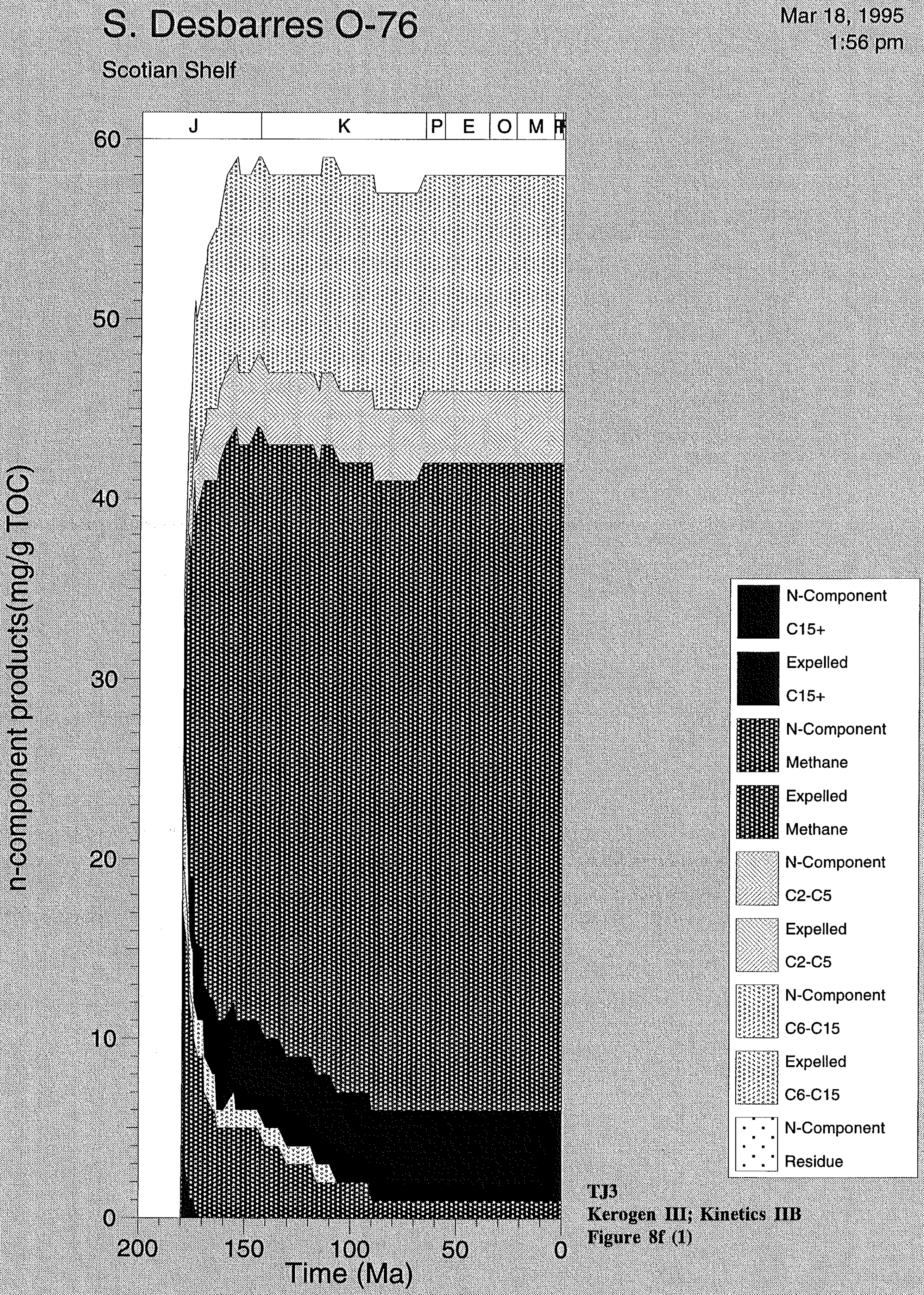
Scotian Shelf

Mar 18, 1995
12:51 pm



**TJ2**
**Kerogen IIB; Kinetics IIB**
**Figure 8e**

35

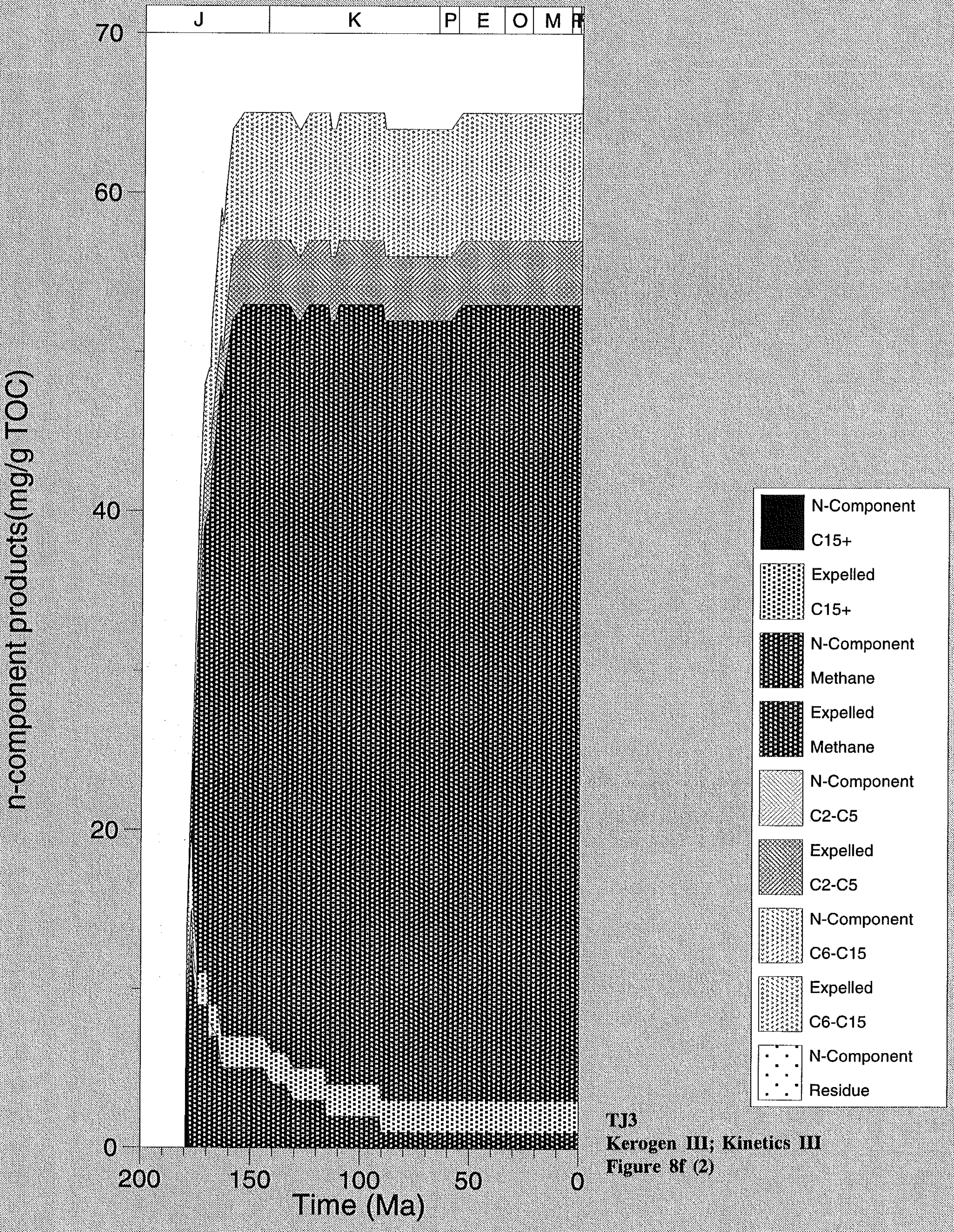


**TJ3**
**Kerogen III; Kinetics IIB**
**Figure 8f (1)**

# S. Desbarres O-76

Scotian Shelf

Mar 18, 1995
1:53 pm

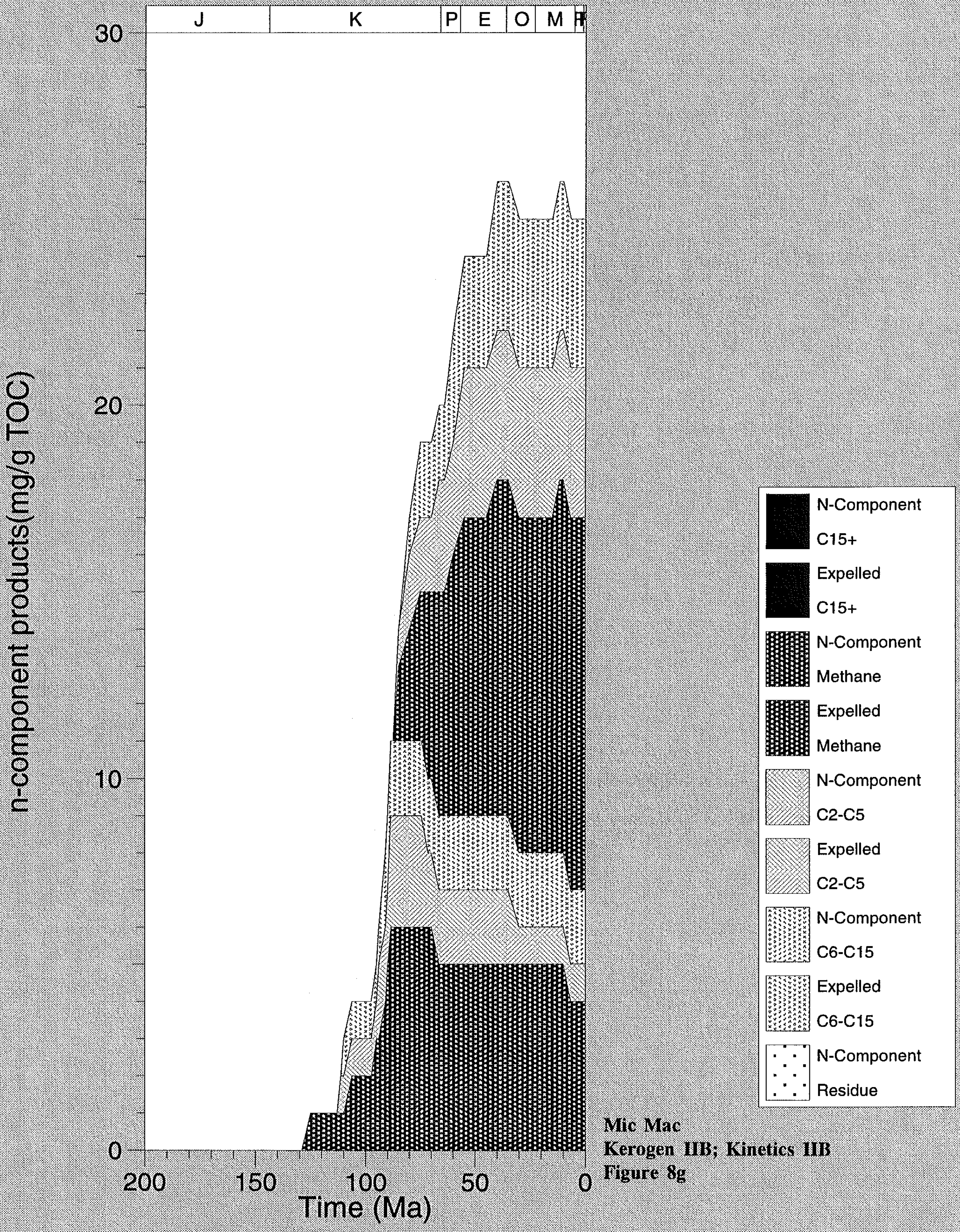


**TJ3**
**Kerogen III; Kinetics III**
**Figure 8f (2)**

# S. Desbarres O-76

Scotian Shelf

Mar 18, 1995
12:49 pm

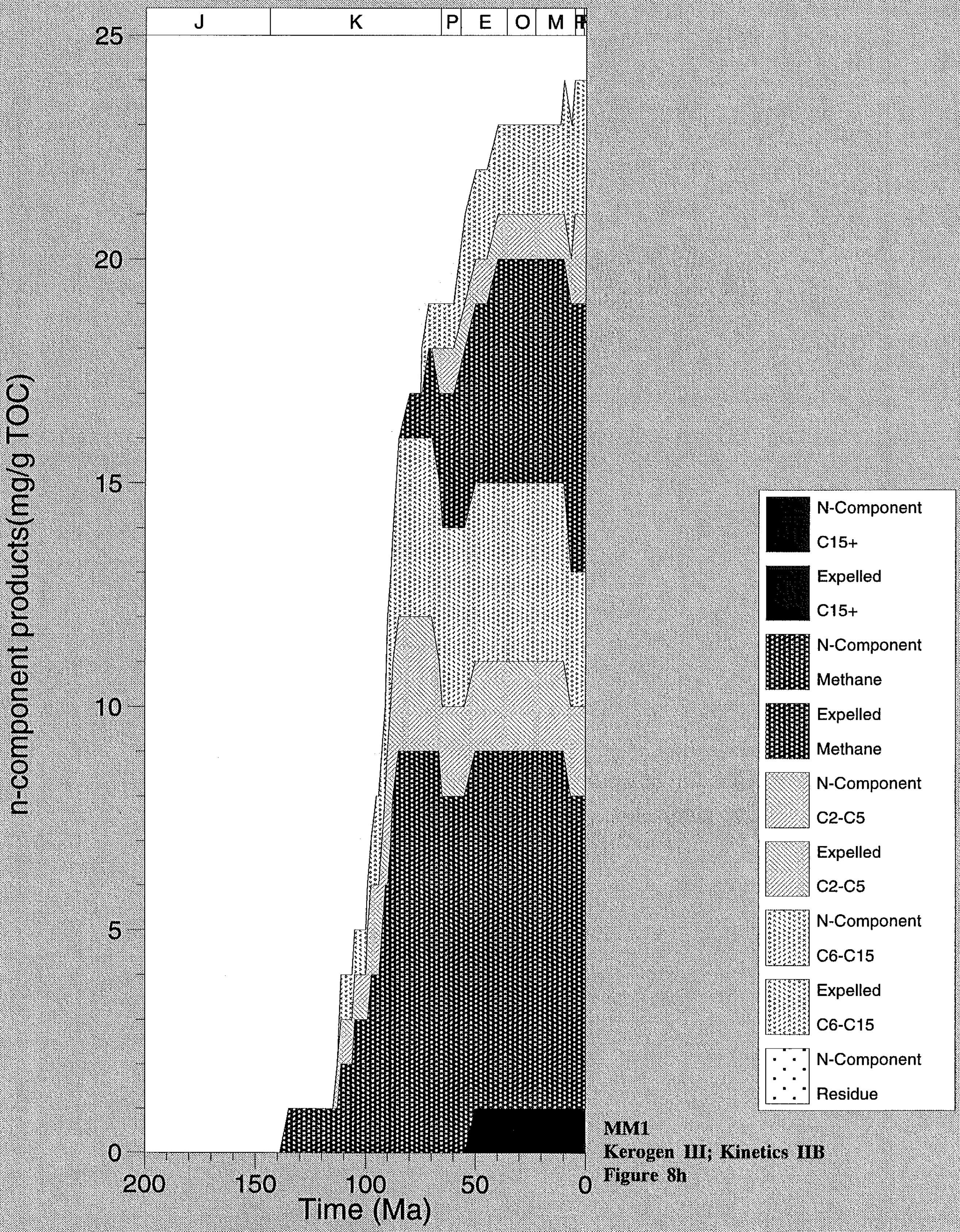


**Mic Mac**
**Kerogen IIB; Kinetics IIB**
**Figure 8g**

## S. Desbarres O-76

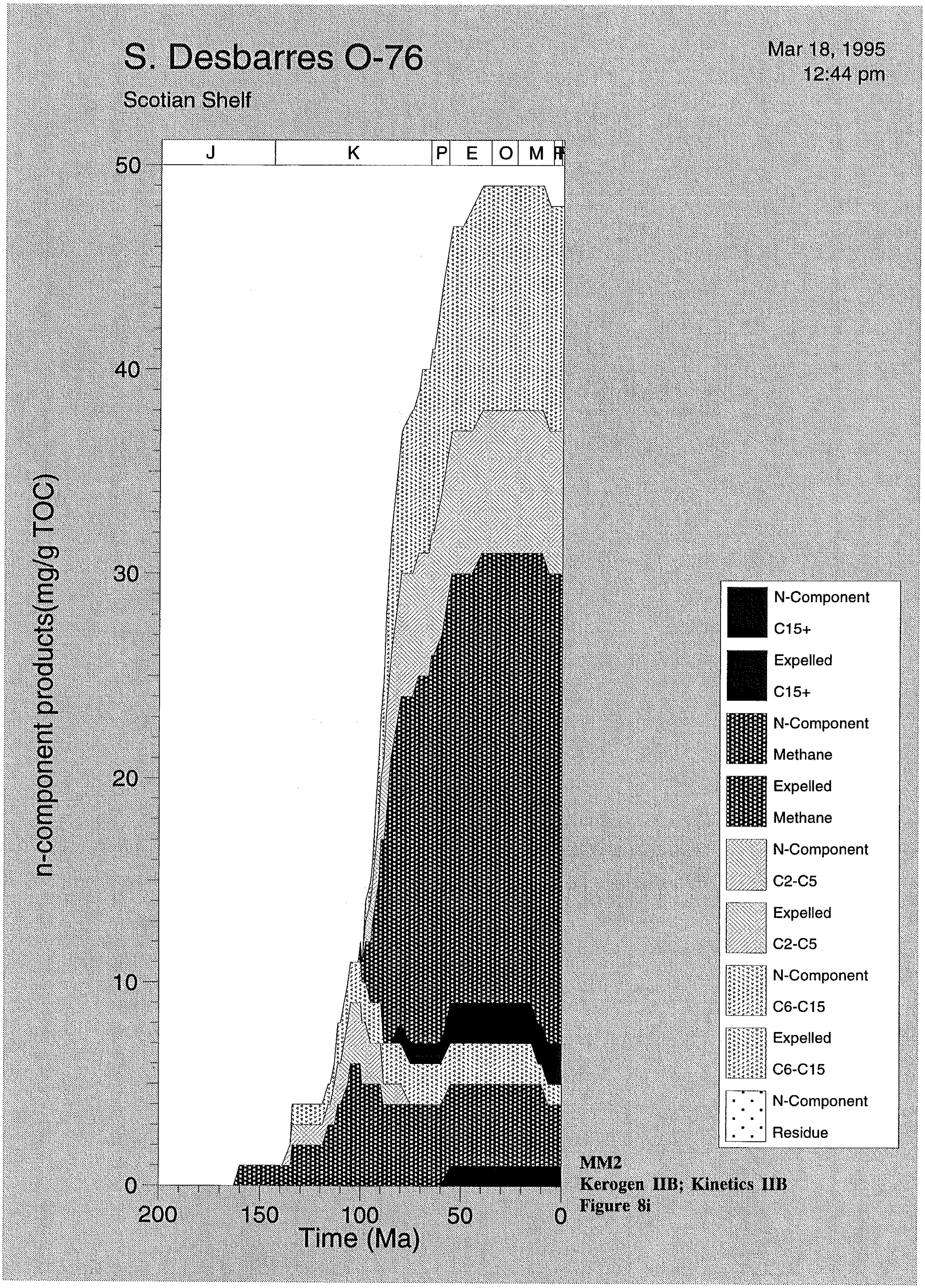
Scotian Shelf

Mar 18, 1995
1:27 pm



**MM1**
**Kerogen III; Kinetics IIB**
**Figure 8h**

21



**MM2**
**Kerogen IIB; Kinetics IIB**
**Figure 8i**

# S. Desbarres O-76

Scotian Shelf

Mar 18, 1995
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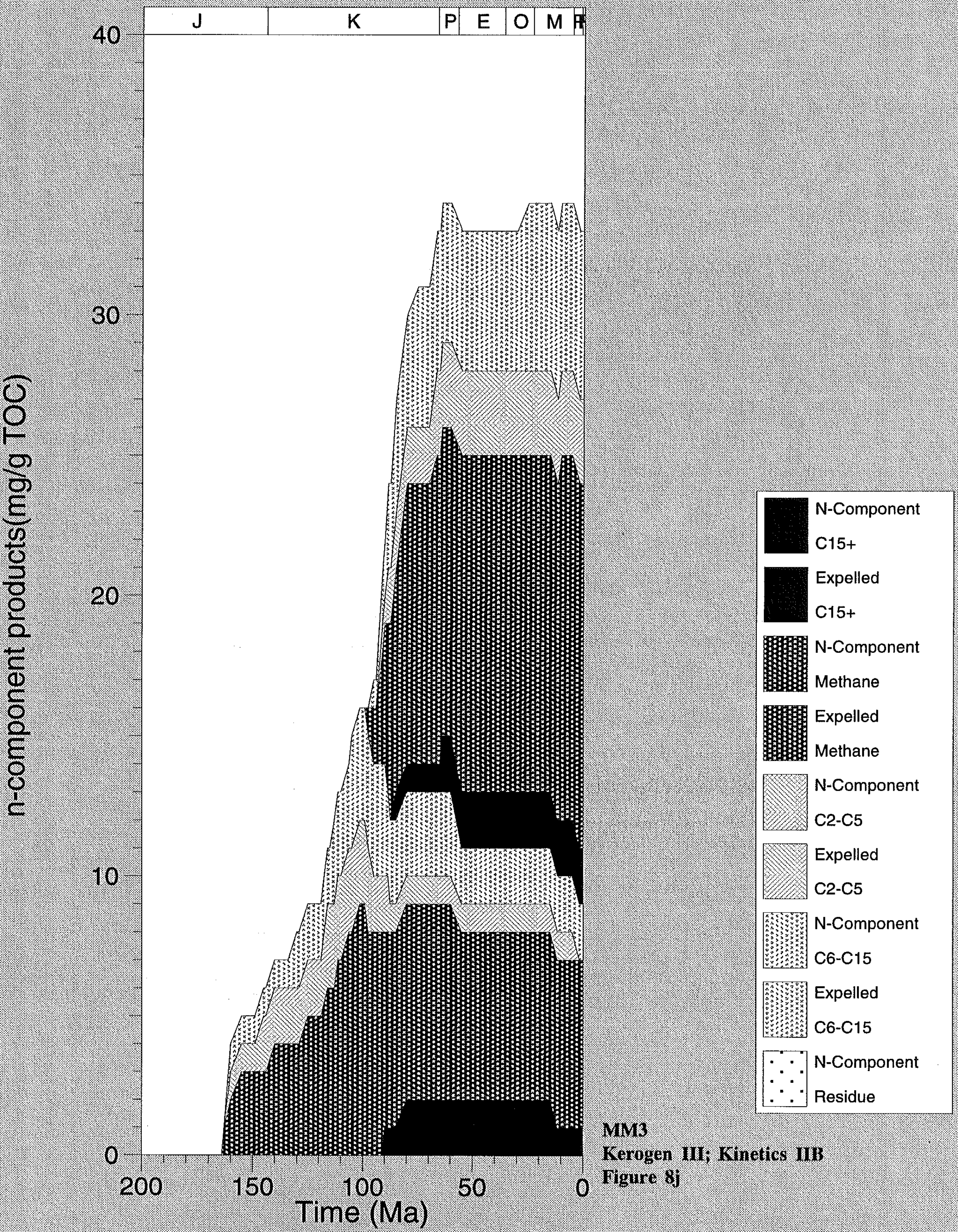
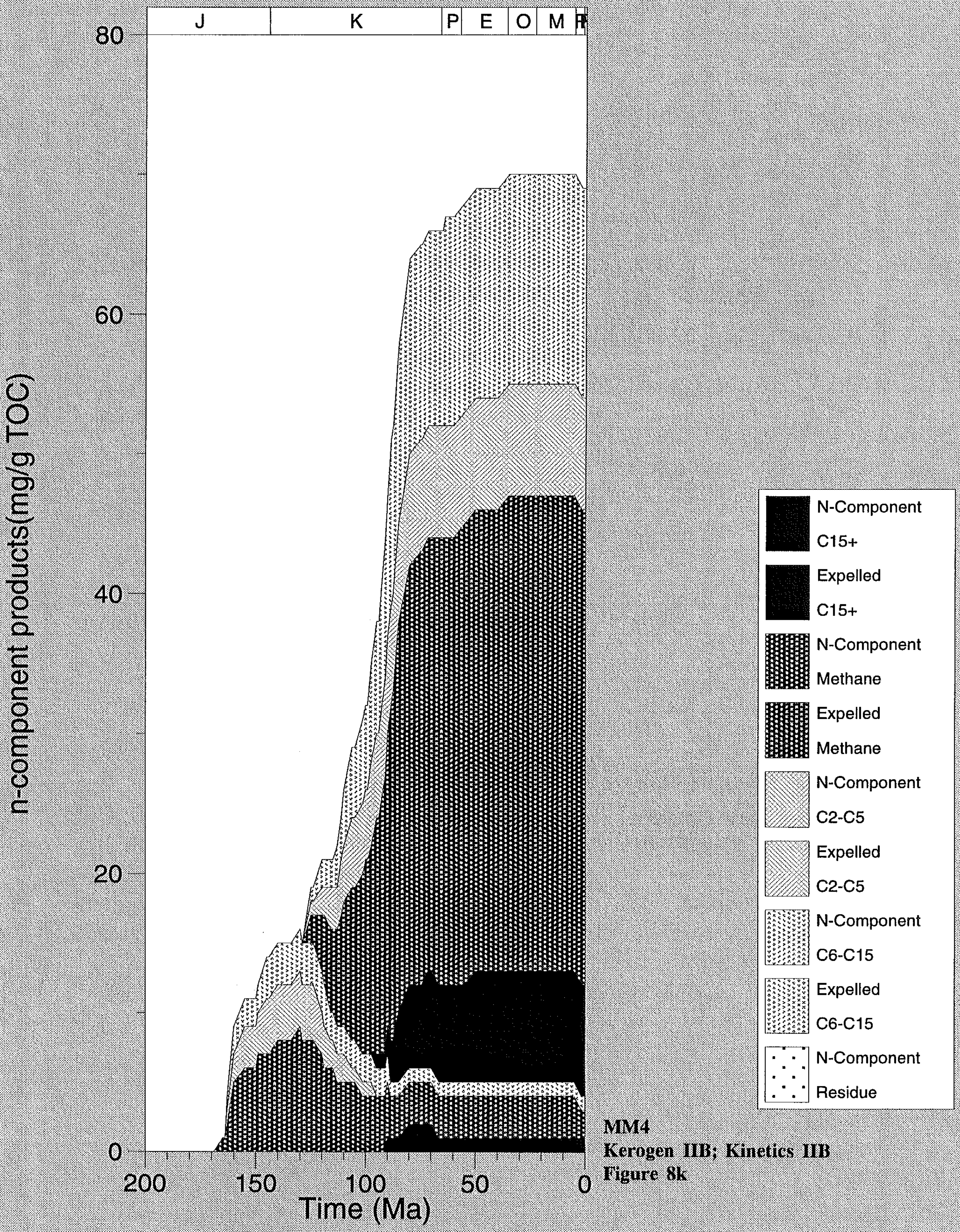


**MM3**
**Kerogen III; Kinetics IIB**
**Figure 8j**

# S. Desbarres O-76

Scotian Shelf

Mar 18, 1995
12:43 pm

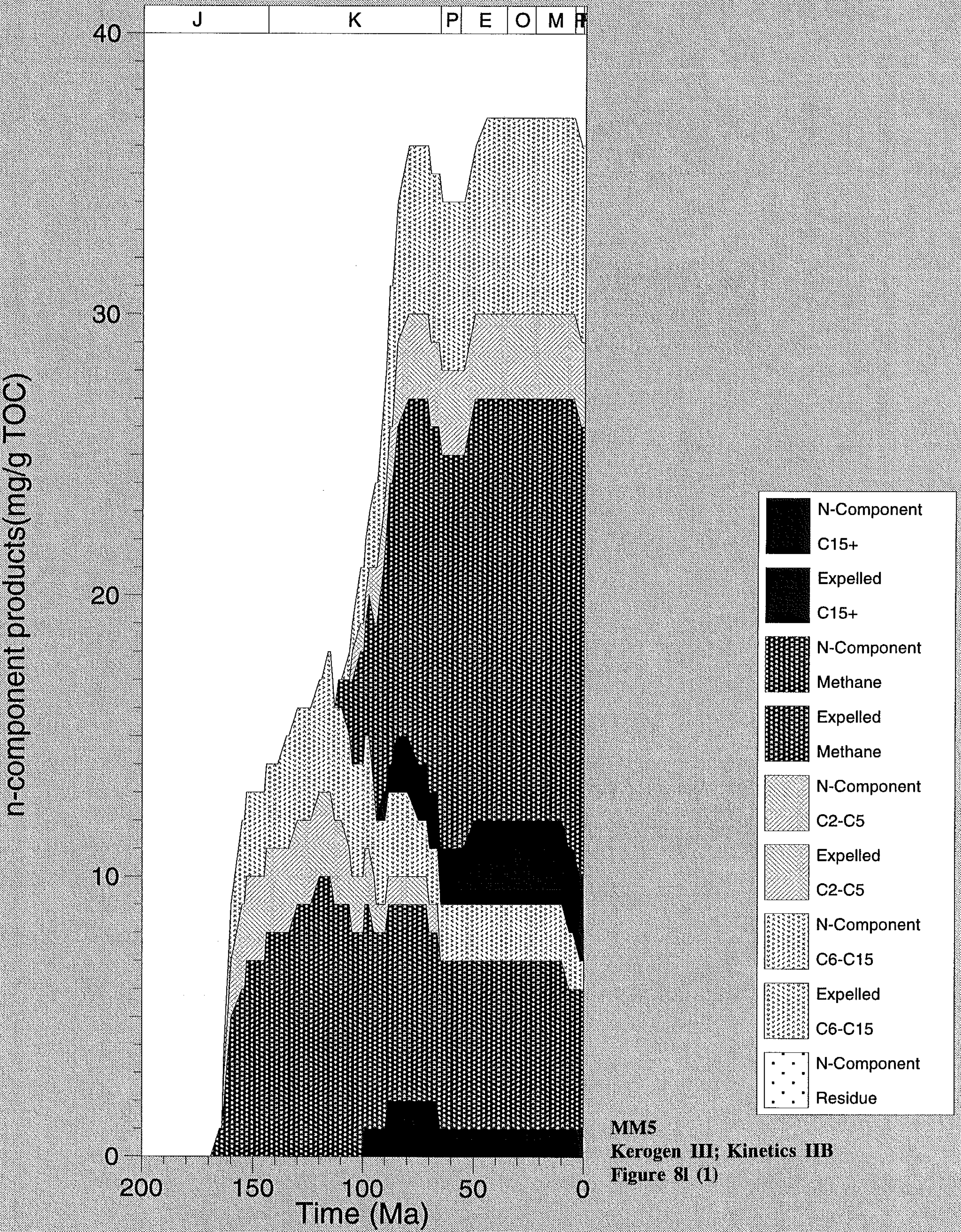


**MM4**
**Kerogen IIB; Kinetics IIB**
**Figure 8k**

# S. Desbarres O-76

Scotian Shelf

Mar 18, 1995
1:32 pm



**MM5**
**Kerogen III; Kinetics IIB**
**Figure 81 (1)**

# S. Desbarres O-76

Scotian Shelf

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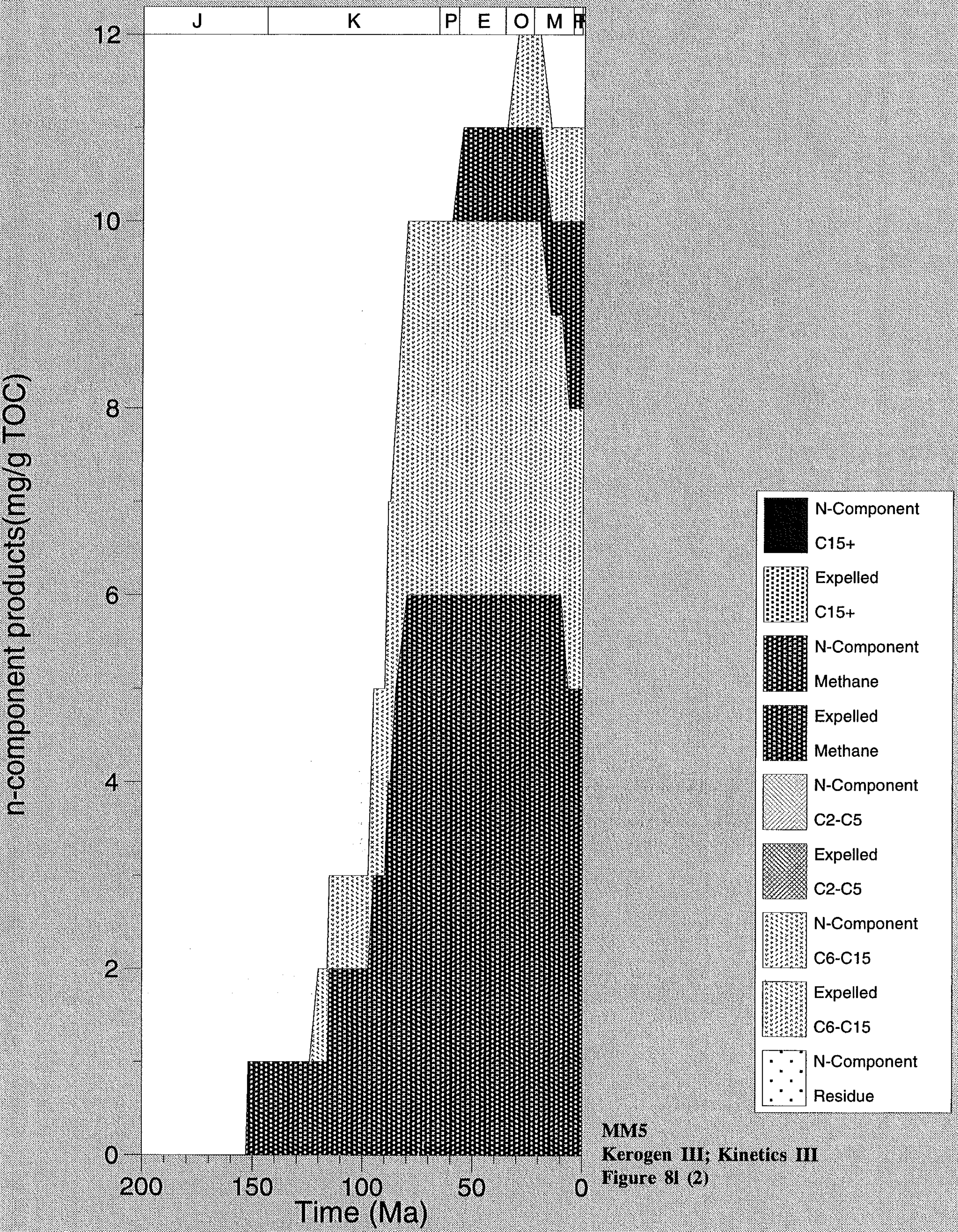

**MM5**
**Kerogen III; Kinetics III**
**Figure 8l (2)**

# S. Desbarres O-76

Scotian Shelf

Mar 18, 1995
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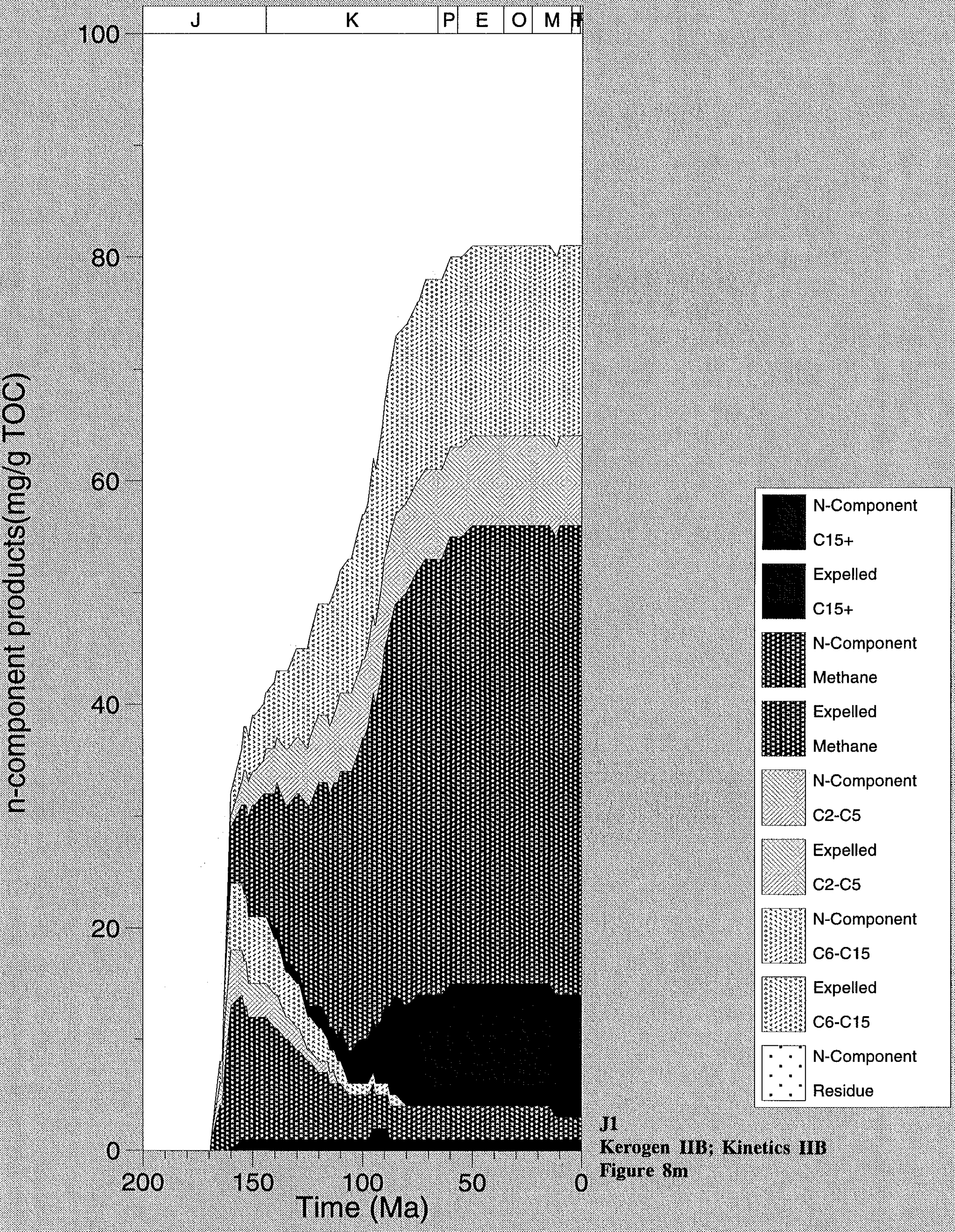
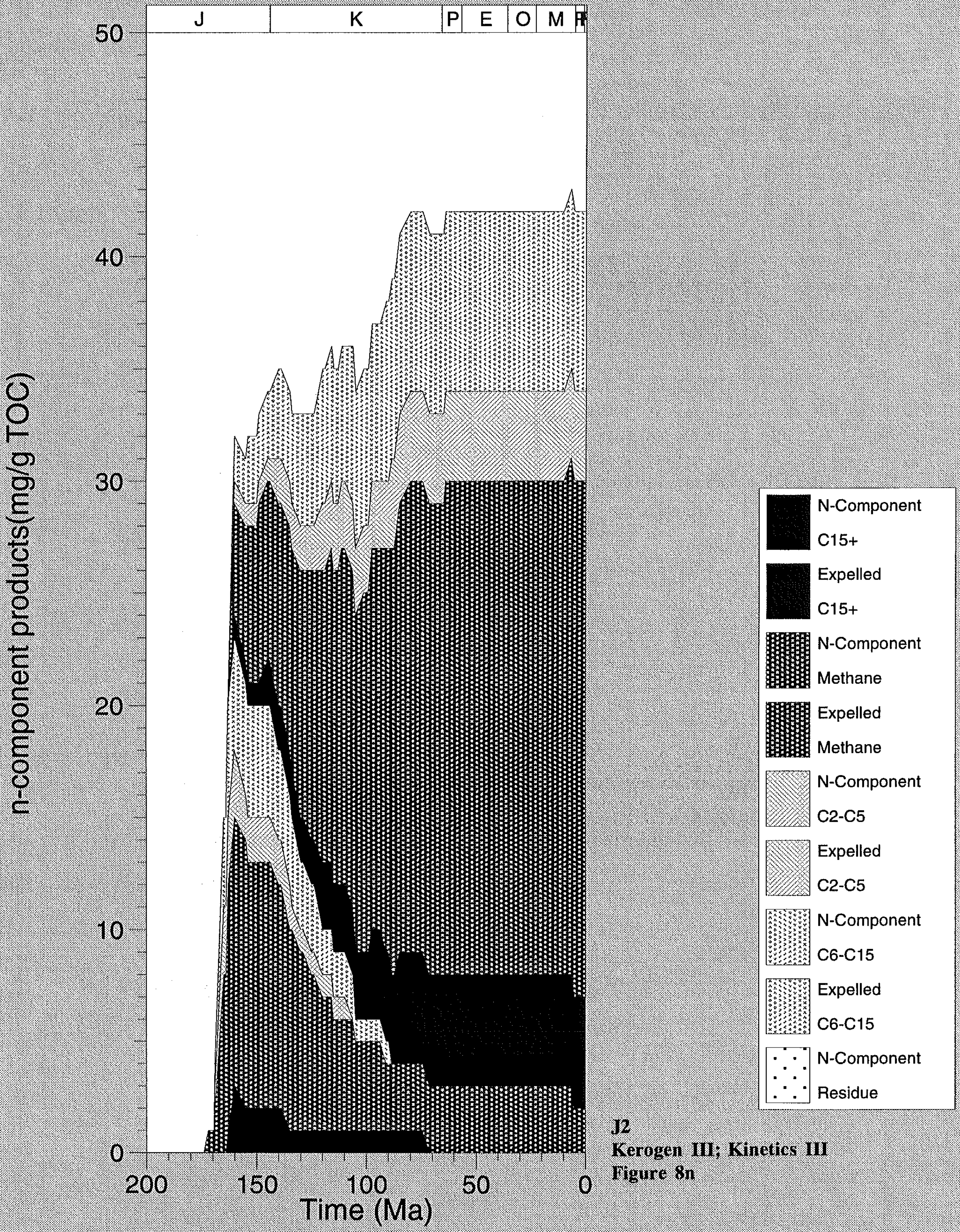


**J1**
**Kerogen IIB; Kinetics IIB**
**Figure 8m**

# S. Desbarres O-76

Scotian Shelf

Mar 18, 1995
1:33 pm



**J2**
**Kerogen III; Kinetics III**
**Figure 8n**

24

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Mar 18, 1995
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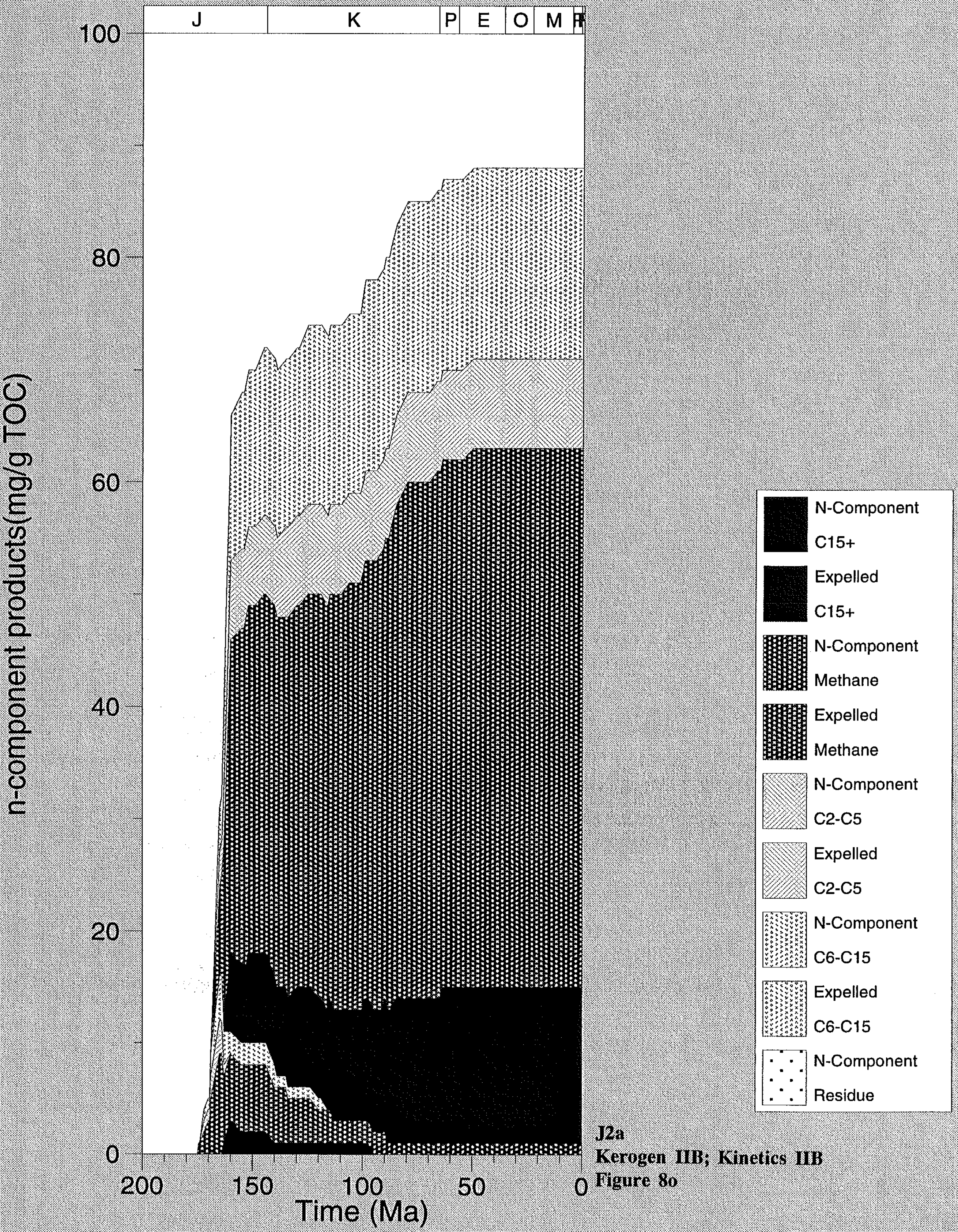

**J2a**
**Kerogen IIB; Kinetics IIB**
**Figure 8o**

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Mar 18, 1995
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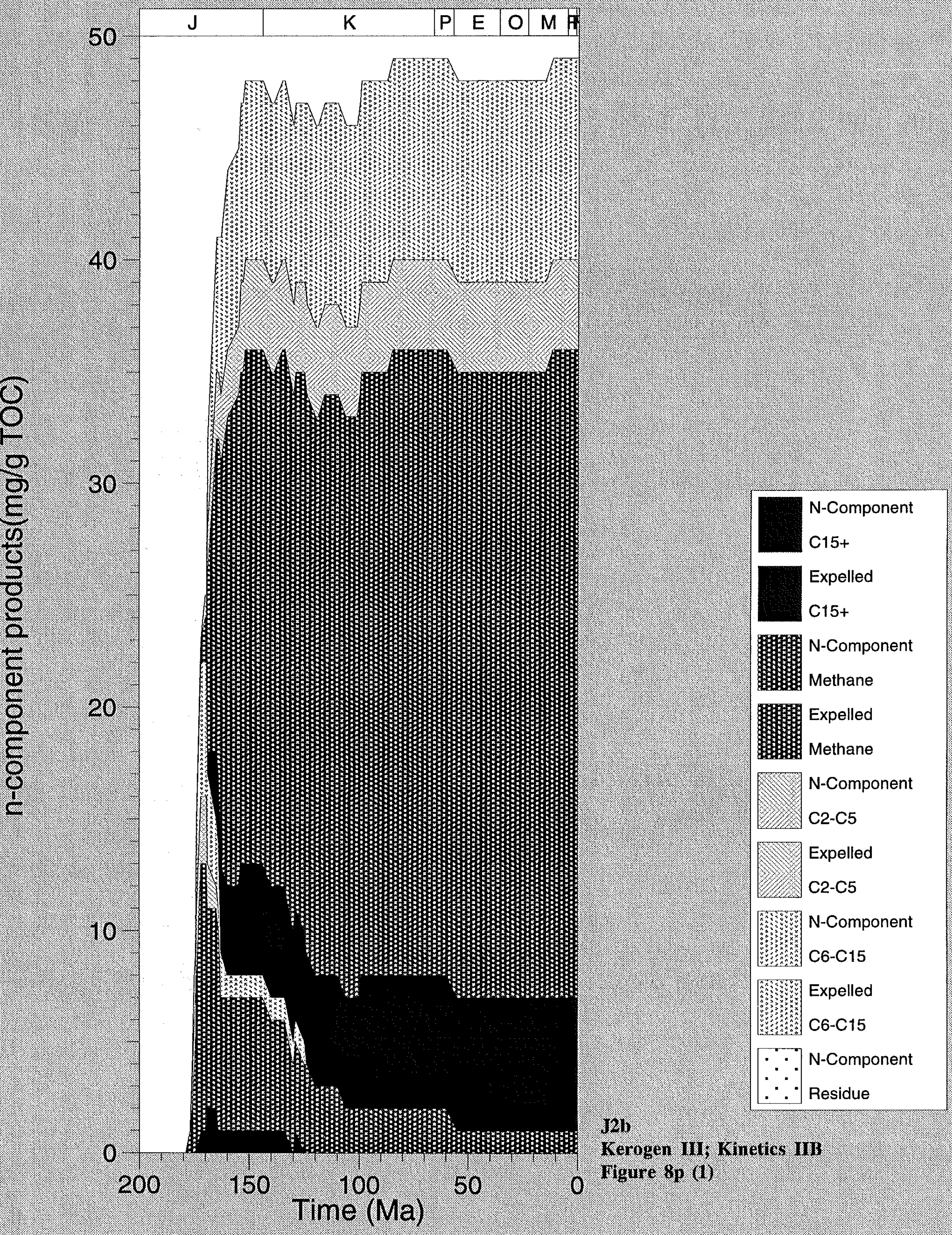

**J2b**
**Kerogen III; Kinetics IIB**
**Figure 8p (1)**

# S. Desbarres O-76

Scotian Shelf

Mar 18, 1995
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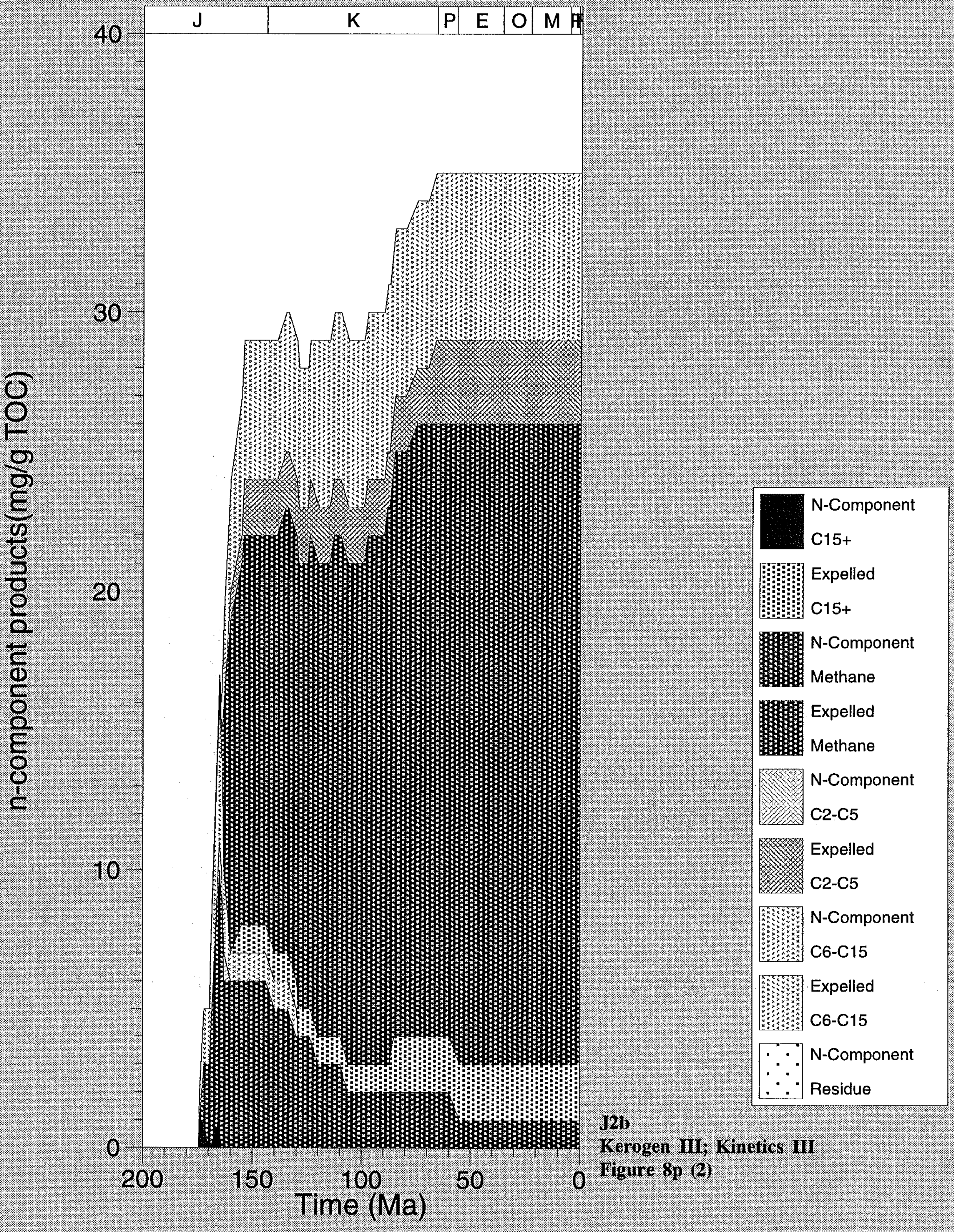

**J2b**
**Kerogen III; Kinetics III**
**Figure 8p (2)**

# S. Desbarres O-76

Scotian Shelf

Mar 18, 1995
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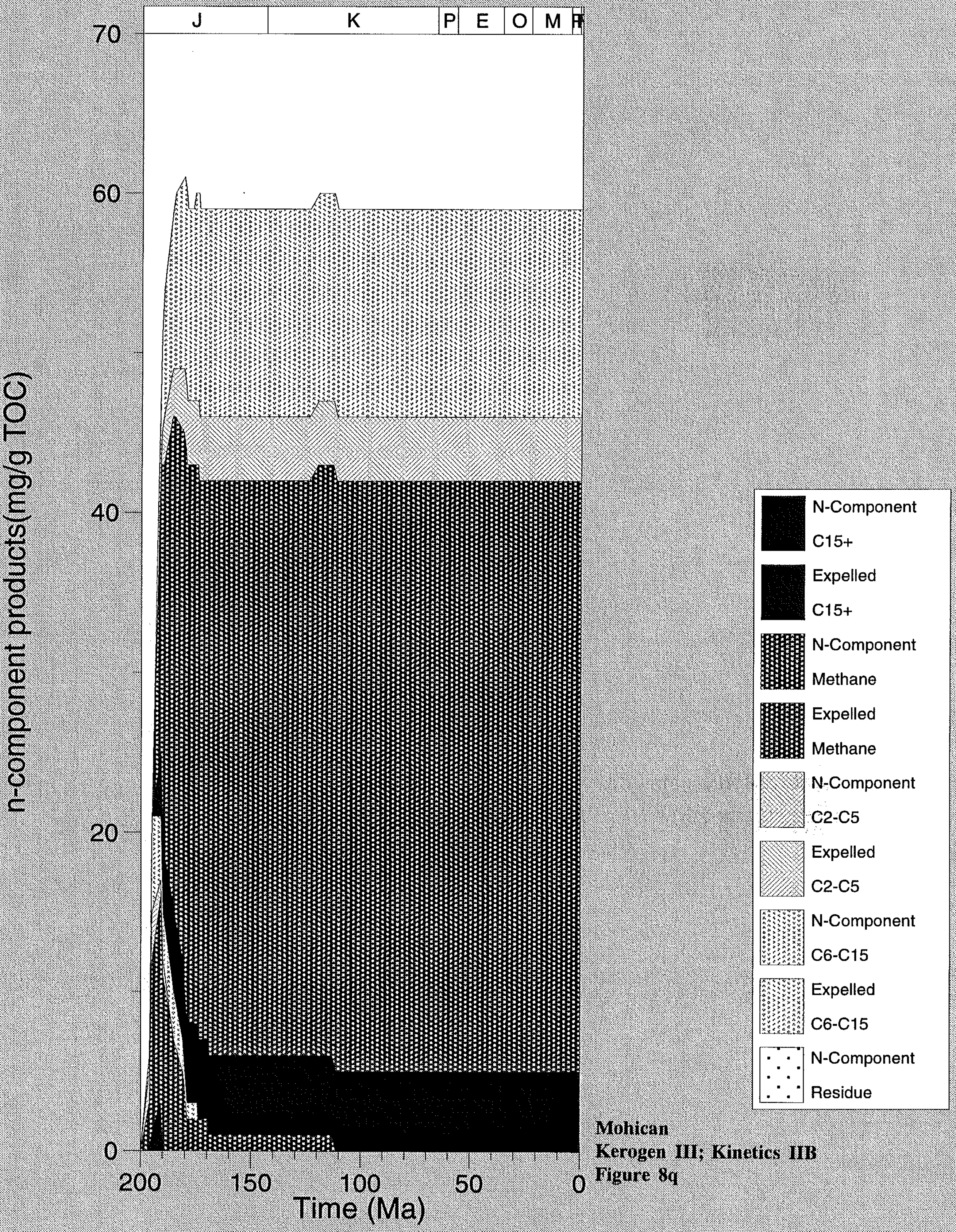

**Mohican**
**Kerogen III; Kinetics IIB**
**Figure 8q**