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28 April 1986

F 1/1/291
F 6325/86

The Director-General
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and Energy
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Attention: C.G. Gatehouse

REPORT F 6325/86

YOUR REFERENCE: EX-441, Project 12/07

TITLE: Source rock evaluation of Cambrian sediments, Officer Basin, South Australia

MATERIAL: Core cuttings

LOCALITY: Amoco-Duval KD-2A and Getty Yarle Lakes-1

IDENTIFICATION: As in Table 1 of report

DATE RECEIVED: 10 September 1985 and 20 January 1986

WORK REQUIRED: TOC. Rock-Eval. Solvent extraction. Liquid chromatography. GC of saturates. Isolation and GC-MS of naphthenes. Methylphenanthrene index. Brief interpretation.

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1. INTRODUCTION

Two samples (1 core, 1 cuttings) from drill holes in the eastern Officer Basin, South Australia, were received for source rock analysis (Table 1). In each case the carbonate unit sampled was believed to be of Early Cambrian age.

Screening for total organic carbon (TOC) revealed that only one sample contained sufficient organic matter to warrant further analysis. The aim of the investigation was to determine which of the following organic-rich facies, described by McKirdy *et al.* (1984) and Weste *et al.* (1984), the sample from Duval KD-2A belonged to:

Environment	Formation	Representative Section
non-marine	Observatory Hill Beds	Byilkaoora-1
marine	'Wintinna Fm'*	Wilkinson-1

*now assigned to Ouldburra Formation.

2. RESULTS

Analytical data are summarised and presented herein as follows:

	Table	Figure
TOC, Rock Eval	2	-
C_{15+} extract yield and composition	3	1
GC-MS of naphthenes	4	2-7
GC-MS of aromatics (methylphenanthrene index)	5	8

3. INTERPRETATIVE COMMENTS ON SAMPLE FROM DUVAL KD-2A DRILL HOLE

1. Although its organic carbon content (TOC = 0.69%) is well above average for ancient carbonates, this sample has *poor source richness* for hydrocarbons (S_1+S_2 < 2 kg h'cs/tonne).

2. Likewise it appears to contain *poor quality gas-prone Type III kerogen* (HI = 78). Similar kerogen has been identified in marine carbonates from Marla-1A (McKirdy *et al.*, 1984).

3. Its high Rock Eval production index (S_1/S_1+S_2 = 0.61) reflects *staining by migrated hydrocarbons*. This interpretation is consistent with both the yield of C_{15+} hydrocarbons (saturated + aromatic = 54 mg/g TOC) and the naphthenic character of the saturated hydrocarbons (alkanes) (Fig. 1).

4. The prominent high-molecular-weight naphthene hump in the alkane chromatogram (Fig. 1) is surmounted by recognisable C_{27}-C_{34} hopanes and probably represents *biodegraded crude oil*. Similar alkane chromatograms have been obtained previously from marine carbonates in Wilkinson-1 and Wallira West-1 (McKirdy and Kantsler, 1980; McKirdy *et al.*, 1984).

5. The sterane distribution of the KD-2A extract (Table 4, parameters 1, 2; Fig. 5) resembles that of the Wilkinson-1, 462.17 metres, source rock extract (McKirdy, unpubl. results), but differs substantially from those of Byilkaoora-1 oil shows and rock extracts (McKirdy *et al.*, 1983, 1984).

6. The methylphenanthrene index of the aromatic hydrocarbons in the KD-2A extract converts to a source maturity (expressed as equivalent vitrinite reflectance) of VR = 0.6%.

4. CONCLUSIONS

1. Carbonate from 298.10-298.17 metres depth in Duval KD-2A is a poor quality gas-prone source rock stained by biodegraded crude oil.

2. Assuming that the hydrocarbons extracted from this rock represent mainly non-indigenous (i.e. migrated) crude oil, the oil originated in a marine carbonate source rock at a maturity equivalent to 0.6% VR.

5. REFERENCES

McKIRDY, D.M. and KANTSLER, A.J., 1980. Oil geochemistry and potential source rocks of the Officer Basin, South Australia. *APEA J.*, 20(1), 68-86.

McKIRDY, D.M., ALDRIDGE, A.K. and YPMA, P.J.M., 1983. A geochemical comparison of some crude oils from pre-Ordovician carbonate rocks. In : BJOROY, M. *et al.* (eds.), *Advances in Organic Geochemistry 1981*, Wiley, Chichester, pp. 99-107.

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RADKE, M., and WESTE, D.H., 1983. The methylphenanthrene index (MPI) : a maturity parameter based on aromatic hydrocarbons. In : BJOROY, M. *et al.* (eds.), *Advances in Organic Geochemistry 1981*, Wiley, Chichester, pp. 504-512.

WESTE, G., SUMMONS, R.E., McKIRDY, D.M., SOUTHGATE, P.N., HENRY, R.L. and BREWER, A.M., 1984. Cambrian palaeoenvironments and source rocks of the eastern Officer Basin. *Geol. Soc. Aust. Abstracts*, 12, 542-544.

TABLE 1: SAMPLES SUBMITTED FOR SOURCE ROCK ANALYSIS

Sample No.	Drill Hole	Depth m	Type	Formation
5337 RS 75	Duval KD-2A	298.10-298.17	Core	?Observatory Hill Beds
5136 RS 08	Getty Yarle Lakes-1	391-393	Cuttings	?Observatory Hill Beds

KEY TO ROCK-EVAL PYROLYSIS DATA SHEET

	PARAMETER	SPECIFICITY
T max	position of S_2 peak in temperature program (^{o}C)	Maturity/Kerogen type
S_1	kg hydrocarbons (extractable)/tonne rock	Kerogen type/Maturity/Migrated oil
S_2	kg hydrocarbons (kerogen pyrolysate)/tonne rock	Kerogen type/Maturity
S_3	kg CO_2 (organic)/tonne rock	Kerogen type/Maturity *
$S_1 + S_2$	Potential Yield	Organic richness/Kerogen type
PI	Production Index ($S_1/S_1 + S_2$)	Maturity/Migrated Oil
PC	Pyrolysable Carbon (wt. percent)	Organic richness/Kerogen type/Maturity
TOC	Total Organic Carbon (wt. percent)	Organic richness
HI	Hydrogen Index (mg h'c (S_2)/g TOC)	Kerogen type/Maturity
OI	Oxygen Index (mg CO_2(S_3)/g TOC)	Kerogen type/Maturity *

*Also subject to interference by CO_2 from decomposition of carbonate minerals.

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TABLE 2: TOC AND ROCK EVAL DATA*

Depth m	Tmax	S_1	S_2	S_3	S_1+S_2	PI	S_2/S_3	PC	TOC	HI	OI
Duval KD-2A ≥ Kavari #2											
298.10-298.17	414	0.83	0.54	0.15	1.37	0.61	3.60	0.11	0.69	78	21
Getty Yarle Lakes-1											
391-393	-	-	-	-	-	-	-	-	0.04	-	-

*See next page for key
- not determined

TABLE 3: ROCK EXTRACT DATA, DUVAL KD-2A, OFFICER BASIN

Depth m	TOC %	Wt Sample Extracted g	Wt EOM mg	EOM Yield		EOM Composition				Alkane Ratios				
				ppm	mg/g TOC	N+Iso %	Naph %	Arom %	Res+Asph %	TMTD/Pr	Np/Pr	Pr/Ph	Pr/n-C_{17}	Ph/n-C_{18}
298.10-298.17	0.69	32.63	67.9	2081	302	2.7	11.2	4.0	82.1	0.30	0.60	0.98	0.58	0.71

N+Iso = normal + iso-alkanes

Naph = naphthenes

Arom = aromatic hydrocarbons

Res = resins

Asph = asphaltenes

TMTD = 2,6,10-trimethyltridecane

Np = norpristane

Pr = pristane

Ph = phytane

n-C_{17} = n-heptadecane

n-C_{18} = n-octadecane

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KEY TO BIOMARKER PARAMETERS OF SOURCE, MATURITY, MIGRATION AND BIODEGRADATION

Parameter	* Derivation	Specificity
1	C_{27} : C_{28} : C_{29} 5α(H)14α(H)17α(H) 20R steranes	Source
2	C_{29} 5α(H)14α(H)17α(H) 20R sterane / C_{27} 5α(H)14α(H)17α(H) 20R sterane	Source
3	C_{29} 13β(H)17α(H) 20R diasterane / C_{27} 13β(H)17α(H) 20R diasterane	Source
4	C_{29} 5α(H)14α(H)17α(H) 20S sterane / C_{29} 5α(H)14α(H)17α(H) 20R sterane	Maturity, Biodegradation
5	C_{27} 13β(H)17α(H) 20S diasterane / C_{27} 13β(H)17α(H) 20R diasterane	Maturity
6	C_{29} 5α(H)14β(H)17β(H) 20R sterane / C_{29} 5α(H)14α(H)17α(H) 20R sterane	Maturity, Migration
7	C_{29} 13β(H)17α(H) 20R+20S diasteranes / C_{29} 5α(H) steranes	Migration, Source
8	C_{30} pentacyclic terpane/C_{30} 17α(H)21β(H) hopane	Source
9	C_{27} 17α(H)-22,29,30-trisnorhopane / C_{27} 18α(H)-22,29,30-trisnorhopane (T_m/T_s)	Maturity, Source
10	T_s / C_{30} 17α(H)21β(H) hopane	Maturity
11	C_{32} 17α(H)21β(H) 22S homohopane / C_{32} 17α(H)21β(H) 22R homohopane	Maturity
12	C_{30} 17β(H)21α(H) moretane / C_{30} 17α(H)21β(H) hopane	Maturity
13	C_{29} 17α(H)-25-norhopane / C_{29} 17α(H)-30-norhopane	Biodegradation
14	pristane / phytane	Source
15	2,6,10-trimethyltridecane / pristane	Maturity
16	pristane / n-heptadecane	Source, Biodegradation, Maturity
17	phytane / n-octadecane	Source, Biodegradation, Maturity

* Ratios calculated from peak areas as follows:

Parameters 1-6 m/z = 217 mass fragmentogram
Parameter 7 m/z = 217, 259 mass fragmentograms
Parameters 8-13 m/z = 191 mass fragmentogram
Parameters 14-17 capillary gas chromatogram of alkanes or whole oil/extract

TABLE 4: BIOMARKER PARAMETERS OF SOURCE, MATURITY, MIGRATION AND BIODEGRADATION FOR ROCK EXTRACT, DUVAL KD-2A, OFFICER BASIN

Well	AMDEL Sample No.	Formation	Depth m	Steranes							Terpanes						Acyclic Alkanes			
Parameter*				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Duval KD-2A	MS-210	?Observatory Hill Beds	298.10-298.17	33:40:27	0.79	2.0	1.0	1.5	0.86	0.96	0.06	3.6	0.10	1.4	0.20	-	0.98	0.30	0.51	0.71

* See key (next page) for derivation and specificity of parameters.

Supplementary source parameter : C_{30} hopane/C_{29} steranes = 10

TABLE 5: ROCK EXTRACT MATURITY BASED ON METHYLPHENANTHRENE INDEX (MPI)*

AMDEL No.	Drill Hole	Depth m	MPI	VR_{calc} %
MS-211	Duval KD-2A	298.10-298.17	0.34	0.60

*Methylphenanthrene index (MPI) and VR_{calc} derived from the following equations (after Radke and Welte, 1983):

$$MPI = \frac{1.5\ (2\text{-}MP + 3\text{-}MP)}{P + 1\text{-}MP + 9\text{-}MP}$$

$$VR_{calc} = 0.6\ MPI + 0.4 \quad (\text{for } VR < 1.35\%)$$

where P = phenanthrene
1-MP = 1-methylphenanthrene
2-MP = 2-methylphenanthrene
3-MP = 3-methylphenanthrene
4-MP = 4-methylphenanthrene

Peak areas measured from m/z 178 (phenanthrene) and m/z 191+192 (methylphenanthrenes) mass fragmentograms of total aromatic hydrocarbon fraction (Fig. 8).

KEY TO MASS FRAGMENTOGRAMS

m/z 191

1-6	C_{20}-C_{25}	tricyclic terpanes
7	C_{24}	tetracyclic terpane
8	C_{26}	tricyclic terpane
9	C_{27}	18α(H)-22,29,30-trisnorhopane (Ts)
10	C_{27}	17α(H)-22,29,30-trisnorhopane (Tm)
11	C_{28}	17α(H)-28,30-bisnorhopane
12	C_{29}	17α(H)-25-norhopane
13	C_{29}	17α(H)21β(H) norhopane
14	C_{30}	pentacyclic terpane
15	C_{29}	17β(H)21α(H) moretane
16	C_{30}	17α(H)21β(H) hopane
17	C_{30}	17β(H)21α(H) moretane
18-22	C_{31}-C_{35}	17α(H)21β(H) 22S (left) and 22R (right) homohopanes

m/z 205

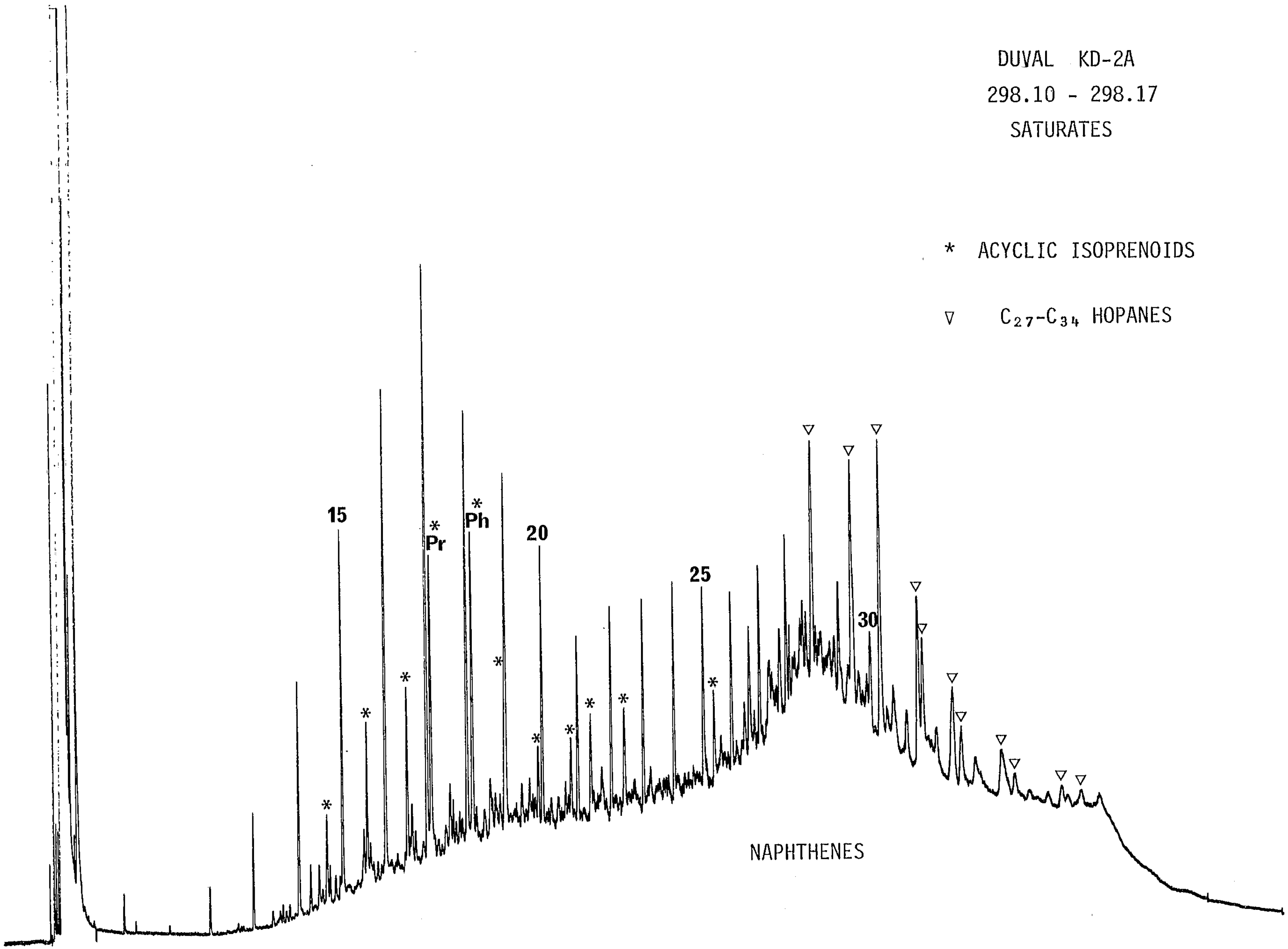
1	C_{28}	3-methyltrisnorhopanes
2	C_{29}	norhopane
3	C_{30}	3-methylnorhopane
4	C_{30}	hopane
5	C_{31}	3-methylhopane
6	C_{31}	22S homohopane
7	C_{32}	22S 3-methylhomohopane + C_{31} 22R homohopane
8	C_{32}	22R 3-methylhomohopane
9-12	C_{33}-C_{36}	3-methylhomohopanes

m/z 217, 259

1	C_{21}	sterane
2	C_{22}	sterane
3 & 4	C_{27}	20S and 20R diasteranes
5 & 8	C_{27}	5α(H)14α(H)17α(H) 20S and 20R steranes
6	C_{27}	5α(H)14β(H)17β(H) 20R sterane
7	C_{27}	5α(H)14β(H)17β(H) 20S sterane + C_{29} 20S diasterane
9	C_{29}	20R diasterane
10 & 13	C_{28}	5α(H)14α(H)17α(H) 20S and 20R steranes
11 & 12	C_{28}	5α(H)14β(H)17β(H) 20R and 20S steranes
14 & 17	C_{29}	5α(H)14α(H)17α(H) 20S and 20R steranes
15 & 16	C_{29}	5α(H)14β(H)17β(H) 20R and 20S steranes

FIGURE 1

DUVAL KD-2A
298.10 - 298.17
SATURATES



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FIGURES 2-7

MASS FRAGMENTOGRAMS OF NAPHTHENES IN ROCK EXTRACT,
DUVAL KD-2A, 298.10-298.17 m

m/z 123	sesquiterpanes (drimanes)
m/z 183	acyclic alkanes (isoprenoids)
m/z 191	triterpanes (incl. hopanes, moretanes)
m/z 177	demethylated triterpanes
m/z 205	methyl triterpanes
m/z 217	steranes
m/z 218	steranes
m/z 231	4-methyl steranes
m/z 259	diasteranes

FIGURE 2

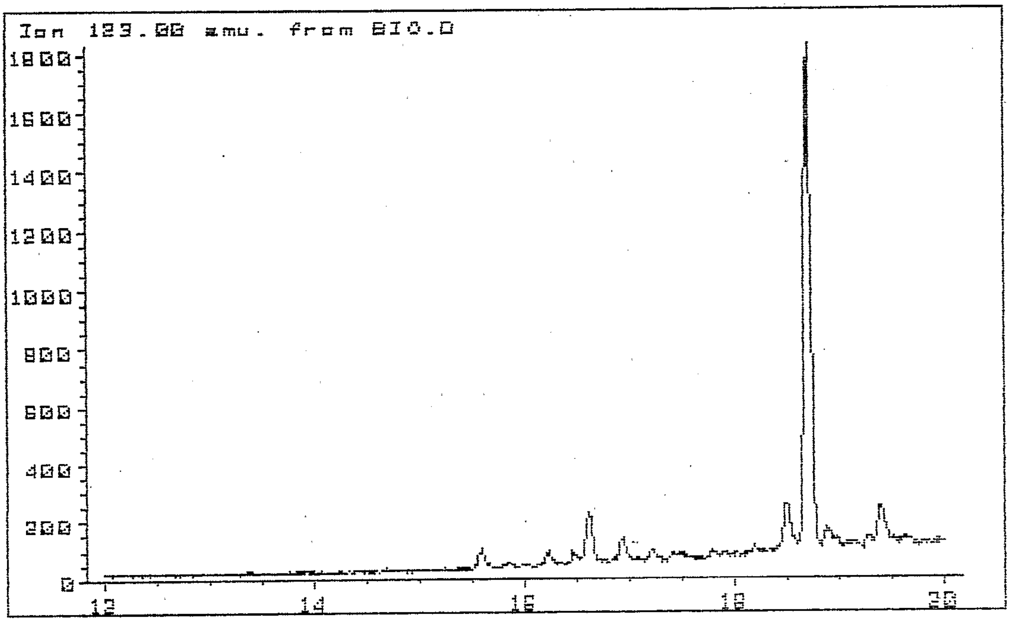
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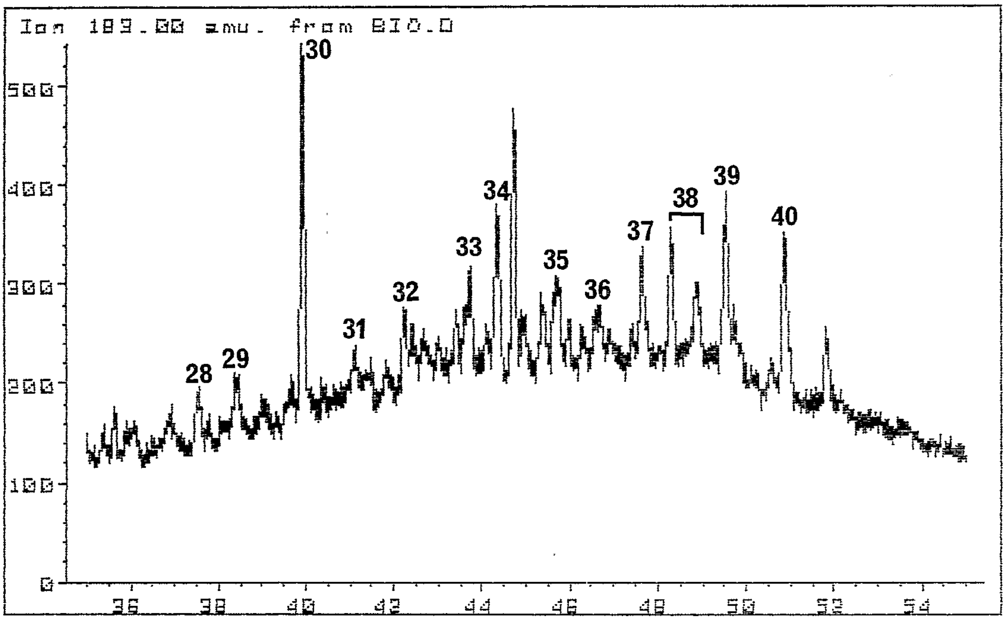
FIGURE 3



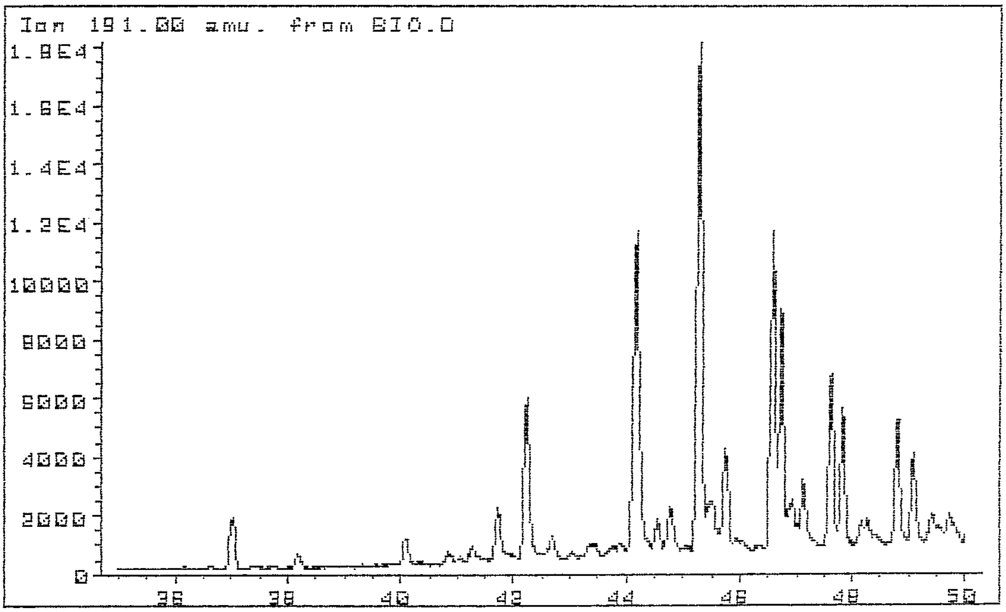


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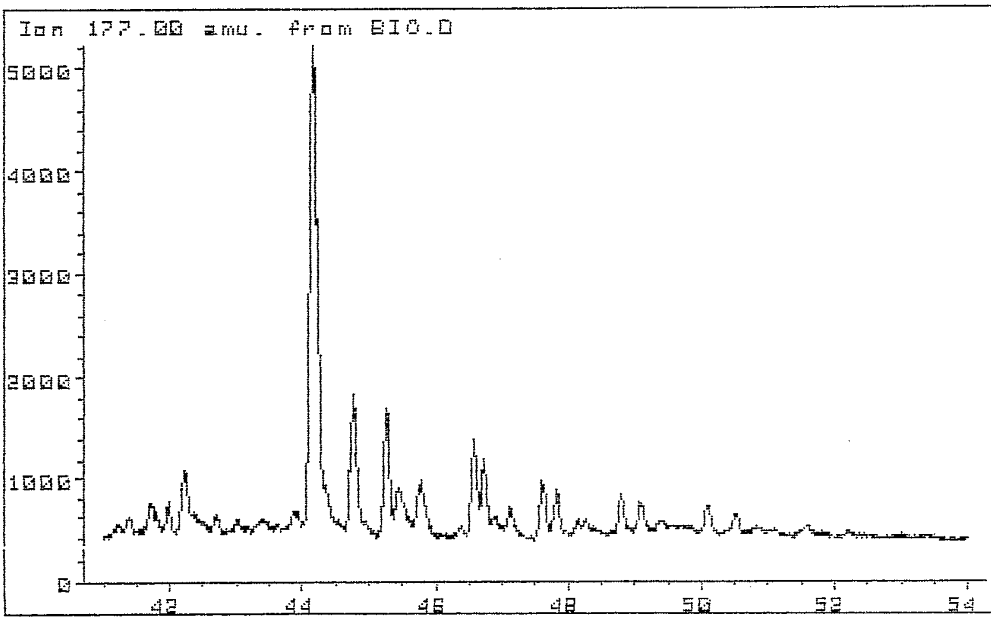
FIGURE 4



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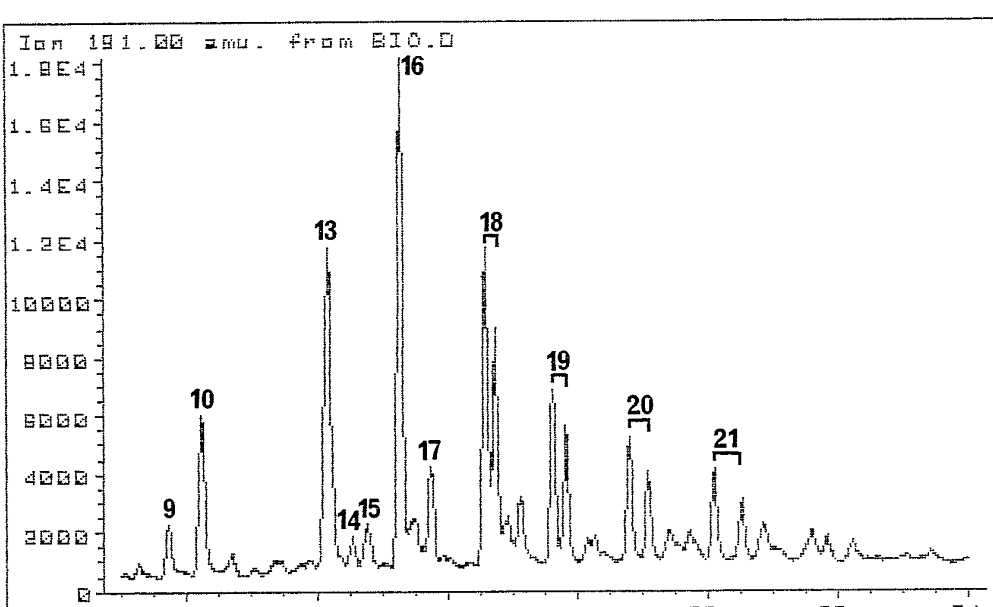

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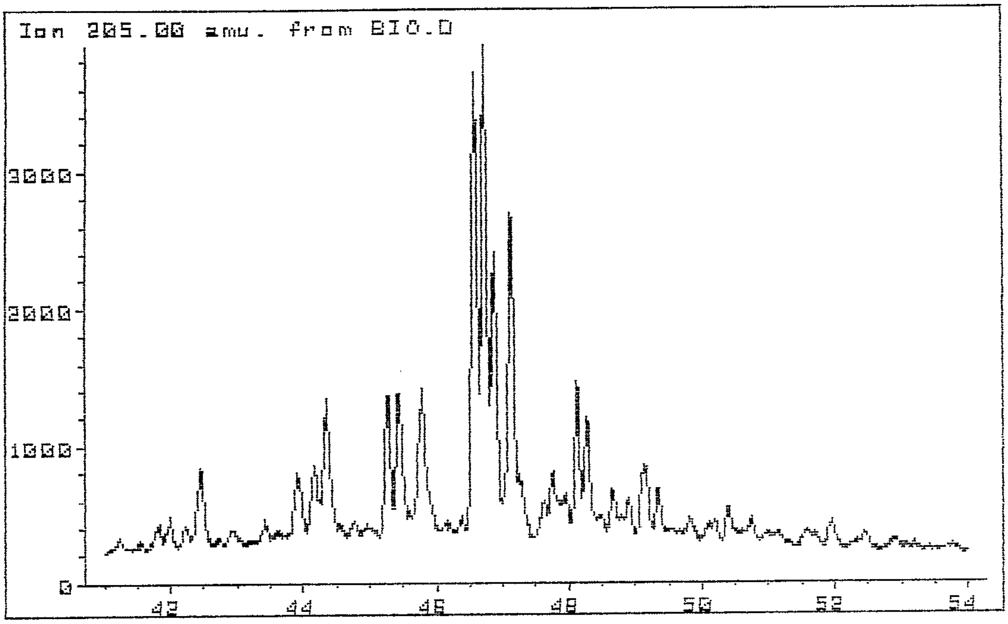
FIGURE 5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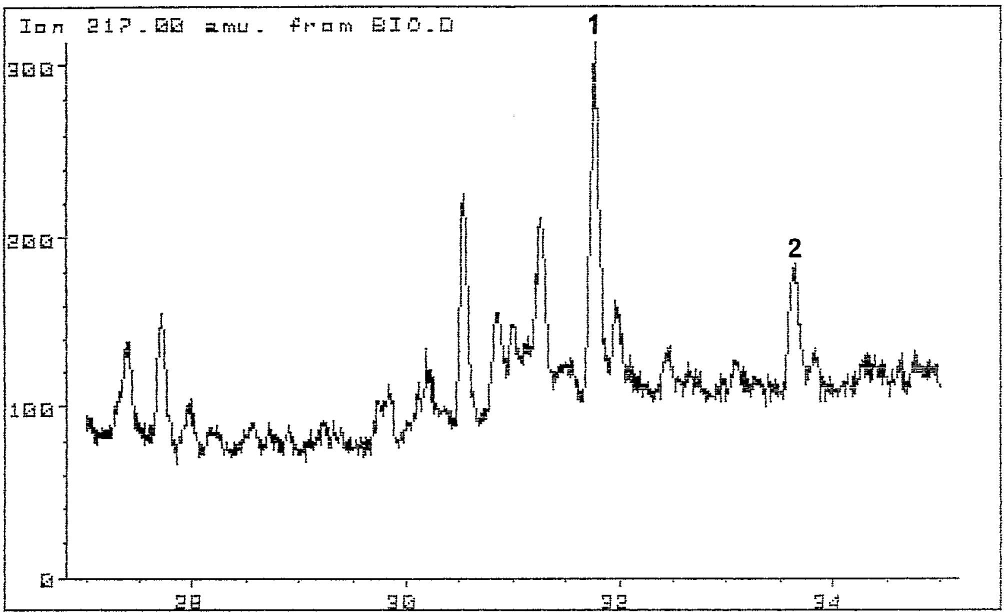
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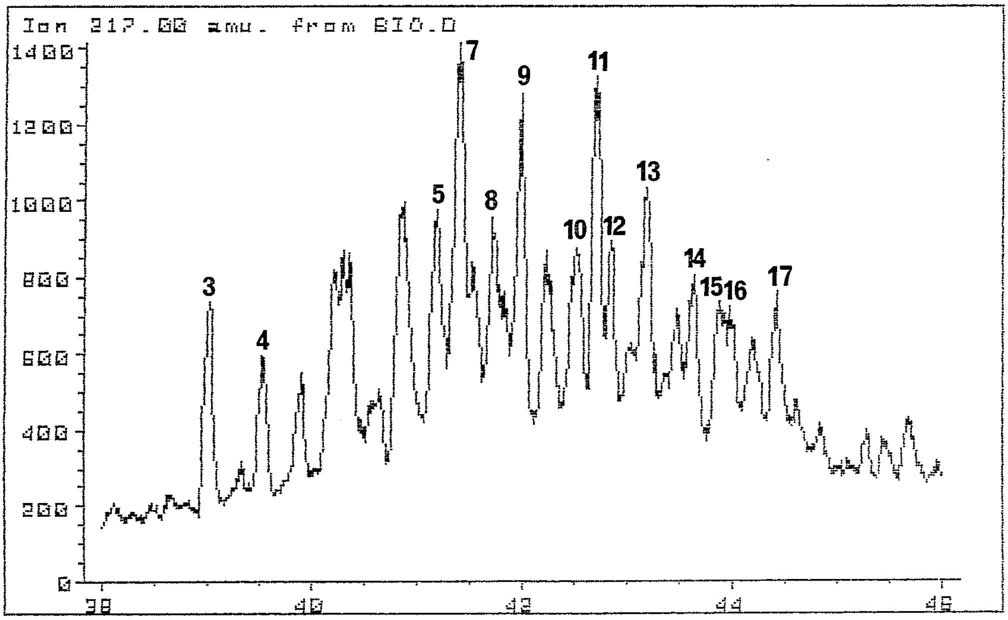
FIGURE 6



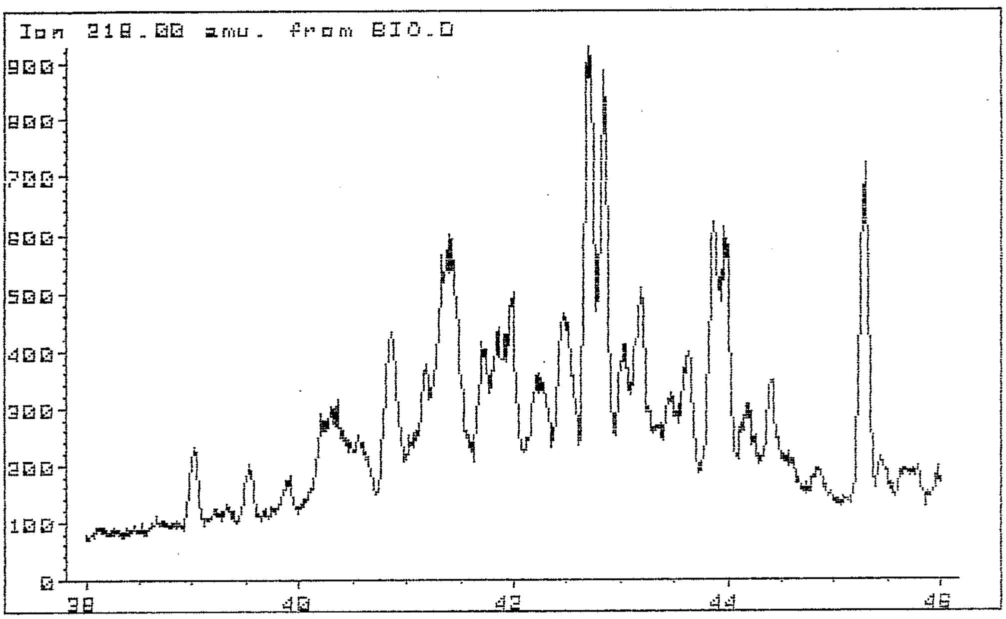


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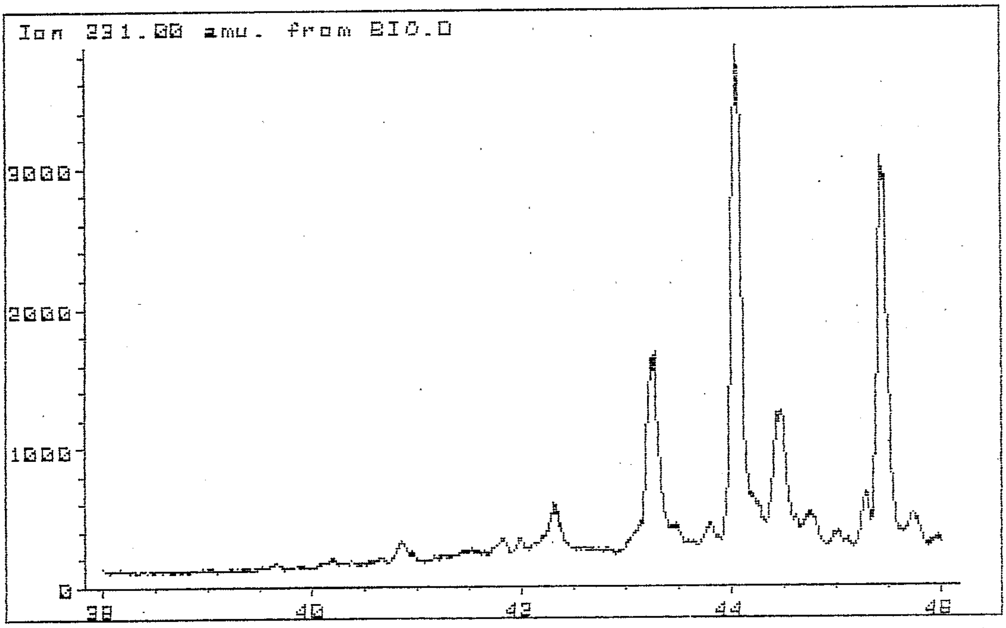
FIGURE 7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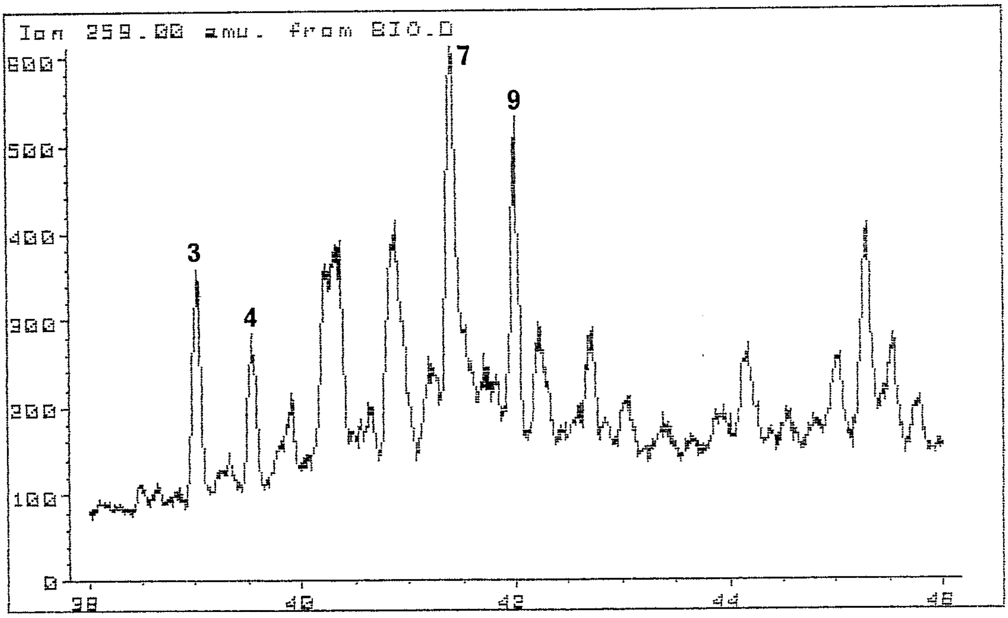
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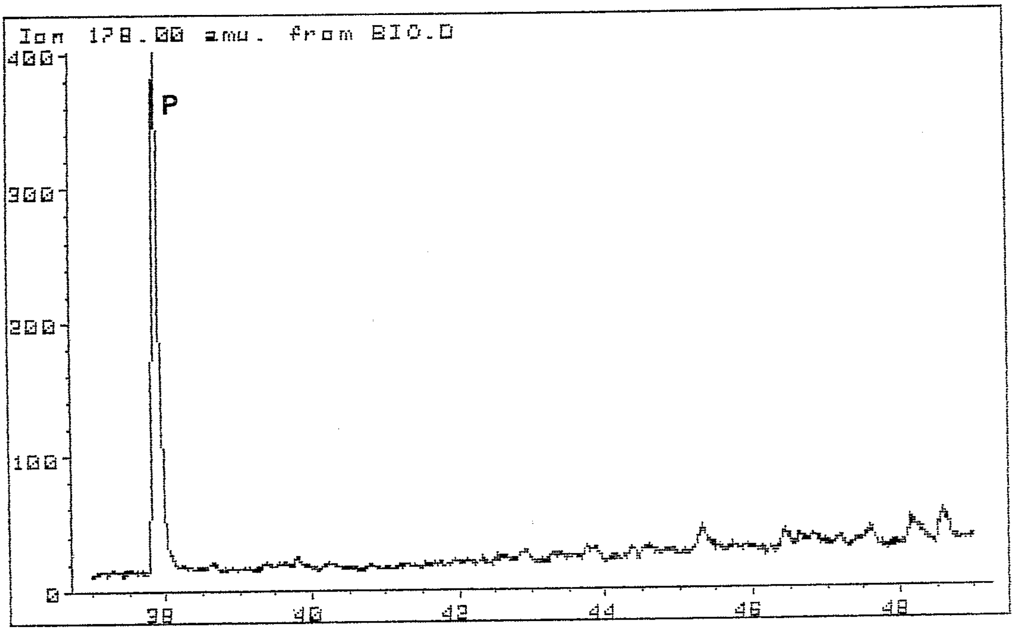
FIGURE 8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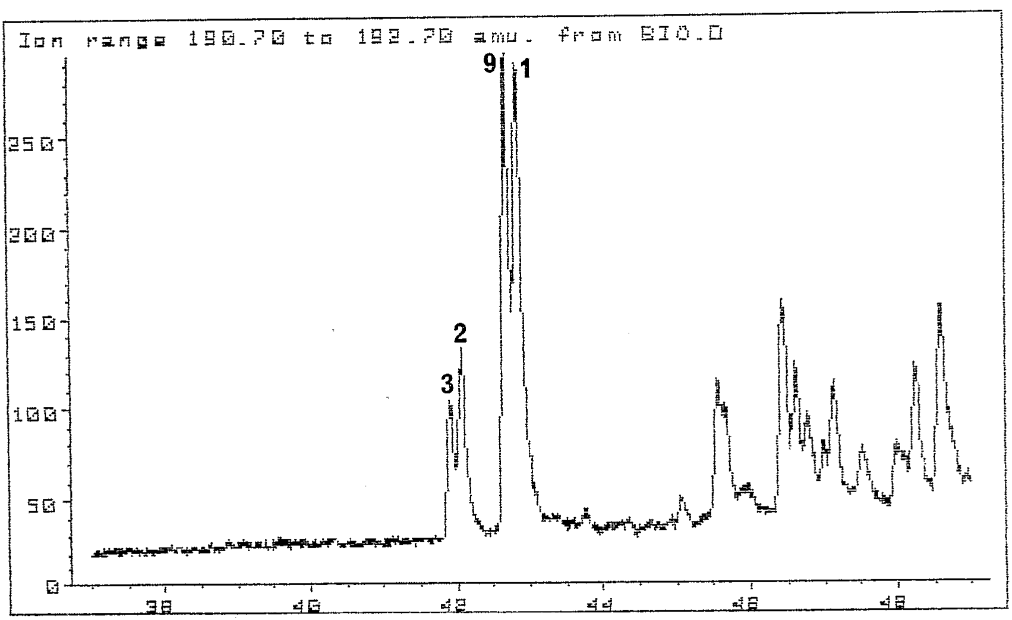
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