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GANE-1
GANK-1
GANT-1

Organic geochemistry of sediments, oils and gases in the GANE-1, GANT-1 and GANK-1 wells, Nuussuaq, West Greenland

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G E U S

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INTRODUCTION

In May 1995 grønArctic Energy Inc. and Platinova A/S were granted an exclusive exploration licence for a 1692 km^2 area covering western Nuussuaq (Fig. 1). grønArctic began their exploration programme in July 1995 by drilling the three slim-core wells GANE#1 (grønArctic Nuussuaq Eqalulik #1), GANK#1 (grønArctic Nuussuaq Kuussuaq #1) and GANT#1 (grønArctic Tunorssuaq #1)(Figs 1–4).

Detailed results from the drilling are confidential but general information has been released by grønArctic Energy and the Mineral Resources Administration for Greenland (MRA) (see Tables 1–3).

The Geological Survey of Denmark and Greenland (GEUS) carried out the well site geological description followed by a major sampling and analytical programme for grønArctic, based on an agreement between grønArctic Energy and the MRA dated May 17, 1995. The present report is a compilation of the organic geochemical work carried out by GEUS for grønArctic Energy. Results from this analytical programme and from continued studies of the core material may be released from 1 April, 1997.

The technical data from the three wells are summarized in Tables 1–3 and the preliminary sedimentological logs in Figs 2–4. Further details are given in the well completion reports, see Bate (1995) for GANE#1 and Dahl *et al.* (1995a, b) for GANK#1 and GANT#1 respectively. The well completion reports contain preliminary sedimentological logs and descriptions as well as all technical information, sample lists and information on hydrocarbon shows.

The organic geochemical data from all three wells are included in one single report because:

- the analytical work on the sediments, oils and gases from the three wells was carried out simultaneously and using the same techniques;
- there are strong geological similarities in the drilled succession between GANE#1 and GANK#1, and also in the organic geochemistry of the sediments and oils;
- there are interesting similarities and variations in maturity between the three wells;
- the three wells together provide a good understanding of the variations in organic richness, hydrocarbon potential and variations in depositional environment in the Upper Cretaceous and Tertiary marine succession of the Nuussuaq Basin.

GGU (now GEUS) has carried out systematic petroleum-related investigations in central West Greenland since 1990 with main emphasis on sedimentology, biostratigraphy and organic geochemistry (Christiansen, 1993; Christiansen *et al.*, 1992, 1994, 1995a, 1996, Dam & Nøhr-Hansen, 1995; Dam & Sønderholm, 1994, 1996) and a large amount of both published and unpublished data has been used for comparison in the present study. Although a large number of samples from GANE#1, GANK#1 and GANT#1 have been or are presently being prepared for palynological dating, systematic results have not yet been obtained. Therefore assumptions on ages are based on the general knowledge from the area that has been reported and published by Nøhr-Hansen (1993, 1994a,b, 1996).

The present report should be read together with a report by Christiansen *et al.* (1994b) which formed the background for a later paper by Christiansen *et al.* (1996). This paper gives all information from previous studies of the Marraat oil, both from surface samples collected in 1992–94 and from cores from the Marraat-1 hole drilled in 1993. Organic geochemical results from the GANW#1 well (grønArctic Nuussuaq West #1), which was drilled in 1994, are also important for comparison of especially the thermal maturity level (Christiansen *et al.*, 1995b).

ANALYTICAL METHODS AND ORGANIC GEOCHEMICAL PROGRAMME

At the well site 'representative' samples were taken out and canned at approximately every 3 metres (see sample lists in the well completion reports by Bate (1995) and Dahl *et al.* (1995a,b)). All other cores were wrapped in alumina foil and packed in core boxes in order to avoid (or at least reduce) contamination.

Some cans and core pieces were air freighted or brought back as hand luggage to Copenhagen during the drilling operation to allow quick analysis. The first results were available already in August-September 1995. The next round of analyses was carried out on the remaining cans that arrived in Copenhagen in early November. Results have constantly been calculated, tabulated and evaluated, and additional canned samples were analysed from intervals with interesting, missing or inconclusive data.

Finally a new round of analytical work started after a detailed sedimentological logging of the cores in late January, February and March, 1996; in this round several number of new oil-impregnated zones were discovered (mainly by their smell) and documented by analysis, and some of the thicker and darker shale beds with only few previous analyses were sampled more closely.

The sample material was prepared and analysed at the source rock laboratory at GEUS; details on some of the analytical methods are given by Bojesen-Koefoed (1989). The oil isotope composition was measured by GEOLAB-NOR in Trondheim, Norway. The gas composition and preparation for gas isotope composition was carried out at GEUS where the gas isotope composition was measured at the University of Copenhagen.

The analytical programme for GANE#1, GANK#1 and GANT#1 respectively included the following techniques:

1) LECO/Rock Eval pyrolysis (n= 83 + 49 + 45, total = 177);
2) Total sulphur analysis (n= 17 + 29 + 38, total = 84);
3) Vitrinite reflectance, R_0 (n= 10 + 6 + 15, total = 31);
4) Extraction in a Soxtech apparatus with subsequent deasphalting and column separation into saturated and aromatic hydrocarbons and NSO compounds (n = 28 + 14 + 18, total = 60);
5) Analysis of saturated hydrocarbons by gas chromatography (GC) and gas chromatography/mass spectrometry (GC/MS) (n = 22 + 14 + 18, total = 54);
6) C-isotope analysis of fractions of oils: total extract, saturated and aromatic hydrocarbons, NSOs and asphaltenes (n = 6 + 0 + 0, total = 6);

7) Head space gas composition (n = 20 + 8 + 13, total = 41), C isotopes of methane, in a few cases also of ethane and propane (n = 5 + 7 + 13, total = 25).

In addition to the organic geochemical analyses mentioned above a number of other analyses are presently being carried out (not included in this report):

8) Preparation of samples for palynological studies;
9) Analysis of porosity, permeability, grain density, oil and water saturation of selected potential reservoir rocks;
10) Preparation of thin sections with subsequent description of petrography and diagenetic history;
11) Apatite Fission Track Analysis (AFTA) for basin modelling studies.

GANE#1

Penetrated interval

The GANE#1 (and the side track GANE#1A) penetrated 498 m of Tertiary volcanics and 209 m of underlying sediments of presumed Paleocene age (Fig. 2; Table 1). It is not yet known whether the well terminated in lowermost Paleocene or Upper Cretaceous sediments. With an altitude of the drill site of 114 m, TD is situated approx. 593 m below sea level.

Oil impregnation has been reported throughout the volcanics, and cores bleeding oil were noted especially in intervals from 5 m to 20 m, from 150 m to 170 m, at 240 m and at 340 m (Fig. 2). In the underlying sediments gas under pressure was recorded at depths from 670 m to TD of 708 m (Fig. 2). Furthermore during relogging of the core, oil impregnation was discovered in the interval from 635 m to 650 m.

Some of the hydrocarbons reported at the well site, either in the core or as a film on the drilling fluid, seem to be contamination by diesel oil or other refined products (grease, lubricants).

The main goals of the analytical programme on sample material from GANE#1 were:

* to analyse, document and interpret the various oils and gases in terms of origin, thermal maturity and depositional environment of source rocks;

* to check the sedimentary succession for possible source rocks by dense screening analyses;

* to interpret the depositional environment of the shales from organic geochemical data and, if possible, find parameters applicable for correlation to the oils;

* to measure the thermal maturity of the sediments in order to model maturity history and variation throughout the Nuussuaq Basin and to compare maturity parameters with the analysed oils.

Screening of sediments (LECO/Rval and vit.ref.)

A large number of mudstones distributed throughout the core of GANE#1 were analysed by LECO/Rock Eval pyrolysis (*n* = 83), for sulphur analysis (*n* = 17) and for vitrinite reflectance (*n* =10). Data are given in Table 4 and shown graphically on the log in Fig. 5.

Generally the content of total organic carbon (TOC) is moderate with most values between 2.5% and 4.5% (average 2.86% ± 1.09%) (Table 4). The Hydrogen Index (HI) varies from 50 to 265 (average 125 ± 47). These values suggest a low to moderate source rock potential for oil (Fig. 6). Total sulphur values (TS) of the mudstones range from less than

0.3% to more than 4% (average 1.45% ± 1.40%) and suggest a marine depositional environment for most of the sediments (Fig. 7).

T_{max} values range from 432°C to 443°C (average 437°C); generally a lot of scattering is observed with only a limited increase in values from top to bottom of the sedimentary succession. It should be noted that samples with HI >125 show distinctly lower values (average 434°C) than samples with HI <125 (average 439°C). These values suggest a maturity level corresponding to the early part of the oil window. This is supported by the vitrinite reflectance measurements that range without a clear gradient from 0.58% to 0.75% (Table 4).

Several samples from the deepest part of the core (below ~660 m) show higher T_{max} values and lower Hydrogen Index values compared to the general level of all other sediments in the core indicating a local postmature interval. This is probably caused by the intrusion recorded from 689.5 m to 696.5 m and possibly also from circulation of hot water in the sandstones in this interval.

Bulk composition, GC and GCMS of sediments

A total of 10 mudstones from GANE#1 were extracted and analysed by gas chromatography (GC), and gas chromatography/mass spectrometry (GCMS). Three of these mudstones show clear evidence of impregnation with crude oil (-369, -370, -373) and they are described in the following section together with oil-impregnated sandstones.

Extraction data are given in Table 5 and shown in Fig. 8. The extracts are relatively homogeneous with moderate extractabilities between 20 and 41 mg SOM/g TOC. All the samples have a high concentration of asphaltenes (38–67%) and the deasphaltened extracts are dominated by NSO compounds (43–79%). The ratio of saturated to aromatic hydrocarbons ranges from 0.6 to 0.9 (Table 5). Such a bulk composition is common in mudstones with a low thermal maturity and a high content of terrestrially derived organic matter.

All gas chromatograms of the saturated hydrocarbons are shown in Fig. 9 and the calculated ratios given in Table 6. The samples are rather similar, all suggesting a significant input of terrestrial organic matter and a relatively low thermal maturity. The terrestrial fingerprint is especially evident from the high Pr/Ph values between 4.4 and 7.9 and the distinct odd-even predominance (CPI between 1.22 and 1.38, Phillippi ratios between 1.54 and 1.82). The latter two ratios show a clear decrease with increasing depth as would be expected with increasing thermal maturity.

The distribution of biomarkers in the saturated fractions has been studied by using m/z 217 (and 218, 355) mass fragmentograms for the steranes and m/z 191 (and 177) for the terpanes. Generally the terpanes occur in much higher concentrations than the steranes. Fig. 10 shows the terpane and sterane distribution for all samples; some of the parameters providing information on thermal maturity and depositional environment are listed in Tables 7 and 8.

The terpanes are dominated by pentacyclics (hopanes, moretanes and a few other compounds), whereas tricyclic terpanes occur only in very low concentrations. The ratio of H29/H30 varies from 0.81 to 1.26 and the extended hopanes show rapidly decreasing contents with increasing carbon number. Both the H31 and H32 have reached equilibrium of isomerization with 22S/22S+22R values close to 0.6 (Table 7). The concentration of moretanes is relatively high with ratios of $\alpha\beta/\alpha\beta+\beta\alpha$ between 0.64 and 0.72. Ts occurs in very low concentration compared to Tm. The ratio of Tm/Tm+17βTm is constant with values of 0.94 and 0.95 (Table 7, Fig. 11). Both bisnorlupane and oleanane occur in varying concentrations from low to high. The steranes are completely dominated by C29 steranes. The steranes have not reached equilibrium of isomerization and 20S/20S+20R values range from 0.36 to 0.52 (Table 7).

Bulk composition, GC, GCMS and C-isotope of oils

Two different types of oils have been documented geochemically in the GANE#1 well. The first type (7 samples analysed + 2 surface samples from the vicinity), which occurs throughout the volcanics, is rather similar to the Marraat oil, whereas the second type, 'previously unknown marine oil', found in the depth interval of 635 m to 650 m is completely different in composition (6 samples analysed). The two types are described separately below.

In volcanics – 'Marraat type oil'

The samples of volcanics with bleeding oil or with oil impregnation yielded high concentrations of extractable material, in particular hydrocarbons. Extraction data are given in Table 5 and shown in Fig. 8. The content of asphaltenes is relatively low and ranges between 0.9% and 12.7% (average 5.1%). The asphaltene-free extracts are dominated by hydrocarbons with high ratios of saturated to aromatic hydrocarbons.

All gas chromatograms of the saturated hydrocarbons are shown in Fig. 9 and the calculated ratios given in Table 6. The samples are rather similar, all suggesting limited biodegradation and a source rock for this oil dominated by terrestrial organic matter and a thermal maturity in the early part of the oil window. The terrestrial fingerprint is especially evident from the high Pr/Ph values between 4.7 and 6.0 and the distinct odd-even predominance (CPI between 1.13 and 1.23, Phillippi ratios between 1.51 and 1.69).

The distribution of biomarkers in the saturated fractions has been studied by using m/z 217 (and 218) mass fragmentograms for the steranes and m/z 191 (and 177) for the terpanes. Generally the terpanes occur in much higher concentrations than the steranes. Fig. 10 shows the terpane and sterane distribution for all samples; some of the parameters providing information on thermal maturity and depositional environment of the source rock to the oil are listed in Tables 7 and 8.

The terpanes are dominated by pentacyclics (hopanes, moretanes and a few other compounds), whereas tricyclic terpanes occur only in very low concentrations. The ratio of H29/H30 varies from 0.81 to 0.97 and the extended hopanes show rapidly decreasing contents with increasing carbon number. Both H31 and H32 have reached equilibrium of isomerization with 22S/22S+22R values close to 0.6 (Table 7). The concentration of moretanes is moderate with ratios of $\alpha\beta/\alpha\beta+\beta\alpha$ between 0.70 and 0.85. Ts occurs in low concentration compared to Tm. The ratio of Tm/Tm+17βTm varies from 0.86 to 0.91 (Table 7, Fig. 11). Both bisnorlupane and oleanane occur in relatively high concentrations with BNL/H30 ratios between 0.44 and 0.77 (not quite certain due to coelution of bisnorlupane with bisnorhopane), and O/H30 ratios between 0.44 and 1.03.

The steranes are dominated by C_{29} steranes. The steranes have not reached equilibrium of isomerization and 20S/20S+20R values range from 0.36 to 0.42 (Table 7).

The carbon isotope composition was analysed for six oils of the Marraat type from GANE#1. In each sample, five fractions were measured: total extract, saturated hydrocarbons, aromatic hydrocarbons, NSO's, and asphaltenes. The samples are relatively constant in composition, especially the uppermost four samples, whereas the two lowermost are slightly different. The Galimov plots (Fig. 12) show a pattern with the saturated hydrocarbons being the most ^{13}C depleted fraction, and increasingly higher concentrations of ^{13}C in aromatics, asphaltenes, and NSO's. The isotope composition is generally lighter (0.5–1) than the values for the oil in the Marraat-1 core published by Christiansen *et al.* (1996) (Fig. 12). Fig. 13 shows the crossplot of aromatic versus saturated hydrocarbons isotope composition that traditionally has been applied to distinguish marine from terrestrial oils/source rocks (Sofer, 1984). All samples plot close to the line dividing the terrestrial and marine field, which is typical of the deltaic oils.

In sediments – 'Previously unknown marine oil'

The samples of sediments with oil impregnation have been recorded in the interval between 635 m and 650 m. In some cases the impregnation is in sandstones with a distinct smell of oil, in other cases the impregnation has also been noted analytically in shales. These shales have high RockEval S1 values and very high extractabilities (> 60 mg SOM/gTOC, compared to 'normal' values below 35). Extraction data are given in Table 5 and shown in Fig. 8.

The content of asphaltenes is relatively low and ranges between 3.5% and 6.2% in sandstones and between 19% and 33% in mudstones (mixture of migrated oil and indigenous bitumen). The asphaltene-free extracts are dominated by hydrocarbons with high ratios of saturated to aromatic hydrocarbons.

All gas chromatograms of the saturated hydrocarbons are shown in Fig. 9 and the calculated ratios are given in Table 6. The samples are rather similar, all suggesting limited biodegradation. Pr/Ph values range between 1.4 and 1.8 and suggest a marine source rock deposited under anoxic conditions.The odd-even relation is difficult to measure due to high concentrations of biomarkers in this retention time interval.

The distribution of biomarkers in the saturated fractions has been studied by using m/z 217 (and 218) mass fragmentograms for the steranes and m/z 191 (and 177, 355) for the terpanes. Generally the terpanes occur in high concentrations whereas regular steranes are virtually absent. Fig. 10 shows the biomarker distribution for all samples; some of the parameters providing information on thermal maturity and depositional environment of the source rock for this the oil are listed in Tables 7 and 8.

The terpanes are dominated by pentacyclics (hopanes, moretanes and a few other compounds), whereas tricyclic terpanes only occur in very low concentrations. The ratio H29/H30 is low with values ranging from 0.48 to 0.64. Bisnorhopane occurs in relatively high concentration with H28/H30 values between 0.18 and 0.40. The extended hopanes occur in rather high concentrations with a peculiar pattern where especially H33 is abundant. Both H31 and H32 have reached equilibrium of isomerization with 22S/22S+22R values close to 0.6 (Table 7). The concentration of moretanes is moderate with ratios of $\alpha\beta/\alpha\beta+\beta\alpha$ between 0.80 and 0.84. Ts occurs in low concentration compared to Tm; Ts/Ts+Tm ranges from 0.14 to 0.30.

In the m/z 191 fragmentogram a homologous series of hitherto unknown compounds is observed. These compounds are characterized by a base peak at 191 amu, and an important fragment at m/z 355. These are 28-norhopanes, ranging from C_{28} to C_{33}. Homologs larger than C_{28} have apparently not been described previously (Schoell *et al.*, 1992). Homologs higher than C_{28} display several chromatographically resolvable isomers, the ratios of which may be potentially useful for maturity estimation. The utility of these parameters is currently being investigated and the results will be reported later. However, based on preliminary correlation established by analyses of a large number of North Sea oils, the maturity of the 'previously unknown marine oil' may be estimated at ~0.4-0.45 20S/20S+20R regular sterane isomerization. This estimate seems to agree well with the overall character of the oil. The presence of C_{28}-bisnorhopane is generally supposed to indicate marine anoxic environments and high bacterial activity.

Regular steranes are virtually absent, and traditional sterane isomerization ratios cannot be measured (Tables 7 and 8). However, in the m/z 217 ion fragmentogram a series of compounds is observed, tentatively identified as methyl-steranes. The series consists exclusively of C_{28}-compounds, showing molecular ions of 386 amu and base peaks at m/z 231 (232). Methylation is present in the A-ring of the sterane molecular skeleton, but the exact position is not known. Mass spectra yielded by compounds belonging to this series appear similar to, albeit not fully compatible with, published spectra of methyl-steranes. This is currently being investigated. The significance of methyl-steranes is not clear, since these compounds are found in sediments deposited in a variety on settings, including marine, lacustrine and hypersaline. However, the consensus seems to be that methyl-steranes in various guises and configurations all originate from algae, although both synthesis by bacteria, and renewed formation by early diagenetic processes have been proposed (Peters & Moldowan, 1993 and references therein; Huang Difan *et al.*, 1994). The near total absence of steranes is highly enigmatic, and neither a plausible explanation for, nor an evaluation of the significance of this feature may be offered at present.

The carbon isotope composition was analysed in one sample of the 'previously unknown marine oil' from GANE#1. Five fractions were measured: total extract, saturated hydrocarbons, aromatic hydrocarbons, NSO's, and asphaltenes. The Galimov plot (Fig. 12) shows a peculiar pattern with the total extract and the aromatic hydrocarbons being the most ^{13}C depleted fractions, and increasingly higher concentrations of ^{13}C in the NSO's and the saturated hydrocarbons and a much higher concentration in the asphaltenes. Fig. 13 shows the crossplot of aromatic versus saturated hydrocarbons isotope composition that traditionally has been applied to distinguish marine from terrestrial oils/source rocks (Sofer, 1984). The sample clearly plots within the marine field.

Thermal maturity of sediments and oils

Although many of the recorded thermal maturity parameters from both GC and GCMS data are partly controlled by the type of organic matter in the source rocks, there are some clear indications of the maturity development in the sedimentary succession in GANE#1 and of the maturity of the source rocks that generated the oils compared to the drilled sediments.

The sediments seem to have a maturity corresponding to the early part of the oil window and there generally seems to be accordance between the screening maturity data (T_{max}, vitrinite reflectance), the GC parameters and the many different GCMS parameters. The drilled sedimentary succession has a thickness of only a little more than 200 metres, and many of the parameters do not show a clear gradient (Fig. 11).

The oil of the Marraat type seems to have a source rock with a maturity in the interval between early mature and peak generation. A number of specific parameters suggest that the oil has a higher maturity than any of the analysed sediments, e.g. CPI, Phillippi ratios, H30/H30+M30, Ts/Ts+Tm, Tm/Tm+17β, whereas the hopane and sterane isomerization data are less conclusive. Based on direct trends it is suggested that sediments with a maturity close to the source rock of the oil would occur at a depth of ~1 km below sea level.

The previously unknown marine oil is very distinct in composition and it is very difficult to compare maturity parameters directly with the drilled sediments. However, generally a number of parameters suggest that the maturity of the marine source rock for this oil must have been just before peak generation maturity, i.e. a higher maturity than both the Marraat type oil and the known sediments.

GANK#1

Penetrated interval

The GANK#1 (and the side track GANK#1A) penetrated 115 m of Tertiary volcanics and 283 m of underlying sediments of presumed Paleocene age (Fig. 3; Table 2). It is not yet known whether the well terminated in lowermost Paleocene or uppermost Cretaceous sediments.

With an altitude of the drill site of 91 m, TD is situated approx. 308 m below sea level.

Hydrocarbons were reported from the volcanics, where oil impregnation was especially noted in the interval from 85 m to 100 m. In the sediments gas under pressure was recorded at a depth of 384 m (Fig. 3). Furthermore during relogging of the core, oil impregnation was discovered at a depth of 331.4 m. Some of the hydrocarbons reported at the well site, especially in intervals from 158 m to 168 m, from 191 m to 197 m, at 270 m and from 380 m to 386 m seem to be contamination by diesel oil or other refined products (grease, lubricants).

The main goals of the analytical programme on sample material from GANK#1 were:

- to analyse, document and interpret the various oils and gases in terms of origin, thermal maturity and depositional environment of source rocks;
- to check the sedimentary succession for possible source rocks by dense screening analyses;
- to interpret the depositional environment of the shales from organic geochemical data and, if possible find parameters applicable for correlation to the oils;
- to measure the thermal maturity of the sediments in order to model maturity history and variation throughout the Nuussuaq Basin and to compare maturity parameters with the analysed oils.

Screening of sediments (LECO/Rval and vit.ref.)

A large number of mudstones distributed throughout the core of GANK#1 were analysed by LECO/Rock Eval pyrolysis (*n* = 49), for sulphur analysis (*n* = 29) and for vitrinite reflectance (*n* =6). Data are given in Table 10 and shown graphically on the log in Fig. 14.

Generally the content of total organic carbon (TOC) is moderate with most values between 2.5% and 4% (average 3.33% ± 1.41%) (Table 10). The Hydrogen Index (HI) varies from 50 to 200 (average 117 ± 44). These values suggest a low to moderate source rock potential for oil (Fig. 15). Total sulphur values (TS) of mudstones are high and range from less than 1% to 5% (average: 2.97% ± 0.99%) which suggest a marine depositional environment (Fig. 16).

T_{max} values range from 421°C to 440°C (average 431°C), generally a lot of scattering is observed with only a limited increase in values from top to bottom. It should be noted that samples with HI>125 show distinct lower values (average 427°C) than samples with HI<125 (average 434°C). These values suggest a maturity level corresponding to immature or the early part of the oil window. This is supported by the few vitrinite reflectance measurements that show values between 0.55 and 0.62% (Table 10).

Bulk composition, GC and GCMS of sediments

A total of eight mudstones from GANK#1 were extracted and analysed by gas chromatography (GC) and gas chromatography/mass spectrometry (GCMS). Extraction data are given in Table 11 and shown in Fig. 17. The extracts are relatively homogeneous with moderate extractabilities between 28 and 38 mg SOM/g TOC. All the samples have high concentration of asphaltenes (40-60%) and the deasphaltened extracts are dominated by NSO compounds (75–95%). The ratio of saturated to aromatic hydrocarbons varies from less than 0.5 to 2 (Table 11). Such a bulk composition is common in mudstones with a low thermal maturity and a high content of terrestrially derived organic matter.

All gas chromatograms of the saturated hydrocarbons are shown in Fig. 18 and the calculated ratios given in Table 12. The samples are rather similar, all suggesting a significant input of terrestrial organic matter and a relatively low thermal maturity. The terrestrial fingerprint is especially evident from the high Pr/Ph values between 4.3 and 8.5, abundant sesqui-terpanes in the C_{13}–C_{15} range, and the distinct odd-even predominance (CPI between 1.56 and 1.84, Phillippi ratios between 2.26 and 3.04). The latter two ratios show a clear decrease with increasing depth as would be expected with thermal increasing maturity. It is remarkable that one of the biomarkers, bisnorlupane, occurs in such high concentrations that it is observed in some of the gas chromatograms.

The distribution of biomarkers in the saturated fractions has been studied by using m/z 217 (and 218) mass fragmentograms for the steranes and m/z 191 (and 177) for the terpanes. Generally the terpanes occur in much higher concentrations than the steranes. Fig. 19 shows the terpane and sterane distribution for all samples; some of the parameters providing information on thermal maturity and depositional environment are listed in Tables 13 and 14.

The terpanes are dominated by pentacyclics (hopanes, moretanes and a few other compounds), whereas tricyclic terpanes only occur in very low concentrations. H30 dominates over H29 and the extended hopanes show rapidly decreasing contents with increasing carbon number. Neither H31 nor H32 have reached equilibrium of isomerization and 22S/22S+22R ranges from 0.43 at depths of ~150 m to equilibrium values near 0.60 at TD (Table 13). The concentration of moretanes is relatively high with ratios of $\alpha\beta/\alpha\beta+\beta\alpha$ between 0.56 and 0.61. Ts occurs in very low concentration compared to Tm. 17βTm occurs in relatively high concentrations and the ratio of Tm/Tm+17βTm generally increases from 0.84 to 0.92 down through the core (Table 13, Fig. 27).

The most distinct biomarker is bisnorlupane which occurs in very high concentrations in most samples. Two isomers, probably 17α(H)-23,28 bisnorlupane and 17β(H)-23,28 bisnorlupane (Rullkötter *et al.*, 1982) are present. Oleanane has only been recorded in a low concentration. The high concentration of bisnorlupane causes some problems since this compound is also noted in the 217 mass fragmentogram where it coelutes with the ααS C_{29} steranes. Therefore the ubiquitously applied sterane isomerization maturity indicator cannot be calculated, with one exception. The steranes are completely dominated by C_{29} steranes.

Bulk composition, GC and GCMS of oils

Two different types of oils have been documented geochemically in the GANK#1 well. The first type (one sample only analysed), which was found in the volcanics at a depth of 88 m, is rather similar to the Marraat oil. The second type, 'Previously unknown marine oil', found in the sediments at a depth of 331 m, is completely different in composition (one sample only analysed).

The two types are rather similar to the oils found in the GANE#1 well (see description in the foregoing). Extraction data are found in Table 11 and Fig. 17, GC data in Table 12 and Fig. 18, GCMS data in Tables 13 and 14 and in Fig. 19.

Thermal maturity of sediments and oils

Although many of the recorded thermal maturity parameters from both GC and GCMS data are partly controlled by the type of organic matter in the source rocks, some interpretations can be made concerning the maturity development in the sedimentary succession and of the maturity of the source rocks that generated the oils compared to that of the drilled sediments.

The sediments seem to have a maturity corresponding to before oil generation and there generally seems to be accordance between the screening maturity data (T_{max}, vitrinite reflectance), GC parameters and the many different GCMS parameters. The drilled sedimentary succession has a thickness of only about 200 metres, and many of the parameters do not show a clear gradient (Fig. 20). However, parameters like Tm/Tm+17β and hopane isomerization seem to be applicable for ranking even within such a limited depth variation.

The oil of the Marraat type seems to have a source rock with a maturity in the interval between early mature and peak generation. A number of specific parameters suggest that the oil has a higher maturity than any of the analysed sediments, e.g. CPI, Phillippi ratios, H30/H30+M30, Ts/Ts+Tm, Tm/Tm+17β and hopane isomerization, whereas sterane isomerization data cannot be used. Based on extrapolation it is suggested that sediments with a maturity close to the source rock of the oil would occur at a depth of ~1 km below sea level.

The 'previously unknown marine oil' is very distinct in composition and it is very difficult to compare maturity parameters directly with the drilled sediments. However, a number of parameters suggest in general that the maturity of the marine source rock for this oil must have been just before peak generation maturity, and therefore has a higher maturity than both the Marraat type oil source and the sediments drilled.

GANT#1

Penetrated interval

The GANT#1 well penetrated 901 m of Upper Cretaceous marine shales and sandstones (Fig. 4, Table 3). The well starts very close to the Cretaceous–Tertiary boundary and it is assumed that GANT#1 terminated in sediments of Campanian or Santonian age. With an altitude of the drill site of 440 m, TD is situated approx. 460 m below sea level. Oil film was noted in drilling fluids at a depth of 824 m, but analytical work suggests this to be caused by contamination.

Gas under pressure was recorded at a number of levels in the deeper part of the hole (Fig. 4). Impregnation of liquid hydrocarbons was not seen in the core at the drill site. During relogging of the core oil-impregnation was observed in the centre of an ~2 m thick dolerite sill at a depth of 610 m.

The main goals of the analytical programme on sample material from GANT#1 were:

* to analyse, document and interpret the various gases in terms of origin, thermal maturity and depositional environment of source rocks;
* to check if any of the indicators of liquid hydrocarbons were caused by crude oil;
* to check the sedimentary succession for possible source rocks by dense screening analysis;
* to interpret the depositional environment of the shales from organic geochemical data and, if possible, find parameters applicable for correlation to oils known elsewhere on Nuussuaq;
* to measure the thermal maturity of the sediments in order to model maturity history and variation throughout the Nuussuaq Basin and to compare maturity parameters with the analysed oils.

Screening of sediments (LECO/Rval and vit.ref.)

A large number of mudstones distributed throughout the core of GANT#1 were analysed by LECO/Rock Eval pyrolysis (n = 45), by sulphur analysis (n = 45) and for vitrinite reflectance (n =15). Data are given in Table 15 and shown graphically on the log in Fig. 21.

Generally the content of total organic carbon (TOC) is moderate to high with most values between 2.5% and 8% (average 4.86% ± 1.87%) (Table 15). Especially the interval below 500 m is rich in TOC with most values above 5% (Fig. 21). The Hydrogen Index (HI) varies from 50 to 140 (average 100 ± 28). These values suggest a low to moderate source rock potential for oil (Fig. 22). Total sulphur values (TS) of mudstones generally range from 1% to 5% (average 2.47% ± 1.02%) and suggest a marine depositional environment (Fig. 23).

T_{max} values range from 431°C to 464°C, generally with a clear increase in values from top to bottom (Fig. 21). This range of values suggests a maturity level corresponding to the early part of the oil window in the uppermost part of the hole, reaching peak generation near the base of the well. This is supported by the vitrinite reflectance measurements that range from 0.63% to 0.96% with a clear gradient from top to bottom (Table 15).

Bulk composition, GC and GCMS of sediments

A total of 17 mudstones from GANT#1 were extracted and analysed by gas chromatography (GC) and gas chromatography/mass spectrometry (GCMS).

Extraction data are given in Table 16 and shown in Fig. 24. The extracts are relatively homogeneous with low to moderate extractabilities between 15 and 26 mg SOM/g TOC. All the samples have moderate to high concentration of asphaltenes (16–57%) with the lowest values near the base (Table 16). The deasphaltened extracts are dominated by NSO compounds (51–80%). The ratio of saturated to aromatic hydrocarbons is quite variable from less than 1 to more than 3.5. Such a bulk composition is common in mudstones with a high content of terrestrially derived organic matter.

All gas chromatograms of the saturated hydrocarbons are shown in Fig. 25 and the calculated ratios given in Table 17. The GC data all suggest a significant input of terrestrial organic matter. This is especially evident from the high Pr/Ph values between 3.9 and 5.9 and the distinct odd-even predominance (CPI between 1.04 and 1.41, Phillippi ratios between 1.15 and 1.97). Both CPI and Phillippi ratios show a clear decrease with increasing depth as would be expected with increasing thermal maturity. Also the envelope of *n*-alkanes distribution changes with increasing depth; in the upper part a maximum is observed around C_{27} changing to C_{19} in the lower part (Fig. 25).

The distribution of biomarkers in the saturated fractions has been studied by using m/z 217 (and 218) mass fragmentograms for the steranes and m/z 191 (and 177) for the terpanes. Generally the terpanes occur in much higher concentrations than the steranes. Fig. 26 shows the terpane and sterane distribution for all samples; some of the parameters providing information on thermal maturity and depositional environment are listed in Tables 18 and 19.

The terpanes are dominated by pentacyclics (hopanes, moretanes and a few other compounds), whereas tricyclic terpanes only occur in very low concentrations. H30 dominates over H29 with ratios of H29/H30 between 0.54 and 0.83. The extended hopanes show rapidly decreasing abundance with increasing carbon number. Both H31 and H32 have reached equilibrium of isomerization with 22S/22S+22R values close to 0.6, with the exception of the uppermost 100 m of the well (Table 18). The concentration of moretanes is relatively high with ratios of αβ/αβ+βα between 0.63 and 0.93. Ts occurs in very low concentration compared to Tm in the uppermost part of the well but higher ratios are noted near TD (Table 21). The ratio of Tm/Tm+17βTm shows a distinct increase from top to base with values from 0.88 to 1.00 (Table 18).

Bisnorlupane has only been recorded in low concentrations in one sample, whereas oleanane occurs in relatively high concentrations in a number of samples scattered down through the well, especially from 650 m to 900 m (Table 19). Bisnorhopane occurs in moderate concentrations in a number of samples, especially in the deepest half of the well.

The steranes are completely dominated by C_{29} steranes. In most of the samples the steranes have not reached equilibrium of isomerization and 20S/20S+20R values range from 0.27 to 0.55 with a general increase from top to base of the well (Table 18).

GC and GCMS of oil from sill

Only one type of oil has been documented geochemically in the GANT#1 well. This type was found by its smell in the centre of a ~2 m thick dolerite sill at a depth of 610 m. This oil, which is dark with a strong odour, is restricted to a mineral-filled fracture. Only limited material was available for analysis after the core was washed with solvent (Sample 439101-805). This material was not separated into fractions but analysed as total extract by GC and GCMS (see data for this single sample in Figs 25 and 26 and in Tables 17, 18 and 19).

The GC and GCMS data suggest limited biodegradation, a source rock dominated by terrestrial organic matter and a thermal maturity late in the oil window. One unknown biomarker (retention time close to n-C_{28} in GC, and a retention time of 42.3 minutes in the GCMS data, noted especially in the m/z 177 and 191 but also in 217) occurs in a very high concentration.

The terrestrial fingerprint is especially evident from the high Pr/Ph value, the distinct odd-even predominance, low concentration of extended hopanes, dominance of C_{29} steranes. It should be noted that both bisnorhopane (H28) and oleanane are present in the oil.

The relatively high thermal maturity is interpreted from hopanes and steranes that are in thermal equilibrium, low concentrations of moretanes, lack of 17βTm.

The composition of the oil shares a lot of characteristics with the mudstones from the deeper part of the GANT#1 well, although the thermal maturity is clearly higher. On the present – but limited – data, it is assumed that the oil was generated locally in the vicinity of the sill by the heat at the time of intrusion and that the oil later migrated into the centre of the sill through fractures.

Thermal maturity of sediments

In contrast to the GANE#1 and GANK#1 wells a clear maturity gradient is observed in the sediments penetrated in GANT#1, as would be expected considering it penetration through a total thickness of 900 metres. There is, however, some scatter of the maturity data, which may be due to either variation in composition of organic material or the local effects of a number of thin dykes and sills that have been recorded down through the hole (Figs 21 and 27). The data from GANT#1 are supported by outcrop data from the Annertuneq area on the north coast of Nuussuaq (~7 km NE of GANT#1) where a clear gradient is also noted in outcrop and shallow core samples from ~35 m below sea level to ~845 m above sea level (immediately below volcanics) (GGU unpublished data, GEUS basin modelling in preparation).

The general gradient in GANT#1 is observed in both screening, GC and GCMS maturity parameters. T_{max} ranges from below 430°C to more than 460°C, R_o ranges from below 0.6% to more than 0.9%, CPI decreases from more than 1.4 to less than 1.05, Phillippi ratios decrease from close to 2 to less than 1.2. A similar increase in maturity is observed using most of the GCMS parameters (Fig. 27). It should be noted that the hopanes have reached equilibrium throughout the core whereas the steranes show a general increase in isomerization values from 0.27 to near equilibrium values of 0.55. Generally there is good correlation between the various parameters.

Most data are in accordance with a conclusion that the GANT#1 well represents the variation from immature, through early mature to mature. The zone of oil generation is from the middle of the penetrated interval with peak generation maturity just before TD.

GAS GEOCHEMISTRY

Gas under pressure was recorded at several levels in all three wells. Previously gas has also been recorded from the Marraat-1 and the GANW#1 wells and from several surface seeps in the region (see results in the report by Christiansen *et al.*, 1995a).

One of the major problems in the interpretation of data from the various sources of gas is the sampling technique. Natural gas easily becomes mixed with atmospheric air during sampling, this is however not a problem for the interpretation of origin based on isotopes but it can makes quantification difficult. More important problems are chromatographic separation (relative loss of methane) and fractionation of gases (loss of light isotopes) may take place during transportation and storage. In the present sample material these problems have been limited although the time period from sampling to analysis varied from a few weeks to many months.

A number of samples were collected and sealed for later gas analyses from all three wells GANE#1, GANK#1 and GANT#1. However, the number of samples was less than hoped for; one of the problems was limitations in available personnel. For logistic reasons all well sites were not manned with geologists or technicians for 24 h per day. Therefore some of the intervals with gas were not properly sampled.

Gas under pressure was sampled from the well head in specially constructed steel cylinders. Furthermore a large number of gases from sealed core samples (cans with mudstones, sandstones, volcanics and intrusions) were analysed and some gas from cans containing drilling and/or formation fluids.

Analytical data on head space composition of a normal series of organic gases up to pentane, and carbon isotopic compositions of methane and ethane are shown in Tables 20 to 22 together with details on sample depths, time of sampling and type of samples. Standard plots showing compositional fields and possible maturity variation are shown in Figures 28 and 29.

GANE#1

Gas under pressure was encountered frequently in the deeper part of GANE#1 between 631 m and 641 m, and in the side-track GANE#1A in the intervals from 684 m to 689 m (gas kick) and from 696.5 m to 702 m.

The analysed gas samples from GANE#1 include two steel cylinders, three canned cores of volcanics, four canned cores of sandstone, two canned cores of dolerite, three canned cores of mudstone, and six glass bottles of formation/drilling fluids (see Table 20).

The gas concentration of the samples varies from very low to very high. All the analysed gases are very dry and completely dominated by methane. With the exception of one sample, the isotope composition of methane is relatively constant between -40.9‰ and -45.1‰. These values suggest that the gas is thermogenic in origin. The wetness data and the isotope data are not in fully accordance, since the dry nature of the gas suggests a high thermal maturity whereas the isotopic composition suggests a low to intermediate thermal maturity.

GANK#1

Records of gas from GANK#1 are limited to some observations of gas bubbles in the drilling fluids between 244 m and 290 m and burning of gas from the flareline at a depth of 384 m.

The analysed gas samples from GANK#1 include only canned cores of mudstone (7) and from one intrusion (see Table 21). Several of the samples have a high concentration of organic gases that are relatively wet with C_1/C_2+C_3 values below 50 and C-isotope composition of methane between -42‰ and -49‰. This is in accordance with gas generated from mudstones with a relatively low thermal maturity like indicated by many of the recorded maturity parameters from the screening data and GCMS.

GANT#1

Gas was recorded at many intervals in the GANT#1 wells Gas was circulated through the flareline at 824 m, 895 m and 901 m (TD). Furthermore gas was noted as percolation from the core from the following intervals: 576 m, 650 m, 714 m, 722 m, 728 m, 767-771 m, 774 m.

The analysed gas samples from GANT#1 include four steel cylinders, six canned cores of sandstone, two canned cores of mudstone and one canned sample of fabric impregnated with possible condensate (see Table 22).

Most of the samples show high concentrations of organic gases, although several values suggest leakage of methane and isotopic fractionation of methane during transportation and storage prior to analysis (see Table 22).

The gases show a wide range in composition and both wetness and isotopic values suggest varying origins. Two samples (247.19 m and 901.29 m) are clearly microbial in origin whereas all the other samples are thermogenic in origin but presumably with a varying maturity representing low, intermediate and high maturity gases. The gases with low and intermediate maturity values may have been generated within the drilled succession whereas the gases with higher values probably have been generated in a deeper level of the basin.

Comparison of gas composition, thermal maturity

Generally the compositional pattern of the analysed gases is not as clear as hoped for. This could possibly have been improved by increasing the number of analyses and a quicker procedure of transportation and analysis so the risk of leakage and fractionation would be minimized. There is, however, clear evidence of three different types of gases in the analysed material: 1) microbial gases (formed by bacteria in surface or groundwater); 2) low to intermediate maturity gases that seem to have been generated in drilled succession (probably associated with the observed oils); and 3) high maturity dry gases that probably have been generated deeper in the sedimentary succession.

It is clear from the present pattern that gas generation in the Nuussuaq basin also took place at relatively low maturity (Fig. 29), in some cases combined with petroleum generation in other cases alone. The origin of the high maturity gases is not quite clear but the most obvious possibilities are generation from a deep coaly non-marine succession (like the Atane Formation) or from a deeply buried marine succession. It can not be excluded that some of the high maturity gases have been generated in the vicinity of some of the recorded intrusions.

DISCUSSION AND CONCLUSIONS

The 1995 drilling programme has given some very important and encouraging organic geochemical results that fully justify further exploration in the Nuussuaq Basin. Although the slim-core wells only reached depths of less than 1 km, three different types of oil and two different types of gas can be demonstrated. Although good single source rocks have still not been identified, the presence of the oils suggest that several good source intervals may be present in the basin. Furthermore the general richness of organic material is so high throughout the sedimentary succession that significant amounts of hydrocarbons may be have been generated even though the individual samples only have a limited potential for liquid hydrocarbons. Furthermore it is now possible to make a direct comparison of the maturity variation and gradient in both the northern and southern area of Nuussuaq. The most important conclusions for exploration are discussed below.

Thermal maturity, comparison of wells

The systematic use of the same analytical techniques and maturity parameters for a number of years in West Greenland now provides a good basis for comparison of the thermal maturity in a number of wells and outcrops.

It is possible to correlate most of the maturity parameters such as T_{max}, R_o, CPI, Phillippi, various Ts, Tm and 17βTm ratios, and various hopane and sterane isomerization values. Although some of the parameters are clearly controlled by variation in composition of the organic matter (especially the amount of terrestrially derived material) a correlation can be suggested that seems to work for maturity ranking of the drilled intervals and outcrop sections (see Fig. 30). The empirical relation between maturity and generation zones is modified from a large number of published studies where especially relations for type II/III kerogen are relevant. Single values of T_{max} and R_o should be used with caution, and it is recommended to apply general trends.

It should be noted that no single parameter is applicable for detailed ranking throughout the maturity interval from immature to postmature. Generally parameters based on CPI, 17βTm, moretane and hopane isomerization are very good for ranking at low maturities (immature, early mature), whereas the sterane isomerization, T_{max}, and R_o are better for intermediate maturities (early mature, mature), whereas T_{max} and especially R_o are better in the late mature and postmature range (wet gas, dry gas zone).

In order to compare the maturity parameters of sediments directly Fig. 30 has been constructed show the position of the drilled intervals. It should be noted that all depths are relative to sea level.

It seems clear from this figure that the minor difference in maturity of the sediments in the GANE#1, GANK#1 and GANW#1 wells is controlled by depth alone. The implications of this is that the now eroded succession of volcanics that was once present before uplift and erosion had a constant thickness in this part of Nuussuaq.

In contrast the GANT#1 well show considerably higher maturity relative to sea level. The difference corresponds to approximately 750 m and may be caused by differences in a number of factors or combination of factors, e.g. thermal gradient (heat flow, underlying major intrusions or zones of hydrothermal activity), major lithological variations with different thermal conductivities, or tilting of the basin during or after uplift in the Tertiary. The GANT#1 well seems to have a slightly higher maturity relative to sea level than the nearby outcrop section at Annertuneq (corresponding to ~200 m).

These problems are presently being studied in a basin modelling project at GEUS. Whatever the reason is for the maturity variation, it is very clear that the 'oil window' is situated considerably deeper in the GANW#1-GANE#1-GANK#1 area than in the Tunorsuaq valley and on the north coast of Nuussuaq.

Source rocks and source rock/oil correlation, mixing of oils

The present study in combination with extensive previous analytical work clearly demonstrates that the Upper Cretaceous and Tertiary sediments in the Nuussuaq Basin are rich in organic material, probably with an average between 3 and 4% (in weight) for the total succession. Good single source rocks for liquid hydrocarbons have still not been identified, although the documented oils clearly demonstrate that significant amounts of hydrocarbons must have been generated.

By far the most of the analysed shales are dominated by terrestrially derived organic material with only a limited generative potential. It should be noted, however, that many of the shales have Hydrogen Indices between 100 and 200, and are likely to be composed of a mixture of organic material without any potential (HI < 50) and a minor fraction of hydrogen-rich material (HI>400?) that may generate liquid hydrocarbon. None of the shales have a biomarker distribution that correlates closely with the Marraat-type oil, but many of the compounds that are distinct for the Marraat oils are found in the sediments although with highly varying ratios.

It is particularly interesting to note the distribution of bisnorlupane and oleanane in the sediments. These two compounds which are diagnostic for the Marraat oil occur in relatively constant quantities in the Marraat oil (BNL slightly more abundant than oleanane) whereas they rarely are found together in the sediments (see Tables 8, 14, and 19). Especially the Paleocene sediments often contain a high concentration of bisnorlupane (especially in GANE#1 and GANK#1) whereas oleanane mainly occurs in the Cretaceous sediments (recorded from GANT#1). This distribution suggests that the Marraat type oil is of mixed origin and was derived from several source intervals throughout the Cretaceous and Tertiary succession. Such a model is very encouraging for exploration because this mixing must have taken place in a reservoir that still may exist.

In the first analytical programme on the Marraat type oils the geochemistry was generally described as very homogeneous (Christiansen *et al.*, 1994) whereas in a later paper (Christiansen *et al.*, 1996) that also included analyses of surface samples farther to the north and east, minor variations in maturity and depositional environment of the source rocks was documented and discussed. There is a tendency towards a lower thermal maturity and more terrestrial fingerprints towards east. This pattern is further enhanced by the present data from GANE#1 and GANK#1. However, the samples from a single well or minor outcrop area still look very homogeneous. Based on all data of Marraat type oils it is suggested that at least 4–5 different oil pools have leaked to the surface.

In contrast it has not been possible to recognize sediments that share any organic geochemical characteristics with the 'previously unknown marine oil', an oil that has a very distinct composition. Such a distinct composition should make it possible to recognize even minor mixing (as low a 10%) with e.g. Marraat type oils. This has not been the case, but the Marraat-type oils from GANE#1 should be checked in more detail to look for any evidence of the series of bisnorhopanes or methyl-steranes. Based on general comparison it is suggested that the source rock for 'the previously unknown marine oil' was deposited in a deeper marine environment with a much higher content of amorphous kerogen derived from marine algae or bacteria and with a only a limited input – if any – of terrestrially derived material. Alternatively the source rock could be lacustrine.

Based on general interpretation of the basin, it is most likely that such a source rock is situated deeper in the succession, where it may be restricted to the centre of one or several depocentres. The geochemical data do not set any limits to the age of the source rock; it may be Early Cretaceous or even older.

RECOMMENDATIONS FOR EXPLORATION

Position of well sites

Previously obtained data and the data presented in this report indicate that the most encouraging area for future exploration is in the southwestern part of Nuussuaq. More shows of oil and gas have been found here compared to the Tunorsuaq valley and the north coast of Nuussuaq, and the maturity gradient makes it possible in the southwest to explore in a deeper part of the sedimentary succession without reaching thermally postmature sediments.

Based on the intensity of oil and gas shows and the interpretation of the geochemical data, the best exploration possibilities seem to be in the area between Marraat-1 and GANE#1. Based on present maturity data, postmature sediments (for oil or condensate) are probably situated deeper than 1.5–2 km below sea level, whereas possibilities for dry gas generation are likely considerably deeper.

Well site positions west of the GANW#1 well have a high risk of reaching postmature sediments very early, this risk being higher the closer the position is to the Itilli valley. Well site positions east of GANK#1 will have a higher risk of no sourcing due to less mature and probably poorer quality source rocks.

It is, however, recommended that structural pattern and ideas on the position of the best reservoirs combined with the logistical limitations govern decision-making at the present stage of exploration.

Further geochemical studies

Further studies should be carried out on the present data and new analyses should be obtained from cores from the GANE#1, GANK#1 and GANT#1 wells:

- the mixing problem should be studied by multivariate statistics based on GC and GCMS parameters, additional C-isotope data of oils may be important in this context (presently being considered by both GEUS and grønArctic consultants);
- better characterization of the 'previously unknown marine oil', comparison with many other oils (ongoing studies at GEUS);
- detailed coal petrography (with fluorescence) in order to characterize and quantify the potential generative part of the organic material (presently being considered by GEUS);
- a more detailed correlation of maturity parameters (ongoing studies at GEUS);
- basin modelling aiming at oil and gas generation and uplift history (ongoing studies at GEUS).

Furthermore it is recommended that similar sampling programmes and analytical methods should be used in future drilling programmes, both with shallow coring and with conventional deep drilling. It is, however, important to obtain more and better samples of fluids and gases.

In addition to sample material from the drilling it is also likely that systematic field work and sampling with subsequent analysis will give further break-throughs for exploration. Pingos and lakes should be systematically sampled for gases, and fracture zones should be systematically studied throughout the region for evidence of liquid hydrocarbons .

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FIGURES

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Fig. 16 TOC versus TS for the GANK#1 well.

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Fig. 25 Gas chromatograms of saturated hydrocarbons from samples from the GANT#1 well, a: pristane, b: phytane; the numbers are *n*-alkane carbons numbers.

Fig. 26 Mass chromatograms of terpanes (m/z 191) and steranes (m/z 217) from samples from the GANK#1 well. The compound assignment is explained in Table 24.

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Fig. 28 C1/C2+C3 (= wetness) versus C-isotope composition of methane. The compositional fields are modified from Schoell (1984).

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Fig. 30 Compilation of maturity parameters from the Nuussuaq Basin (generally type II/III kerogen).

TABLES

Table 1. Technical data from the grønArctic well GANE#1

Well name:	grønArctic Nuussuaq Eqalulik#1 (GANE#1)
Operator:	grønArctic Energy Inc., Regina, Saskatchewan, Canada
Drill contractor:	Petro Drilling Ltd., Halifax, Nova Scotia, Canada
Locality:	Aaffarsuaq valley, Nuussuaq, West Greenland
Coordinates:	70°28′25" N, 54°00′40" W
Elevation:	114 m a.s.l.
Well spud date:	July 10, 1995
Termination:	August 6, 1995
Rig type:	Longyear 44 Diamond Core Drill, adapted mining rig
Total depth:	707 m, ~100% core recovery
Hole diameter:	0–202 m: 96.0 mm (HQ rods), 202–510 m: 75.8 mm (NQ rods), 510–707 m: 60 mm (BQ rods)
Core diameter:	0–202 m: 63.5 mm, 202–510 m: 47.6 mm, 510–707m: 36.5 mm
Status:	Plugged and abandoned
Main target:	Structural Marraat-type prospect (oil generated from Tertiary deltaic source rock, Tertiary or Cretaceous sandstone reservoir)
Formations drilled:	Lower Tertiary volcanics (500 m), Lower Tertiary and ?Cretaceous siliciclastic sediments (207 m)
Hydrocarbons:	Some oil bleeding from core in volcanics; some oil impregnation in sandstones, some gas under pressure in sandstones

Table 2. Technical data from the grønArctic well GANK#1

Well name:	grønArctic Nuussuaq Kuussuaq#1 (GANK#1)
Operator:	grønArctic Energy Inc., Regina, Saskatchewan, Canada
Drill contractor:	Petro Drilling Ltd., Halifax, Nova Scotia, Canada
Locality:	Aaffarssuaq valley, Nuussuaq, West Greenland
Coordinates:	70°28′25" N, 53°53′25" W
Elevation:	91 m a.s.l.
Well spud date:	August 11, 1995
Termination:	August 28, 1995
Rig type:	Longyear 44 Diamond Core Drill, adapted mining rig
Total depth:	398 m , ~100% core recovery
Hole diameter:	0–168 m: 96.0 mm (HQ rods), 168–398 m: 75.8 mm (NQ rods)
Core diameter:	0–168 m: 63.5 mm, 168–398 m: 47.6 mm
Status:	Plugged and abandoned
Main target:	Structural Marraat-type prospect (oil generated from Tertiary deltaic source rock, Tertiary or Cretaceous sandstone reservoir)
Formations drilled:	Lower Tertiary volcanics (115 m), Lower Tertiary and ?Cretaceous clastic sediments (273 m)
Hydrocarbons:	Traces of oil in volcanics and sediments, some gas under pressure in sandstones

Table 3. Technical data from the grønArctic well GANT#1

Well name:	grønArctic Nuussuaq Tunorssuaq#1 (GANT#1)
Operator:	grønArctic Energy Inc., Regina, Saskatchewan, Canada
Drill contractor:	Petro Drilling Ltd., Halifax, Nova Scotia, Canada
Locality:	Tunorssuaq valley, Nuussuaq, West Greenland
Coordinates:	70°42′70" N, 53°36′02" W
Elevation:	~440 m a.s.l.
Well spud date:	July 14, 1995
Termination:	August 11, 1995
Rig type:	Longyear 50 Diamond Core Drill, adapted mining rig
Total depth:	901 m, ~100% core recovery
Hole diameter:	0–249 m: 96.0 mm (HQ rods), 249–901 m: 75.8 mm (NQ rods)
Core diameter:	0–249 m: 63.5 mm, 249–901 m: 47.6 mm
Status:	Plugged and abandoned
Main target:	Structural Serfat-type prospect (oil/condensate generated from mid-Cretaceous source rock, marine Upper Cretaceous or non-marine Lower Cretaceous sandstone reservoir)
Formations drilled:	Lower Tertiary and Upper Cretaceous siliciclastic sediments (901 m)
Hydrocarbons:	Some gas under pressure in many sandstone units

Table 4. Screening data, **Core 439001 (GANE#1)**

Depth GEUS No.	TOC(%)	TS(%)	S_1	S_2	HI	T_{max}(°C)	R_o(%)	n
497.7 m -693	3.40		0.57	6.04	178	430		
499.5 m -692	3.69		0.33	4.28	116	437		
501.8 m -691	3.11		0.28	3.88	125	439		
503.9 m -429	1.94		0.21	1.19	66	438	0.70	68/68
504.0 m -690	3.02		0.36	4.04	134	439		
505.3 m -689	2.35		0.14	1.22	52	439		
507.9 m -688	2.30		0.20	1.82	79	441		
510.0 m -687	3.84		0.77	6.76	176	432		
510.3 m -511	3.81	3.38	0.87	5.58	146	436	0.66	68/81
513.0 m -686	3.65		0.56	4.88	134	438		
515.5 m -684	3.33		0.41	3.82	115	436		
518.0 m -683	2.02		0.18	1.48	73	442		
520.0 m -682	2.48		0.50	3.44	139	432		
522.0 m -681	3.87		0.83	6.60	171	434		
526.4 m -512	4.83	3.42	1.14	9.53	197	432	0.69	75/75
526.7 m -680	3.86		0.72	7.52	195	433		
530.0 m -679	4.46		0.96	8.46	190	432		
532.0 m -678	3.88		0.51	6.38	164	435		
533.9 m -677	2.71		0.40	3.90	144	435		
534.5 m -513	2.92	2.81	0.50	4.09	140	433	0.70	62/65
536.5 m -646	3.07		0.34	4.26	139	435		
536.7 m -676	5.45		0.87	9.56	175	430		
537.3 m -675	2.78		0.29	3.46	125	436		
540.0 m -673	4.12		0.67	7.00	170	430		
541.9 m -645	5.59		0.86	10.36	185	432		
542.0 m -672	5.36		0.78	9.70	181	432		
543.7 m -671	2.95		0.35	4.40	149	436		
553.3 m -644	3.80		0.40	5.60	147	430		
564.4 m -642	2.31		0.20	1.76	76	436		
564.7 m -514	2.09	4.25	0.36	3.20	103	437	0.75	70/91

565.3 m	-668	2.37		0.23	1.92	81	438		
565.8 m	-641	2.46		0.22	2.06	84	437		
567.8 m	-667	4.72		0.79	9.50	201	430		
568.2 m	-640	4.21		0.40	8.00	190	429		
570.2 m	-345	0.42	0.35	0.09	0.36	86	437		
578.4 m	-348	2.73	1.64	0.51	5.14	188	433		
581.5 m	-349	2.22		0.37	0.52	23*	532*		
582.0 m	-636^{A}	2.19		0.12	1.84	84	440		
583.0 m	-664	2.09		0.07	1.52	73	439		
584.0 m	635^{A}	2.04		0.12	1.54	76	439		
584.4 m	-350	2.73	0.22	0.51	5.14	188	433		
585.5 m	-634^{A}	2.03		0.11	1.46	72	439		
585.5 m	-663	2.14		0.12	1.54	72	438		
587.1 m	-662	1.98		0.10	1.52	77	440		
588.1 m	633^{A}	1.88		0.08	1.36	73	441		
588.6 m	-352	2.09	0.24	0.10	1.48	71	440		
589.0 m	-632^{A}	1.98		0.09	1.40	71	442		
589.0 m	-661	2.03		0.10	1.42	70	439		
591.0 m	-660	1.87		0.07	1.22	65	443		
591.1 m	-353	2.27		0.10	1.56	69	439		
591.8 m	-354	2.13	0.25	0.10	1.66	78	444		
592.1 m	-631^{A}	2.16		0.12	1.64	76	441		
593.0 m	-659	1.90		0.10	1.34	71	439		
593.7 m	-630^{A}	2.11		0.11	1.62	77	441		
594.7 m	-658	2.56		0.19	2.62	102	434		
595.2 m	-629^{A}	2.16		0.17	2.20	102	437		
597.2 m	-627^{A}	2.17		0.08	1.92	89	439		
597.4 m	-657	2.88		0.28	3.22	112	436		
599.1 m	-356	1.56	0.26	0.16	1.56	100	440		
600.0 m	-459	2.23		0.13	1.46	67	439	0.67	56/65
604.9 m	-358	0.60	0.37	0.10	0.52	87	442		
607.1 m	-626^{A}	2.43		0.20	2.50	103	438		

608.9 m -665								
615.9 m -515	2.50	0.50	0.28	2.16	86	435	0.68	57/65
627.1 m -366[A]	1.88		0.27	2.02	107	434		
633.4 m -621[A]	4.57		1.42	12.10	265	432		
633.7 m -368[A]	2.88	0.38	0.40	4.22	147	434		
635.4 m -369[A]	3.95	2.36	1.36	7.60	192	431	0.58	40/62
635.8 m -620[A]	5.69		1.15	7.14	126	433		
636.5 m -619[A]	3.45		0.50	3.64	105	438		
637.6 m -618[A]	1.45		2.82	2.28	157	438		
640.0 m -617[A]	4.39		2.51	5.98	136	436		
641.4 m -370[A]	3.81	2.64	1.71	5.44	143	436	0.60	33/39
642.0 m -616[A]	3.57		1.48	6.54	183	437		
643.5 m -615[A]	3.09		0.56	3.68	119	439		
644.6 m -371[A]	2.49	1.20	0.32	3.30	133	433		
645.8 m -614[A]	2.96		0.42	4.74	160	438		
649.4 m -373[A]	2.05	0.40	0.33	2.72	133	436	0.71	37/49
649.8 m -613[A]	3.41		0.74	6.78	199	432		
651.6 m -612[A]	3.23		0.73	6.32	196	437		
663.5 m -520[A]	2.68		0.13	1.80	67*	457*		
669.6 m -522[A]	0.30		0.01	0.04	13*	n.d.*		
678.7 m -607[A]	2.32		0.10	0.82	35*	485*		
679.8 m -526[A]								
680.2 m -606[A]	2.41		0.15	0.74	31*	512*		

* elevated value due to thermal effect from dykes and sills or occasionally hydrothermal solutions (omitted from calculations)

[A]: from sidetrack (GANE#1A)

Table 5. Extraction data, **Core 439001 (GANE#1)**

Depth	GEUS No.	Extract[1]	Asph (%)	Sat (%)[2]	Aro (%)[2]	NSO (%)[2]	Sat/Aro
5.6 m	-01[O]	n.a.[W]	0.9	59.4	15.9	24.7	3.73
5.6 m	-01[O]	n.a.[C]	4.2	64.8	13.9	21.3	4.66
47.1 m	-55[O]	n.a.[W]	6.8	34.2	25.3	40.5	1.35
147.8 m	-128[O]	n.a.[W]	2.3	56.7	23.2	20.2	2.44
147.8 m	-128[O]	n.a.[W]	2.1	57.6	23.2	19.2	2.48
152.9 m	-132[O]	n.a.[W]	1.7	58.7	18.3	23.0	3.21
152.9 m	-132[O]	n.a.[W]	2.1	57.9	19.9	22.2	2.91
158.2 m	-107[O]	n.a.[W]	8.8	60.5	17.0	22.3	3.57
158.2 m	-107[O]	n.a.[W]	9.2	60.5	17.3	22.2	3.50
241.0 m	-477[O]	n.a.[W]	1.8	80.3	6.1	13.6	13.16
241.0 m	-477[O]	n.a.[C]	12.7	76.4	9.1	14.5	8.40
267.8 m	-200[O]	n.a.[W]	4.9	67.6	9.2	24.7	7.35
267.8 m	-200[O]	n.a.[C]	8.8	63.5	9.6	21.3	6.61
503.0 m	-429	27[E]	53.0	9.1	12.1	78.8	0.75
510.3 m	-511	41[E]	37.9	26.1	30.9	43.0	0.84
526.4 m	-512	36[E]	47.3	23.4	30.5	46.1	0.77
534.5 m	-513	36[E]	61.2	18.2	26.0	55.8	0.70
564.7 m	-514	32[E]	59.2	21.5	23.1	55.4	0.93
600.0 m	-459	20[E]	66.7	10.0	16.7	73.3	0.60
615.0 m	-515	24[E]	60.8	16.7	22.2	61.1	0.75
635.4 m	-369[O]	93[E]	19.7	33.5	22.0	44.5	1.52
638.1 m	-648[O]	n.a.[C]	4.6	57.3	16.4	26.4	3.49
638.5 m	-647[O]	n.a.[C]	3.5	62.1	14.1	23.8	4.40
640.3 m	-654[O]	n.a.[C]	6.2	46.4	18.0	35.6	2.58
641.4 m	-370[O]	87[E]	22.2	30.1	24.2	45.7	1.25
649.4 m	-373[O]	61[E]	33.2	21.8	20.3	57.9	1.07
surf.	439805[O]	n.a.[C]	33.3	18.2	18.2	63.6	~1
surf.	439905[O]	n.a.[C]	2.8	85.3	3.8	10.7	22.42

n.a: not available
1: (mg SOM/g TOC)
2: relative concentration of asphaltene-free extract
O: oil
W: core washed only
C: core crushed and washed only
E: core crushed and extracted

Table 6. Gas chromatography data, **Core 439001 (GANE#1)**

Depth GEUS No.	Pr/Ph	Pr/*n*17	Ph/*n*C18	Iso/*n*C	CPI[1]	Philippi[2]
5.6 m -01[O]	5.17	3.31	0.65	1.03	1.19	1.55
47.1 m -55[O]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
147.8 m -128[O]	5.16	3.47	0.62	1.00	1.18	1.52
152.9 m -132[O]	4.90	2.03	0.27	0.49	1.15	1.51
158.2 m -107[O]	4.79	6.87	1.08	2.43	1.17	1.55
241.0 m -477[O]	5.24	0.85	0.18	0.29	1.23	1.69
267.8 m -200[O]	5.96	2.90	0.55	0.89	1.13	1.57
503.0 m -429	7.31	2.75	0.37	0.72	1.32	1.82
510.3 m -511	4.36	1.69	0.54	0.71	1.28	1.54
526.4 m -512	7.03	6.06	0.90	1.62	1.38	1.63
534.5 m -513	7.90	5.95	0.77	1.54	1.28	1.53
564.7 m -514	6.52	4.28	0.67	1.19	1.36	1.75
600.0 m -459	7.17	2.08	0.24	0.48	1.26	1.71
615.0 m -515	5.84	2.13	0.36	0.59	1.22	1.57
635.4 m -369[O]	2.65	1.44	0.72	0.65	n.a.	n.a.
638.1 m -648[O]	2.62	1.74	0.69	0.70	n.a.	n.a.
638.5 m -647[O]	2.60	1.71	0.68	0.70	n.a.	n.a.
640.3 m -654[O]	3.42	1.80	0.57	0.80	n.a.	n.a.
641.4 m -370[O]	4.76	1.69	0.47	0.83	n.a.	n.a.
649.4 m -373(O)	4.02	1.44	0.39	0.50	n.a.	n.a.
surf. 439805[O]	3.29	1.69	0.20	0.08	1.20	1.51
surf. 439905[O]	4.81	1.60	0.15	0.08	1.20	1.51

n.a.: not available

[1]: defined as $2 \text{ x } (C_{23}+C_{25}+C_{27}+C_{29}+C_{31}) / C_{22} + 2 \text{ x } (C_{24}+C_{26}+C_{28}+C_{30}) + C_{32}$

[2]: defined as $2 \text{ x } C_{29} / (C_{28}+C_{30})$

[O]: oil

Table 7. GC/MS data on thermal maturity, **Core 439001 (GANE#1)**

Depth	GEUS no.	Ts/Ts +Tm	Tm/Tm +17β	H31 22S/22S +22R	H32 22S/22S +22R	H30 αβ/αβ +βα	S29 20S/20S +20R	S29 ββ/αα +ββ
5.6 m	-01^{O}	0.14	0.91	0.59	0.58	0.82	0.37	0.35
47.1 m	-55^{O}	0.12	0.90	0.58	0.60	0.81	0.39	0.40
147.8 m	-128^{O}	0.15	0.91	0.60	0.62	0.85	0.39	0.34
152.9 m	-132^{O}	0.15	0.91	0.60	0.62	0.85	0.40	0.36
158.2 m	-107^{O}	0.14	0.91	0.61	0.61	0.83	0.42	0.33
241.0 m	-477^{O}	0.34	0.87	0.57	0.58	0.73	0.36	0.36
267.8 m	-200^{O}	0.21	0.86	0.60	0.58	0.70	0.40	0.37
503.0 m	-429	0.02	0.94	0.60	0.60	0.64	0.36	0.19
510.3 m	-511	0.10	0.95	0.61	0.58	0.72	0.52	0.47
526.4 m	-512	0.03	0.95	0.60	0.60	0.71	n.a.	n.a.
534.5 m	-513	0.02	0.94	0.60	0.59	0.68	0.50	0.37
564.7 m	-514	0.02	0.95	0.60	0.60	0.70	0.49	0.49*
600.0 m	-459	0.01	0.95	0.63	0.61	0.71	0.42	0.24
615.0 m	-515	0.02	0.95	0.59	0.62	0.75	0.31	0.24
635.4 m	-369$^{(O)}$	0.30	1.00	0.57	0.57	n.a.	n.a.	n.a.
638.1 m	-648^{O}	0.24	1.00	0.58	0.61	0.83	n.a.	n.a.
638.5 m	-647^{O}	0.22	1.00	0.60	0.60	0.80	n.a.	n.a.
640.3 m	-654^{O}	0.27	1.00	0.58	0.61	0.84	n.a.	n.a.
641.4 m	-370$^{(O)}$	0.24	1.00	0.56	0.60	0.84	0.38	0.50
649.4 m	-373$^{(O)}$	0.14	1.00	0.60	0.60	0.80	0.30	0.45
surf.	439805^{O}	0.27	0.85	0.58	0.59	0.82	0.35	0.36
surf.	439905^{O}	0.14	0.92	0.59	0.58	0.83	0.35	0.31

n.a.: not available

*: Value not reliable, coelution with other compounds

^{O}: Oil

Table 8. *GC/MS data on depositional environment*, **Core 439001 (GANE#1)**

Depth	GEUS No.	BNL/H30	H28/H30	H29/H30	O/H30	S27[1]	S28[1]	S29[1]	S27/S29[2]
5.6 m	-01[O]	0.56*	0.00	0.81	0.83	15	14	71	0.21
47.1 m	-55[O]	0.55*	0.00	0.88	0.95	14	13	73	0.19
147.8 m	-128[O]	0.56*	0.00	0.81	0.95	14	13	73	0.19
152.9 m	-132[O]	0.53*	0.00	0.87	0.97	12	13	75	0.17
158.2 m	-107[O]	0.44*	0.00	0.83	1.03	13	13	74	0.17
241.0 m	-477[O]	0.77*	0.00	0.92	0.44	31	13	56	0.54
267.8 m	-200[O]	0.73*	0.00	0.97	0.65	29	14	57	0.51
503.0 m	-429	0.03	0.00	1.07	0.01	24	11	65	0.17
510.3 m	-511	0.23	0.00	0.81	0.05	24	11	65	0.38
526.4 m	-512	0.83	0.00	0.85	0.39	n.a.	n.a.	n.a.	n.a.
534.5 m	-513	0.15	0.00	0.85	0.05	12	10	78	0.16
564.7 m	-514	0.29	0.00	0.95	0.01	11	8	81	0.13
600.0 m	-459	0.09	0.00	1.26	0.02	13	10	77	0.17
615.0 m	-515	0.02	0.00	0.87	0.00	8	6	86	0.10
635.4 m	-369(O)	0.00	n.a.	n.a.	0.00	n.a.	n.a.	n.a.	n.a.
638.1 m	-648[O]	0.00	0.25	0.55	0.00	n.a.	n.a.	n.a.	n.a.
638.5 m	-647[O]	0.00	0.30	0.61	0.00	n.a.	n.a.	n.a.	n.a.
640.3 m	-654[O]	0.00	0.29	0.48	0.00	n.a.	n.a.	n.a.	n.a.
641.4 m	-370(O)	0.00	0.40	0.60	0.00	36	8	56	0.63
649.4 m	-373(O)	0.00	0.18	0.64	0.00	16	6	78	0.20
surf.	439805[O]	0.37*	0.00	0.65	0.51	29	16	55	0.53
surf.	439905[O]	0.42*	0.00	0.57	0.80	16	14	70	0.23

n.a.: not available
1: calculated as % of C_{27}, C_{28} and C_{29} for ααR isomers in m/z 217
2: calculated as ratio of C_{27} to C_{29} of ααR isomers in m/z 217
O: oil
*: value not reliable, coelution with other compounds

Table 9. Carbon isotope data for total extracts and fractions, **Core 439001 (GANE#1)**

Depth GEUS No.	Extr.	Sat	Aro	NSO	Asph
5.6 m -01^{O}		-28.57	-26.65	-26.57	-26.49
147.8 m -128^{O}	-27.24	-28.35	-26.19	-25.97	-26.29
152.9 m -132^{O}	-27.37	-28.50	-26.44	-26.04	-26.07
158.2 m -107^{O}	-27.21	-28.12	-26.43	-26.38	-26.60
241.0 m -477^{O}		-28.06	-27.12	-26.93	-27.14
267.8 m -200^{O}		-28.17	-27.13	-26.92	-27.15
538.1 m -648^{O}	-32.23	-31.49	-32.00	-31.92	-28.57

^{O}: oil

Table 10. Screening data, **Core 439201 (GANK#1)**

Depth	GEUS No.	TOC(%)	TS(%)	S_1	S_2	HI	T_{max}(°C)	R_o(%)	n
120.9 m	-30	5.00	3.86	0.31	9.62	192	422		
130.7 m	-33	5.73	4.59	0.40	11.38	199	421		
136.2 m	-36	4.32	3.59	0.10	4.48	93 –	426		
144.1 m	-38	2.15	3.05	0.04	1.56	73 –	434		
151.5 m	-40	2.29	2.37	0.06	1.52	66 –	434	0.58	41/61
157.6 m	-42	2.98	3.81	0.12	3.22	108 –	431		
163.1 m	-44	2.61	3.02	0.10	2.50	96 –	435		
167.6 m	-46	3.30	3.47	0.22	5.74	174	429		
174.7 m	-48	1.00	0.24	0.03	0.76	76 –	434		
180.8 m	-50	0.31	0.32	0.00	0.12	38 –	430		
188.9 m	-52	3.18	2.92	0.15	3.32	104 –	433	0.57	50/50
198.7 m	-54	2.53	2.87	0.12	2.64	104 –	435		
229.4 m	-66	4.45	4.86	0.20	4.76	107 –	432		
240.3 m	-70	2.59	2.71	0.10	2.26	87 –	432		
252.3 m	-73	2.30	2.87	0.07	1.36	59 –	435		
259.3 m	-76	2.94	2.96	0.19	4.04	138	428		
281.6 m	-83	3.52	3.51	0.21	4.66	132	428		
310.2 m	-93	2.96	2.70	0.12	2.26	76 –	439		
318.8 m	-96	2.09	2.42	0.11	1.18	56 –	440		
326.9 m	-99	1.36		0.08	0.16	12*	521*		
352.1 m	-108	3.53	2.73	0.34	4.73	134	435	0.56	41/61
359.8 m	-111	2.94	3.89	0.24	3.07	104 –	440		
365.9 m	-113	3.28	4.20	0.33	4.23	129	434	0.62	65/65
371.8 m	-115	2.97	3.12	0.27	2.96	100 –	435		
379.5 m	-118	2.87	2.72	0.26	3.03	106 –	436	0.62	70/70
387.0 m	-121	2.56	2.82	0.21	3.48	136	431		
389.5 m	-122	1.88	2.24	0.11	2.54	135	434		
392.6 m	-123	1.74	2.34	0.11	2.12	122 –	434		
395.8 m	-124	2.36	3.09	0.18	3.64	154	431	0.55	41/58
396.5 m	-125	2.53	2.81	0.15	2.40	95 –	438		

* elevated value due to thermal effect from dykes and sills or occasionally hydrothermal solutions (omitted from calculations)

Table 11. Extraction data, **Core 439201 (GANK#1)**

Depth	GEUS No.	Extract[1]	Asph (%)	Sat (%)[2]	Aro (%)[2]	NSO (%)[2]	Sat/Aro
88.4 m	-520[O]	n.a.[W]	18.0	45.2	14.3	40.5	3.16
151.5 m	-40	28[E]	55.9	2.5	2.5	95.0	1.00
158.6 m	-545	n.a.[E]	40.5	10.3	9.5	80.2	1.08
164.2 m	-549	n.a.[E]	44.5	9.8	8.2	82.0	1.19
188.9 m	-52	31[E]	51.8	7.1	15.3	77.6	0.46
229.4 m	-66	21[E]	34.6	13.7	12.6	73.7	1.07
259.3 m	-76	46[E]	38.6	9.5.	12.2	78.4	0.78
270.2 m	-206[O]	n.a.[C]	1.3	73.4	13.1	13.4	5.60
310.2 m	-93	35[E]	39.8	10.8	15.7	73.5	0.69
331.4 m	-202[O]	n.a.[C]	54.2	20.0	6.7	73.3	3.00
352.1 m	-108	36[E]	41.7	7.4	18.2	74.4	0.41
365.9 m	-113	35[E]	54.0	15.9	8.0	76.1	1.99
379.5 m	-118	30[E]	48.8	12.3	7.7	80.0	1.60
395.8 m	-124	38[E]	52.0	11.0	14.6	74.4	0.75

n.a: not available
1: (mg SOM/g TOC)
2: relative concentration of asphaltene-free extract

[O]: oil
[W]: core washed only
[C]: core crushed and washed only
[E]: core crushed and extracted

Table 12. Gas chromatography data, **Core 439201 (GANK#1)**

Depth GEUS No.	Pr/Ph	Pr/*n*17	Ph/*n*C18	Iso/*n*C	CPI[1]	Philippi[2]
88.4 m -520^{O}	4.22	0.50	0.10	0.14	1.19	1.55
151.5 m -40	6.87	4.83	0.79	1.44	1.84	2.81
158.6 m -545	5.80	6.06	1.10	1.66	1.80	2.90
164.2 m -549	4.32	3.65	0.92	1.07	1.84	3.04
188.9 m -52	7.19	7.31	1.07	1.93	1.75	2.79
229.4 m -66	5.93	3.27	0.60	0.99	1.72	2.71
259.3 m -76	8.63	9.47	1.25	2.04	1.70	2.51
270.2 m -206^{O}	3.69	0.78	0.17	0.21	1.02	1.02
310.2 m -93	8.94	7.78	1.00	2.04	1.73	2.64
331.4 m -202$^{(O)}$	1.47	0.82	0.72	0.45	1.35	1.79
352.1 m -108	8.51	7.51	0.99	2.04	1.68	2.59
365.9 m -113	6.66	6.56	0.98	1.66	1.70	2.56
379.5 m -118	7.49	6.70	0.95	1.72	1.71	2.67
395.8 m -124	7.61	7.03	0.93	1.73	1.56	2.26

n.a.: not available
1: defined as 2 x $(C_{23}+C_{25}+C_{27}+C_{29}+C_{31})$ / C_{22} + 2 x $(C_{24}+C_{26}+C_{28}+C_{30})$ + C_{32}
2: defined as 2 x C_{29} / $(C_{28}+C_{30})$
^{O}: oil

Table 13. GC/MS data on thermal maturity, **Core 439201 (GANK#1)**

Depth	GEUS no.	Ts/Ts +Tm	Tm/Tm +17β	H31 22S/22S +22R	H32 22S/22S +22R	H30 αβ/αβ +βα	S29 20S/20S +20R	S29 ββ/αα +ββ
88.4 m	-520^{O}	0.14	0.95	0.56	0.59	0.84	0.39	0.40
151.5 m	-40	0.04	0.84	0.46	0.44	0.56	n.a.	n.a.
158.6 m	-545	0.04	0.85	0.50	0.43	0.59	n.a.	n.a.
164.2 m	-549	0.04	0.86	0.53	0.48	0.60	0.38	0.32
188.9 m	-52	0.03	0.83	0.47	0.45	0.57	n.a.	n.a.
229.4 m	-66	0.04	0.83	0.54	0.43	0.61	0.17	0.30
259.3 m	-76	0.02	0.87	0.55	0.50	0.61	n.a.	n.a.
270.2 m	-206^{O}	0.20	n.a.	0.39	0.39	0.79	0.33	0.37
310.2 m	-93	0.02	0.85	0.57	0.49	0.60	n.a.	n.a.
331.4 m	-202^{O}	0.29	1.00	0.60	0.60	0.87	n.a.	n.a.
352.1 m	-108	0.02	0.87	0.56	0.53	0.60	n.a.	n.a.
365.9 m	-113	0.02	0.91	0.56	0.57	0.58	n.a.	n.a.
379.5 m	-118	0.02	0.90	0.56	0.59	0.58	n.a.	n.a.
395.8 m	-124	0.02	0.92	0.57	0.58	0.58	n.a.	n.a.

n.a.: not available

^{O}: Oil

Table 14. *GC/MS data on depositional environment*, **Core 439201 (GANK#1)**

Depth GEUS No.	BNL/H30	H29/H30	O/H 30	S27[1]	S28[1]	S29[1]	S27/S29[2]
88.4 m -520[O]	0.37	0.82	0.57	13	12	75	0.17
151.5 m -40	1.81	0.69	0.00	17	7	6	0.22
158.6 m -545	0.74	0.67	0.01	16	7	77	0.21
164.2 m -549	0.16	0.70	0.11	21	11	68	0.30
188.9 m -52	1.07	0.74	0.01	20	5	75	0.26
229.4 m -66	0.05	0.61	0.03	18	13	69	0.26
259.3 m -76	0.62	0.67	0.02	18	9	73	0.24
270.2 m -206(O)	0.62	0.53	0.15	38	20	42	0.94
310.2 m -93	0.62	0.62	0.01	17	9	74	0.23
331.4 m -202(O)	0.00	0.52	0.00	n.a.	n.a.	n.a.	n.a.
352.1 m -108	0.31	0.71	0.01	9	9	82	0.10
369.9 m -113	0.55	0.76	0.01	13	8	79	0.16
379.5 m -118	0.59	0.81	0.01	15	7	78	0.19
395.8 m -124	0.80	0.78	0.01	16	10	74	0.20

1: calculated as % of C_{27}, C_{28} and C_{29} for ααR isomers in m/z 217
2: calculated as ratio of C_{27} to C_{29} of ααR isomers in m/z 217

[O]: oil

Table 15. Screening data, **Core 439101 (GANT#1)**

Depth GEUS No.		TOC(%)	TS(%)	S_1	S_2	HI	T_{max}(°C)	R_o(%)	n
58.2 m	-13	1.49	1.06	0.04	0.78	52	437		
68.1 m	-18	2.02	1.36	0.06	0.84	42	436	0.63	16/29
75.3 m	-20	1.60	1.26	0.06	0.84	53	436		
88.0 m	-23	2.90	2.82	0.08	1.55	53	431		
97.2 m	-102	2.42	1.16	0.10	1.26	52	431	0.66	29/40
121.9 m	-26	3.08	2.26	0.12	2.56	83	437		
254.7 m	-153	5.78	4.88	0.48	7.98	138	434		
267.3 m	-158	3.56	2.13	0.16	3.22	91	443	0.67	30/47
277.2 m	-161	3.12	2.65	0.17	3.00	96	437		
286.7 m	-164	3.59	3.68	0.25	3.94	110	434		
295.1 m	-167	2.67	2.03	0.12	2.18	82	437		
310.0 m	-172	3.64	2.76	0.23	3.26	89	437		
322.2 m	-176	3.59	3.68	0.21	3.66	102	443	0.64	42/65
331.5 m	-179	4.30	3.26	0.36	4.86	113	437		
340.0 m	-182	3.45	2.30	0.21	3.26	95	440		
354.5 m	-187	4.58	3.66	0.37	5.10	111	436		
374.9 m	-193	5.07	1.52	0.40	7.00	138	438	0.64	53/58
385.2 m	-197	3.83	3.66	0.39	4.98	130	435		
401.1 m	-202	2.82	2.29	0.32	3.36	119	431		
416.9 m	-207	4.07	3.75	0.45	4.34	107	437		
466.2 m	-360	3.19	1.13	0.28	2.90	91	437		
476.0 m	-363	5.31	3.39	0.57	6.78	128	437	0.71	42/72
490.1 m	-368	4.38	3.11	0.52	5.84	133	437		
506.8 m	-373	7.57	3.02	0.97	10.08	133	440		
519.1 m	-378	6.50	2.14	0.87	6.18	95	442	0.76	36/48
535.7 m	-382	5.45	3.30	0.73	6.72	123	439		

Continued at next page

Table 15. Screening data, **Core 439101 (GANT#1) continued**

Depth	GEUS No.	TOC(%)	TS(%)	S_1	S_2	HI	T_{max}(°C)	R_o(%)	n
551.2 m	-388	5.64		0.72	7.00	124	440		
567.5 m	-503	3.53	0.20	0.60	3.35	95	449		
589.4 m	-401	7.16	2.66	1.22	9.87	138	442	0.71	35/90
593.9 m	-505	5.78	2.20	0.89	6.15	106	446		
606.9 m	-506	6.36	3.02	0.99	7.32	115	438		
608.0 m	-407	5.86	2.99	0.87	6.84	117	444		
645.9 m	-419	7.52		0.90	9.68	129	441	0.74	41/54
671.2 m	-425	6.69		0.96	8.30	124	443		
691.6 m	-433	6.21		0.81	7.46	120	441	0.74	21/22
706.8 m	-437	8.84		1.49	12.16	138	443	0.79	35/78
794.0 m	-465	4.79	0.54	0.33	4.70	98	444	0.76	9/63
797.1 m	-518	8.61	1.32	1.28	9.18	107	448	0.86	66/75
813.1 m	-519	6.58	2.99	0.91	3.16	48	467		
836.7 m	-520	7.18	2.84	1.42	6.97	97	449	0.93	68/78
850.3 m	-482	6.63		0.89	6.86	103	448		
859.2 m	-487	6.64		0.81	6.32	95	450		
869.5 m	-521	3.43	2.83	0.44	2.32	68	449		
879.5 m	-494	4.69	2.34	0.42	3.18	68	452		
894.5 m	-522	6.46	1.15	0.88	3.90	60	464	0.96	47/75

Table 16. Extraction data, **Core 439101 (GANT#1)**

Depth GEUS No.	Extract[1]	Asph (%)	Sat (%)[2]	Aro (%)[2]	NSO (%)[2]	Sat/Aro
68.1 m -18	15[E]	56.9	14.3	9.5	76.2	1.51
97.2 m -102	15[E]	51.0	10.5	10.5	78.9	1.00
267.3 m -158	27[E]	55.1	16.9	15.7	66.7	1.08
322.2 m -176	25[E]	56.5	14.3	10.7	75.0	1.33
374.9 m -193	22[E]	56.8	16.2	14.9	68.9	1.09
476.0 m -363	20[E]	53.3	14.6	7.3	78.0	2.00
519.1 m -378	17[E]	50.5	13.5	21.3	65.2	0.63
589.4 m -401	19[E]	41.4	16.7	6.0	77.4	2.78
608.0 m -407	19[E]	37.5	19.1	9.6	71.3	1.99
610.6 m -805[O]	n.a.[W]	n.a.	n.a.	n.a.	n.a.	n.a.
645.9 m -419	18[E]	47.2	16.5	10.1	73.4	1.63
691.6 m -433	21[E]	40.4	35.3	10.1	54.7	3.50
706.8 m -437	26[E]	28.2	38.4	10.8	50.8	3.56
794.0 m -465	20[E]	32.6	14.7	5.9	79.4	2.49
797.2 m -518	16[E]	46.3	11.4	10.1	78.5	1.13
836.7 m -520	20[E]	32.3	17.2	8.6	74.2	2.00
869.5 m -521	18[E]	36.9	13.3	6.7	80.0	2.04
894.5 m -522	18[E]	16.2	18.1	5.6	76.4	3.23

n.a: not available
1: (mg SOM/g TOC)
2: relative concentration of asphaltene-free extract

[E]: core crushed and extracted
[W]: core washed only
[O]: oil

Table 17. Gas chromatography data, **Core 439101 (GANT#1)**

Depth GEUS No.	Pr/Ph	Pr/*n*17	Ph/*n*C18	Iso/*n*C	CPI[1]	Philippi[2]
68.1 m -18	4.78	2.38	0.36	0.52	1.41	1.97
97.2 m -102	4.86	2.16	0.34	0.49	1.34	1.87
267.3 m -158	4.71	2.57	0.44	0.62	1.43	1.91
322.2 m -176	4.80	2.55	0.44	0.63	1.38	1.81
374.9 m -193	5.64	3.11	0.49	0.77	1.25	1.60
476.0 m -363	5.91	2.71	0.45	0.73	1.20	1.58
519.1 m -378	5.71	2.24	0.40	0.71	1.15	1.43
589.4 m -401	4.84	1.36	0.24	0.35	1.19	1.52
608.0 m -407	4.78	1.27	0.25	0.36	1.17	1.45
610.6 m -805[O]	4.58	2.34	0.46	0.62	1.42	1.53
645.9 m -419	4.84	1.80	0.38	0.56	1.11	1.41
691.6 m -433	5.67	1.38	0.23	0.43	1.04	1.35
706.8 m -437	4.44	1.53	0.31	0.47	1.19	1.48
794.0 m -465	4.84	0.71	0.14	0.20	1.09	1.27
797.2 m -518	4.71	0.63	0.11	0.17	1.09	1.26
836.7 m -520	4.54	0.53	0.11	0.18	1.11	1.31
869.5 m -521	3.86	0.77	0.17	0.22	1.04	1.15
894.5 m -522	4.50	0.65	0.14	0.23	1.06	1.20

n.a.: not available

1: defined as $2 \text{ x } (C_{23}+C_{25}+C_{27}+C_{29}+C_{31}) / C_{22} + 2 \text{ x } (C_{24}+C_{26}+C_{28}+C_{30}) + C_{32}$

2: defined as $2 \text{ x } C_{29} / (C_{28}+C_{30})$

[O]: oil

Table 18. GC/MS data on thermal maturity, **Core 439101 (GANT#1)**

Depth	GEUS no.	Ts/Ts +Tm	Tm/Tm +17β	H31 22S/22S +22R	H32 22S/22S +22R	H30 αβ/αβ +βα	S29 20S/20S +20R	S29 ββ/αα +ββ
68.1 m	-18	0.02	0.88	0.57	0.55	0.63	0.27	0.26
97.2 m	-102	0.02	0.90	0.58	0.56	0.63	0.31	0.25
267.3 m	-158	0.04	0.94	0.59	0.59	0.68	0.36	0.27
322.2 m	-176	0.03	0.94	0.60	0.59	0.68	0.40	0.25
374.9 m	-193	0.05	0.95	0.60	0.59	0.74	0.45	0.29
476.0 m	-363	0.06	0.96	0.60	0.62	0.78	0.51	0.40
519.1 m	-378	0.06	0.97	0.59	0.61	0.77	0.42	0.37
589.4 m	-401	0.09	0.99	0.59	0.65	0.93	0.46	0.54
608.0 m	-407	0.10	0.99	0.59	0.64	0.89	0.50	0.54
610.6 m	-805^{O}	0.16	1.00	0.62	0.63	0.82	0.50	0.51
654.9 m	-419	0.11	0.96	0.60	0.61	0.92	0.51	0.55
691.6 m	-433	0.13	0.99	0.60	0.61	0.93	0.51	0.55
706.8 m	-437	0.16	0.99	0.62	0.62	0.93	0.55	0.56
794.0 m	-465	0.13	0.99	0.58	0.61	0.91	0.54	0.54
797.2 m	-518	0.10	0.99	0.59	0.63	0.89	0.48	0.51
836.7 m	-520	0.21	1.00	0.60	0.64	0.93	0.49	0.55
869.5 m	-521	0.16	1.00	0.58	0.61	0.90	0.51	0.52
894.5 m	-522	0.43	1.00	0.57	0.63	0.88	n.a.	n.a.

n.a.: not available
^{O}: oil

Table 19. *GC/MS data on depositional environment*, **Core 439101 (GANT#1)**

Depth	GEUS No.	BNL/H30	H28/H30	H29/H30	O/H30	S27[1]	S28[1]	S29[1]	S27/S29[2]
68.1 m	-18	0.00	0.00	0.75	0.01	25	18	57	0.45
97.2 m	-102	0.00	0.00	0.82	0.02	26	17	57	0.47
267.3 m	-158	0.00	0.00	0.71	0.02	26	16	58	0.45
322.2 m	-176	0.00	0.00	0.72	0.02	21	17	62	0.34
374.9 m	-193	0.04	0.00	0.80	0.26	19	16	65	0.29
476.0 m	-363	0.00	0.36	0.83	0.26	21	17	62	0.33
519.1 m	-378	0.00	0.11	0.78	0.03	16	12	72	0.22
589.4 m	-401	0.00	0.11	0.73	0.01	17	11	72	0.23
608.0 m	-407	0.00	0.02	0.62	0.01	21	16	63	0.34
610.6 m	-805[O]	0.00	0.34	0.91	0.30	5	18	77	0.65
645.9 m	-419	0.00	0.44	0.63	0.42	9	11	80	0.12
691.6 m	-433	0.00	0.22	0.62	0.50	12	14	74	0.17
706.8 m	-437	0.00	0.15	0.54	0.21	13	15	72	0.19
794.0 m	-465	0.00	0.31	0.68	1.94	15	12	73	0.20
797.2 m	-518	0.00	0.00	0.71	0.04	12	8	80	0.15
836.7 m	-520	0.00	0.05	0.56	0.14	14	13	73	0.19
869.5 m	-521	0.00	0.02	0.55	0.01	29	14	57	0.51
894.5 m	-522	0.00	0.08	0.71	0.66	n.a.	n.a.	n.a.	n.a.

1: calculated as % of C_{27}, C_{28} and C_{29} for ααR isomers in m/z 217.
2: calculated as ratio of C_{27} to C_{29} of ααR isomers in m/z 217.

[O]: oil

Table 20. Gas data from the GANE #1 well

GEUS no.	Depth (m)	Time (d.m./h)	Type	CH_4 (ppm)	C_2H_6 (ppm)	C_3H_8 (ppm)	iC_4H_{10} (ppm)	nC_4H_{10} (ppm)	iC_5H_{12} (ppm)	nC_5H_{12} (ppm)	Wetness	$\delta^{13}C$ CH_4 $(^{0}/_{00})$	$\delta^{13}C$ C_2H_6 $(^{0}/_{00})$	$\delta^{13}C$ C_3H_8 $(^{0}/_{00})$	Comments
439001-186	296.71	16.7/16:30	Core in can Volcanics	5680	6.0	33.2	n.p.	n.p.	n.p.	n.p.		n.a.	n.a.	n.a.	
439001-275	467.05	19.7/11:35	Core in can Volcanics	36	2.3	n.p.	n.p.	n.p.	n.p.	n.p.	n.c.	n.a.	n.a.	n.a.	
439001-283	490.47	19.7/17:45	Core in can Volcanics	10	0.39	0.11	n.p.	n.p.	n.p.	n.p.	n.c.	n.a.	n.a.	n.a.	
439001-349	581.51	31.7/15:45	Core in can Mudstone	106	2.93	1.91	n.p.	n.p.	n.p.	n.p.	n.c.	n.a.	n.a.	n.a.	
439001-353	591.12	31.7/23:15	Core in can Mudstone	93	18.3	9.97	n.p.	n.p.	n.p.	n.p.	n.c.	n.a.	n.a.	n.a.	
439007	631.0	22.7/13:15	Steel cylinder	823000	28	8	n.p.	n.p.	n.p.	n.p.	22000	-45.4			thermogenic, low maturity
439001-368	633.73	1.8/23:20	Core in can Mudstone	44400	333	330	67.3	144	28	18	67.0	-45.1	n.a.	n.a.	thermogenic, low maturity
439009	684.60	2.8/21:20	Steel cylinder	3060	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	00	-2.5	n.a.	n.a.	?? (fractionated?)
439010	684.60	3.8/9:30	Bottle w. water	183000	12	6	n.p.	n.p.	n.p.	n.p.	10000	n.a.	n.a.	n.a.	
439011	684.6	3.8/10:00	Bottle w. water	44000	43	19	n.p.	n.p.	n.p.	n.p.	710		n.a.	n.a.	
439012	684.6	2.8/24:00	Bottle w. water	89000	5.6	n.p.	n.p.	n.p.	n.p.	n.p.	16000		n.a.	n.a.	
439001-528 B	686.07		Core in can Sandstone	131	4.54	n.p.	n.p.	n.p.	n.p.	n.p.	n.c.		n.a.	n.a.	
439001-529 D	688.81		Core in can Sandstone	102	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.c.		n.a.	n.a.	
439001-530 A	689.79		Core in can Dolerite	9100	4.02	n.p.	n.p.	n.p.	n.p.	n.p.	2260	-40.9	n.a.	n.a.	thermogenic, med. maturity
439001-531 C	694.59		Core in can Dolerite	3460	2.41	n.p.	n.p.	n.p.	n.p.	n.p.	n.c.		n.a.	n.a.	
439014	695.00	4.8/9:00	Bottle w. water	40000	32	16	n.p.	n.p.	n.p.	n.p.	833		n.a.	n.a.	
439001-564	701.92	6.8/16:20	Core in can Sandstone	908	5.01	6.59	n.p.	n.p.	n.p.	n.p.	78.3	n.a.	n.a.	n.a.	thermogenic, low maturity
439001-565	704.26	6.8/21:25	Core in can Sandstone	622	3.08	1.32	n.p.	n.p.	n.p.	n.p.	141	-43.8	n.a.	n.a.	thermogenic, low maturity
439020	707.00	6.8/17:00	Bottle w. water	286000	80	n.p.	n.p.	n.p.	n.p.	n.p.	3500		n.a.	n.a.	
439021	707.00	6.8/10:45	Bottle w. water	100000	41	12	n.p.	n.p.	n.p.	n.p.	2000		n.a.	n.a.	

n.p. not present
n.c. not calculated
n.a. not available

Table 21. Gas data from the GANK #1 well

GEUS no.	Depth (m)	Time (d.m./h)	Type	CH_4 (ppm)	C_2H_6 (ppm)	C_3H_8 (ppm)	iC_4H_{10} (ppm)	nC_4H_{10} (ppm)	iC_5H_{12} (ppm)	nC_5H_{12} (ppm)	Wetness	$\delta^{13}C$ CH_4 $(^0/_{00})$	$\delta^{13}C$ C_2H_6 $(^0/_{00})$	$\delta^{13}C$ C_3H_8 $(^0/_{00})$	Comments
439201-036	136.17	14.8/17:25	Core in can Mudstone	175	0.4	n.p.	n.p.	n.p.	n.p.	n.p.	438	n.a.	n.a.	n.a.	
439201-046	167.61	15.8/05:00	Core in can Mudstone	332	6.4	n.p.	n.p.	n.p.	n.p.	n.p.	51.9	n.a.	n.a.	n.a.	
439201-054	194.47	16.8/22:25	Core in can Mudstone	46700	2110	384	54	30.8	10.4	3.5	18.7	-49.5	n.a.	n.a.	thermogenic, low maturity
439201-099	326.87	18.8/20:10	Core in can Mudstone	57	38.0	123	16.5	29.6	n.p.	n.p.	n.c.	n.a.	n.a.	n.a.	
439201-105	343.28	19.8/02:00	Core in can Dolerite	286	1.83	n.p.	n.p.	n.p.	n.p.	n.p.	156	n.a.	n.a.	n.a.	
439201-113	365.88	19.8/12:00	Core in can Mudstone	230000	5300	1920	122	152	11	7	31.9	-46.9	-32.3	n.a.	thermogenic, low maturity
439201-118	379.46	19.8/16:10	Core in can Mudstone	133000	4630	1540	140	122	24	8	21.6	-41.9	n.a.	n.a.	thermogenic, low maturity
439201-125	396.50	20.8/10:20	Core in can Mudstone	5500	1310	440	40	44	5.4	4.8	3.14	n.a.	n.a.	n.a.	

n.p. not present
n.c. not calculated
n.a. not available

Table 22. Gas data from the GANT #1 well

GEUS no.	Depth (m)	Time (d.m./h)	Type	CH_4 (ppm)	C_2H_6 (ppm)	C_3H_8 (ppm)	iC_4H_{10} (ppm)	nC_4H_{10} (ppm)	iC_5H_{12} (ppm)	nC_5H_{12} (ppm)	Wetness	$\delta^{13}C$ CH_4 $(^0/_{00})$	$\delta^{13}C$ C_2H_6 $(^0/_{00})$	$\delta^{13}C$ C_3H_8 $(^0/_{00})$	Comments
439107	247.19	23.7/21:20	Steel cylinder	7600	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	00	-65.4	n.a.	n.a.	microbial
439111	608.08	31.7/19:00	Steel cylinder	26900	240	30	n.p.	n.p.	n.p.	n.p.	100	-34.8	n.a.	n.a.	thermogenic, high maturity
439112	608.08	4.8/9:00	Steel cylinder	642000	410	n.p.	n.p.	n.p.	n.p.	n.p.	1566	-35.0	n.a.	n.a.	thermogenic, high maturity
439116	608.08	4.8/12:10	Fabric in can	37200	36	16.3	1.2	3.9	0.5	1	711	-37.0	n.a.	n.a.	thermogenic, high maturity
439101-420	649.42	1.8/21:55	Core in can (S)	188900	3350	562	68	192	30	18	48.2	-46.0	-30.4	n.a.	thermogenic, low maturity
439101-447	737.03	2.8	Core in can (S)	82000	256	40.2	n.p.	n.p.	n.p.	n.p.	277	-40.1	n.a.	n.a.	thermogenic, med. maturity
439101-449	743.68	2.8	Core in can (S)	264000	390	1600	86	242	28	39	133	-40.4	n.a.	n.a.	thermogenic, med. maturity
439101-450	747.06	3.8	Core in can (S)	5197	1196	0.4	n.p.	0.9	n.p.	n.p.	n.c.	-24.8	n.a.	n.a.	thermogenic, high maturity, (leaked, fractionated?)
439101-457	769.31	3.8	Core in can (S)	23000	1560	278	8.8	21.7	1.9	2.6	12.5	-36.8	n.a.	n.a.	thermogenic, high maturity, (leaked?)
439101-458	774.01	3.8/9:00	Core in can (S)	107000	1910	349	3	7	n.p.	n.p.	47.1	-39.7	n.a.	n.a.	thermogenic, med. maturity
439101-465	793.96	3.8	Core in can (M)	43200	632	101	4.1	10.9	0.9	1.33	58.9	-39.1	n.a.	n.a.	thermogenic, med. maturity
439101-472	816.19	3.8/21:30	Core in can (M)	38800	193	82	5.68	10.3	0.9	1.3	141	-20.8	n.a.	n.a.	thermogenic, high maturity, (leaked?, fractionated?)
439128	901.29	10.8/23:45	Steel cylinder	33900	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	00	-68.0	n.a.	n.a.	microbial

n.p.	not present
n.c.	not calculated
n.a.	not available

Table 23. Compound assignment of terpanes and steranes (Fig. 10, 19 and 26, Tables 7, 8, 13, 14, 18 and 19)

Terpanes

Ts	C_{27}	18α(H) trisnorneohopane
Tm	C_{27}	17α(H) trisnorhopane
17β	C_{27}	17β(H) trisnorhopane
BNL	C_{28}	17α(H) bisnorlupane
H28	C_{28}	17α(H), 21α(H) bisnorhopane
H29	C_{29}	17α(H), 21β(H) norhopane
M29	C_{29}	17β(H), 21α(H) normoretane
O*	C_{30}	18α(H) oleanane
αβ H30	C_{30}	17α(H), 21β(H) hopane
βα M30	C_{30}	17β(H), 21α(H) moretane
H31	C_{31}	17α(H), 21β(H) homohopanes (22S + 22R)
H32	C_{32}	17α(H), 21β(H) bishomohopanes (22S + 22R)
H33	C_{33}	17α(H), 21β(H) trishomohopanes (22S + 22R)

Steranes

S27 ααR	C_{27}	5α(H), 14α(H), 17α(H) sterane (20R)
S28 ααR	C_{28}	5α(H), 14α(H), 17α(H) sterane (20R)
S29 ααR	C_{29}	5α(H), 14α(H), 17α(H) sterane (20R)
S29 ααS	C_{29}	5α(H), 14α(H), 17α(H) sterane (20S)
S29 ββR	C_{29}	5α(H), 14β(H), 17β(H) sterane (20R)
S29 ββS	C_{29}	5α(H), 14β(H), 17β(H) sterane (20S)

*: Note: In the m/z 191 ion fragmentogram, a peak eluting fractionally earlier than 17α(H)21β(H)-hopane (peak labelled O) is attributed to 18α(H)-oleanane. A related, but uncommon compound, lupane, is known to have a very similar retention time on the type of column used. The mass spectra of oleanane and lupane are very similar, but the lupane spectra comprises a m/z 369 fragment, related to loss of an isopropyl-sidechain from the E-ring. Oleanane does not show such fragmentation due to lack of an equivalent sidechain, and accordingly, the mass spectrum does not display a significant m/z 369 fragment. In a number of West Greenland samples, mass spectra of the compound presently identified as oleanane show a minor m/z 369 fragment. Possibly, this indicates a contribution of lupane to the peak attributed to oleanane. The relative proportions of oleanane and lupane cannot be evaluated from the data available, but the problem is currently being investigated in collaboration with Dr. M. G. Fowler (Geological Survey of Canada, Calgary). The possible presence of lupane is primarily scientific reasons, and is presently not anticipated to be of major importance for the exploration in the area.

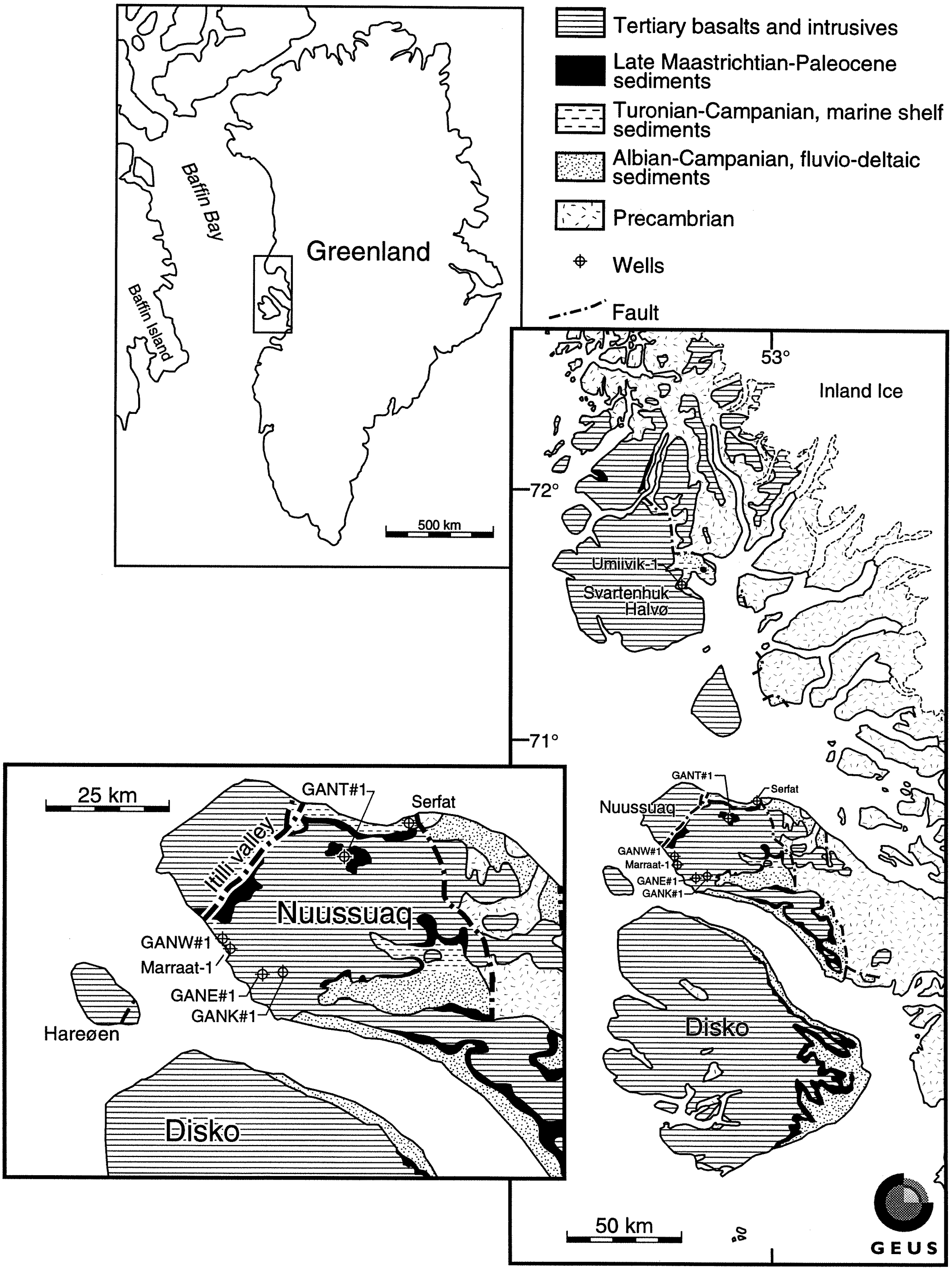

Tertiary basalts and intrusives
Late Maastrichtian-Paleocene sediments
Turonian-Campanian, marine shelf sediments
Albian-Campanian, fluvio-deltaic sediments
Precambrian
Wells
Fault
Baffin Bay
Baffin Island
Greenland
500 km
53°
Inland Ice
72°
Umiivik-1
Svartenhuk Halvø
71°
GANT#1
Serfat
Nuussuaq
GANW#1
Marraat-1
GANE#1
GANK#1
Disko
50 km
GEUS
25 km
Itilli valley
Hareøen

Fig. 1

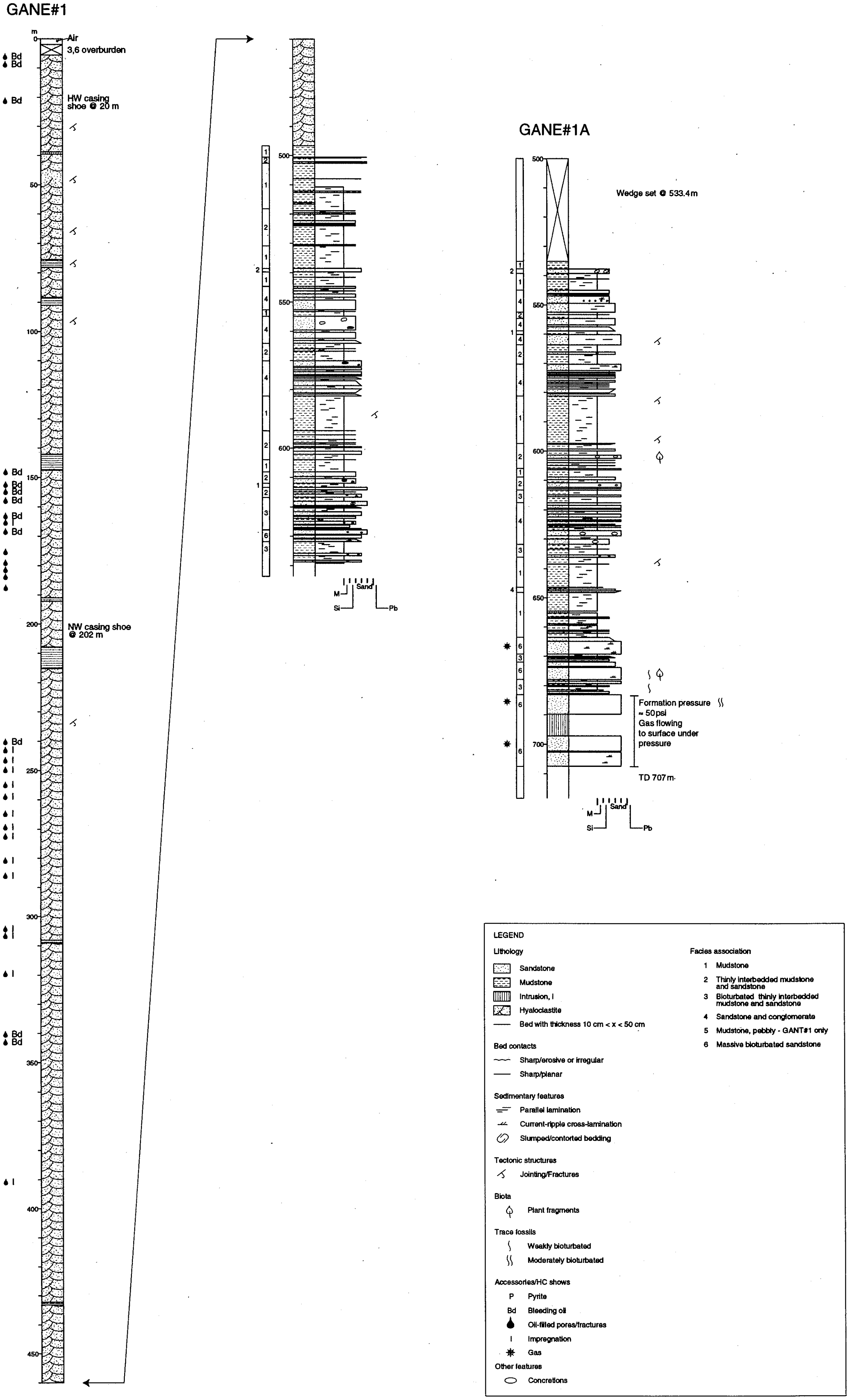

GANE#1
m
Air
3,6 overburden
HW casing shoe @ 20 m
NW casing shoe @ 202 m
Bd
I
0
50
100
150
200
250
300
350
400
450
500
550
600
M
Si
Sand
Pb
GANE#1A
Wedge set @ 533.4m
650
700
Formation pressure ≈ 50psi
Gas flowing to surface under pressure
TD 707m
LEGEND
Lithology
Sandstone
Mudstone
Intrusion, I
Hyaloclastite
Bed with thickness 10 cm < x < 50 cm
Bed contacts
Sharp/erosive or irregular
Sharp/planar
Sedimentary features
Parallel lamination
Current-ripple cross-lamination
Slumped/contorted bedding
Tectonic structures
Jointing/Fractures
Biota
Plant fragments
Trace fossils
Weakly bioturbated
Moderately bioturbated
Accessories/HC shows
P Pyrite
Bd Bleeding oil
Oil-filled pores/fractures
I Impregnation
Gas
Other features
Concretions
Facies association
1 Mudstone
2 Thinly interbedded mudstone and sandstone
3 Bioturbated thinly interbedded mudstone and sandstone
4 Sandstone and conglomerate
5 Mudstone, pebbly - GANT#1 only
6 Massive bioturbated sandstone

Fig. 2

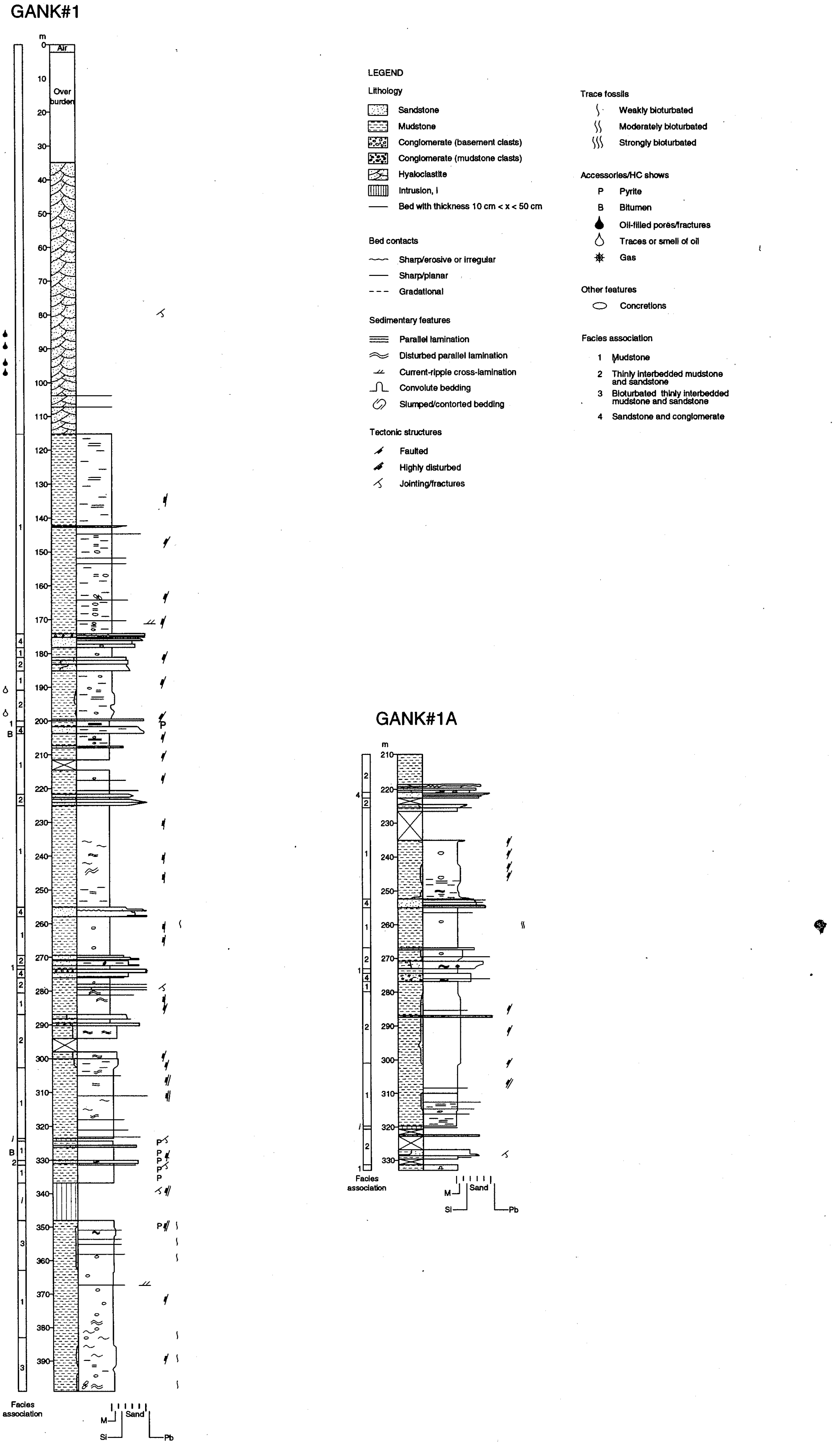

GANK#1
m
Air
Over burden
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360
370
380
390
Facies association
M
Si
Sand
Pb
LEGEND
Lithology
Sandstone
Mudstone
Conglomerate (basement clasts)
Conglomerate (mudstone clasts)
Hyaloclastite
Intrusion, I
Bed with thickness 10 cm < x < 50 cm
Bed contacts
Sharp/erosive or irregular
Sharp/planar
Gradational
Sedimentary features
Parallel lamination
Disturbed parallel lamination
Current-ripple cross-lamination
Convolute bedding
Slumped/contorted bedding
Tectonic structures
Faulted
Highly disturbed
Jointing/fractures
Trace fossils
Weakly bioturbated
Moderately bioturbated
Strongly bioturbated
Accessories/HC shows
P Pyrite
B Bitumen
Oil-filled pores/fractures
Traces or smell of oil
Gas
Other features
Concretions
Facies association
1 Mudstone
2 Thinly interbedded mudstone and sandstone
3 Bioturbated thinly interbedded mudstone and sandstone
4 Sandstone and conglomerate
GANK#1A
m
210
220
230
240
250
260
270
280
290
300
310
320
330
Facies association
M
Si
Sand
Pb

Fig. 3

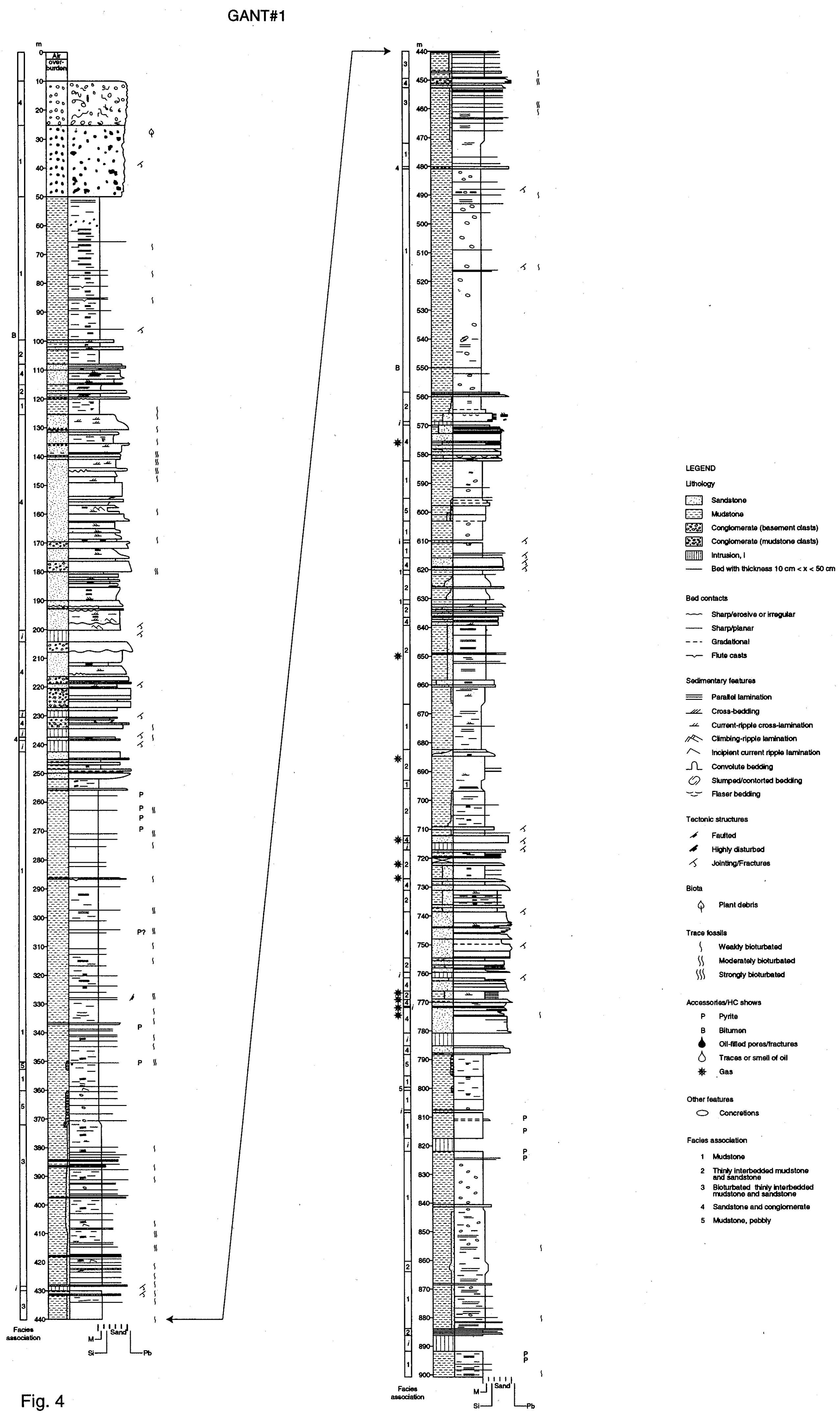

GANT#1
m
Air over-burden
Facies association
M
Si
Sand
Pb
LEGEND
Lithology
Sandstone
Mudstone
Conglomerate (basement clasts)
Conglomerate (mudstone clasts)
Intrusion, I
Bed with thickness 10 cm < x < 50 cm
Bed contacts
Sharp/erosive or irregular
Sharp/planar
Gradational
Flute casts
Sedimentary features
Parallel lamination
Cross-bedding
Current-ripple cross-lamination
Climbing-ripple lamination
Incipient current ripple lamination
Convolute bedding
Slumped/contorted bedding
Flaser bedding
Tectonic structures
Faulted
Highly disturbed
Jointing/Fractures
Biota
Plant debris
Trace fossils
Weakly bioturbated
Moderately bioturbated
Strongly bioturbated
Accessories/HC shows
P Pyrite
B Bitumen
Oil-filled pores/fractures
Traces or smell of oil
Gas
Other features
Concretions
Facies association
1 Mudstone
2 Thinly interbedded mudstone and sandstone
3 Bioturbated thinly interbedded mudstone and sandstone
4 Sandstone and conglomerate
5 Mudstone, pebbly

Fig. 4

GANE-1 well
1:5000

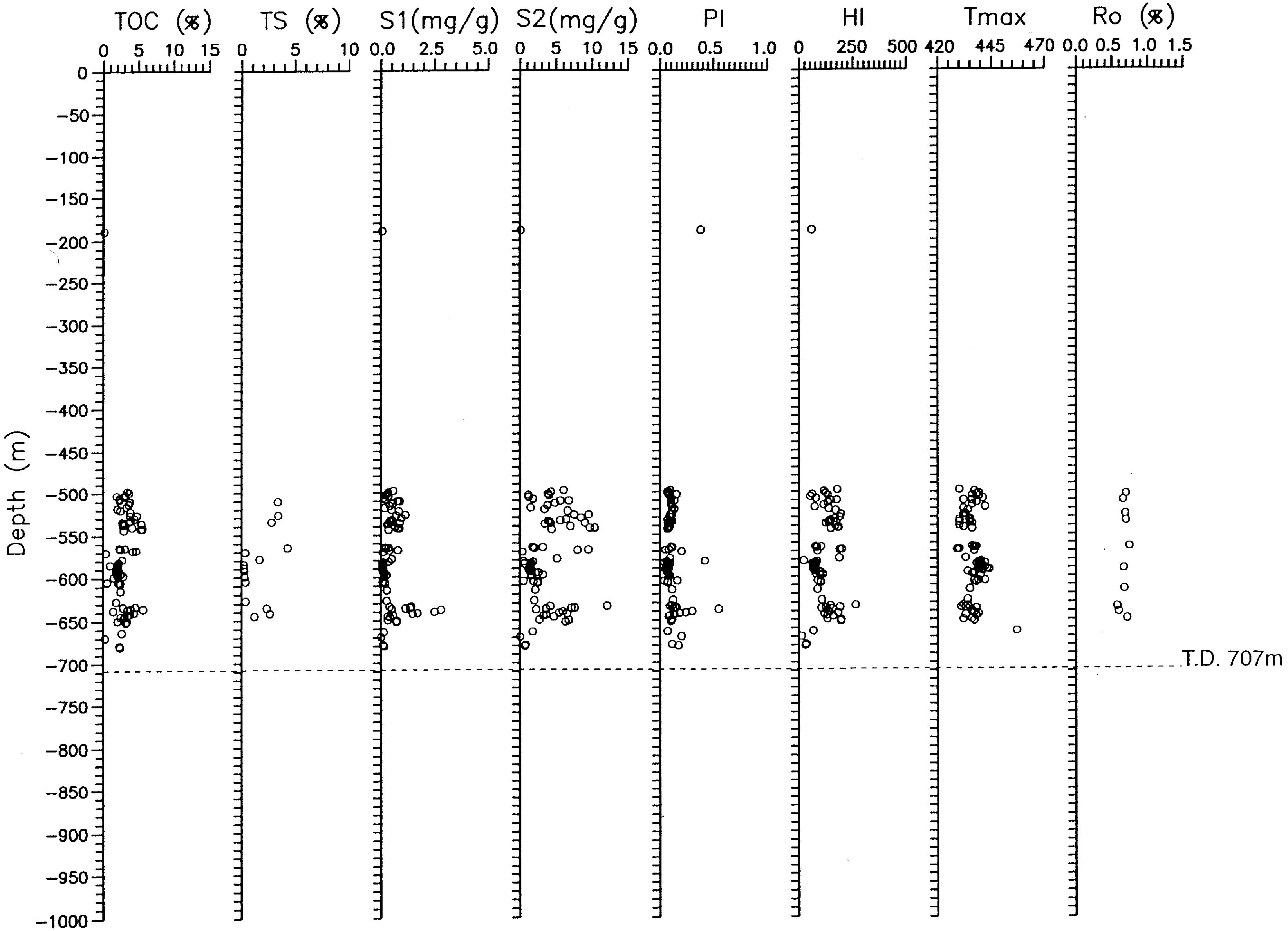


Fig. 5

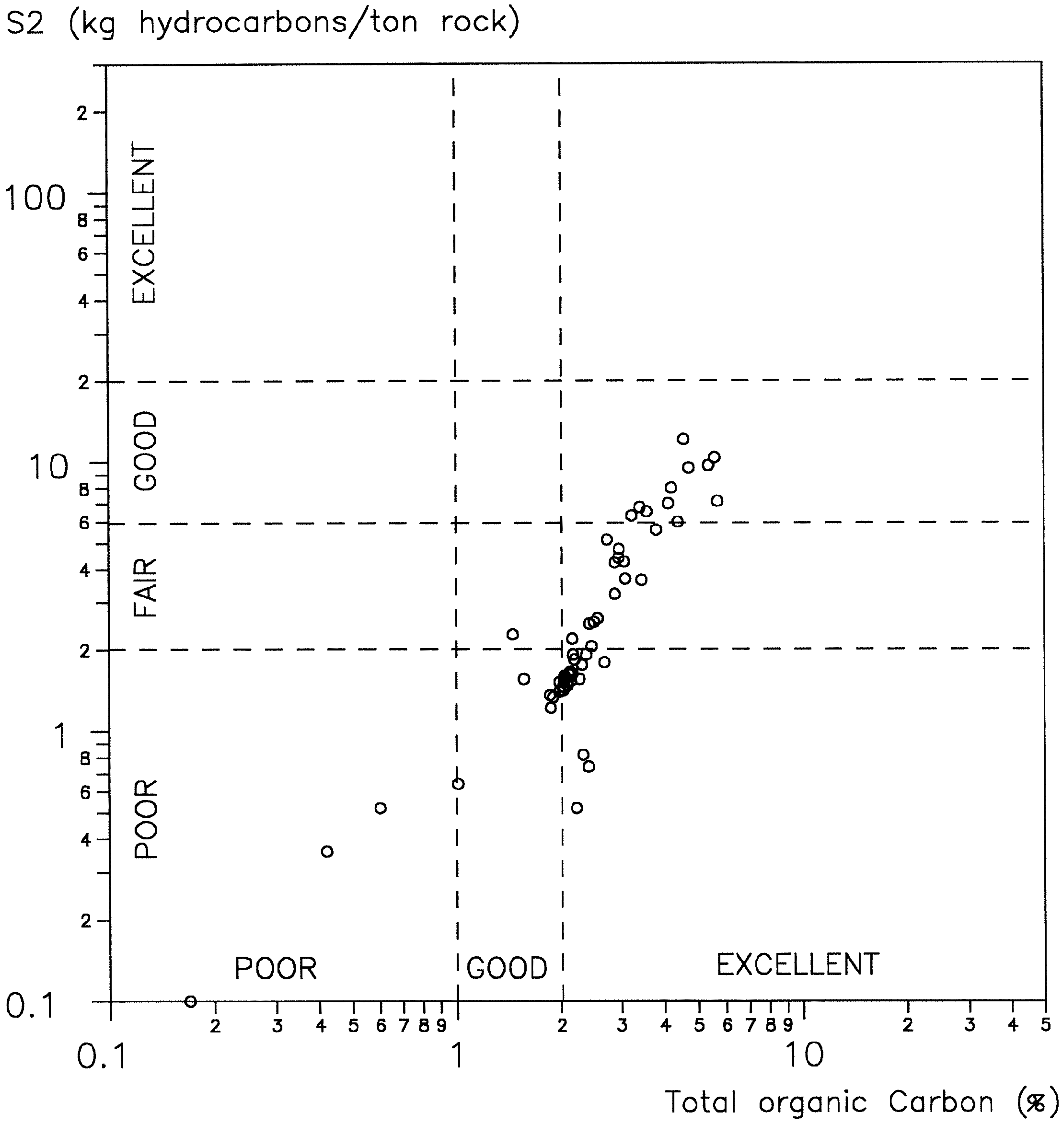

S2 (kg hydrocarbons/ton rock)
0.1
2
4
6
8
1
2
4
6
8
10
2
4
6
8
100
2
EXCELLENT
GOOD
FAIR
POOR
POOR
GOOD
EXCELLENT
0.1
2
3
4
5
6
7
8
9
1
2
3
4
5
6
7
8
9
10
2
3
4
5
Total organic Carbon (%)

Fig. 6

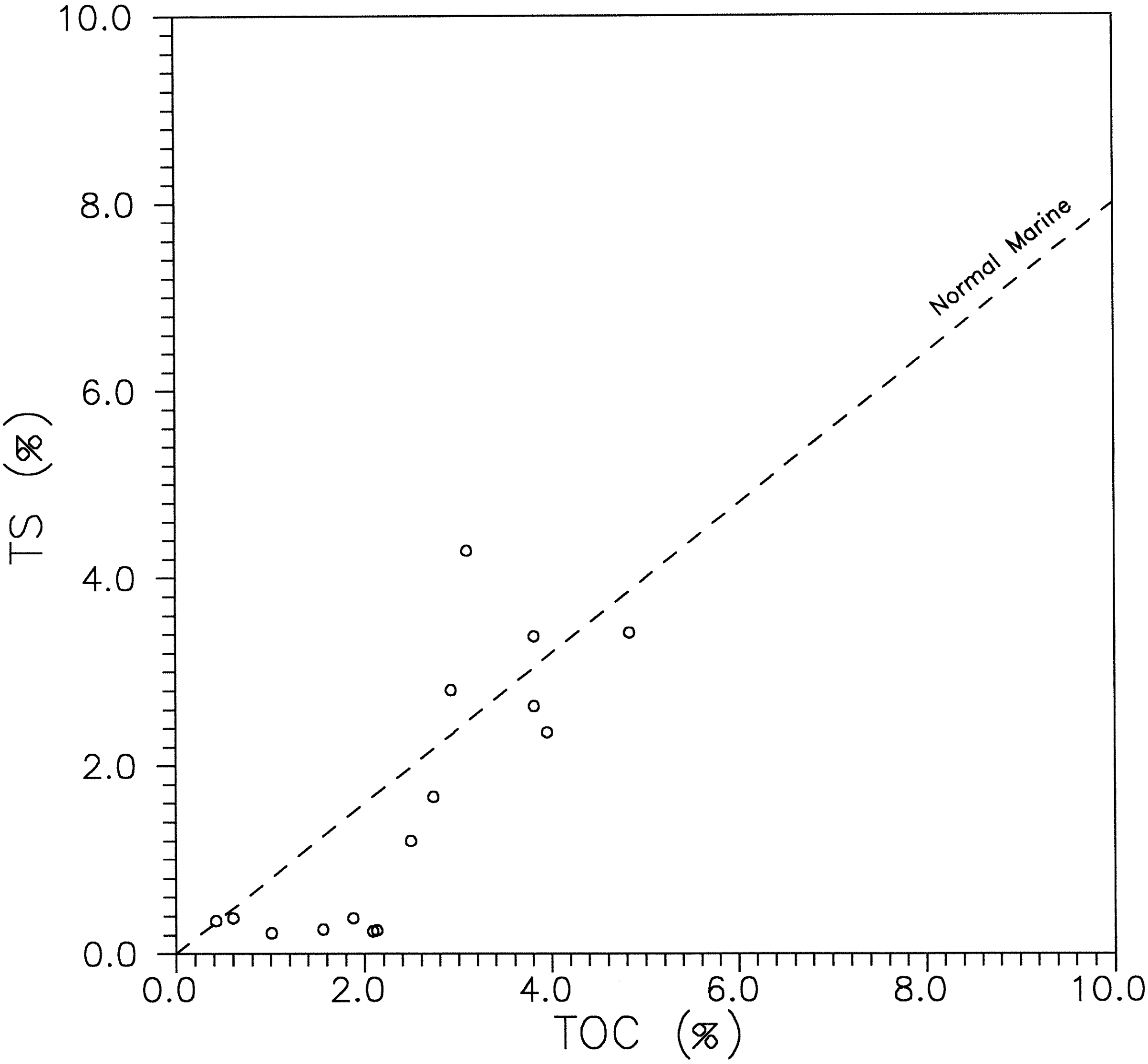


Fig. 7

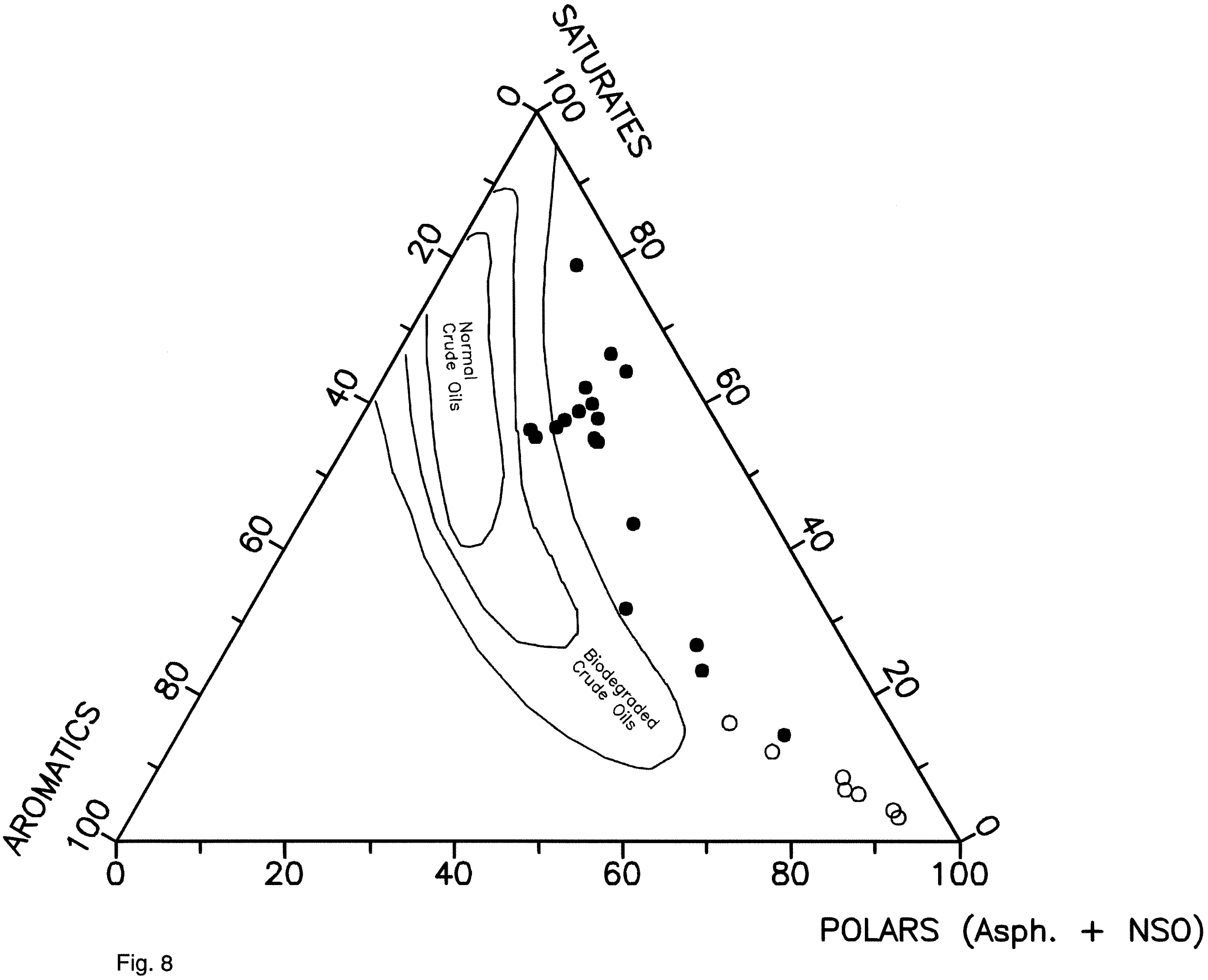
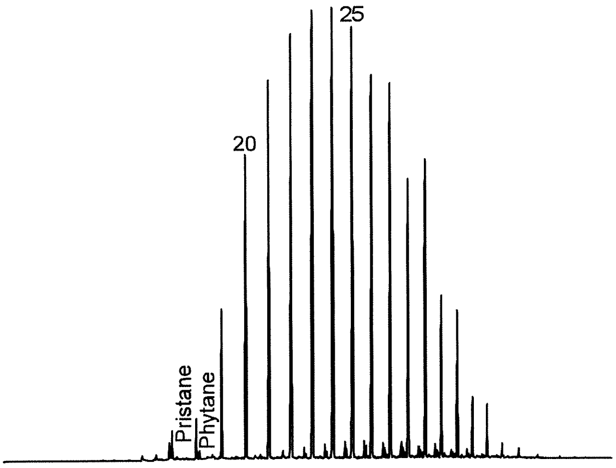
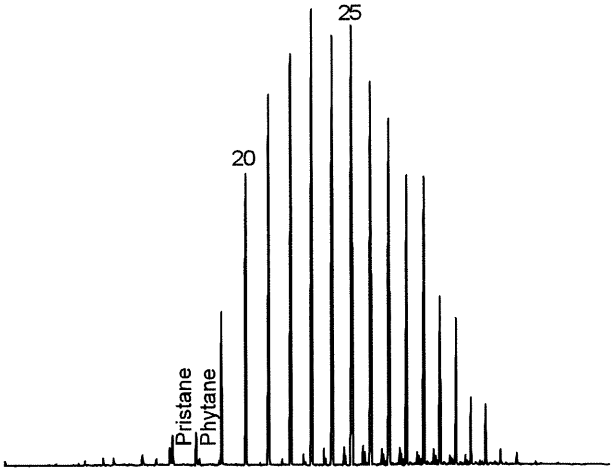

SATURATES
AROMATICS
POLARS (Asph. + NSO)
0
20
40
60
80
100
Normal Crude Oils
Biodegraded Crude Oils

Fig. 8

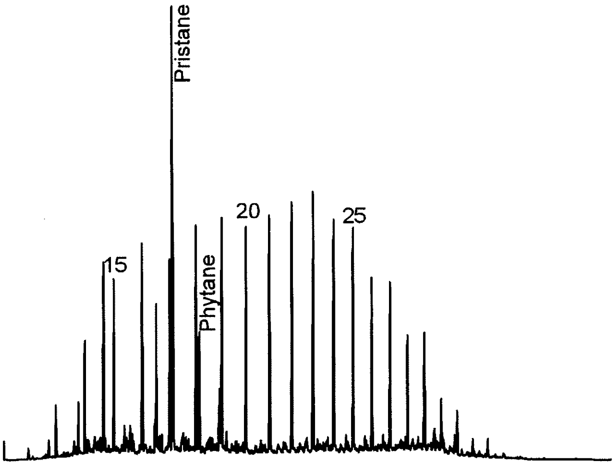


439805 (Outcrop sample)

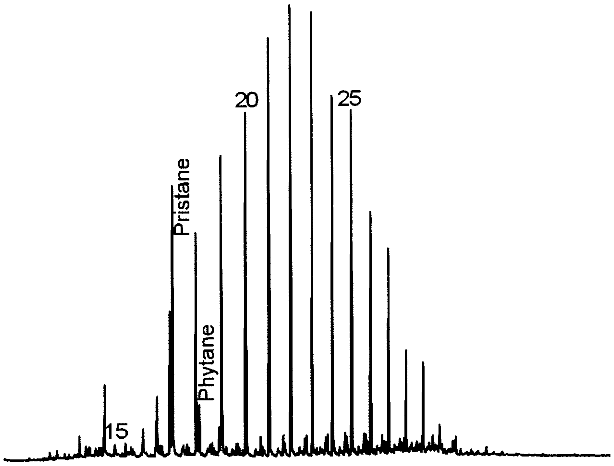


439905 (Outcrop sample)

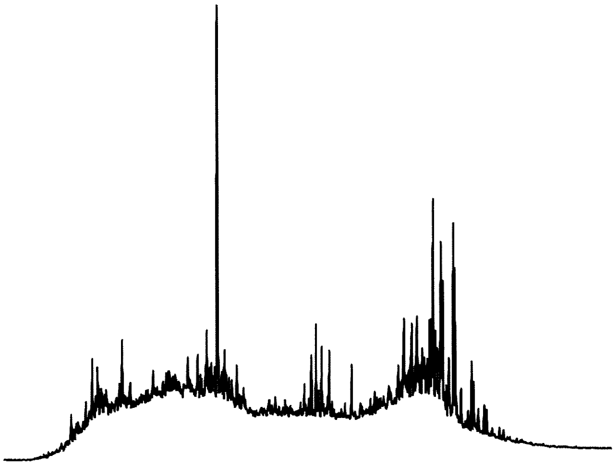
Fig. 9



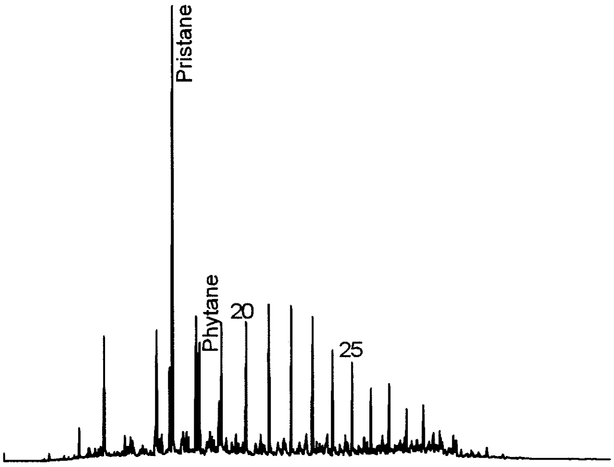
439001-01 (5.6 m)



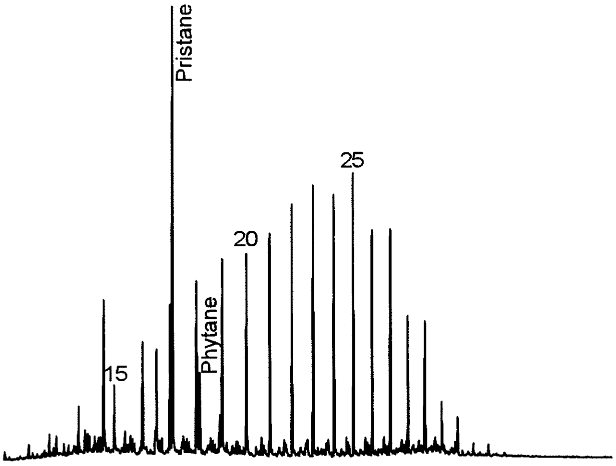
439001-132 (152.9 m)



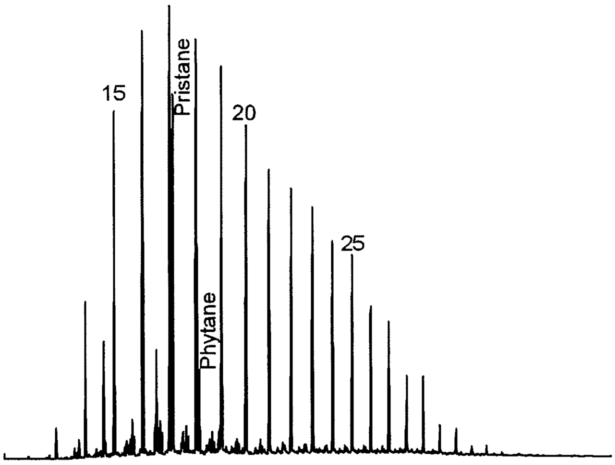
439001-55 (47.1 m)



439001-107 (158.2 m)

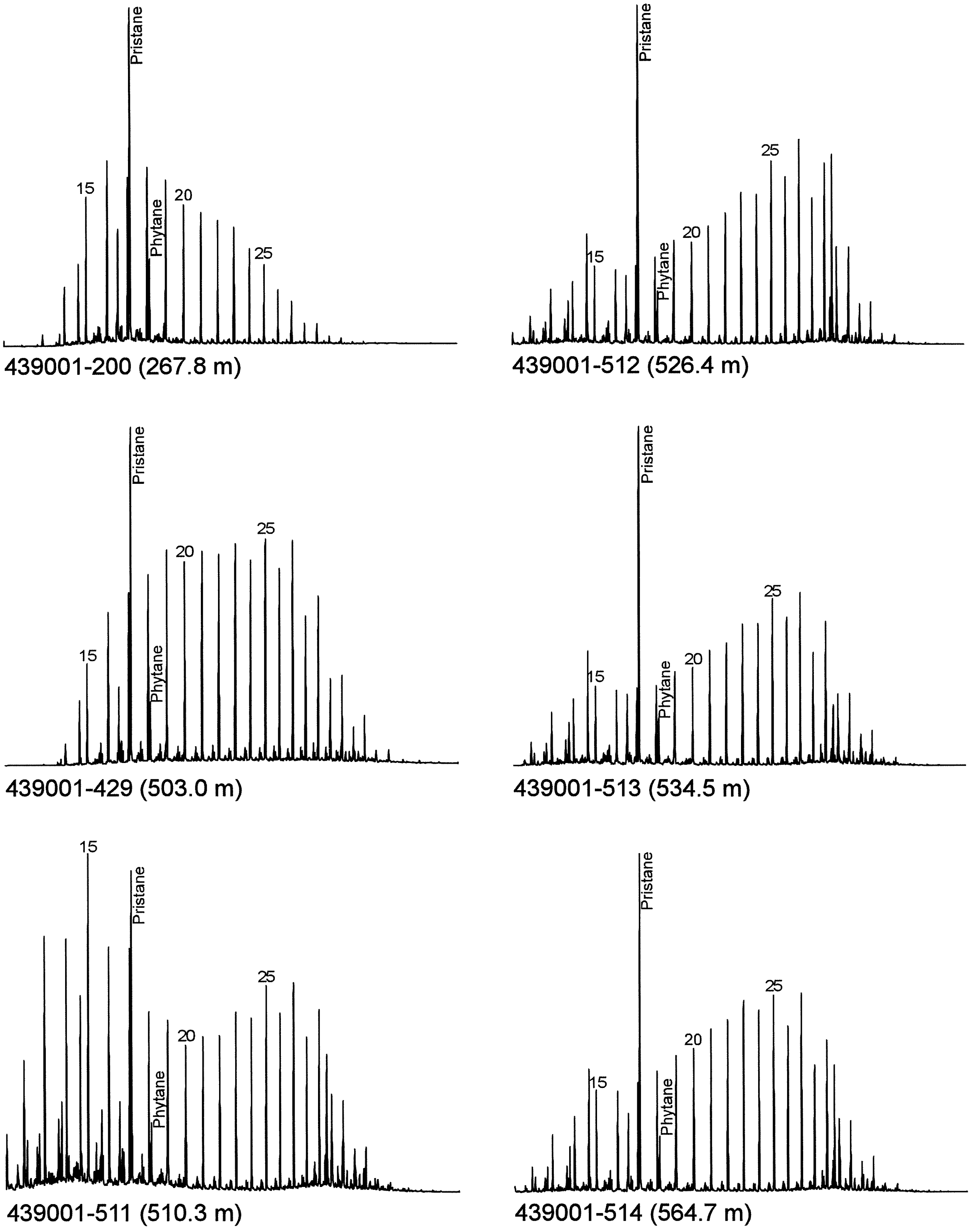


439001-128 (147.8 m)



439001-477 (241.0 m)

Fig. 9 ctd.



439001-200 (267.8 m)

439001-512 (526.4 m)

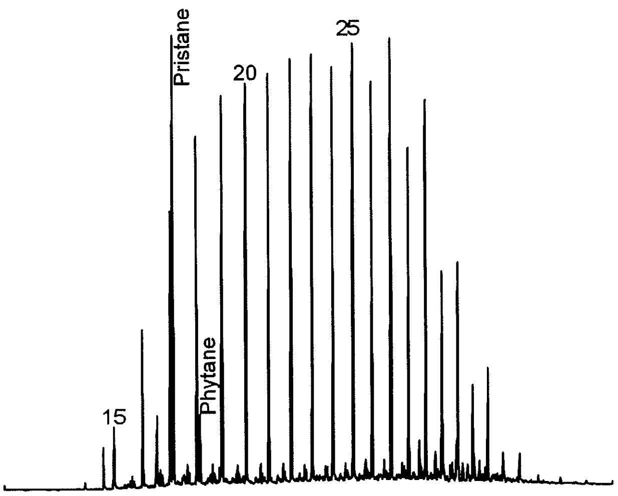
439001-429 (503.0 m)

439001-513 (534.5 m)

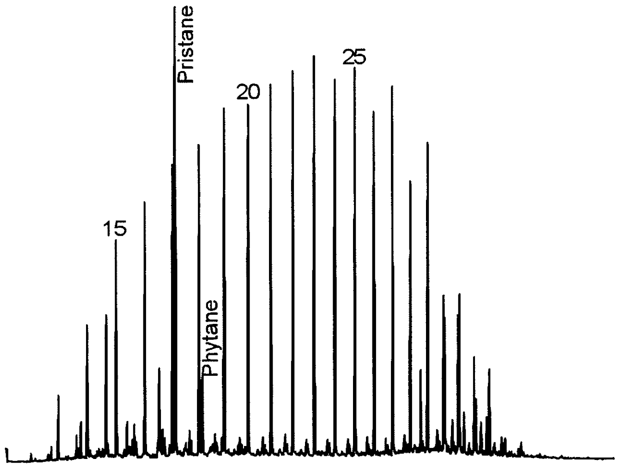
439001-511 (510.3 m)

439001-514 (564.7 m)

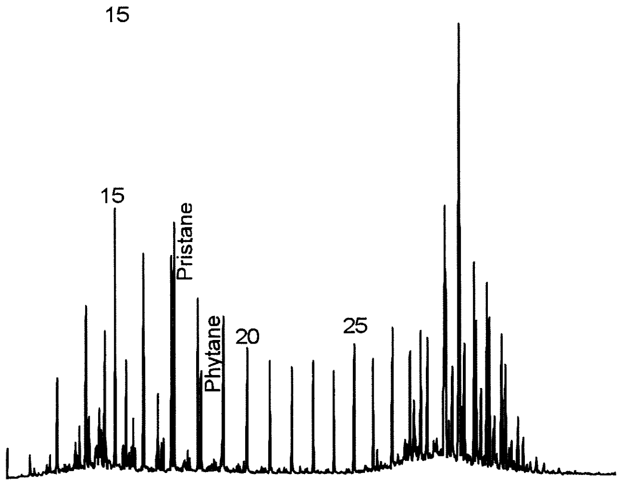
Fig. 9 ctd.



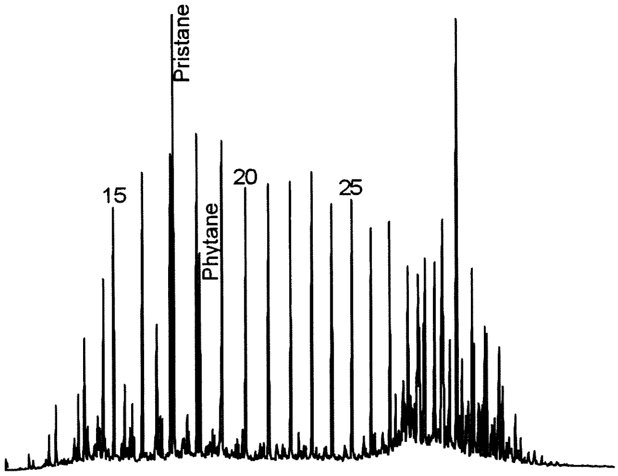
439001-459 (600.0 m)



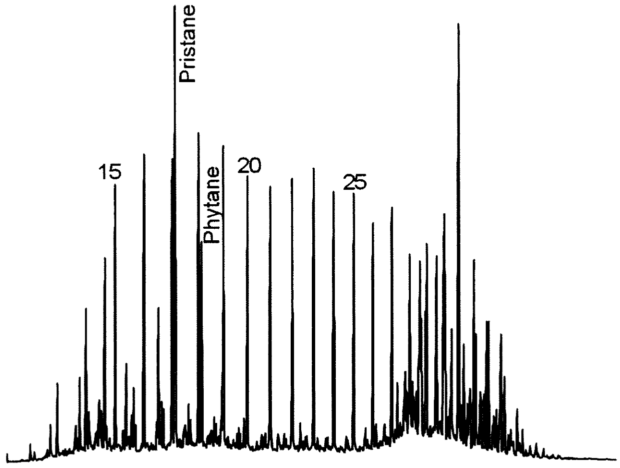
439001-515 (615.0 m)



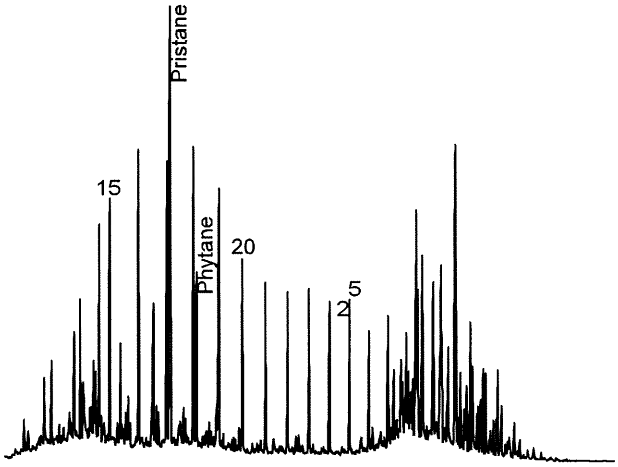
439001-369 (635.4 m)



439001-648 (638.1 m)

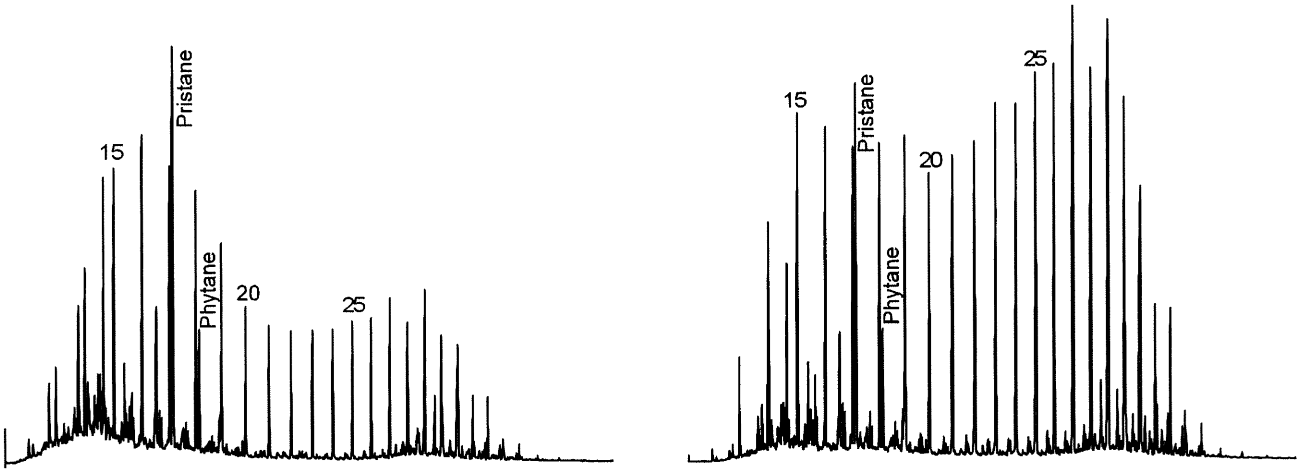


439001-647 (638.5 m)



439001-654 (640.3 m)

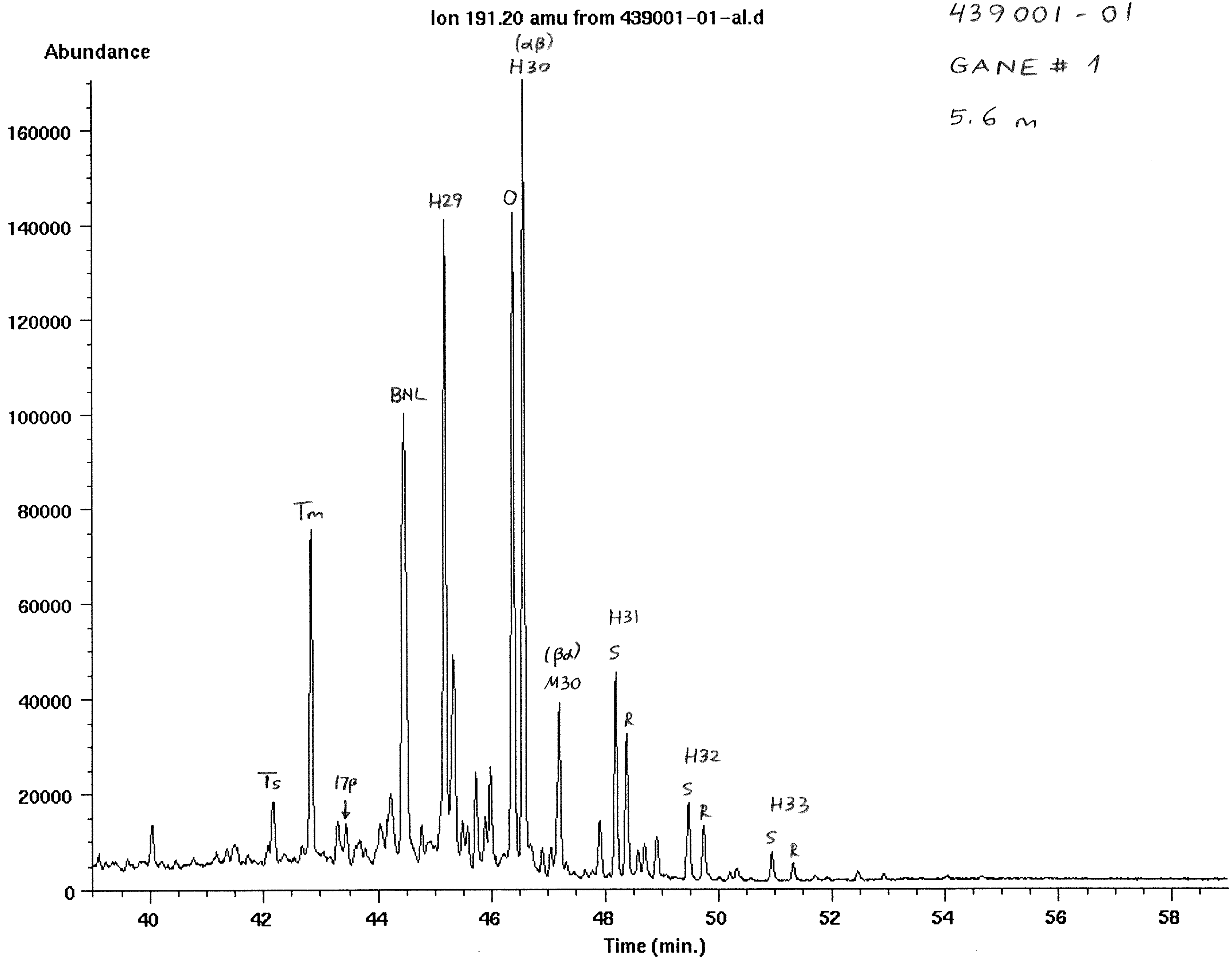
Fig. 9 ctd.



439001-370 (641.4 m)

439001-373 (649.4 m)

Fig. 9 ctd.



439001 - 01
GANE # 1
5.6 m

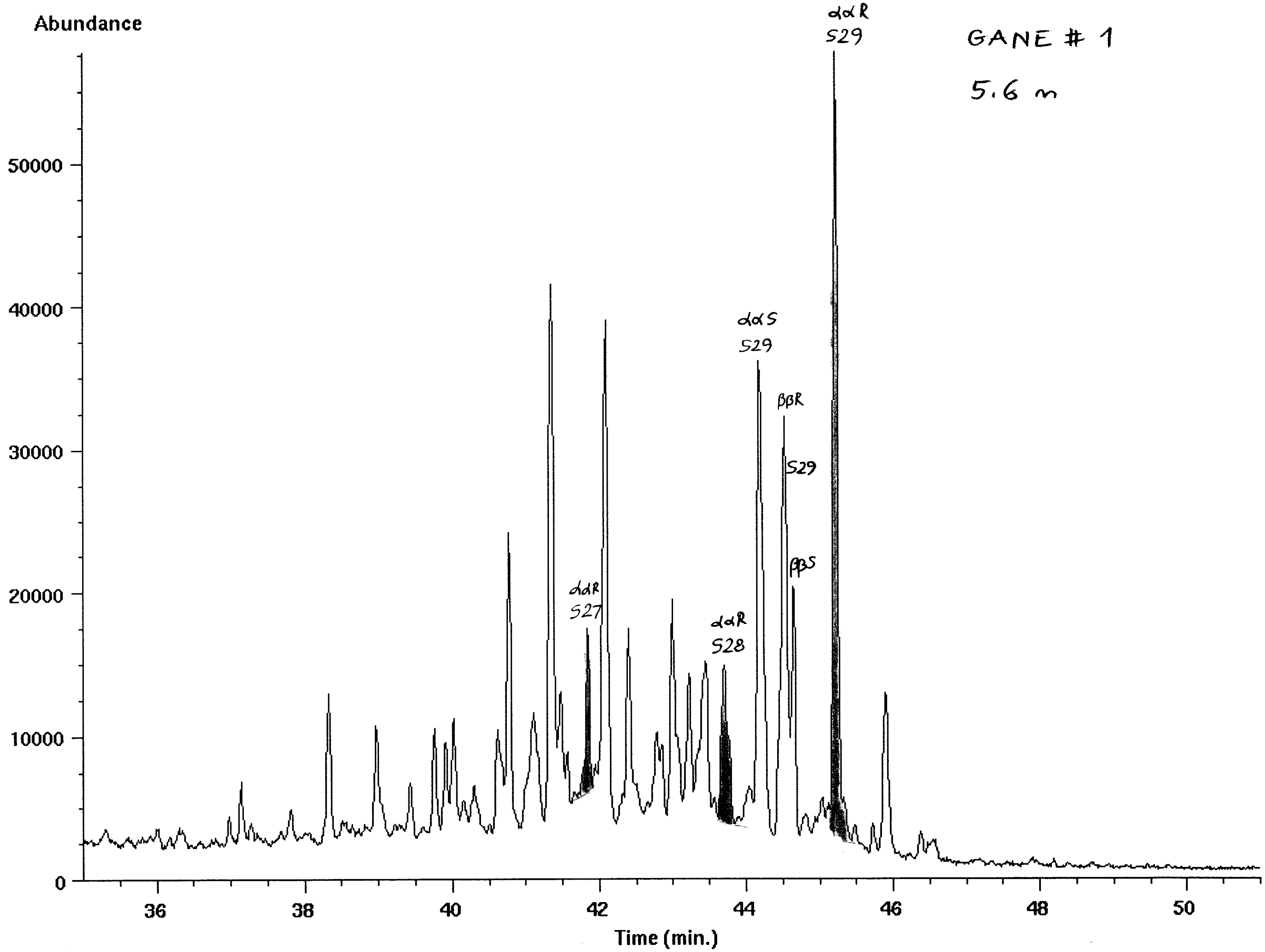
Fig. 10 continues

Ion 217.20 amu from 439001-01-al.d

439001 - 01

GANE # 1

5.6 m

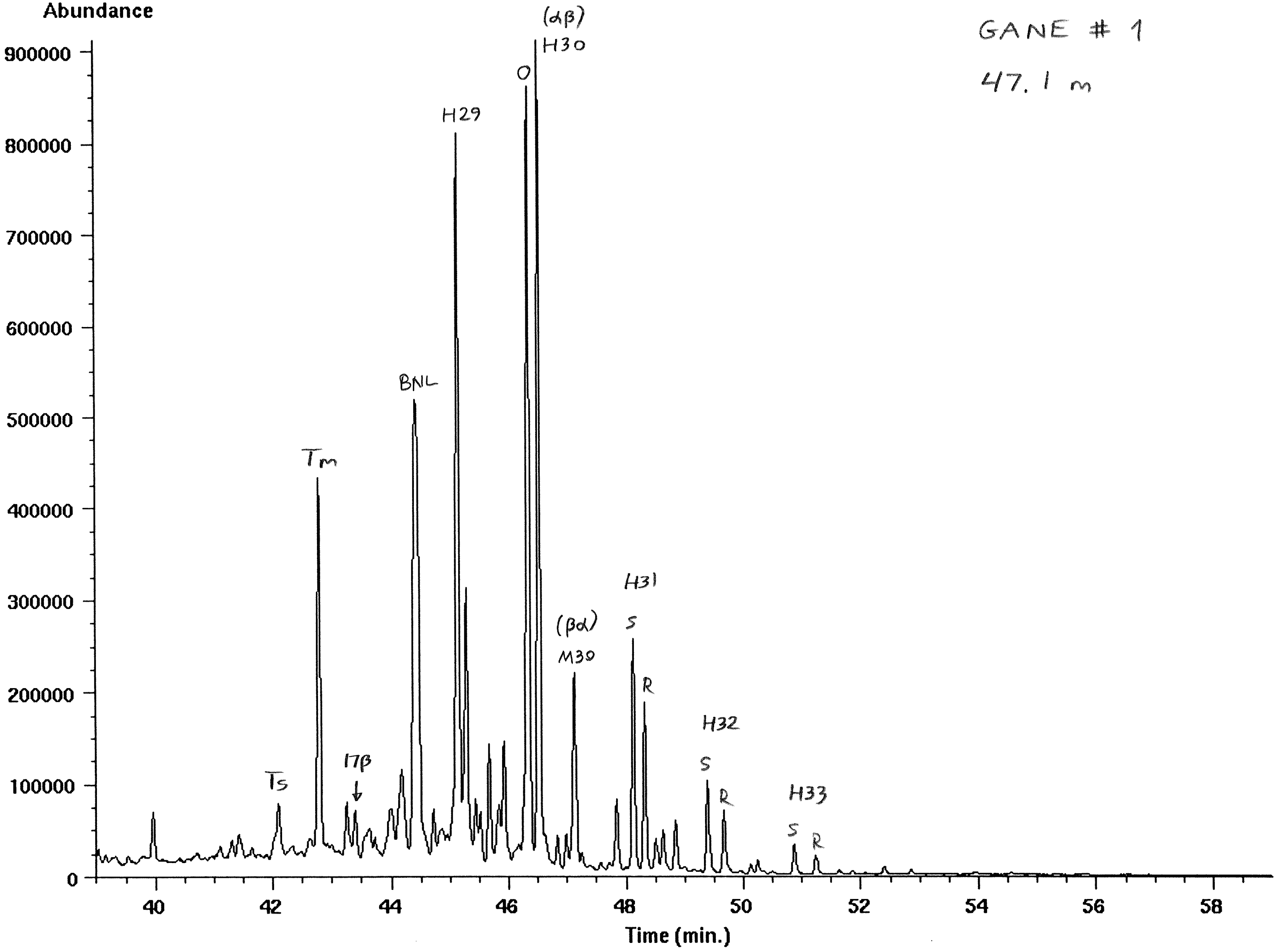


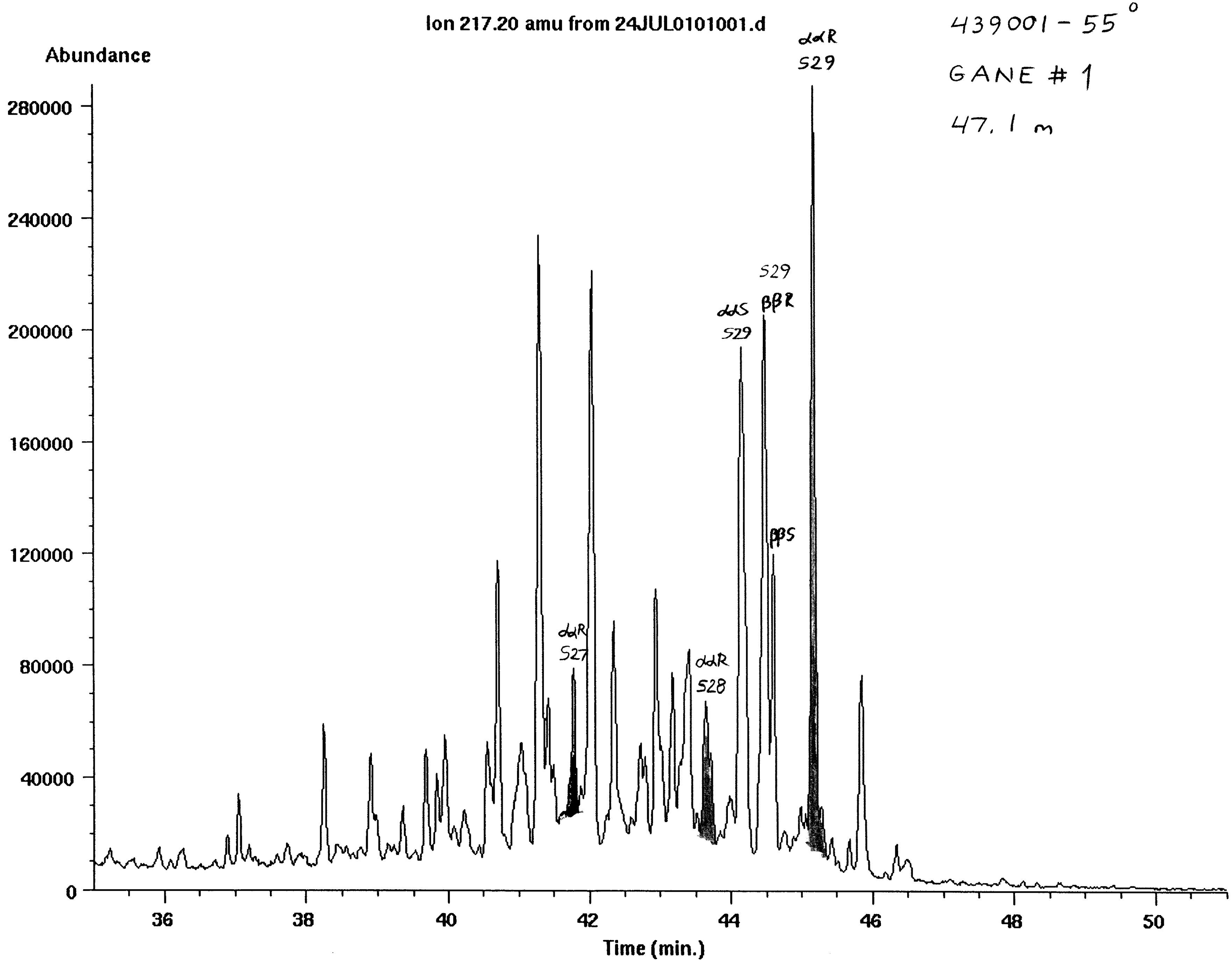
Ion 191.20 amu from 24JUL0101001.d

439001-55°

GANE # 1

47.1 m





439001 - 55°

GANE # 1

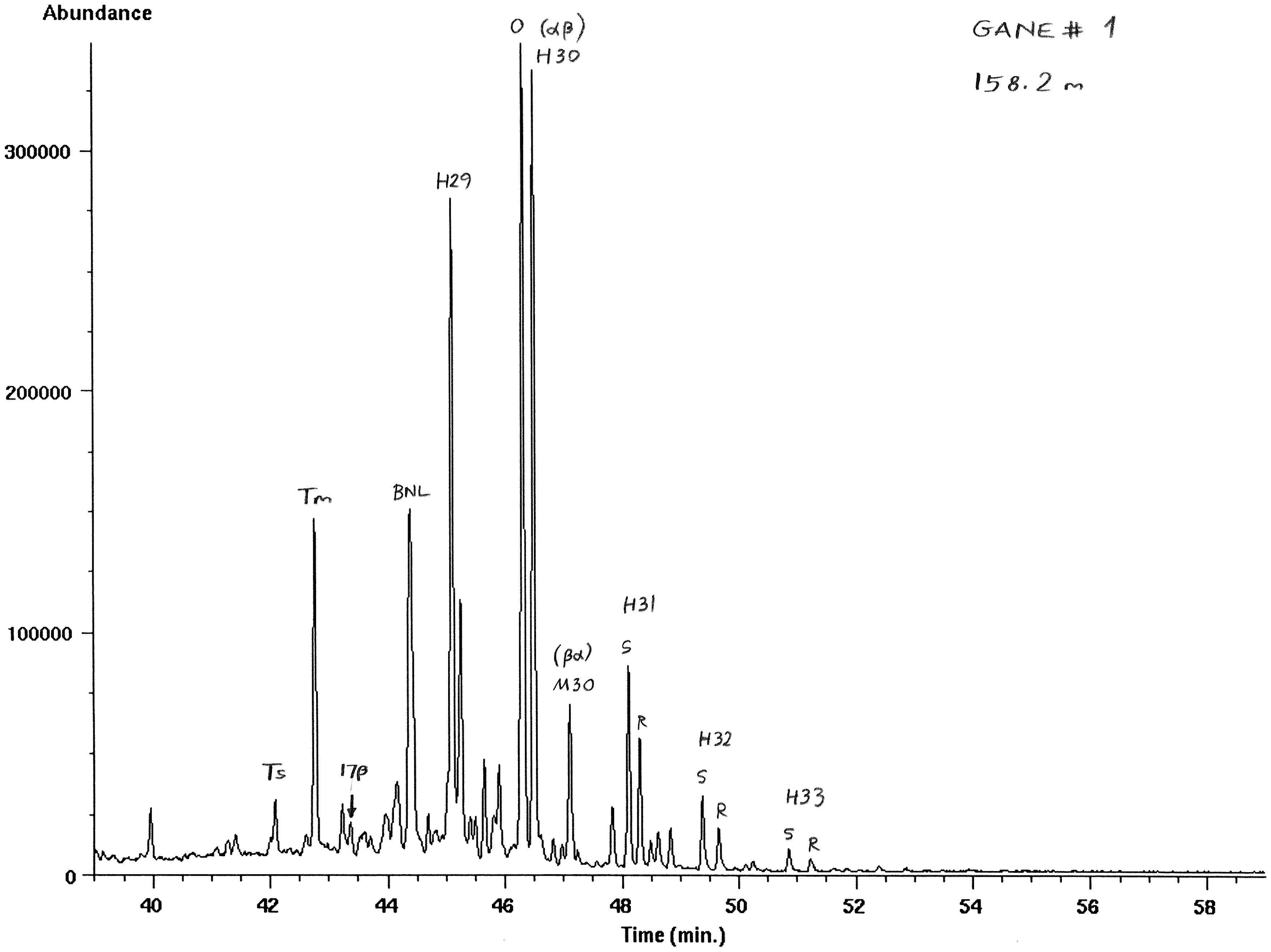
47.1 m

Ion 191.20 amu from 24JUL0201002.d

439001 - 107°

GANE # 1

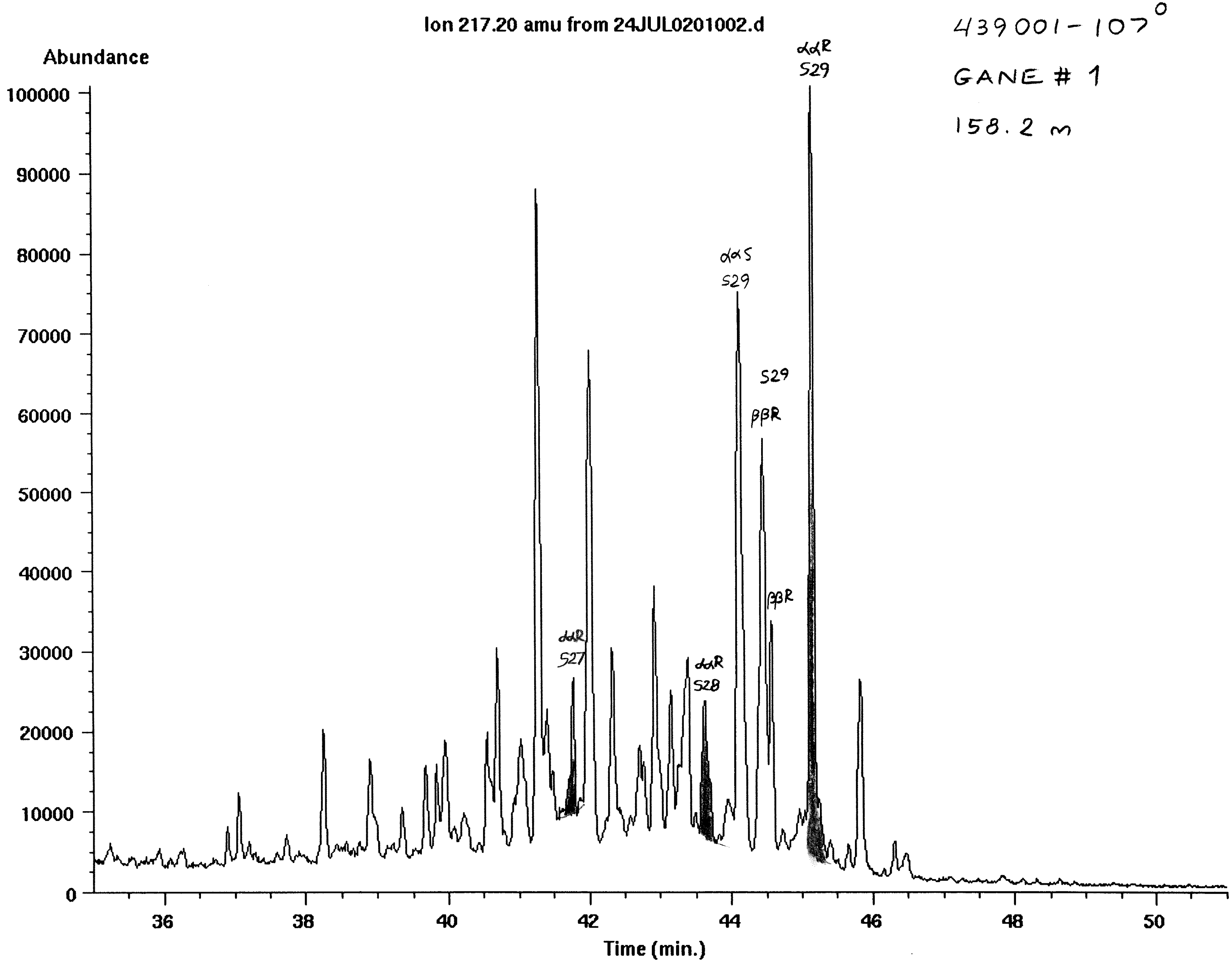
158.2 m



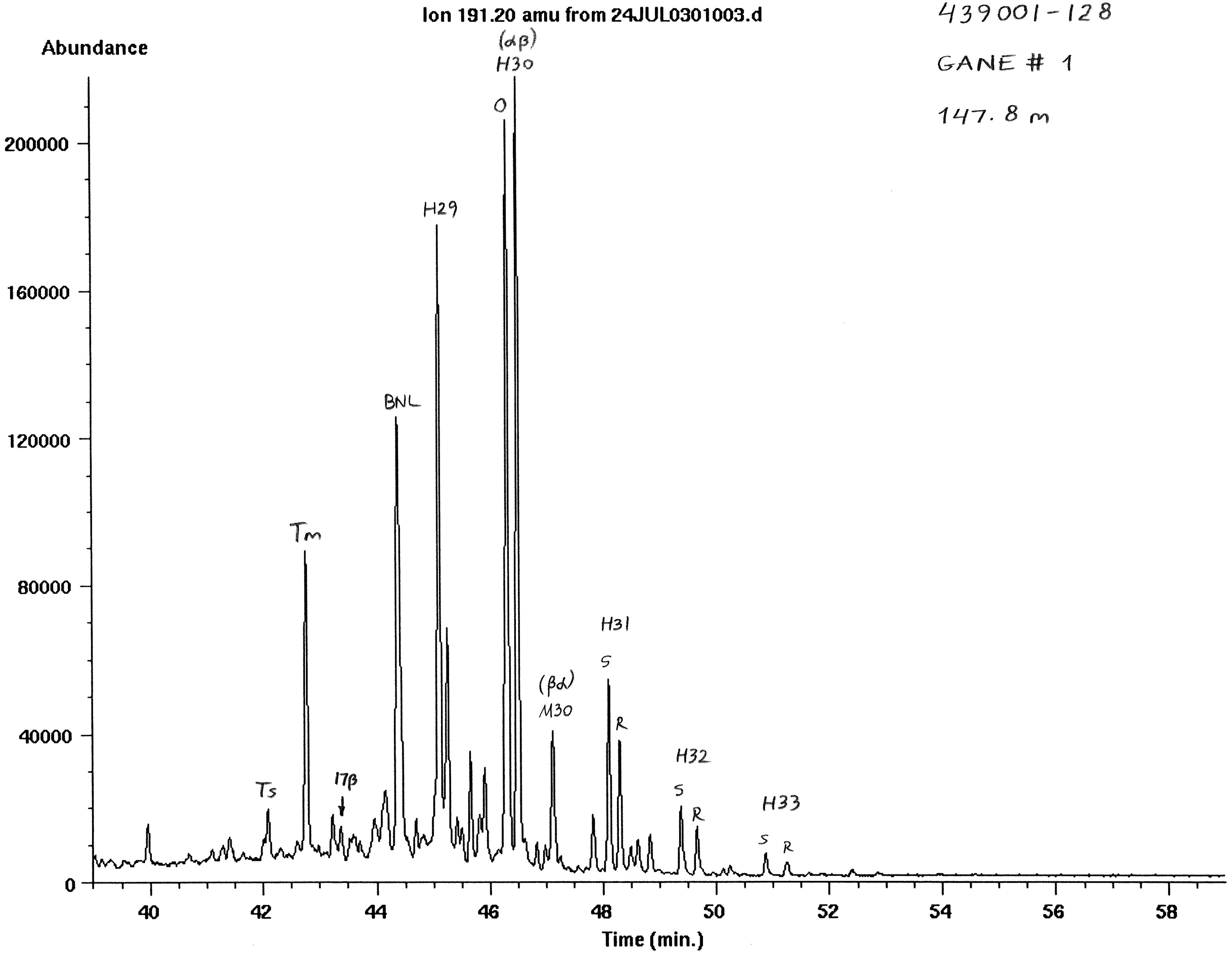
439001-107°

GANE # 1

158.2 m



Ion 217.20 amu from 24JUL0201002.d



439001-128°

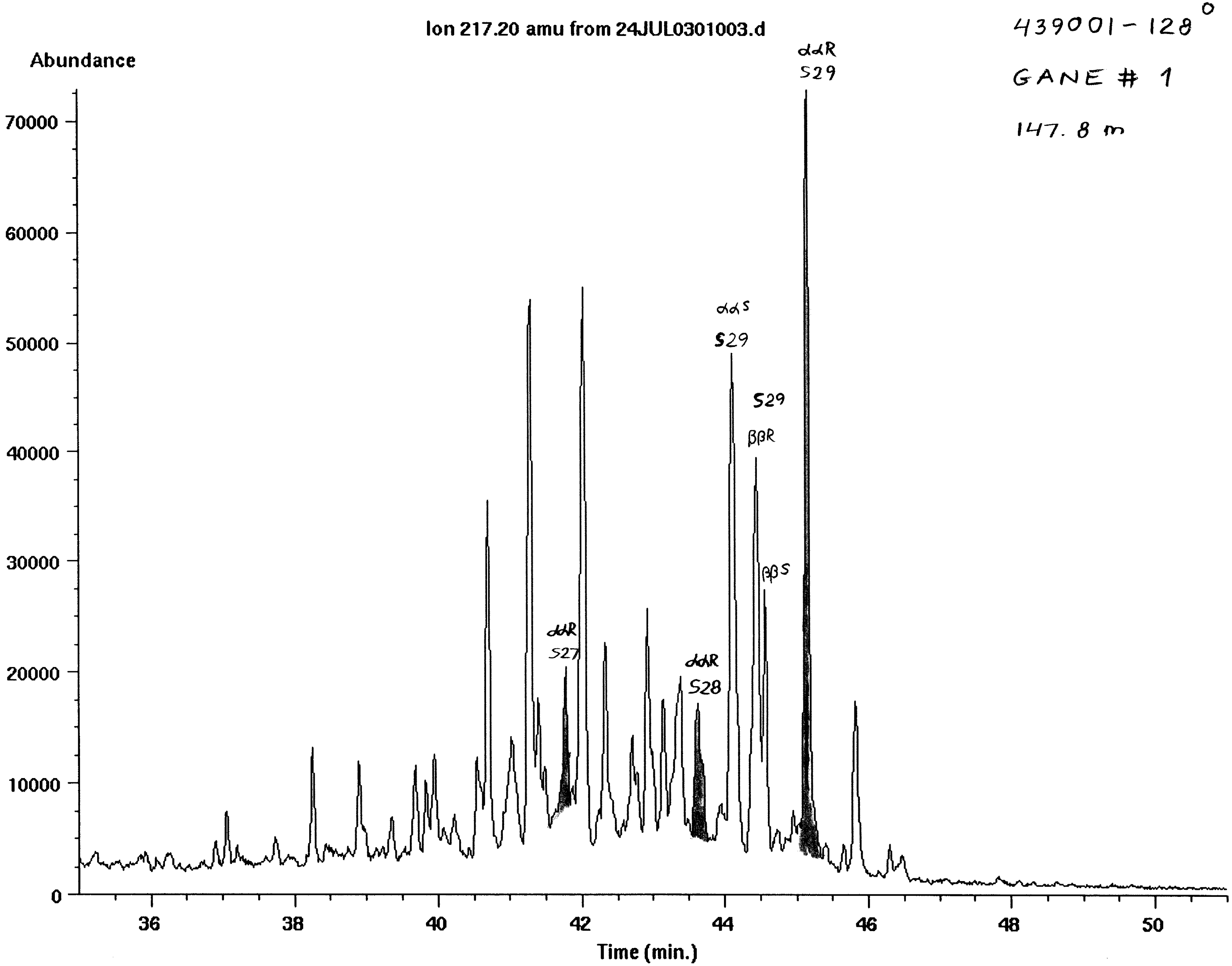
GANE # 1

147.8 m

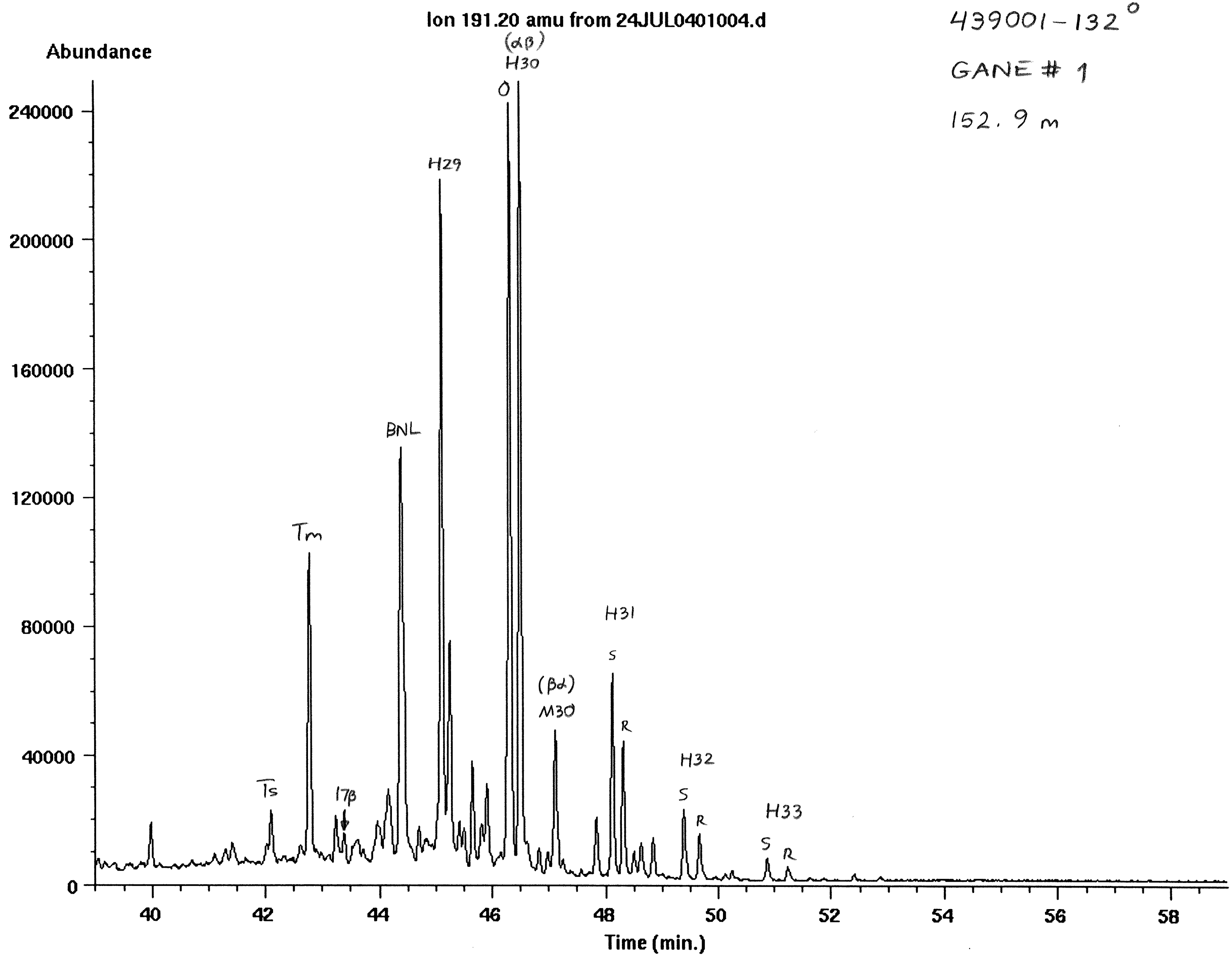
439001-128°

GANE # 1

147.8 m



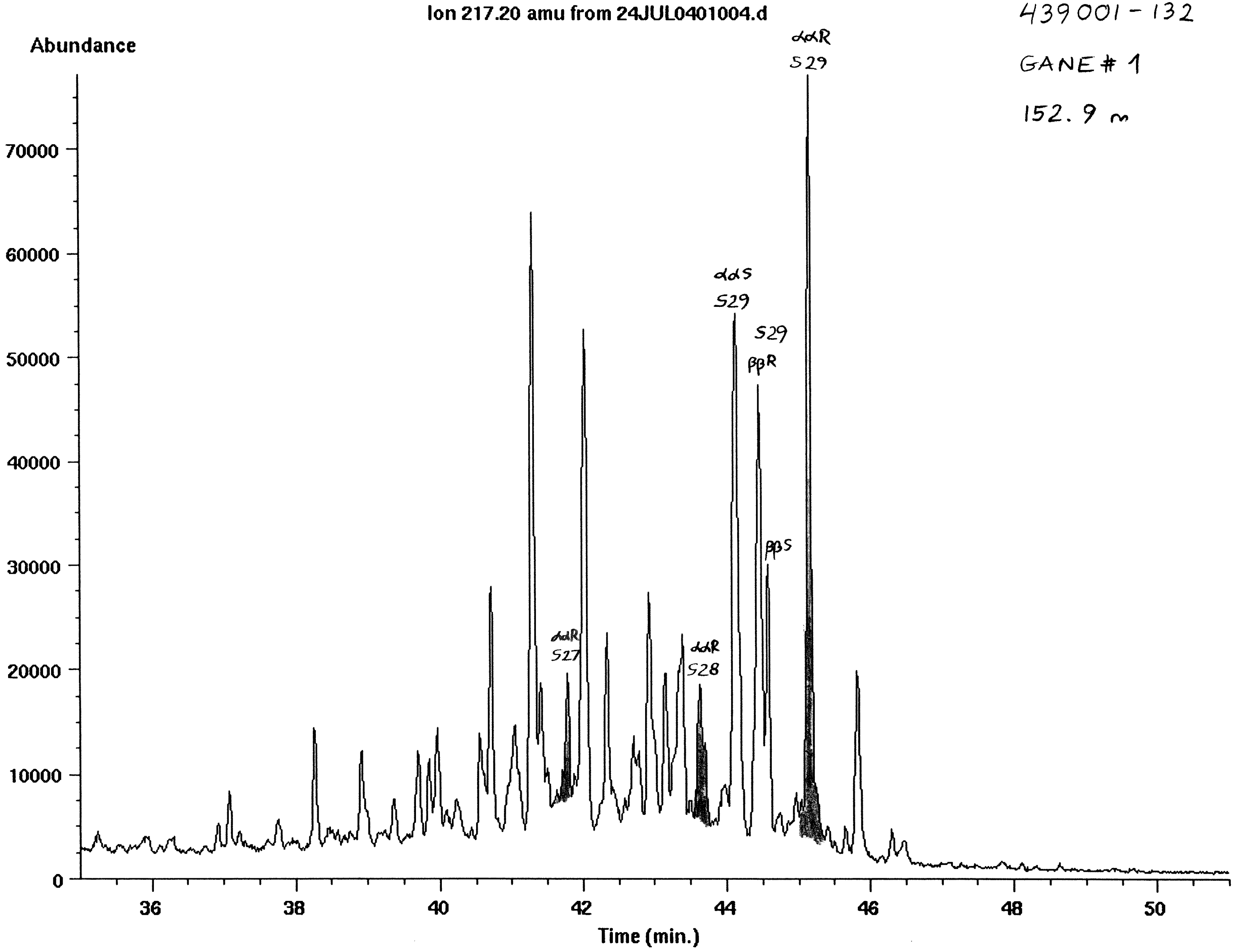
Ion 217.20 amu from 24JUL0301003.d



439001-132°

GANE # 1

152.9 m

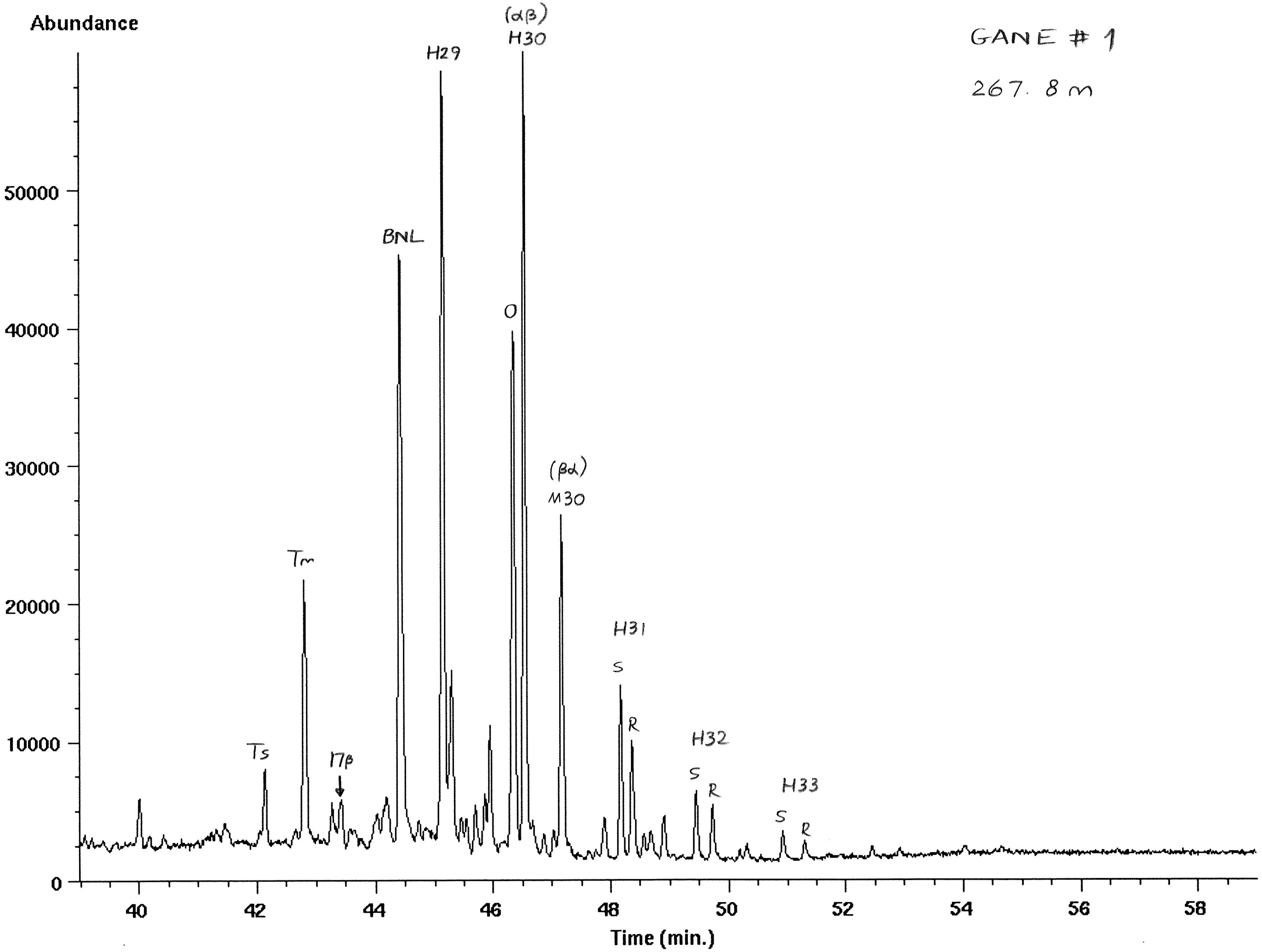


439001 - 132°

GANE # 1

152.9 m

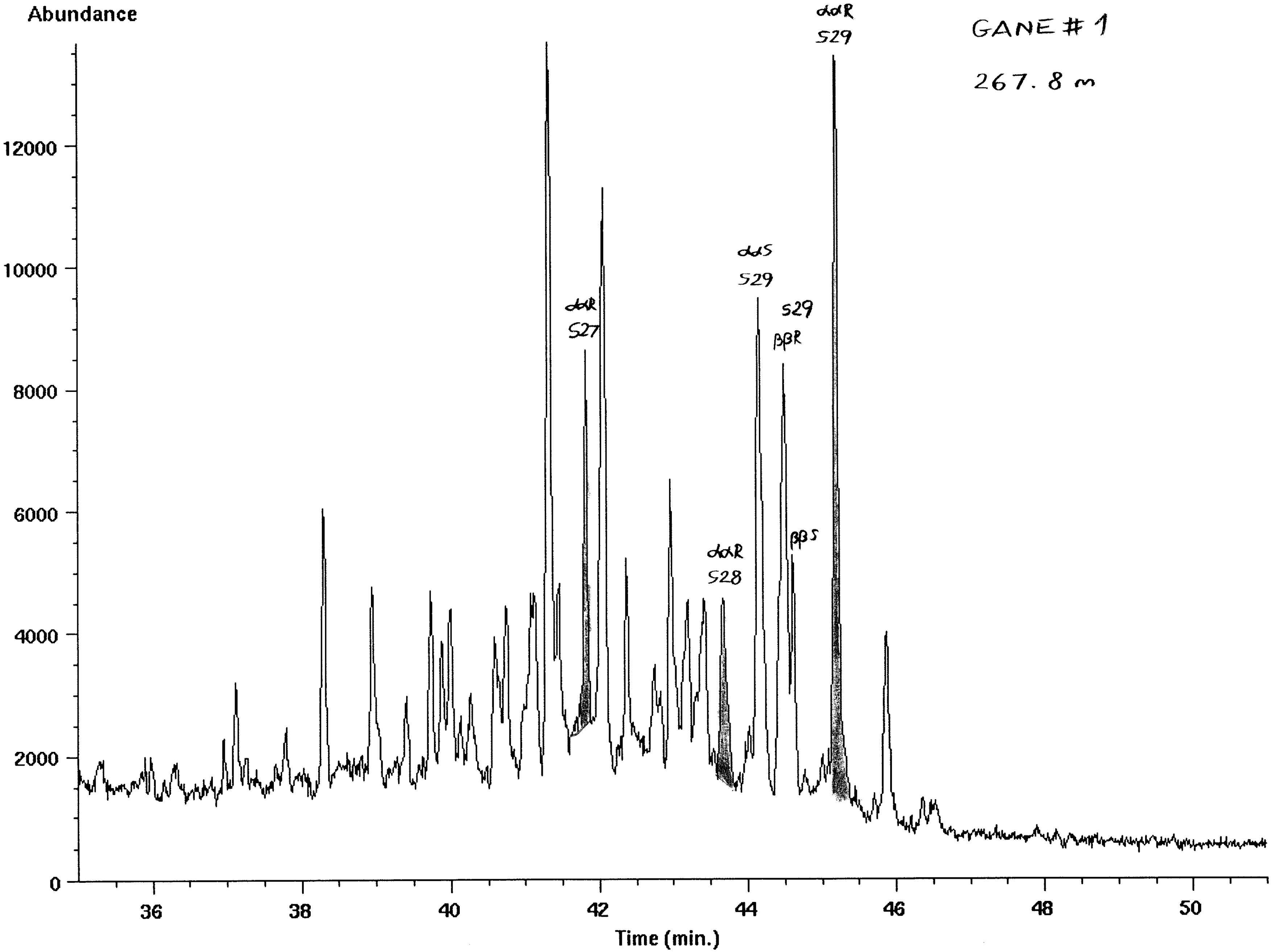
Ion 191.20 amu from 439001-200al.d



439001 - 200

GANE # 1

267. 8 m



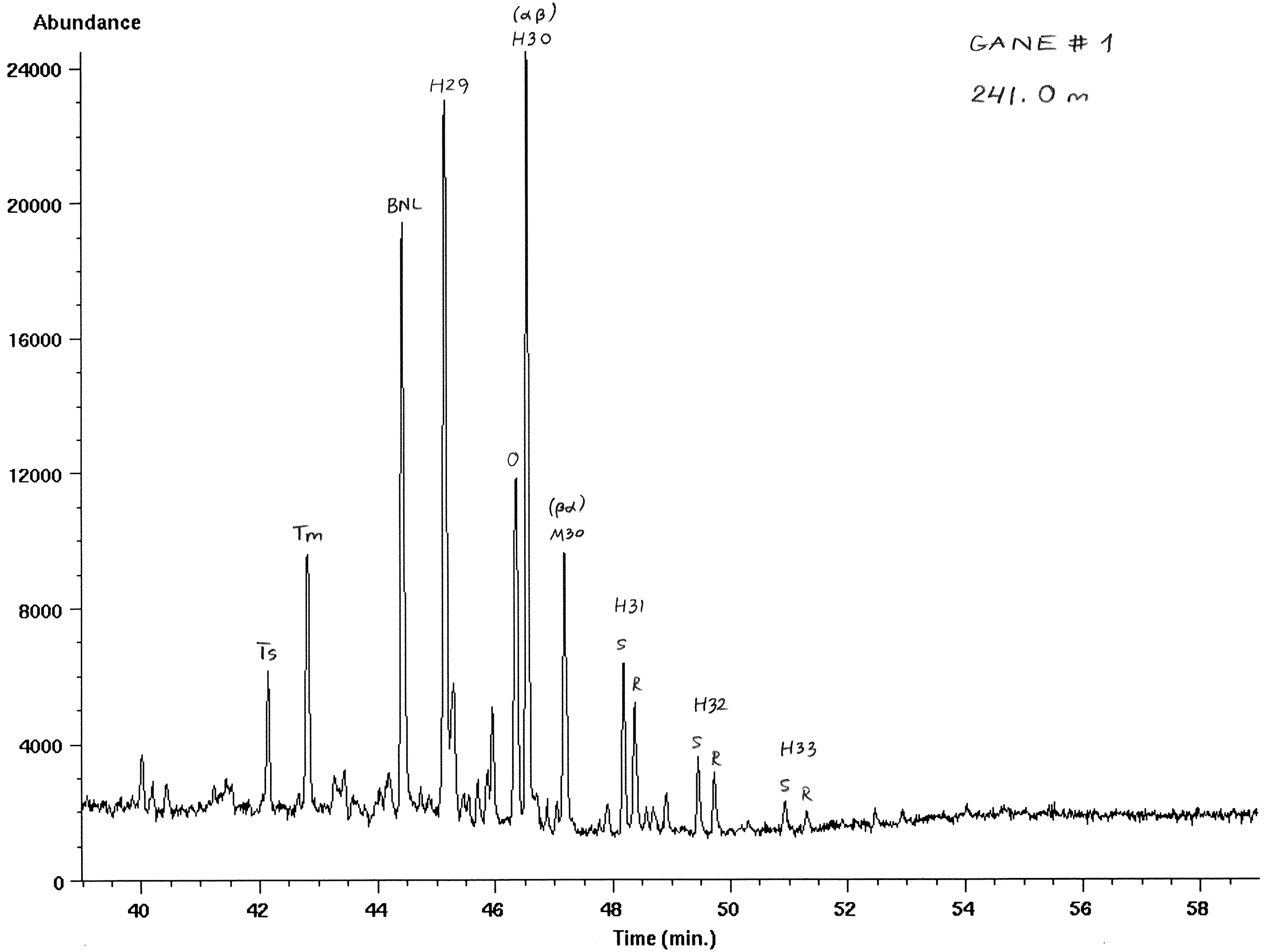
Ion 217.20 amu from 439001-200al.d

439001 - 200

GANE # 1

267. 8 m

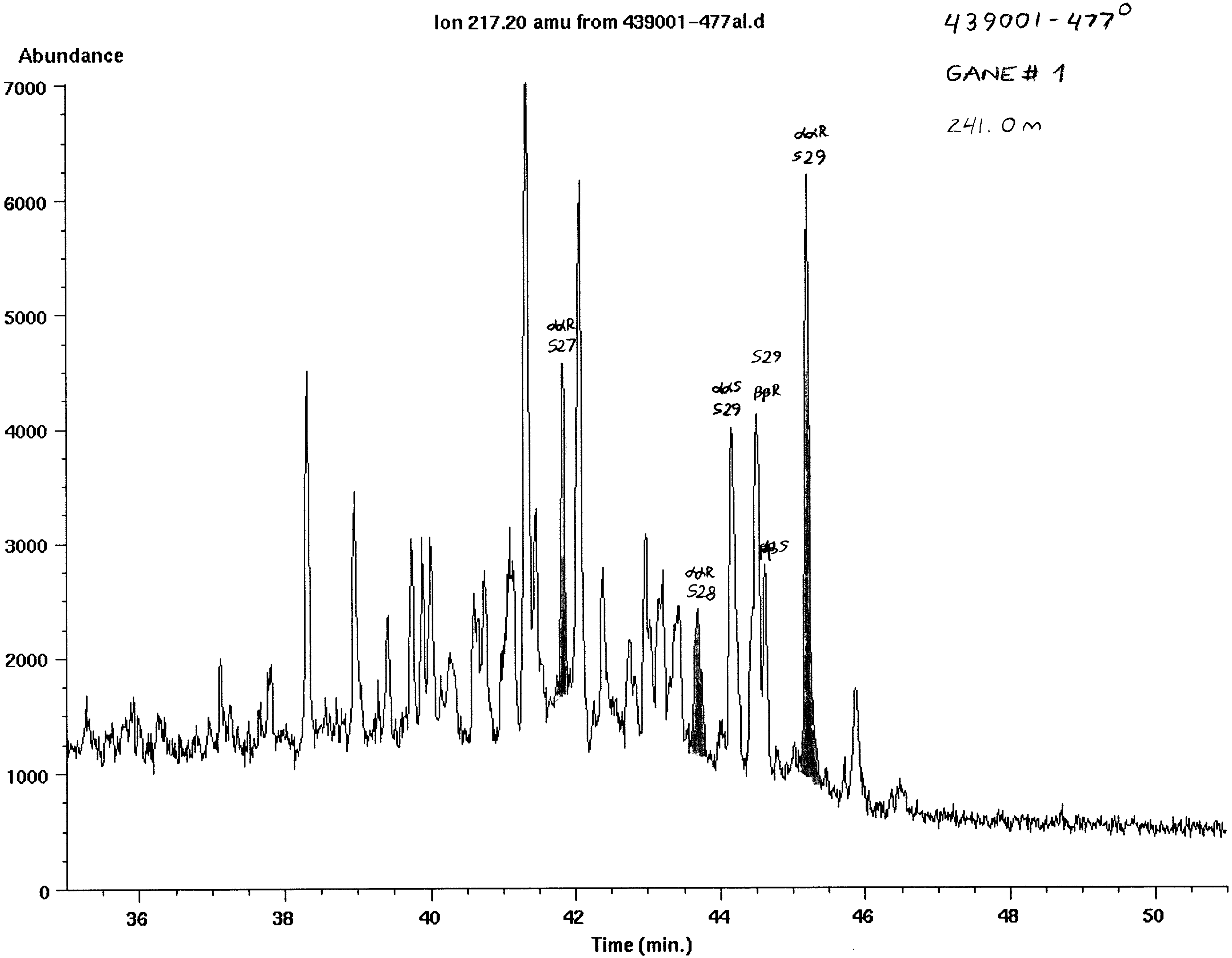
Ion 191.20 amu from 439001-477al.d



439001-477°

GANE #1

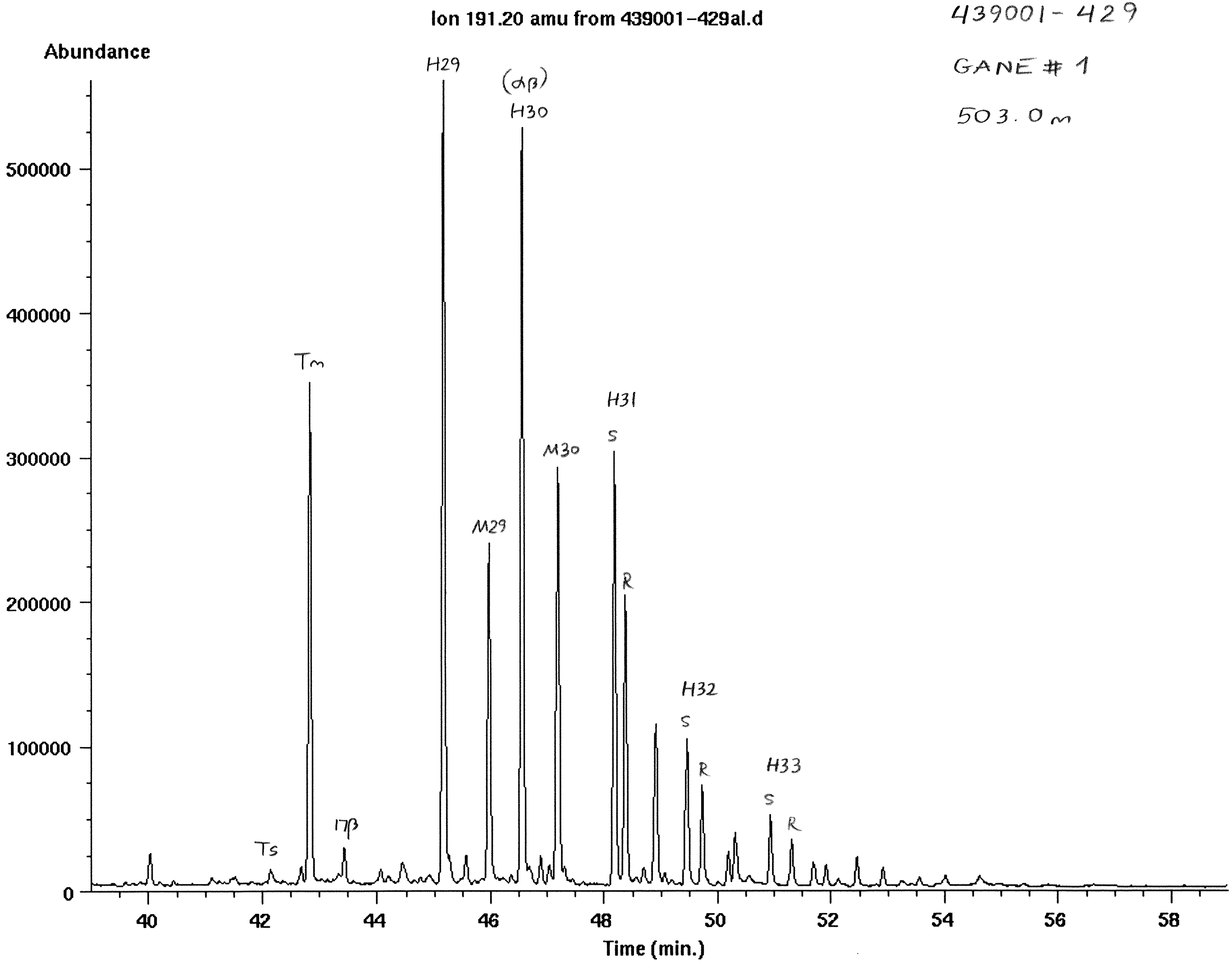
241.0 m



439001-477°

GANE # 1

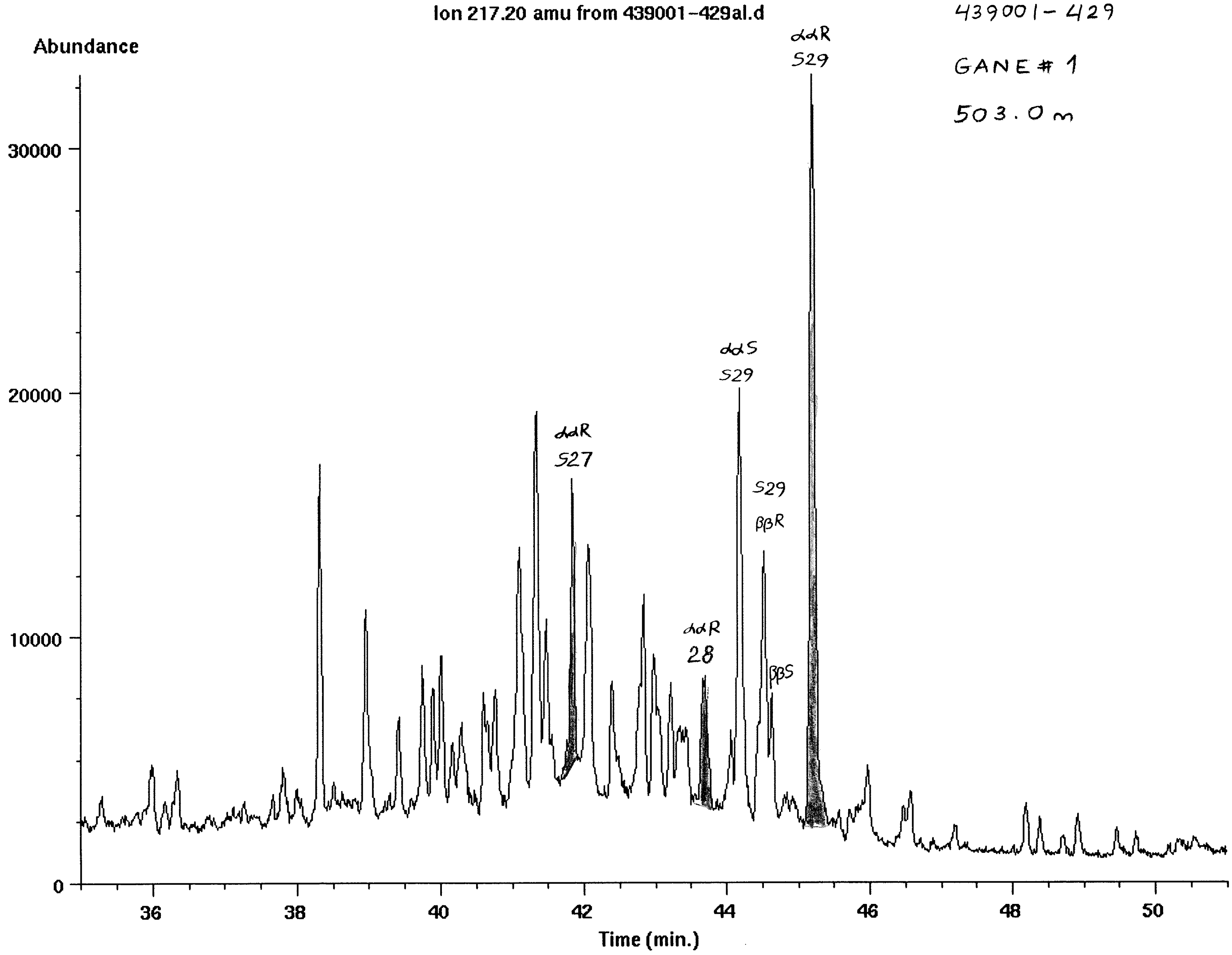
241.0 m



439001-429

GANE #1

503.0m

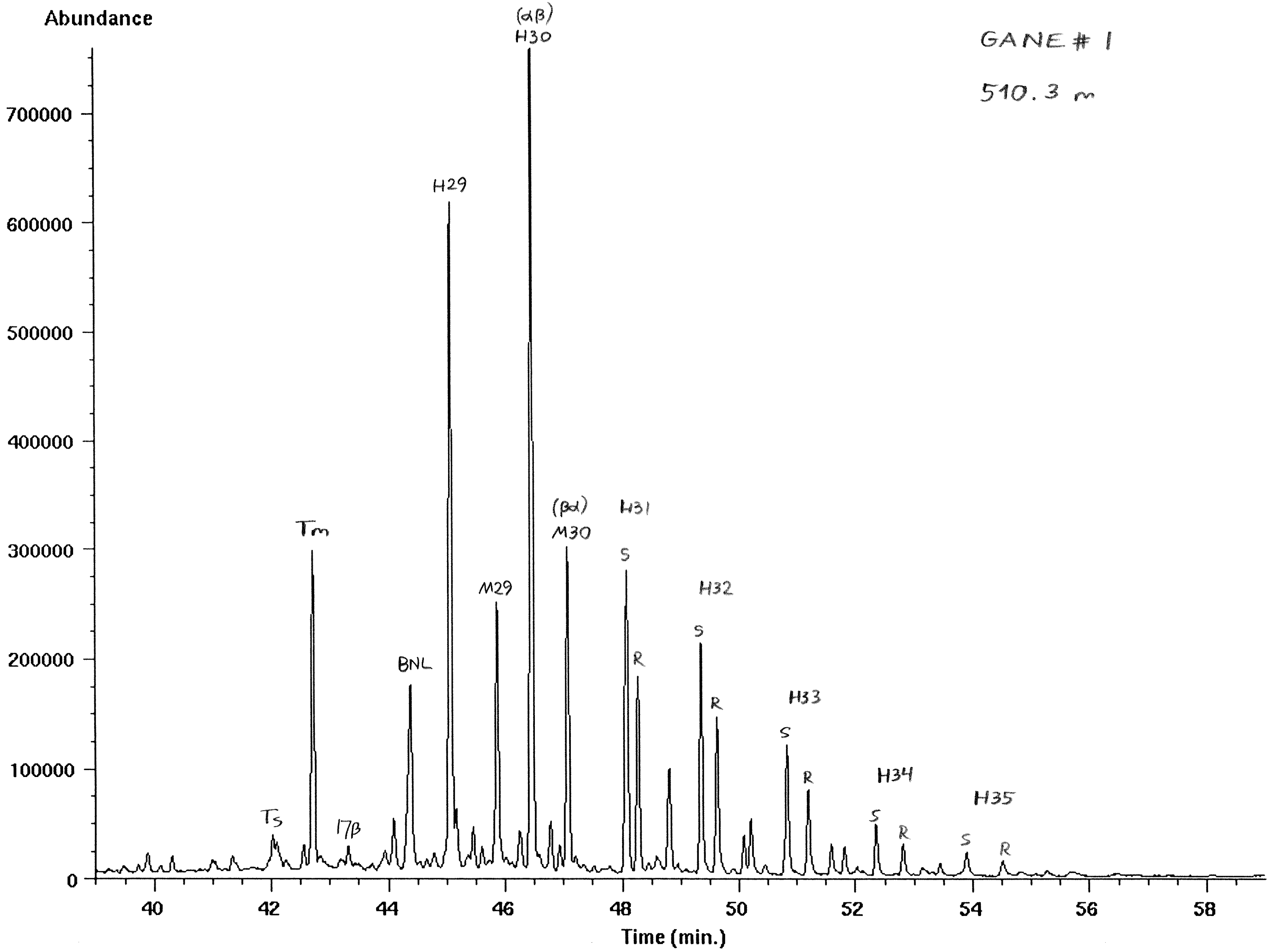


439001-429

GANE # 1

503.0 m

Ion 191.20 amu from 439001-511al.d



439001 - 511

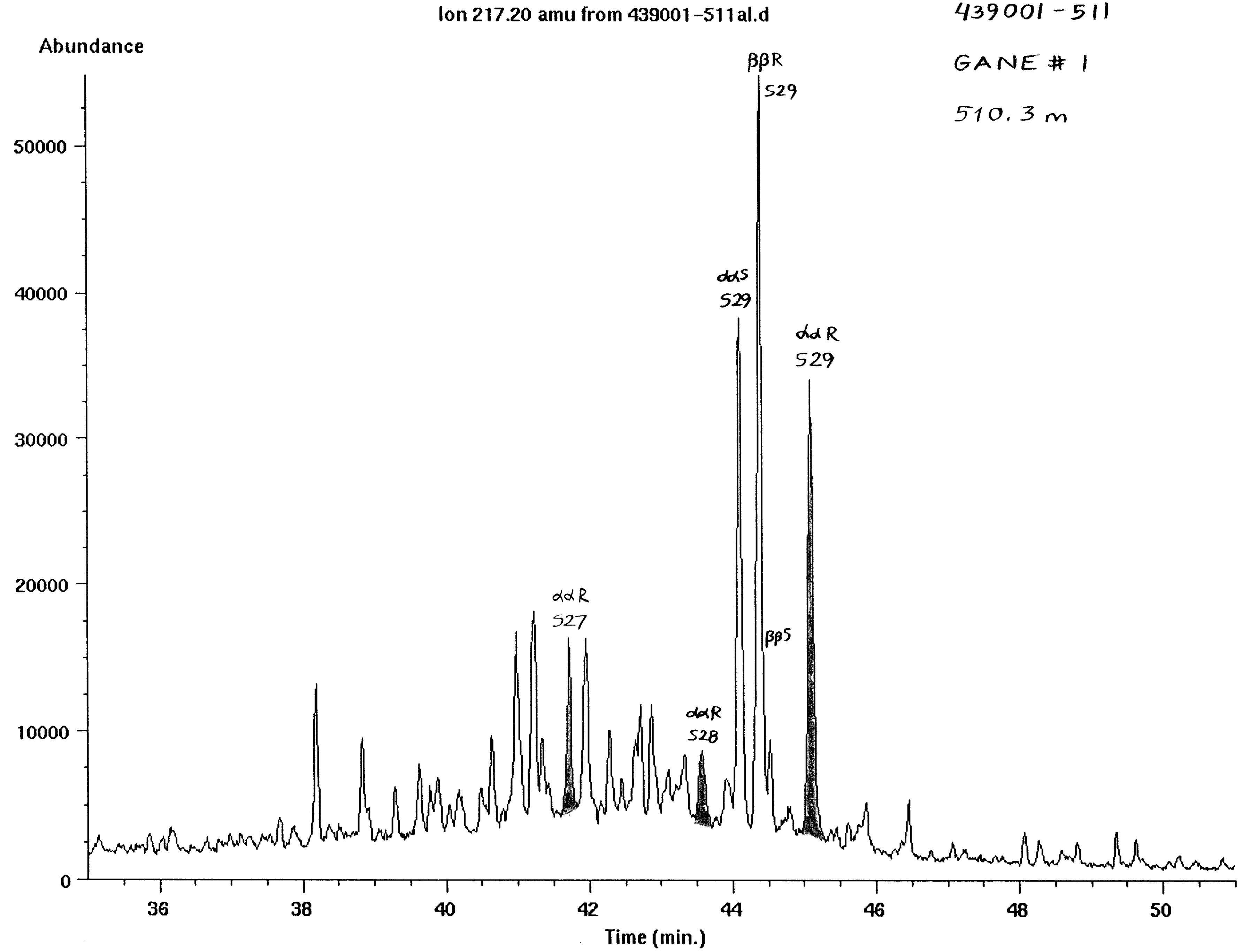
GANE # 1

510.3 m

439001 - 511

GANE # 1

510.3 m

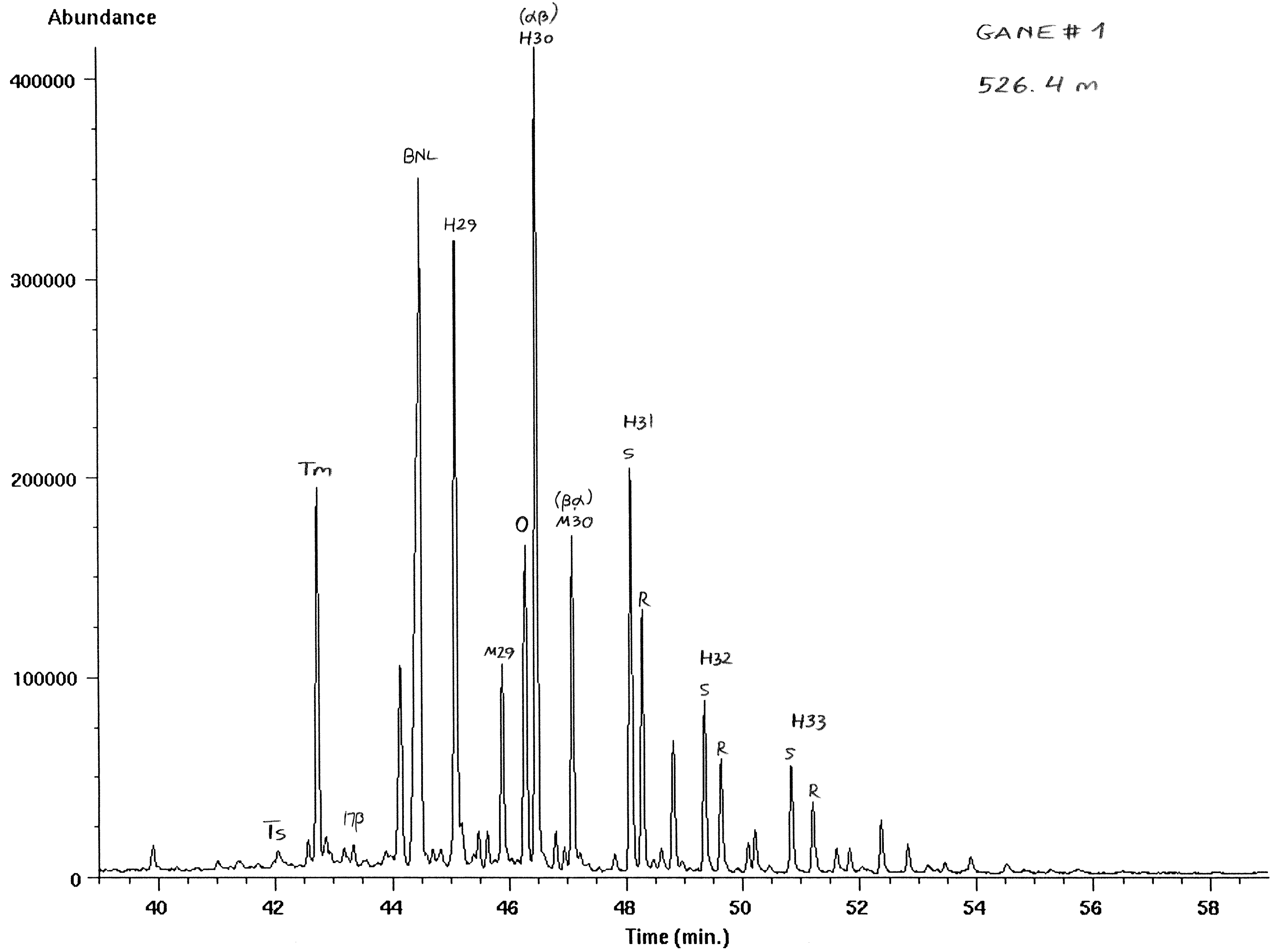


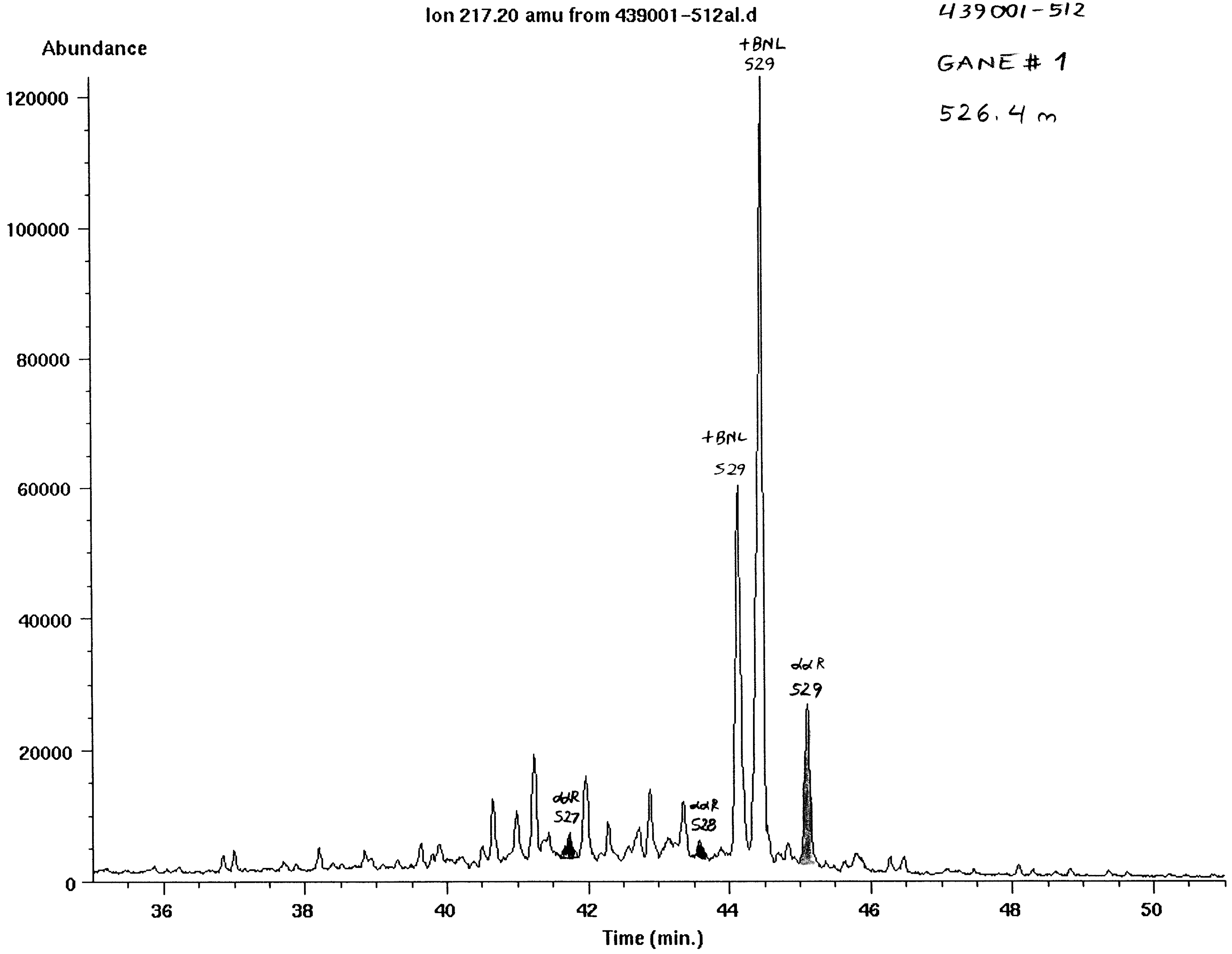
Ion 191.20 amu from 439001-512al.d

439 001 - 512

GANE # 1

526.4 m

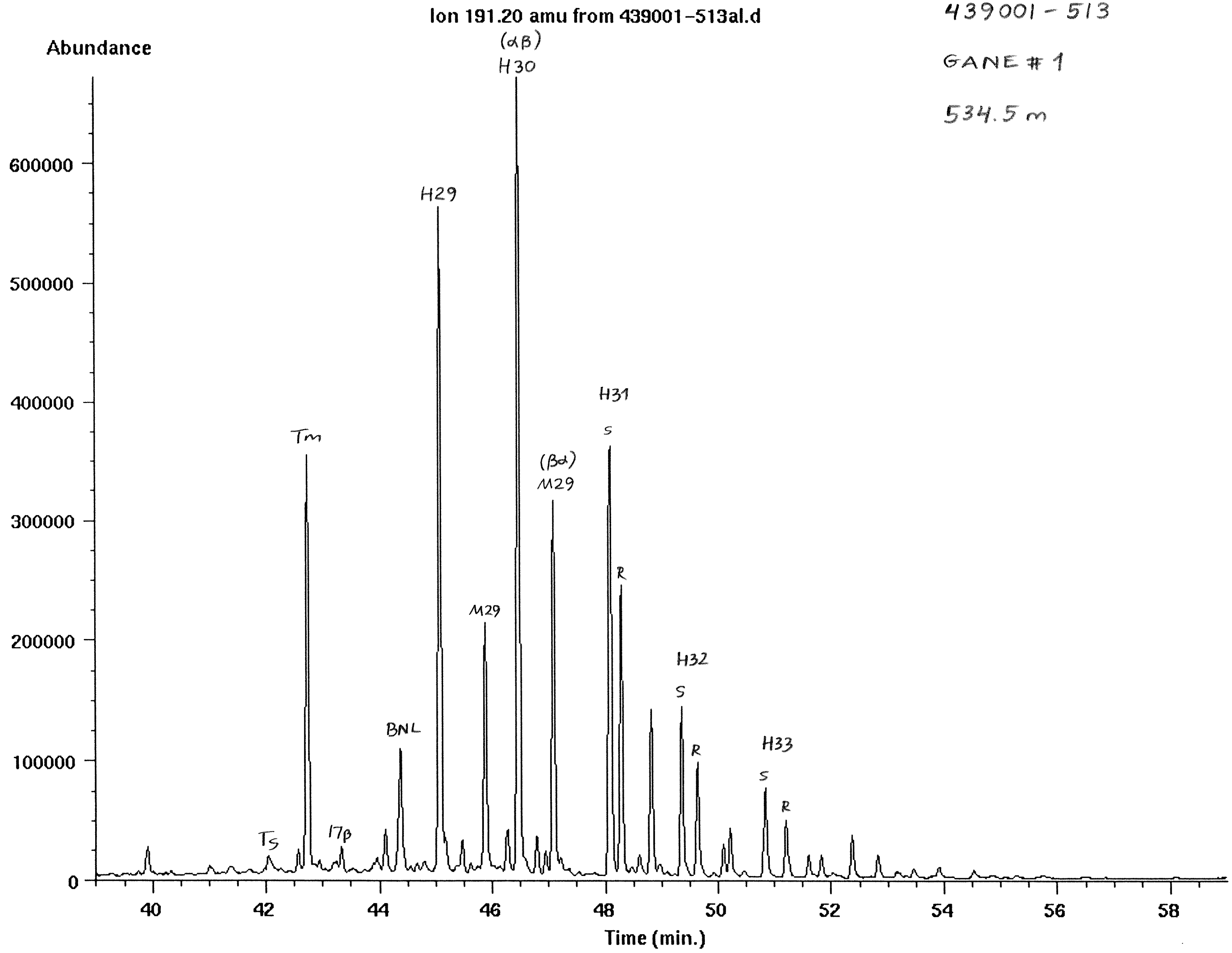




439001-512

GANE # 1

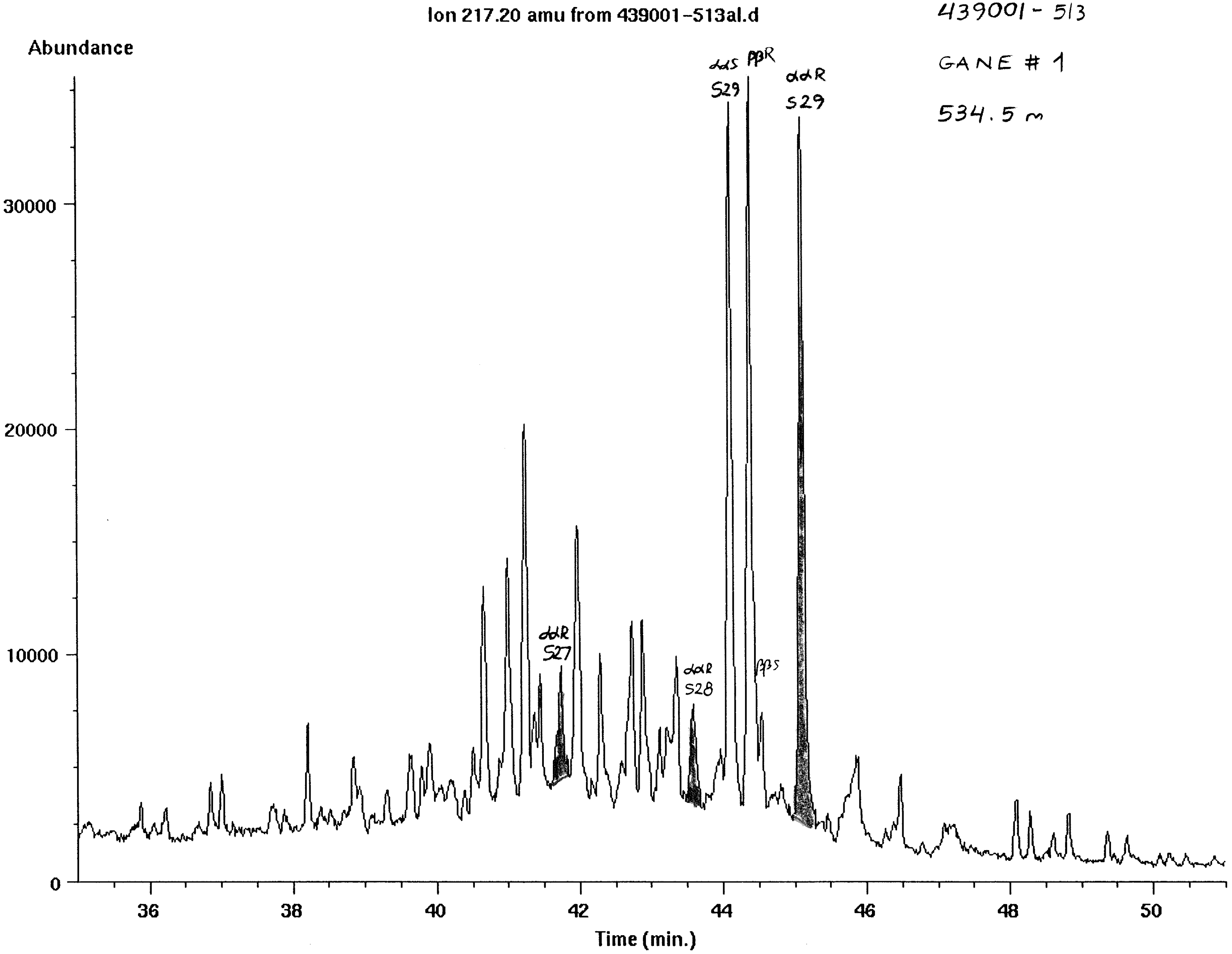
526.4 m



439001 - 513

GANE # 1

534.5 m



439001 - 513

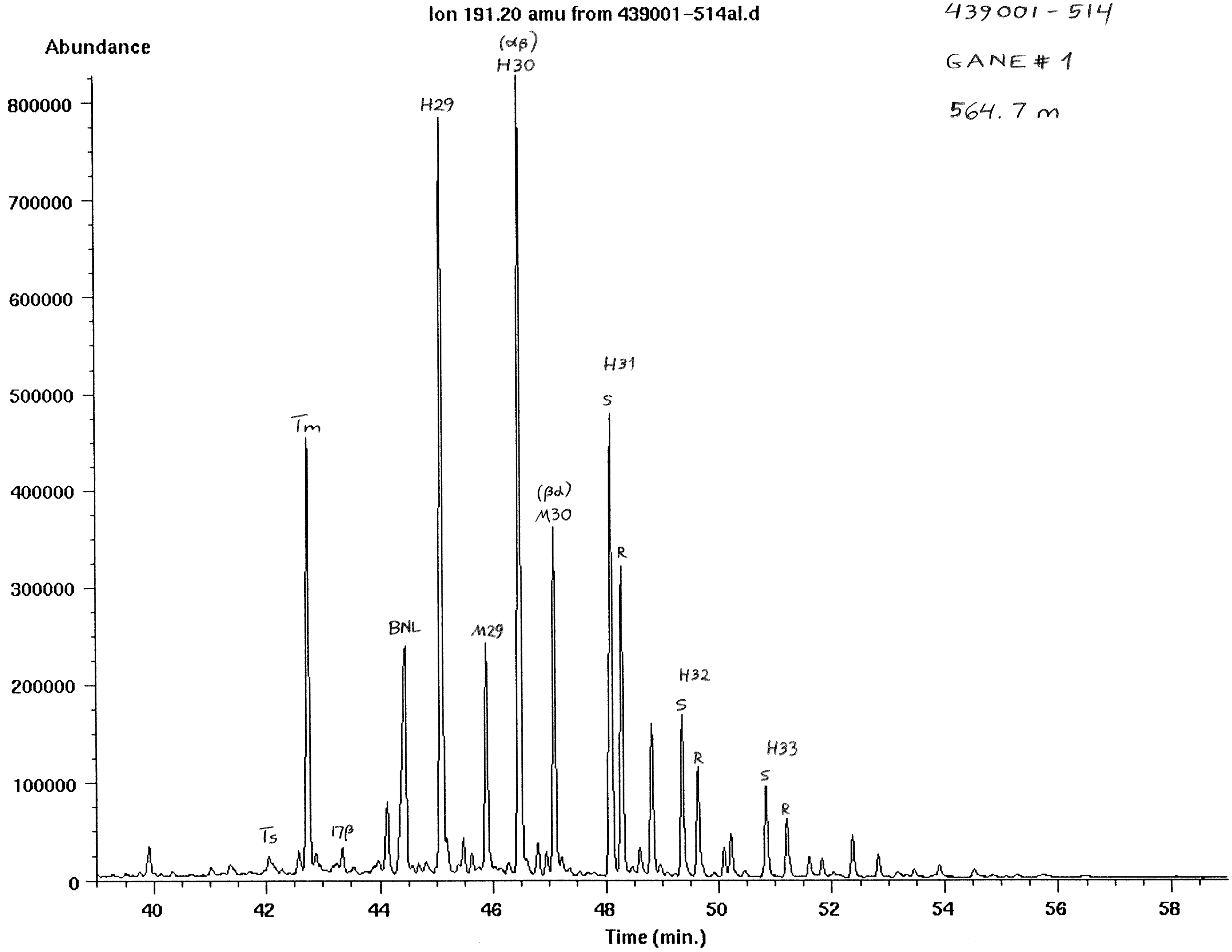
GANE # 1

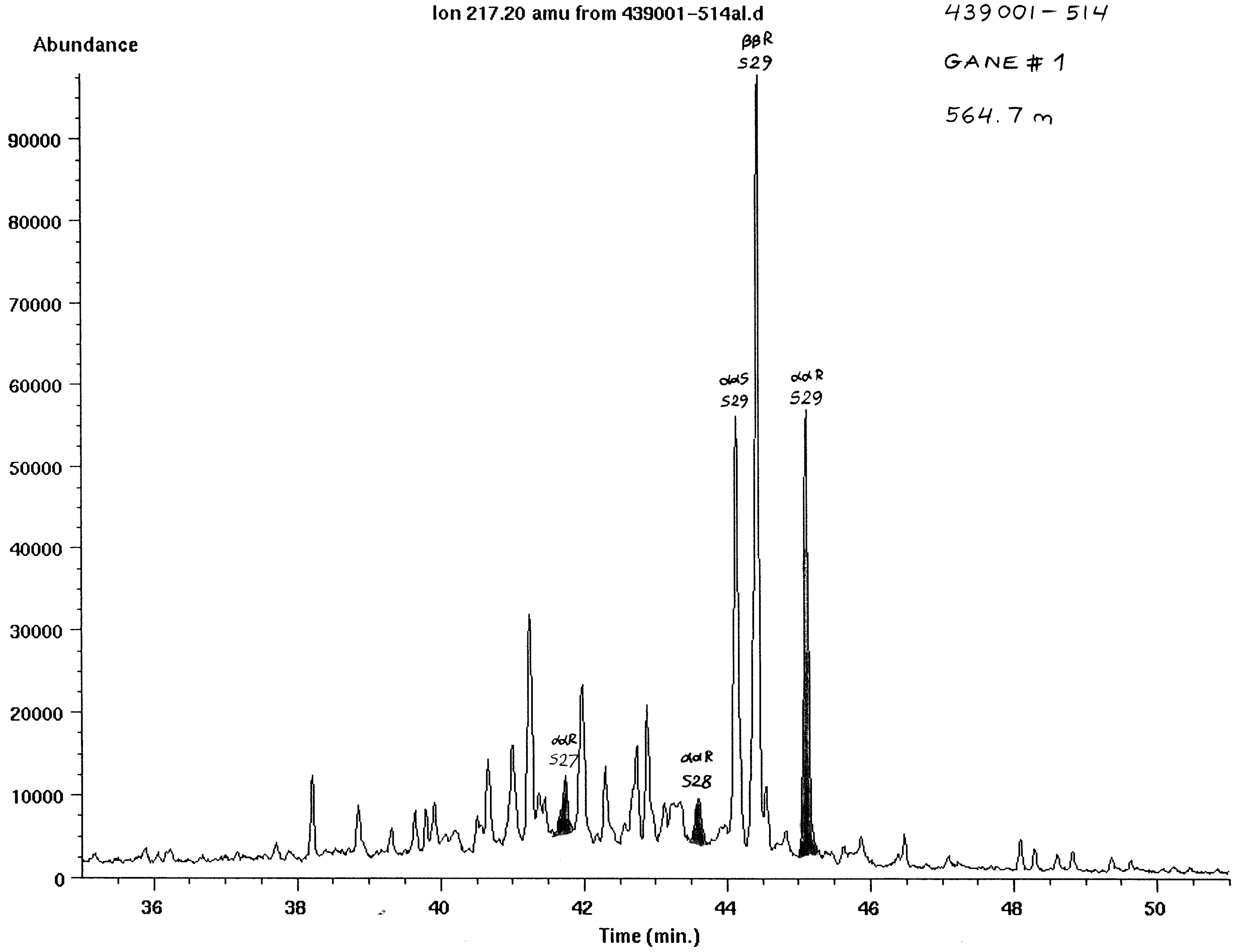
534.5 m

439001 - 514

GANE # 1

564.7 m





439001 – 514

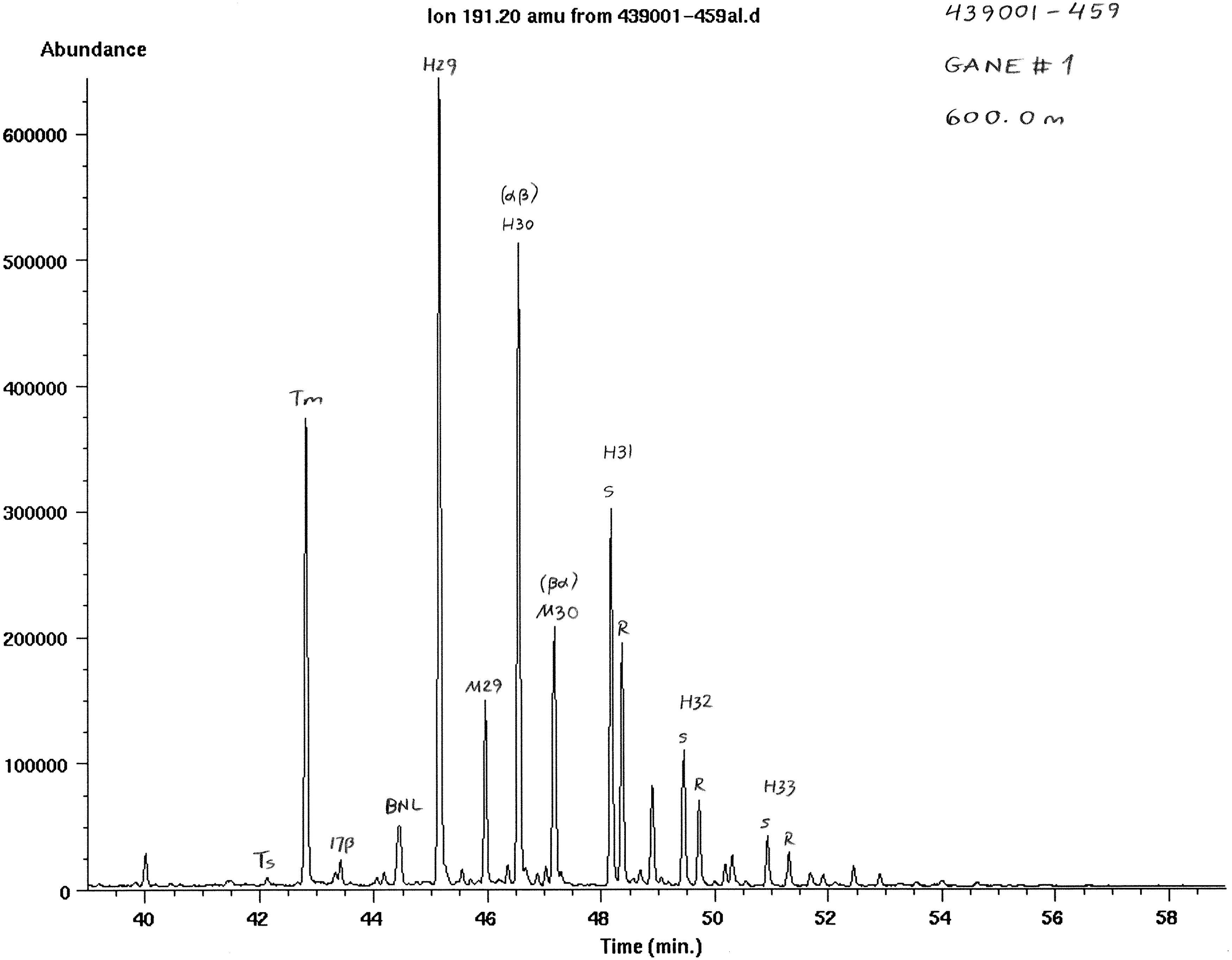
GANE # 1

564.7 m

439001 - 459

GANE # 1

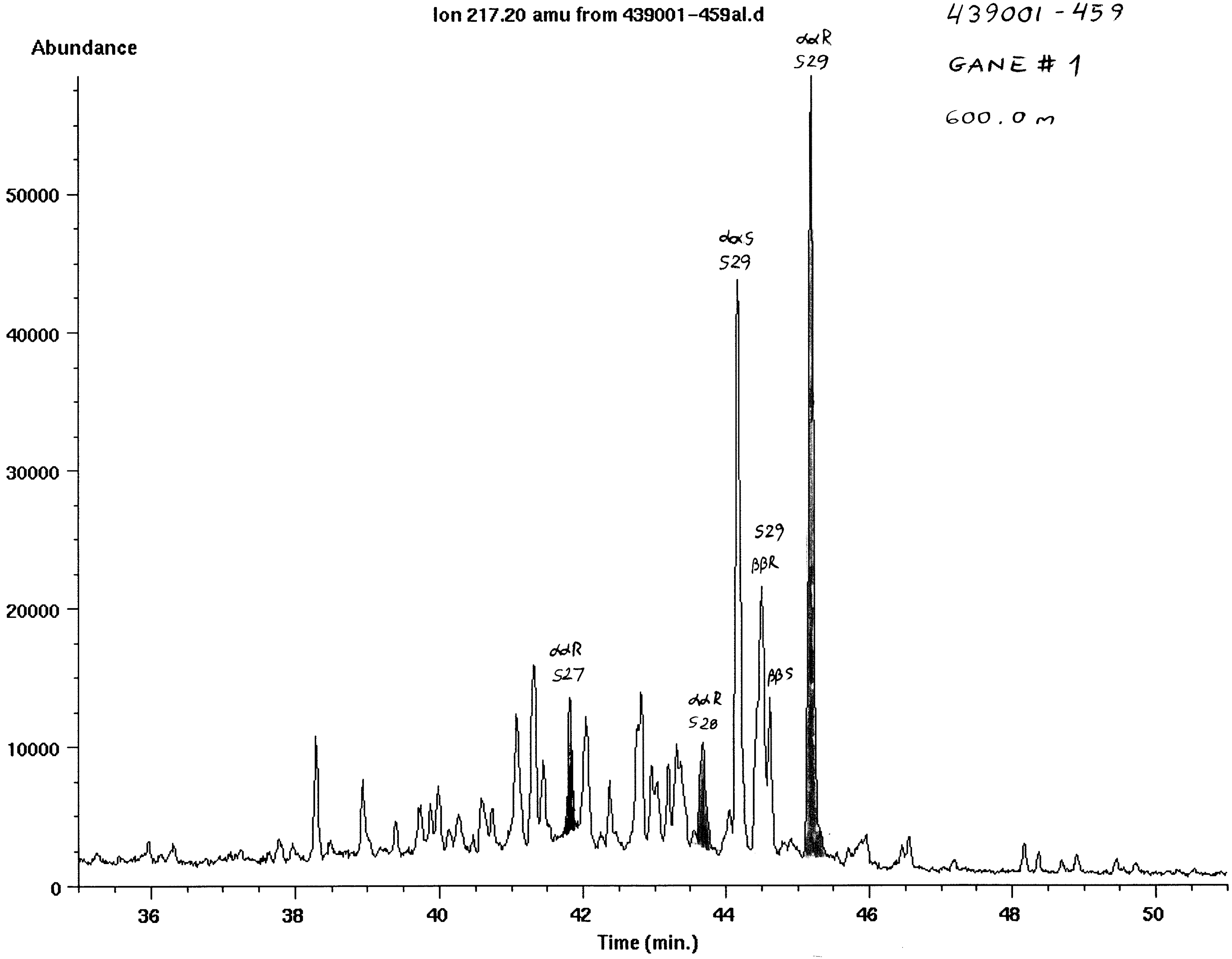
600.0 m

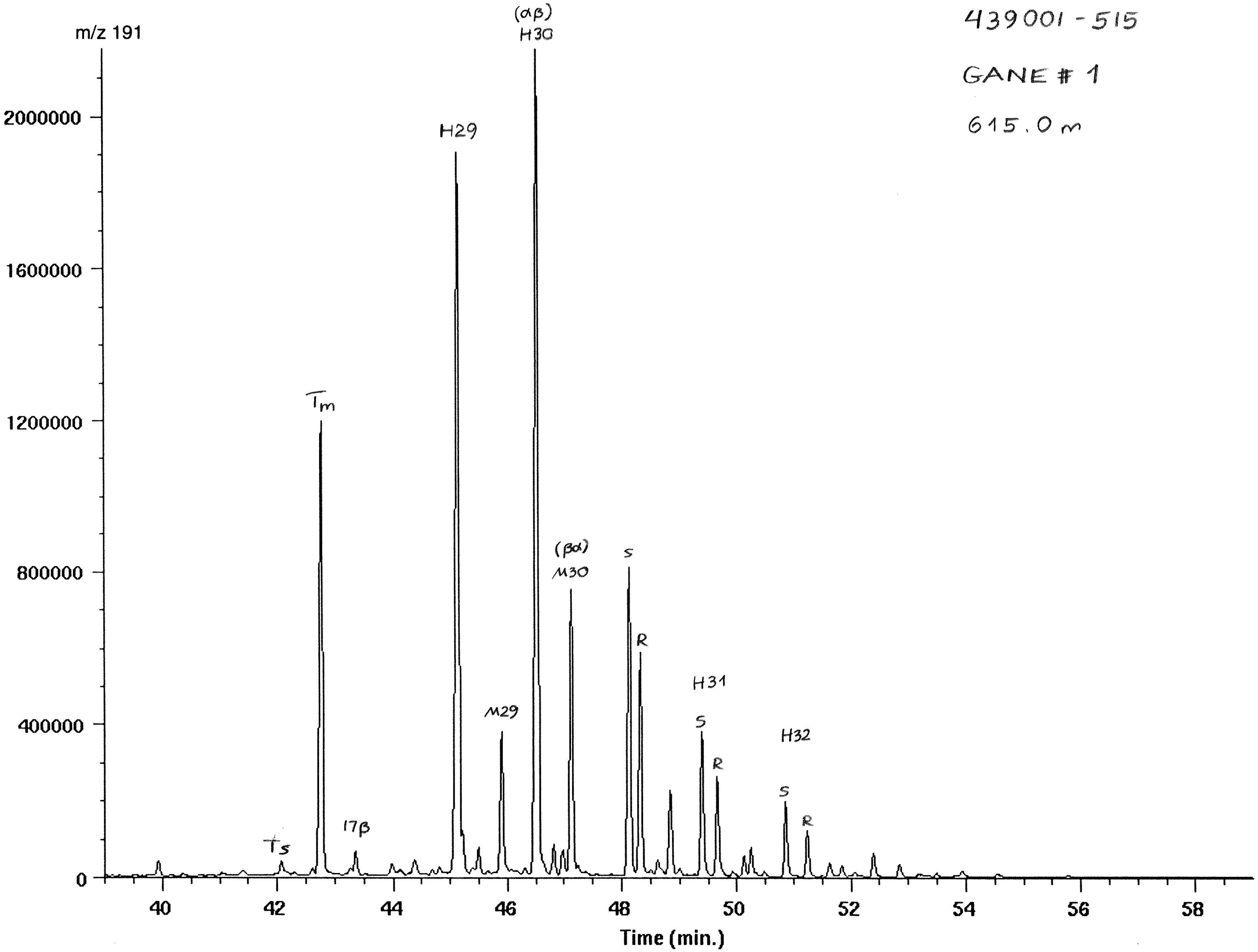


439001 - 459

GANE # 1

600.0 m

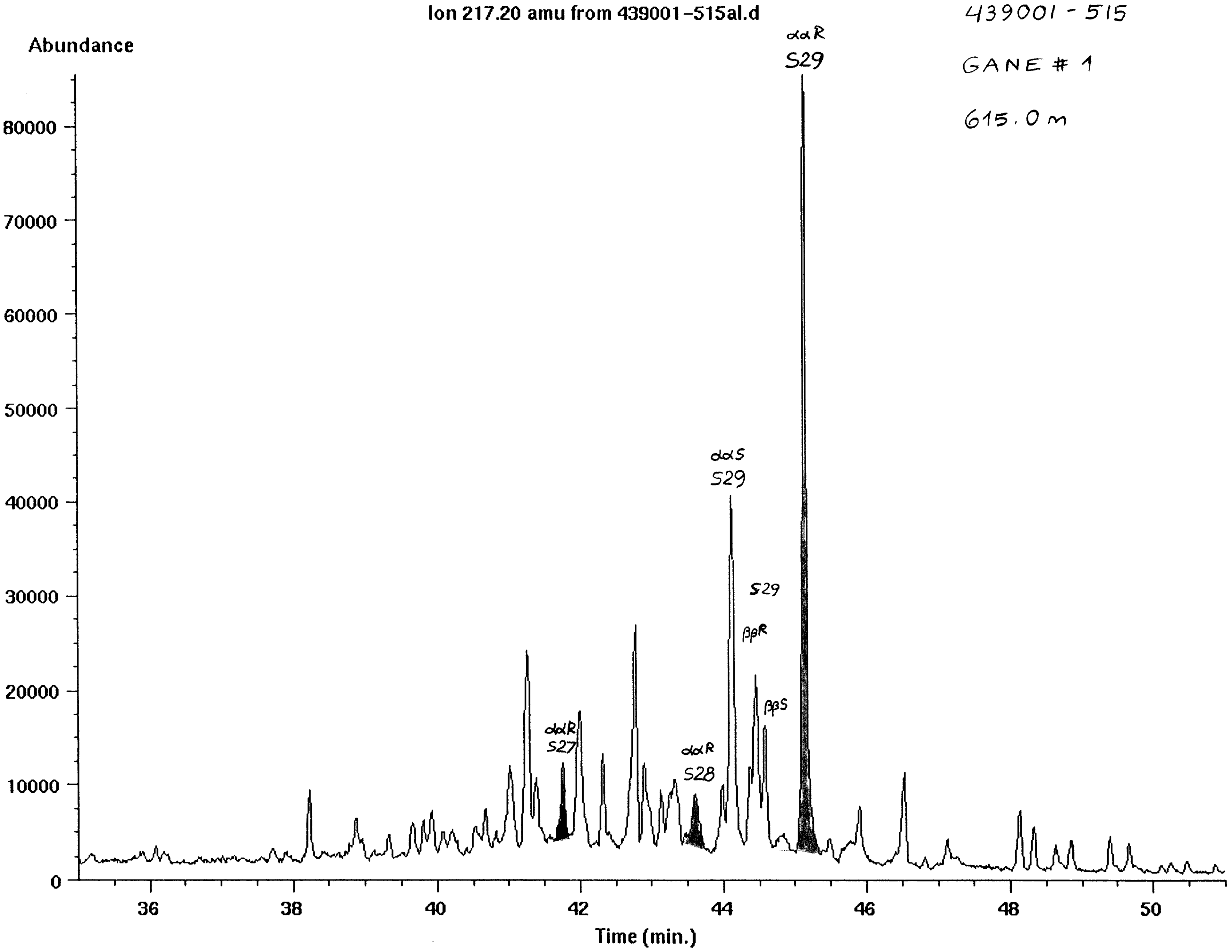




439001-515

GANE # 1

615.0 m



439001 - 515

GANE # 1

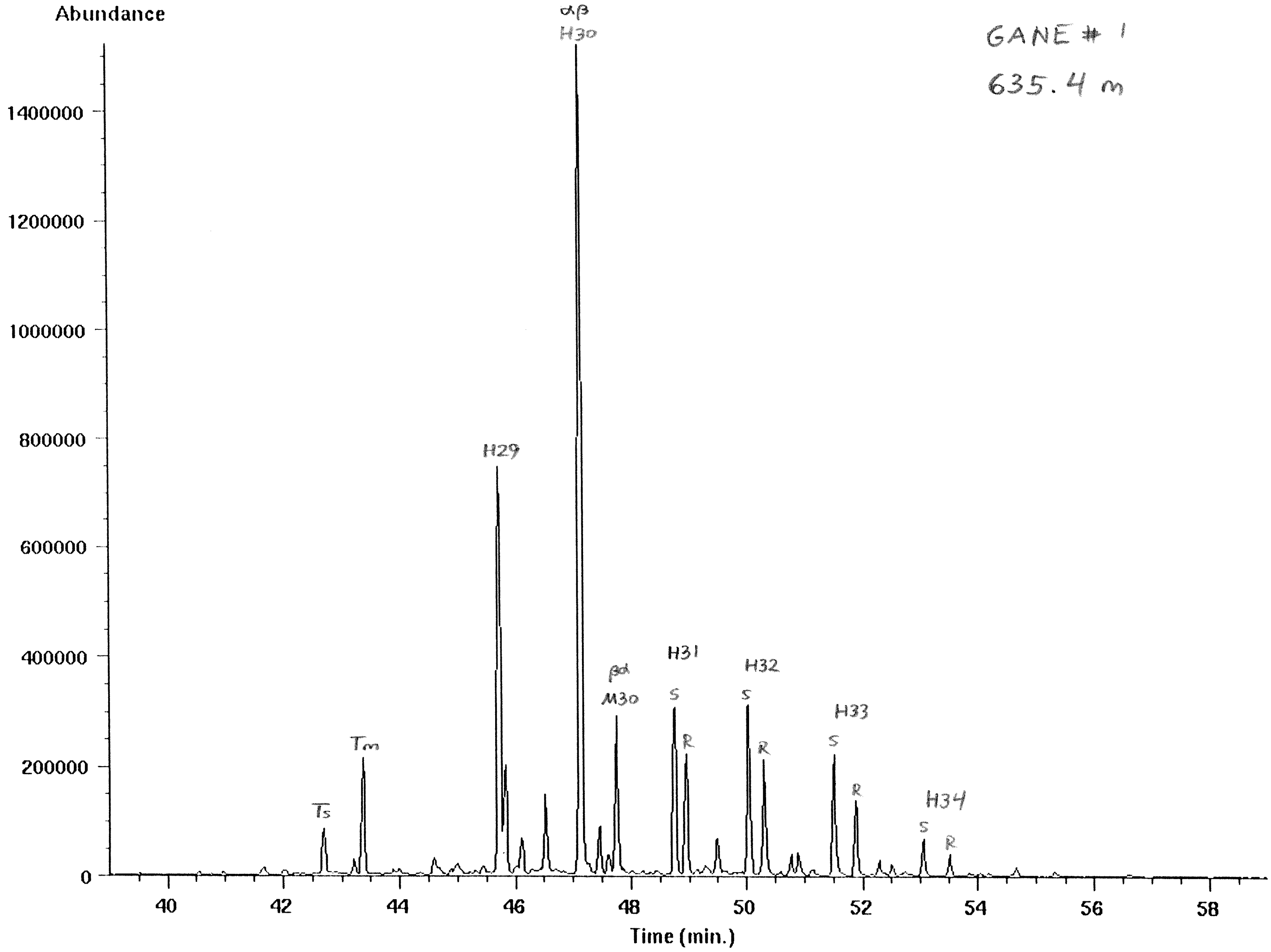
615.0 m

439001 - 369 (0)

GANE # 1

635.4 m

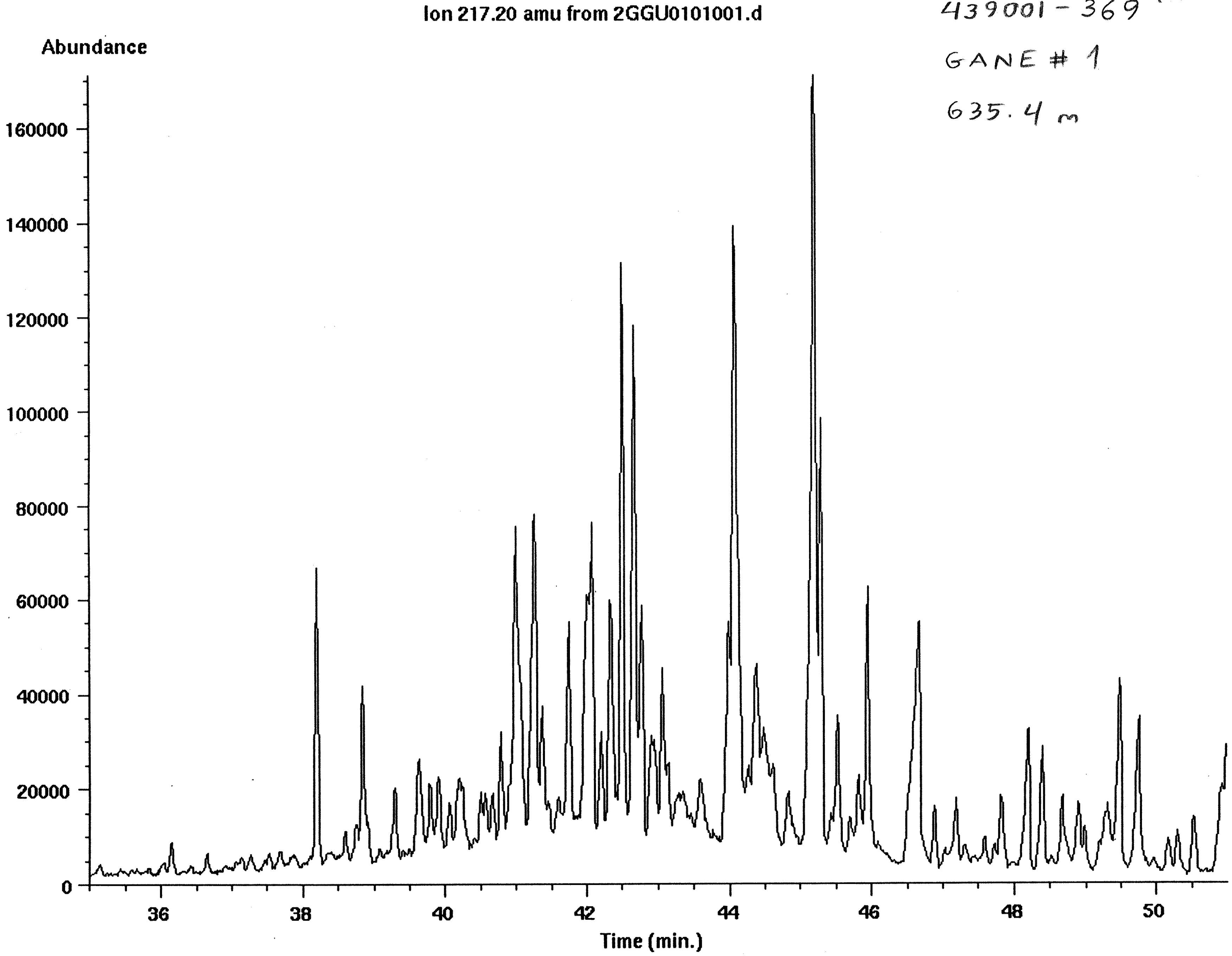
Ion 191.20 amu from 439001-369-O.d



439001 - 369 (o)

GANE # 1

635.4 m

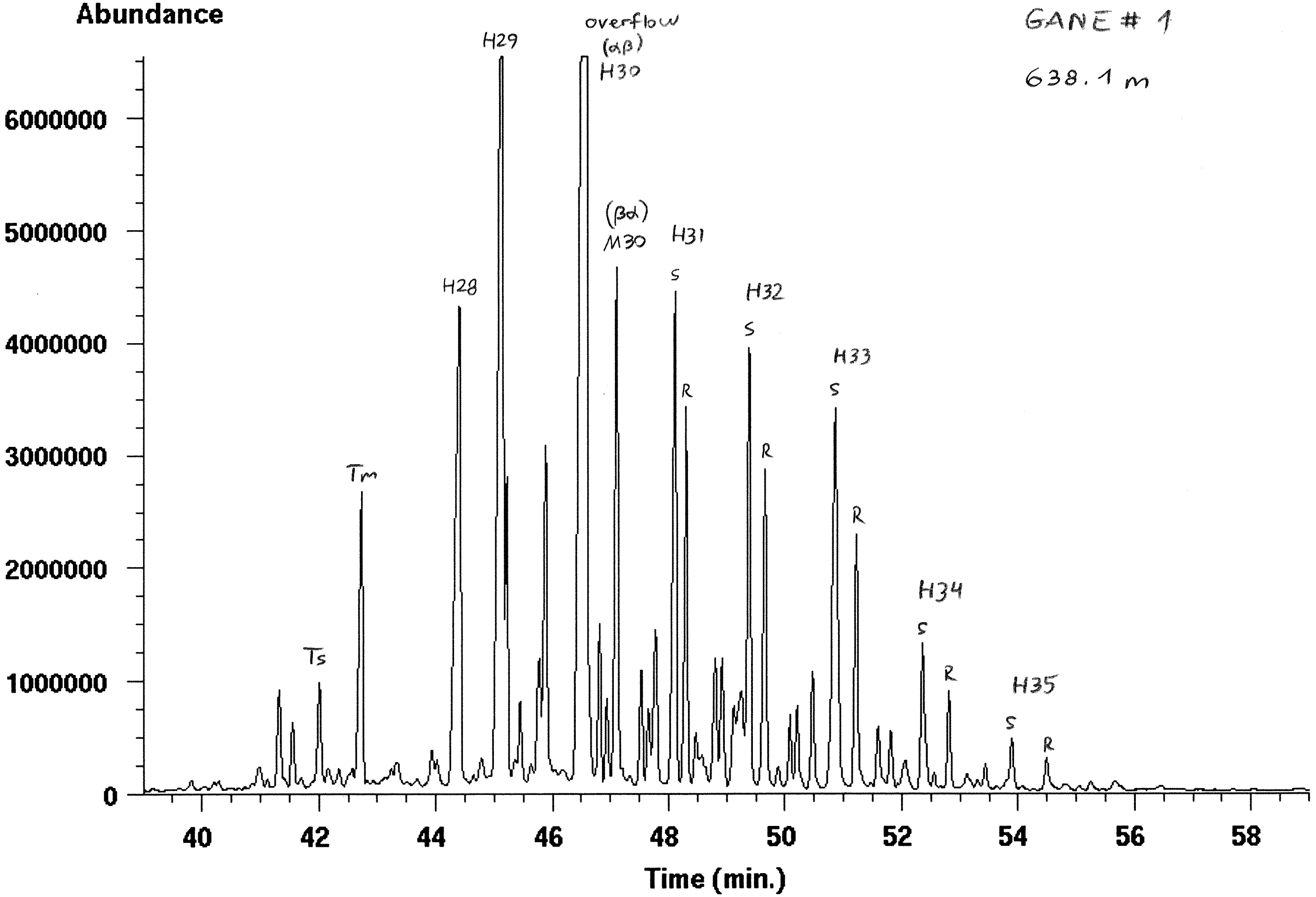


Ion 191.20 amu from 439001-648al.d

439001 - 648°

GANE # 1

638.1 m

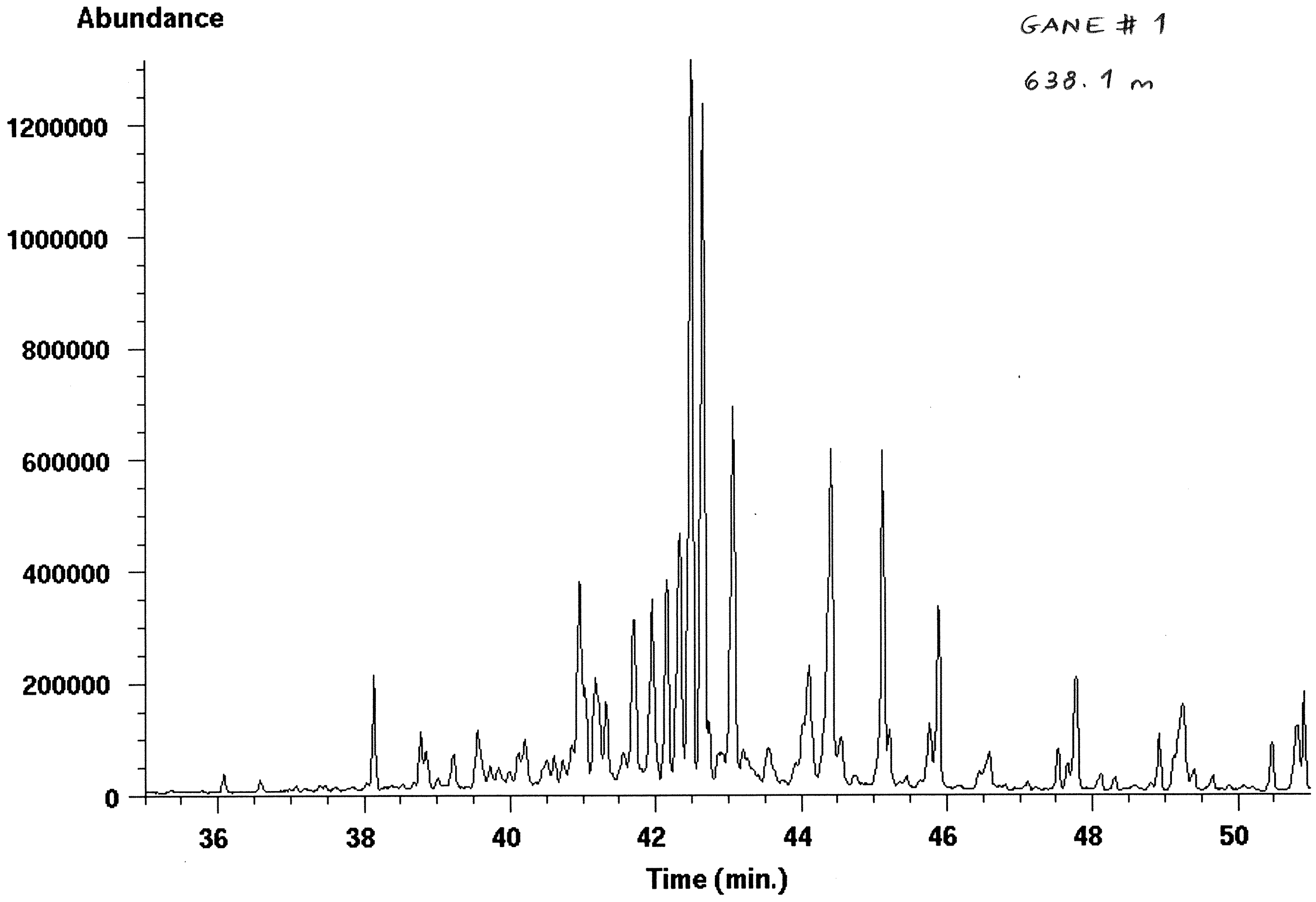


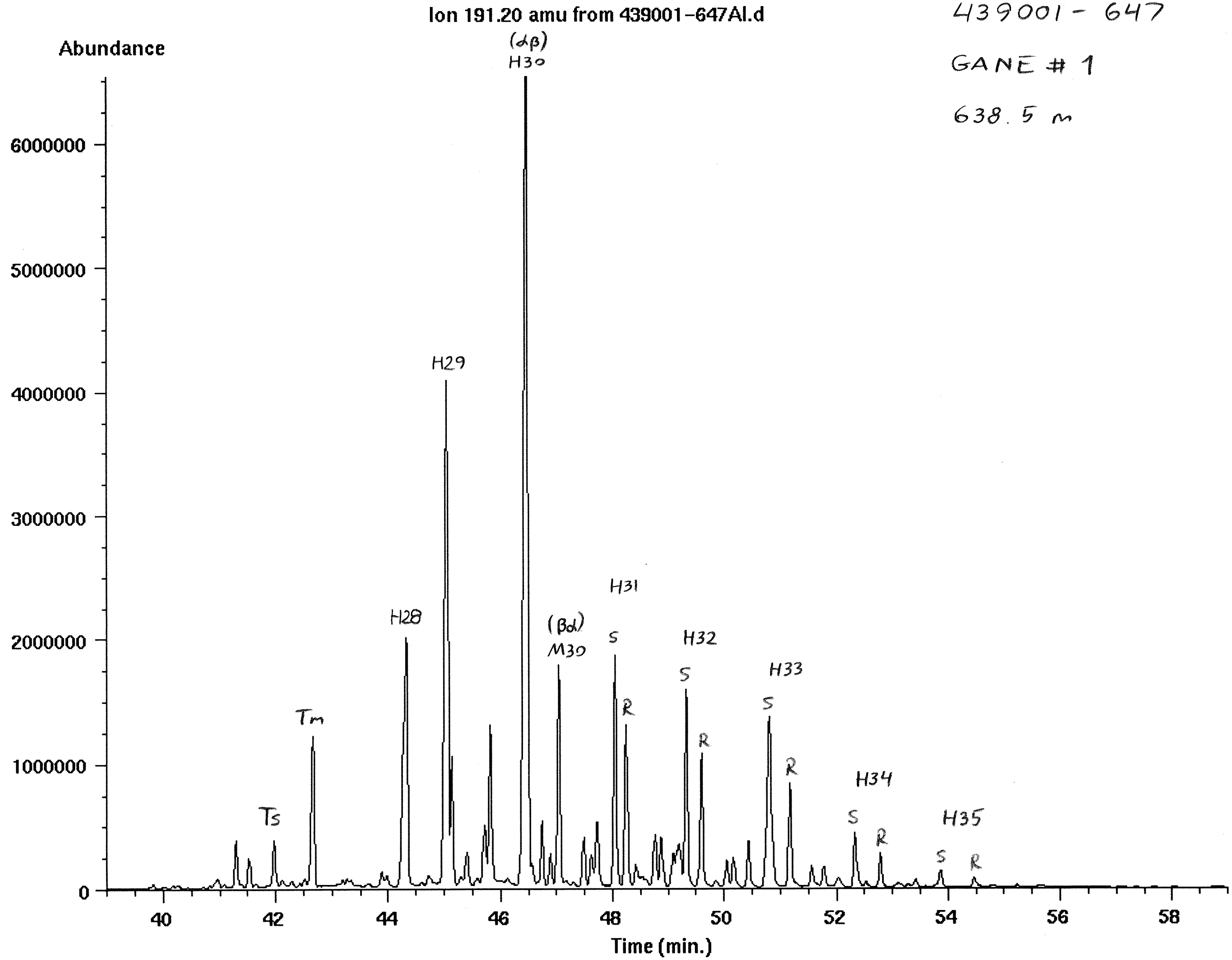
Ion 217.20 amu from 439001–648al.d

439001-648^{0}

GANE # 1

638. 1 m





439001 - 647^{0}

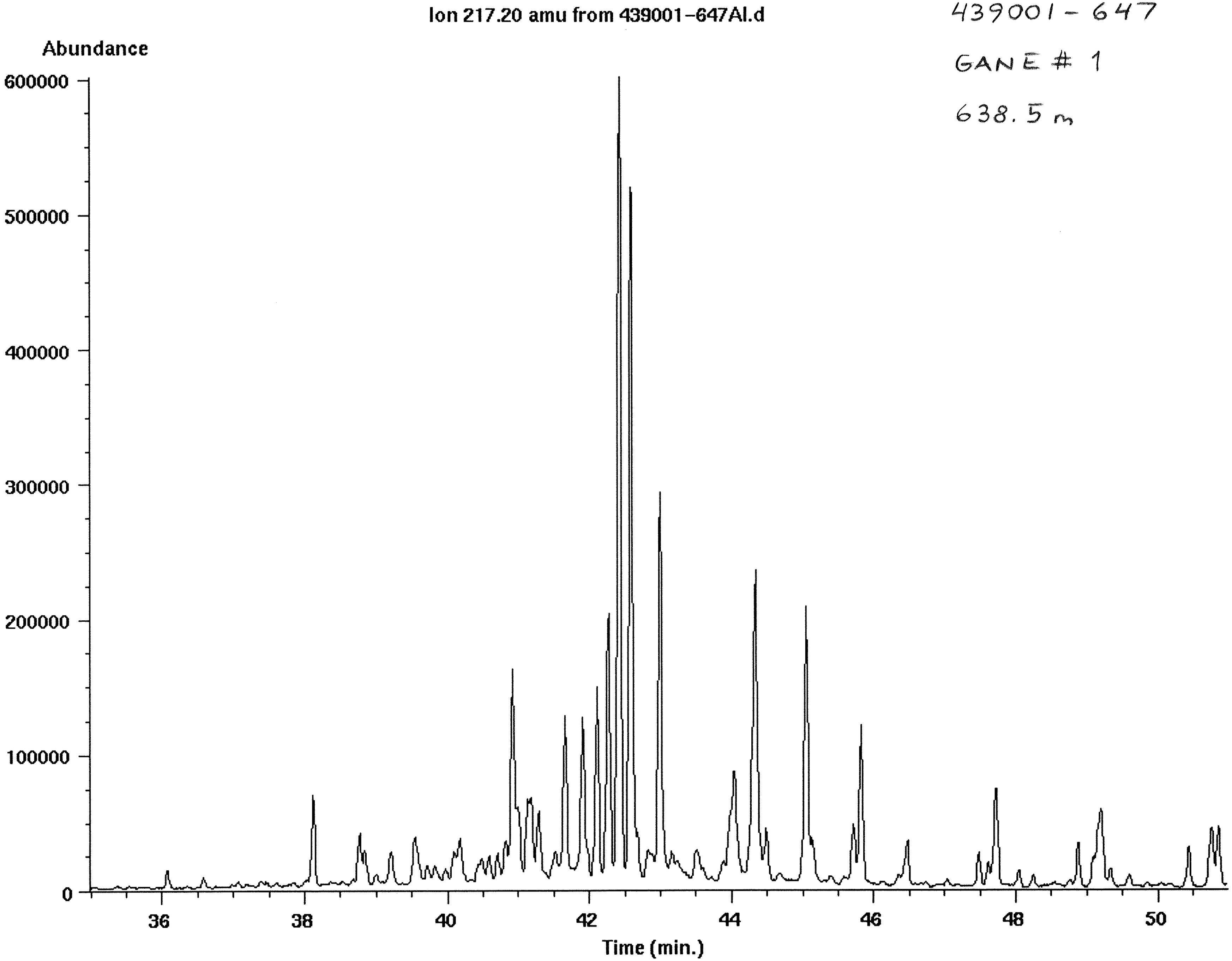
GANE # 1

638.5 m

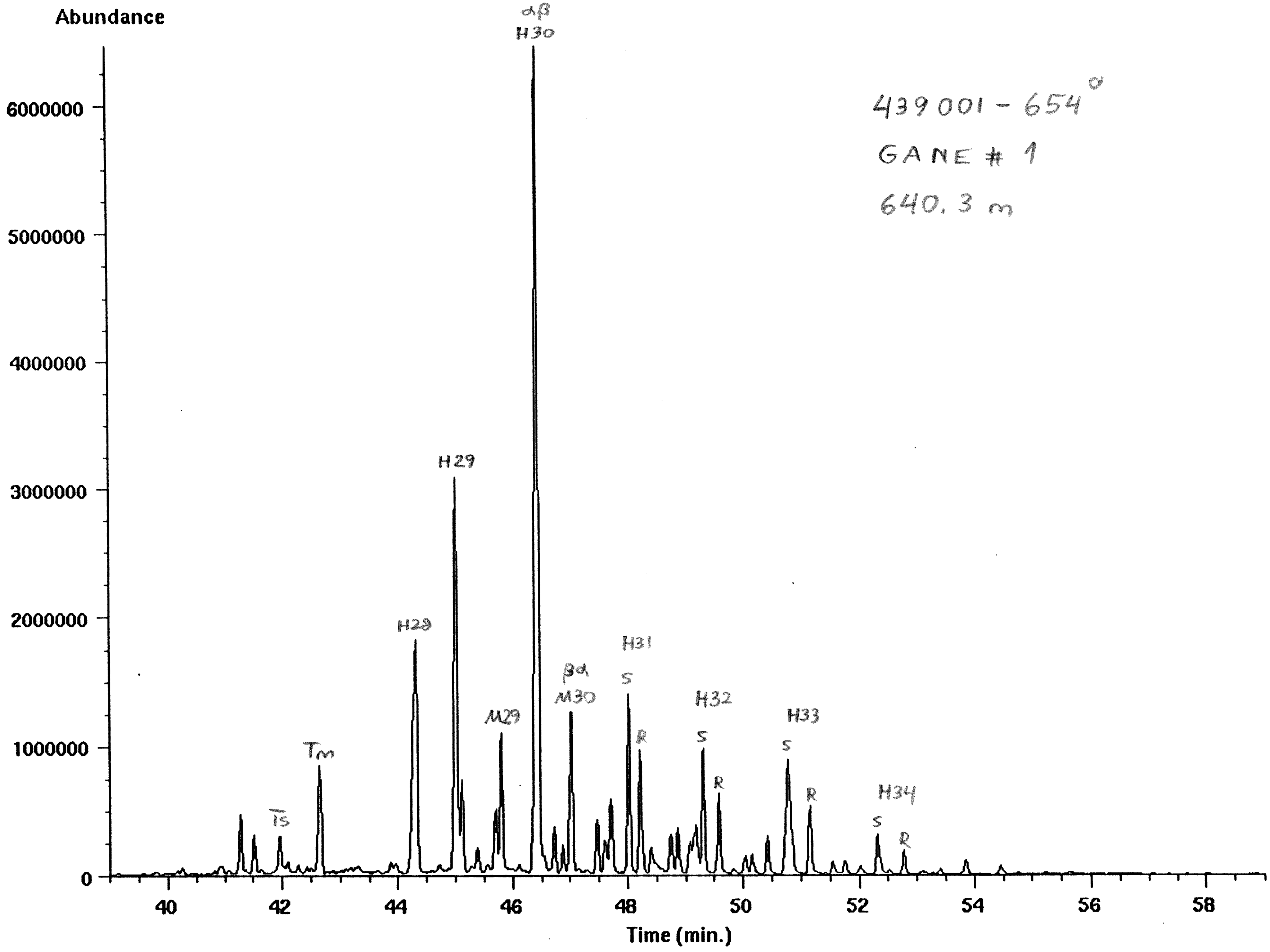
439001 - 647 0

GANE # 1

638.5 m



Ion 191.20 amu from 439001-654AI.d



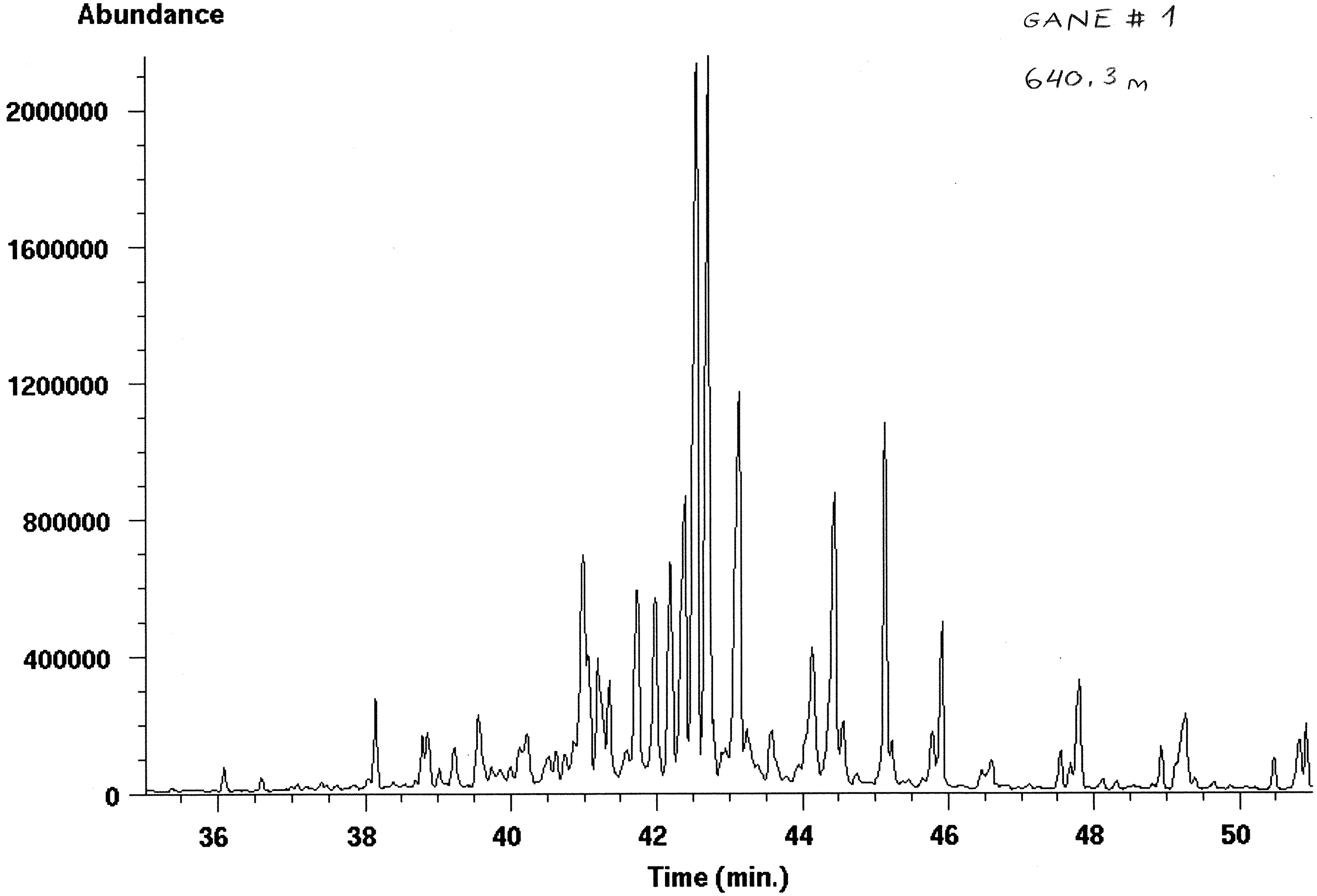
439001-654°
GANE # 1
640.3 m

Ion 217.20 amu from 439001-654al.d

439001-654

GANE # 1

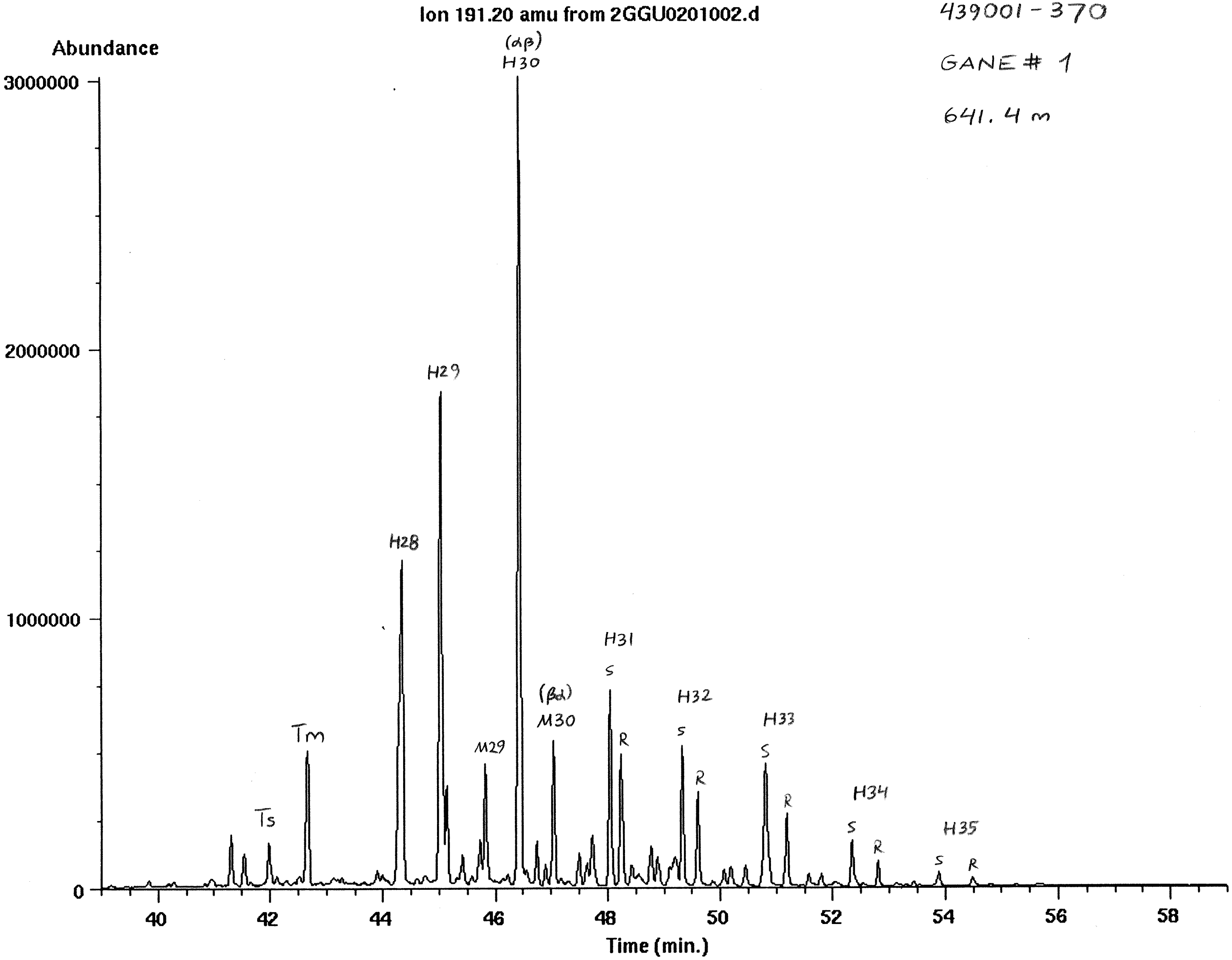
640.3 m



$439001-370^{(o)}$

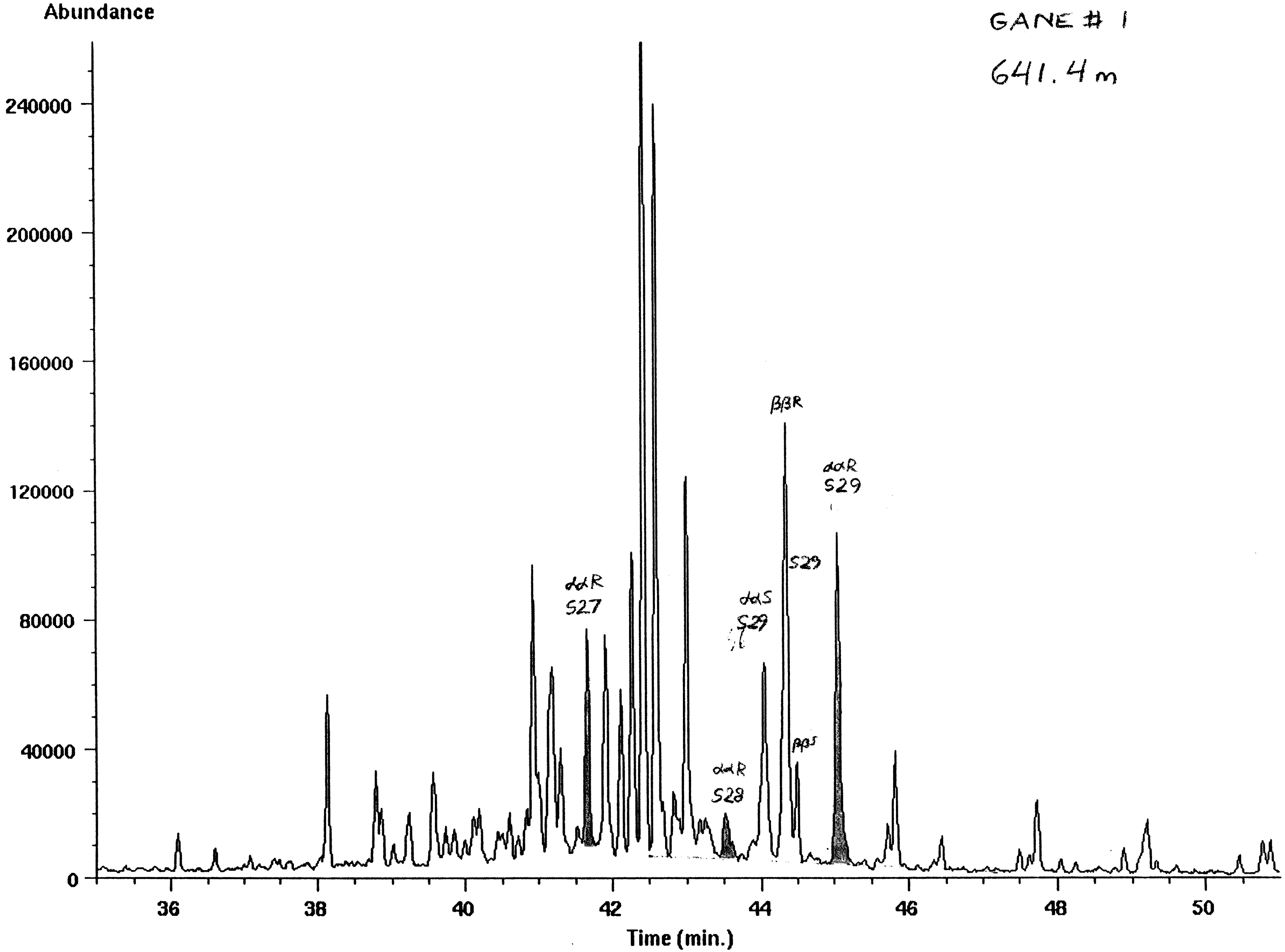
GANE # 1

641.4 m

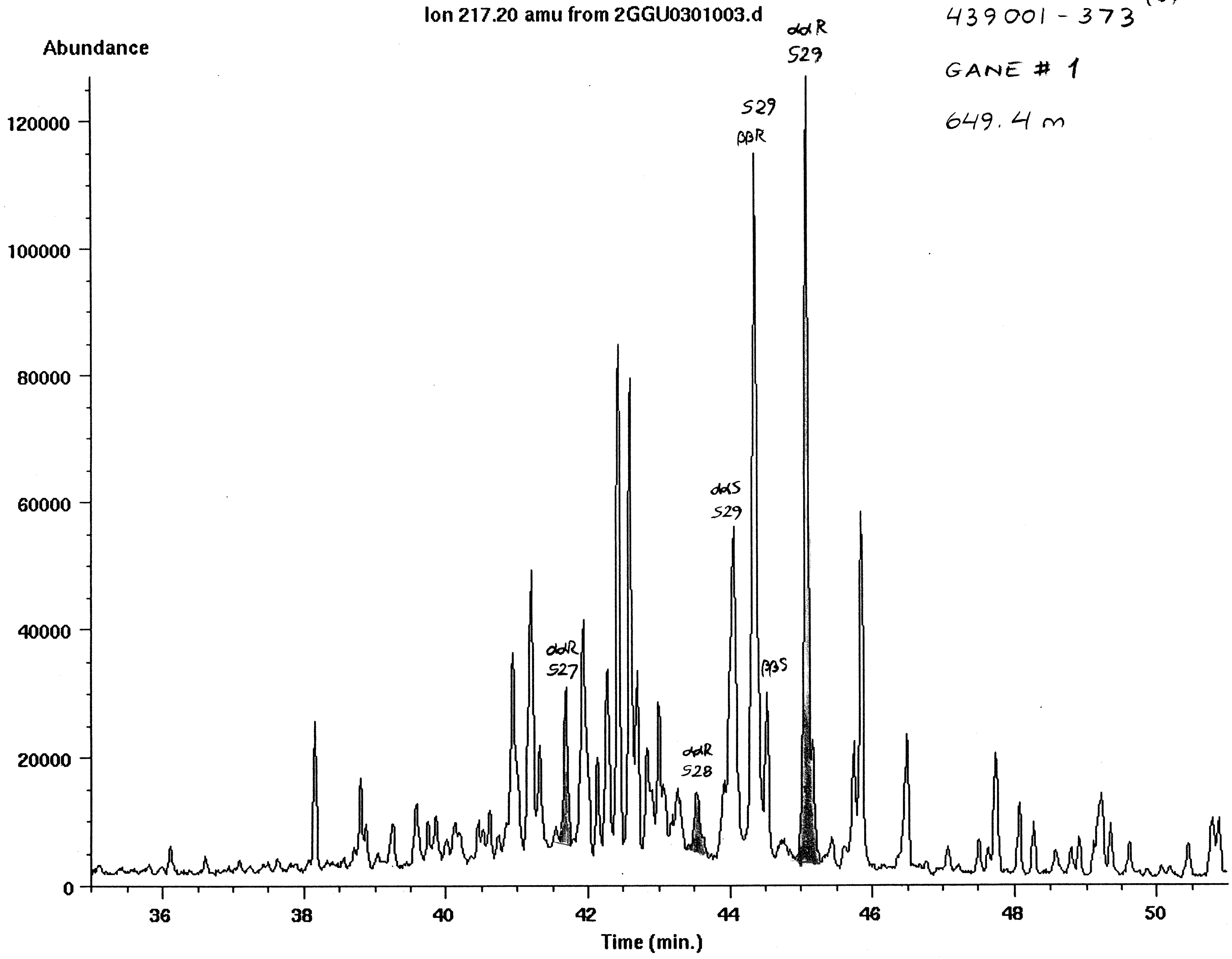


439001-370 (o)
GANE # 1
641.4 m

Ion 217.20 amu from 2GGU0201002.d



Ion 217.20 amu from 2GGU0301003.d



439001 - 373 (0)

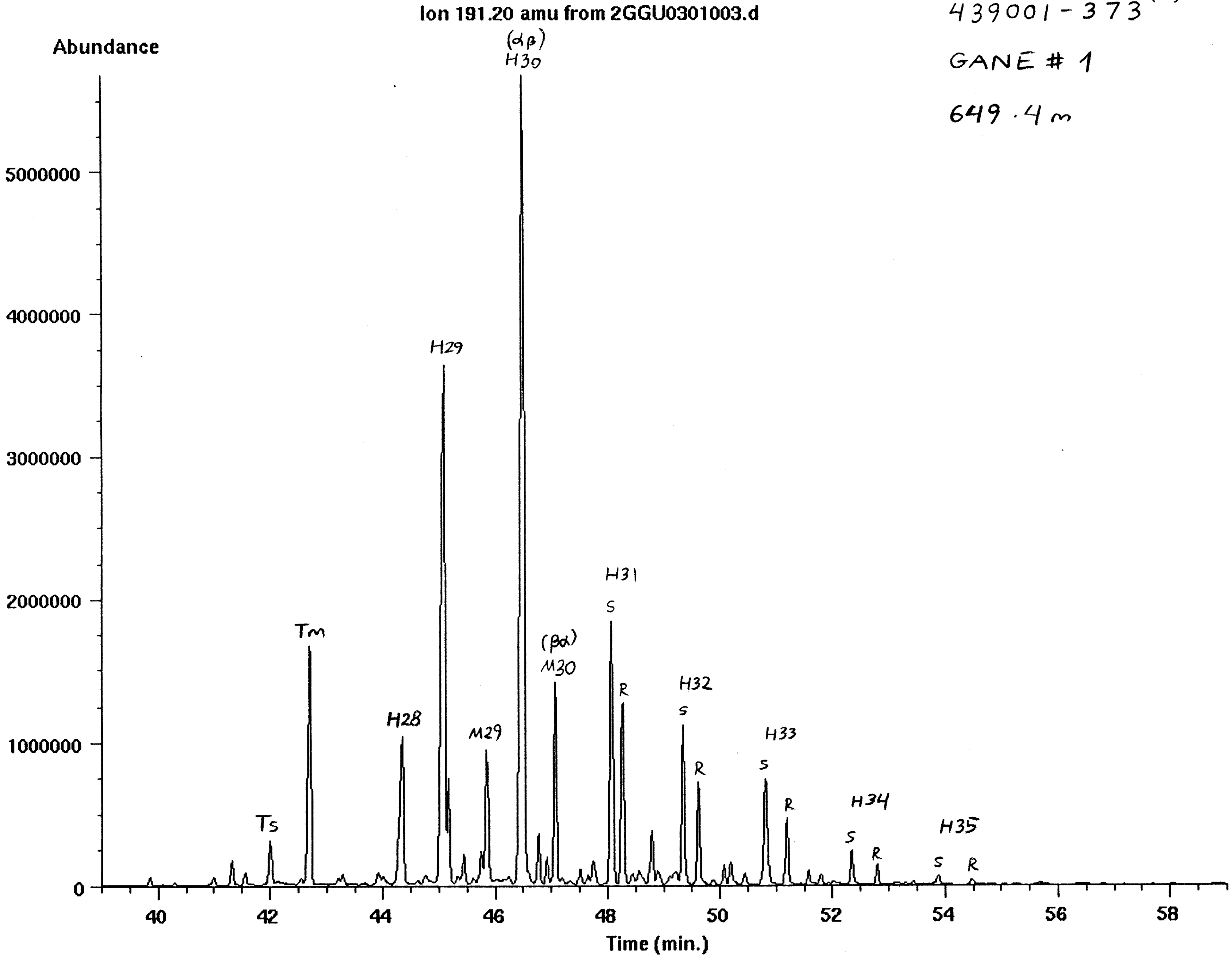
GANE # 1

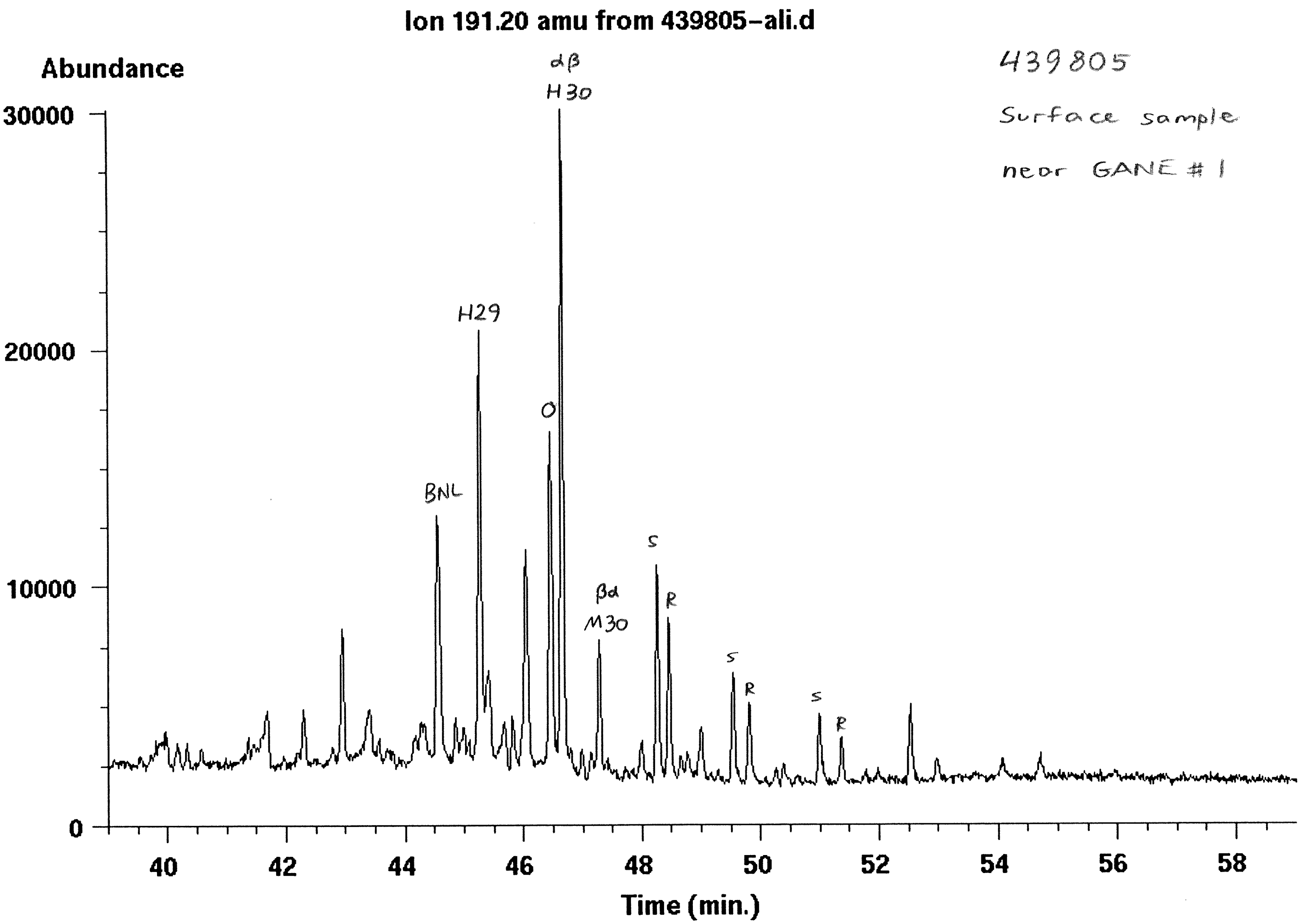
649.4 m

439001 - 373 (0)

GANE # 1

649 .4 m



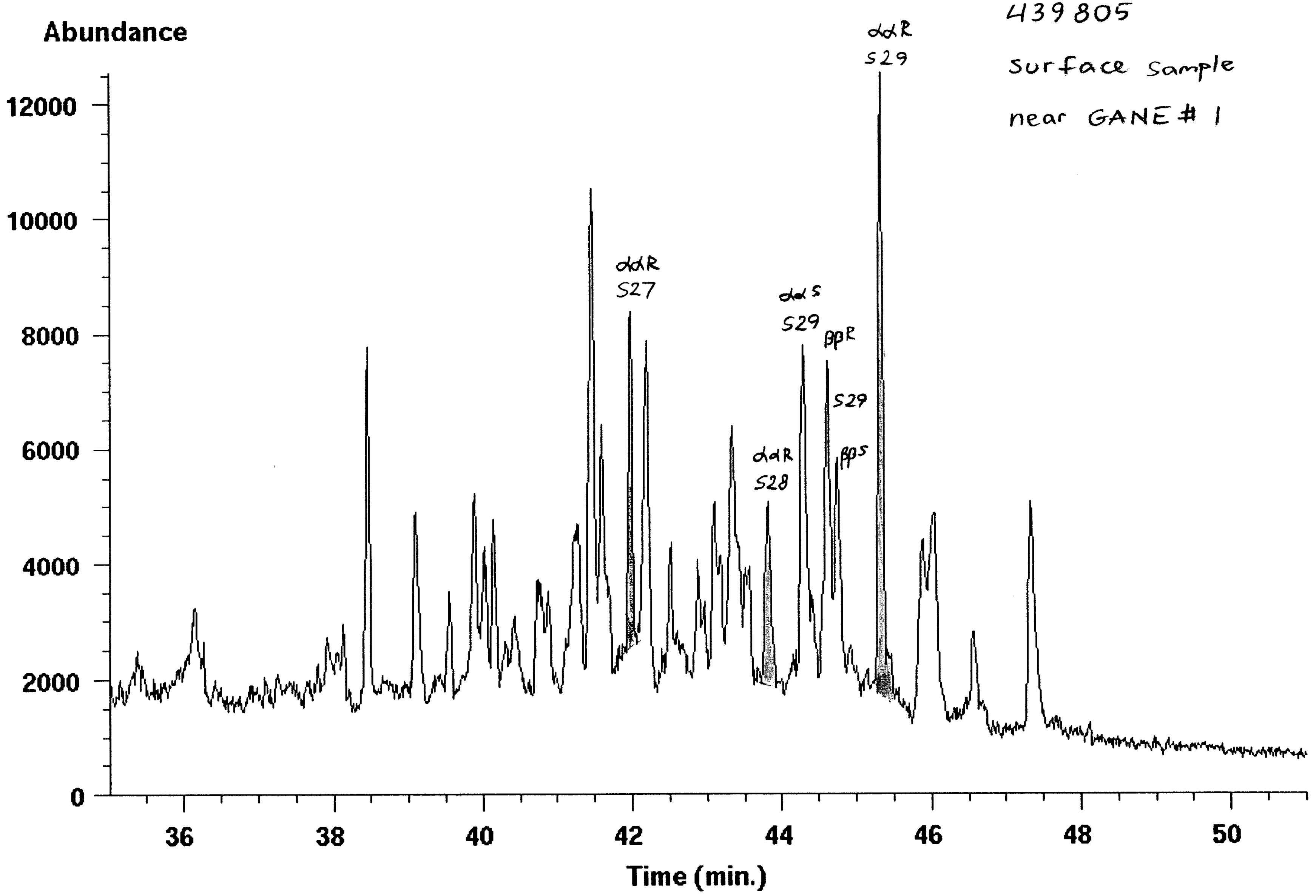


439805

Surface sample

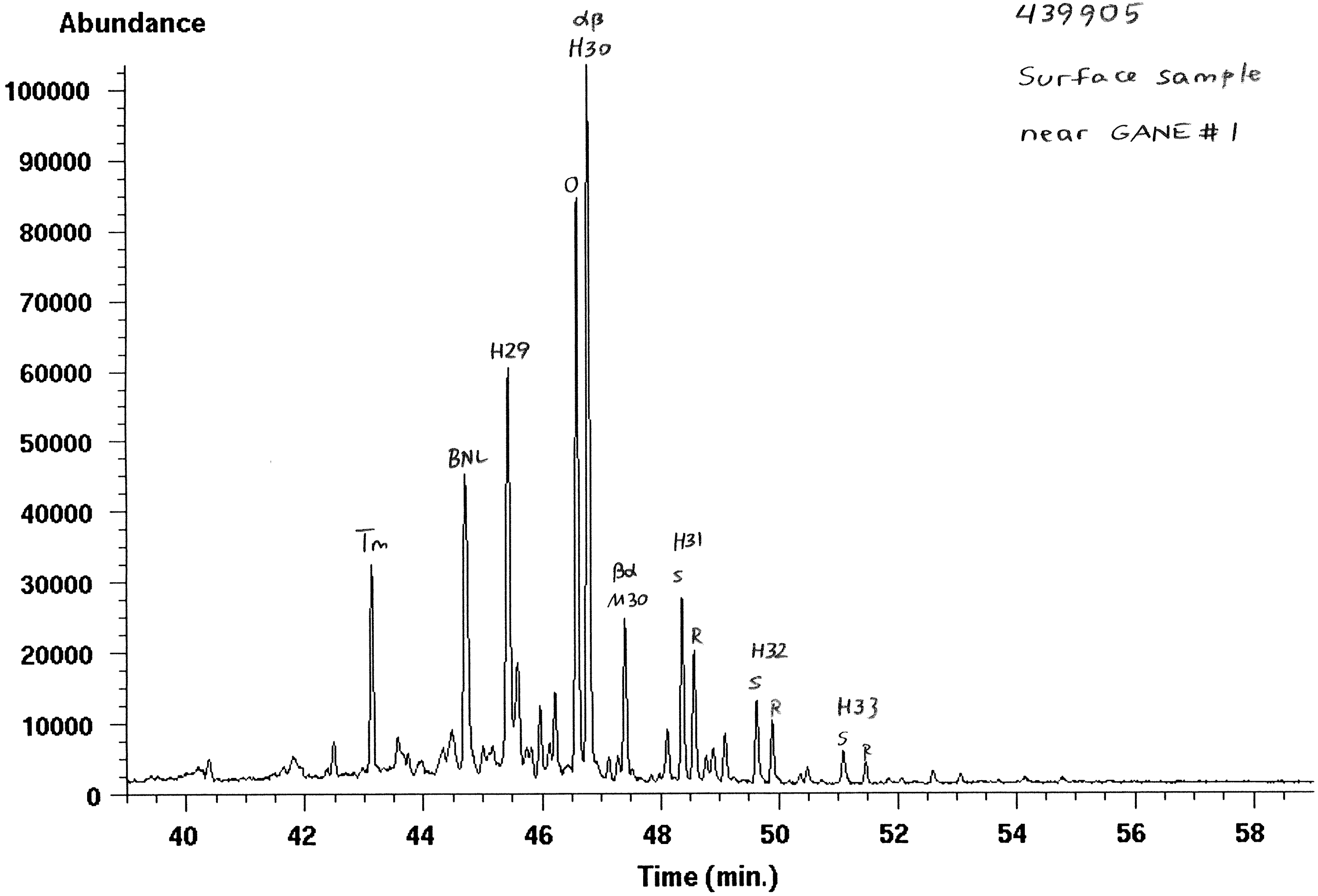
near GANE #1

Ion 217.20 amu from 439805-ali.d



439805
surface sample
near GANE # 1

Ion 191.20 amu from 439905-ali.d

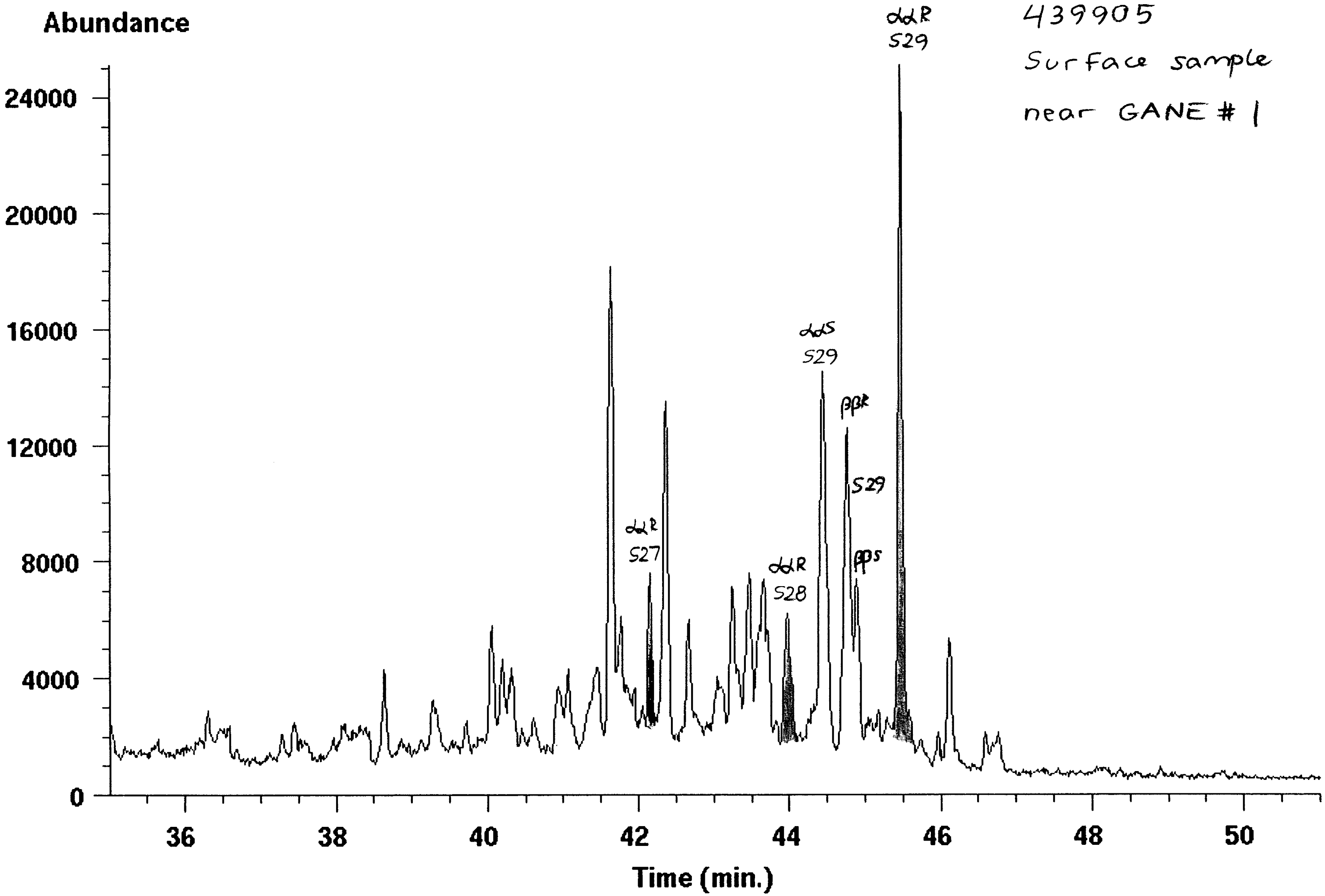


439905

Surface sample

near GANE #1

Ion 217.20 amu from 439905-ali.d



439905
Surface sample
near GANE # 1

GANE-1 well
1:5000

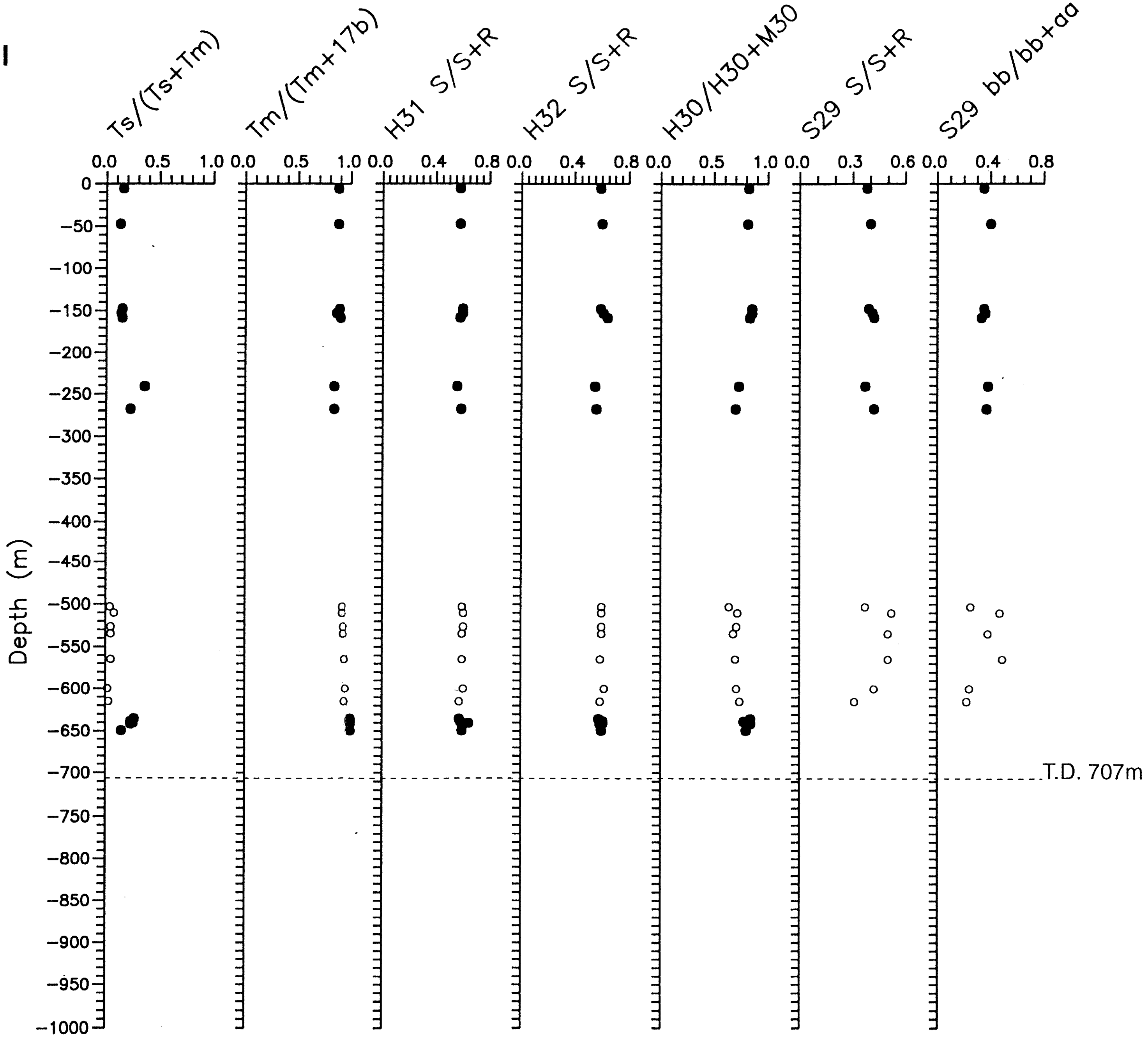


Fig. 11

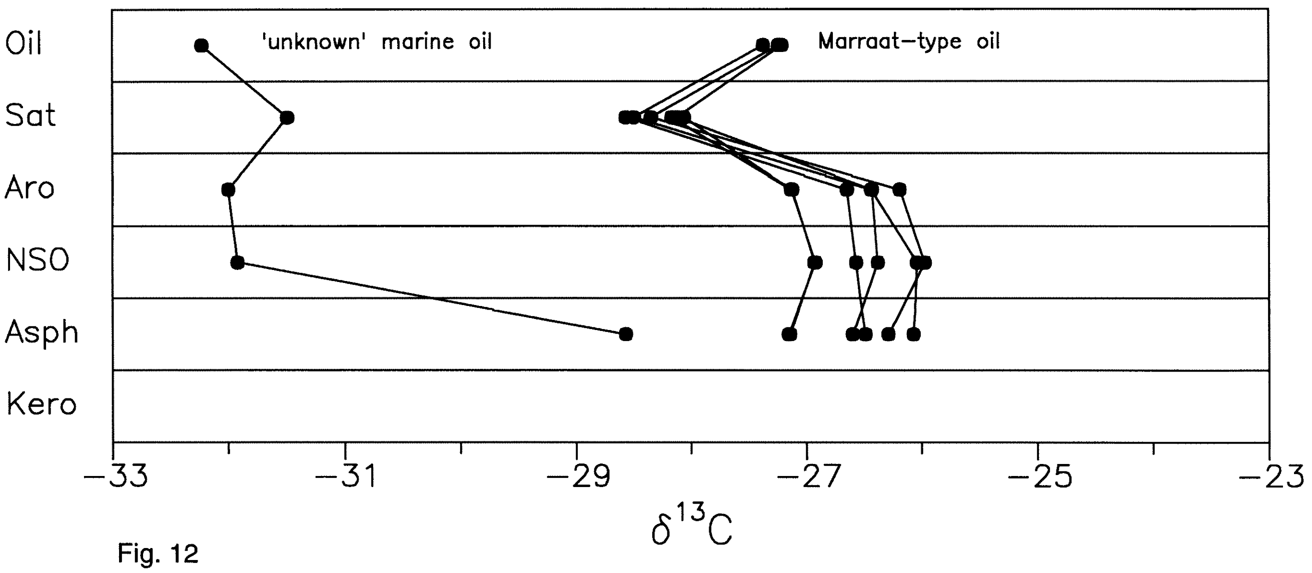
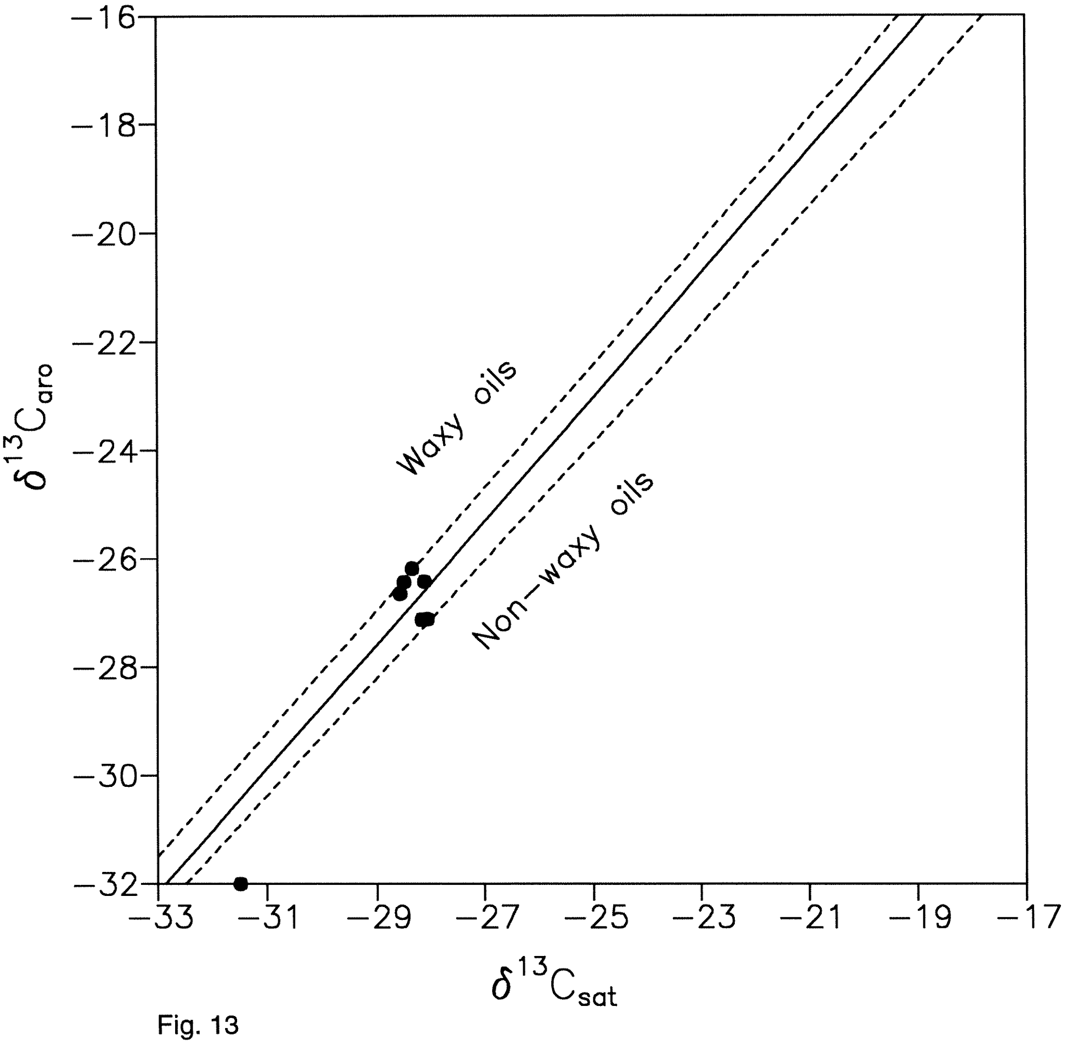

Oil
Sat
Aro
NSO
Asph
Kero
'unknown' marine oil
Marraat–type oil
−33
−31
−29
−27
−25
−23
δ13C

Fig. 12



$\delta^{13}C_{aro}$
$\delta^{13}C_{sat}$
−16
−18
−20
−22
−24
−26
−28
−30
−32
−33
−31
−29
−27
−25
−23
−21
−19
−17
Waxy oils
Non–waxy oils

Fig. 13

GANK-1 well
1:5000

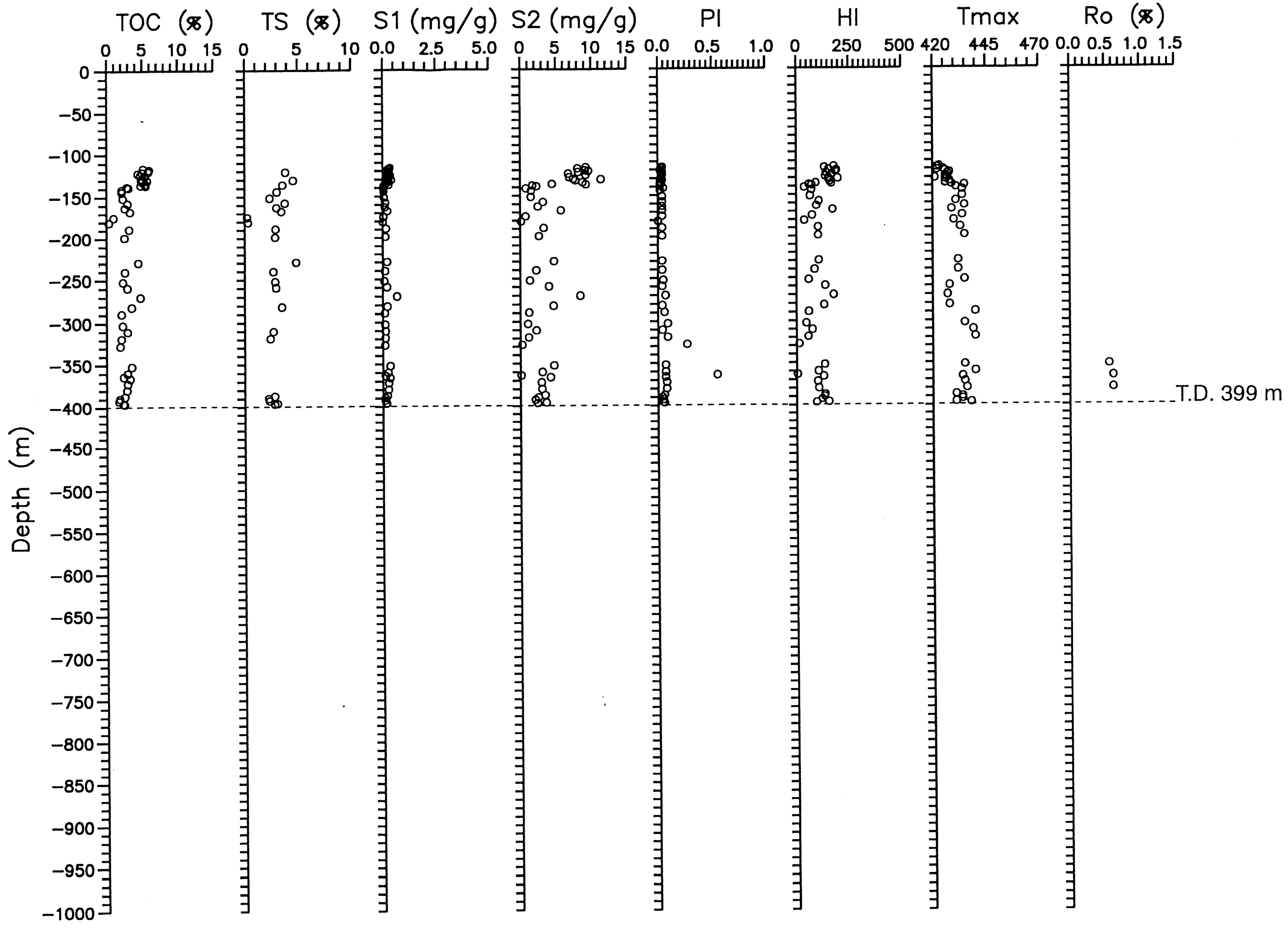


Fig. 14

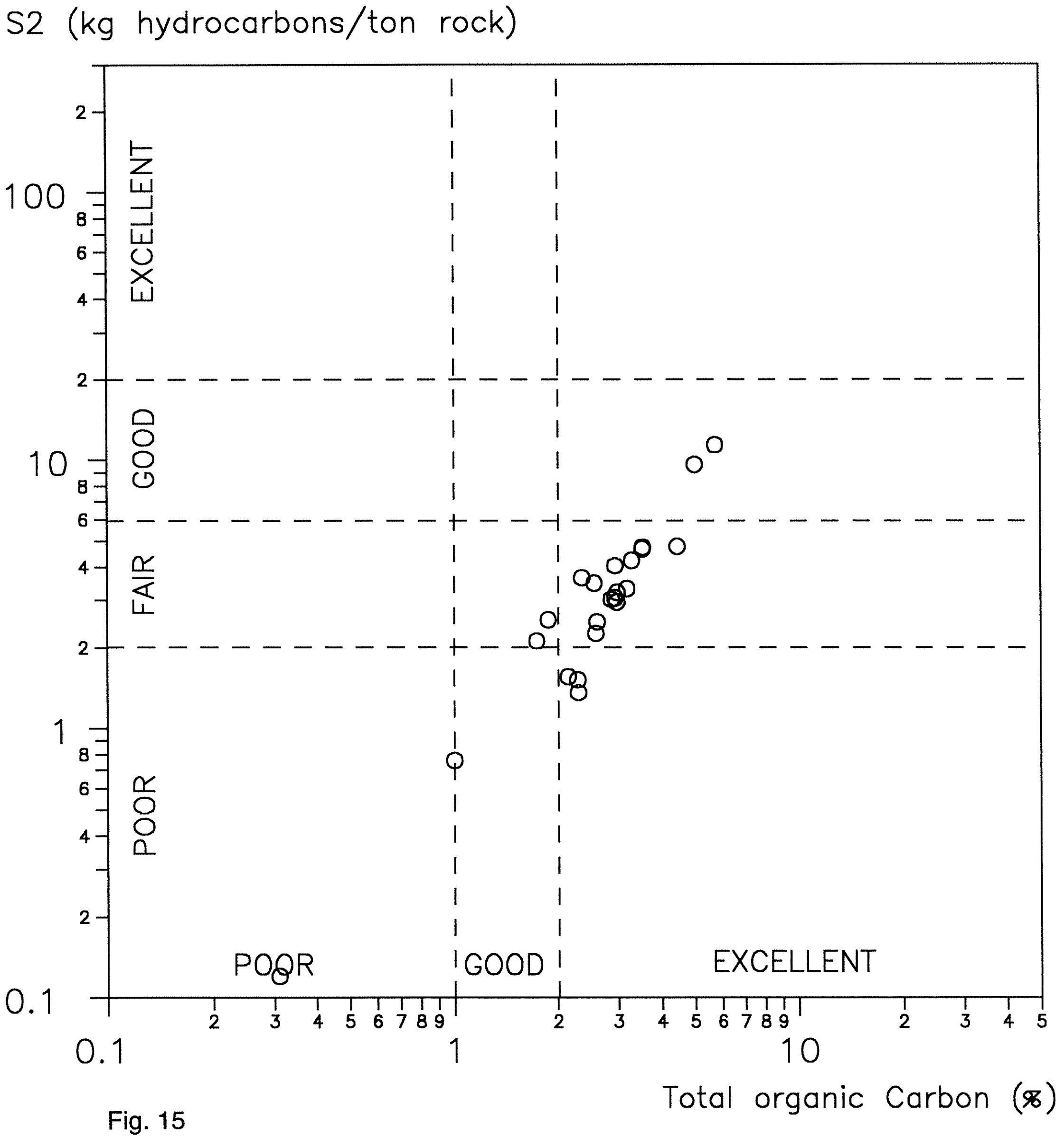

S2 (kg hydrocarbons/ton rock)
100
10
1
0.1
2
8
6
4
EXCELLENT
GOOD
FAIR
POOR
POOR
GOOD
EXCELLENT
0.1
1
10
2 3 4 5 6 7 8 9
Total organic Carbon (%)

Fig. 15

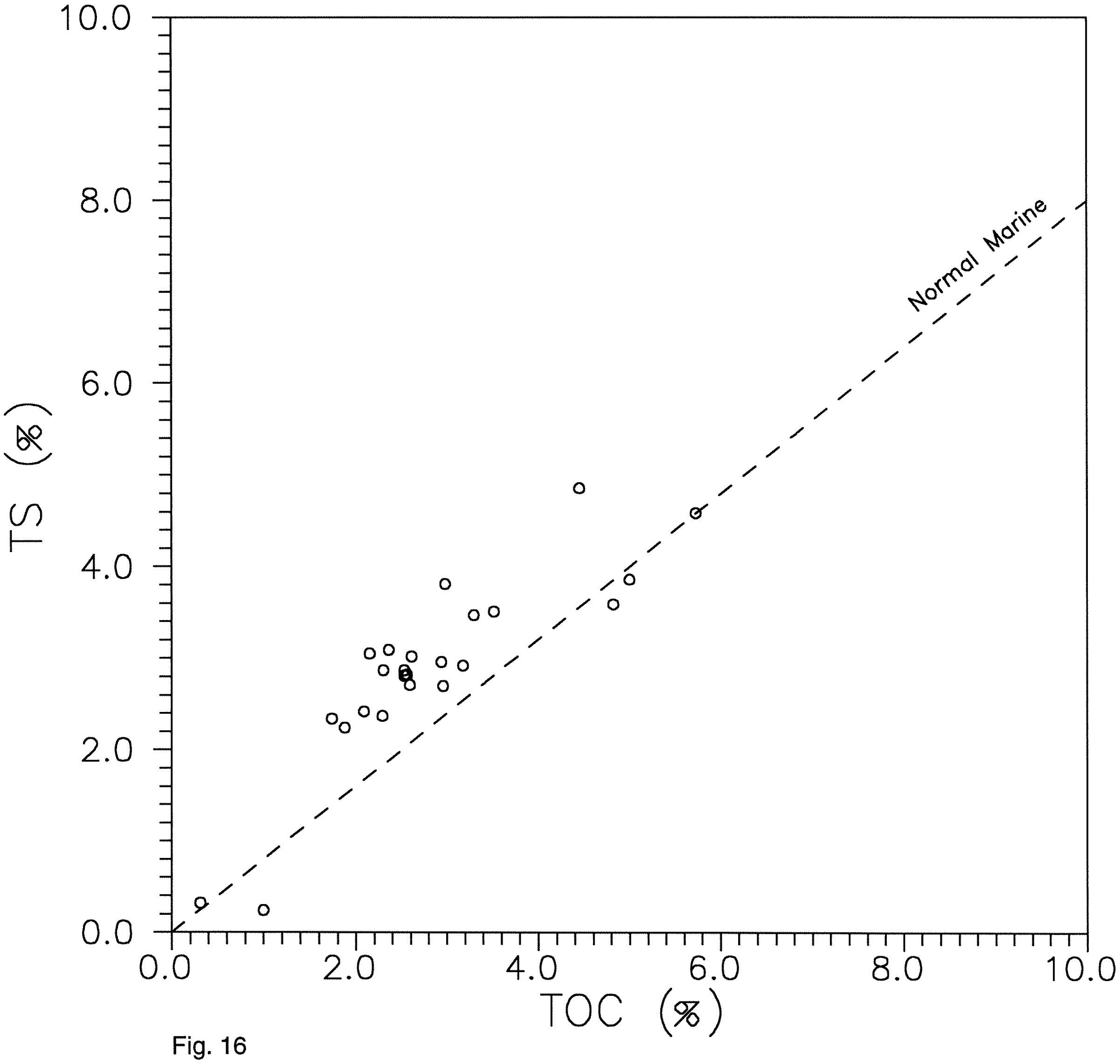


Fig. 16

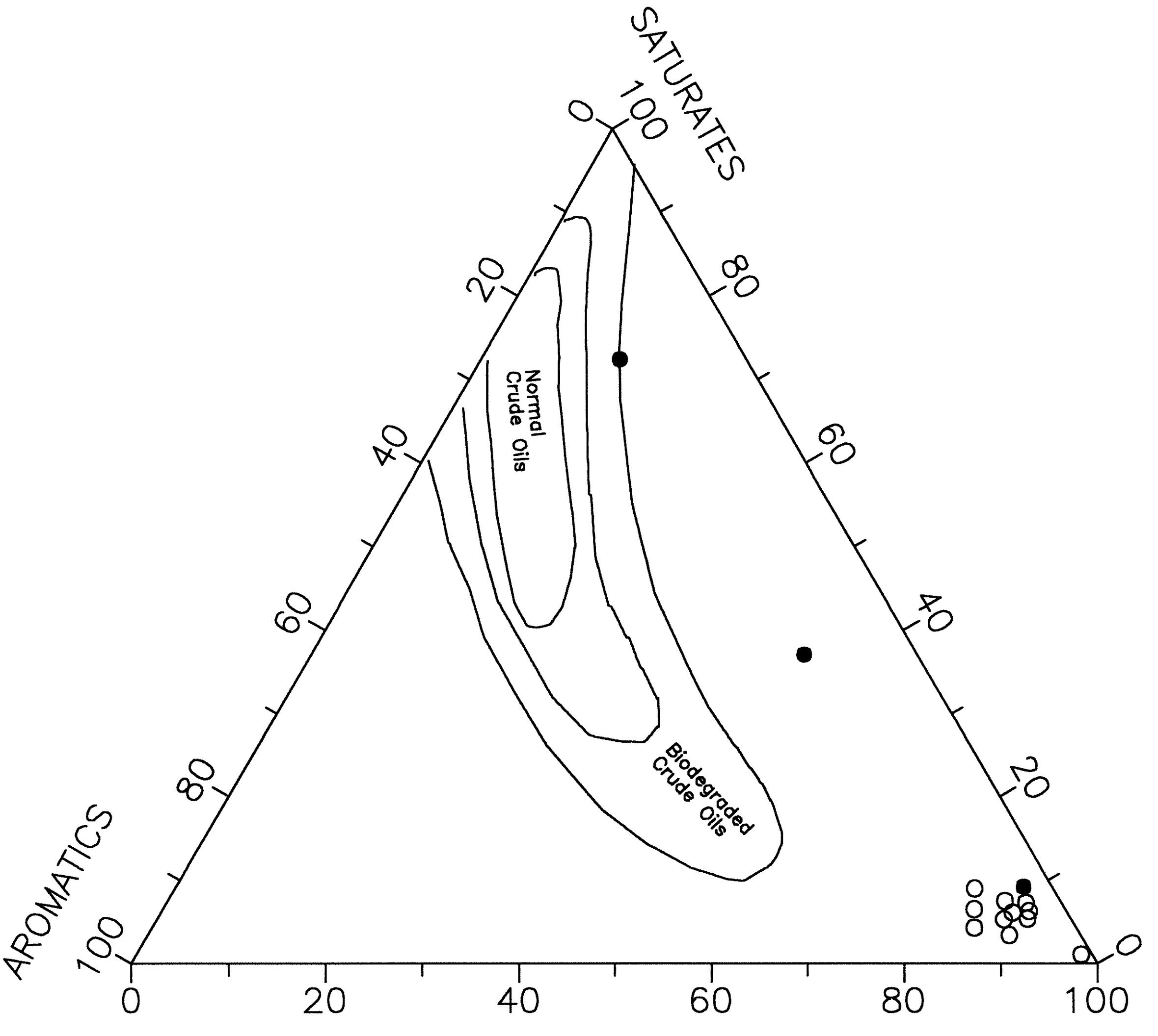
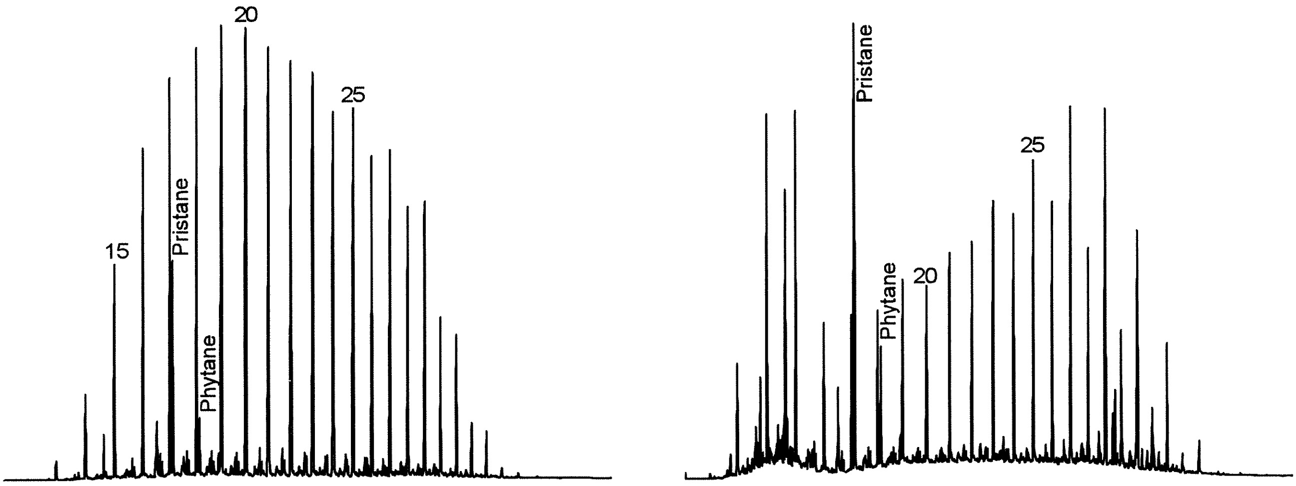
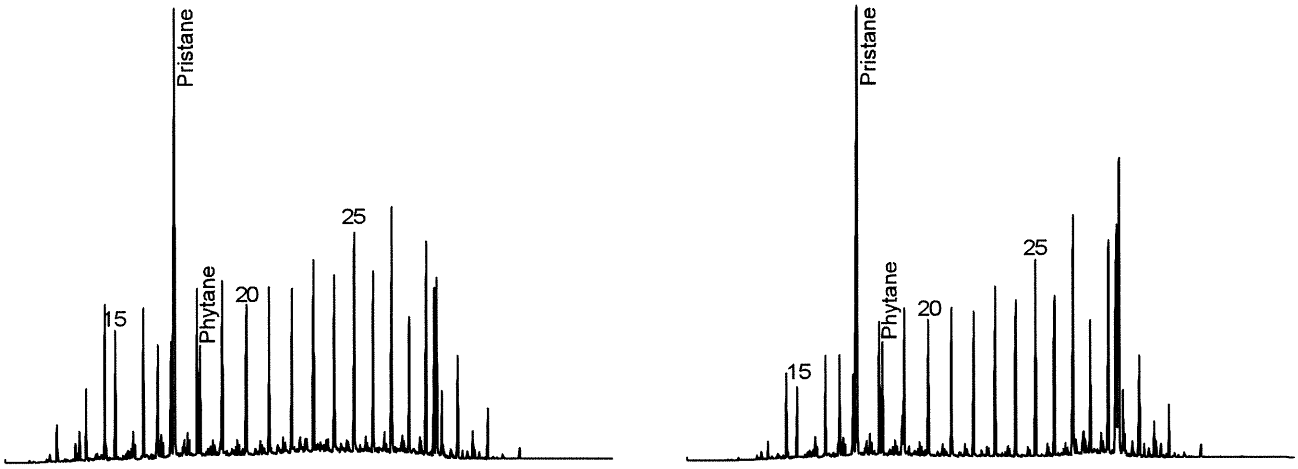

SATURATES
AROMATICS
POLARS (Asph. + NSO)
Normal Crude Oils
Biodegraded Crude Oils
0
20
40
60
80
100

Fig. 17



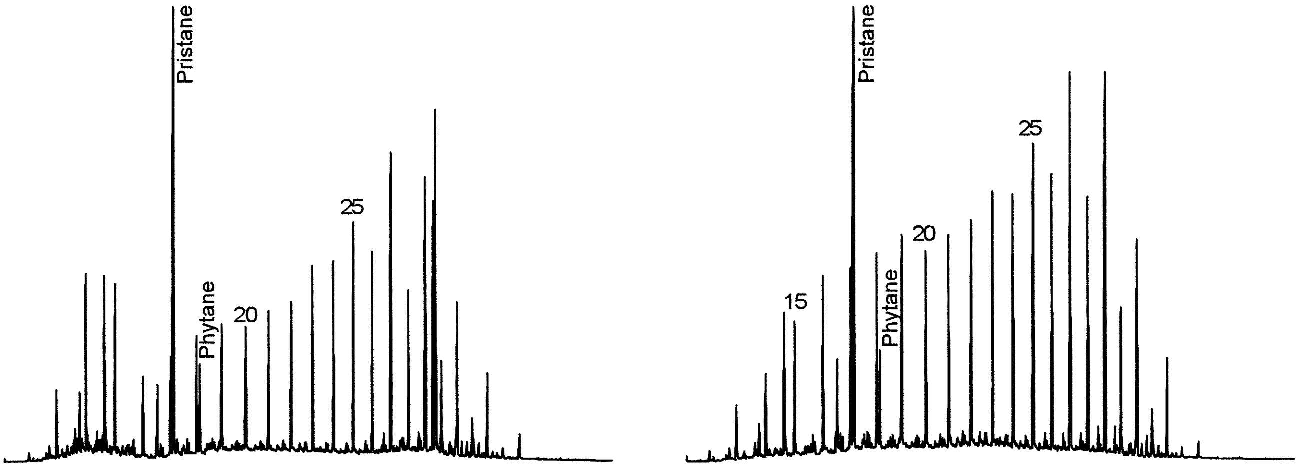
439201-520 (88.4 m)

439201-549 (164.2 m)



439201-40 (151.5 m)

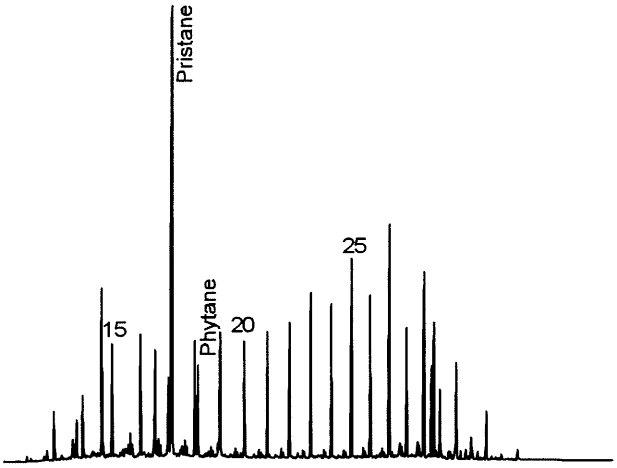
439201-52 (188.9 m)



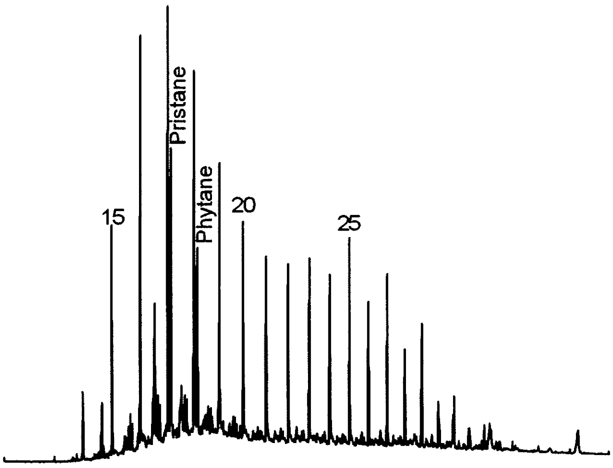
439201-545 (158.6 m)

439201-66 (229.4 m)

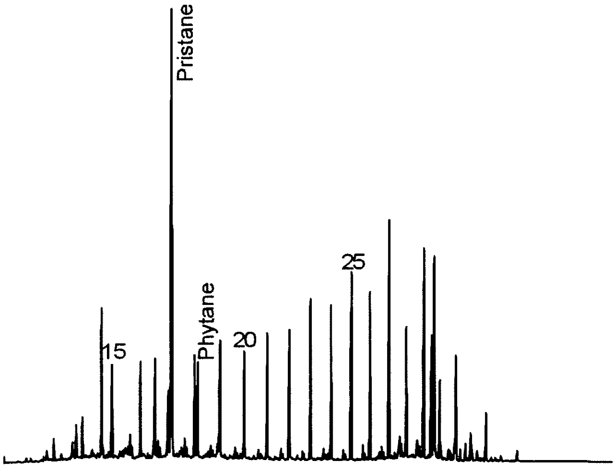
Fig. 18



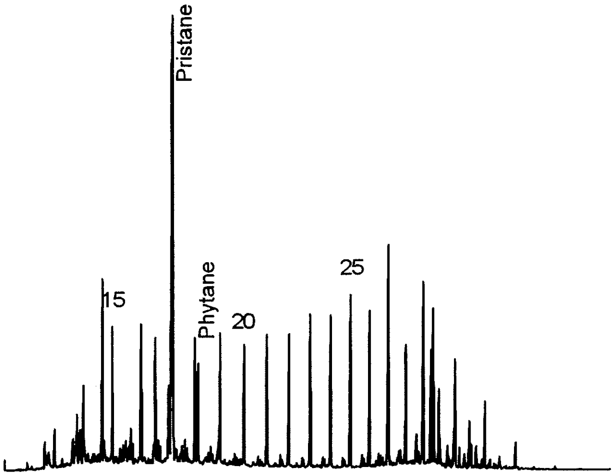
439201-93 (243 m)



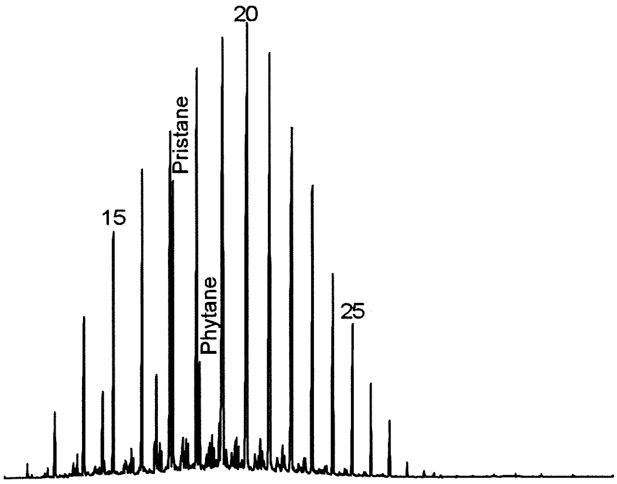
439201-202 (331.4 m)



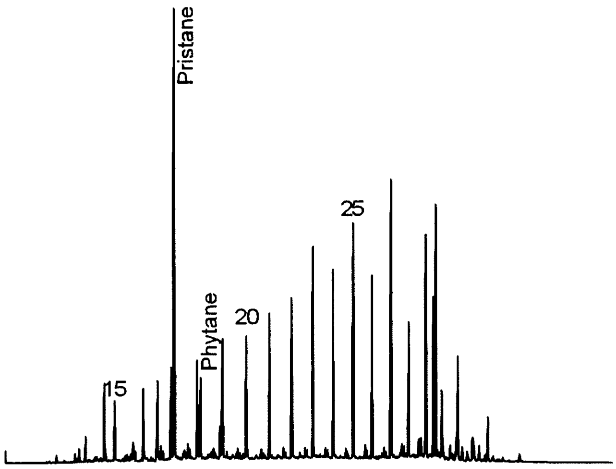
439201-76 (259.3 m)



439201-108 (352.1 m)

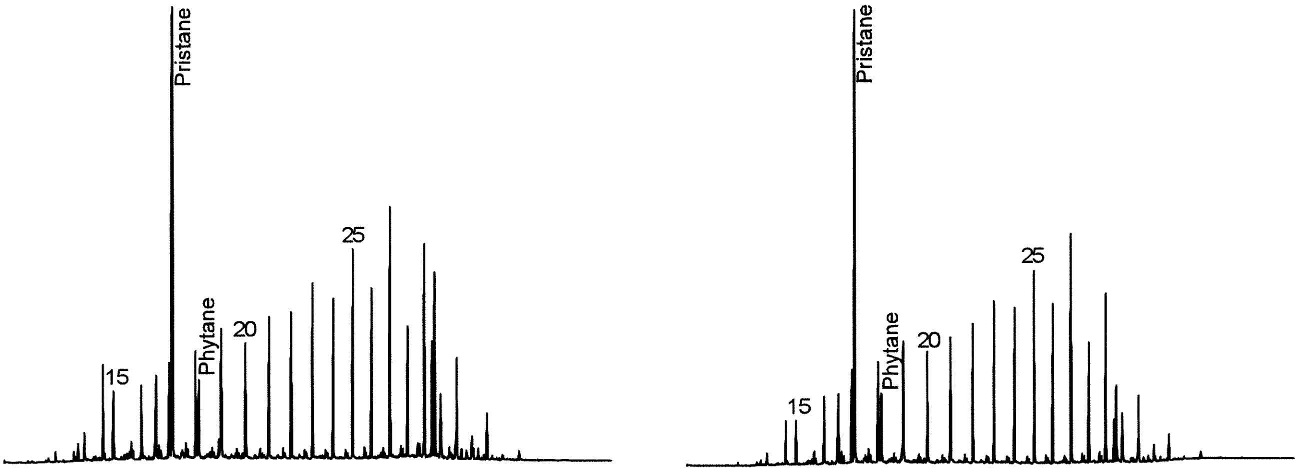


439201-206 (270.2 m)



439201-113 (365.9 m)

Fig.18 ctd.



439201-118 (379.5 m)

439201-124 (395.8 m)

Fig.18 ctd.

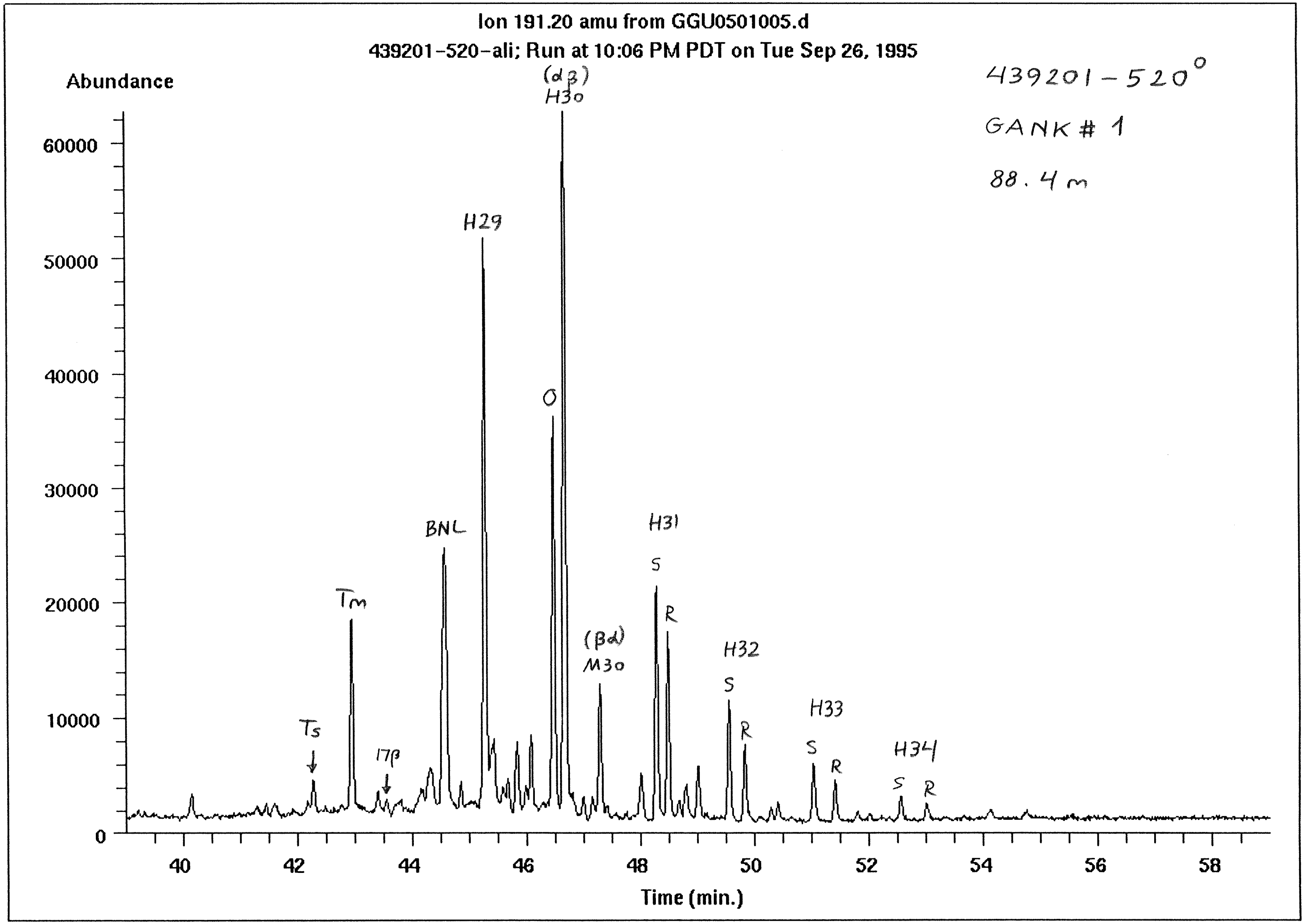


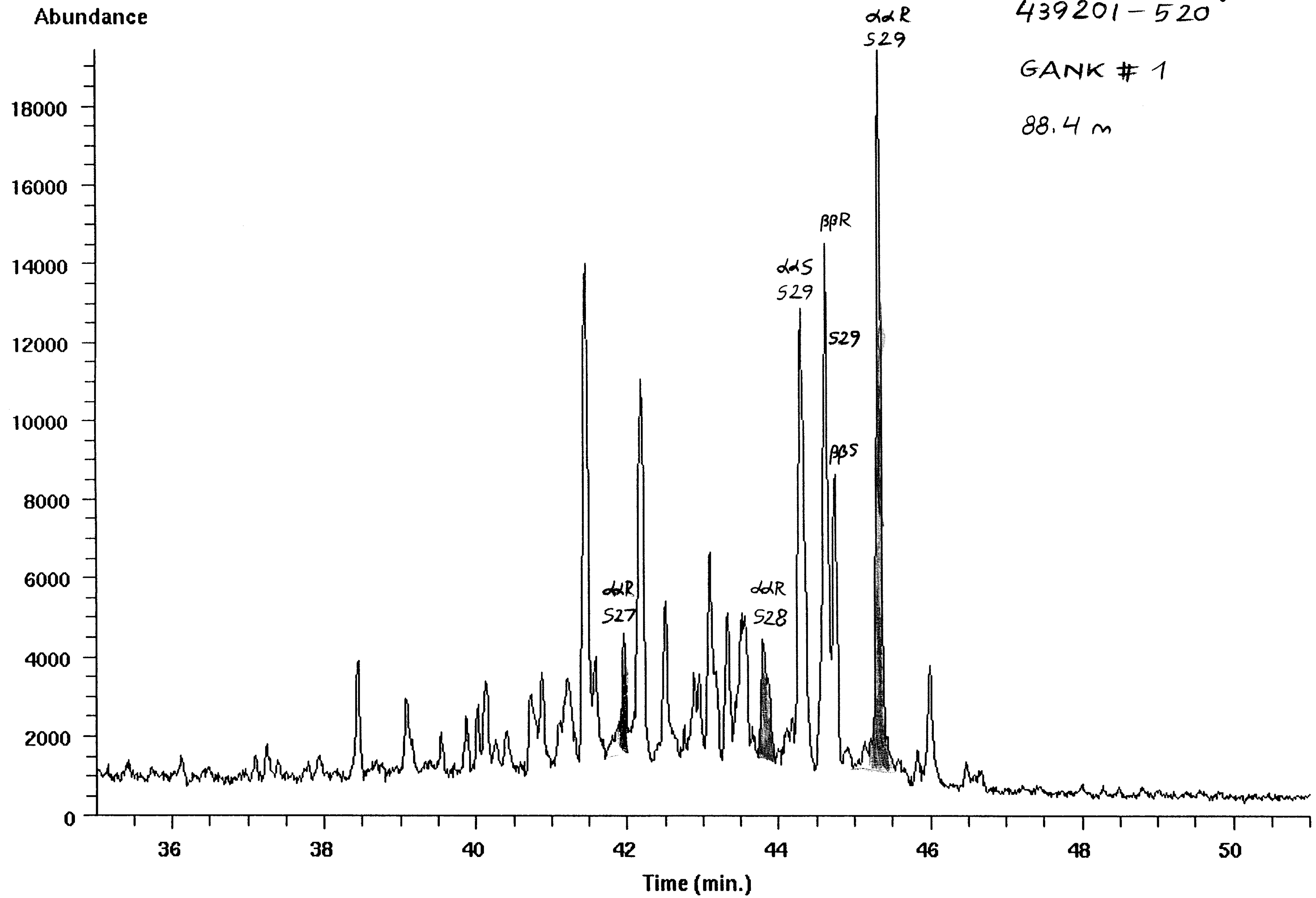
Fig. 19 continues

Ion 217.20 amu from GGU0501005.d
439201-520-ali; Run at 10:06 PM PDT on Tue Sep 26, 1995

439201 - 520°

GANK # 1

88.4 m

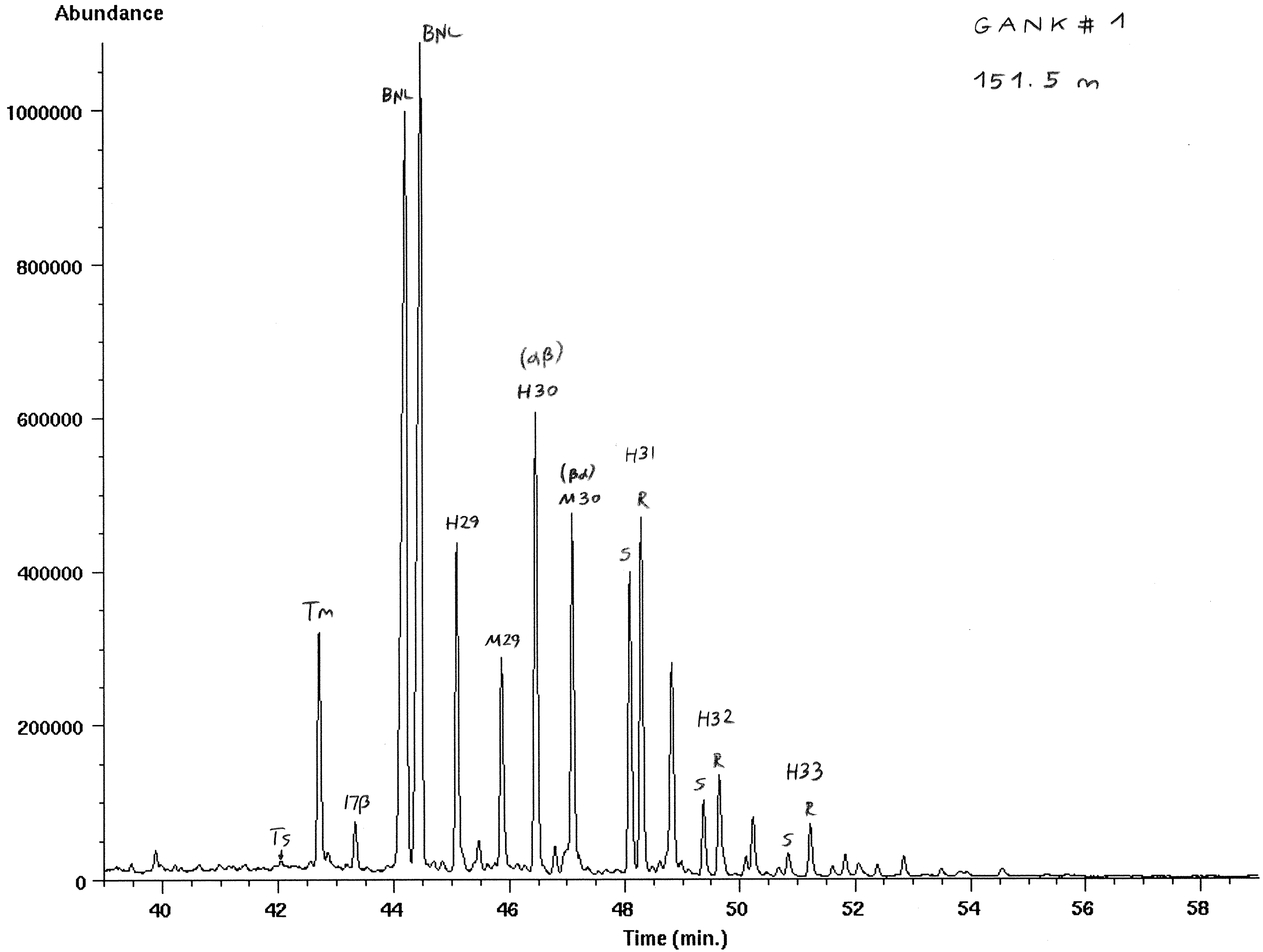


439201-40

GANK # 1

151.5 m

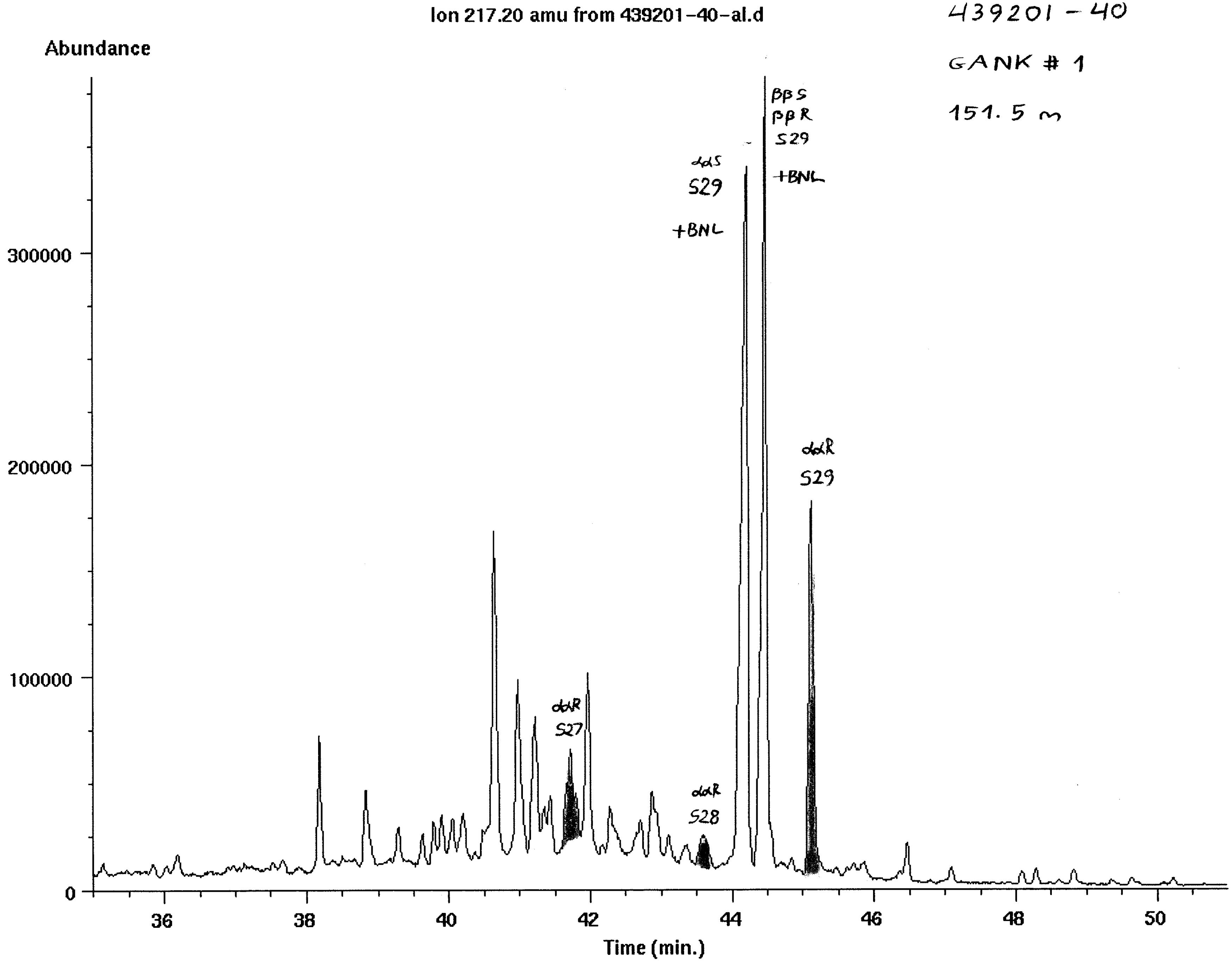
Ion 191.20 amu from 439201-40-al.d

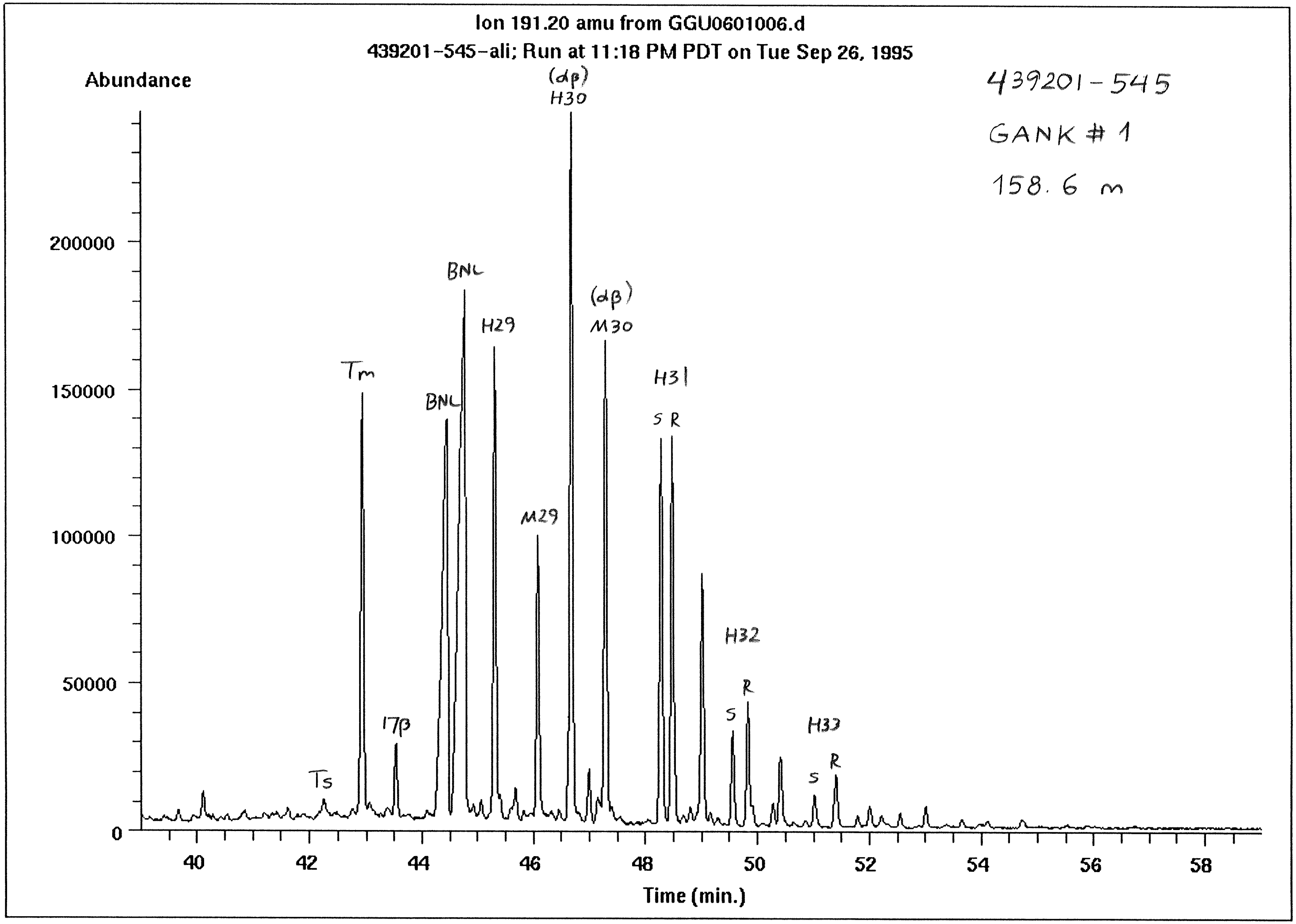


439201 - 40

GANK # 1

151.5 m



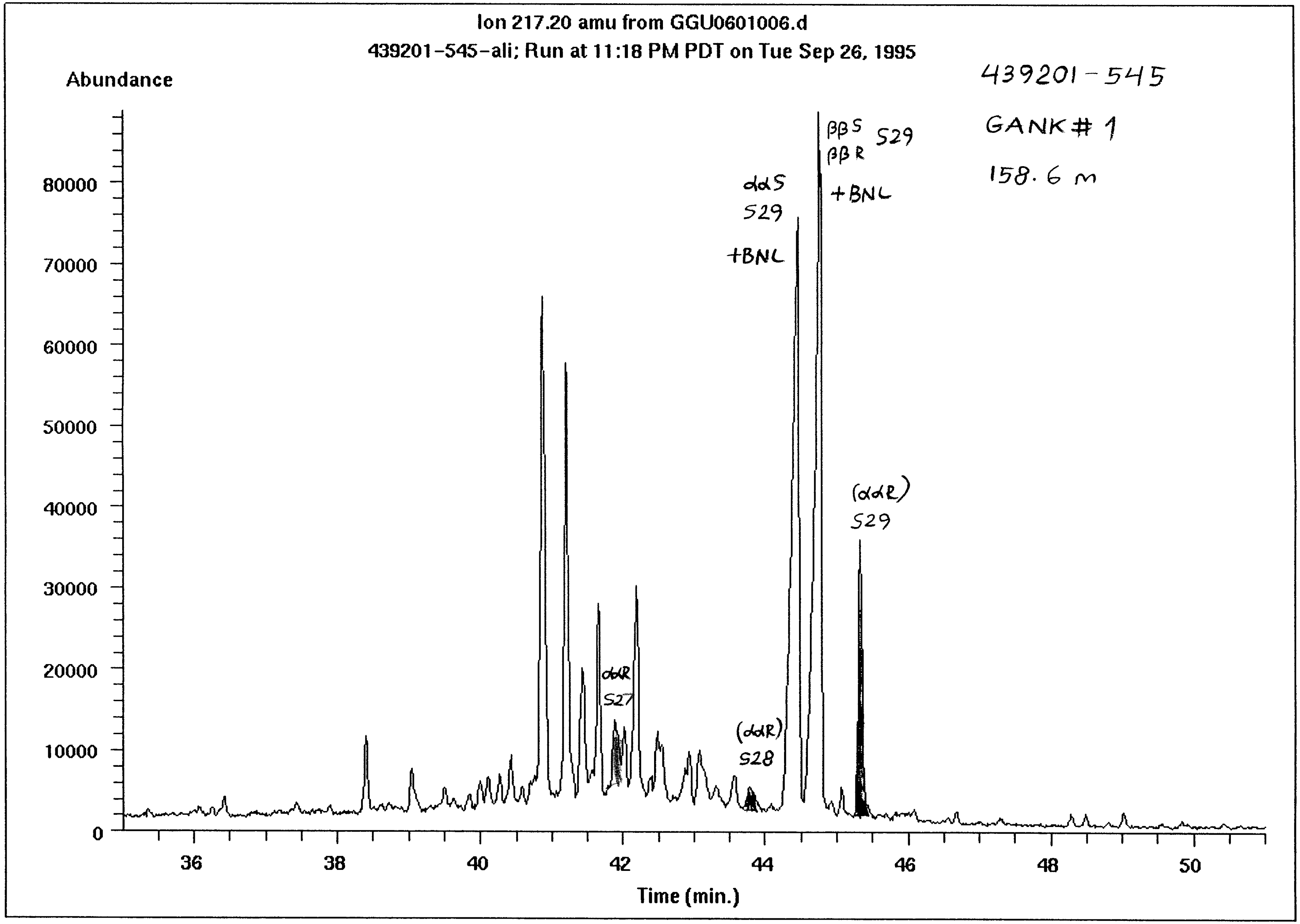

Ion 191.20 amu from GGU0601006.d

439201-545-ali; Run at 11:18 PM PDT on Tue Sep 26, 1995

439201-545

GANK # 1

158.6 m



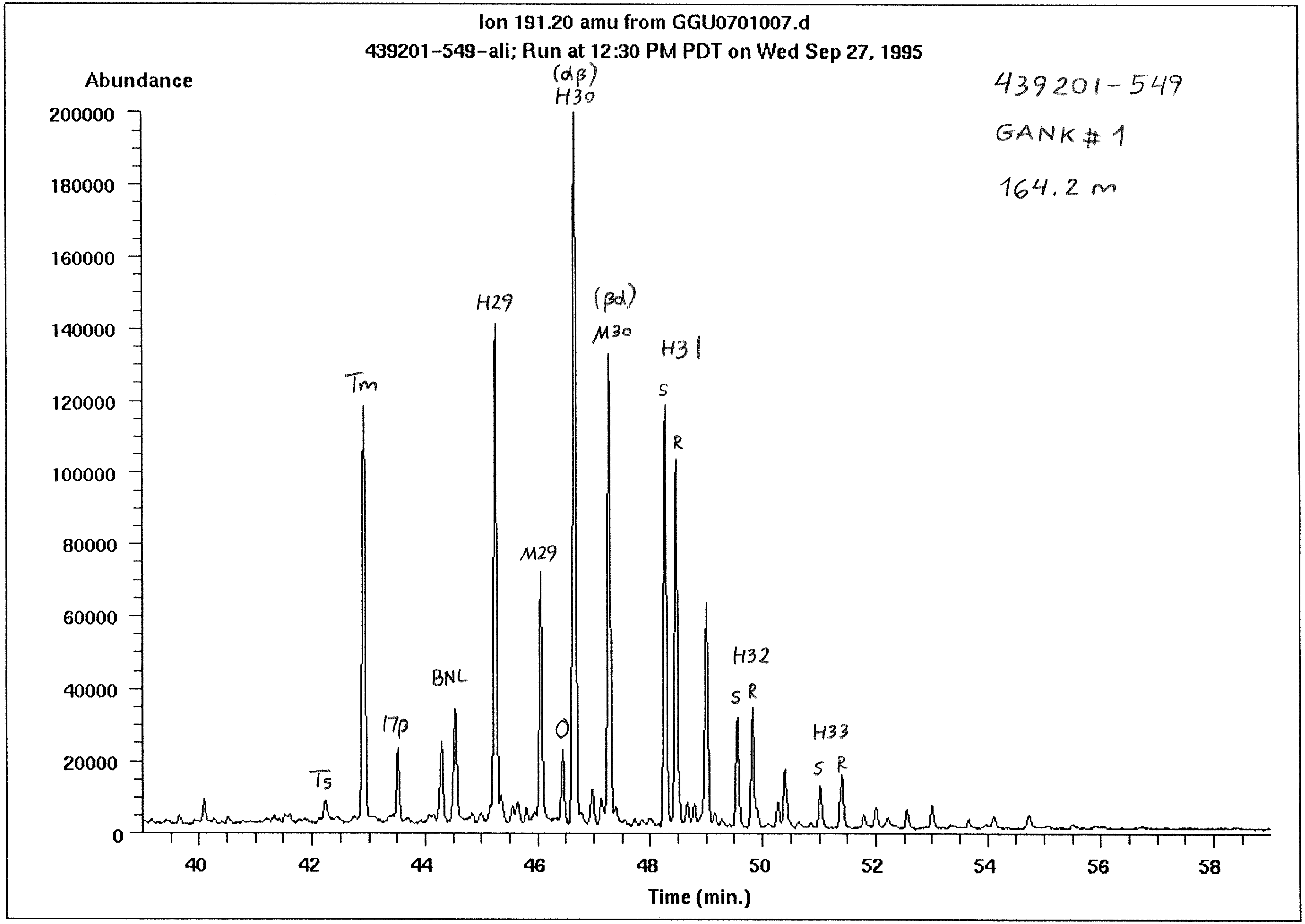
Ion 217.20 amu from GGU0601006.d

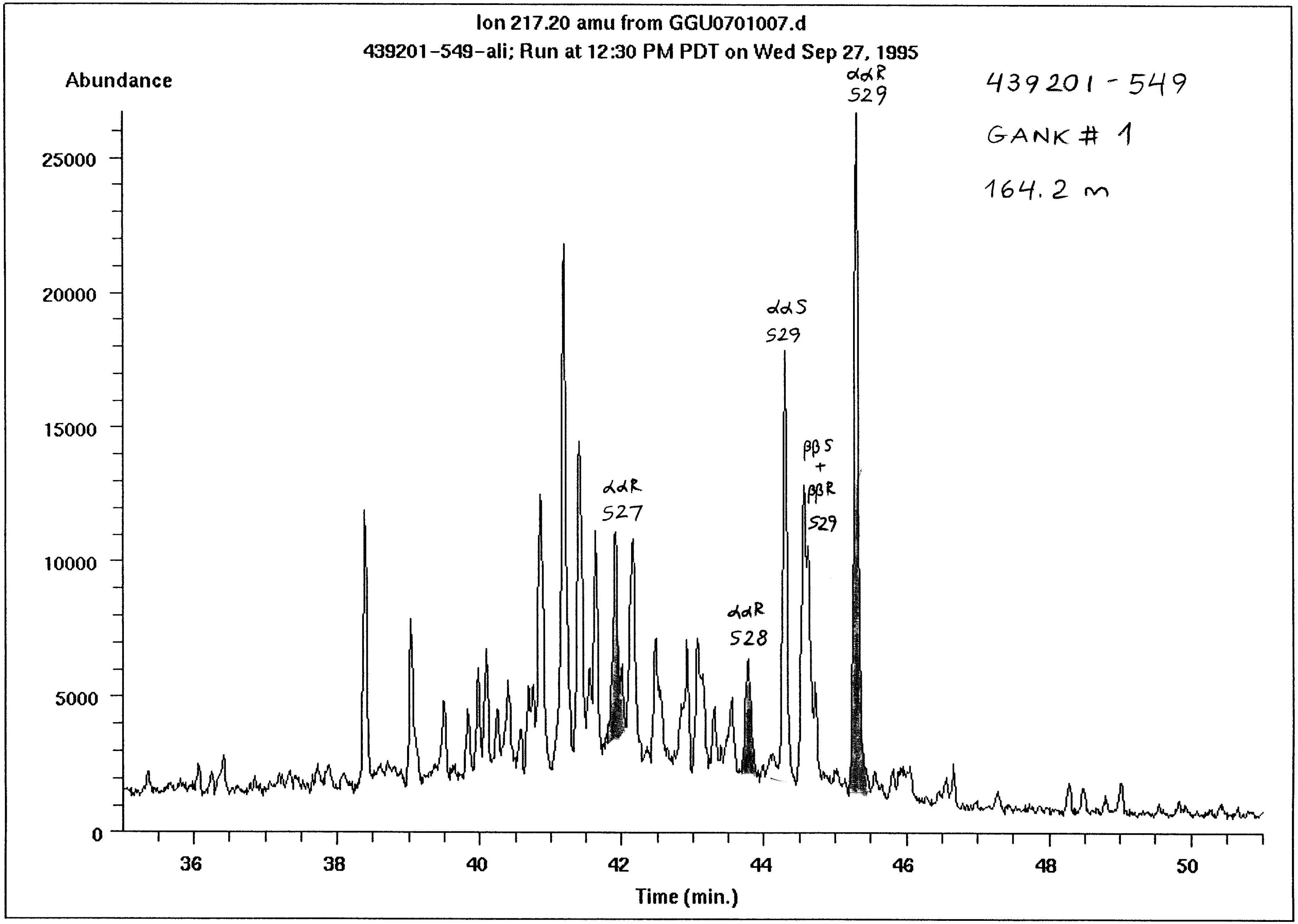
439201-545-ali; Run at 11:18 PM PDT on Tue Sep 26, 1995

439201-545

GANK#1

158.6 m


Ion 191.20 amu from GGU0701007.d
439201-549-ali; Run at 12:30 PM PDT on Wed Sep 27, 1995
Abundance
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
40
42
44
46
48
50
52
54
56
58
Time (min.)
439201-549
GANK # 1
164.2 m
Ts
Tm
17β
BNL
H29
M29
O
(αβ)
H30
(βα)
M30
H31
S
R
H32
S
R
H33
S
R



Ion 217.20 amu from GGU0701007.d

439201-549-ali; Run at 12:30 PM PDT on Wed Sep 27, 1995

439201 - 549

GANK # 1

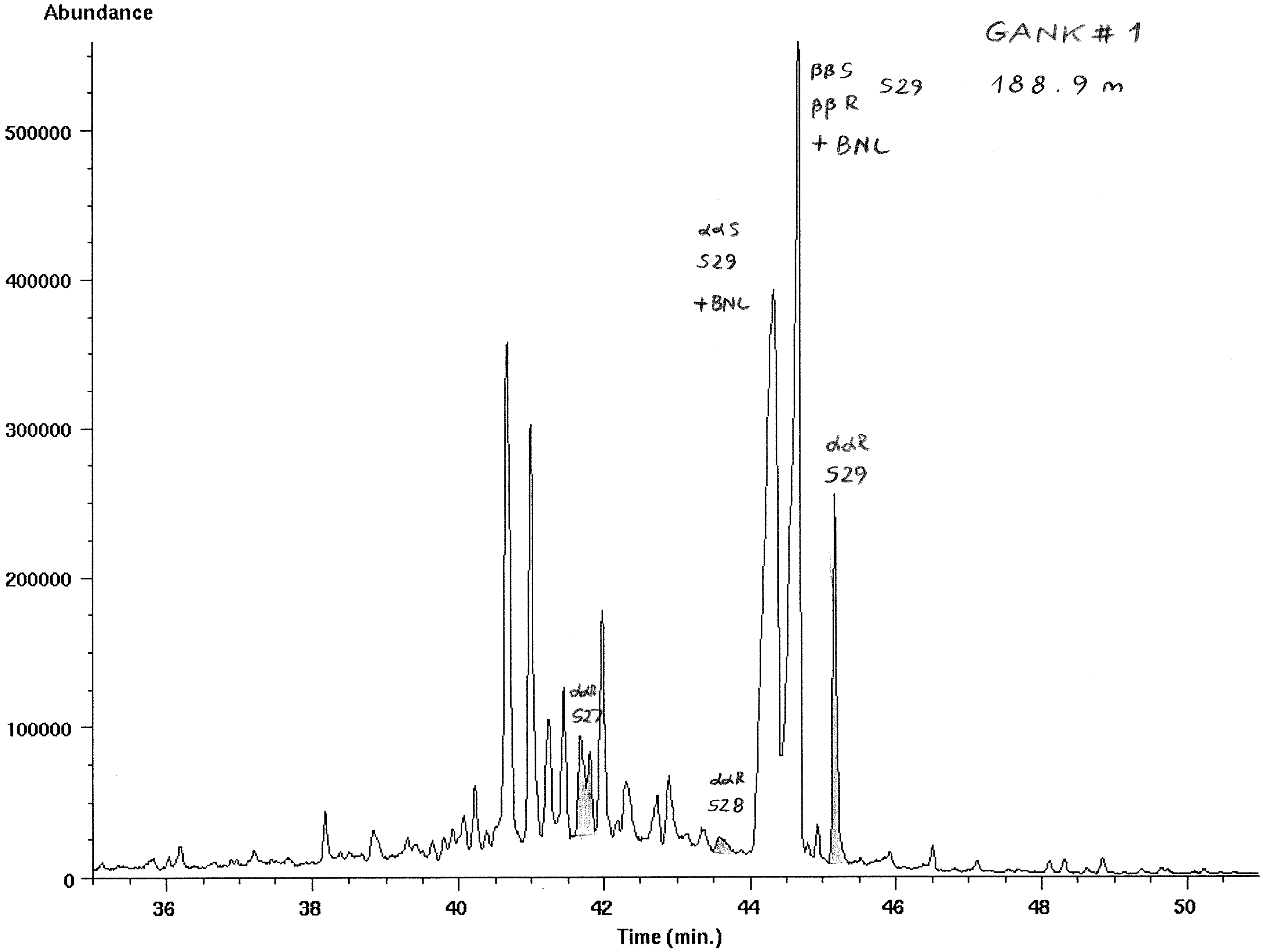
164.2 m

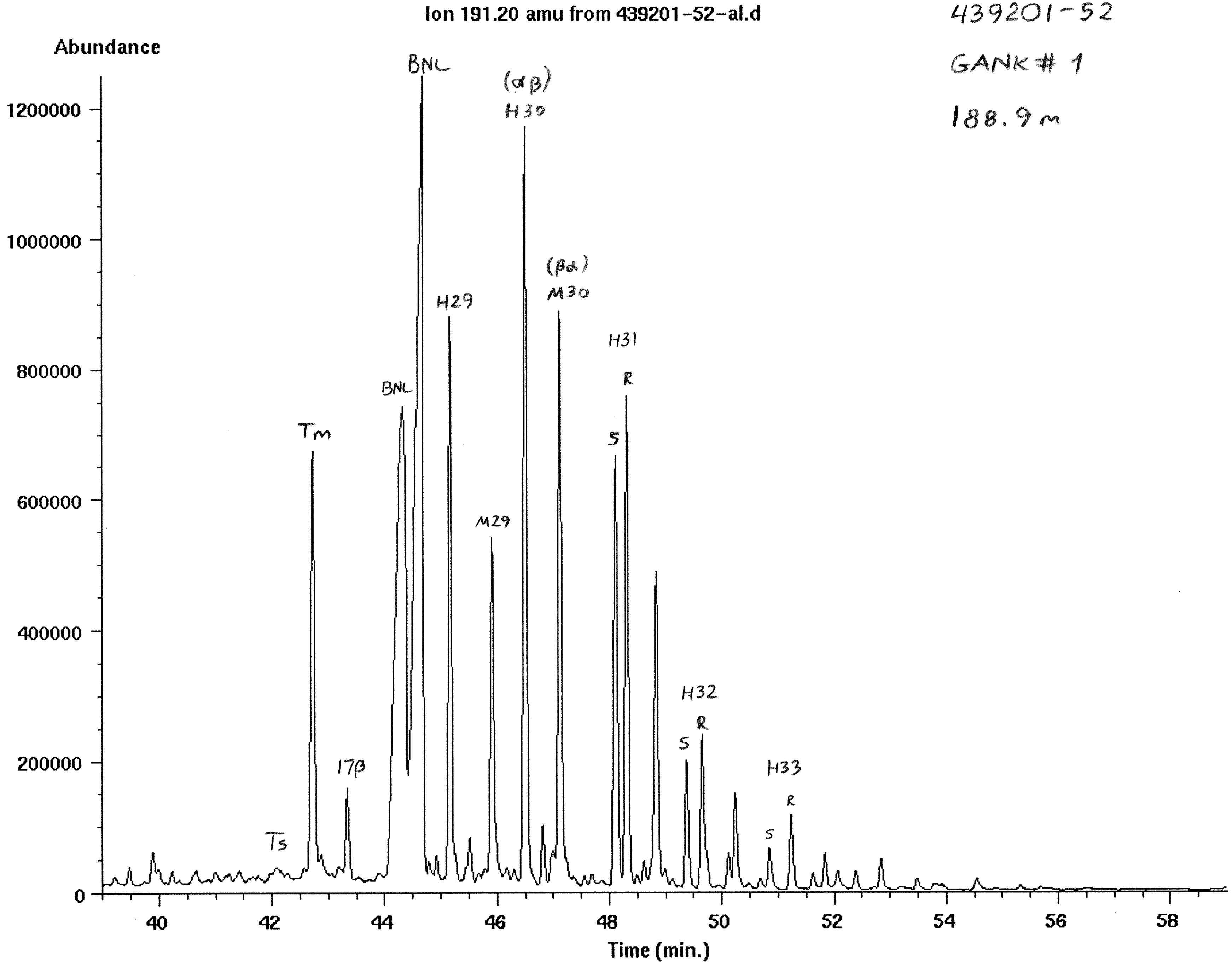
Ion 217.20 amu from 439201-52-al.d

439201-52

GANK#1

188.9 m



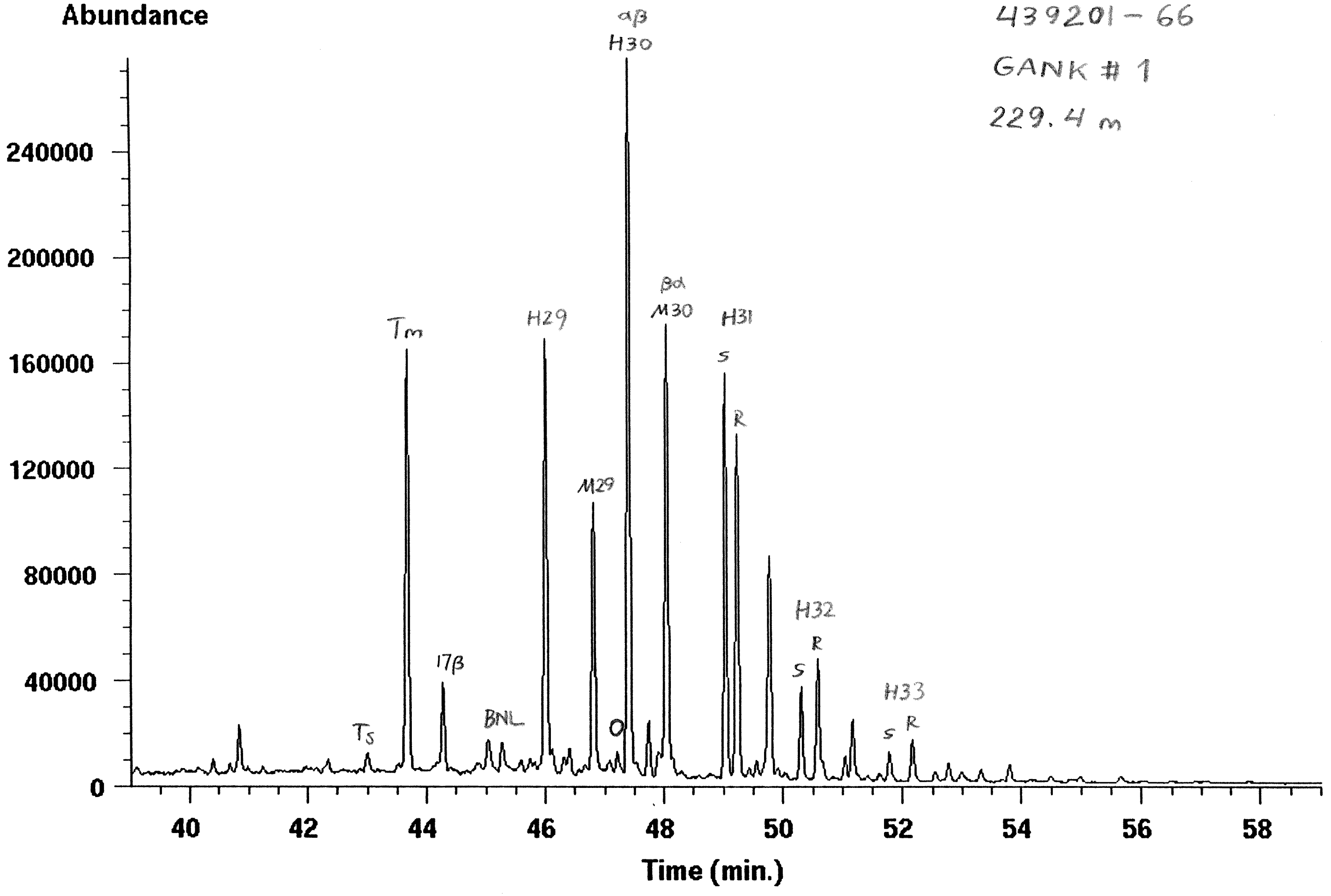


439201-52

GANK# 1

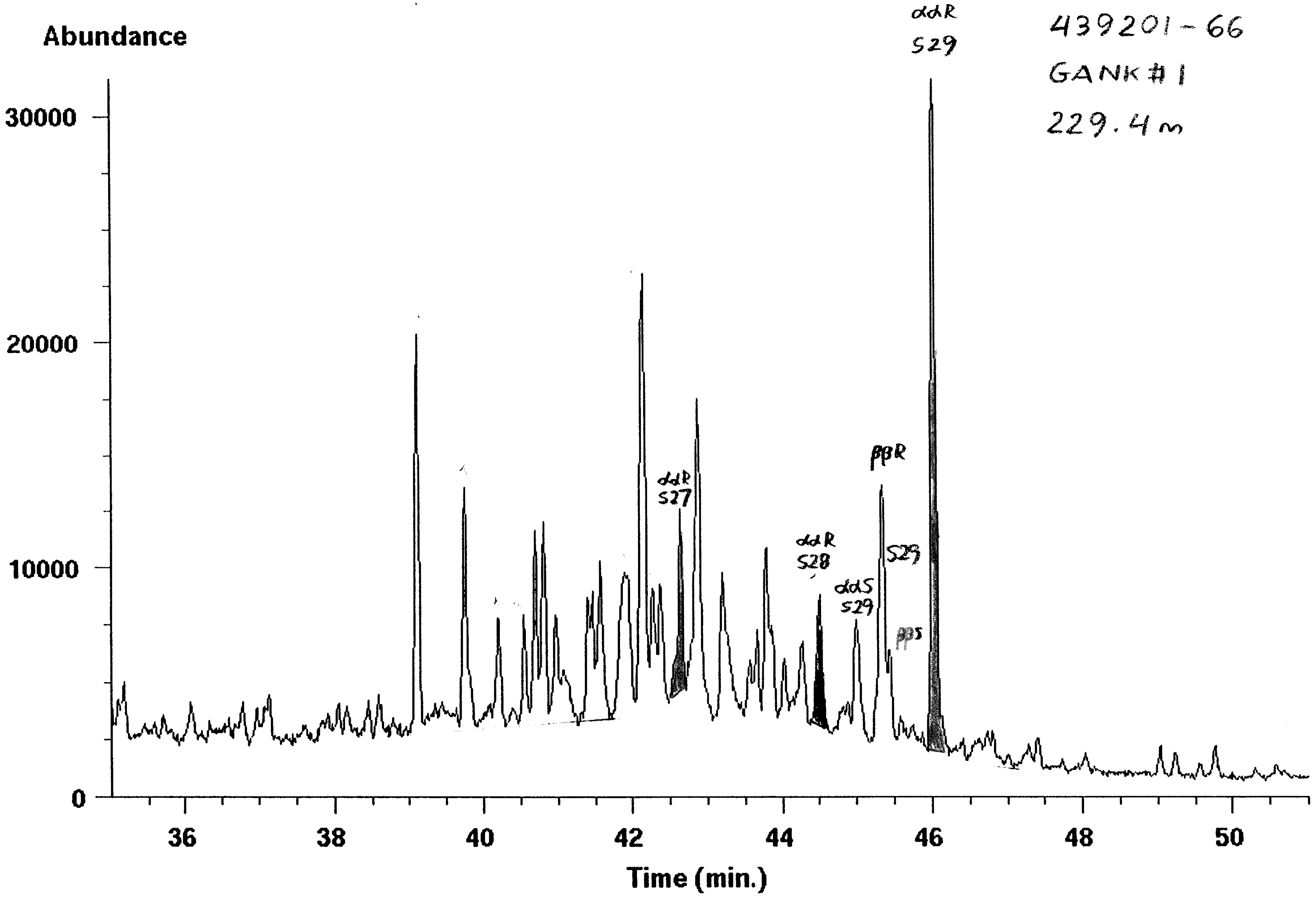
188.9m

Ion 191.20 amu from GGUab0101004.d

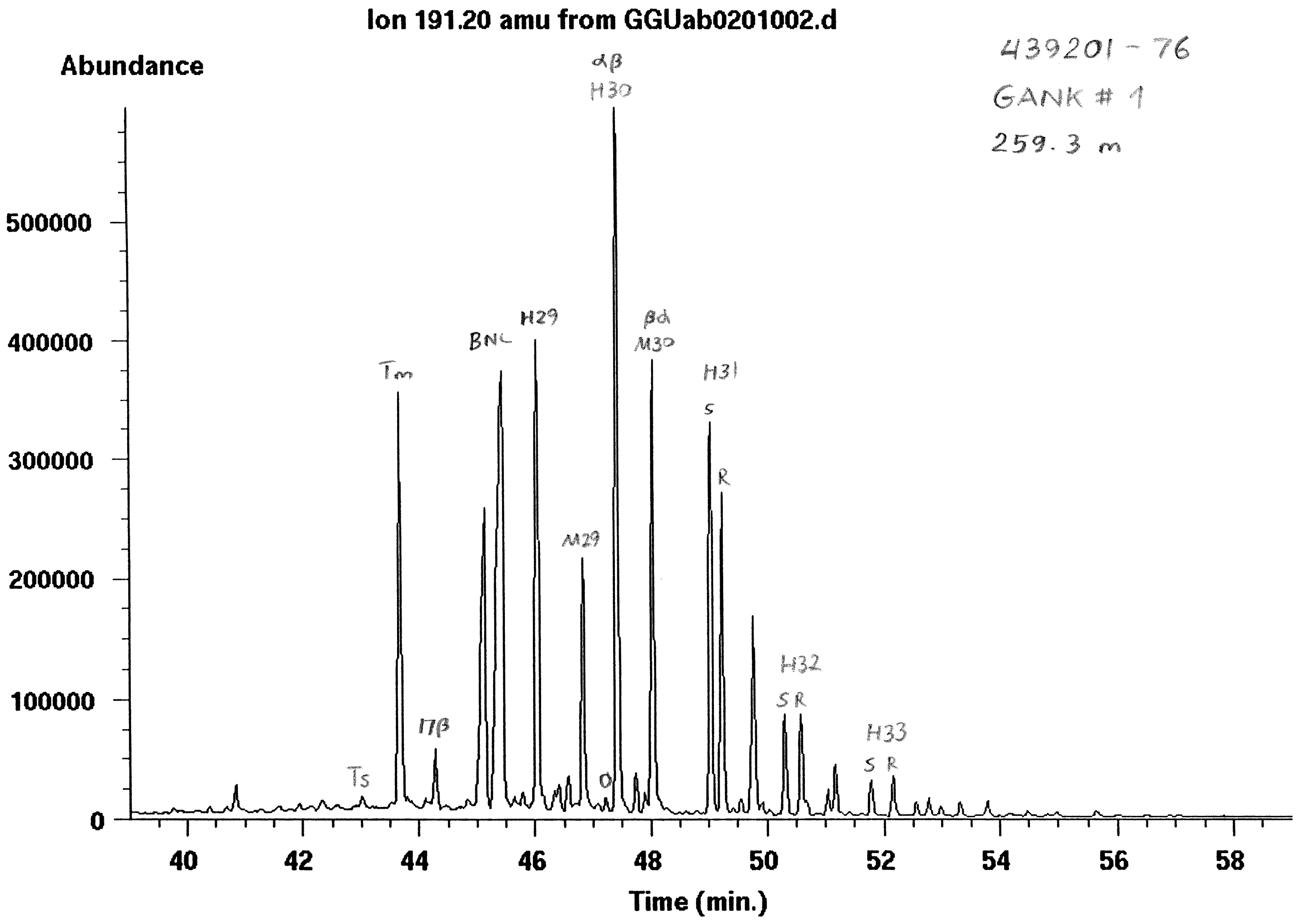


439201 – 66
GANK # 1
229.4 m

Ion 217.20 amu from GGUab0101004.d

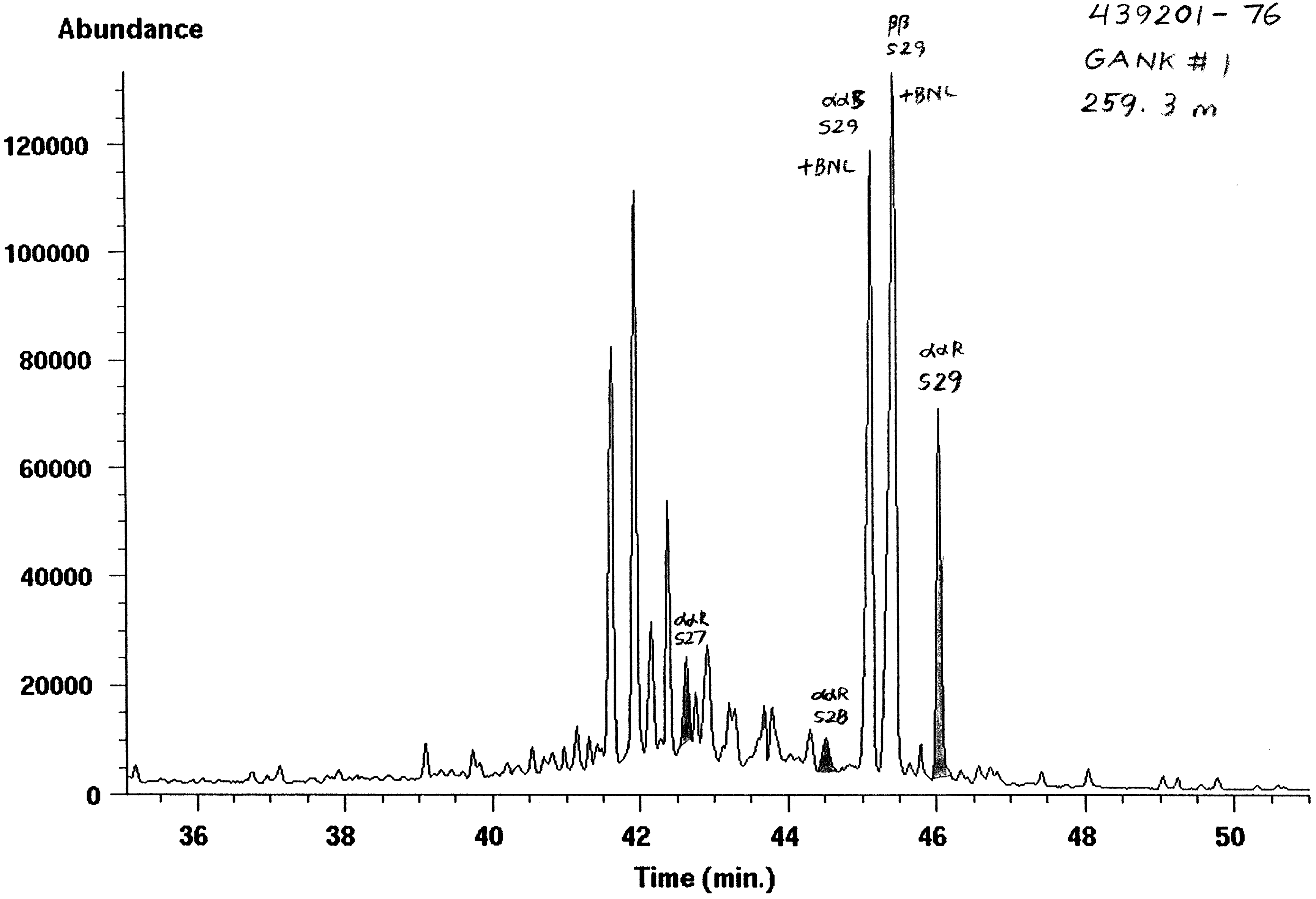


439201-66
GANK #1
229.4 m



439201 - 76
GANK # 1
259.3 m

Ion 217.20 amu from GGUab0201002.d



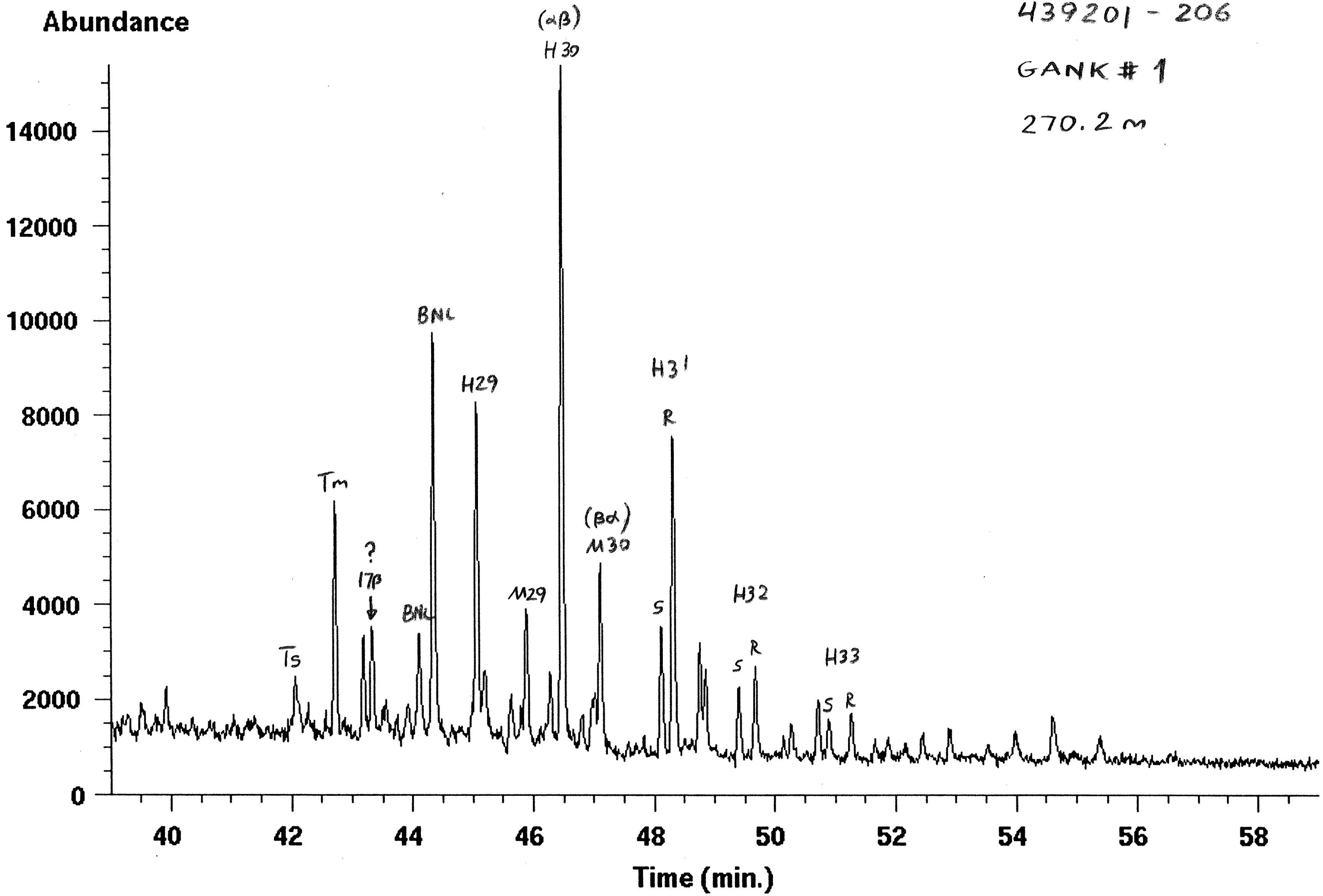
439201- 76
GANK # 1
259. 3 m

Ion 191.20 amu from 439201-206al.d

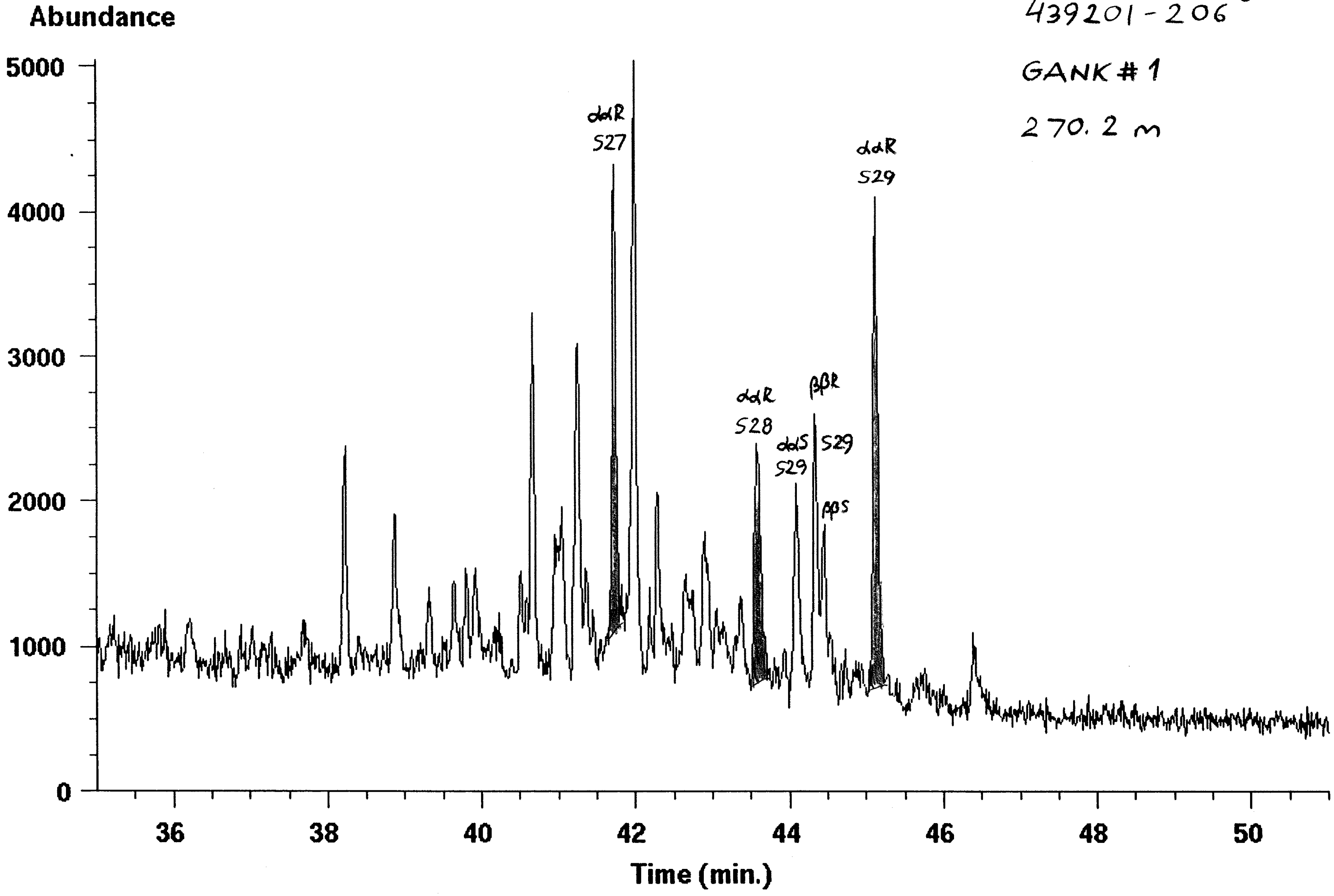
439201 - 206 ⁰

GANK # 1

270.2 m



Ion 217.20 amu from 439201-206al.d



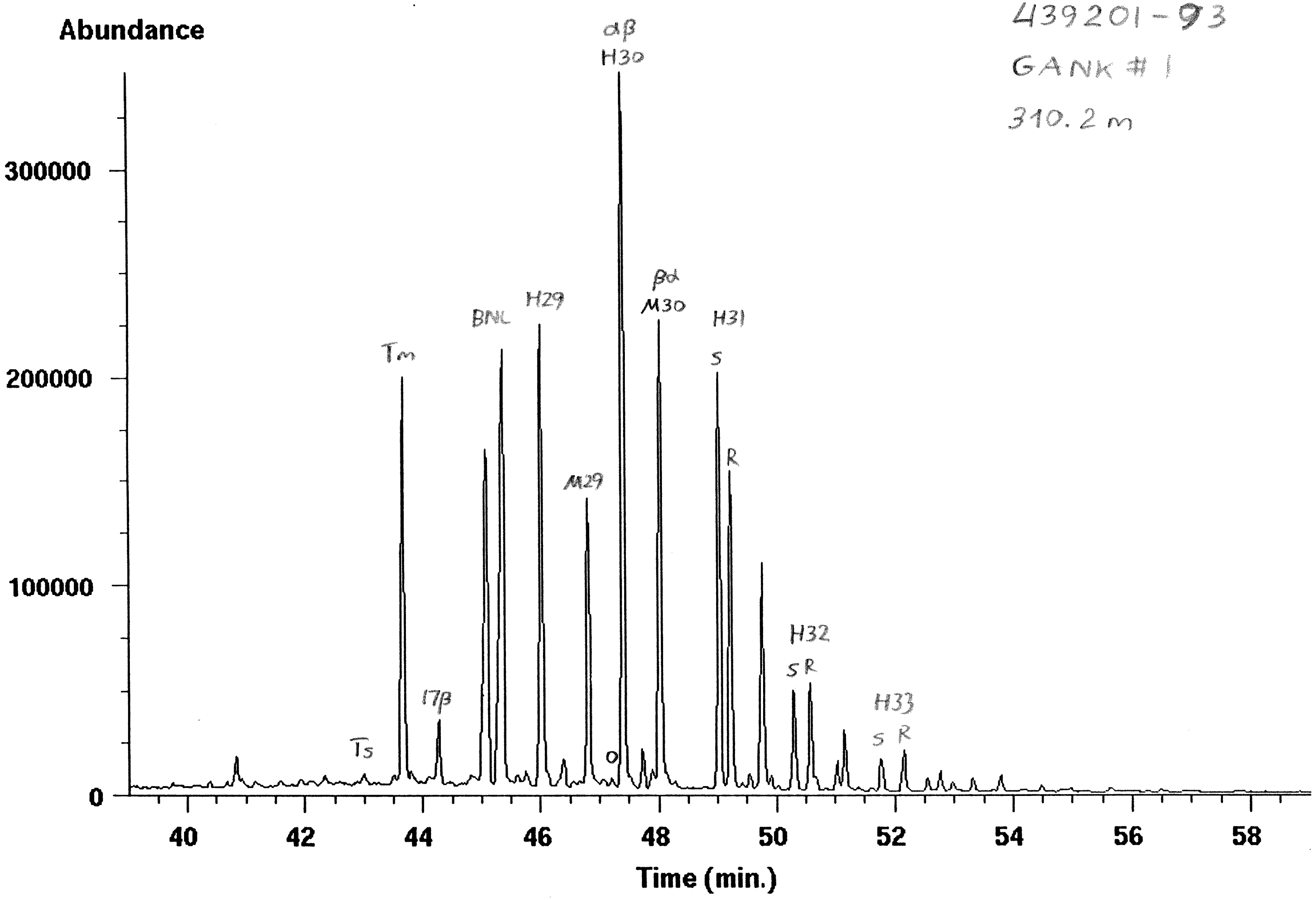
439201-206^{0}

GANK # 1

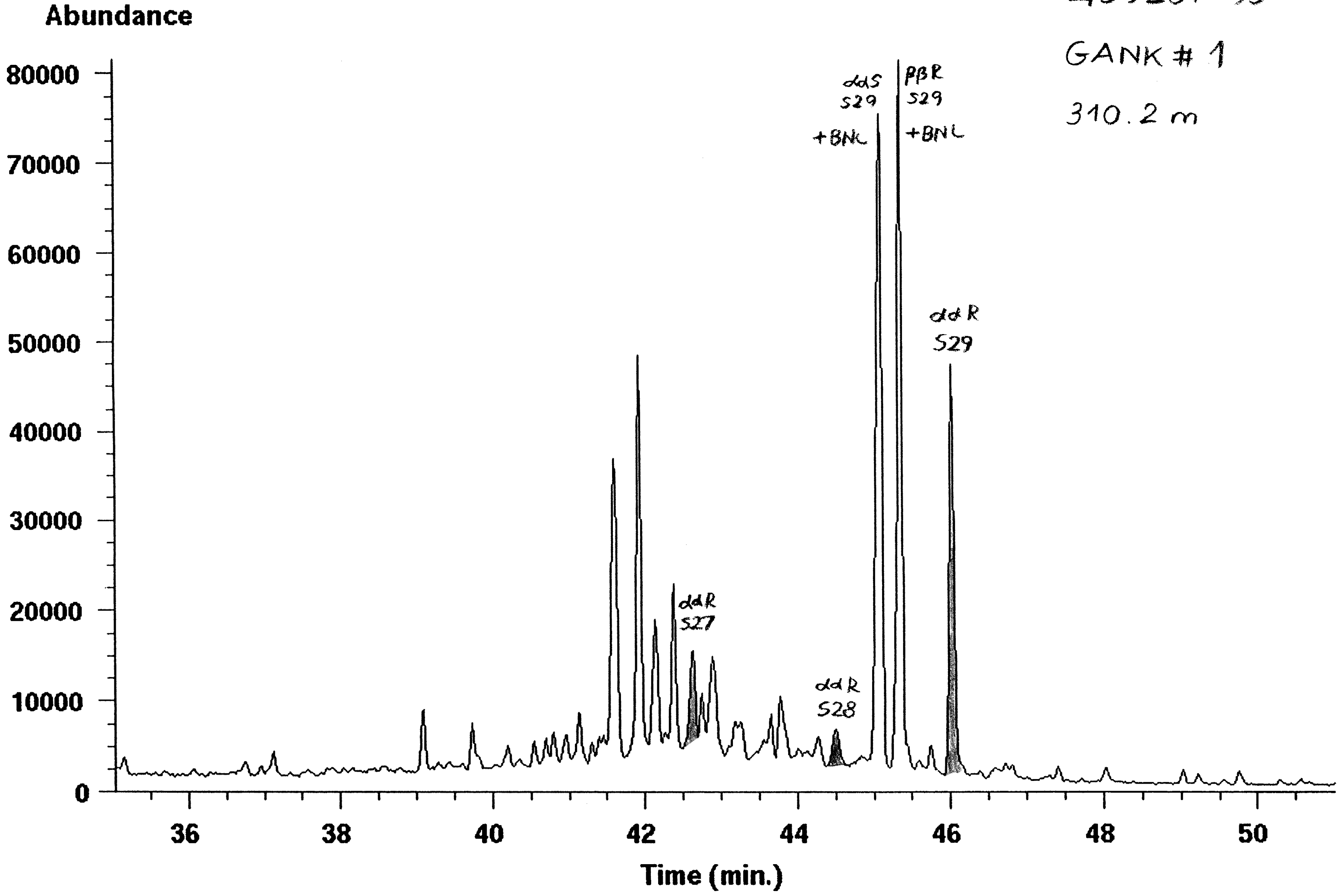
270.2 m

Ion 191.20 amu from GGUab0301003.d

439201-93
GANK #1
310.2 m



Ion 217.20 amu from GGUab0301003.d

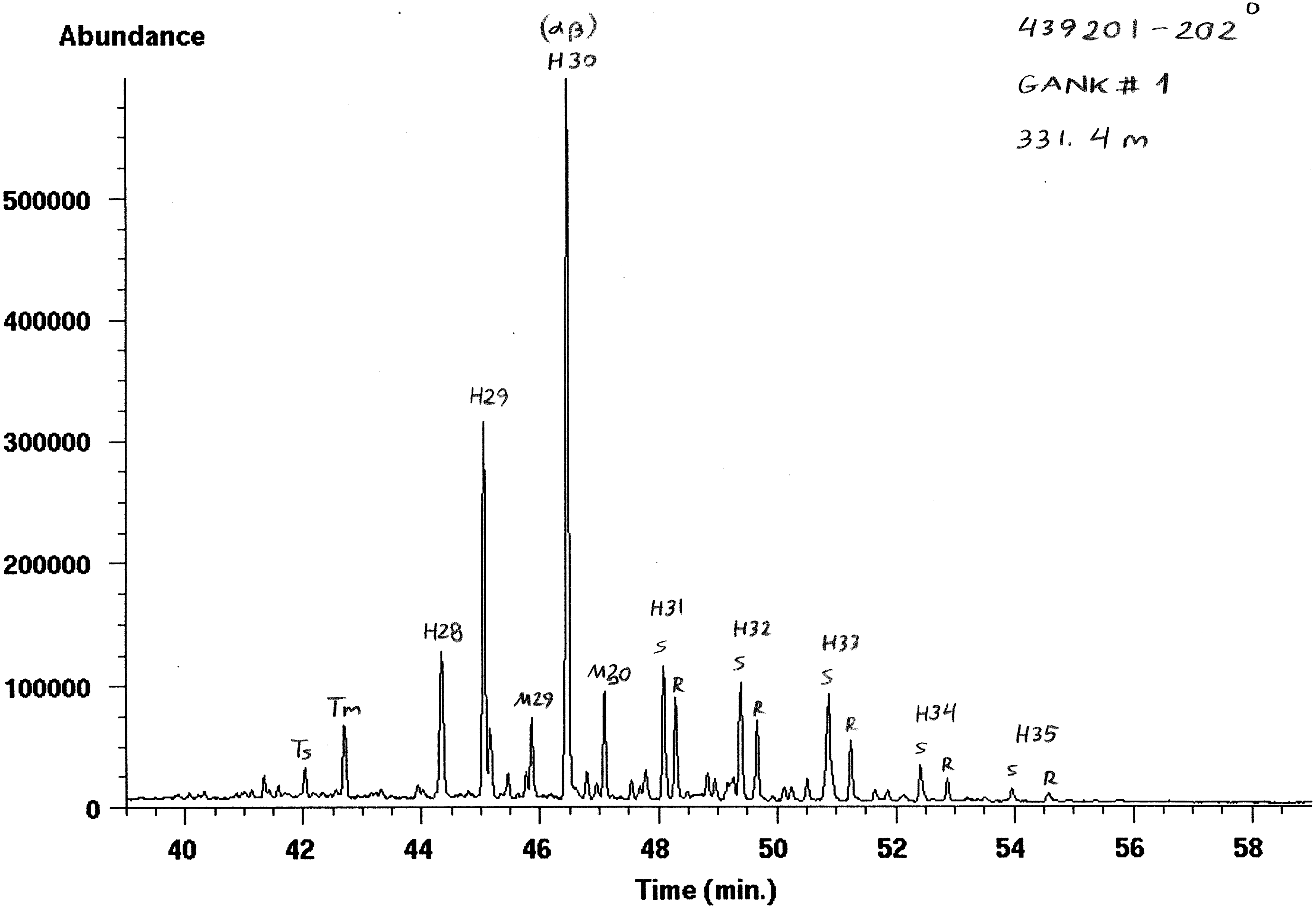


439201-93

GANK # 1

310.2 m

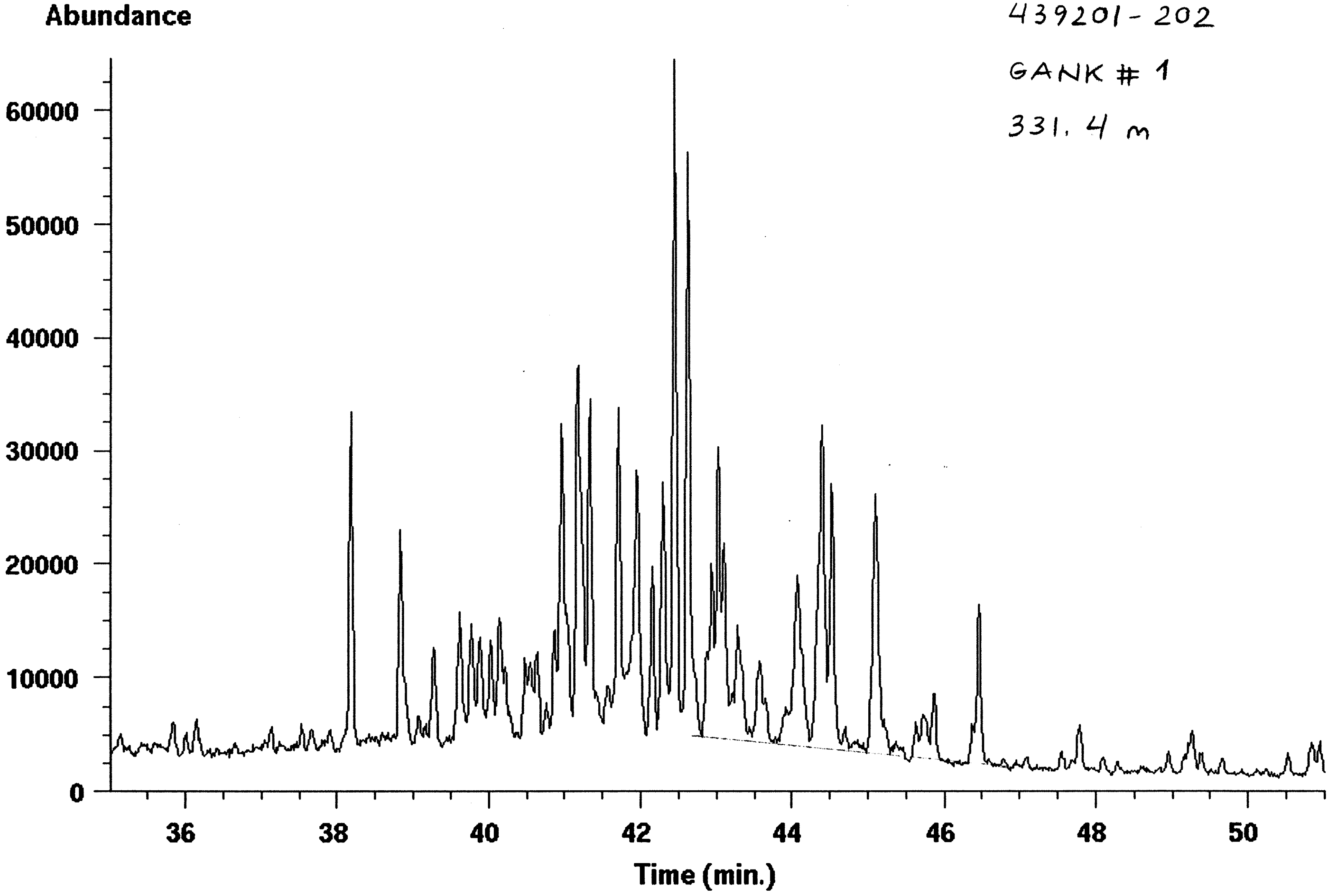
Ion 191.20 amu from 439201-202al.d



439201-202°

GANK # 1

331.4 m



Ion 217.20 amu from 439201-202al.d

439201-202°

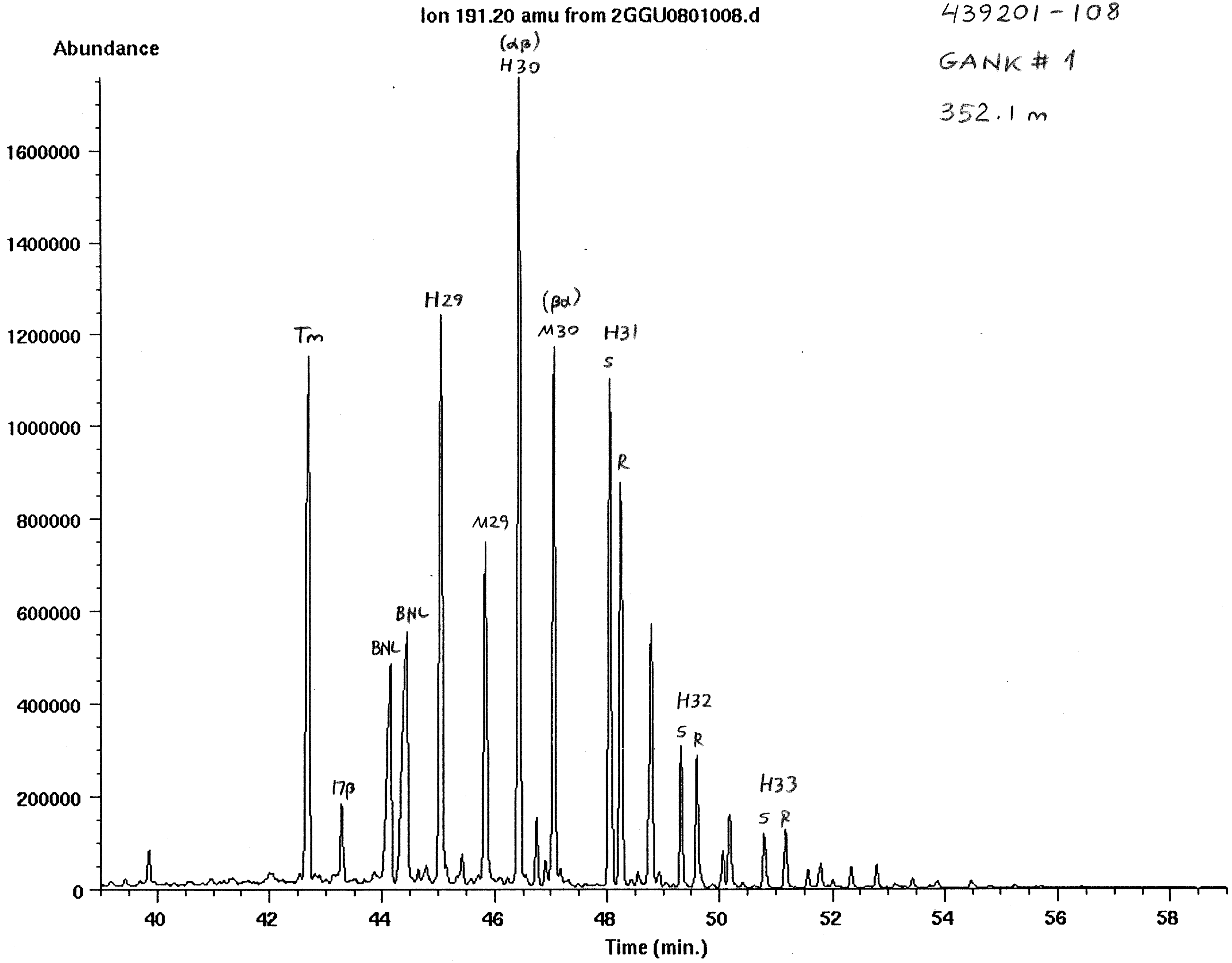
GANK # 1

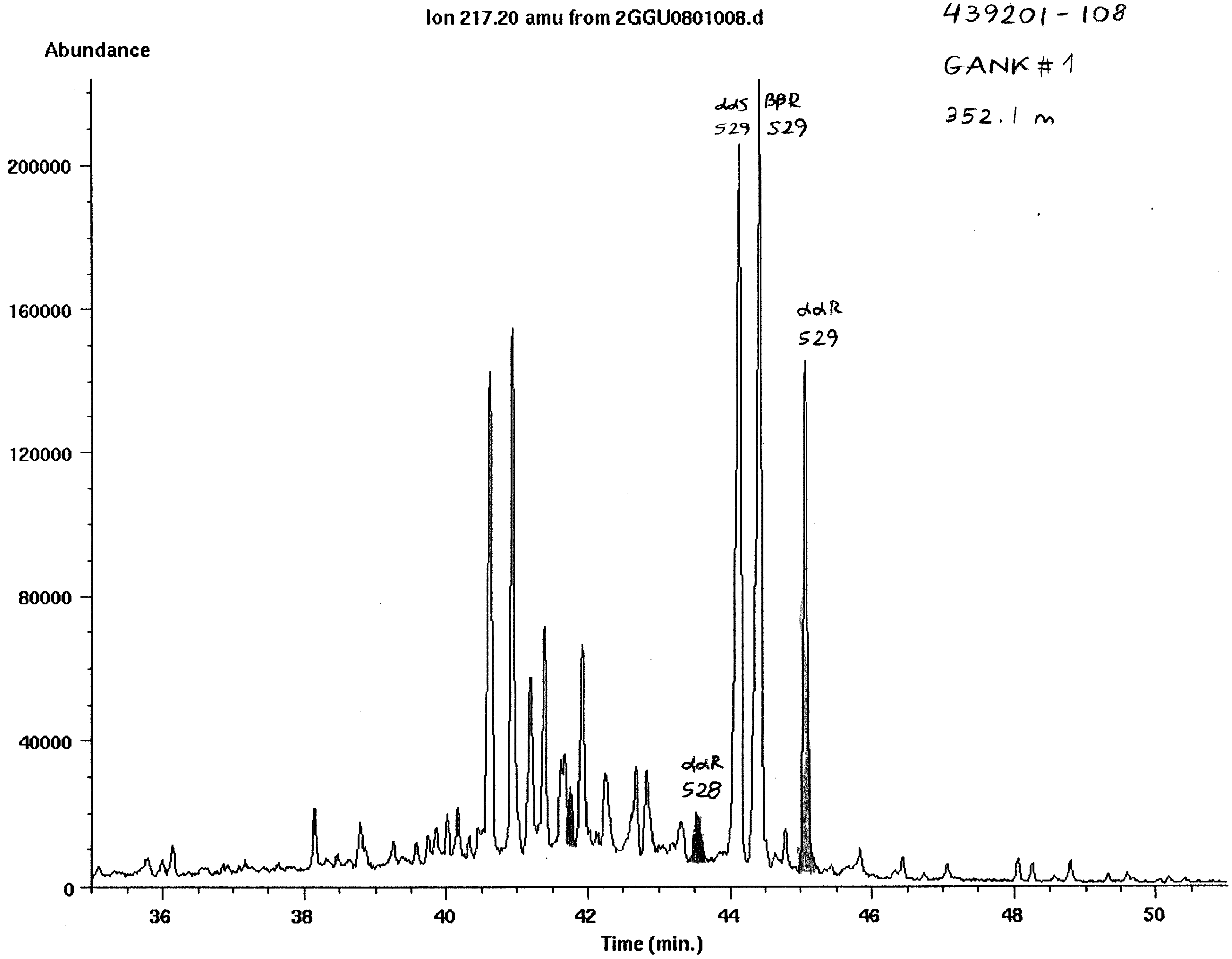
331.4 m

439201 - 108

GANK # 1

352.1 m

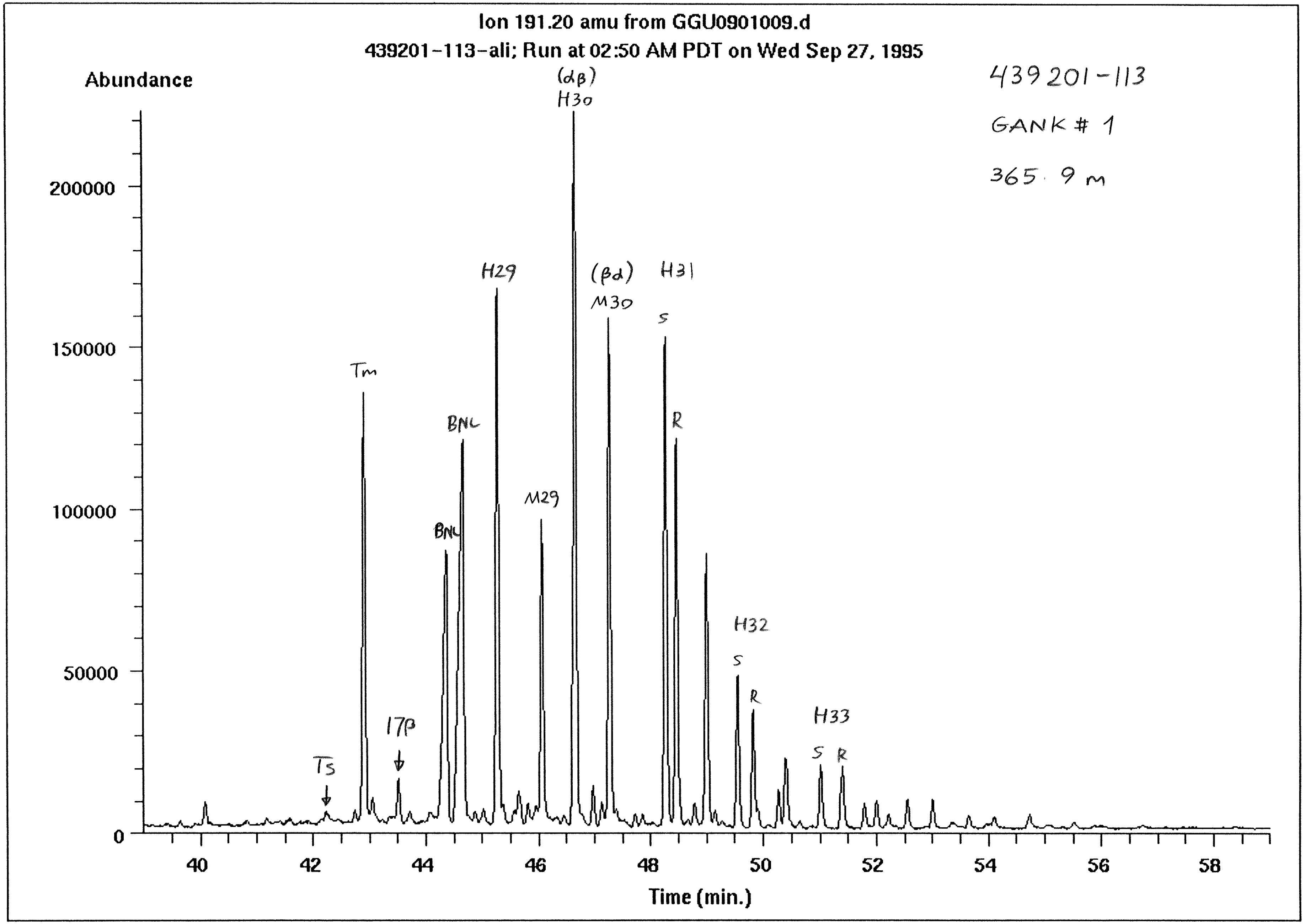




439201 - 108

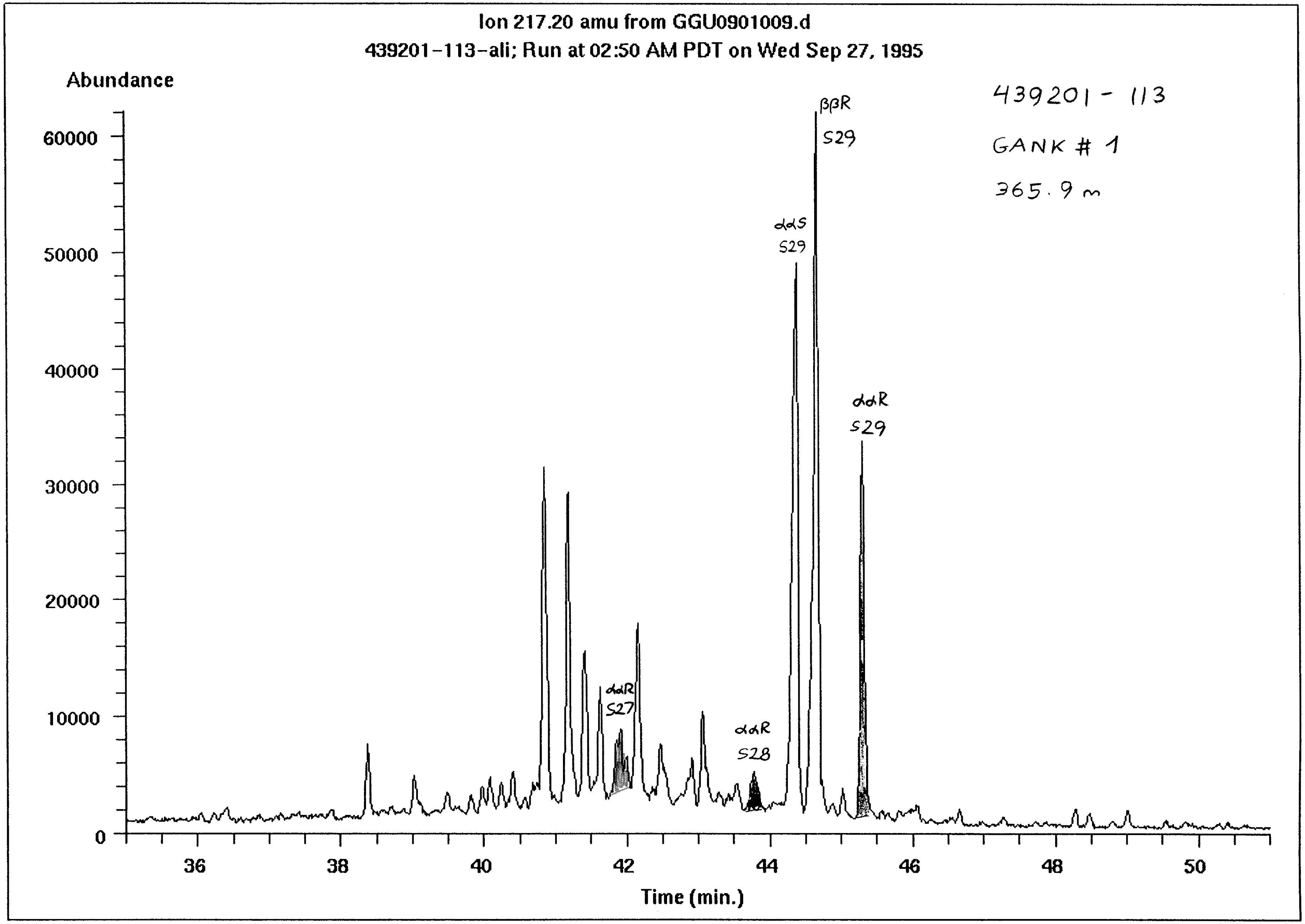
GANK # 1

352.1 m



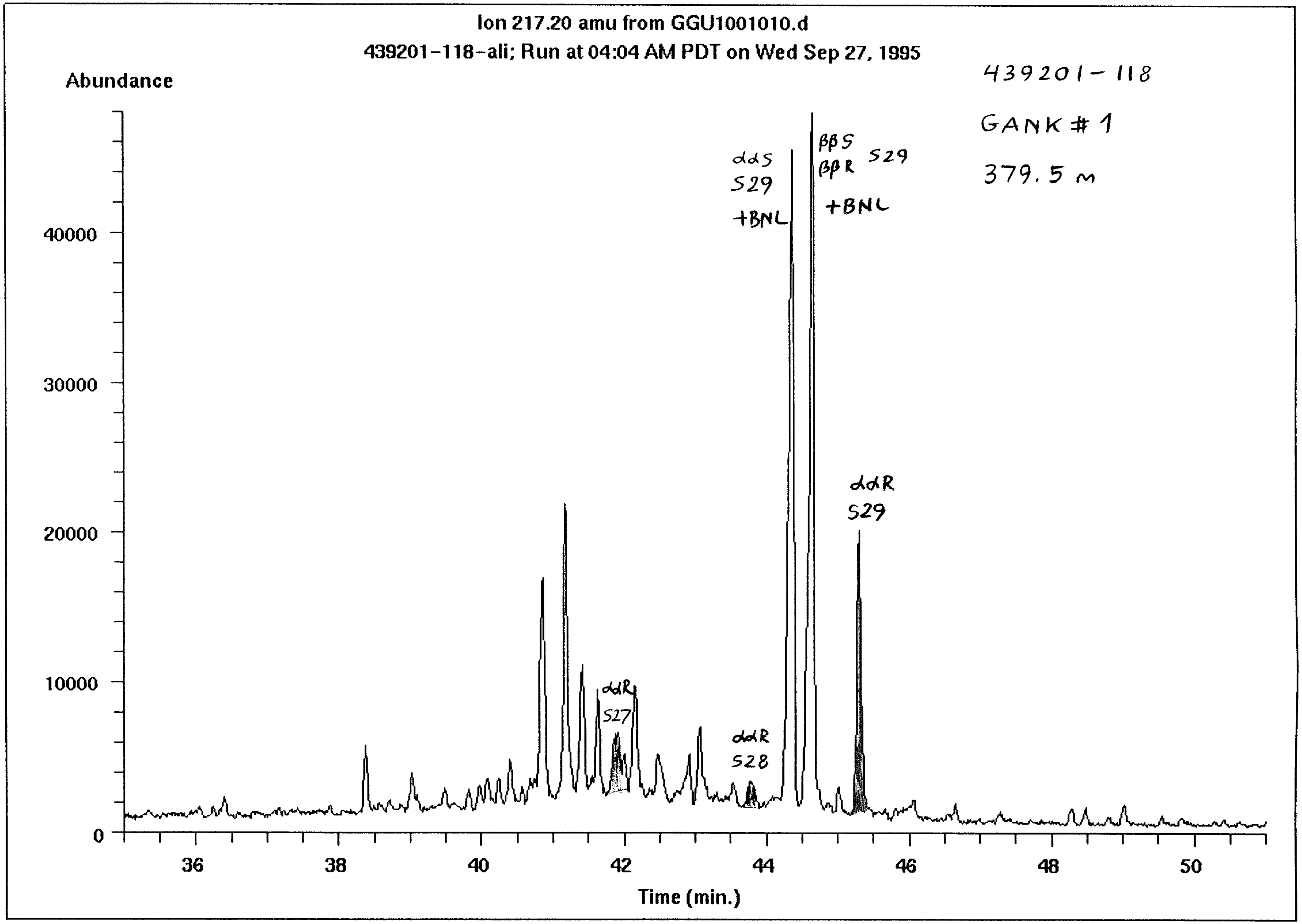
Ion 191.20 amu from GGU0901009.d
439201-113-ali; Run at 02:50 AM PDT on Wed Sep 27, 1995

439201-113
GANK # 1
365.9 m



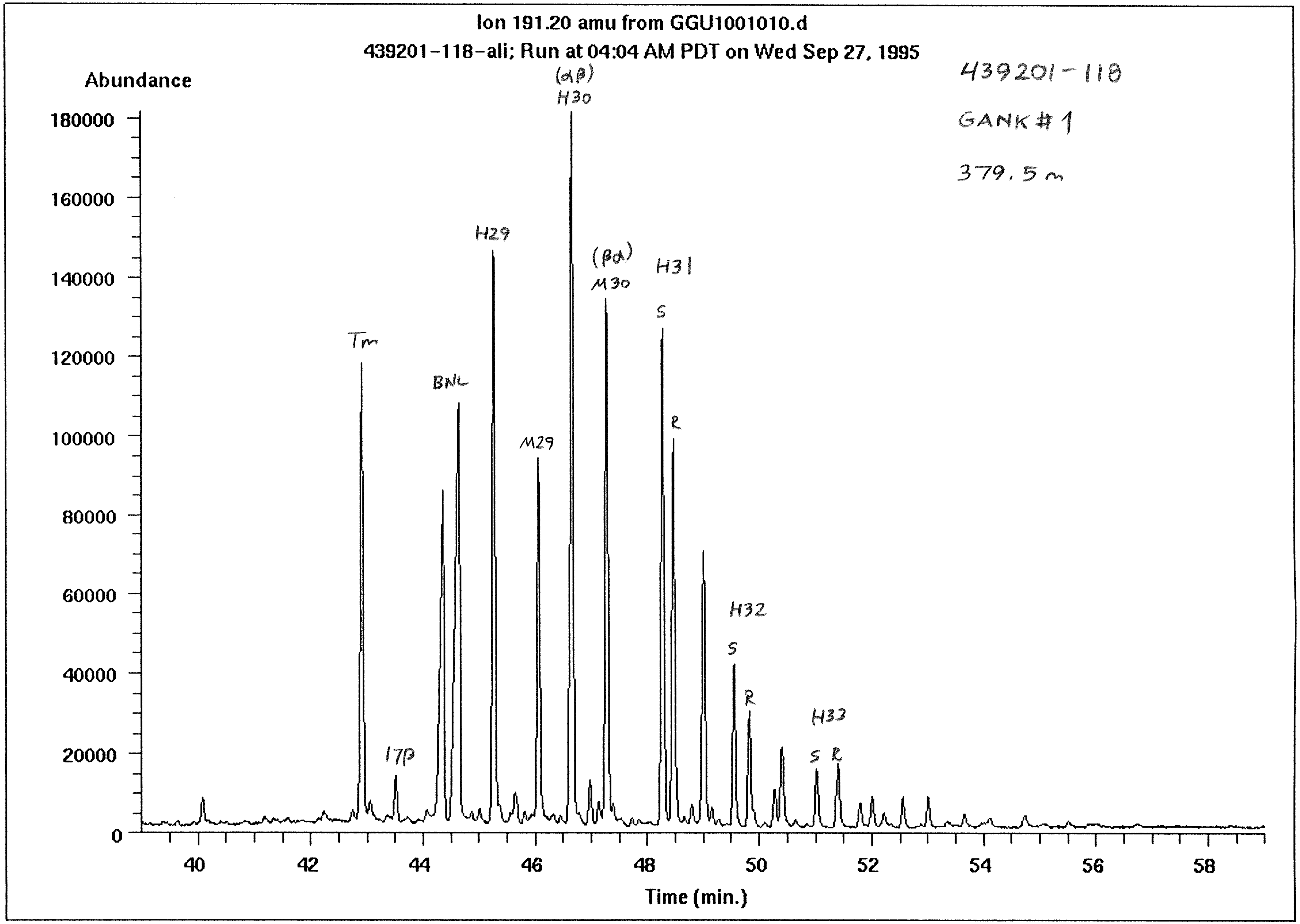
Ion 217.20 amu from GGU0901009.d
439201-113-ali; Run at 02:50 AM PDT on Wed Sep 27, 1995

439201 - 113
GANK # 1
365.9 m



Ion 217.20 amu from GGU1001010.d
439201-118-ali; Run at 04:04 AM PDT on Wed Sep 27, 1995

439201-118
GANK #1
379.5 m



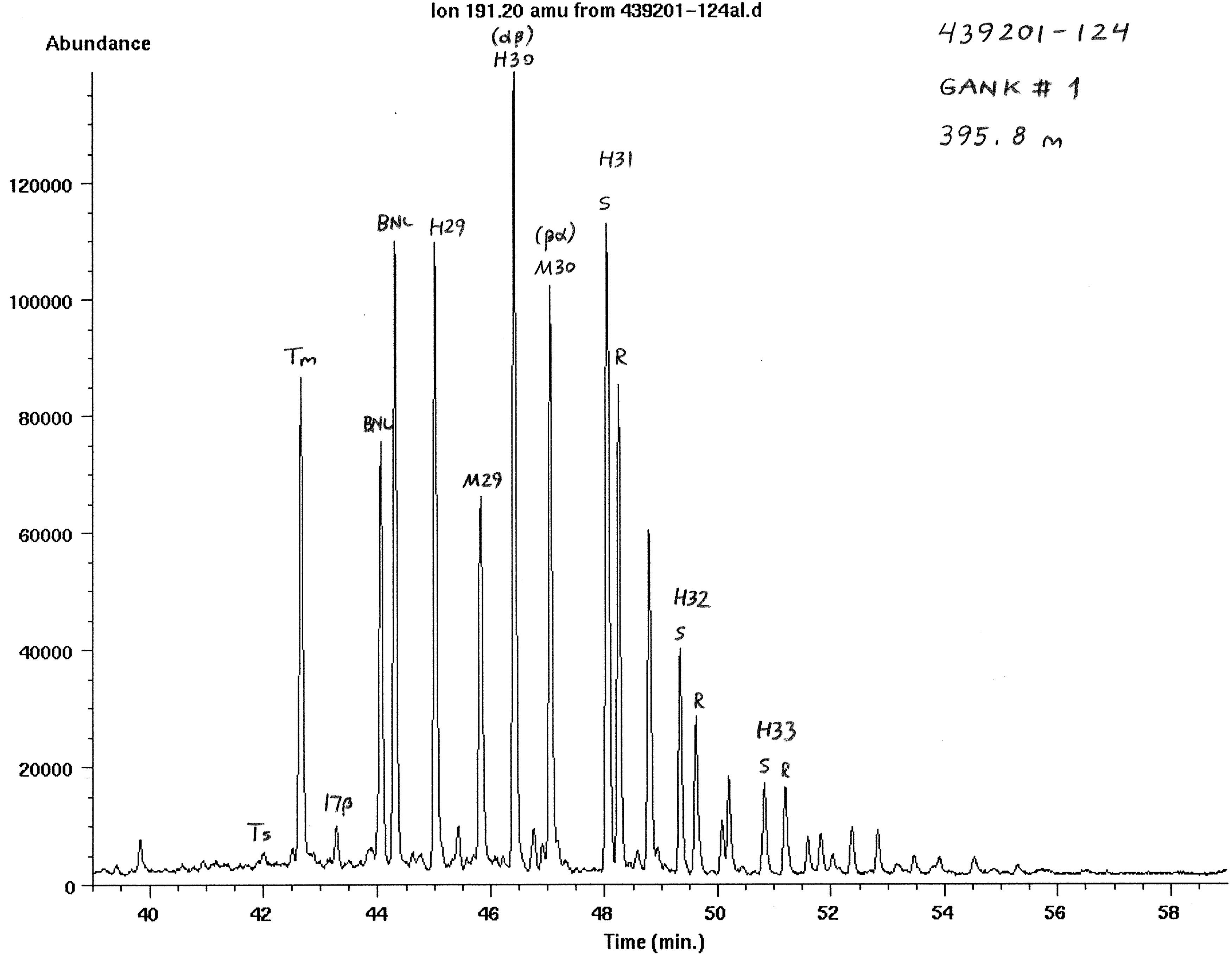
Ion 191.20 amu from GGU1001010.d
439201-118-ali; Run at 04:04 AM PDT on Wed Sep 27, 1995

439201-118
GANK #1
379.5 m

439201-124

GANK # 1

395.8 m

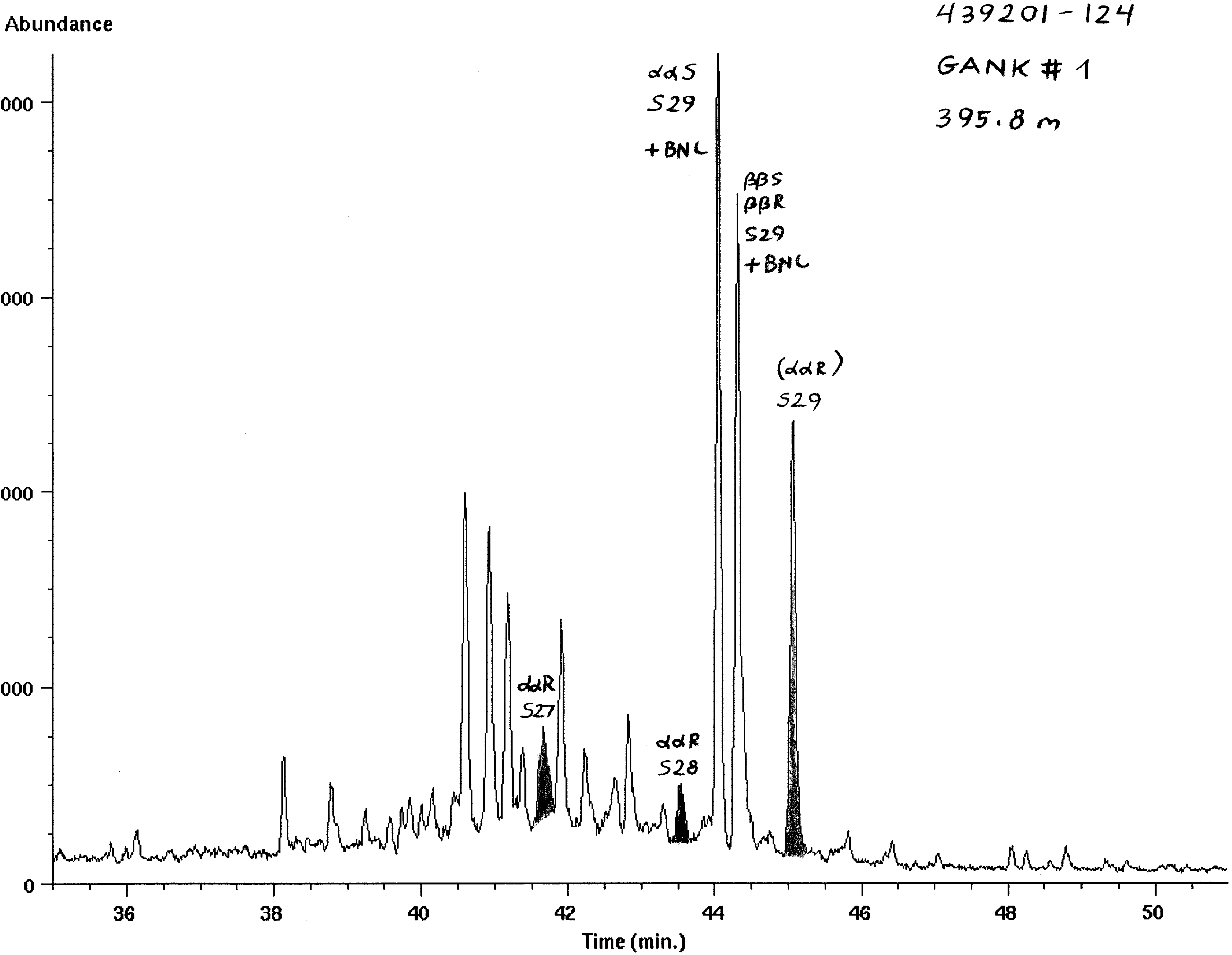


Ion 217.20 amu from 439201-124al.d

439201-124

GANK # 1

395.8 m



GANK-1 well
1:5000

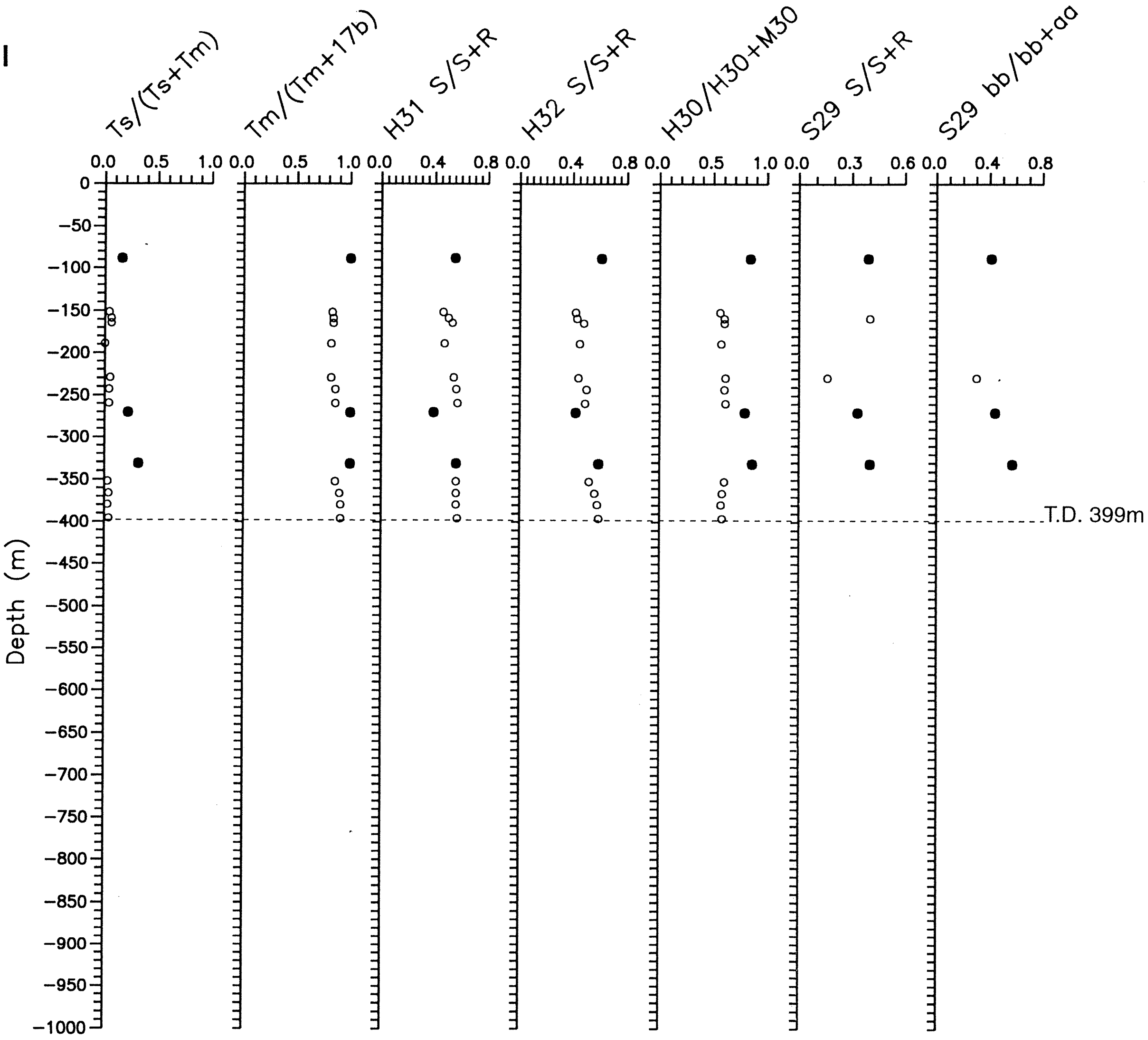


Fig. 20

GANT-1 well
1:5000

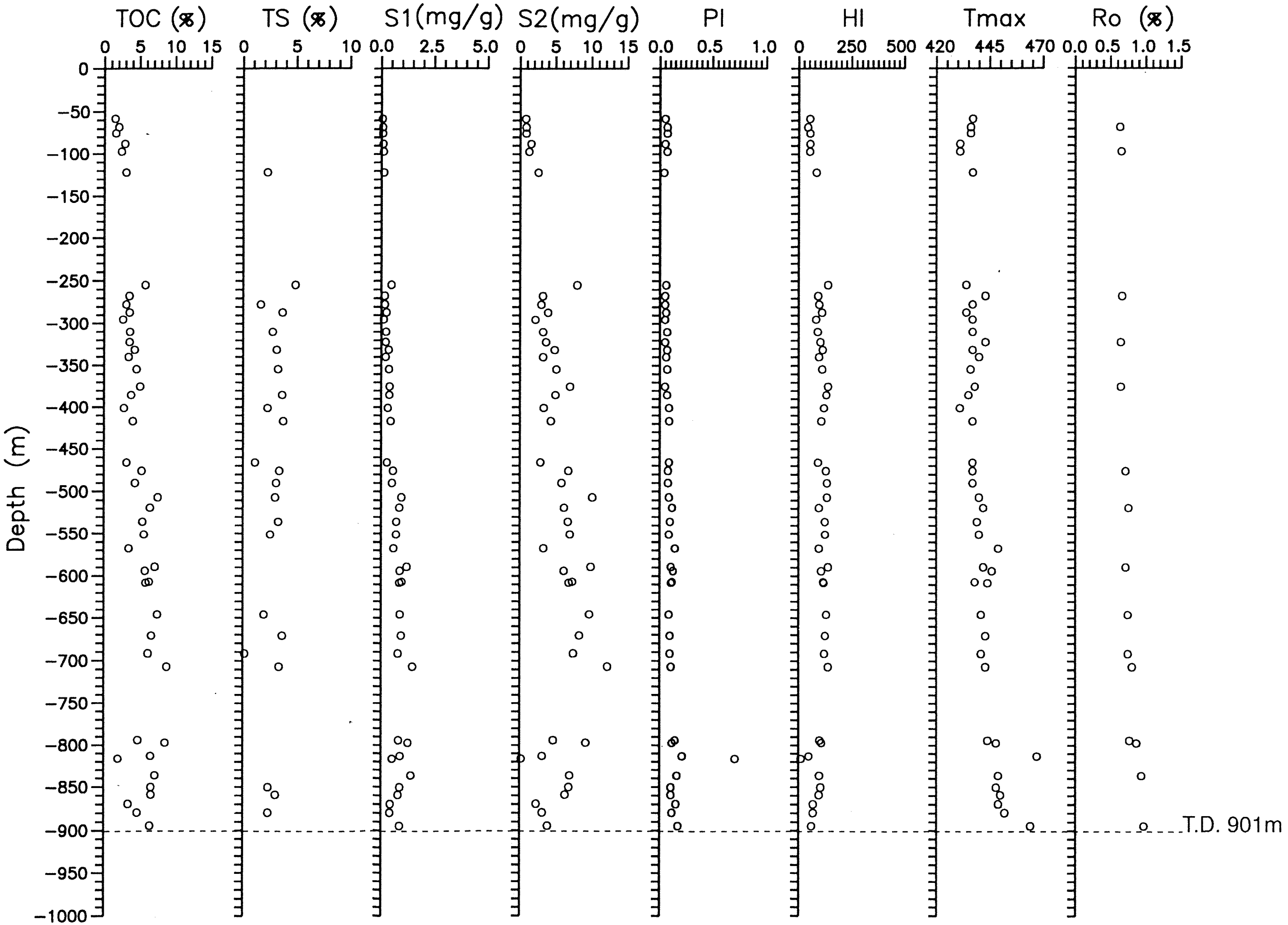


Fig. 21

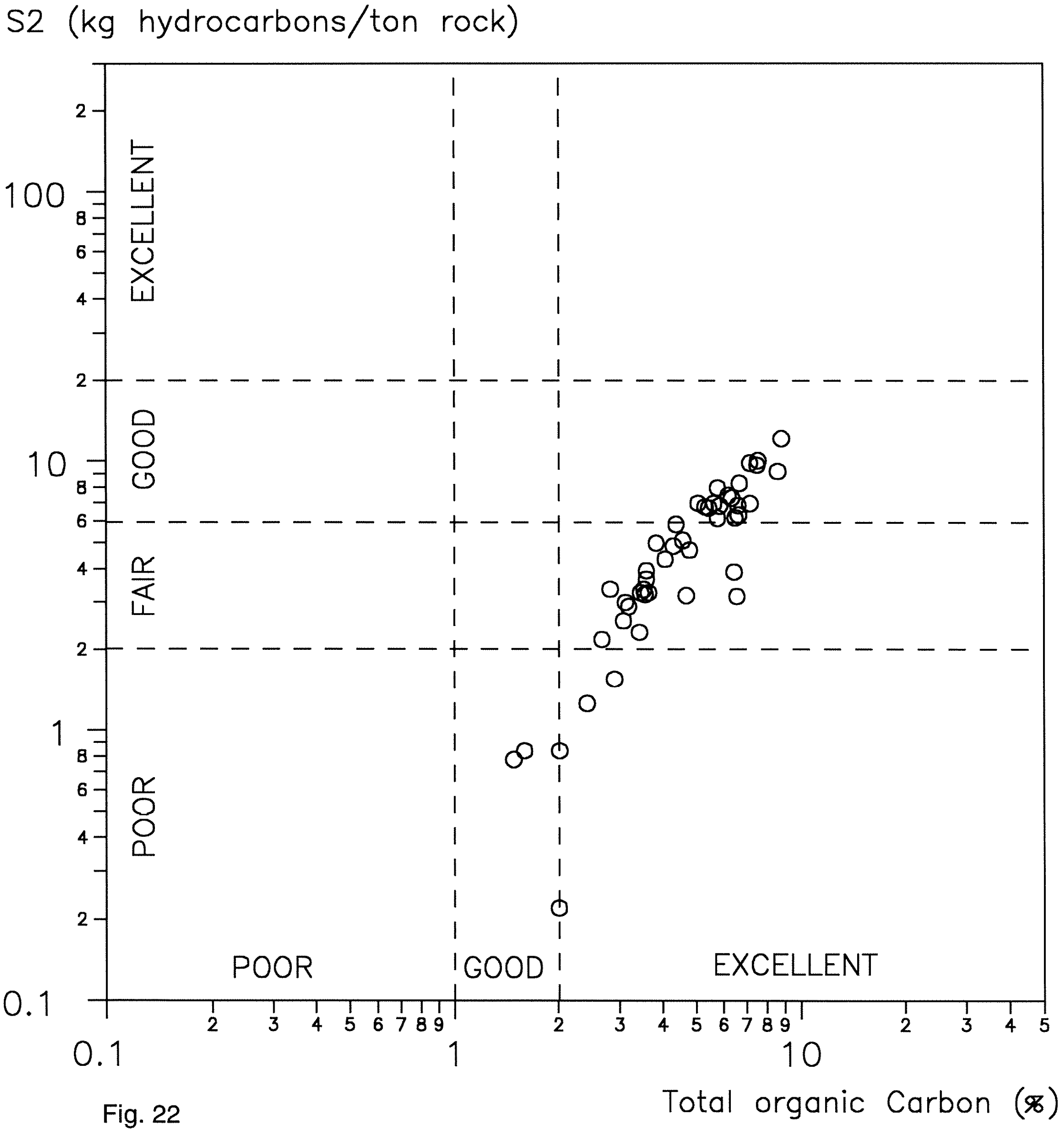

S2 (kg hydrocarbons/ton rock)
EXCELLENT
GOOD
FAIR
POOR
POOR
GOOD
EXCELLENT
0.1
1
10
100
2
4
6
8
0.1
1
10
2 3 4 5 6 7 8 9
2 3 4 5
Total organic Carbon (%)

Fig. 22

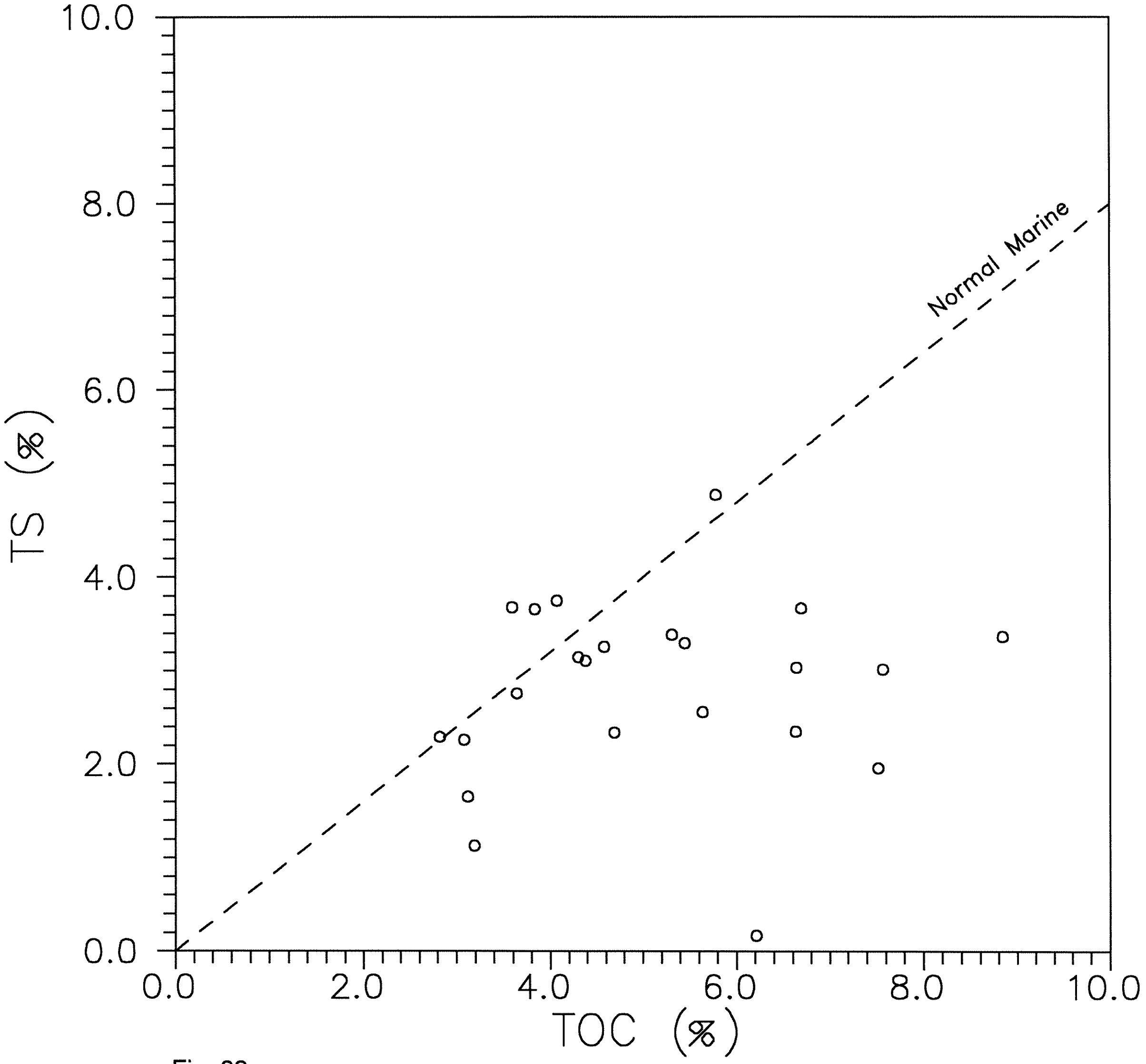


Fig. 23

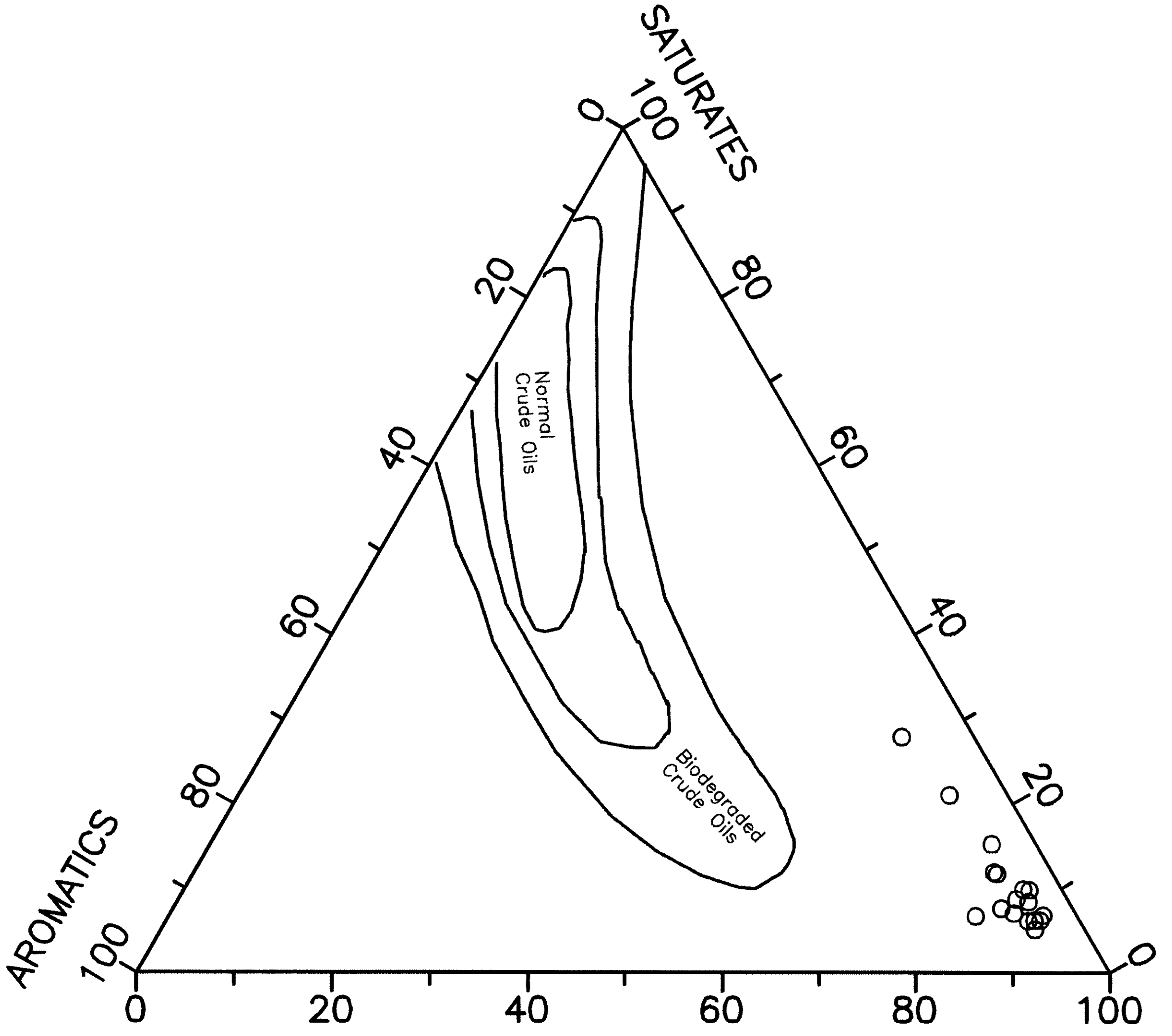
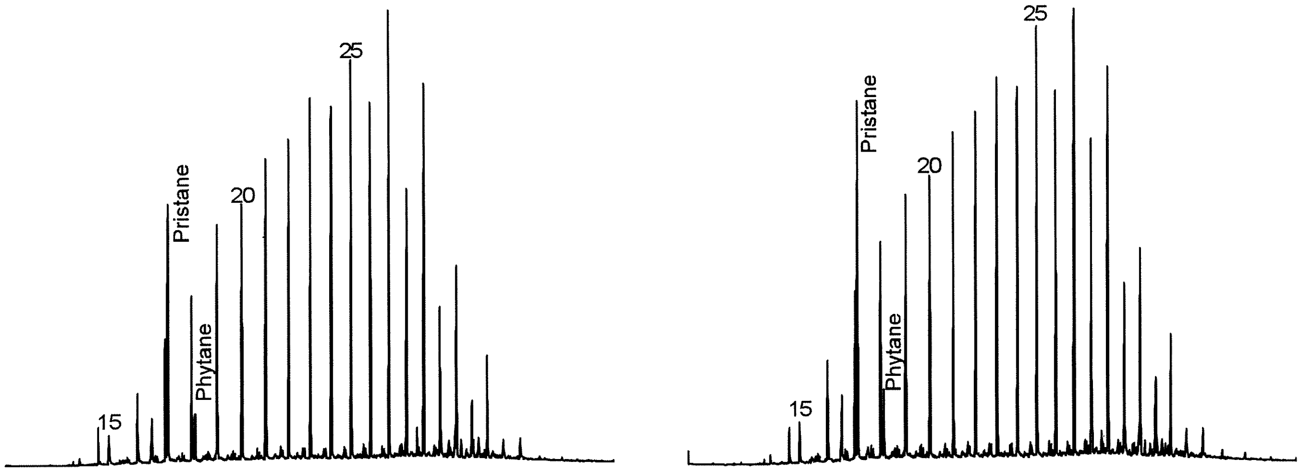
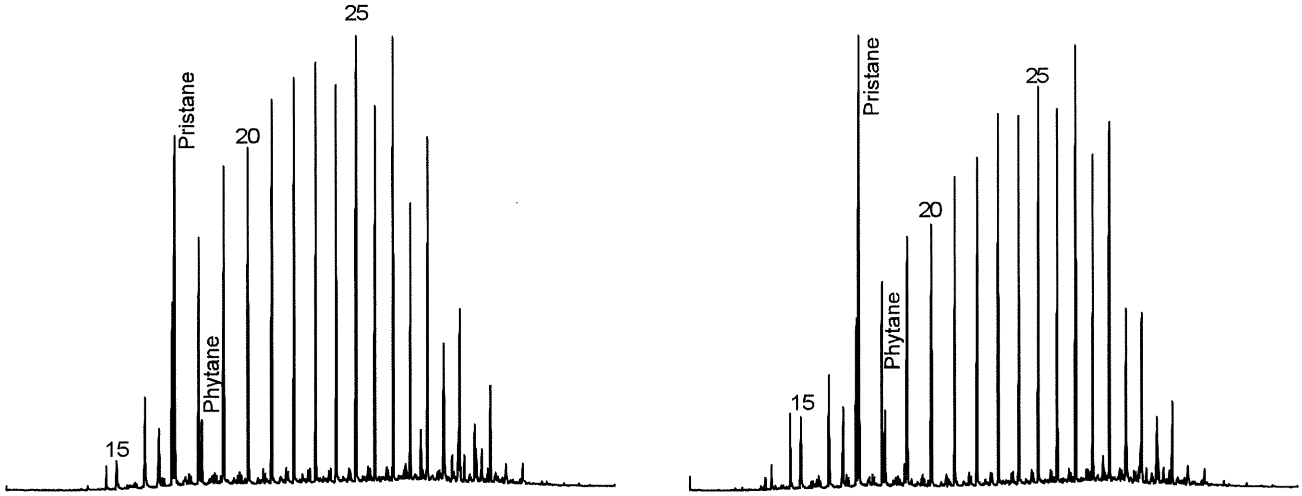

SATURATES
AROMATICS
POLARS (Asph. + NSO)
Normal Crude Oils
Biodegraded Crude Oils
0
20
40
60
80
100

Fig. 24



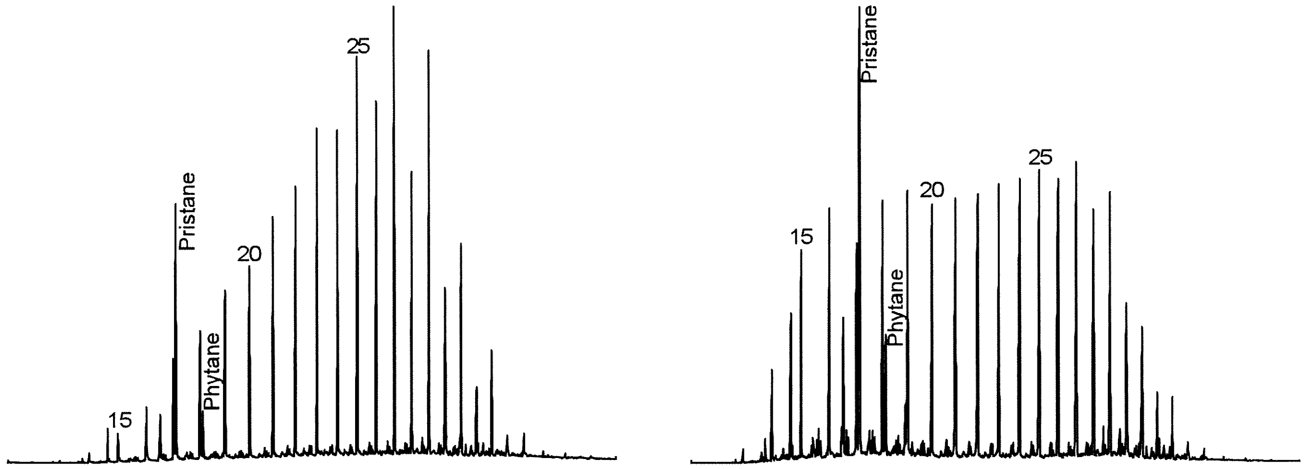
439101-18 (68.1 m)

439101-176 (322.2 m)



439101-102 (97.2 m)

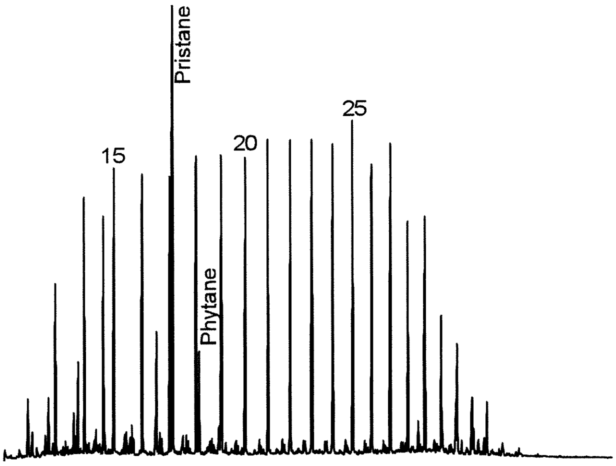
439101-193 (374.9 m)



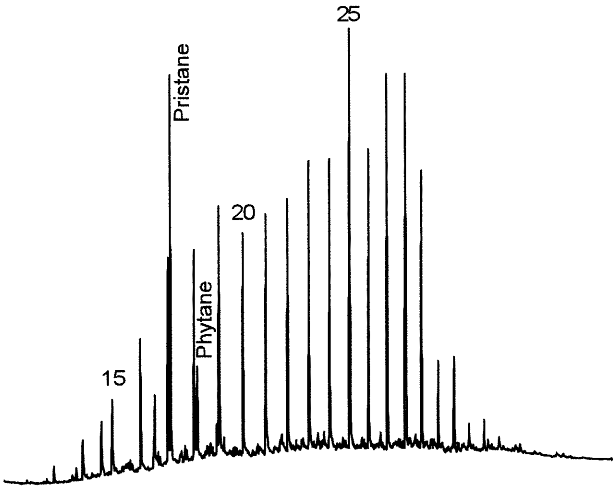
439101-158 (267.3 m)

439101-363 (476.0 m)

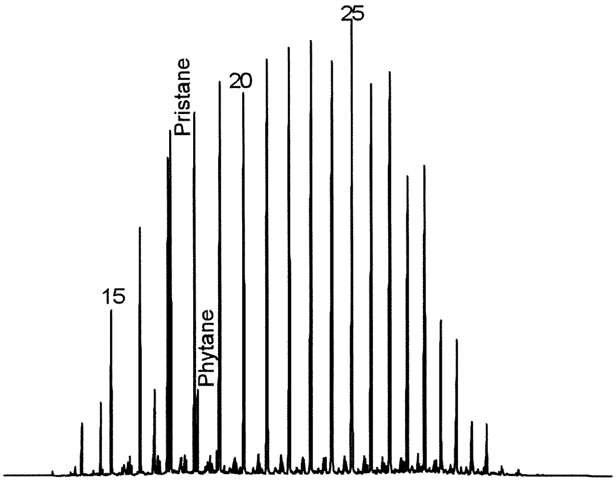
Fig. 25



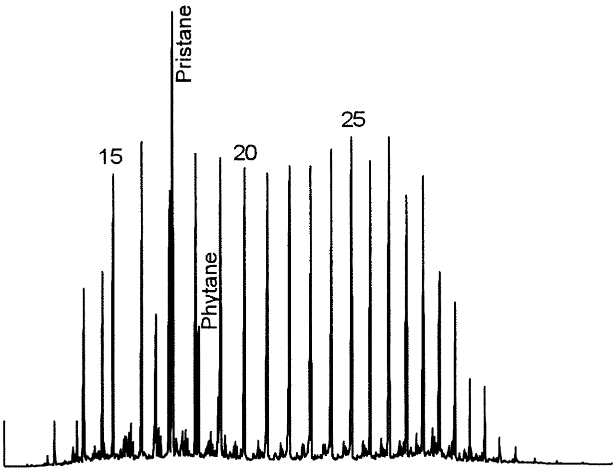
439101-378 (519.1 m)



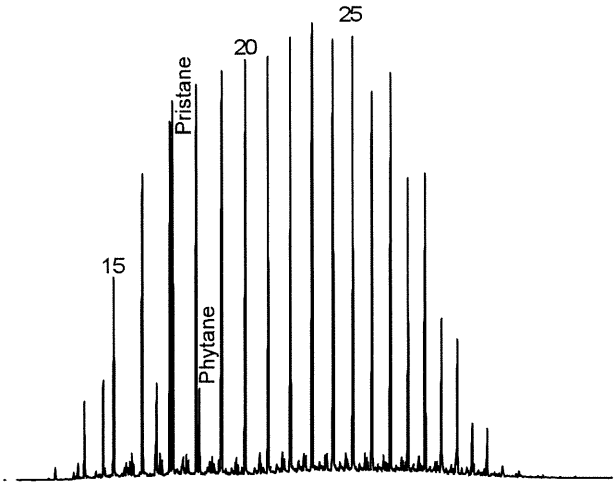
439101-805 (610.55 m, Bulk oil/extr.)



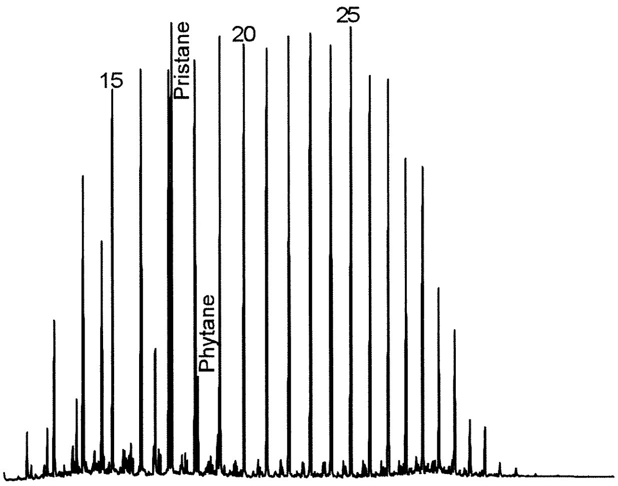
439101-401 (589.4 m)



439101-419 (645.9 m)

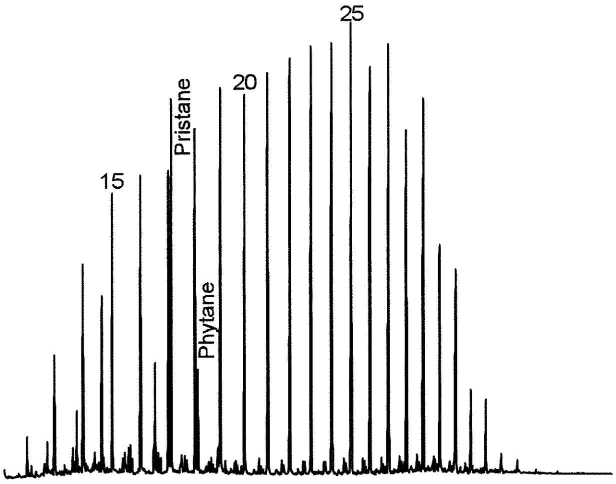


439101-407 (608.0 m)

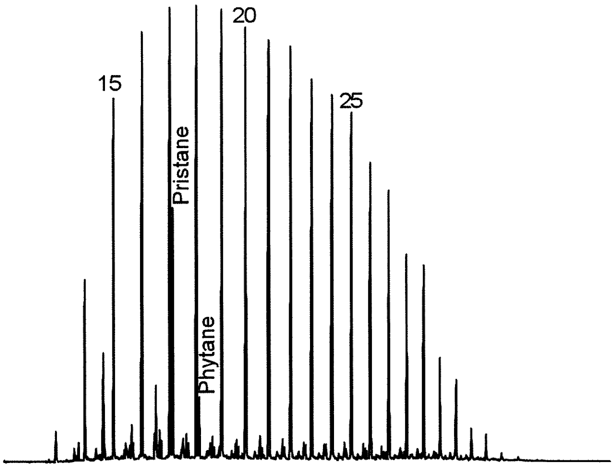


439101-433 (691.6 m)

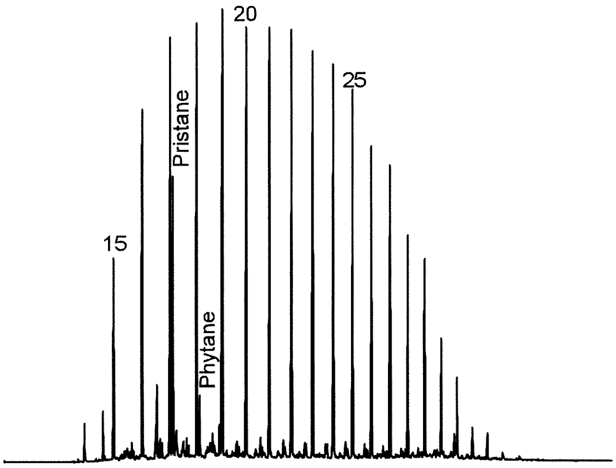
Fig 25 ctd.



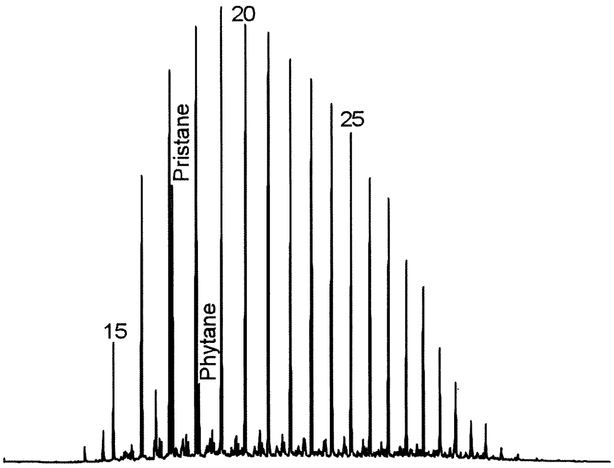
439101-437 (706.8 m)



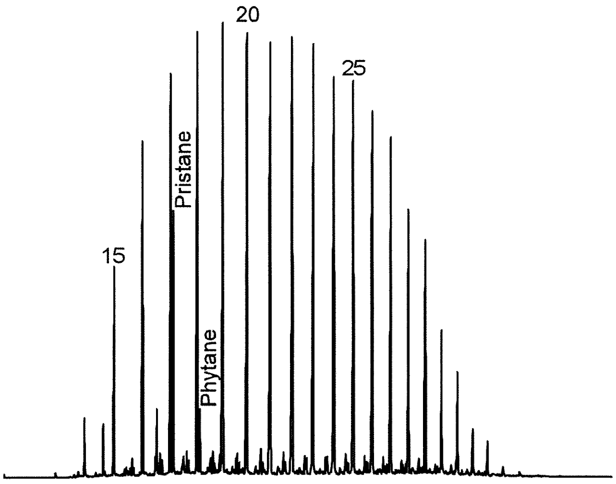
439101-520 (836.7 m)



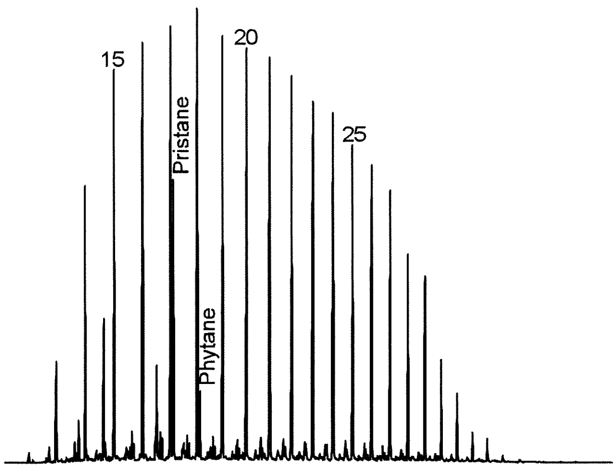
439101-465 (794.0 m)



439101-521 (869.5 m)



439101-518 (797.2 m)



439101-522 (894.5 m)

Fig 25 ctd.

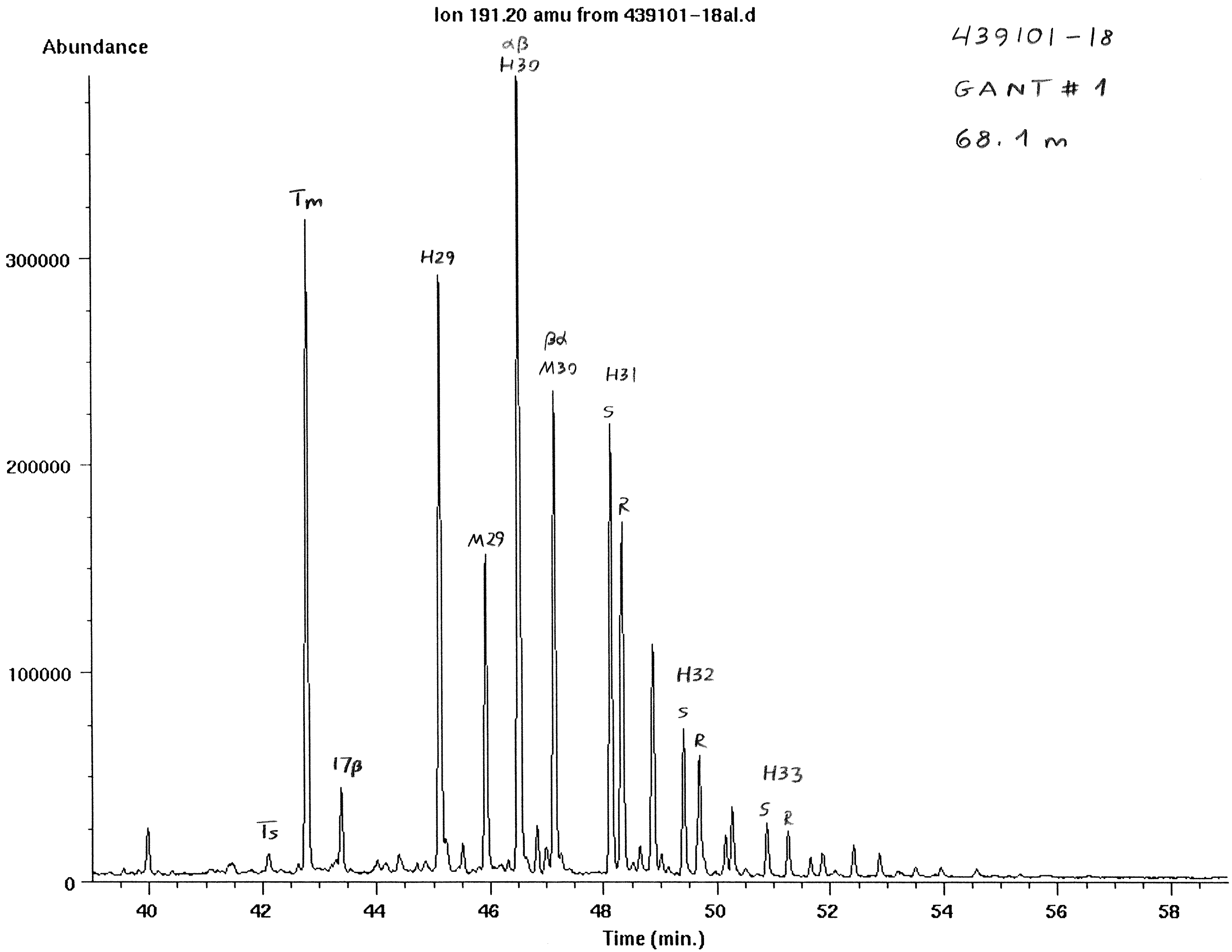
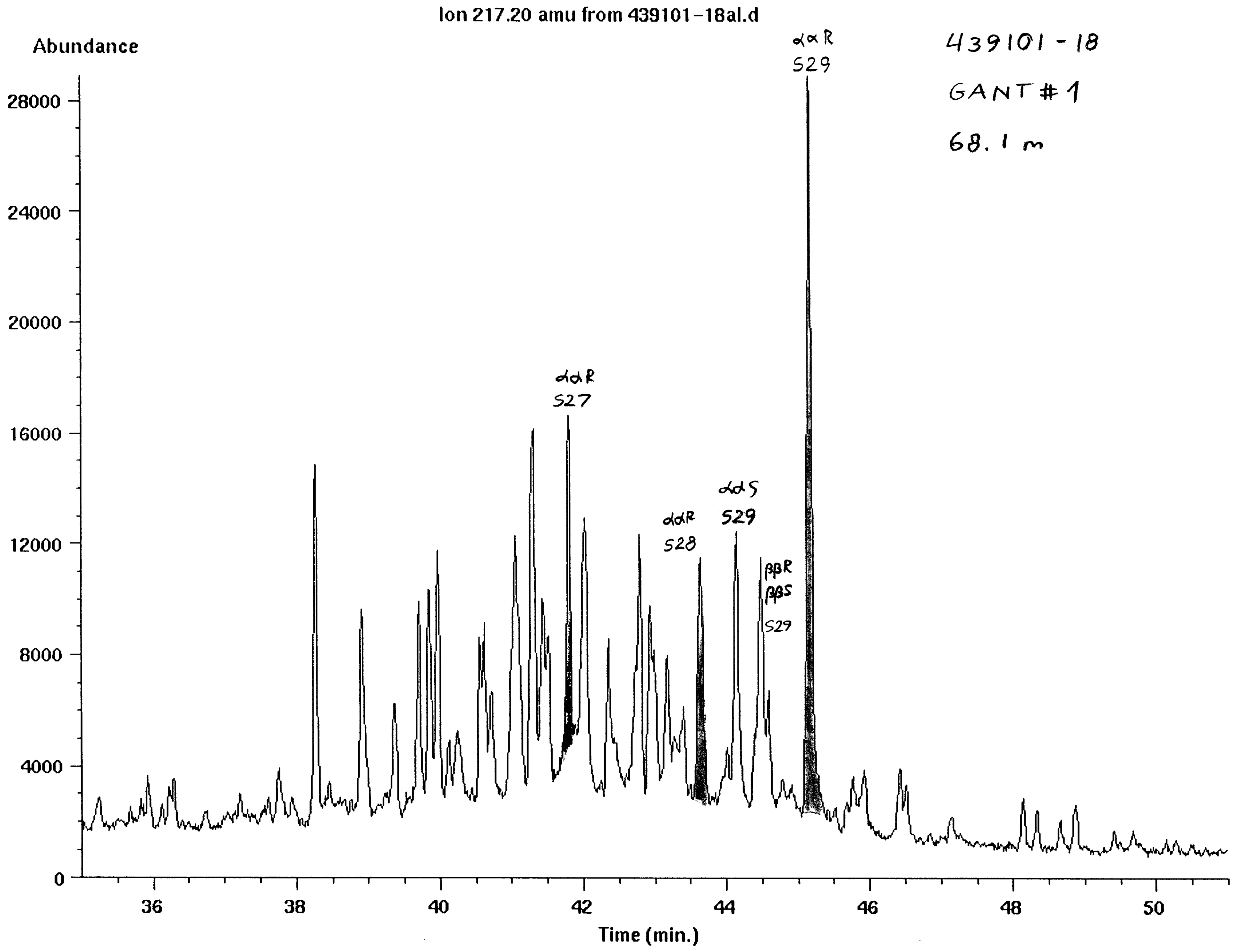


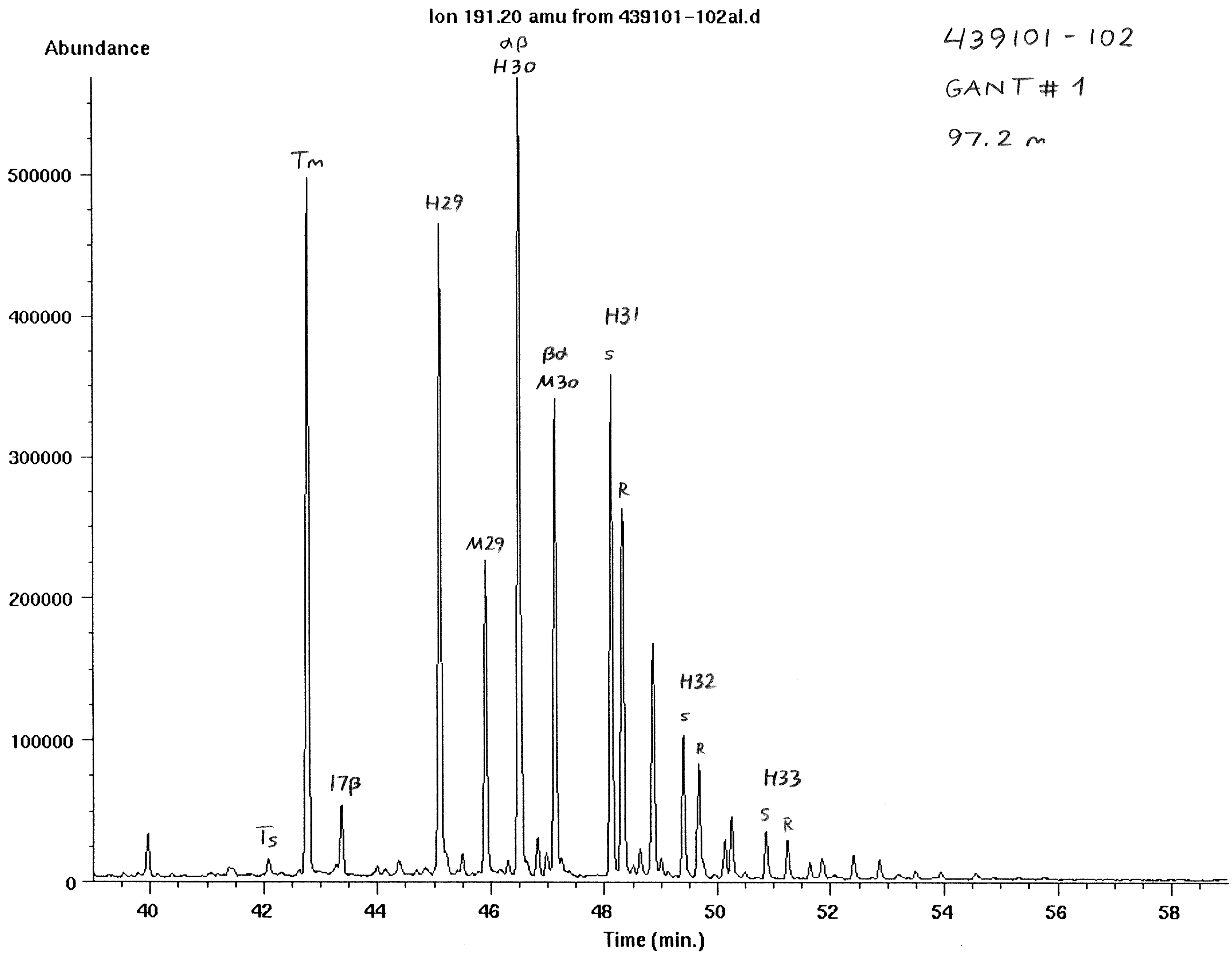
Fig. 26 continues



439101 - 18

GANT # 1

68.1 m

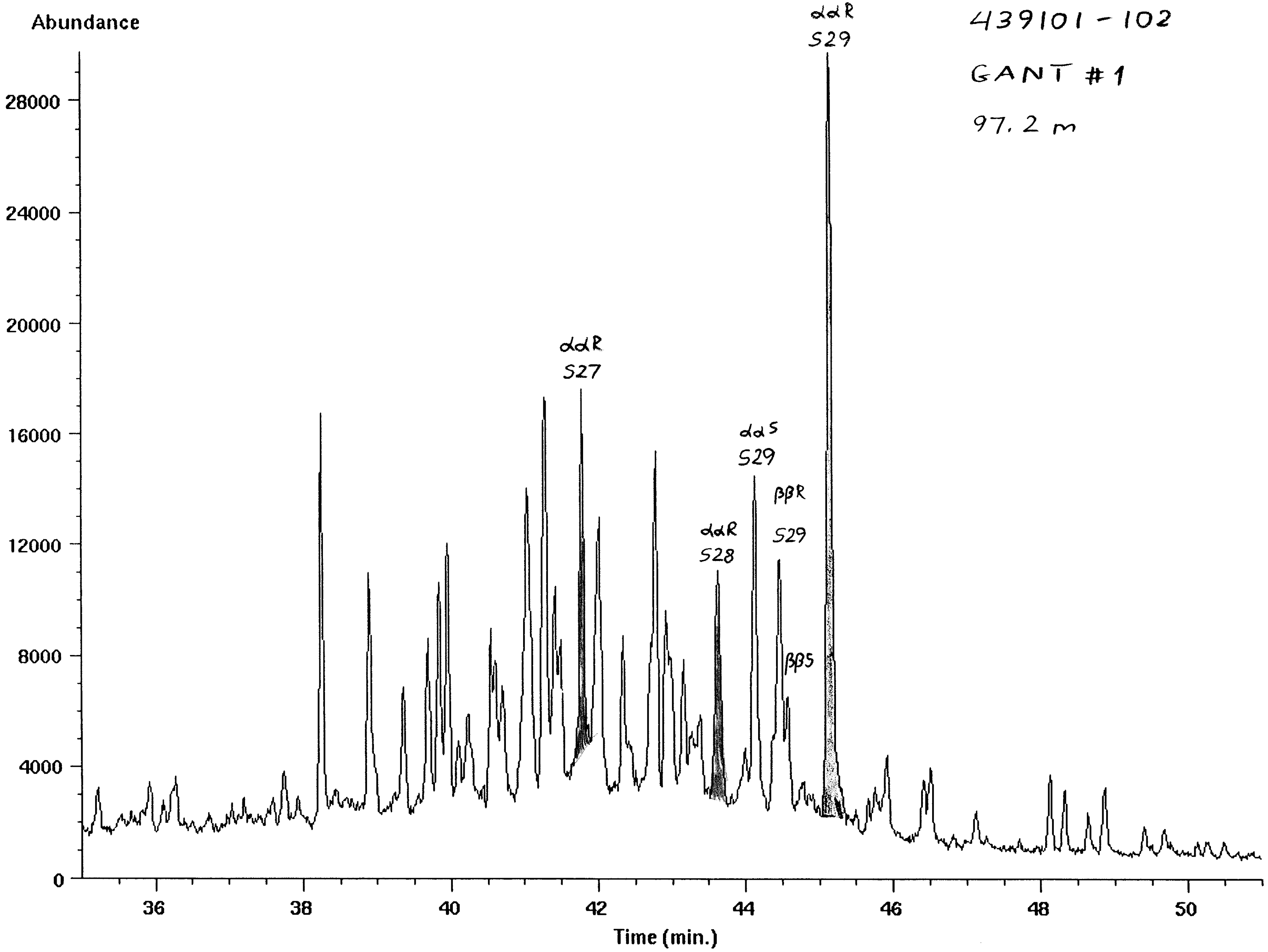


439101 - 102

GANT # 1

97.2 m

Ion 217.20 amu from 439101-102al.d

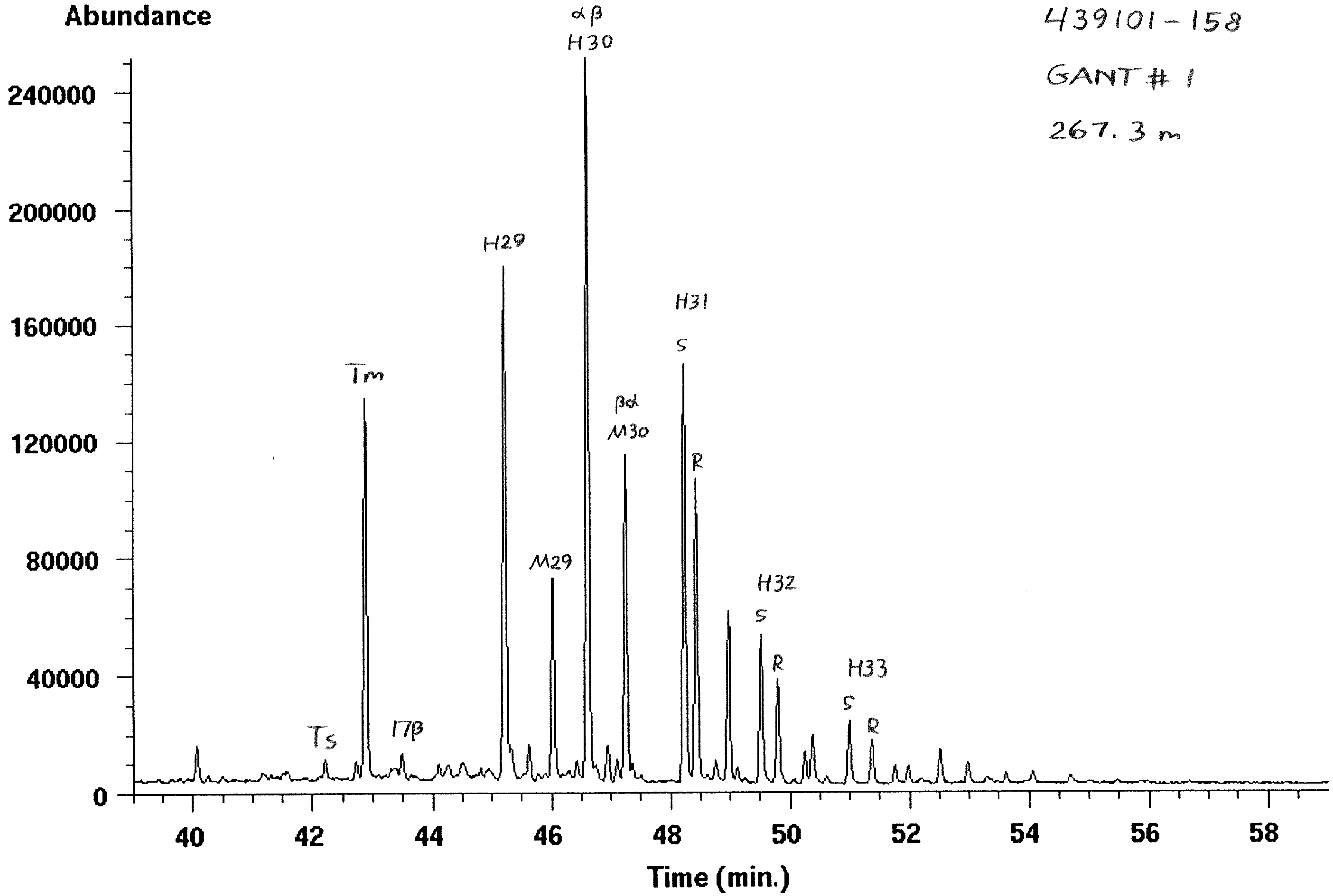


439101 - 102

GANT #1

97.2 m

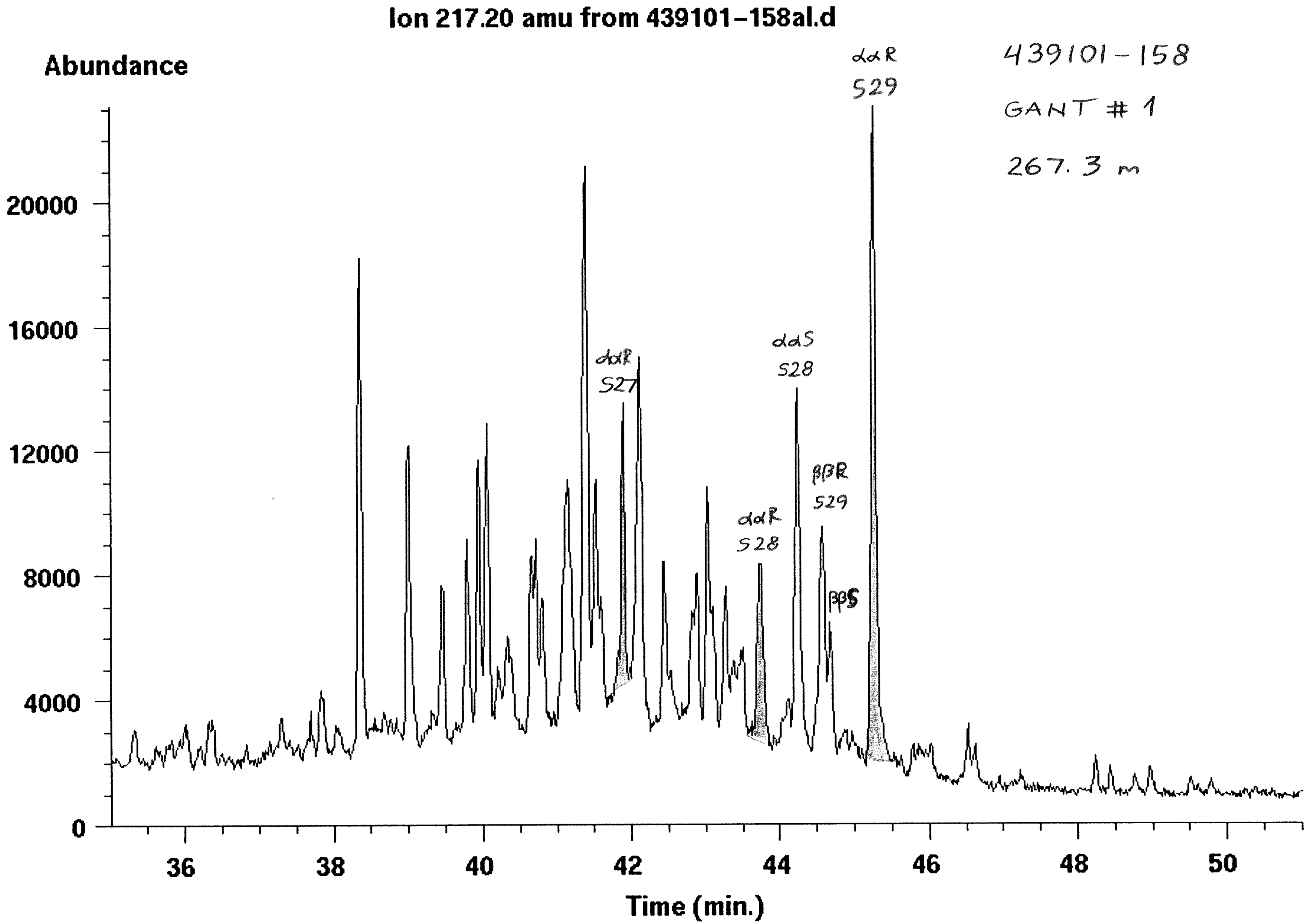
Ion 191.20 amu from 439101-158al.d



439101-158

GANT # 1

267.3 m



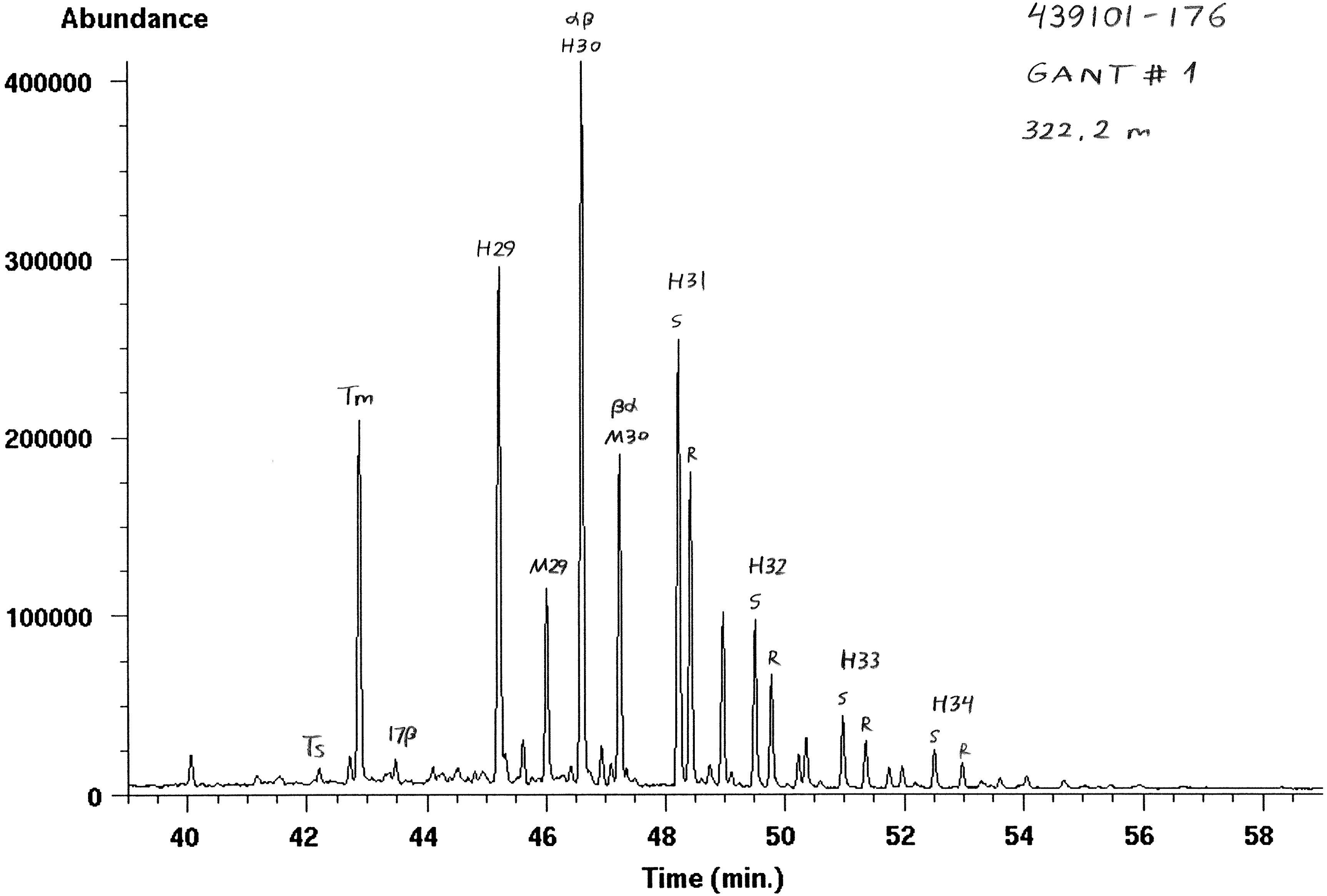
439101-158

GANT # 1

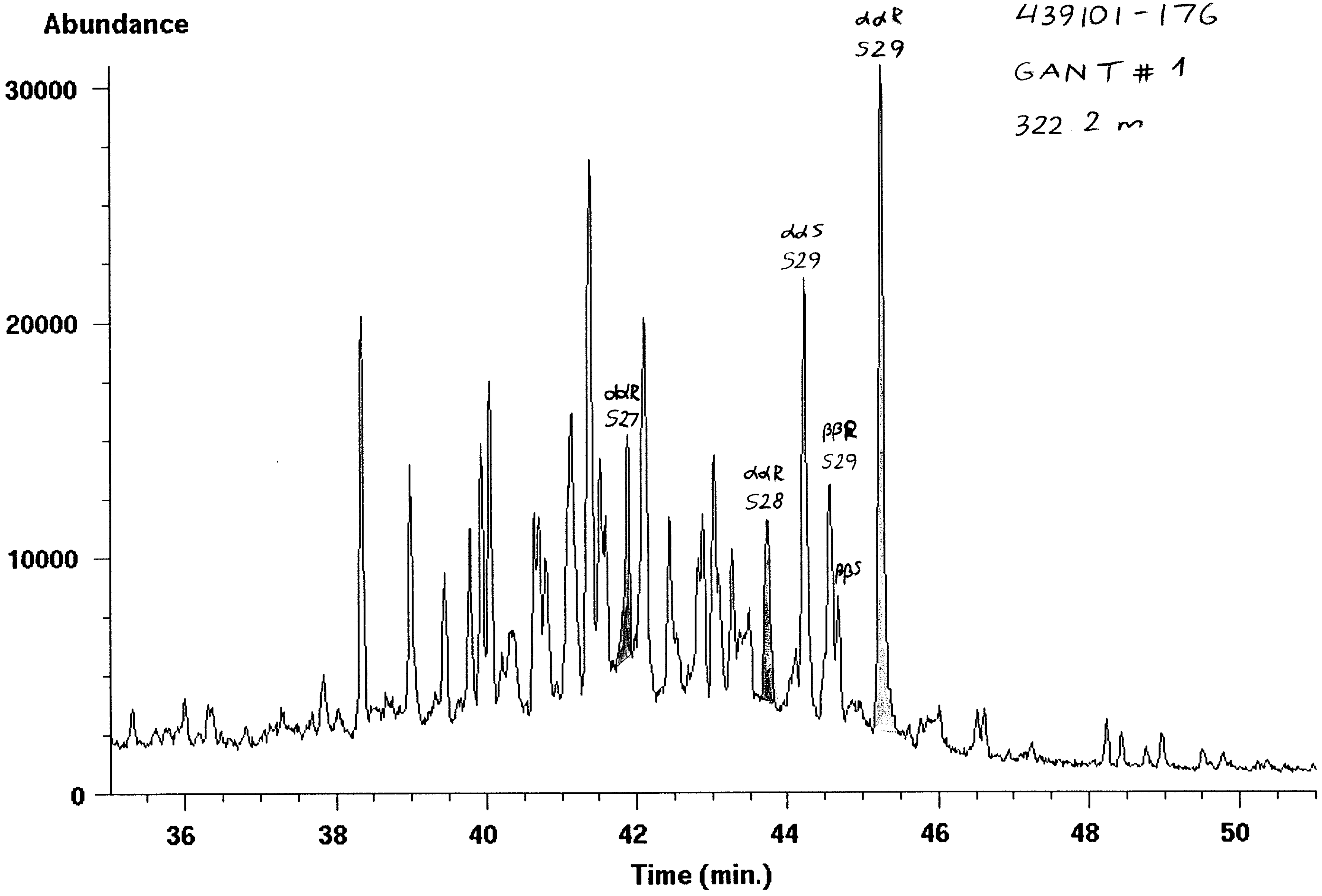
267.3 m

Ion 191.20 amu from 439101-176al.d

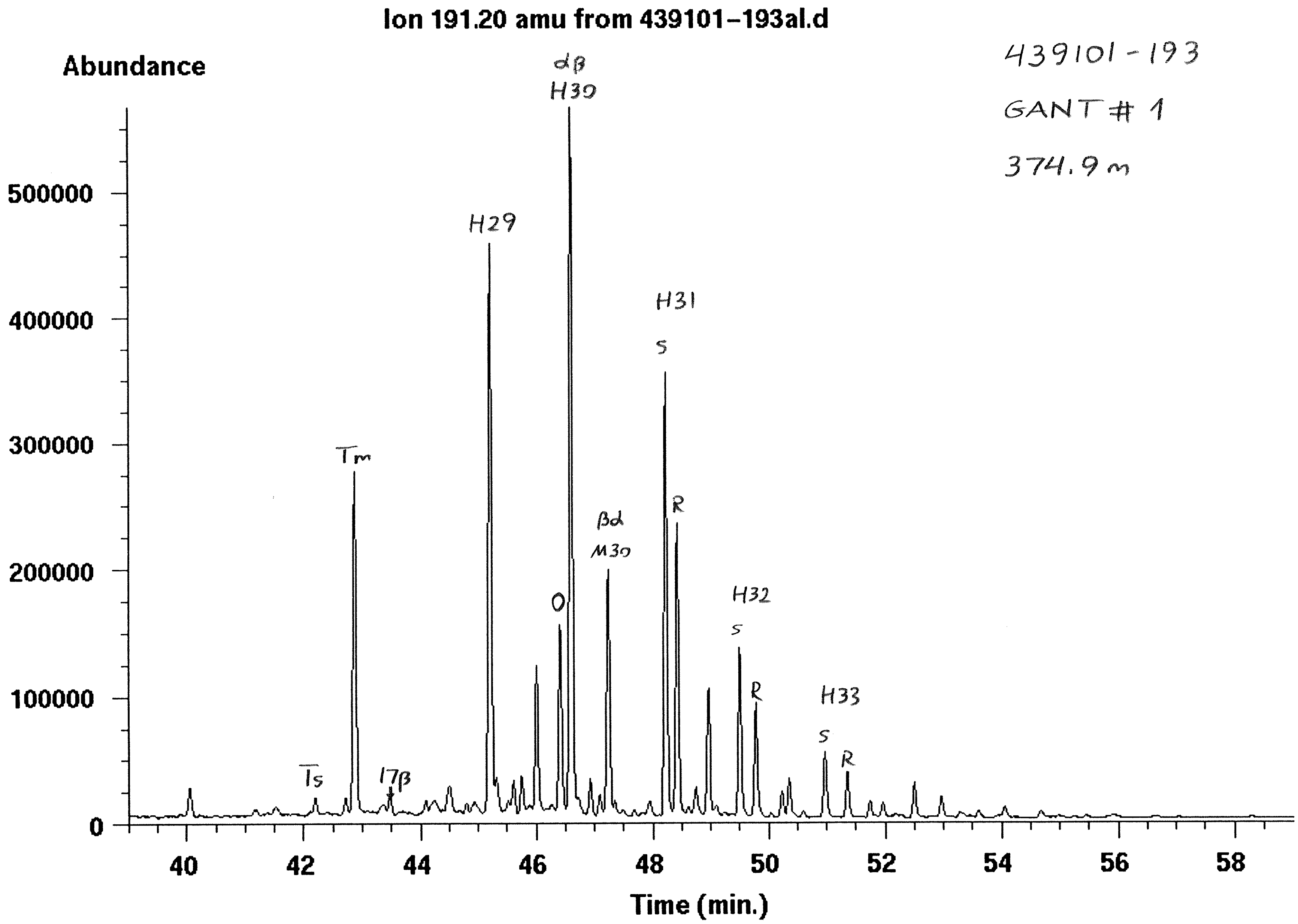
439101 - 176
GANT # 1
322,2 m



Ion 217.20 amu from 439101-176al.d



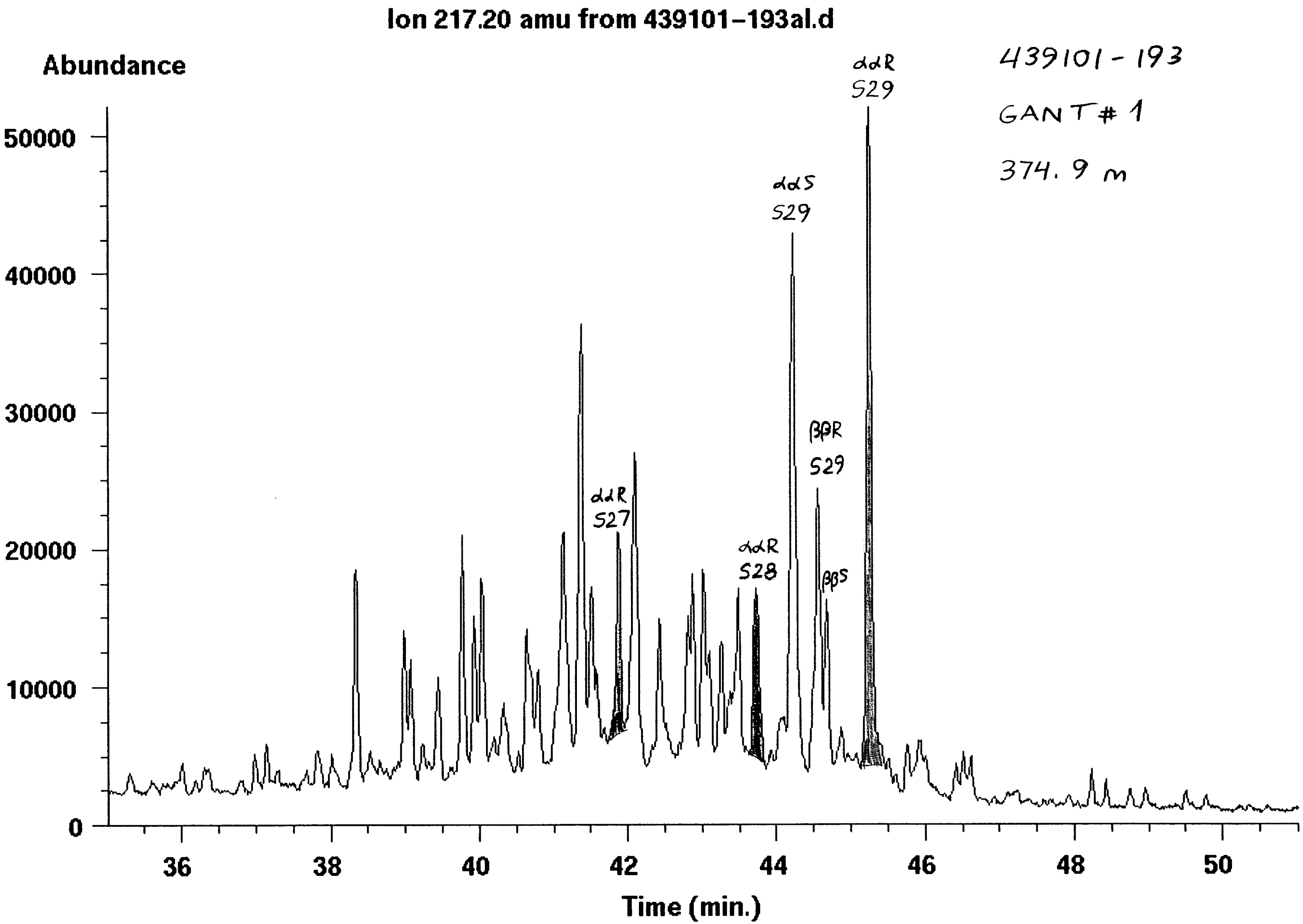
439101-176
GANT # 1
322.2 m



439101-193

GANT # 1

374.9 m



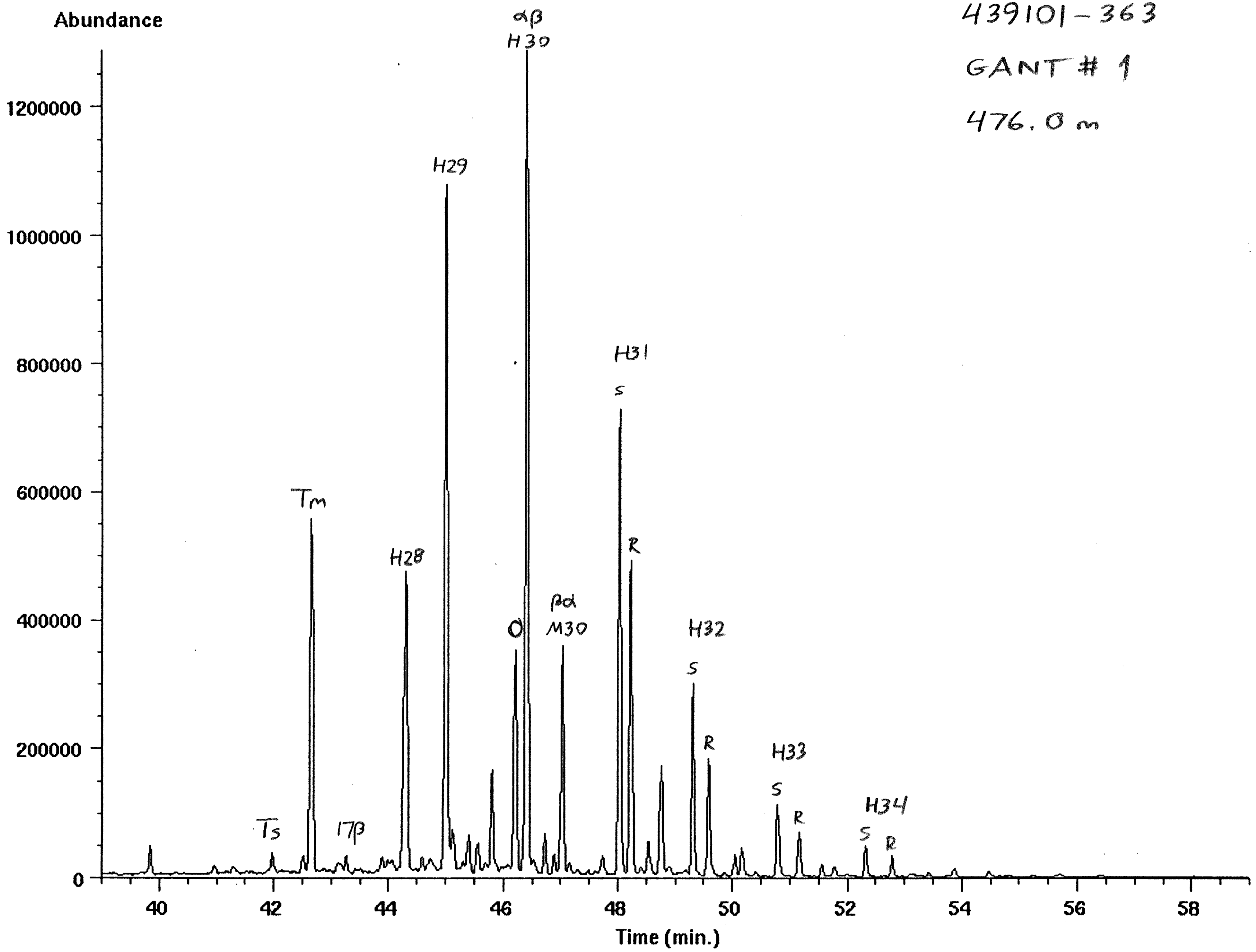
439101 - 193

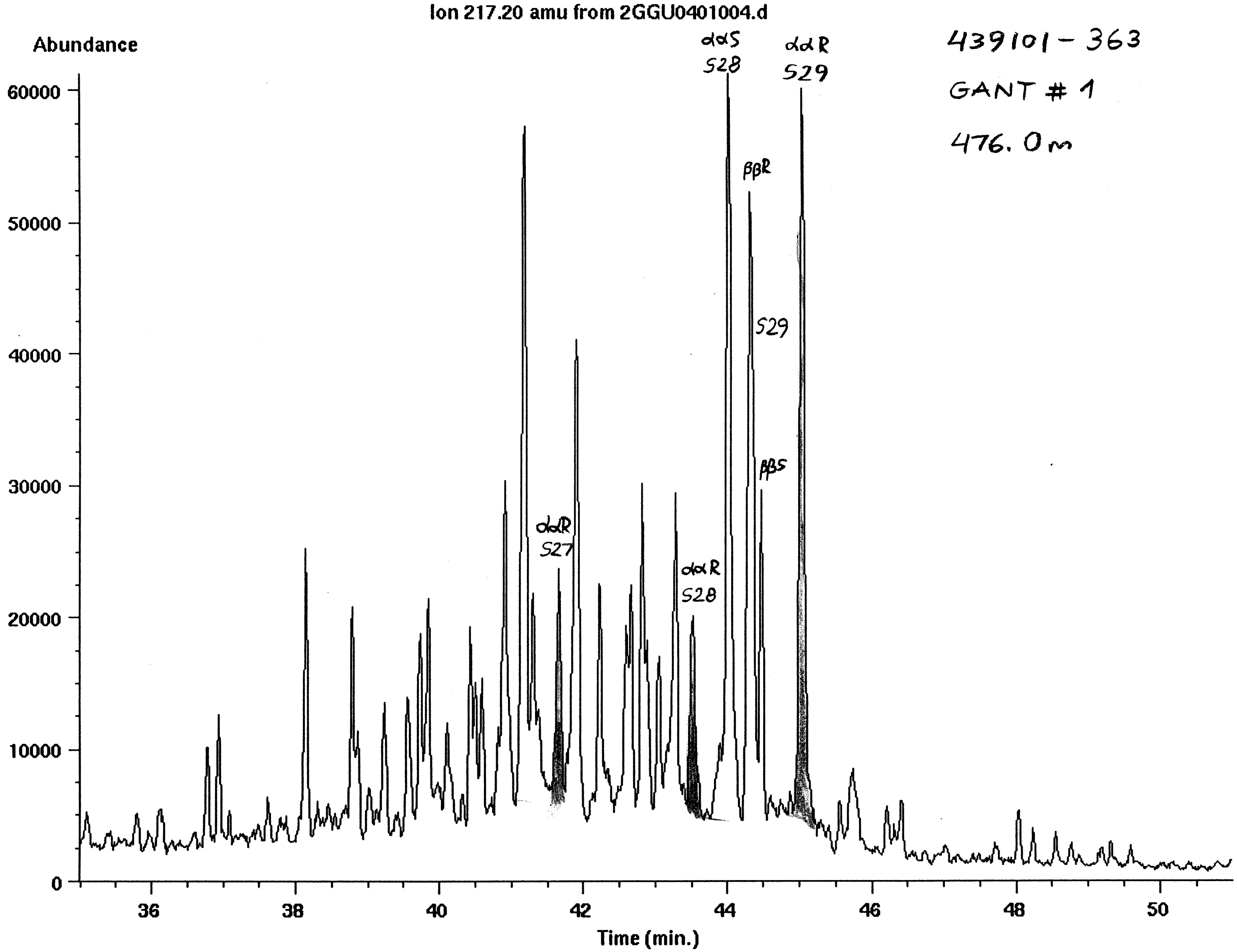
GANT # 1

374.9 m

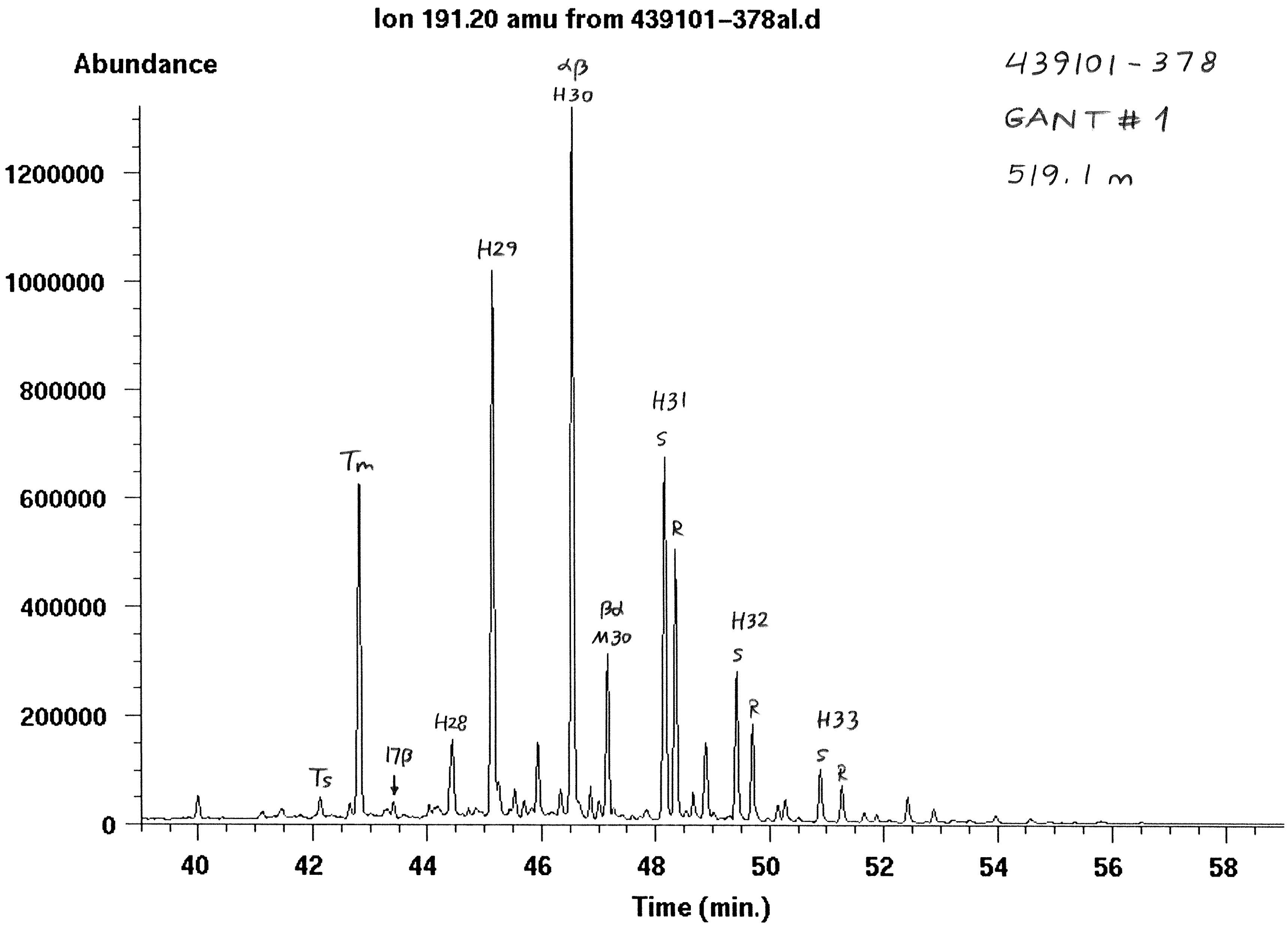
Ion 191.20 amu from 2GGU0401004.d

439101-363
GANT # 1
476.0 m



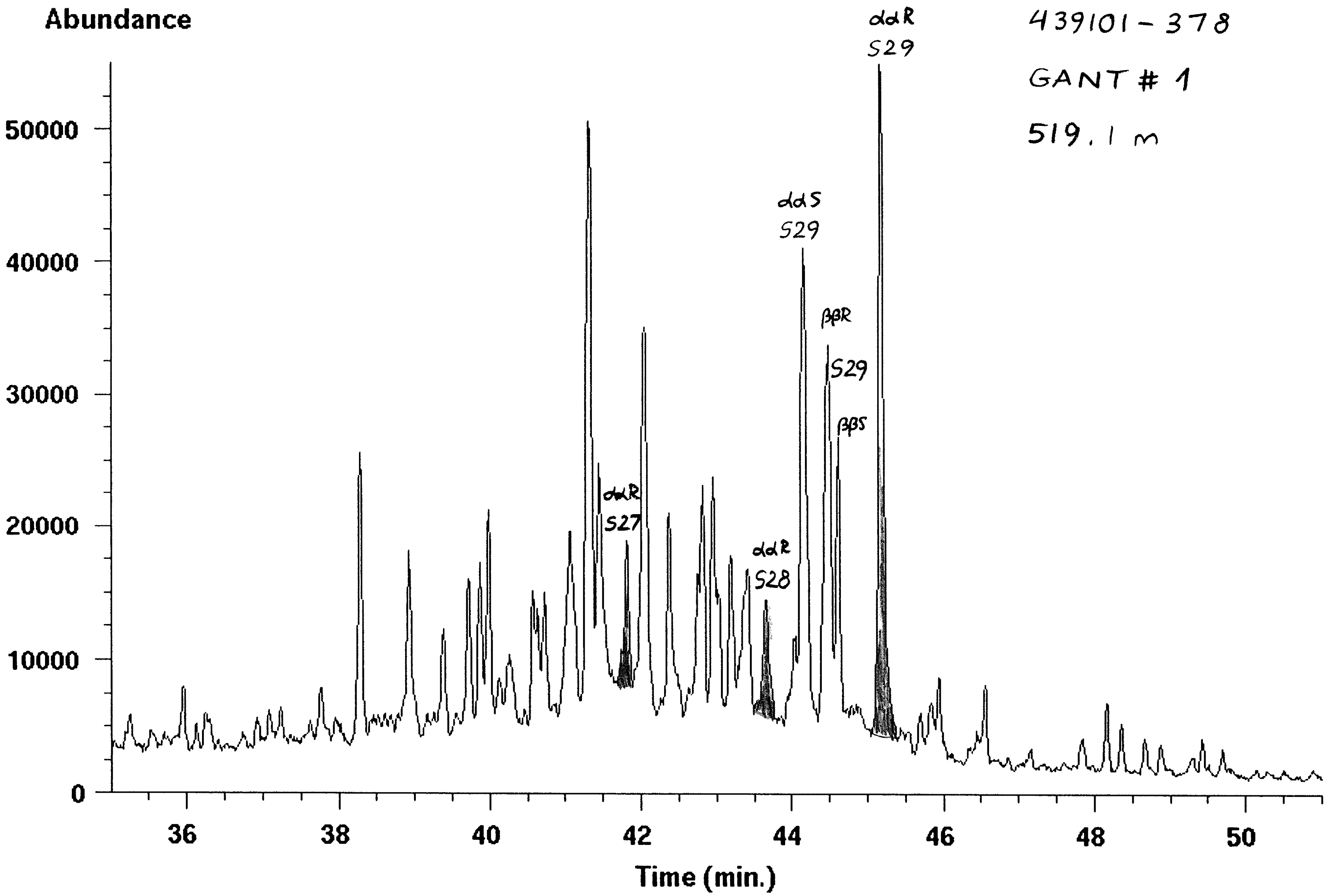


439101 - 363
GANT # 1
476.0m



439101 - 378
GANT # 1
519.1 m

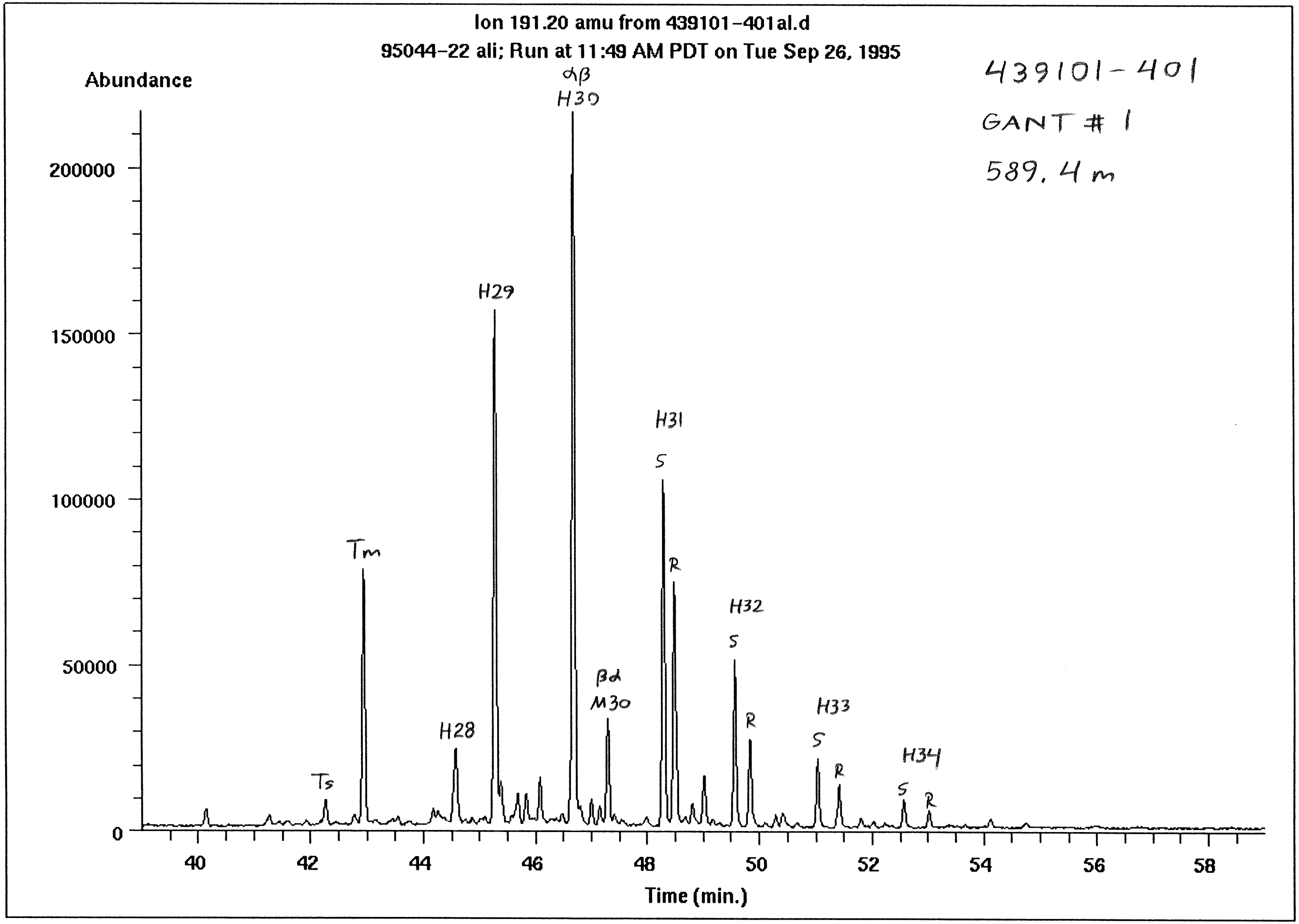
Ion 217.20 amu from 439101-378al.d



439101 - 378

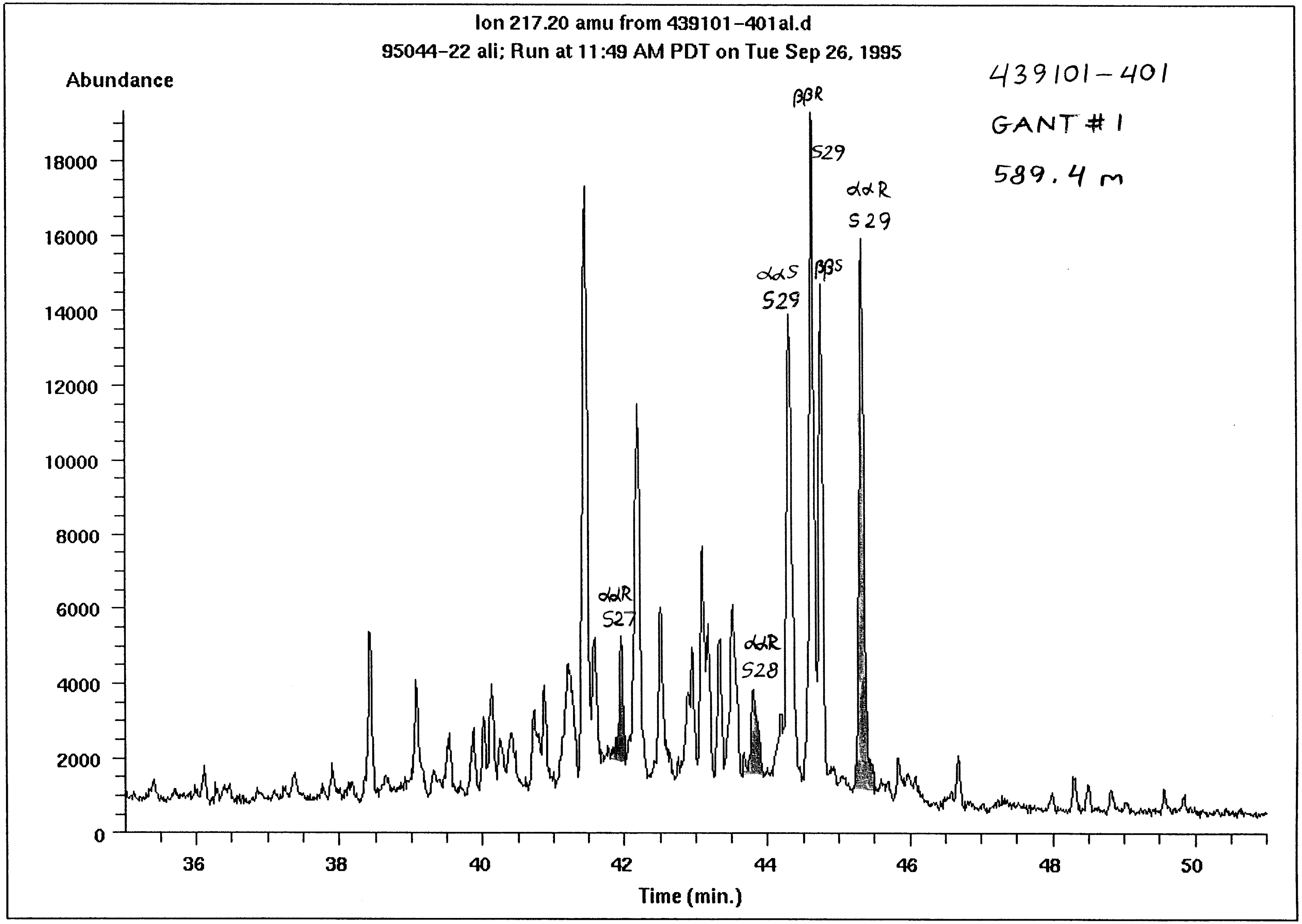
GANT # 1

519.1 m



Ion 191.20 amu from 439101-401al.d
95044-22 ali; Run at 11:49 AM PDT on Tue Sep 26, 1995

439101-401
GANT # 1
589.4 m



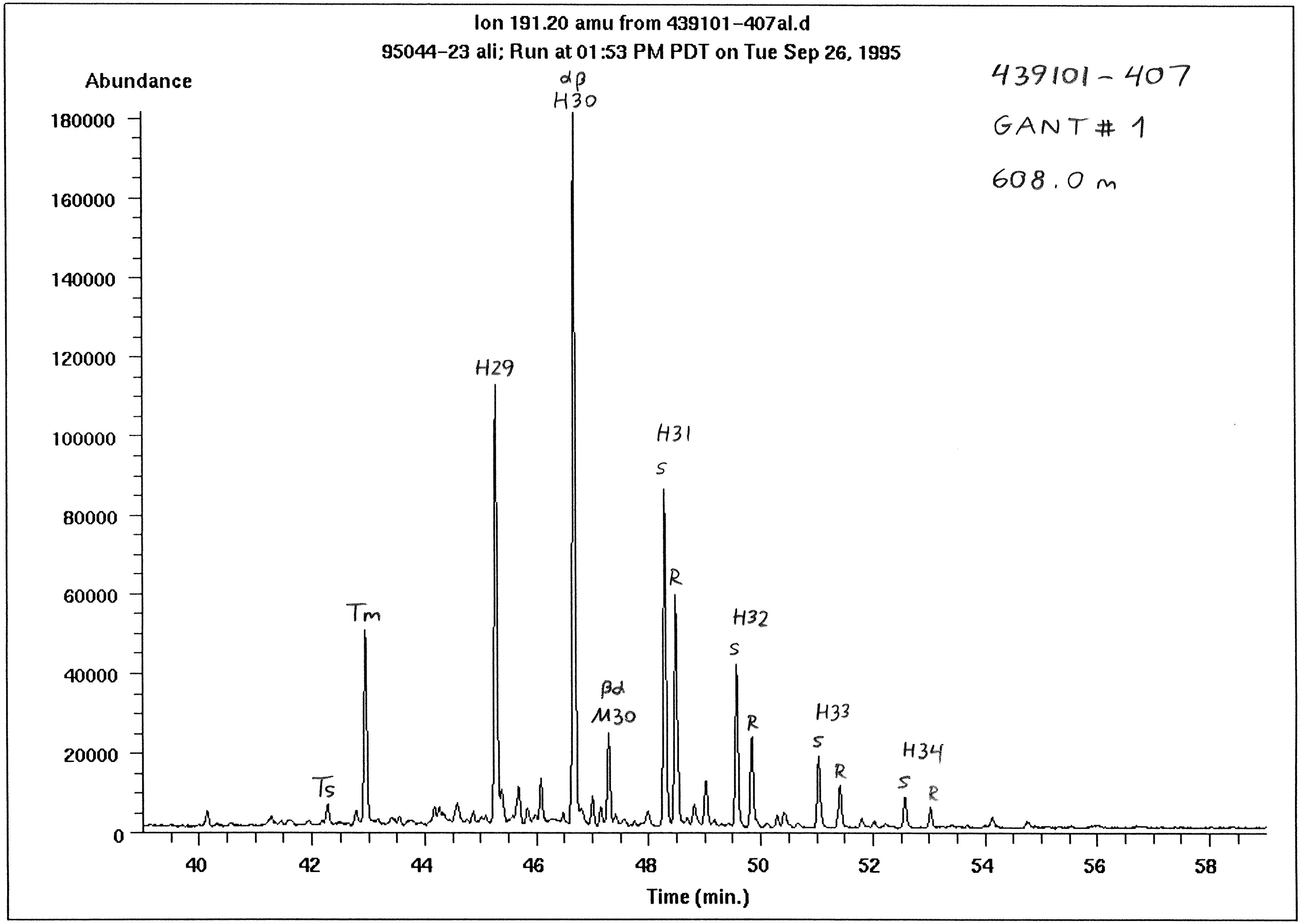
Ion 217.20 amu from 439101-401al.d

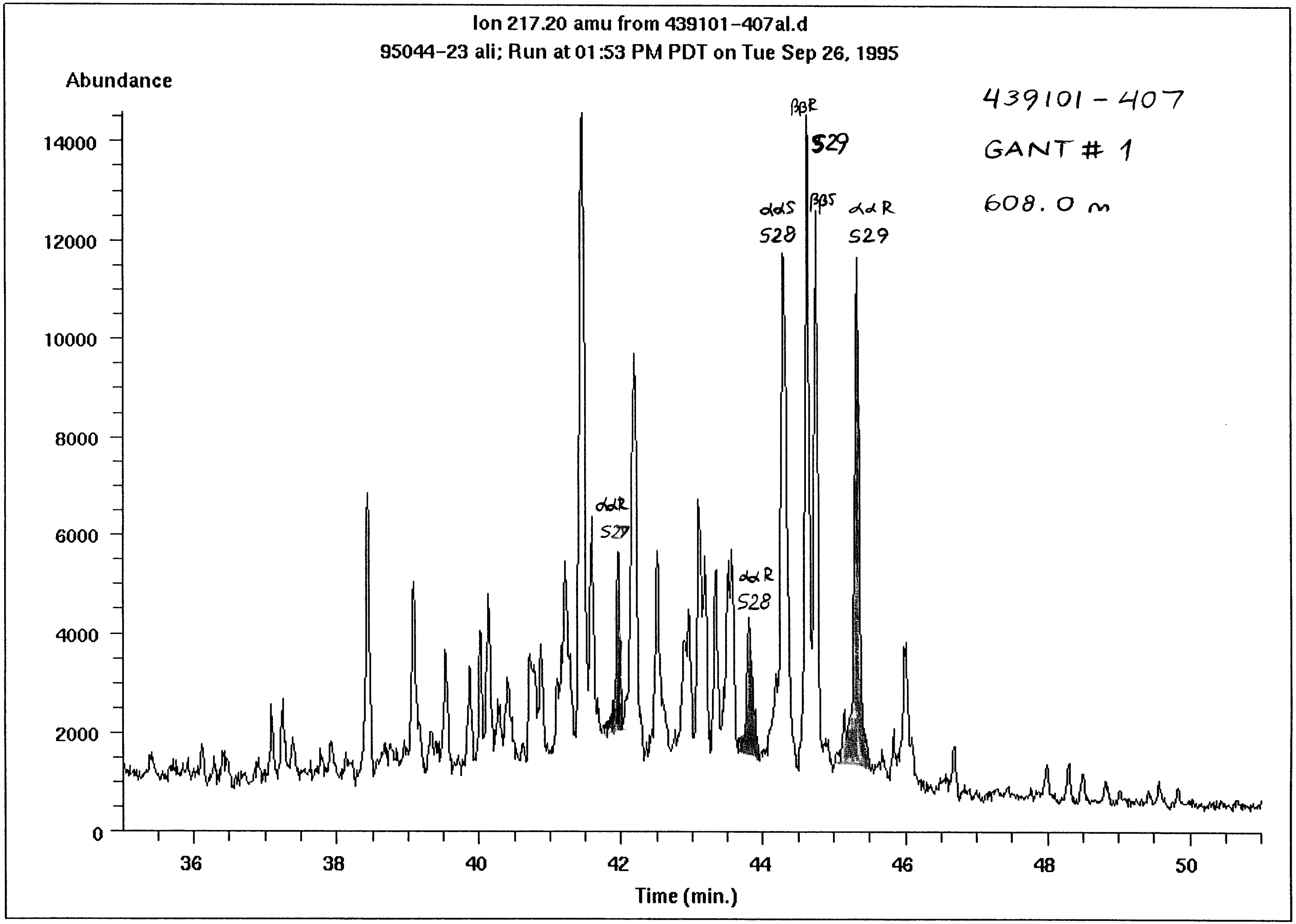
95044-22 ali; Run at 11:49 AM PDT on Tue Sep 26, 1995

439101-401

GANT #1

589.4 m


Ion 191.20 amu from 439101-407al.d
95044-23 ali; Run at 01:53 PM PDT on Tue Sep 26, 1995
439101-407
GANT # 1
608.0 m
Abundance
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Time (min.)
40
42
44
46
48
50
52
54
56
58
Ts
Tm
H29
αβ
H30
βα
M30
H31
S
R
H32
S
R
H33
S
R
H34
S
R



Ion 217.20 amu from 439101-407al.d
95044-23 ali; Run at 01:53 PM PDT on Tue Sep 26, 1995

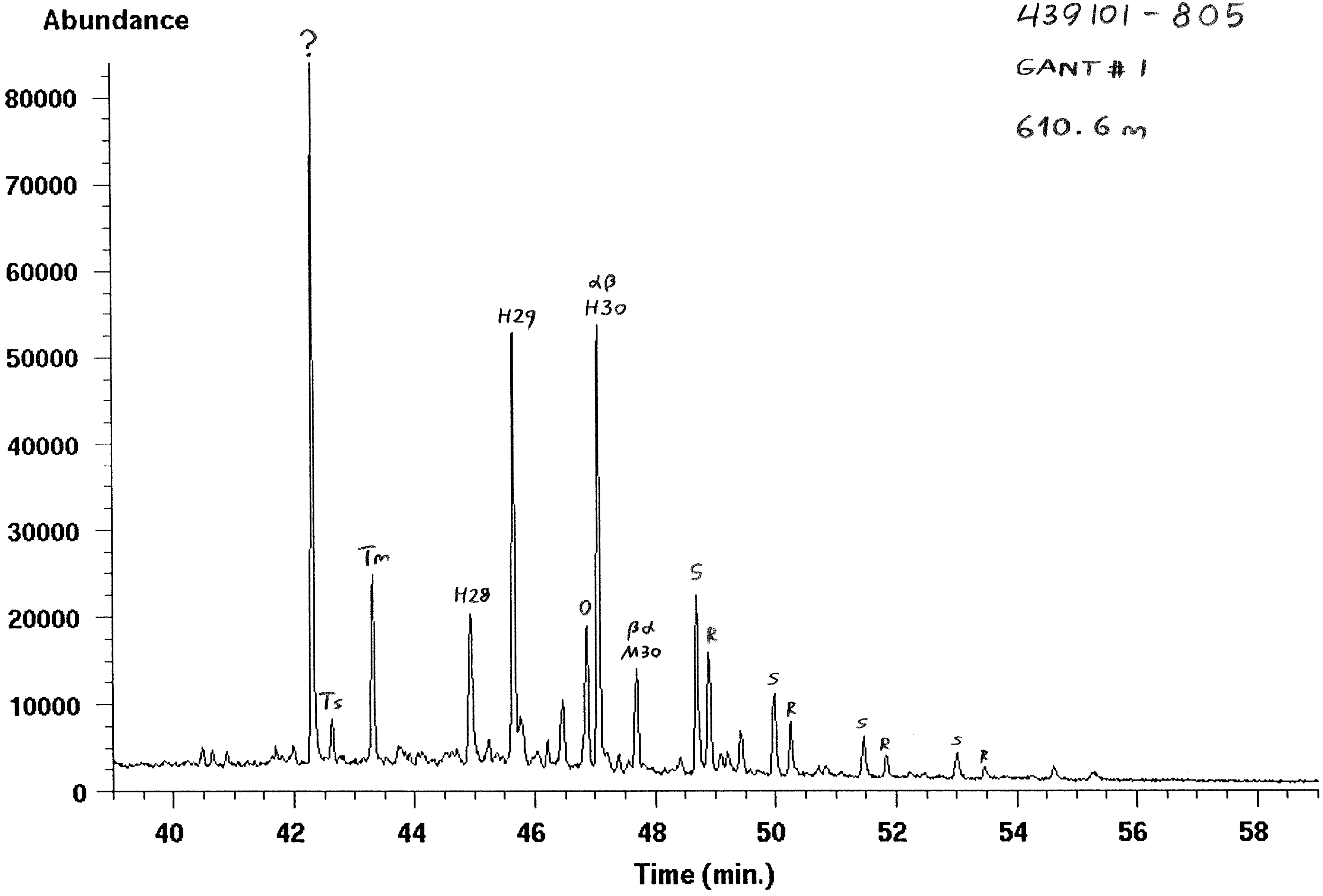
439101-407
GANT # 1
608.0 m

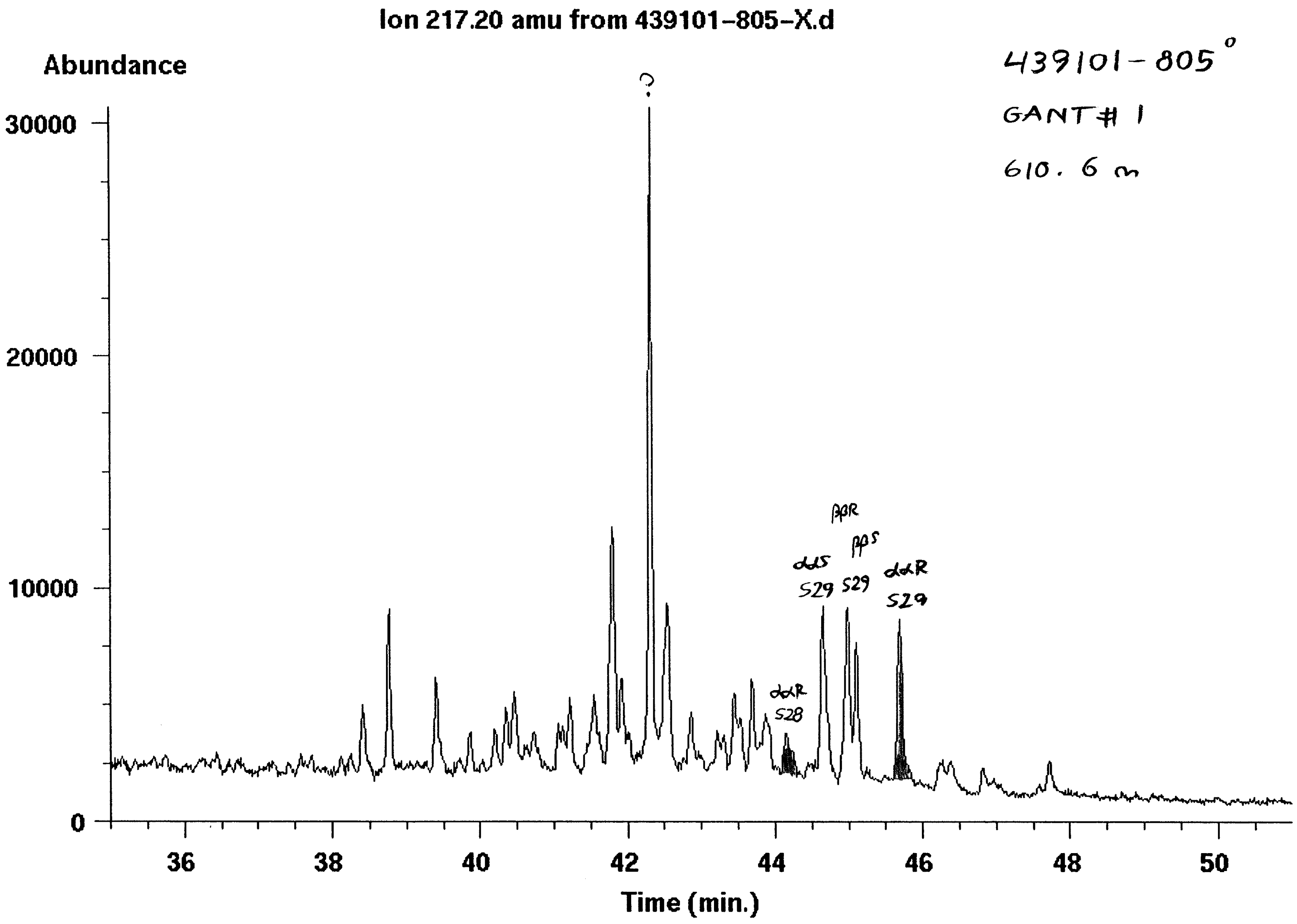
Ion 191.20 amu from 439101-805-X.d

439101 - 805°

GANT # 1

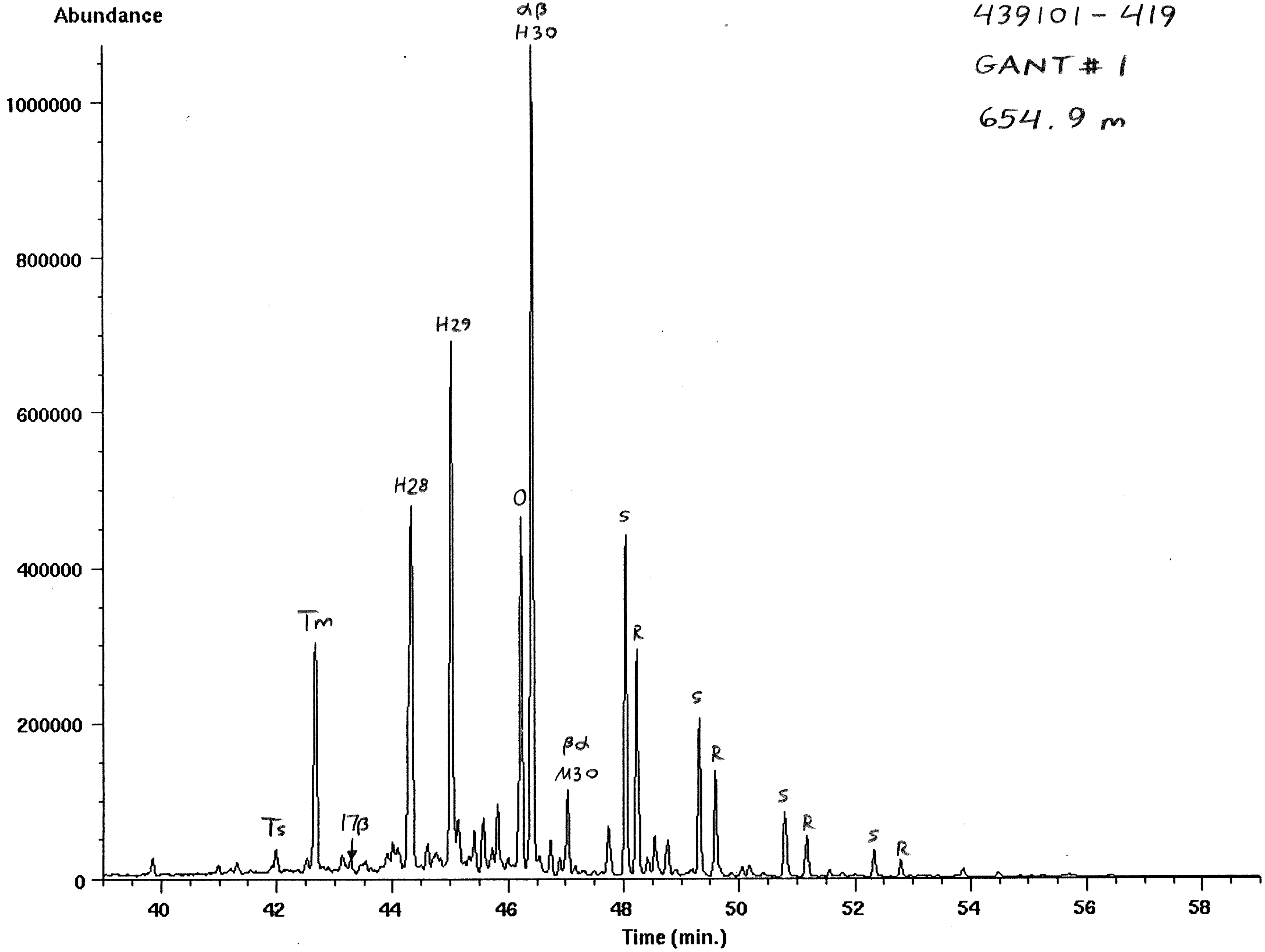
610.6 m





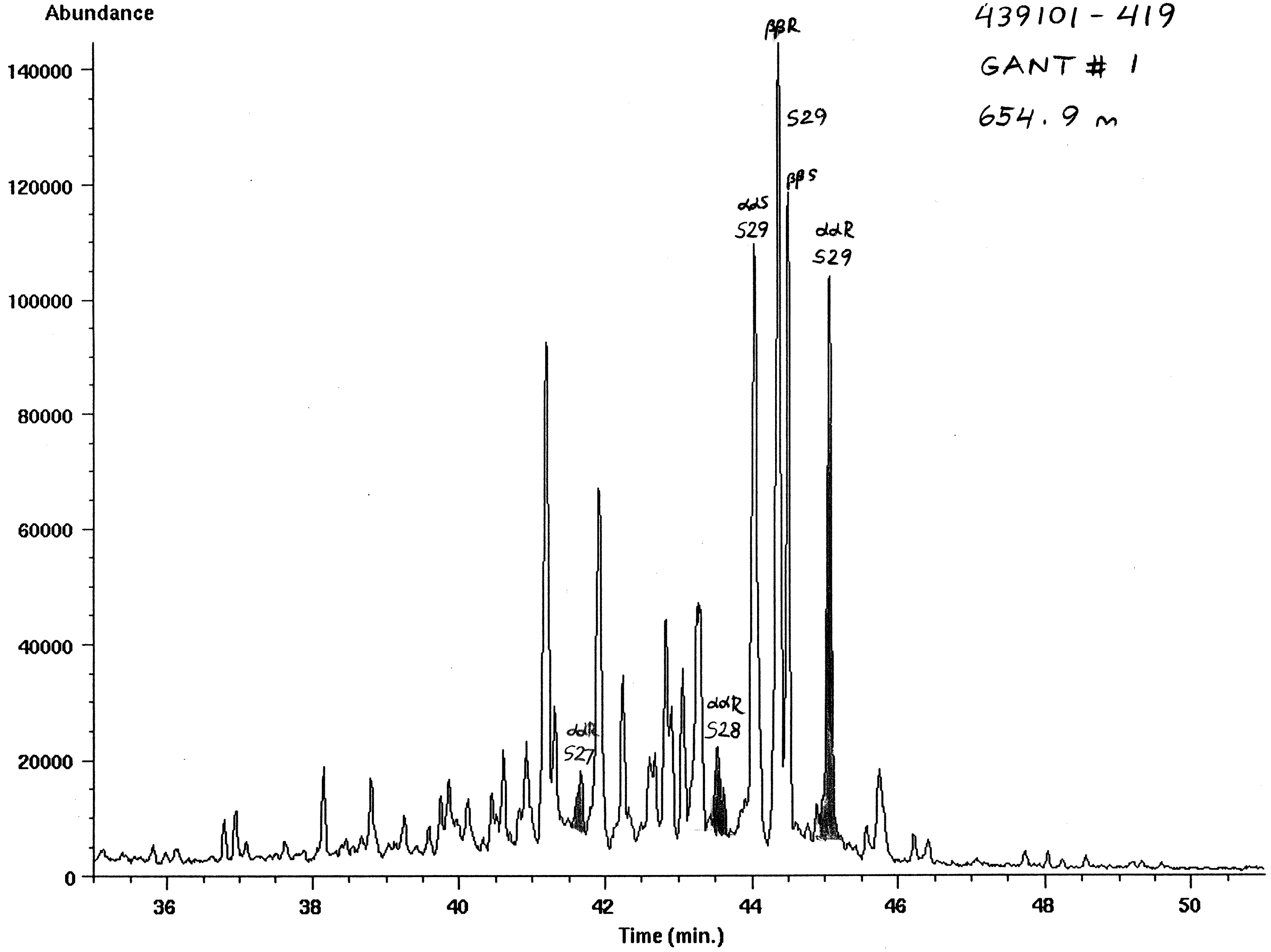
439101-805°
GANT#1
610.6 m

Ion 191.20 amu from 2GGU0501005.d



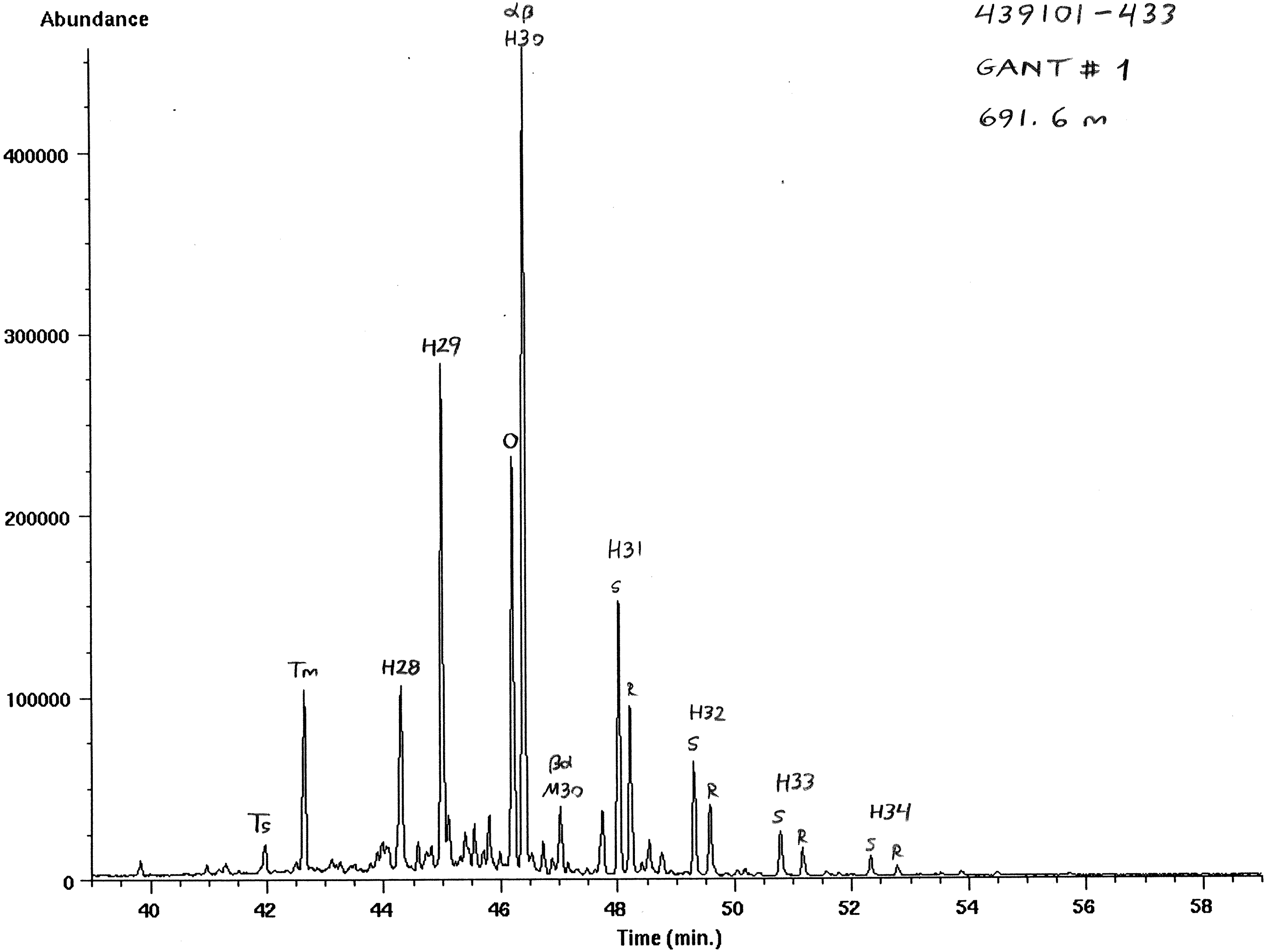
439101 - 419
GANT # 1
654.9 m

Ion 217.20 amu from 2GGU0501005.d



439101 - 419
GANT # 1
654.9 m

Ion 191.20 amu from 2GGU0601006.d



439101-433

GANT # 1

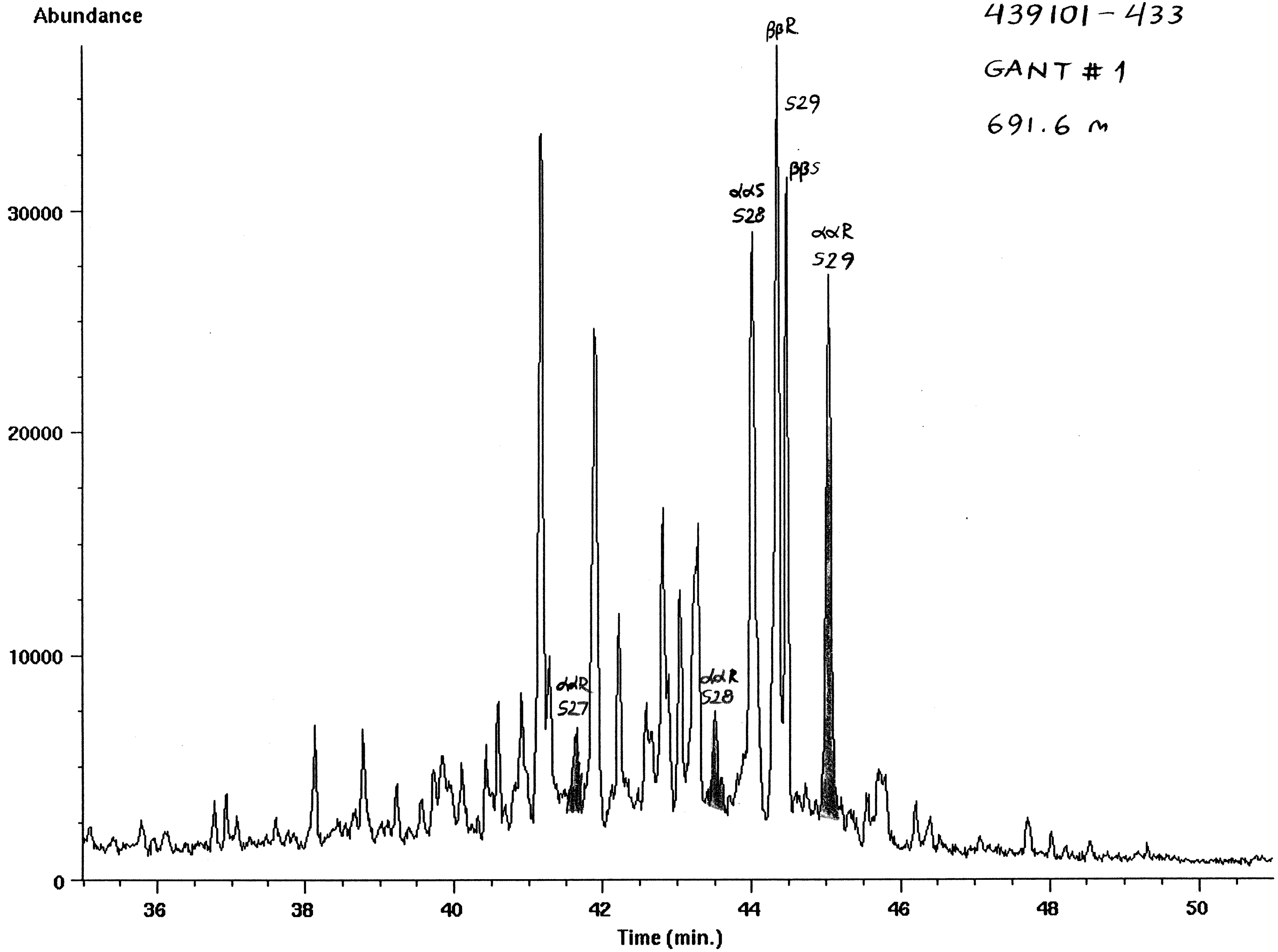
691.6 m

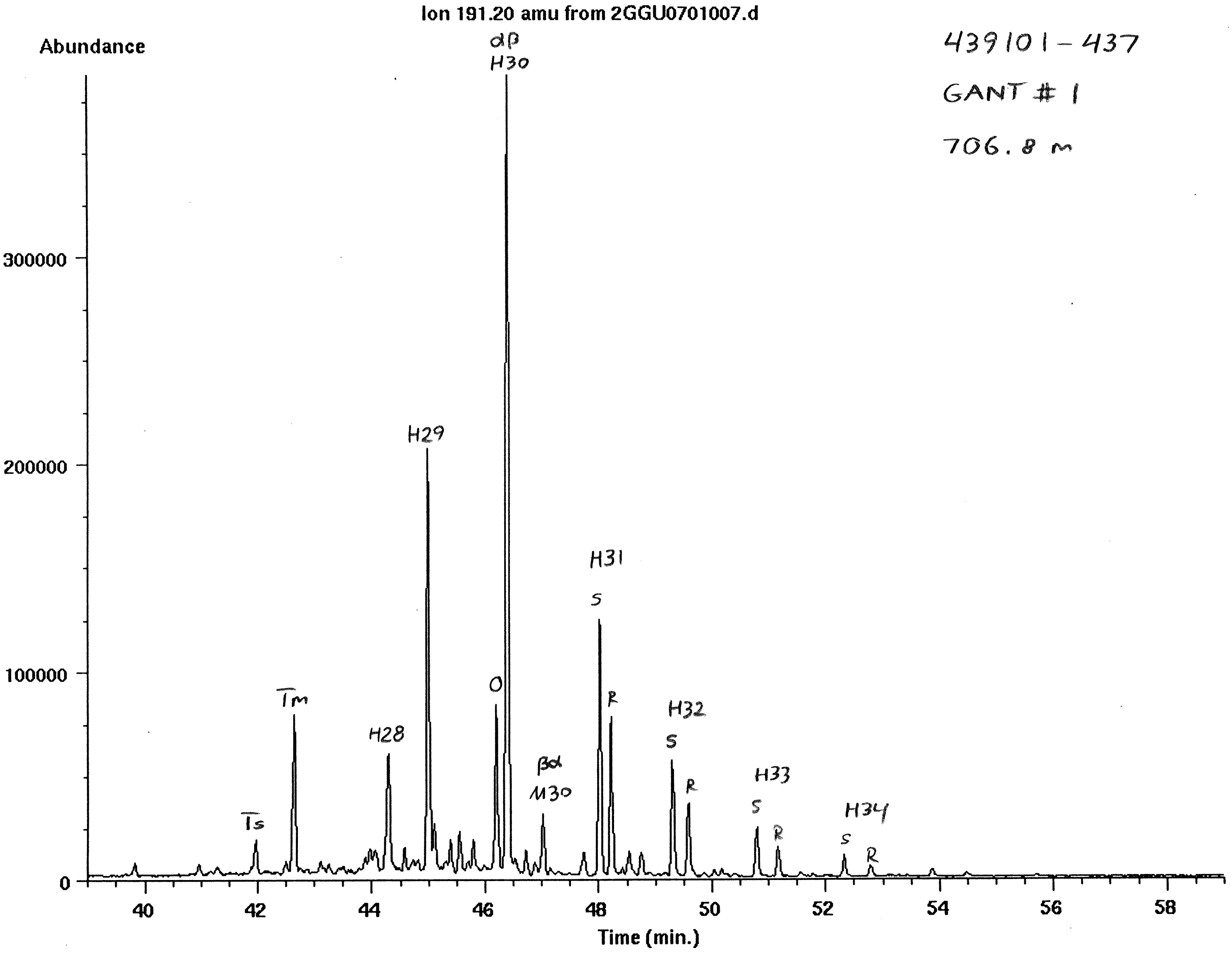
Ion 217.20 amu from 2GGU0601006.d

439101 - 433

GANT # 1

691.6 m

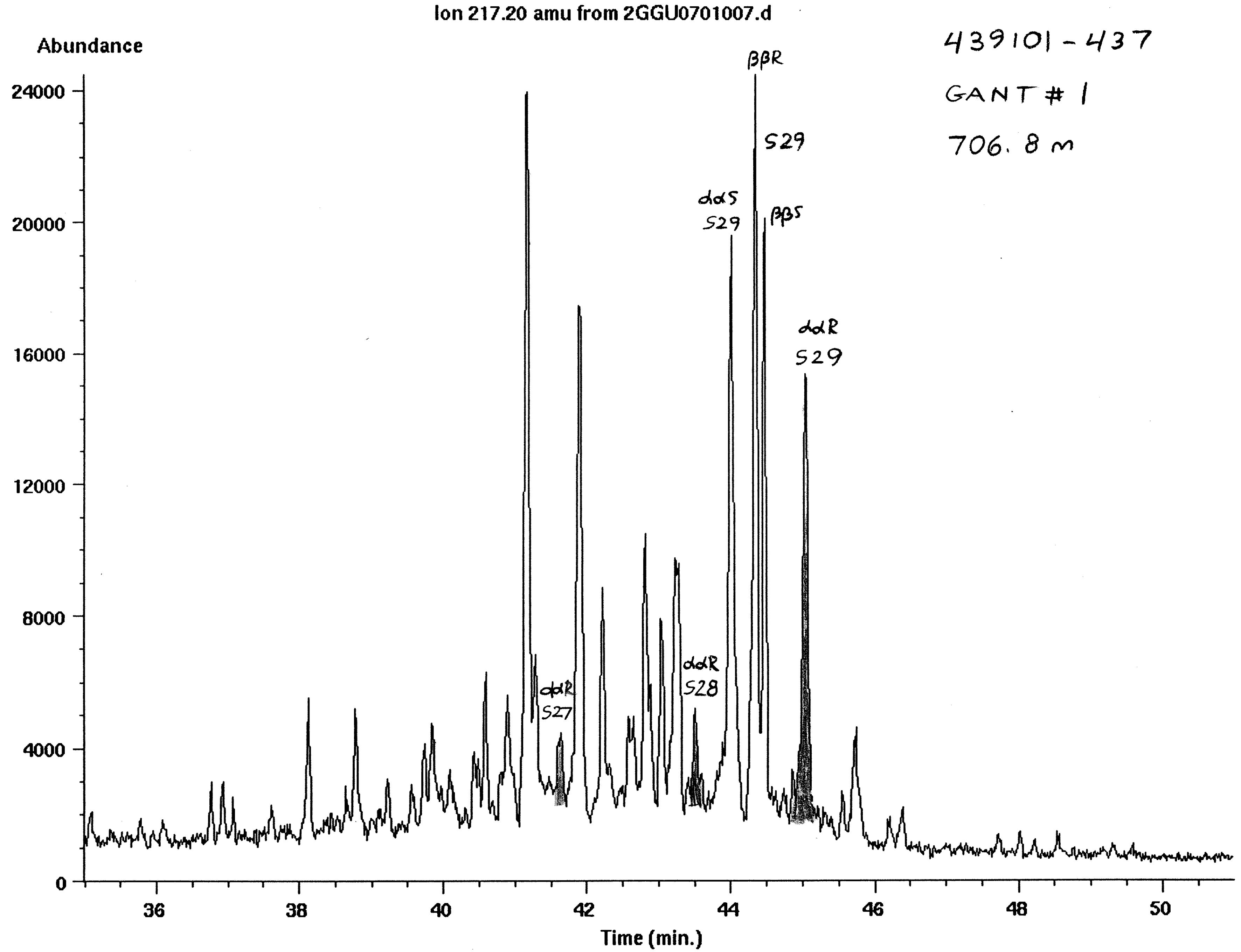




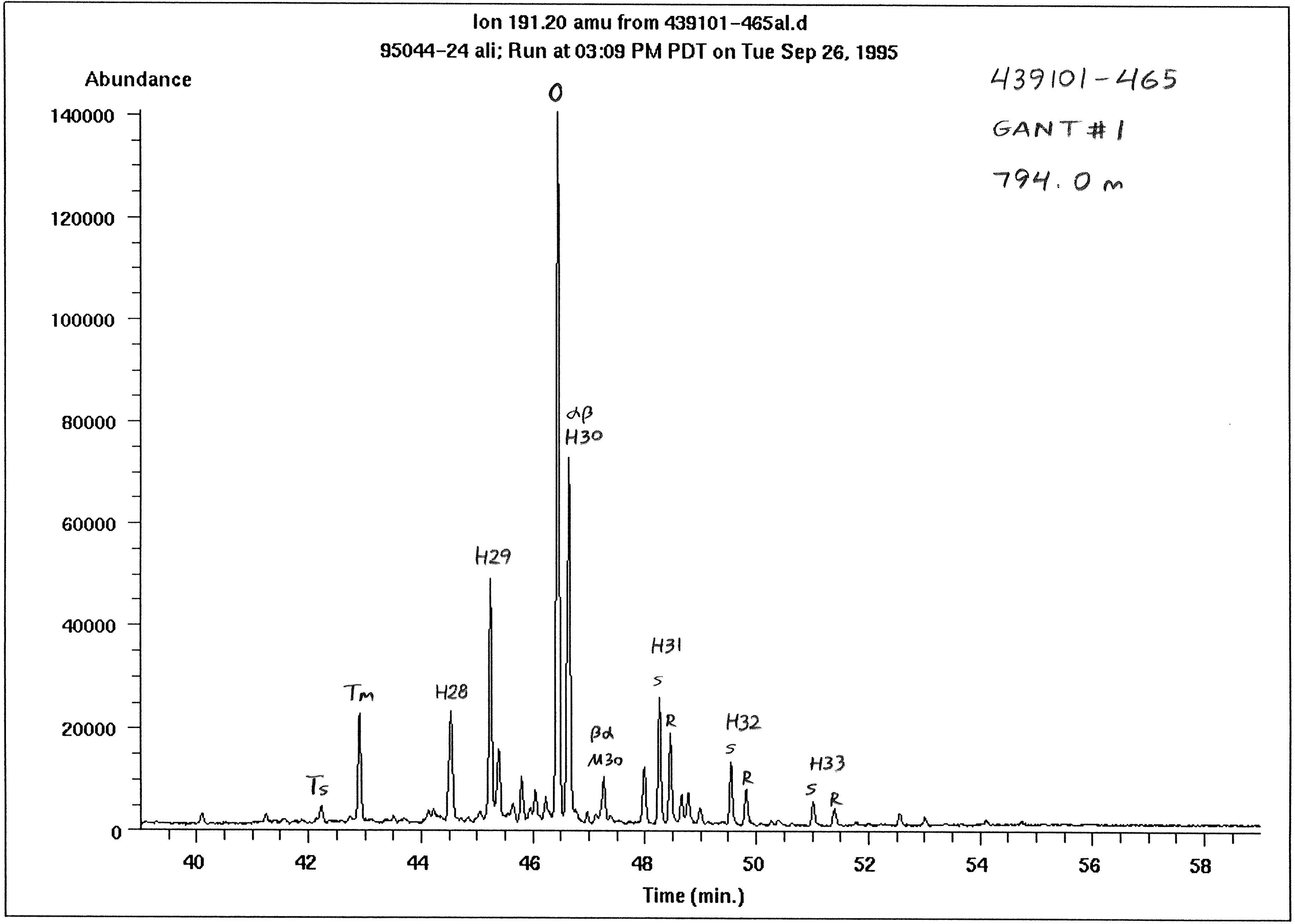
439101-437

GANT # 1

706.8 m



439101-437
GANT # 1
706.8 m



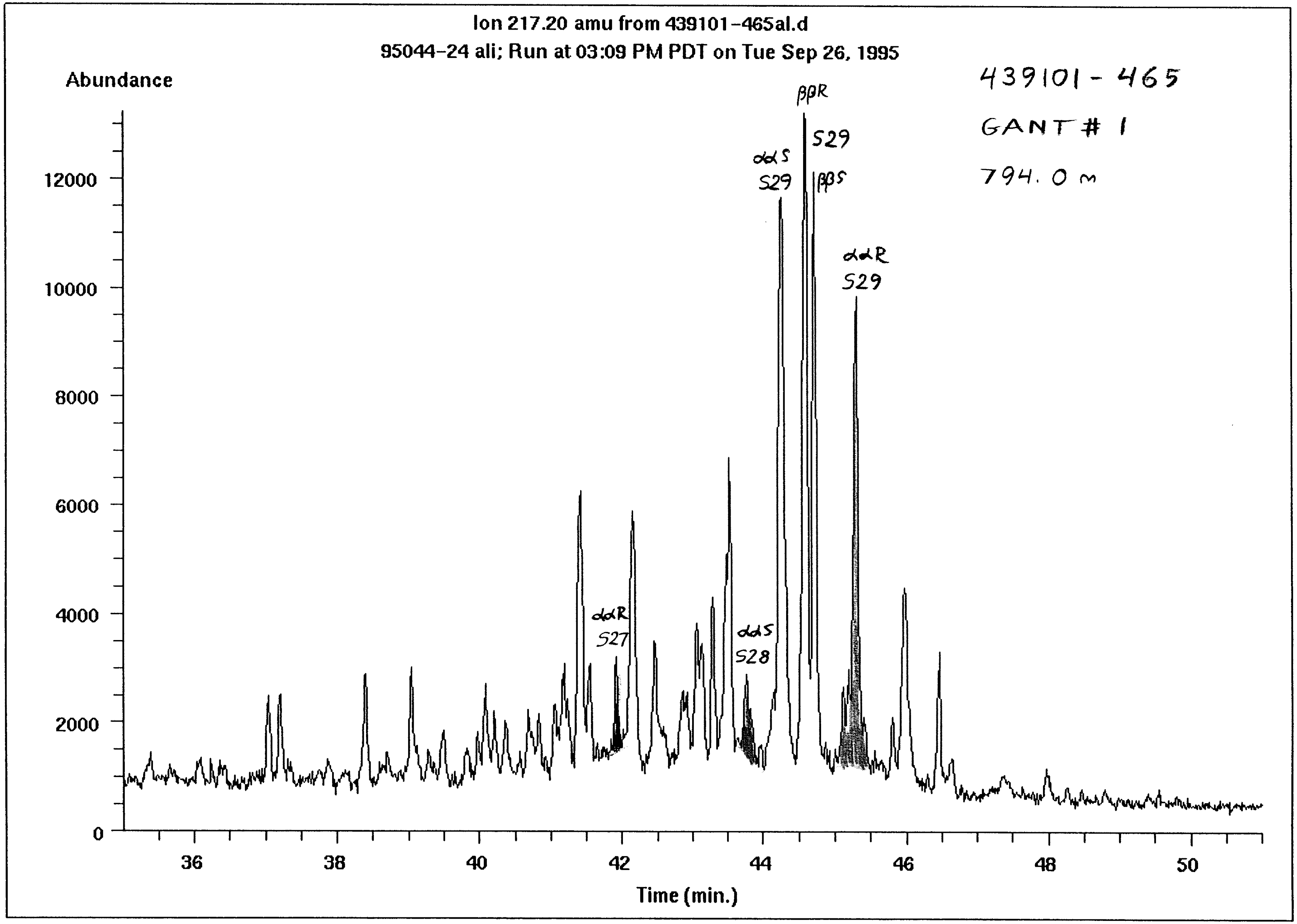
Ion 191.20 amu from 439101-465al.d

95044-24 ali; Run at 03:09 PM PDT on Tue Sep 26, 1995

439101-465

GANT#1

794.0 m



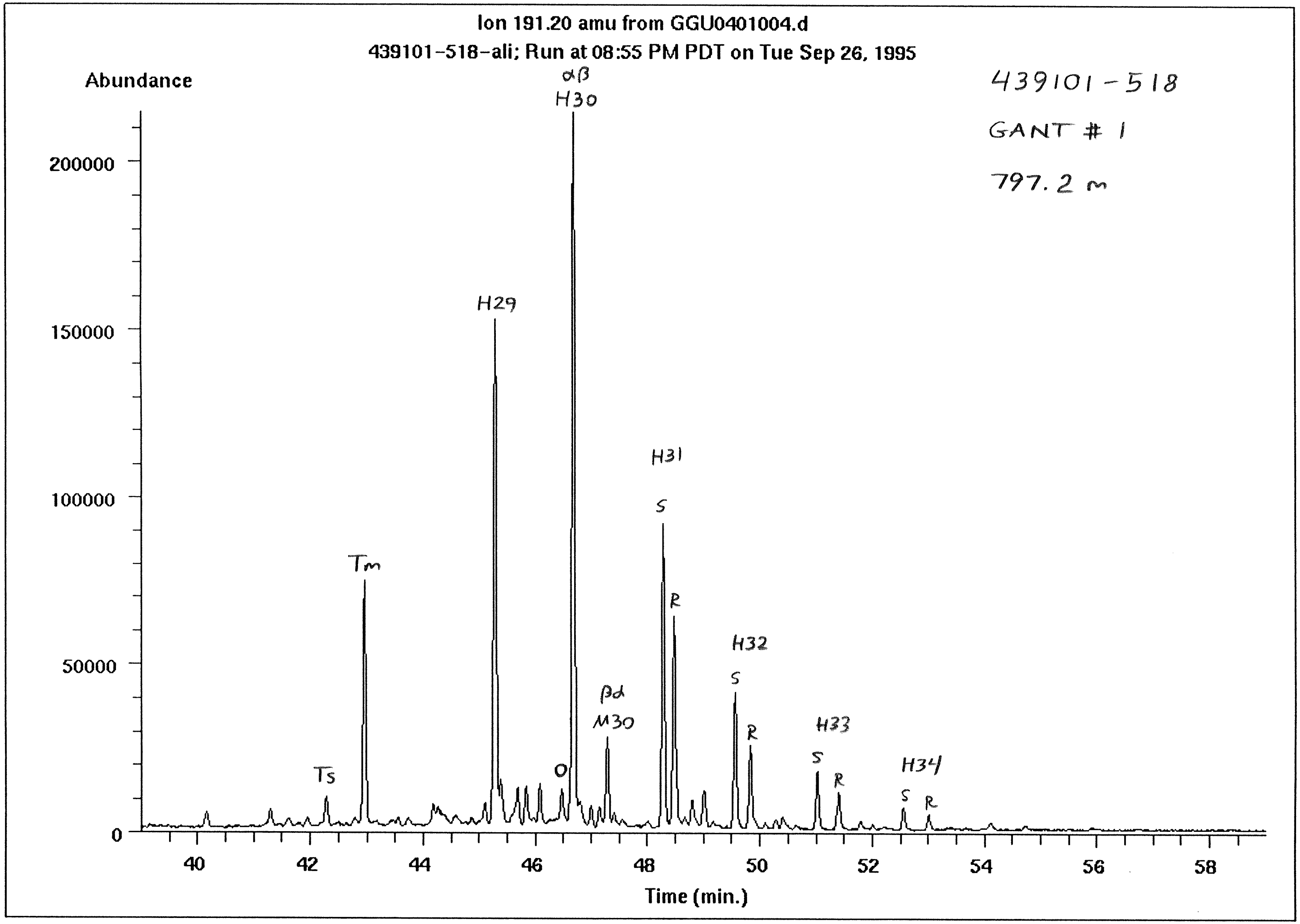
Ion 217.20 amu from 439101-465al.d

95044-24 ali; Run at 03:09 PM PDT on Tue Sep 26, 1995

439101 - 465

GANT # 1

794.0 m



Ion 191.20 amu from GGU0401004.d

439101-518-ali; Run at 08:55 PM PDT on Tue Sep 26, 1995

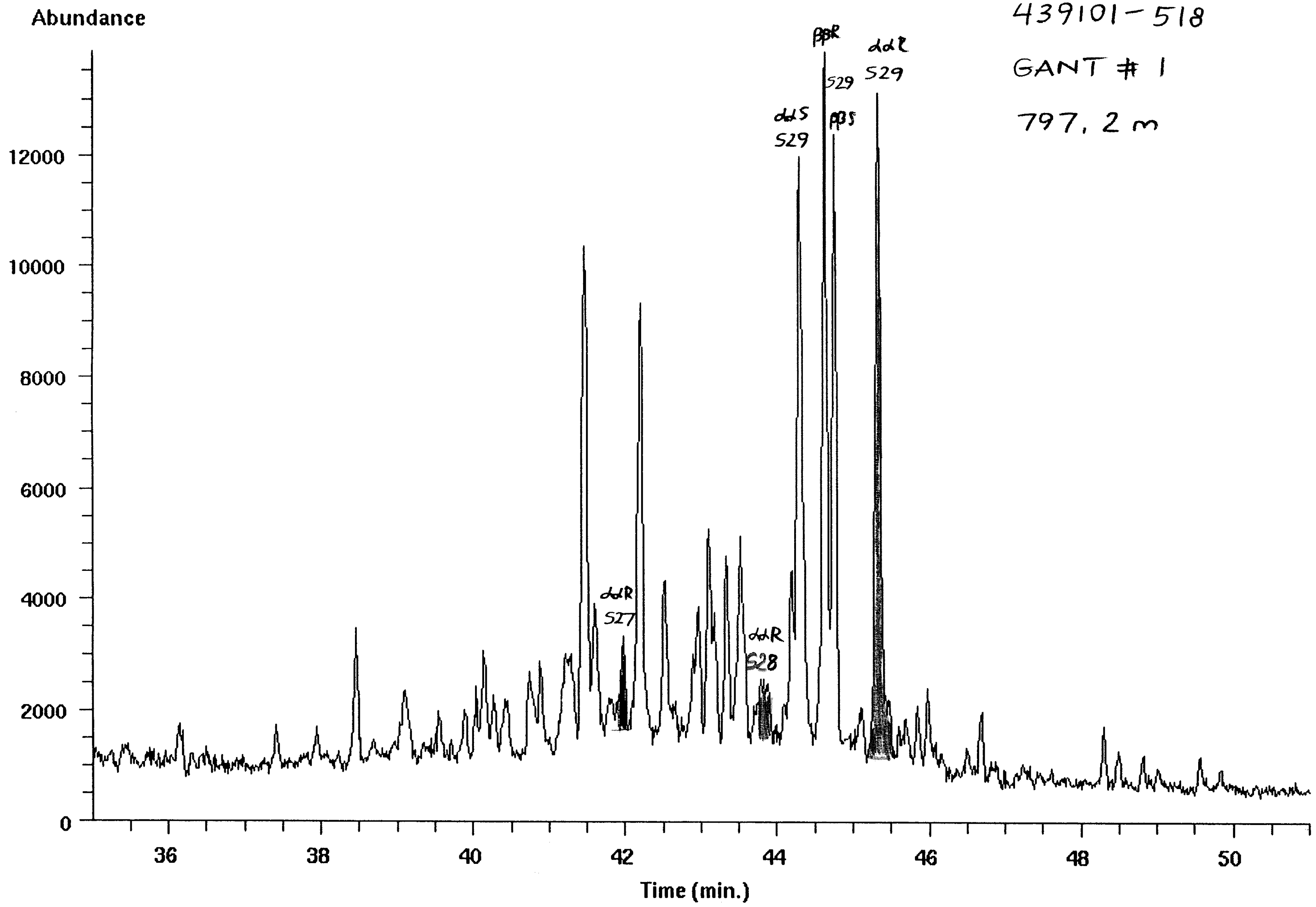
439101-518

GANT # 1

797.2 m

Ion 217.20 amu from GGU0401004.d

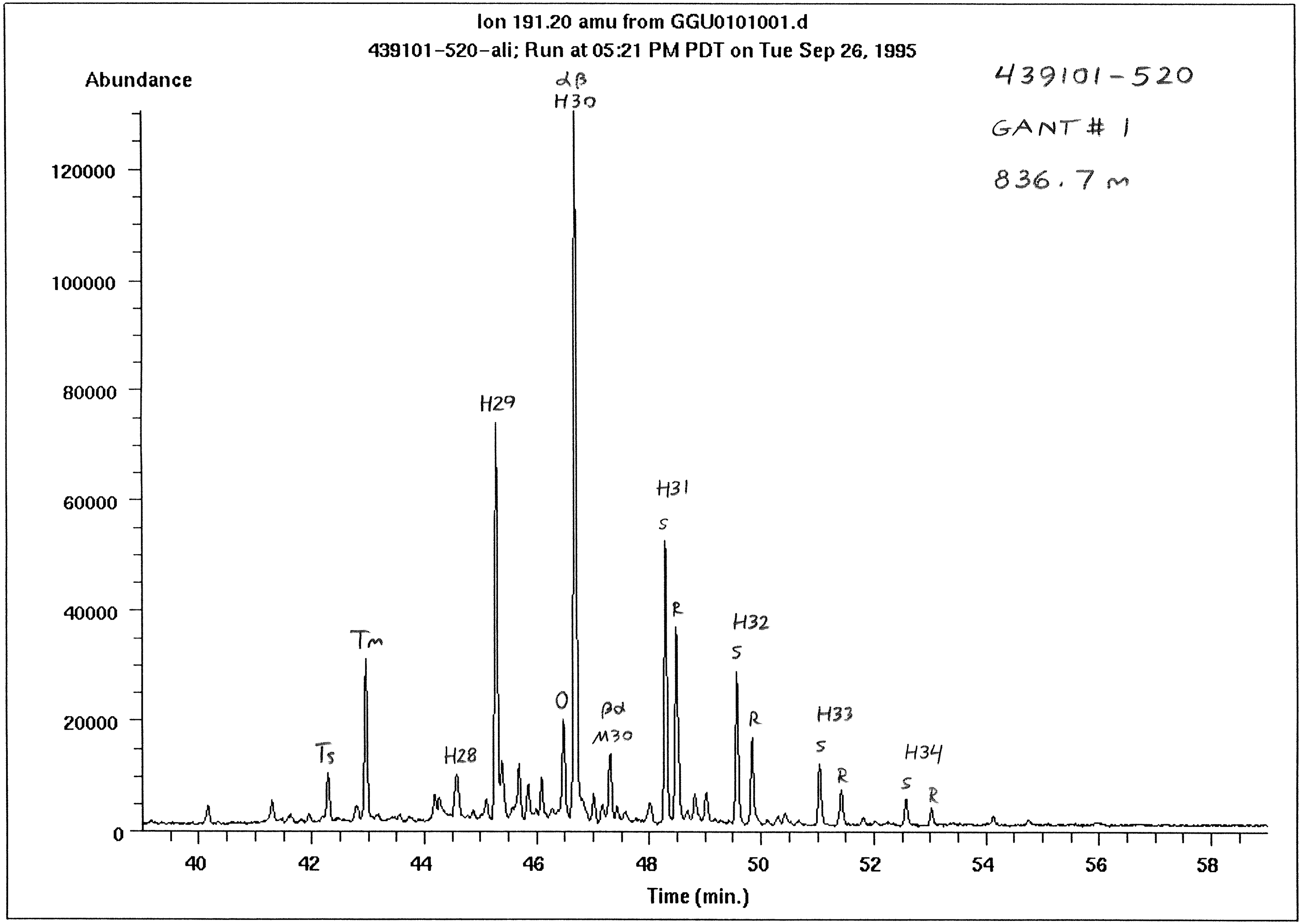
439101-518-ali; Run at 08:55 PM PDT on Tue Sep 26, 1995



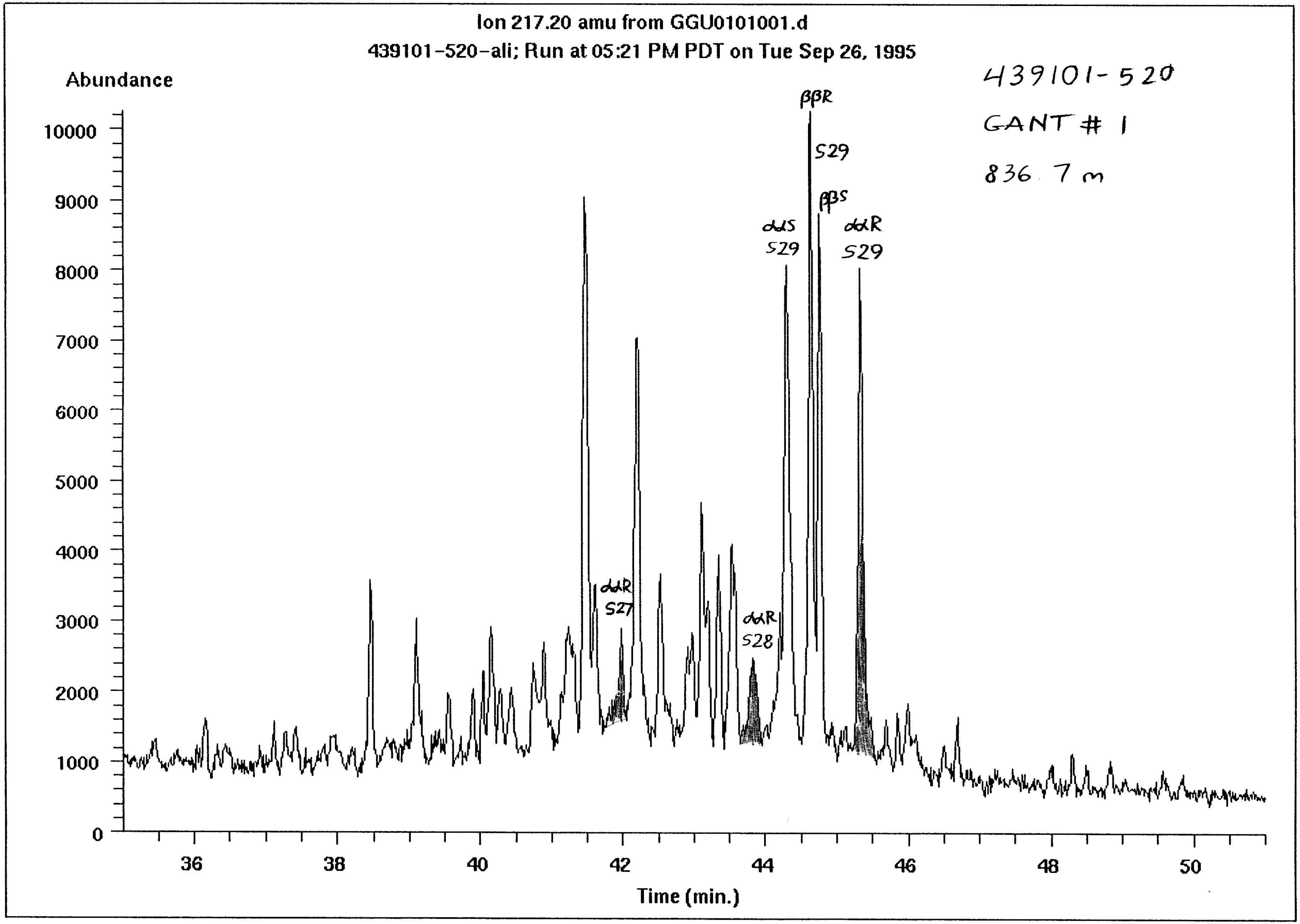
439101-518

GANT # 1

797, 2 m


Ion 191.20 amu from GGU0101001.d
439101-520-ali; Run at 05:21 PM PDT on Tue Sep 26, 1995

439101-520
GANT # 1
836.7 m



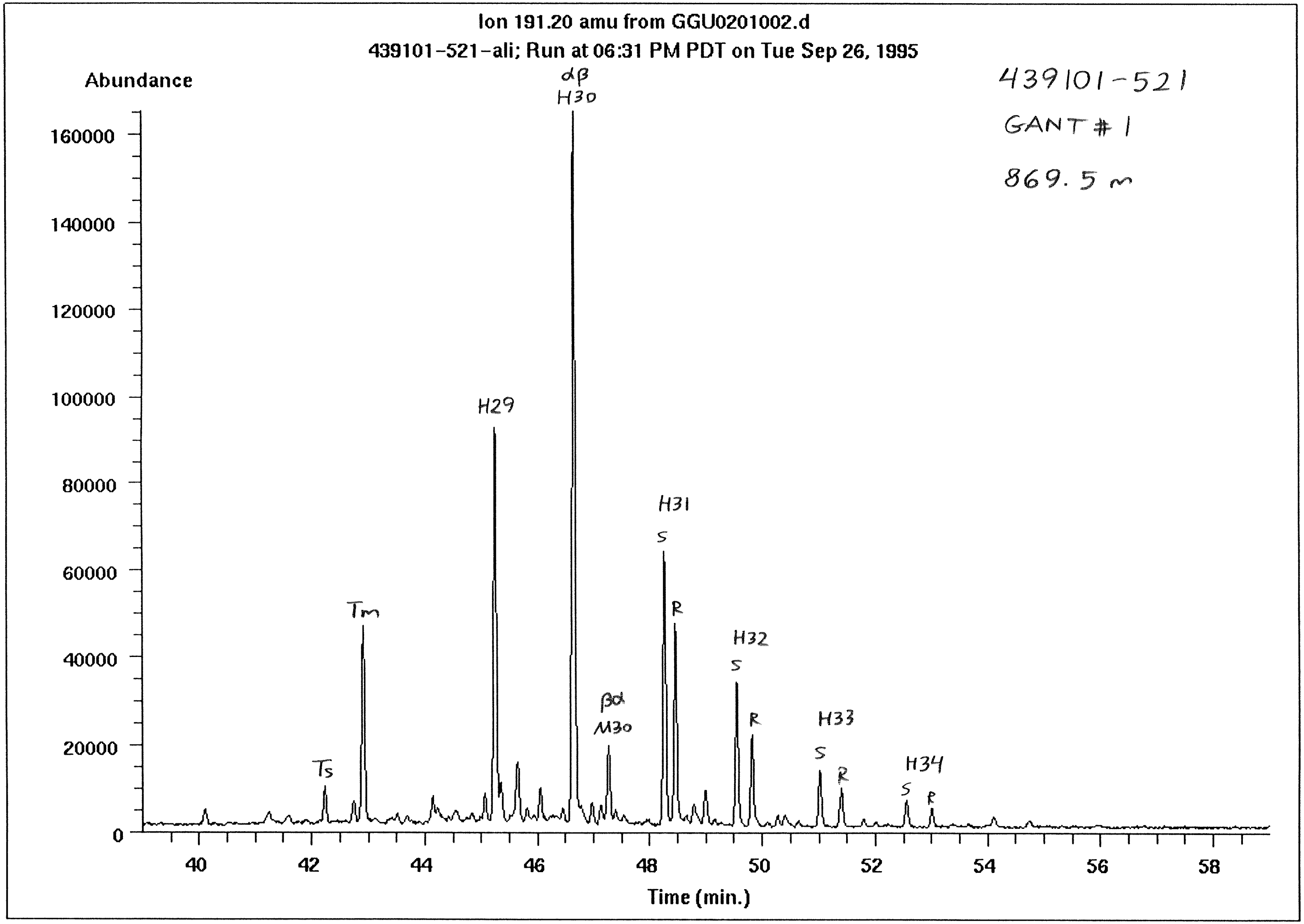
Ion 217.20 amu from GGU0101001.d

439101-520-ali; Run at 05:21 PM PDT on Tue Sep 26, 1995

439101-520

GANT # 1

836.7 m



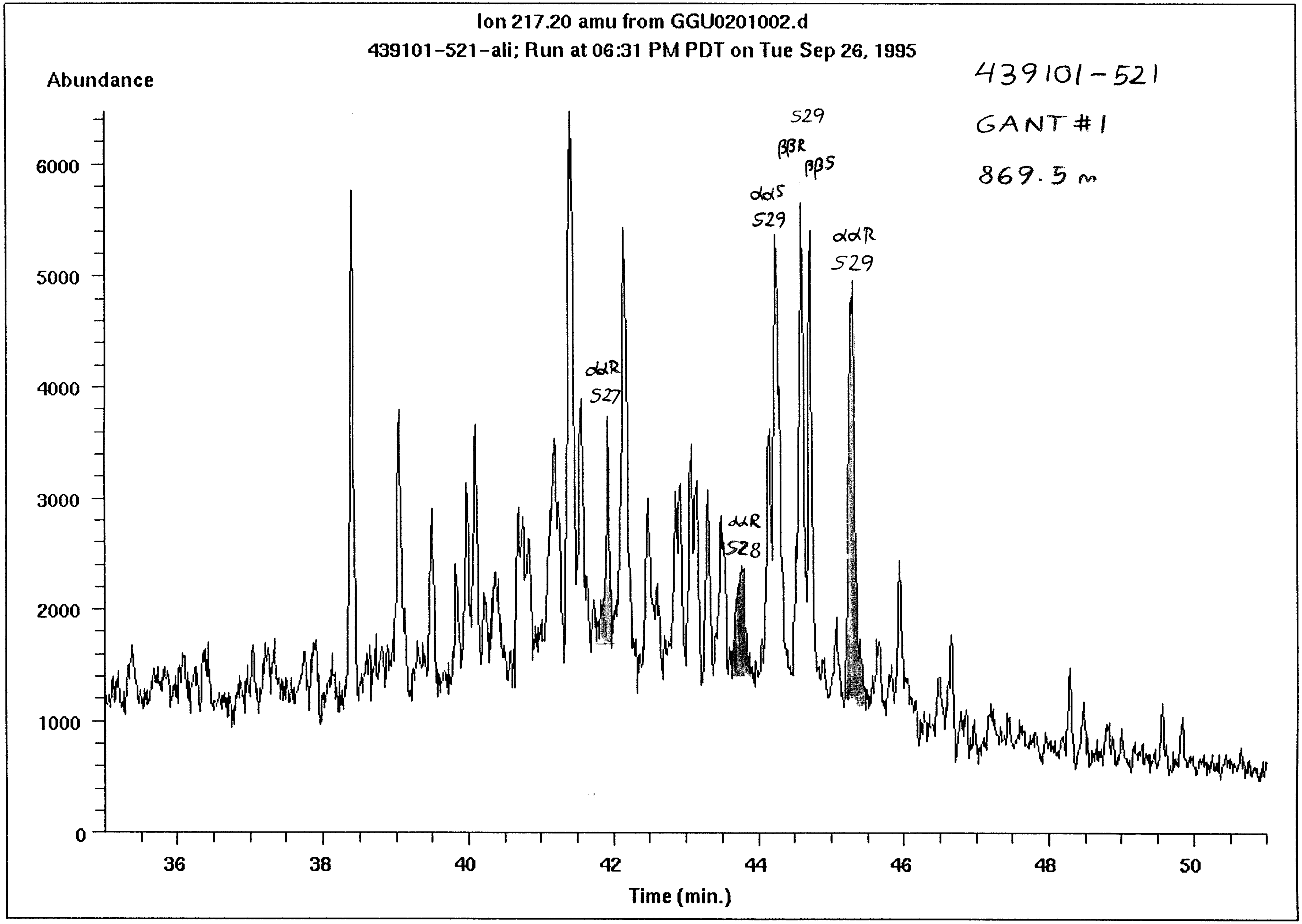
Ion 191.20 amu from GGU0201002.d

439101-521-ali; Run at 06:31 PM PDT on Tue Sep 26, 1995

439101-521

GANT # 1

869.5 m



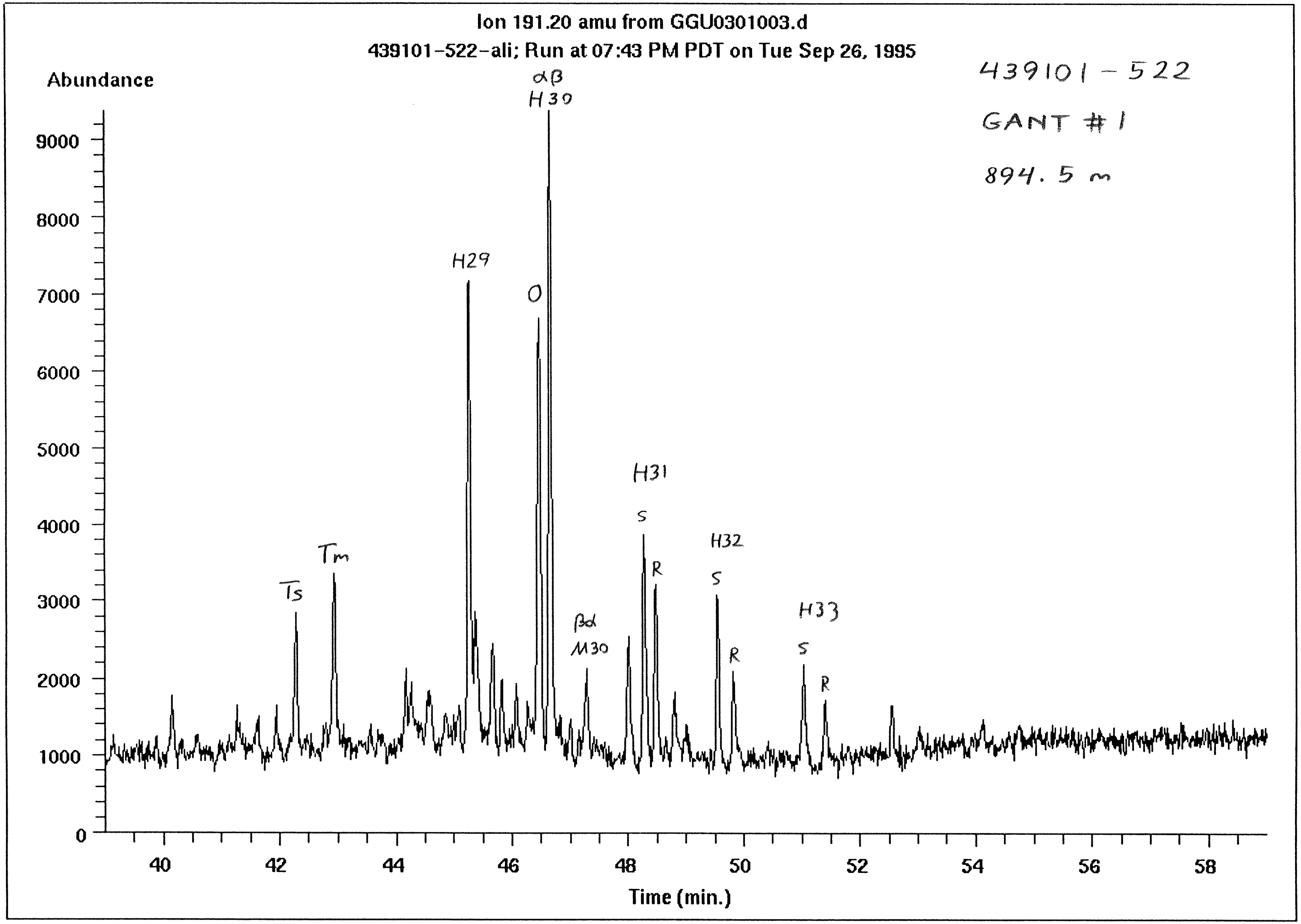
Ion 217.20 amu from GGU0201002.d

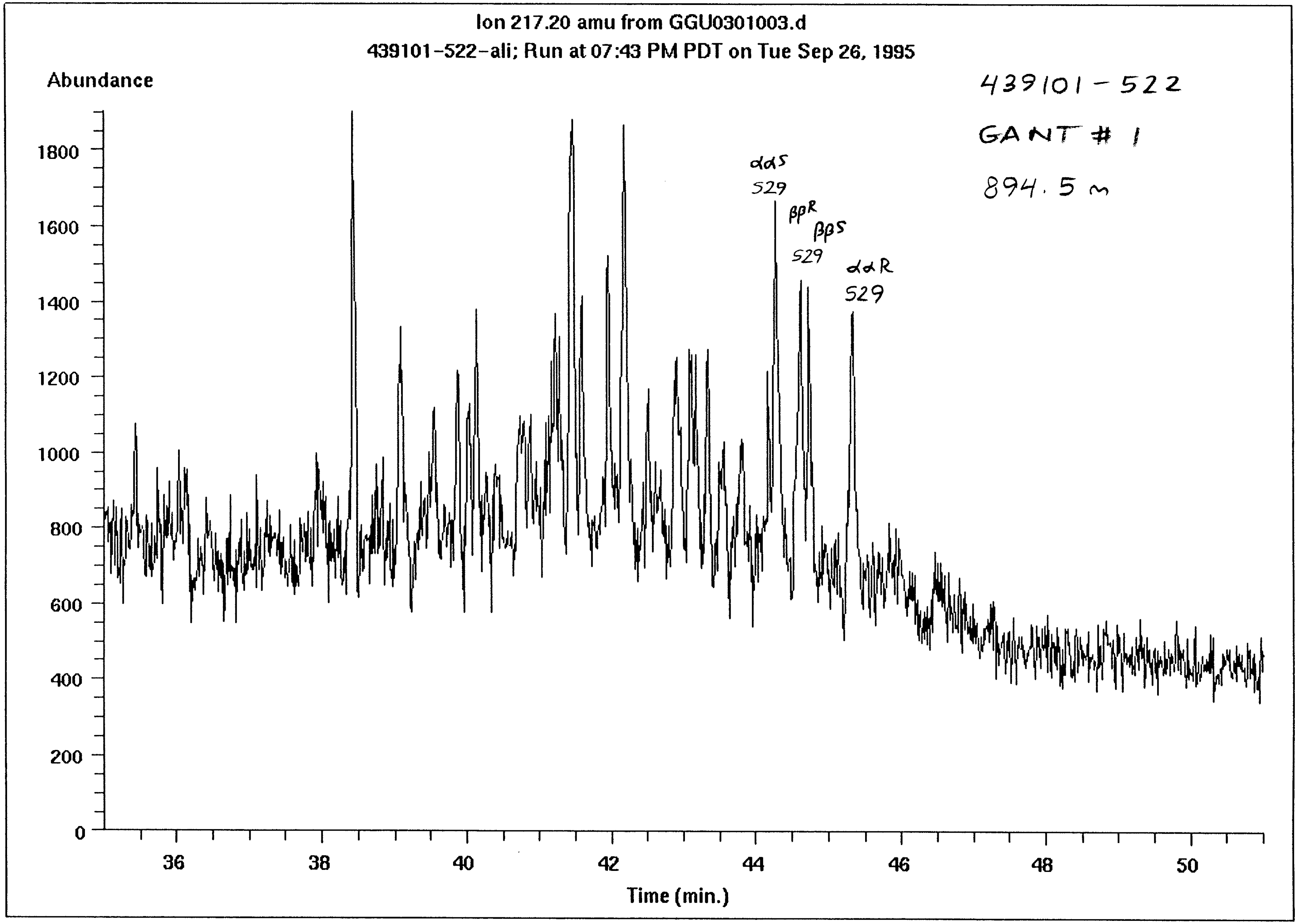
439101-521-ali; Run at 06:31 PM PDT on Tue Sep 26, 1995

439101-521

GANT #1

869.5 m


Ion 191.20 amu from GGU0301003.d
439101-522-ali; Run at 07:43 PM PDT on Tue Sep 26, 1995
439101 - 522
GANT #1
894.5 m
Abundance
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
αβ
H30
H29
O
Ts
Tm
βα
M30
H31
S
R
H32
S
R
H33
S
R
40
42
44
46
48
50
52
54
56
58
Time (min.)



Ion 217.20 amu from GGU0301003.d

439101-522-ali; Run at 07:43 PM PDT on Tue Sep 26, 1995

439101 - 522

GANT # 1

894.5 m

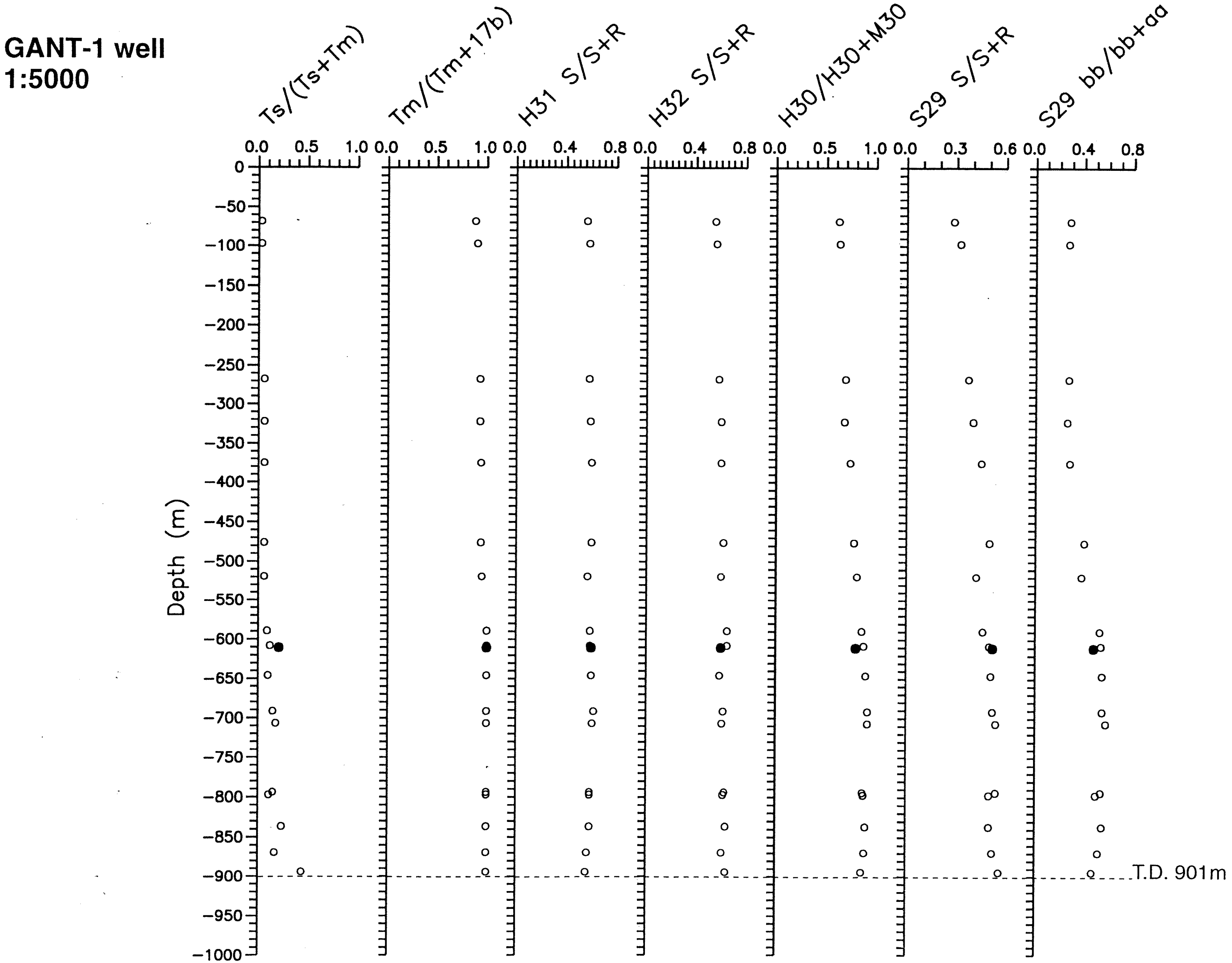
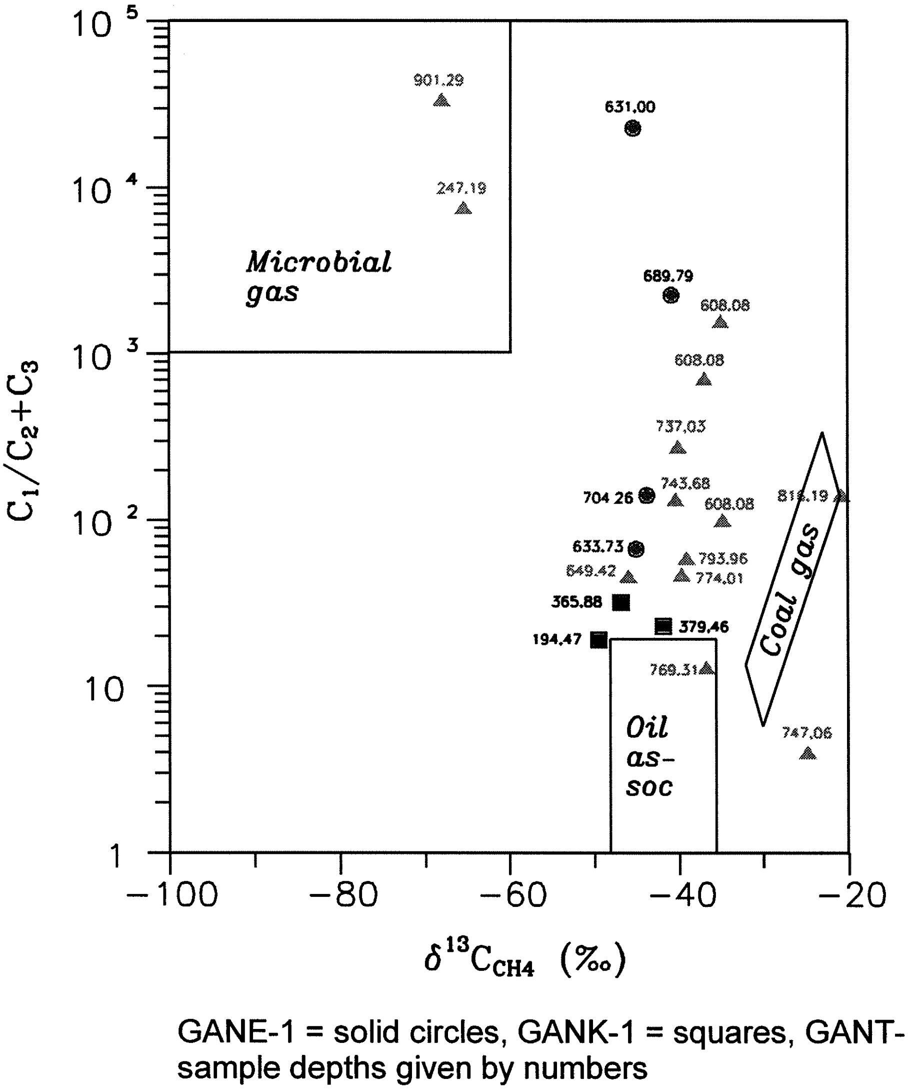

GANT-1 well
1:5000
Ts/(Ts+Tm)
Tm/(Tm+17b)
H31 S/S+R
H32 S/S+R
H30/H30+M30
S29 S/S+R
S29 bb/bb+aa
0.0 0.5 1.0
0.0 0.5 1.0
0.0 0.4 0.8
0.0 0.4 0.8
0.0 0.5 1.0
0.0 0.3 0.6
0.0 0.4 0.8
Depth (m)
0
−50
−100
−150
−200
−250
−300
−350
−400
−450
−500
−550
−600
−650
−700
−750
−800
−850
−900
−950
−1000
T.D. 901m

Fig. 27



GANE-1 = solid circles, GANK-1 = squares, GANT-1 = triangles
sample depths given by numbers

Fig. 28

C13 isotopic data of methane and ethane maturity lines Ro: 0.5 to 2.0 plotted

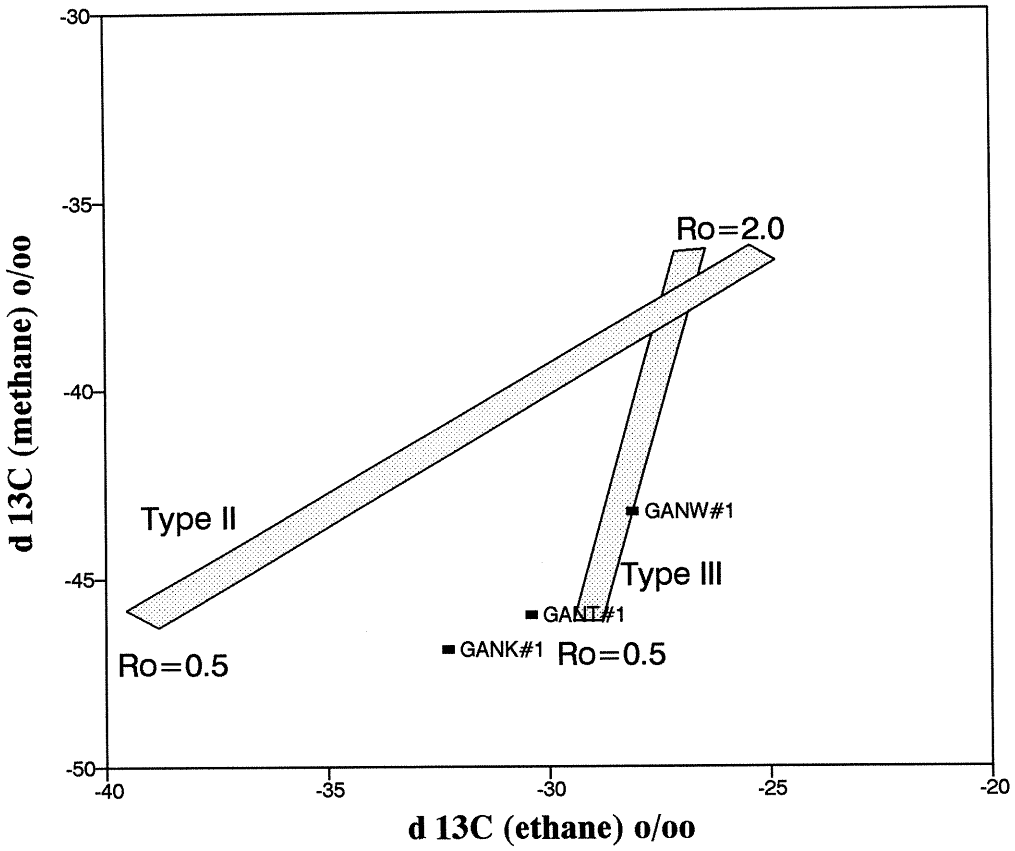
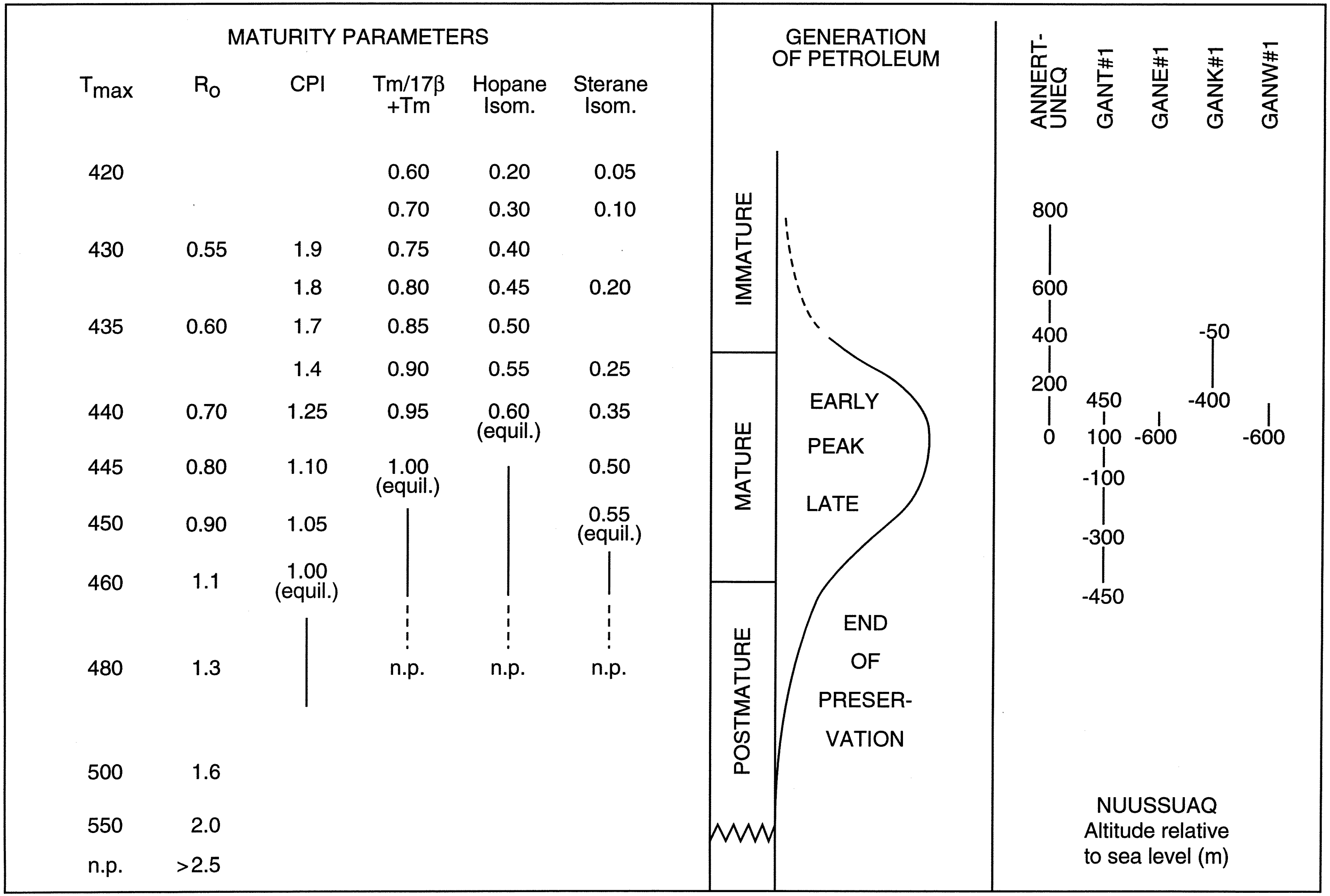


Fig. 29



T_{max}	R_o	CPI	Tm/17β +Tm	Hopane Isom.	Sterane Isom.
420			0.60	0.20	0.05
			0.70	0.30	0.10
430	0.55	1.9	0.75	0.40	
		1.8	0.80	0.45	0.20
435	0.60	1.7	0.85	0.50	
		1.4	0.90	0.55	0.25
440	0.70	1.25	0.95	0.60 (equil.)	0.35
445	0.80	1.10	1.00 (equil.)		0.50
450	0.90	1.05			0.55 (equil.)
460	1.1	1.00 (equil.)			
480	1.3		n.p.	n.p.	n.p.
500	1.6				
550	2.0				
n.p.	>2.5				

Fig. 30

S1.0-96.003/FGC

GANE-1 well
1:5000

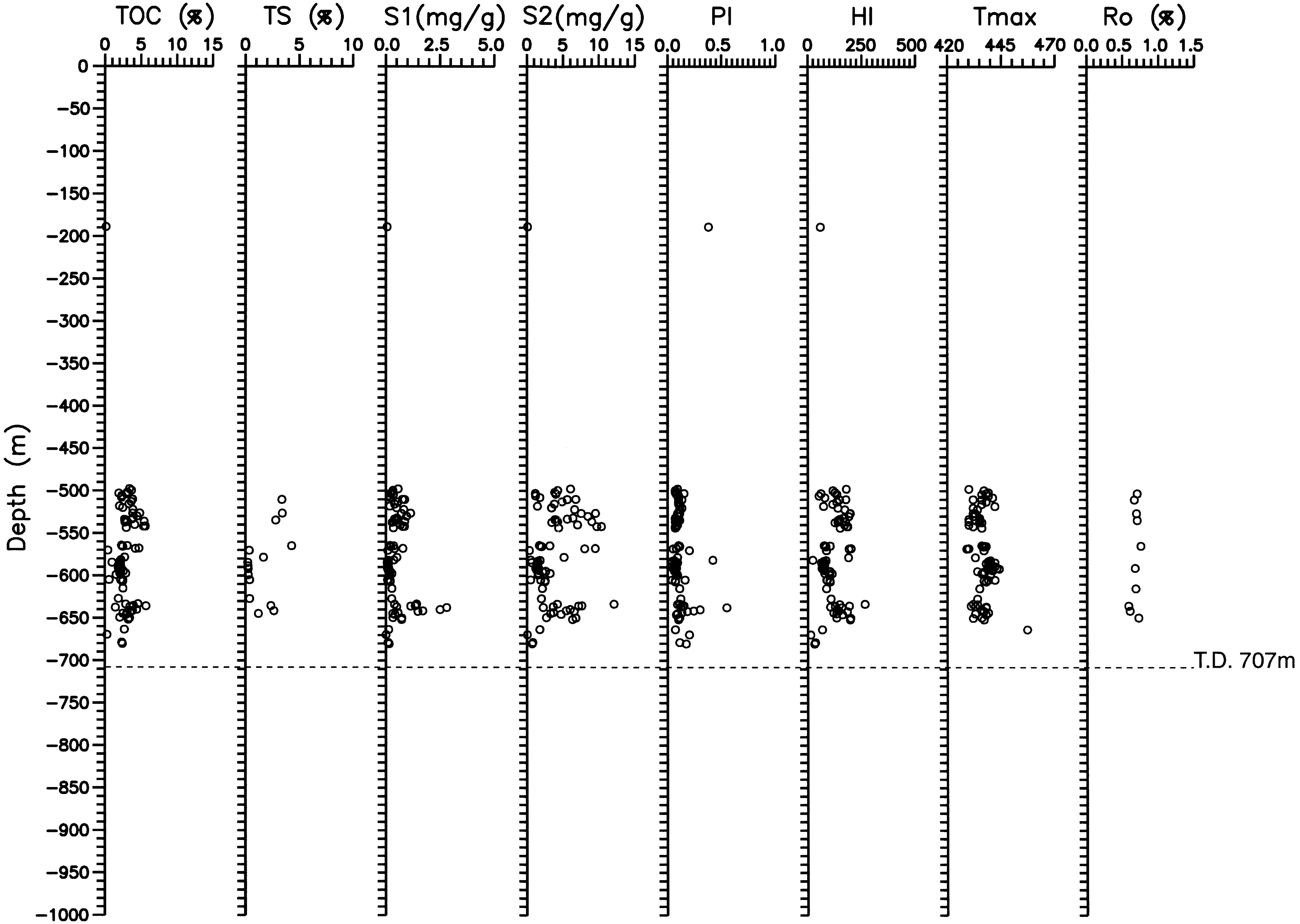


Fig. 5

GANE-1 well
1:5000

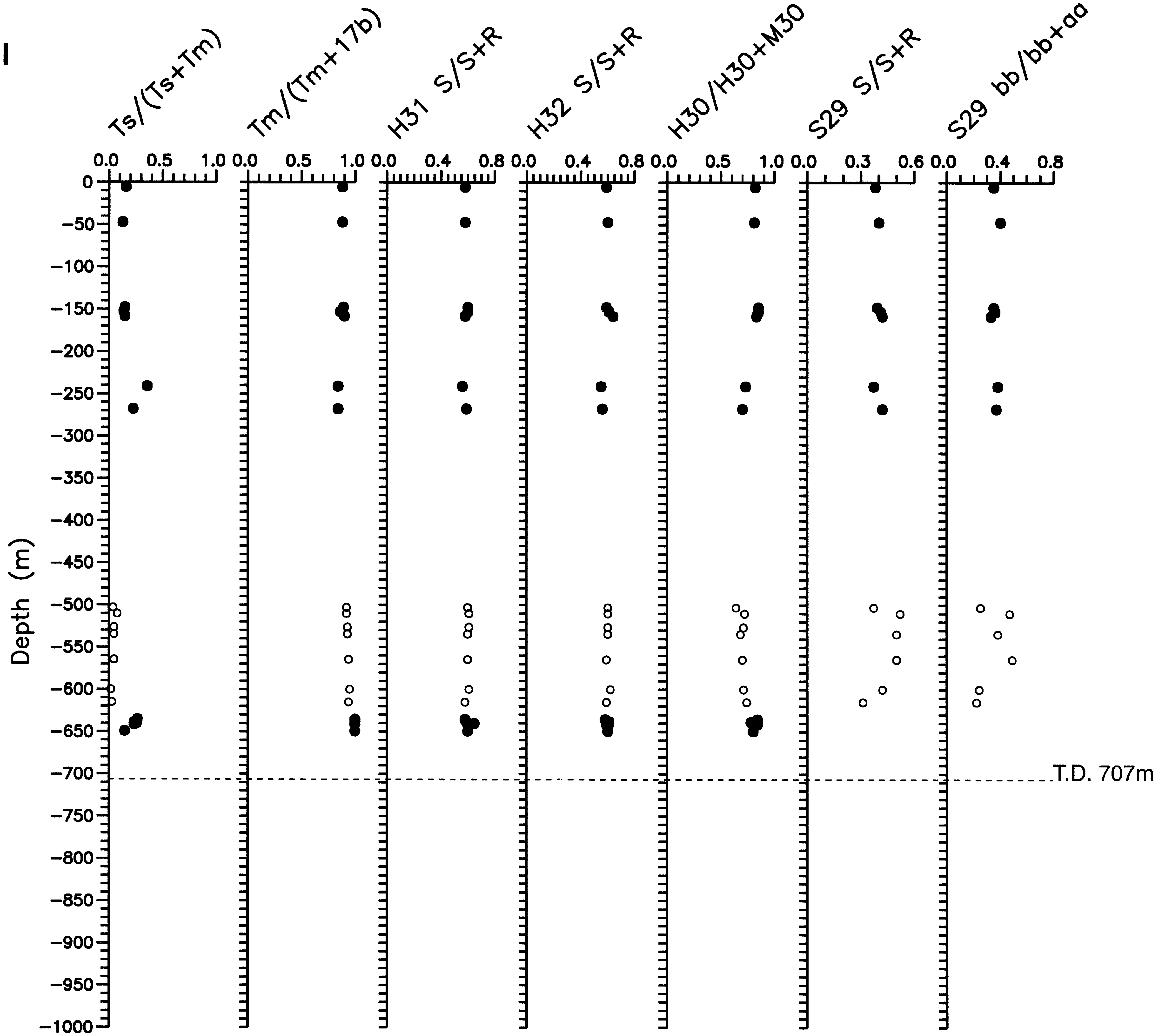


Fig. 11

GANK-1 well
1:5000

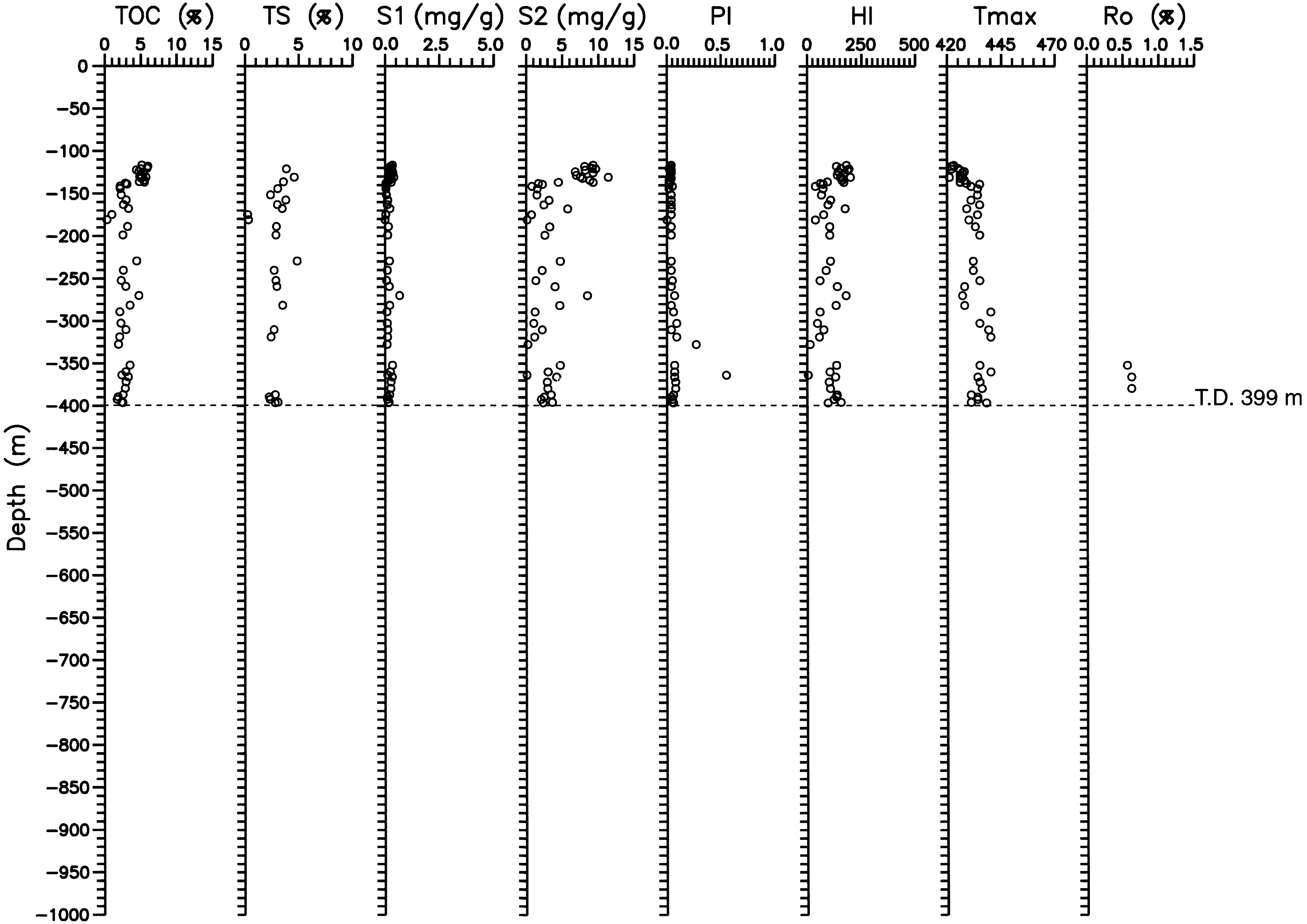


Fig. 14

GANK-1 well
1:5000

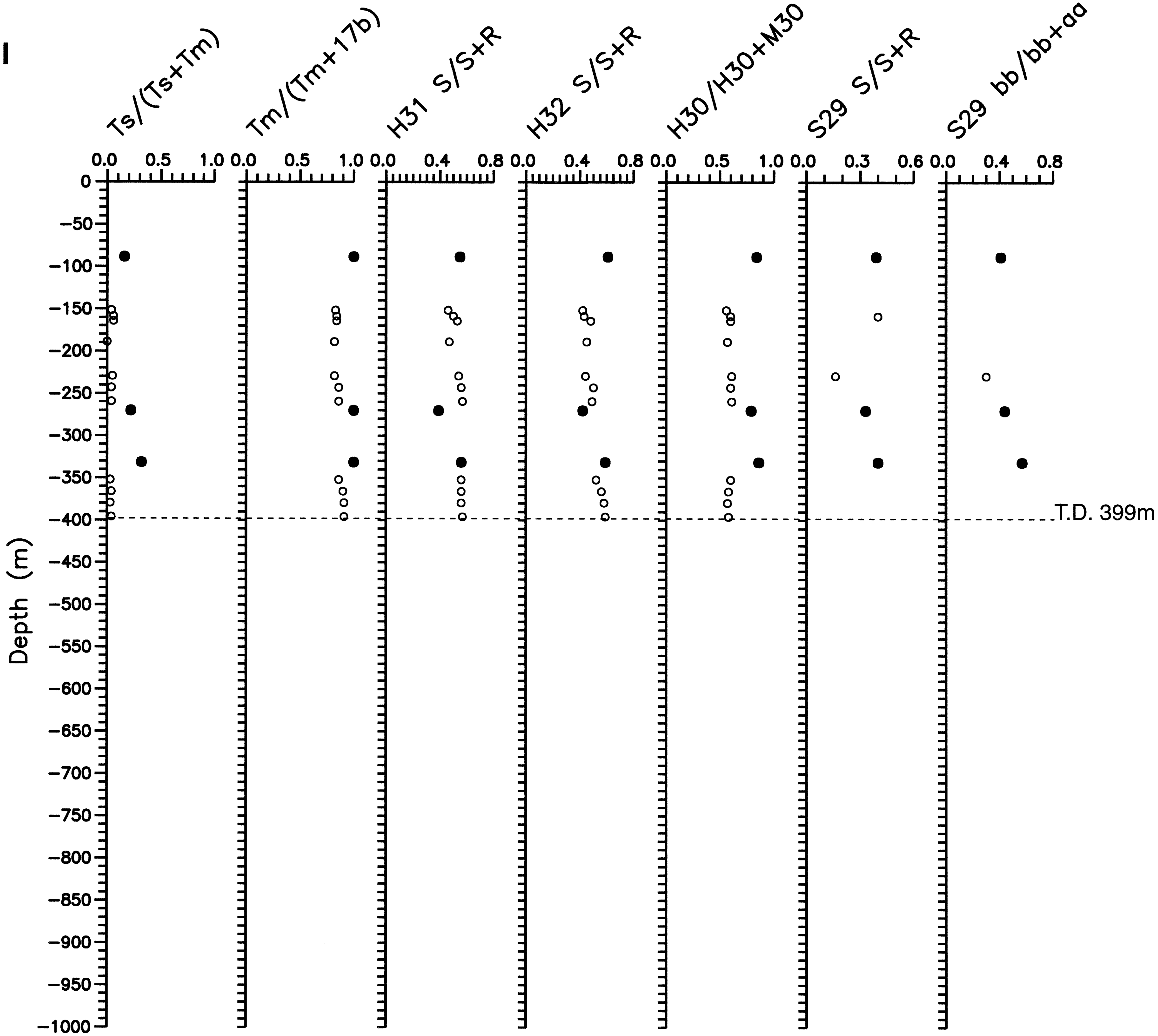


Fig. 20

GANT-1 well
1:5000

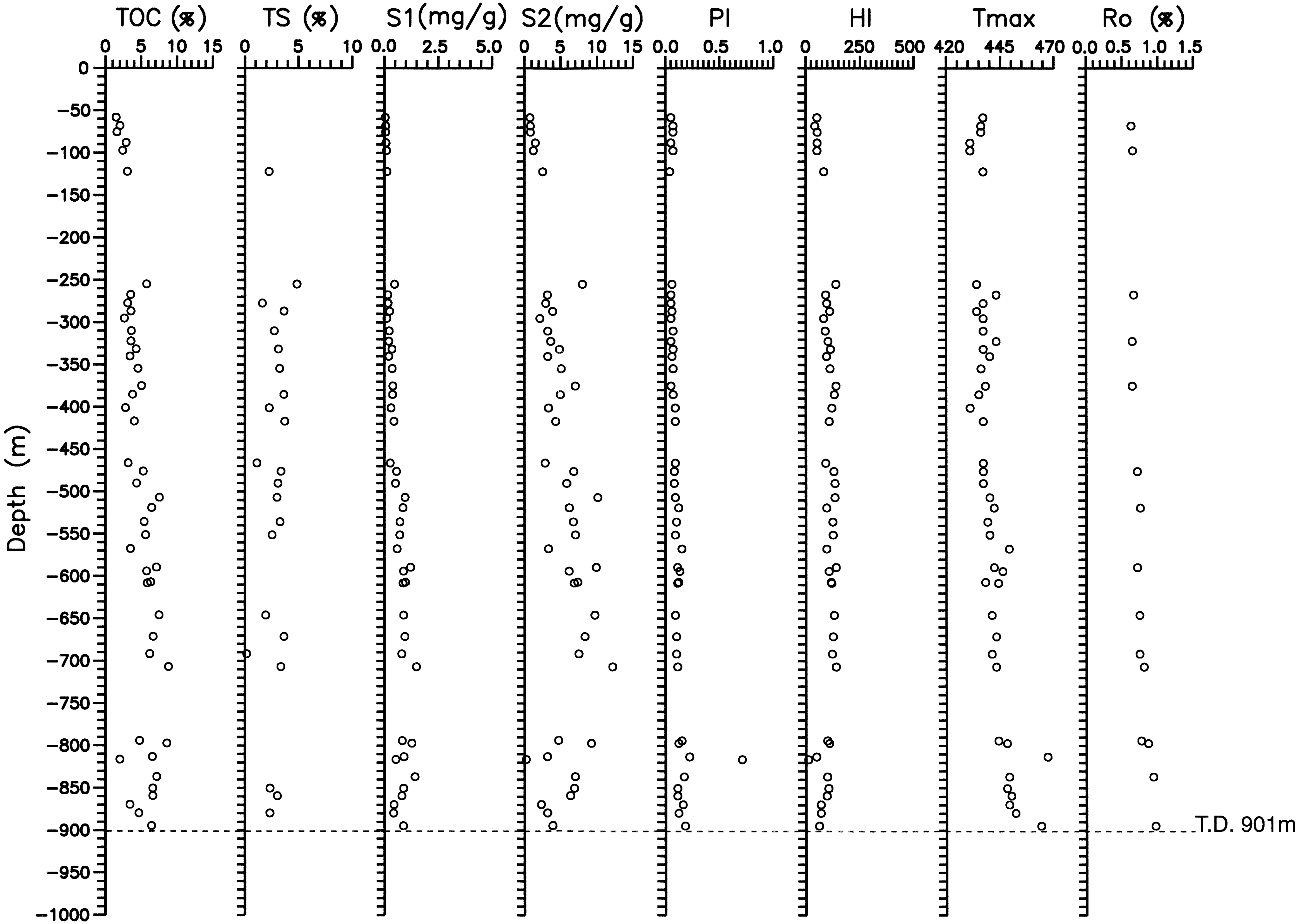


Fig. 21

GANT-1 well
1:5000

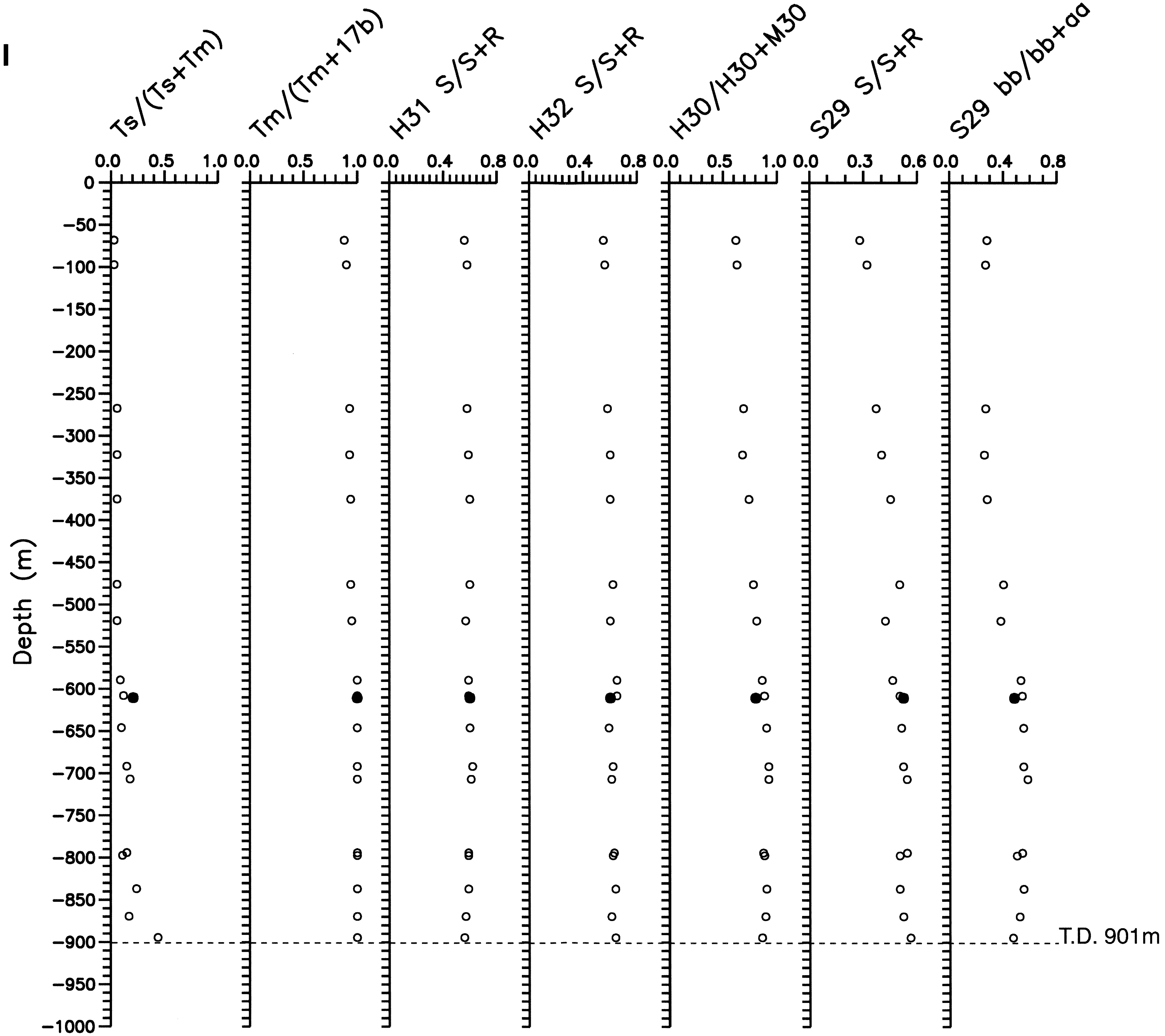


Fig. 27