GEOCHEMICAL CHARACTERIZATION OF OILS AND RESIDUAL STAINING IN THE SCALLOP-1 WELL AND KIPPER FIELD, GIPPSLAND BASIN, AUSTRALIA

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SUMMARY

- The oil from 2840 m. in the Scallop-1 well is extremely similar to the oil from 2318m. in the Kipper-2 well. The degree of similarity is such that these two oils may be from the same migration charge and migrated in part along a common migration pathway.

- The stains (as typified by the stain from 3031.5 m.) appear to be from a very similar source as the oils. However, the stain at 3031.5 m. is slightly more mature than the oils, suggesting generation from a slightly more mature interval.

- The sterane biomarkers in the oil from Scallop-1 well contain significant concentrations of C_{30} steranes indicative of some input from a lacustrine source. This suggests that the *P. Mawsonii* interval of the Golden Beaches may be a source. However, a more detailed study is required to establish the potential (if any) of this interval.

EXPLORATION IMPLICATIONS

- The reservoirs at 2840 m. in the Scallop-1 and 2318 m. in the Kipper-2 may be plumbed into the same migration pathway.

- The gas sands (with the stains) appear to have seen a slightly different charge(s) of oil since the stains are more mature than the Scallop-1 tested oil.

- The source potential of the *P. Mawsonii* may warrant further investigation.

INTRODUCTION

Objectives

- Determine if the oil recovered in the Scallop-1 well is genetically related to oil from the adjacent Kipper Field.

- Determine what type of oil has migrated through the wet Scallop reservoirs

- Determine if the *P. Mawsonii* unit of Golden Beaches Group has contributed oil and/or gas to Golden Beaches accumulations.

Sample Set

Scallop-1 well: One oil and three stained core samples

Kipper Field: One oil

In addition, compound specific isotope analyses were provided by Esso Australia for two samples from the Kipper-1 well and one sample from the E. Pilcherd well were available (see Table I for depths).

Sample depths and identifications are contained in Table 1.

Analytical Procedures

Oil samples:

Whole oil gas chromatography , liquid chromatography, compound specific isotope analysis (CSIA), and saturate biomarker gas chromatography-mass spectrometry (gc-ms). In addition, the oil from the Scallop-1 well was analyzed by gas chromatography-mass spectrometry/mass spectrometry (gc-ms/ms).

Rock samples:

Extraction, total extract gas chromatography, liquid chromatography, and saturate fraction gas chromatography. In addition, one rock extract was analyzed by CSIA and saturate biomarker gc-ms.

RESULTS and DISCUSSION

- *The Scallop-1 oil is very probably from the same source as the oil in the Kipper Field. The tested oil from the Scallop-1 and the oil from the Kipper-2 well are mostly from a typical Type IIIC Gippsland source. These oils are likely from the same migration charge that was trapped in two separate reservoirs (i.e., have in part a common migration pathway).*

1. A Gippsland Type IIIC source for these oils is indicated by:

   a. The whole oil chromatograms (Fig. 1, 2) are characteristic of Type IIIC Gippsland Basin oils. The gradually increasing concentrations of normal alkanes with increasing molecular weight implies generation from a predominantly highstand source (Curry and Bohacs, as described in

Curry and Bohacs, 2002). In addition, the oils have high pristane/phytane ratios (Table 1, Fig. 3).

b. The distributions of sterane and triterpane biomarkers are characteristic of Type IIIC oils, including high proportions of C_{29} steranes (Fig. 4; Table 2) and high triterpane/sterane ratios (Table 2). These oils do not have the elevated concentrations of C_{31} hopanes (e.g., C_{31}-S/C_{30} hopane ratios > 1) which are sometimes observed in oils from the central and western areas of the basin (e.g., Barracouta Field) (Curry, 2003).

2. The occurrence of a common source for the oil in the Scallop-1 well and the oil in the Kipper-2 well is indicated by:

   a. The distribution of normal alkanes in the Scallop-1 oil (Fig. 1), and the oil from the Kipper-2 well (Fig. 2) are very similar when the effects of evaporation of the light ends (due to prolonged storage) of the Kipper-2 oil are taken into account. In addition, the pristane/phytane and pristane/n-C_{17} ratios are also very similar (Table 1).

   b. The sterane and triterpane biomarker distributions of the Scallop-1 oil and the Kipper-2 oil are virtually identical (Fig. 5, 6;Table 2).

   c. Compound-specific isotope analysis (CSIA) of these samples generally show differences in isotope ratios of the n-alkanes of less than 1 ‰ except in the C_{21}-C_{24} range (Fig. 7, Table 3) for the Scallop-1 and Kipper-2 oils. The Kipper-1 RFT's have slightly different (more negative) values. The wider spread of isotope ratios in the C_{21}-C_{24} range may be due to variations in the concentrations of locally generated diterpanes which have been extracted into the oil charge. The cause of the anomalously low value for n-C_{22} in the Kipper-2 oil is not known.

3. The possibility that the oil at 2840 m. in the Scallop-1 and 2318 m. in the Kipper-2 were from the same charge of oil migrating in part on a common migration pathway is indicated by:

   a. The biomarker distributions have an uncommonly high degree of similarity, not only in the distributions of the major components, but also the smaller compounds.

   b. The only significant differences in the CSIA data occur only in a narrow molecular weight range, suggesting the possibility of addition of specific, possibly locally generated, components to the common oil.

- *The stains in the Scallop-1 well appear to from the same or a very similar source to the oils in the Scallop-1 and Kipper wells. However, the oil stain at 3031.5 m. appears to be slightly more mature than the oils. This difference in* *maturity suggests that the stain may be from a different, slightly more mature source interval than the oils*

1. Total extract gas chromatograms of the oil stains contain high concentrations of anomalous components that appear to be contamination or drilling additive. This is shown by the compound class distributions (Table 1), which show low concentrations of saturates and aromatics compared to polar fractions. Consequently, the total extract gas chromatograms were not useful in this study.

2. The similarity in sources between the stains and the oils is indicated by:

   a. The biomarker distributions for the stain from 3031.5 m. are very similar to those for the oils (Fig. 5, 6, 8; Table 2) and are indicative of a predominantly Type IIIC source. (Because of the similarity of the saturate fraction chromatograms of the extracts, only one extract sample was further analyzed by gc-ms and CSIA.)

   b. The distribution of normal alkanes in the saturate fractions of the three stains (Fig. 9, 10, 11) are very similar to the normal alkane distributions in the produced oils in the Scallop-1 and Kipper-2 wells (Fig. 1, 2).

   c. The similarity of the CSIA data between the 3031.5 m. extract and the oils (Fig. 7; Table 3).

   The $\delta^{13}C$ values of the components in the C_{13}-C_{17} range in the E. Pilcherd extract (Fig. 7, Table 3) are > 2 ‰ different from those of the Kipper-2 and Scallop-1 oils. This difference may indicate input from a different source facies. However, because of the $\delta^{13}C$ values of the Gippsland coals vary by > 2.5 ‰ (Curry, unpublished data), the different source may be another Gippsland Type IIIC facies. In addition, lowstand coals generate significantly higher concentrations of C_{13}-C_{17} components relative to higher molecular components as compared to highstand coals (Curry, 2003). Consequently, input from a different, lowstand facies would dominant the isotopic composition of the extract.

3. The oil stain from 3031.5 m. appears to be slightly more mature than the Scallop-1 oil. This is indicated by:

   a. Higher C_{29} (20-S)/(20-S+20-R) sterane isomerization ratio (Table 2)
   Higher Ts/Tm ratio (Table 2)
   Lower C_{30} moretane/(C_{30} moretane + C_{30} hopane) ratio (Table 2)
   Lower pristane/n-C_{17} ratio (Table 1, Fig. 3)
   Lower CPI values (Fig. 1, 9).

b. This difference in maturity suggests that the oil stain is from a slightly more mature source interval than the Scallop-1 and Kipper-2 oils.

- *Biomarker data suggest that there may be a contribution to the Scallop-1 oil from an algal-dominated organic facies. This suggests that the P. Mawsonii may have contributed some charge to this oil. However, a further and more detailed study of the hydrocarbons in the area and the P. Mawsonii rocks is necessary to definitely delineate the contribution of the P. Mawsonii (if any).*

1. A detailed gc-ms/ms analysis of the Scallop-1 oil showed the occurrence of small but significant concentrations of C_{30} steranes (Fig. 12). These C_{30} steranes are not regular (24-n-propyl) C_{30} steranes derived from marine organic matter. Instead, the gc-ms/ms analysis indicated that they are most likely C_{30} dinosteranes (Peters et. al., in press).

2. Dinosteranes are derived from dinoflagellates in either lacustrine or marine environments. However, this oil appears to lack any other, more definitive indicators of marine input, including:

   a. Low concentrations of C_{27} and C_{28} steranes (Fig. 5, 12a, 12b; Table 2). Note that in Fig. 12 the maximum concentrations of the C_{27} and C_{28} steranes (as indicated by the scale boxes on the right of the mass fragmentograms) are significantly less than that of the C_{30} dinosteranes.

   b. Absence of C_{30} regular steranes (Fig. 12D).

   c. High pristane/phytane ratio (Table 1, Fig. 3).

   d. Low polar and high saturate fraction concentrations (Table 1).

3. The occurrence of lacustrine-derived steranes in fairly significant concentrations suggests that the Scallop-1 oil may contain hydrocarbons generated from the *P. Mawsonii* interval of the Golden Beaches Group. However, a more extensive study of the area is required to determine the extent of contribution from the P. Mawsonii.

REFERENCES

Curry D.J. and Bohacs K.M. (2002) Sequence Stratigraphic Controls on the Oil Generation Potential of Coals. Abstracts of the 2002 Canadian Society for Organic Petrography meeting, Banff, Alberta.

Peters K.P., Moldowan M., and Walters C. C. "The Biomarker Guide" (2nd edition) (in press).

TABLE 1: SAMPLE IDENTIFICATION AND BASIC DATA

URC No.	Sample Type	Well	Depth (m)	% Saturates	% Aromatics	% Polars	Pristane/ Phytane	Pristane/ n-C17
232968	Oil	Scallop-1	2840	77.0	20.0	2.3	5.45	0.95
93918	Oil	Kipper-2	2318	82	14.7	2.4	5.79	0.84
232972A	Core XT	Scallop-1	3031.5	25	5	70	6.16	0.96
232972B	Core XT	Scallop-1	3100.4	1	0	99	5.01	1.24
232972C	Core XT	Scallop-1	3144	4	6	90	5.91	0.68

TABLE 2
GAS CHROMATOGRAPHY-MASS SPECTROMETRY DATA

	Well Depth (m) Type URC No.	Scallop-1 2840 oil 232968	Kipper-2 2318 oil 93918	Scallop-1 3031.5 core 232972A
STERANES				
THERMAL MATURITY	**ION**			
% C29 aaa (20S) / (20S+20R)	217	44.92	45.43	52.84
C29 aaa (20S) / (20R)	217	0.82	0.83	1.12
% C29 abb / (abb + aaa)	217/218	47.38	48.18	51.87
% C27 ba	217	56.00	48.05	53.40
% C27 ba (20S) / (20S + 20R)	217	61.77	63.80	65.53
TOTAL STERANES	217	36183	22787	45371
TOTAL ISOSTERANES	218	43310	27706	64820
TOTAL DIASTERANES	217	70827	43969	87037
(C21 + C22)/C28 abb	217/218	0.43	0.37	0.34
DEPOSITIONAL ENVIRONMENT				
% C27 abb	218	16.90	17.52	14.45
% C28 abb	218	14.29	14.86	14.94
% C29 abb	218	68.46	66.60	70.22
% C30 abb	218	0.35	1.03	0.38
% TOTAL C27	217/218	8.77	9.40	8.36
% TOTAL C28	217/218	14.90	16.57	15.84
% TOTAL C29	217/218	69.24	67.69	69.26
% TOTAL C30	217/218	19.20	18.57	17.59
TERPANES/STERANES	191/217/218	2.95	2.81	2.90
Pregnane/Homopregnance	217	2.45	2.00	1.79
DEPOSITONAL ENVIRONMENT & BIODEGRADATION				
	ION			
DIA-/REG. STER.	217/218	0.89	0.87	0.79
C27 ba (20R) / (20S)	217	0.96	0.74	0.84

TABLE 2 (CONT'D)

TERPANES	Well Depth (m) Type	Scallop-1 2840 oil	Kipper-2 2318 oil	Scallop-1 3031.5 core
THERMAL MATURITY	ION			
% C32 ab (22S)/(22S +22R)	191	56.97	58.37	59.70
% C30 ab	191	86.06	87.22	90.70
% Ts/(Ts + Tm)	191	23.77	24.01	26.63
Ts/Tm	191	0.31	0.32	0.42
% C30 Moretane/(C30 Mortane + C3(	191	13.94	12.78	9.30
C30 Hopane/(C30 Moretane + C29 N	191	4.32	4.59	7.16
% C29 NorMoretane/(C29 NorMoreta	191	11.29	11.64	6.75
% C29 NorHopane/(C29 NorHopane	191	35.38	35.06	33.94
% (Ts + Tm)/(Ts + Tm + C30 Hopane	191	22.03	21.80	20.32
DEPOSITONAL ENVIRONMENT				
% 18a-Oleanane	191	3.17	2.77	2.66
% TRICYCLICS	191	7.82	7.46	9.43
C23/SUM(C23-C25)	191	0.49	0.52	0.51
% Gammacerance	191	3.31	4.10	2.89
C35/C32 HomoHopane	191	0.11	0.17	0.14
% TOTAL C27 PENTACYCLICS	191	6.45	6.34	6.24
% TOTAL C28 PENTACYCLICS	191	1.93	2.03	1.1
% TOTAL C29 PENTACYCLICS	191	14.10	13.89	13.48
% TOTAL C30 PENTACYCLICS	191	26.55	26.06	29.698
% TOTAL C31 PENTACYCLICS	191	16.34	16.23	16.45
% TOTAL C32 PENTACYCLICS	191	9.33	9.61	10.1
% TOTAL C33 PENTACYCLICS	191	4.88	5.22	5.59
% TOTAL C34 PENTACYCLICS	191	2.60	2.95	2.89
% TOTAL C35 PENTACYCLICS	191	1.04	1.59	1.37
TOTAL TRITERPANES	191	443195	265466	572138

TABLE 3
COMPOUND SPECIFIC ISOTOPE RATIO ANALYSES
SCALLOP, KIPPER, E. PILCHARD WELLS
GIPPSLAND BASIN, AUSTRALIA

URC No	93918	232968			232972A	
Well Name	Kipper2	Scallop1	Kipper 1	Kipper 1	Scallop1	E.Pilchard-1
Depth (m)	2318.4	2840	1823.3	2028.4	3031.5	3090-30[illegible]
Sample Type	Oil	Oil	RFT 4	RFT 5	Core	Cuttings
Data Source	URC	URC	EAL	EAL	URC	EAL
Compounds	$\delta^{13}C$ (per mil)					
nC7			-25.73	-25.52		
nC8			-25.77	-25.67		
nC9			-26.34	-25.9		
nC10			-26.37	-26.04		
nC11			-26.59	-26.14		
nC12		-26.49	-26.61	-26.08		
nC13	-26.36	-26.55	-26.88	-26.23	-25.73	
nC14	-25.63	-26.15	-26.82	-26.29	-26.10	-28.03
nC15	-25.80	-26.37	-27.16	-26.32	-26.24	-28.08
nC16	-25.68	-26.36	-27.17	-26.39	-26.17	-28.25
nC17	-25.17	-25.46	-27.26	-26.37		-27.94
nC18	-26.18	-26.67	-27.29	-26.34	-26.32	-27.88
nC19	-26.59	-27.13	-27.41	-26.55	-26.39	-27.52
nC20	-26.90	-27.13	-27.26	-26.35	-26.66	-27.62
nC21	-28.05	-27.33	-27.39	-26.47	-27.86	-27.59
nC22	-29.38	-27.11	-27.12	-26.6	-27.92	-27.55
nC23			-27.39	-26.58	-27.52	-27.72
nC24	-29.08		-27.27	-26.69	-28.44	-28.16
nC25	-28.42		-27.54	-27.28	-28.01	-28.15
nC26	-29.04		-27.56		-28.48	-28.45
nC27	-28.18		-27.81			-28.56
nC28	-28.14		-28.19			-29.14
nC29	-28.02		-28.94		-28.35	-29.83
nC30	-28.49		-29.15		-28.44	-30.15
nC31						-30.57
nC32						-31.09

Fig. 1

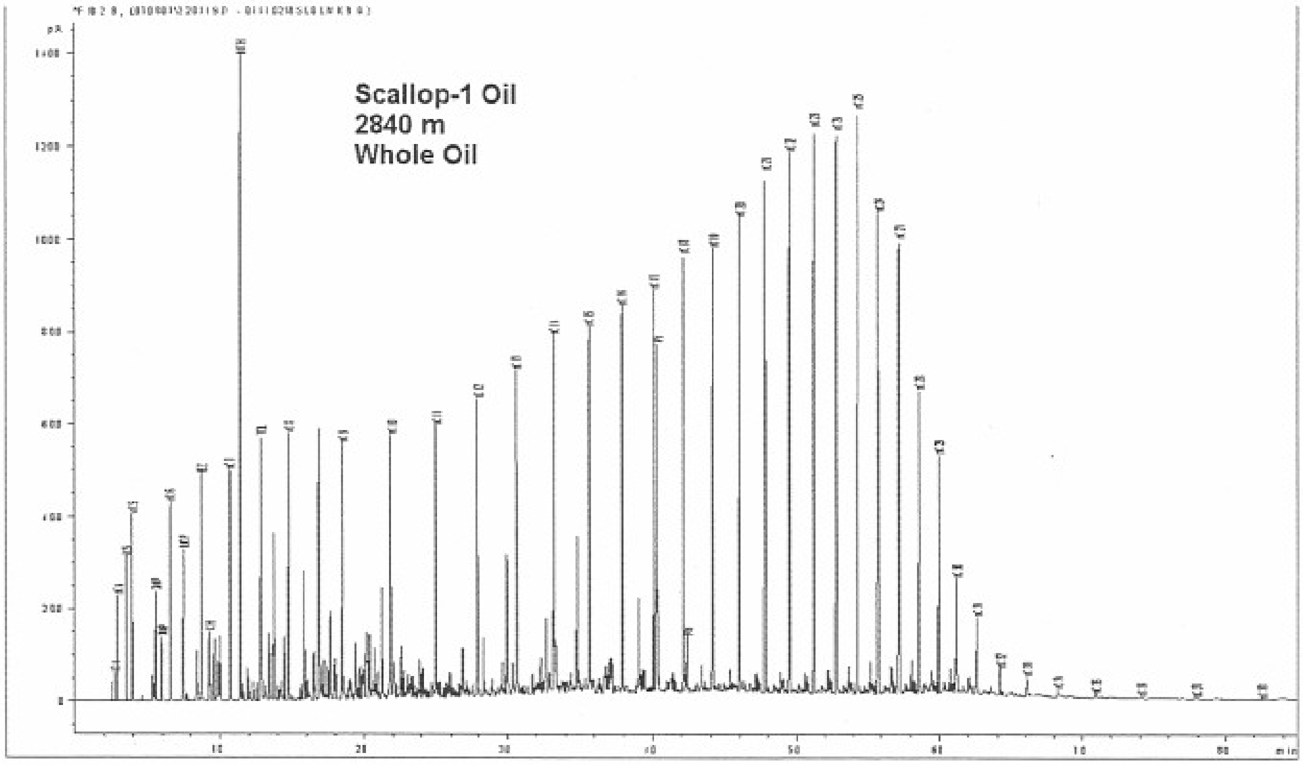
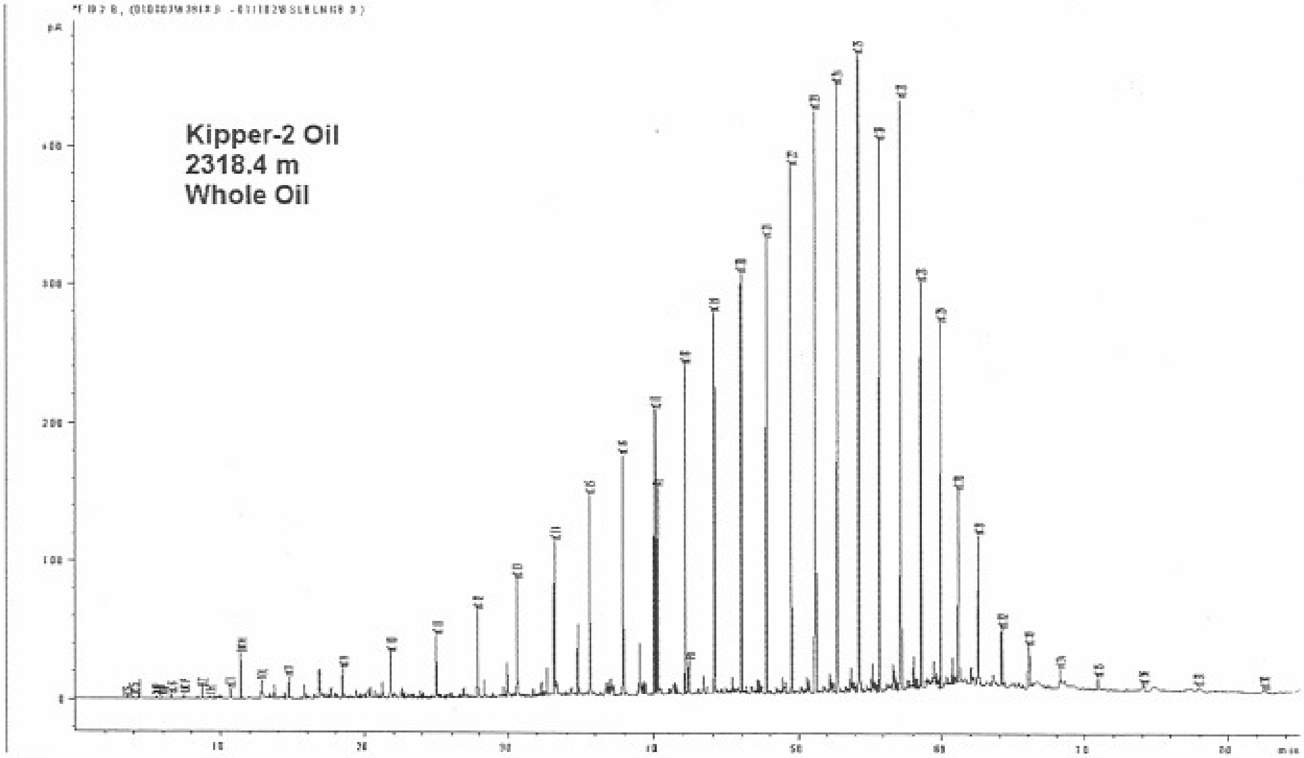


Fig. 2



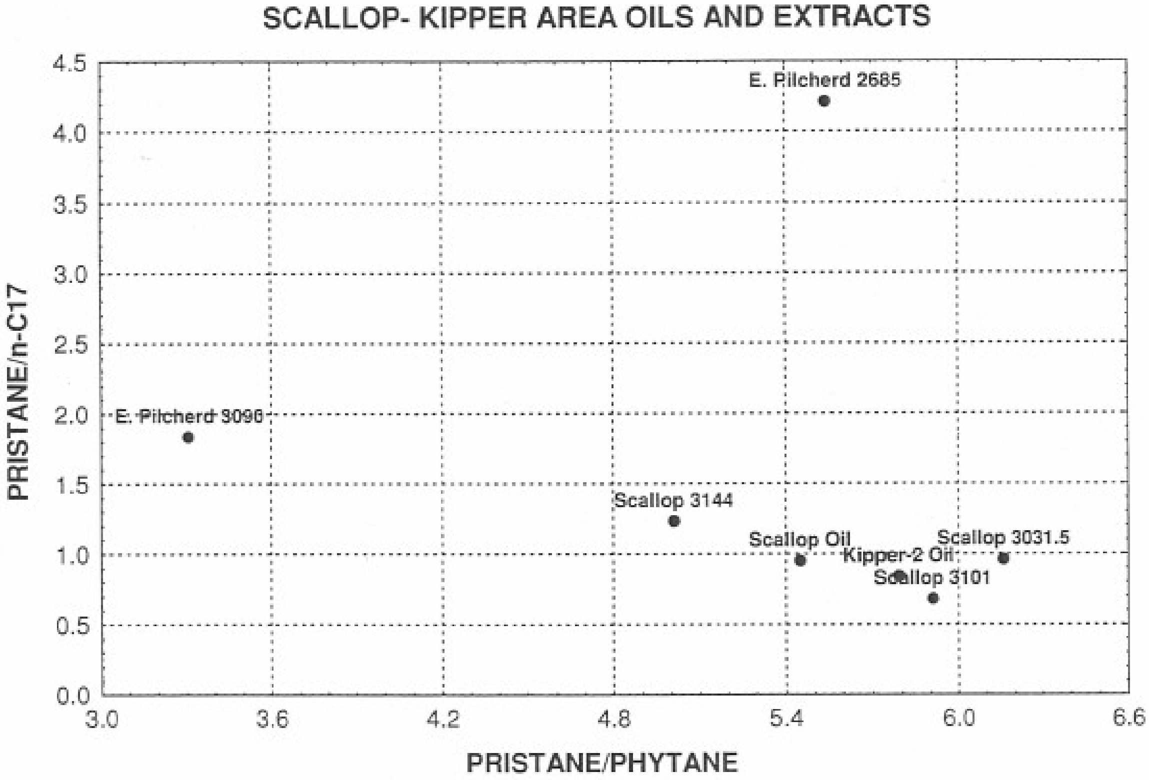


Fig. 3

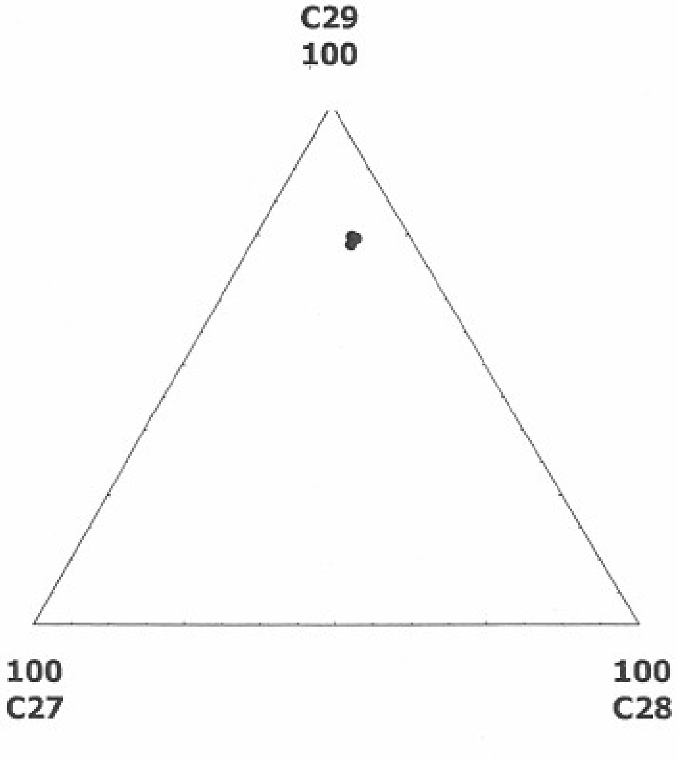


Fig. 4: Sterane Group Distribution

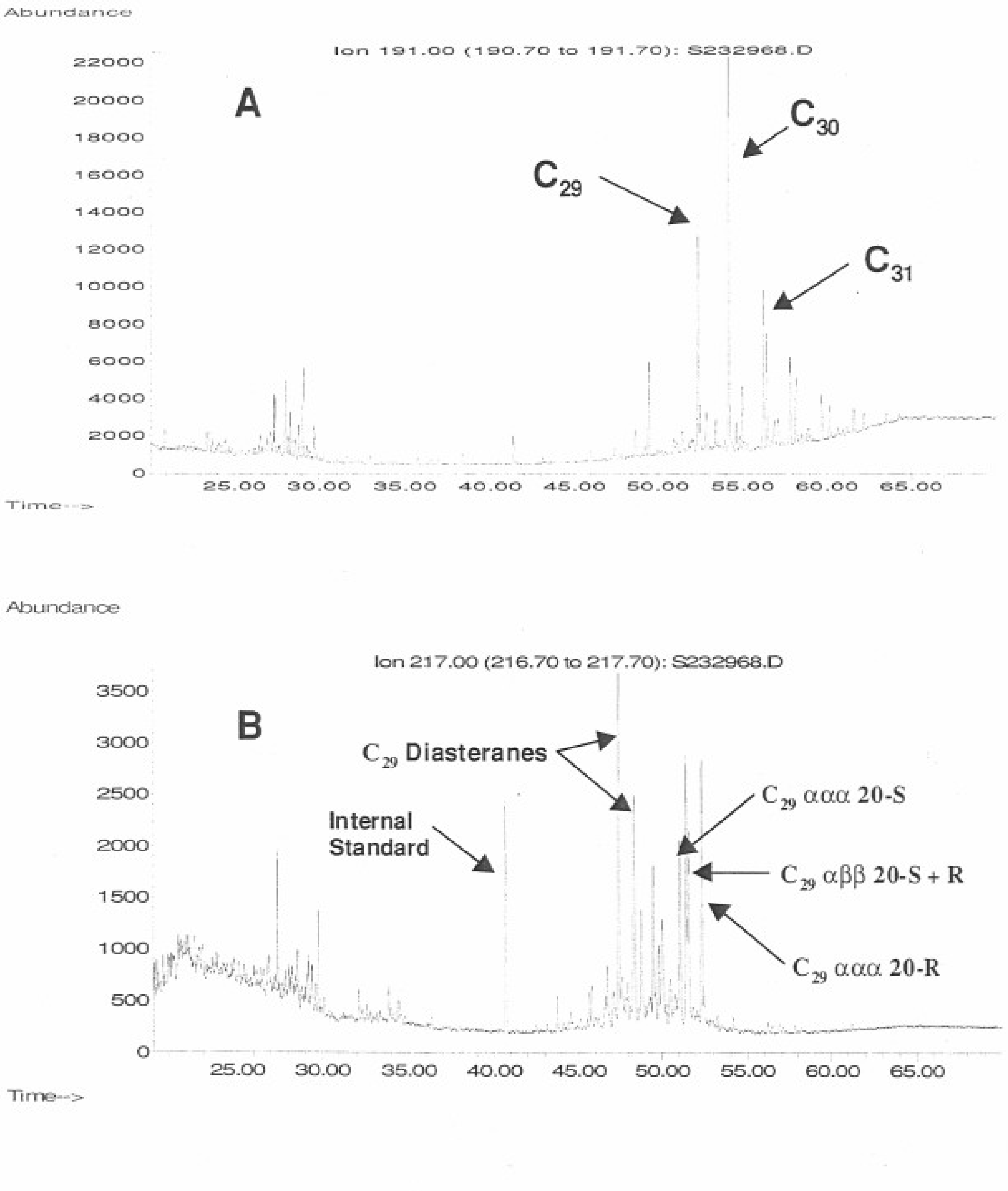


Fig 5: Scallop-1 Oil 2840 m.
A: Triterpanes
B: Steranes

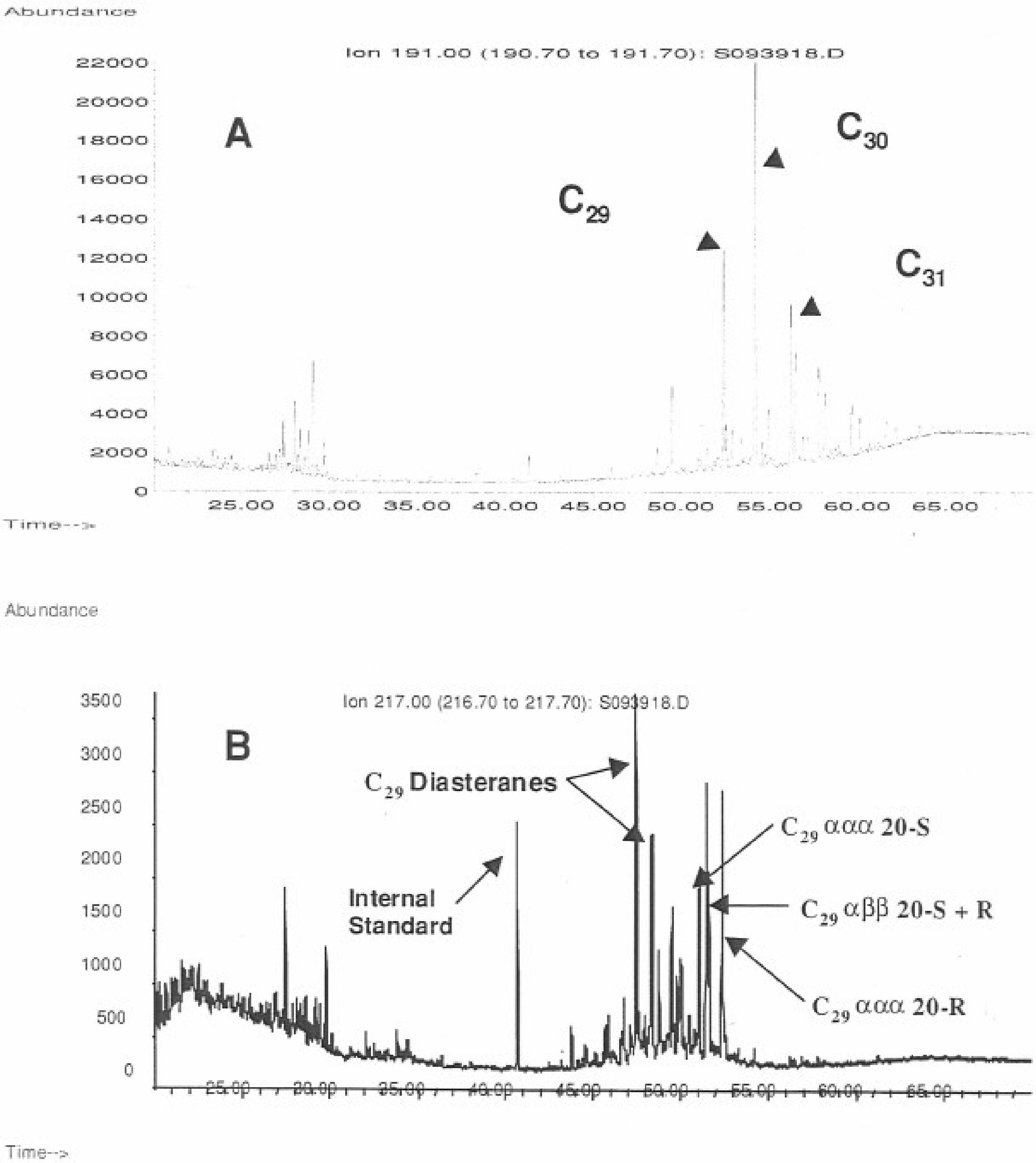


Fig 6: Kipper-2 Oil 2318 m.
A: Triterpanes
B: Steranes

COMPOUND SPECIFIC ISOTOPE RATIOS: NORMAL ALKANES

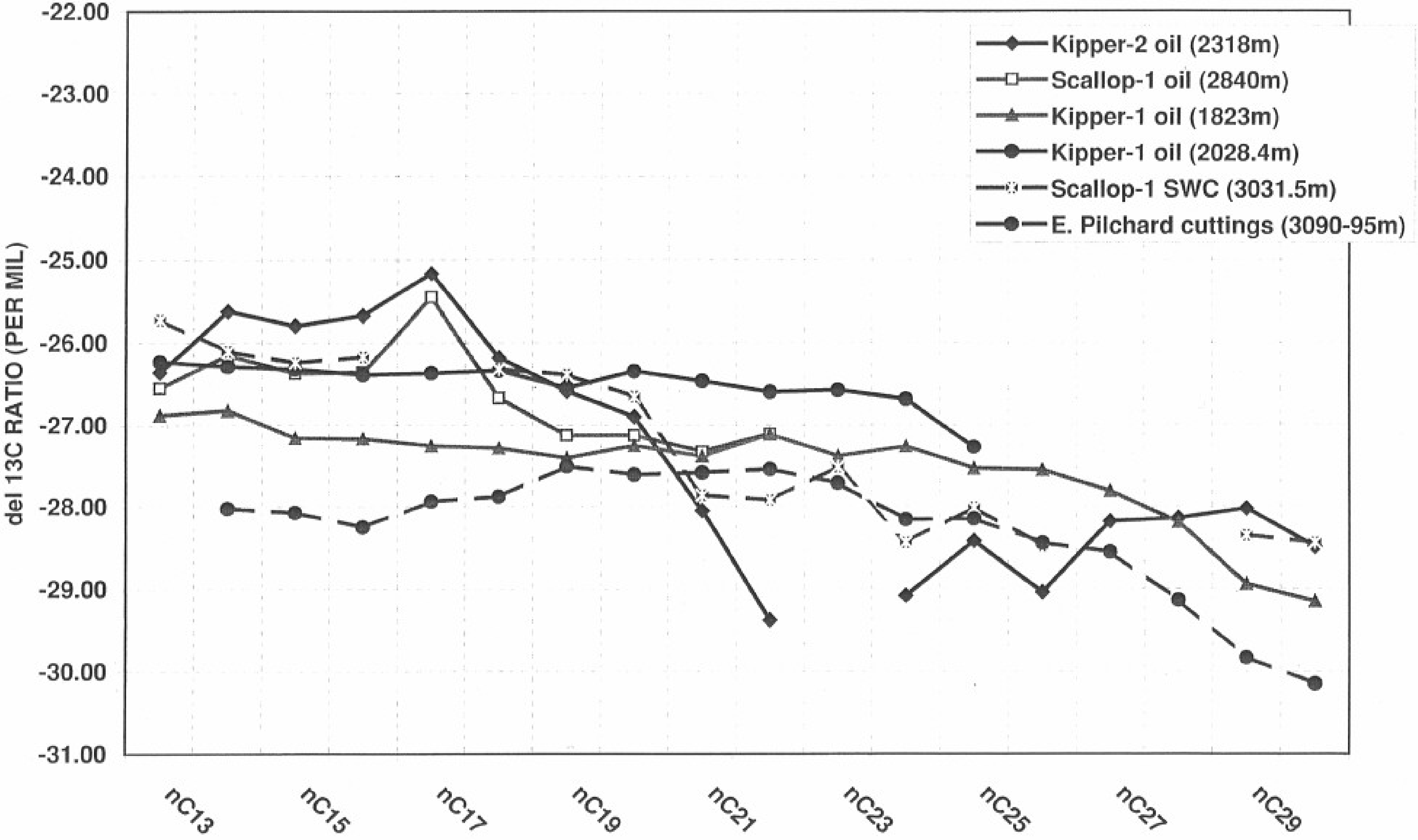


Fig. 7

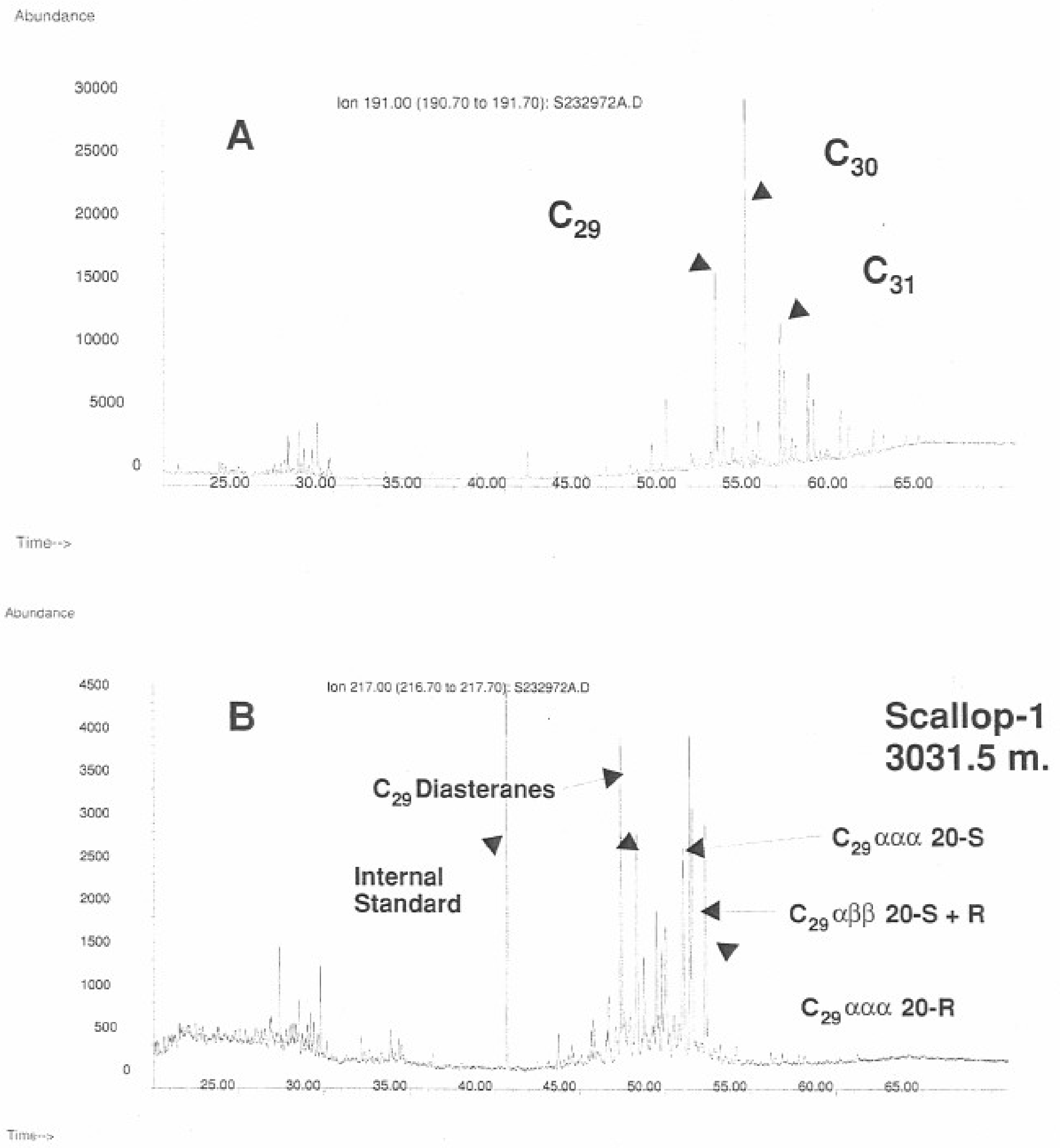
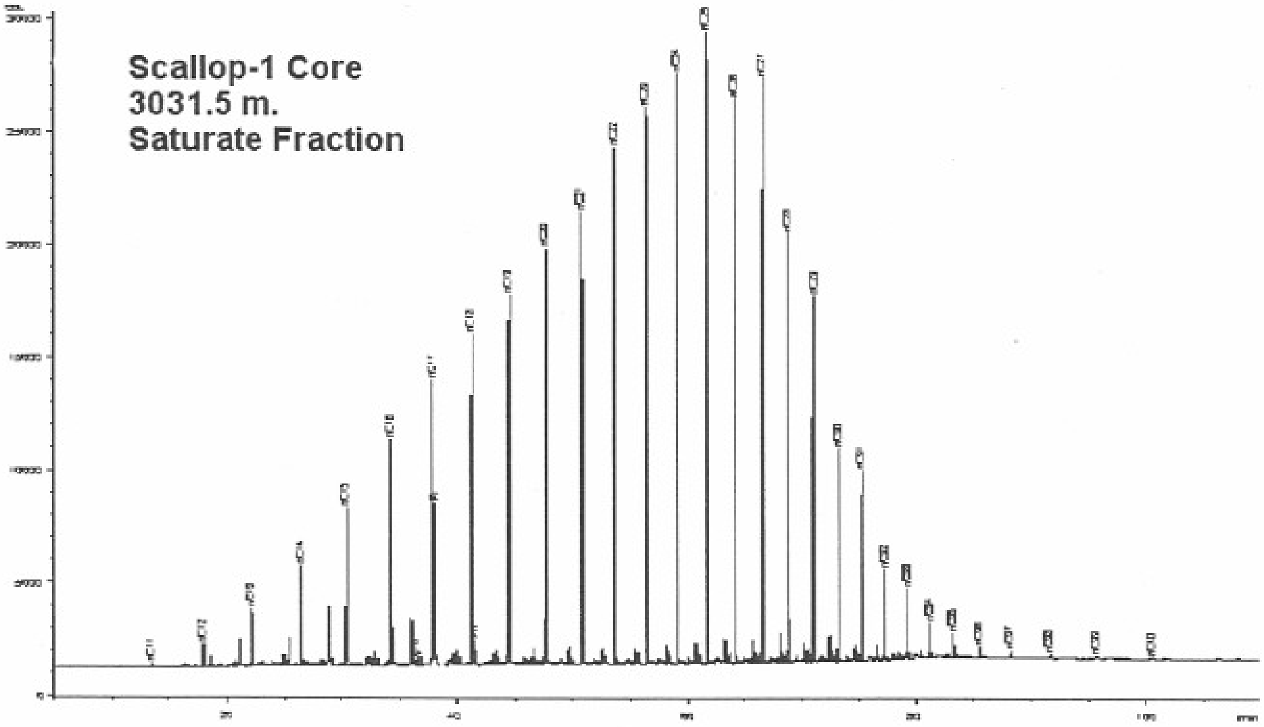


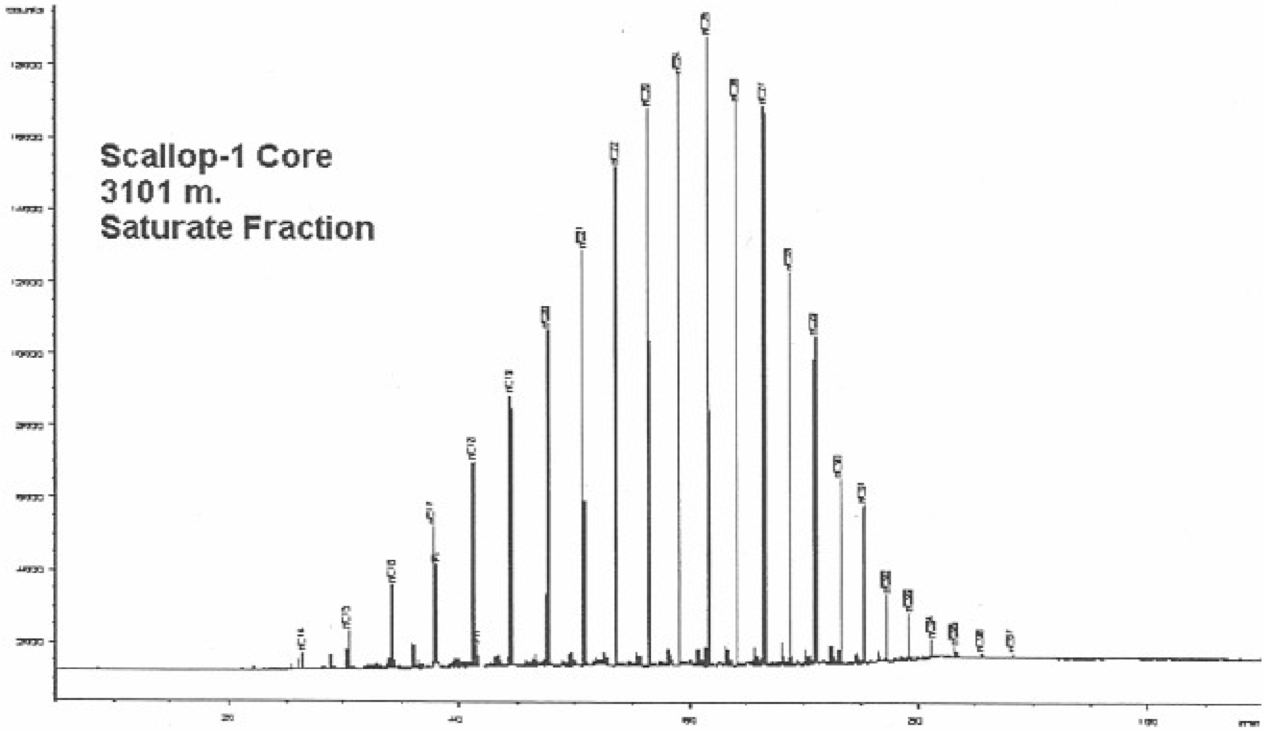
Fig. 8 Scallop-1 Extract 3031.5 m.
A: Triterpanes
B: Steranes

Fig. 9



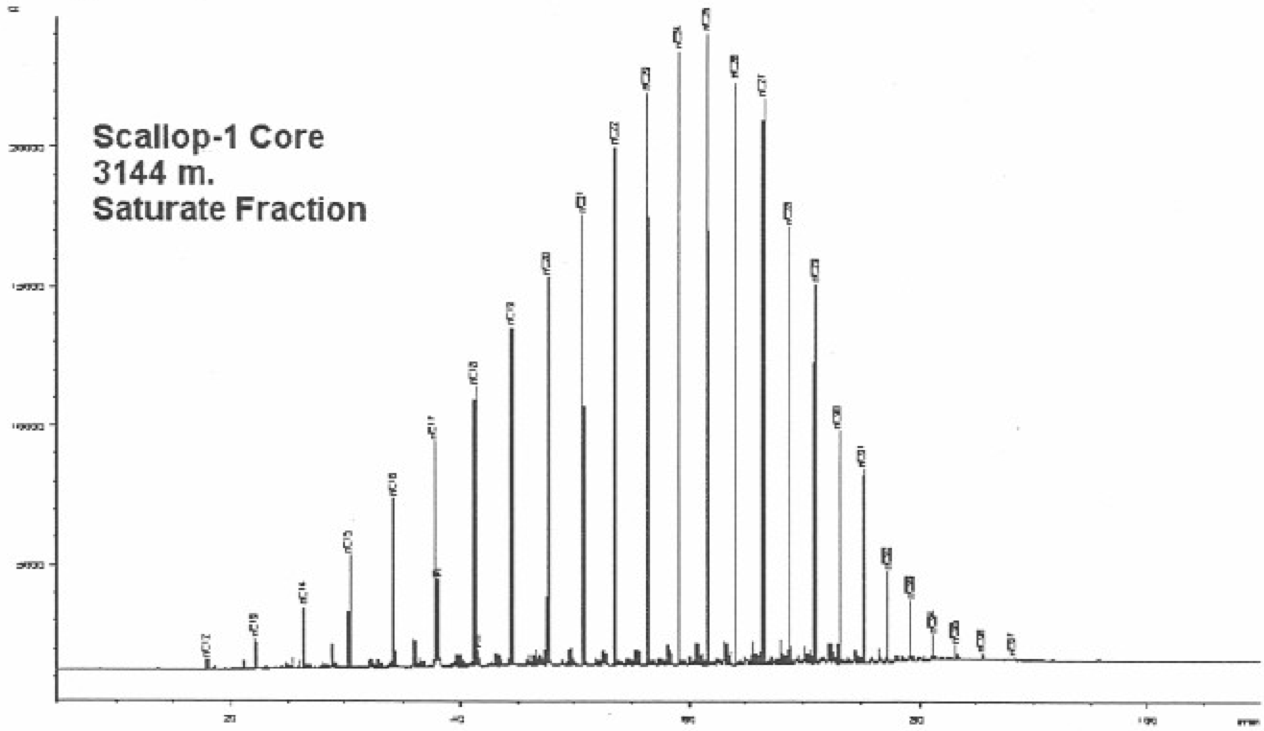
Scallop-1 Core
3031.5 m.
Saturate Fraction

Fig. 10



Scallop-1 Core
3101 m.
Saturate Fraction

Fig. 11



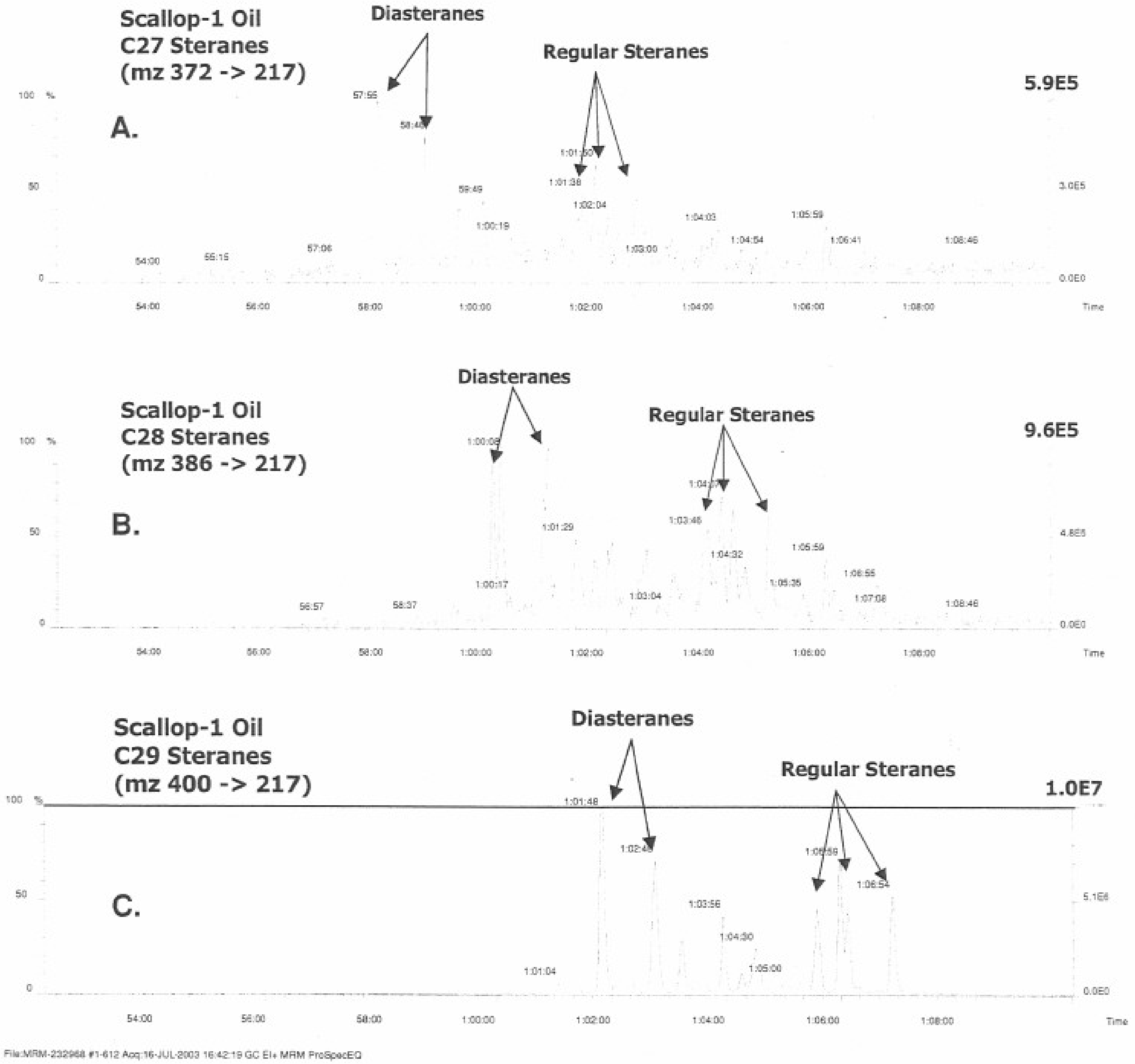
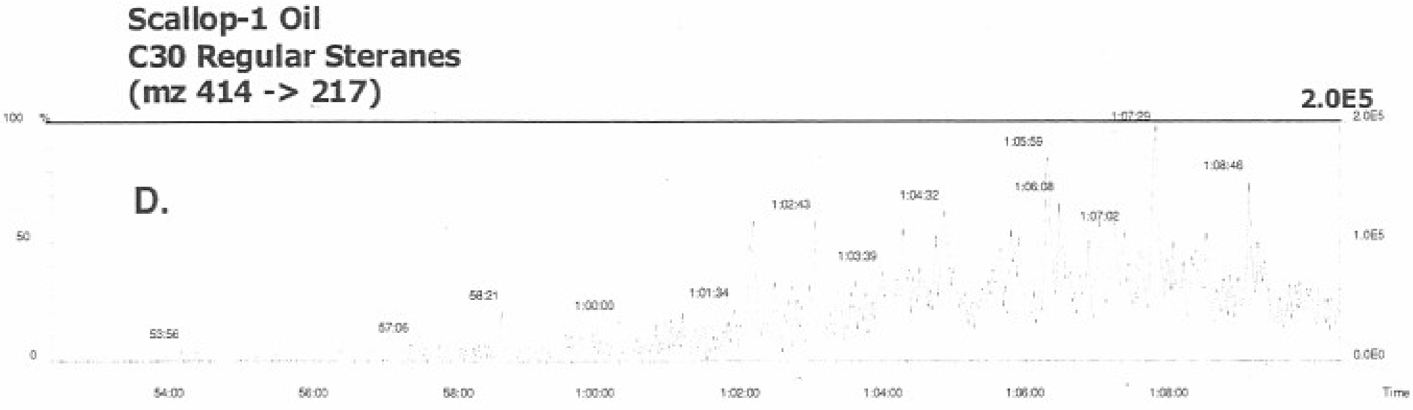


Fig. 12: GC-MS/MS data for sterane distributions

A. C27 steranes (regular + diasteranes)
B. C28 steranes (regular + diasteranes)
C. C29 steranes (regular + diasteranes)



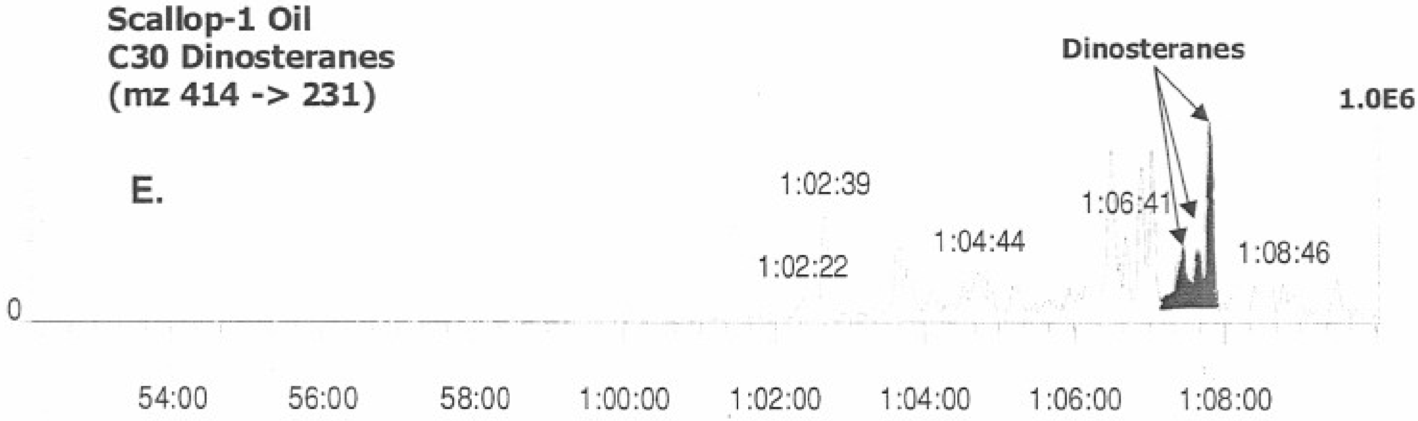


Fig. 12 (con'td) :

D: Occurrence of regular (24-n-propyl) steranes characteristic of marine organic matter
E: Occurrence of C_{30} steranes indicating dinoflagellate-derived input (lacustrine OM)

Note the large differences in concentrations, as indicated by higher maximum abundances and lower signal-to-noise ratios in the C29 steranes and dinosteranes as compared to the other species