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Reconnaissance Study of Petroleum Source-Rock Characteristics of
Core Samples from the Sisquoc and Monterey Formations in a
North-South Subsurface Transect across the Onshore Santa Maria Basin and
in Surface Sections along the Santa Barbara-Ventura Coast,
Southern California

by

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ABSTRACT

Organic and inorganic geochemical analyses were completed on 44 samples from the Sisquoc and Monterey Formations, including 37 samples from 6 wells in a north-south transect in the onshore Santa Maria basin and 7 samples from surface outcrops along the Santa Barbara coast. Determinations included major oxides, total carbon, carbonate carbon, vitrinite reflectance, thermal alteration index, elemental analysis of kerogen (C, H, N, O, S), pyrolysis assay by thermal evolution analysis-flame ionization detector, and C₄-C₇ gasoline-range hydrocarbon analysis.

Results show considerable variation in both inorganic sedimentary components and organic carbon (range, 0.6-14.7%). The kerogens in the sample set are immature and marginally mature type I and type II kerogens, and the set averages 65% amorphous material, and 35% herbaceous, humic, and inertinite particles. In terms of petroleum-source potential, the sample set is on average good to excellent. Most kerogens in the sample set exceed 1% total organic carbon (TOC), about half exceed 2%, and about a quarter exceed 5%. Nearly all samples have total hydrocarbon yield from pyrolysis assay exceeding 0.2%, and all samples have volatile hydrocarbon yield exceeding 200 ppm.

Some thermal maturity parameters have distinct trends related to maximum thermal exposure as estimated from silica diagenetic grade. With increasing maximum thermal exposure, TAI increases, Tmax increases, atomic O/C decreases, and total C₄-C₇ gasoline range hydrocarbon abundance increases. Trends related to maximum thermal exposure are indistinct or slight in values for the volatile proportion of total hydrocarbon from pyrolysis assay, atomic H/C, and vitrinite reflectance.

INTRODUCTION

The Monterey Formation in the Santa Maria and Santa Barbara-Ventura basins has received considerable attention in recent years both as an oil source and as an oil reservoir. As an oil-source, the Monterey Formation has some unusual characteristics. For example, increasing evidence suggests that most parameters widely used to judge thermal maturity of kerogen are either misleading or difficult to interpret in the Monterey Formation, partly because of compositional characteristics and partly because much Monterey oil is probably generated at levels of organic metamorphism normally considered as immature (McCulloh, 1979; Orr, 1983; Walker and others, 1983; Kruege, 1983; Petersen and Hickey, 1984, 1987). Because of its economic importance, Monterey organic geochemistry has been studied mainly by the petroleum industry, and very few data on Monterey kerogens and oils have been made available in the public domain. An area where data are especially sparse is the Santa Maria and Santa Barbara-Ventura basins. The purpose of this report is to make accessible a set of kerogen data for the area.

The report provides organic and inorganic analytical data on 44 rock samples from the Monterey Formation and overlying Sisquoc Formation of the Santa Maria and Santa Barbara-Ventura basins (Figure 1). Included are 37 samples from 6 wells comprising a north-south transect within the onshore Santa Maria basin from the Santa Maria Valley oil field to the Lompoc oil field (Figure 2; Tables 1 and 2). This transect was designed as a reconnaissance study of kerogen thermal maturity parameters in the Monterey Formation and lower part of the overlying Sisquoc Formation. Because the Monterey is relatively thin (<1500 ft or 450 m) in this area, the total range of thermal exposure within the Monterey in an individual well is relatively small - about

19-31°C, based on geothermal gradients of 40-70°C/km (French, 1940; Pisciotto, 1981). In order to cover a fuller range of thermal exposure, the study was thus based on laterally equivalent sets of samples from 6 different wells at various levels of maturity. Part of the analytical data reported here for the 37 subsurface samples was previously summarized in an abstract by Isaacs and Magoon (1984) and cited by Isaacs and Petersen (1987).

The remaining 7 samples are outcrop samples representing a small reconnaissance set of laterally equivalent strata from the transitional marl-siliceous member of the Monterey Formation in the coastal area between Point Conception and Rincon Point (Figure 3). Based on well-studied silica diagenetic patterns (Isaacs, 1982; Keller, 1984), samples represent increasing diagenetic grade as follows: Goleta Slough (opal-A), Rincon Point (opal-A + opal-CT), Gaviota East Beach (opal-CT), and Black Canyon (quartz) (Figure 3).

METHODS

Sample Selection

Subsurface samples were selected from core material previously collected from Union Oil Company and Arco Oil and Gas Company. Within each well, samples were chosen to represent the siliceous shale/mudstone of the Sisquoc Formation (where available) and a broad range of the lithotypes in the Monterey Formation; included with the Monterey are 2 fine-grained samples from the underlying Point Sal Formation. The Monterey samples should not be interpreted as lithotypes especially representative or typical of the interval from which they were sampled. Nor should average values of the samples be interpreted as average values of the sequence as a whole. Heterogeneity of composition is so marked in the Monterey Formation in this area that several hundred samples would be needed for confident determination of mean values (Isaacs, 1987).

Outcrop samples from the Santa Barbara-Ventura coastal area were selected from the transitional-marl siliceous member of the Monterey Formation, a member which has ubiquitous carbonate and on average more organic matter than the formation as a whole (Isaacs, 1983). Samples were intended to represent pairs of calcareous silica-rich rocks and calcareous silica-poor rocks. However, the two samples from Rincon Point are similar in composition (see Tables 7 and 8), and only one sample was processed from Black Canyon due to limited availability of fresh outcrops. This small set of samples is highly select and was not designed to represent average values for the Monterey Formation in the Santa Barbara-Ventura coastal area as a whole.

Sample Preparation

Samples were prepared for three different types of analysis: (1) organic analysis; (2) inorganic analysis; and (3) (not reported here) determination of bulk density and grain density. Samples were cut on a free-flowing water saw or (where friable) on a dry saw. Amounts submitted for organic analysis ranged from 138 to 330 g, and amounts for inorganic analysis from 6 to 15 g.

In comparing results from the organic and inorganic analyses, note that the two sets of analyses were not performed on powder splits of the same piece of sample, but on separate pieces of sample. Where a single piece of bulk sample was large enough, all analytical pieces (including density plugs) were cut from the same chunk and represent matching or nearly matching pieces. However, a uniform chunk of each sample was not in all cases large enough or

properly shaped to allow matching pieces for both sets of analyses. In some cases, moreover, separate chunks of sample had to be aggregated in order to obtain sufficient material (av 200 g) for the organic analyses.

The level of correspondence between the material used for inorganic analysis and the material used for organic analysis is listed in Table 2. In this table, "exact match" means that a single chunk of sample was trimmed to represent a single stratigraphic horizon and was cut vertically into pieces for the two sets of analyses so that the two pieces were as exactly matching as possible (except for any lateral differences). "Near match" means that a single chunk of sample was trimmed and cut vertically into two pieces that were almost matching, but one of the pieces included 5-10% material not included in the other piece (for example, where the bulk chunk was slightly tapered). "Part match" means that a single chunk of sample was cut into two pieces, but the bulk sample was quite irregular in shape so that the two pieces did not exactly correspond (for example, the inorganic piece may have included only half the thickness represented by the organic piece). "Similar" means that the two pieces were not cut from the same bulk chunk but represented separate pieces of rock that looked lithologically similar.

Organic Analytical Techniques

Samples in this study were processed for organic geochemical parameters along with samples in the U.S. Geological Survey's oil and gas source rock study of the National Petroleum Reserve in Alaska (NPRA) (Claypool and Magoon, 1988). Parameters determined were: total carbon (of whole rock); organic carbon (of whole rock); vitrinite reflectance; thermal alteration index (TAI); elemental composition including C, H, N, O, S, ash (of kerogen concentrate); results from pyrolysis assay by thermal evolution analysis-flame ionization detector (TEA-FID); and abundance of C₄-C₇ gasoline-range hydrocarbon compounds (of whole rock). The TEA-FID method (including results for total hydrocarbon, volatile hydrocarbon, and Tmax) is similar to Rock-Eval pyrolysis, but results are not exactly comparable.*

All organic-matter analyses were performed by Geochem Research, Inc., of Houston, Texas. The techniques used in the analysis were detailed by Claypool and Magoon (1988) except for O and S determinations. Oxygen abundance was determined by the Unterzaucher technique. Sulfur abundance was determined by the conversion of sulfur to sulfate (decomposition of organic matter by combustion in a Schoeniger flask in oxygen, with the SO₂-SO₃ mixture absorbed in aqueous hydrogen peroxide), and the sulfate was measured in 80% isopropanol by titration with Ba(ClO₄) solution using Thorin indicator.

Inorganic Analytical Techniques

A matching or similar piece of each sample was analyzed for major element abundances by X-ray fluorescence spectroscopy (XRF). These analyses were performed on undried powders by the U.S. Geological Survey's Branch of Geochemistry as described by Taggart and others (1981, 1987); identical

* In the abstract by Isaacs and Magoon (1984), values of volatile hydrocarbon and total hydrocarbon were incorrectly identified as S₁ and S₁+S₂ respectively.

Figure 1. (A) Location of Neogene basins in southern California, showing the approximate distribution of the Monterey Formation (dot pattern). After Blake and others (1978). (B) Oil and gas fields in the onshore Santa Maria basin, California. From California Division of Oil and Gas (1974).

Table 1. Well locations.

Well name	API No.	Section-Township-Range
Union Annex 1	04-083-01831	6- 7N-33W
Union SMVU		
Signal-Brown 1	04-083-02834	25-10N-34W
Union Harris A-2	04-083-04094	12- 8N-34W
Union Dome 18	04-083-02157	24- 9N-34W
Union Newlove 51	04-083-02306	25- 9N-34W
Los Nietos-Gulf	04-083-04065	11- 9N-34W
S.S.T. 25-11

Figure 2. Map and cross-section of the onshore Santa Maria basin showing well locations. Map from California Division of Oil and Gas (1974); cross-section from Krammes and Curran (1959).

Table 2. Well depths and geologic formation of Santa Maria subsurface samples. "Level of match" indicates the level of correspondence between sample pieces used for kerogen analysis and pieces used for inorganic geochemical analysis (see text for explanation). All surface samples were exactly matched.

No Well	Sample designation	Depth interval (tray)	Formation	Level of match
1 Union Annex 1	1398	1390-1415 (3)	Sisquoc	part match
2	1826	1815-1828 (2)	Sisquoc	part match
3	2609	2600-2618	Monterey	exact match
4	2753	2751-2755	Monterey	exact match
5	2928	2911-2945	Monterey	near match
6 Union Signal Brown 1	3165	3160-3170	Sisquoc	similar
7	3734	3725-3743	Monterey	exact match
8	3765	3753-3778	Monterey	part match
9	3922	3911-3933	Monterey	part match
10 Union Harris A-2	6117	6112-6122 (1&2)	Sisquoc	similar
11	8013	8006-8021 (1)	Monterey	exact match
12	8014	8006-8021 (4)	Monterey	near match
13	8805	8794-8812 (6)	Monterey	near match
14A	9512A	9509-9515 (1)	Monterey	combined for kerogen
14B	9512B	9509-9515 (1)	Monterey	
15	9513	9509-9515 (2)	Monterey	exact match
16 Union Dome 18	9774	9763-9784	Sisquoc	similar
17	9871	9868-9875	Sisquoc	similar
18	10197	10188-10205 (4)	Monterey	near match
19	10317	10310-10323 (5)	Monterey	exact match
20	10767	10757-10777 (8)	Monterey	similar
21	10952	10949-10956 (3)	Monterey	part match
22 Union Newlove 51	530	520-540	Sisquoc	similar
23	1202	1191-1216	Sisquoc	similar
24	2037	2033-2041 (4)	Monterey	similar
25	2441	2435-2447 (3)	Monterey	similar
26	2455	2447-2463 (5)	Monterey	similar
27	2788	2785-2790	Monterey	similar
28	3256	3247-3265 (1&3)	Point Sal	similar
29	3500	3491-3509 (3)	Point Sal	similar
30 Los Nietos-Gulf SST 25-11	8081	8075-8088 (3)	Monterey	part match
31	8082	8075-8088 (1)	Monterey	near match
32	8587	8581-8593 (2)	Monterey	near match
33	8698	8692-8704 (1)	Monterey	near match
34	8762	8757-8767 (2)	Monterey	part match
35	8795	8791-8799 (1)	Monterey	near match
36	9115	9106-9124	Monterey	near match
37	9155	9155	Monterey	part match

Figure 3. (A) Sample localities and (B) silica diagenetic grade in the transitional marl-siliceous member of the Monterey Formation along the Santa Barbara-Ventura coast. From Keller (1984); based partly on Isaacs (1980).

Table 3. Carbon abundance and elemental composition of kerogen, analyzed by Geochem Research, Inc. Abundances of total carbon and organic carbon are reported as a weight fraction of the whole rock, and elemental analyses as a fraction of the kerogen concentrate. Except for methods used to determined O and S (see text), analytical methods were described by Claypool and Magoon (1988).

Sample Number	Well	Depth	Total Carbon %	Organic Carbon %	Elemental Analysis (%)					Atomic ratios				
					C	H	N	O	S	Ash	H/C	O/C	C/N	S/C
1	Union Annex #1	1398	1.62	1.38	44.43	4.75	2.02	9.86	-	2.44	1.27	0.17	25.66	-
2	Union Annex #1	1826	2.11	2.04	53.40	5.44	2.65	9.79	4.74	14.03	1.21	0.14	23.51	0.03
3	Union Annex #1	2609	1.46	1.24	51.97	5.59	2.13	-	-	13.04	1.28	-	28.46	-
4	Union Annex #1	2753	1.74	1.62	67.16	7.35	2.65	7.49	-	2.60	1.30	0.08	29.56	-
5	Union Annex #1	2928	6.70	4.36	49.84	5.11	0.90	4.14	8.38	7.07	1.22	0.06	64.60	0.06
6	Union Signal Brown	3165	4.69	4.59	56.86	5.36	1.17	5.51	11.05	7.13	1.12	0.07	56.69	0.07
7	Union Signal Brown	3734	8.51	7.99	63.13	6.83	1.81	6.69	11.25	3.59	1.29	0.08	40.69	0.07
8	Union Signal Brown	3765	19.19	10.10	55.01	5.92	3.12	6.44	-	11.15	1.28	0.09	20.57	-
9	Union Signal Brown	3922	17.11	13.10	62.51	6.83	1.97	5.53	10.08	5.47	1.30	0.07	37.02	0.06
10	Union Harris A-2	6117	0.86	0.58	36.00	3.68	1.81	-	-	15.58	1.22	-	23.20	-
11	Union Harris A-2	8013	1.94	1.83	56.70	6.21	1.87	3.18	-	5.85	1.30	0.04	35.37	-
12	Union Harris A-2	8014	2.60	2.39	40.26	4.16	1.75	3.42	-	14.98	1.23	0.06	26.84	-
13	Union Harris A-2	8805	3.95	1.28	37.27	4.07	1.00	2.13	13.45	21.63	1.30	0.04	43.48	0.14
14	Union Harris A-2	9512	3.69	1.73	57.16	4.92	1.99	2.76	22.36	11.68	1.03	0.04	33.51	0.15
15	Union Harris A-2	9513	8.33	1.17	47.06	4.11	1.33	3.61	-	15.37	1.04	0.06	41.28	-
16	Union Dome 18	9774	1.06	0.75	38.92	3.86	1.71	3.21	7.62	16.14	1.18	0.06	26.55	0.07
17	Union Dome 18	9671	2.58	1.03	44.87	4.85	1.25	2.88	11.04	18.17	1.29	0.05	41.87	0.09
18	Union Dome 18	10197	2.83	1.60	42.13	4.53	1.77	2.82	13.26	22.37	1.28	0.05	27.77	0.12
19	Union Dome 18	10317	3.44	1.84	38.06	3.99	1.29	2.24	12.25	21.14	1.25	0.04	34.42	0.12
20	Union Dome 18	10767	3.29	3.20	37.47	3.86	1.34	3.16	15.45	39.50	1.23	0.06	32.62	0.15
21	Union Dome 18	10952	3.16	2.40	40.45	3.50	1.86	3.47	-	16.52	1.03	0.06	25.37	-
22	Union Newlove 51	530	7.19	6.37	59.95	7.18	0.96	4.02	11.00	10.81	1.43	0.05	72.85	0.07
23	Union Newlove 51	1202	1.18	0.58	42.52	4.08	2.49	7.55	10.64	15.80	1.14	0.13	19.92	0.09
24	Union Newlove 51	2037	6.81	4.93	49.73	5.66	1.77	6.52	9.80	11.19	1.36	0.10	32.77	0.07
25	Union Newlove 51	2441	15.34	14.69	62.27	6.92	1.95	4.10	13.21	7.67	1.32	0.05	37.25	0.08
26	Union Newlove 51	2455	11.40	3.54	55.30	6.22	1.11	3.48	13.13	12.75	1.34	0.05	58.12	0.09
27	Union Newlove 51	2788	4.43	1.60	42.16	4.50	1.35	3.72	13.35	21.75	1.27	0.07	36.43	0.12
28	Union Newlove 51	3256	5.09	1.87	44.28	4.83	1.08	4.19	13.62	18.62	1.30	0.07	47.83	0.12
29	Union Newlove 51	3500	1.87	1.47	48.35	4.93	1.99	4.87	6.99	15.33	1.21	0.08	28.34	0.05

Table 3. continued

Sample Number	Well	Depth	Total Carbon %	Organic Carbon %	C	H	N	O	S	Ash	H/C	O/C	C/N	S/C
30	SST 25-11	8081	3.10	2.01	48.32	5.28	1.38	3.37	15.23	21.53	1.30	0.05	40.85	0.12
31	SST 25-11	8082	2.29	2.07	46.59	5.06	1.73	3.05	-	13.30	1.29	0.05	31.42	-
32	SST 25-11	8587	11.27	0.66	41.82	4.51	0.62	3.13	-	18.97	1.28	0.06	78.68	-
33	SST 25-11	8698	10.42	2.89	57.25	5.46	1.30	4.25	12.71	14.49	1.14	0.06	51.37	0.08
34	SST 25-11	8762	5.99	1.22	39.71	4.17	2.18	2.12	12.72	18.83	1.25	0.04	21.25	0.12
35	SST 25-11	8795	10.28	2.59	20.17	2.13	0.92	1.87	5.19	10.81	1.26	0.07	25.57	0.10
36	SST 25-11	9115	8.48	4.29	50.32	4.62	1.45	2.79	16.76	24.05	1.09	0.04	40.48	0.12
37	SST 25-11	9155	9.08	1.13	38.53	3.71	1.18	3.00	-	23.58	1.15	0.06	38.09	-
38	UGO-2B-1B	surface	8.06	5.98	25.40	3.14	2.70	8.18	4.09	4.75	1.47	0.24	10.97	0.06
39	UGO-2B-11A	surface	4.64	3.38	35.63	4.10	2.00	9.57	7.32	5.02	1.37	0.20	20.78	0.08
40	RIN-K-1	surface	10.31	6.76	30.55	3.46	1.63	7.22	12.11	10.85	1.35	0.18	21.86	0.15
41	RIN-K-3	surface	14.42	10.44	51.68	5.64	3.52	7.08	10.68	9.13	1.30	0.10	17.13	0.08
42	GE-K-2B	surface	11.45	6.97	59.28	6.29	2.86	6.85	12.23	7.60	1.26	0.09	24.18	0.08
43	GE-K-3	surface	8.44	4.76	51.66	5.54	3.47	5.83	7.59	7.31	1.28	0.08	17.37	0.06
44	BLK-K-1	surface	8.17	5.05	32.82	3.77	0.90	3.54	5.52	8.09	1.37	0.08	42.54	0.06

Table 4. Visual identification of kerogen, mean and mode values for vitrinite reflectance, thermal alteration index (TAI), data from pyrolysis assay (TEA-FID), and total abundance of C₄-C₇ gasoline-range hydrocarbons, analyzed by Geochem Research, Inc. Total hydrocarbon and volatile hydrocarbon are reported as a weight fraction of the whole rock, and C₄-C₇ gasoline-range hydrocarbons as a volume fraction of the whole rock. Table 5 details gasoline-range compounds, and Table 6 lists vitrinite reflectance observations. Analytical methods were described by Claypool and Magoon (1988).

Sample Number	Depth	Visual kerogen Identification					Pyrolysis assay (TEA-FID)							Total C4-C7 ppm
		Amorphous %	Herbaceous %	Humic %	Inertinite %	Ro, % Mean	Mode	TAI	Total hydro-carbon %	Volatile hydro-carbon ppm	Tmax, C	Volatile/ total hydro-carbon		
1	1398	80	0	20	0	0.34	0.31	1.1	0.37	489	421	0.13	75	
2	1826	67	17	17	0	0.33	0.31	1.1	0.54	900	424	0.17	47	
3	2609	67	17	17	0	0.37	0.31	1.1	0.30	410	431	0.14	99	
4	2753	80	0	20	0	-	-	1.1	0.47	595	428	0.13	59	
5	2928	99	0	0	0	0.32	0.31	1.1	2.15	3357	435	0.16	85	
6	3165	99	0	0	0	-	-	1.1	2.28	4894	425	0.21	85	
7	3734	99	0	0	0	-	-	1.3	4.80	6059	436	0.13	56	
8	3765	99	0	0	0	-	-	1.3	6.63	4994	447	0.08	252	
9	3922	99	0	0	0	-	-	1.5	8.08	9262	442	0.11	149	
10	6117	57	29	14	0	0.32	0.31	1.8	0.14	186	449	0.13	253	
11	8013	80	20	0	0	-	-	2.1	0.57	1688	447	0.30	223	
12	8014	80	20	0	0	-	-	2.1	0.94	2050	452	0.22	139678	
13	8805	44	44	11	0	0.33	0.31	2.3	0.63	1387	465	0.22	3380	
14	9512	50	38	13	0	-	-	2.5	0.55	850	467	0.15	35566	
15	9513					0.38	0.31	2.5	0.42	834	468	0.20	50783	
16	9774	36	36	18	9	0.37	0.31	2.3	0.22	314	453	0.14	11542	
17	9871	40	40	10	10	0.36	0.31	2.3	0.44	605	454	0.14	28497	
18	10197	67	0	17	17	0.38	0.31	2.3	0.73	1113	460	0.15	10560	
19	10317	67	0	17	17	-	-	2.3	0.78	1088	462	0.14	4258	
20	10767	36	36	18	9	0.45	0.51	2.3	1.26	867	466	0.07	82788	
21	10952	44	44	11	0	0.60	0.69	2.3	0.76	1306	469	0.17	28451	
22	530	99	0	0	0	0.21	0.31	2.3	4.81	11974	455	0.25	224	
23	1202	57	29	14	0	0.35	0.31	2.3	0.10	231	451	0.23	108	
24	2037	99	0	0	0	-	-	1.1	1.52	1946	439	0.13	98	
25	2441	99	0	0	0	-	-	1.1	9.76	9502	437	0.10	186	
26	2455	44	44	11	0	-	-	1.1	2.16	2573	437	0.12	409	
27	2788	40	40	10	10	0.31	0.31	1.1	0.80	885	438	0.11	241	
28	3256	40	40	10	10	-	-	1.3	1.11	2078	448	0.19	179	
29	3500	44	22	22	11	0.41	0.47	1.3	0.61	950	450	0.16	114	

Table 4. continued

Sample Number	Depth	Visual kerogen identification				Ro, % Mean	Mode	TAI	Pyrolysis assay (TEA-FID)					Total C4-C7 ppm
		Amorphous %	Herbaceous %	Humic %	Inertinite %				Total hydro-carbon %	Volatile hydro-carbon ppm	Tmax, C	Volatile/ total hydro-carbon		
30	8081	67	0	17	17	-	-	2.0	1.12	1449	452	0.13	879	
31	8082	99	0	0	0	-	-	2.0	1.07	1133	451	0.11	5833	
32	8587	40	40	10	10	0.30	0.31	2.1	0.33	761	457	0.23	3400	
33	8698	44	44	11	0	0.31	0.31	2.3	1.48	1328	467	0.09	5126	
34	8762	50	25	13	13	0.33	0.31	2.3	0.58	973	461	0.17	1176	
35	8795	44	44	11	0	0.33	0.31	2.3	1.23	1130	464	0.09	36413	
36	9115	40	40	10	10	0.37	0.31	2.3	1.74	803	466	0.05	7756	
37	9155	44	44	11	0	0.38	0.31	2.3	0.50	1062	459	0.21	4818	
38	surface	67	17	17	0	0.21	0.11	1.1	2.36	2357	445	0.10	191	
39	surface	80	20	0	0	0.28	0.31	1.1	1.72	2060	447	0.12	534	
40	surface	67	17	17	0	0.24	0.31	1.5	3.25	2202	443	0.07	230	
41	surface	50	50	0	0	0.24	0.31	1.7	5.41	7496	438	0.14	172	
42	surface	50	50	0	0	0.33	0.31	1.7	3.45	1803	446	0.05	82	
43	surface	57	29	14	0	-	-	1.7	2.39	1047	446	0.04	209	
44	surface	67	33	0	0	-	-	1.5	2.75	1808	435	0.07	376	

Table 5. Abundance of C₄ to C₇ gasoline range hydrocarbon compounds, analyzed by Geochem Research, Inc. Each compound is given as a weight percent of the total. Analytical techniques were described by Claypool and Magoon (1988).

Sample number	Well	Depth	Iso butane	N- Butane	Neo pentane	Iso pentane	N- pentane	2,2-Di methyl butane	Cyclo pentane	2,3-Di methyl butane
1	Union Annex #1	1398	16.2	54.1	0.0	4.8	6.7	0.1	1.6	0.5
2	Union Annex #1	1826	15.6	52.0	0.0	5.4	6.9	0.1	1.8	0.3
3	Union Annex #1	2609	20.7	35.9	0.0	8.5	0.7	0.1	1.9	0.7
4	Union Annex #1	2753	9.7	42.2	0.0	7.9	11.0	0.1	1.8	0.6
5	Union Annex #1	2928	14.6	48.8	0.0	7.4	12.7	0.0	1.6	0.4
6	Union Signal Brown	3165	14.0	51.8	0.0	4.8	12.3	0.1	1.7	0.4
7	Union Signal Brown	3734	11.8	39.5	0.0	8.4	12.0	0.2	1.7	0.6
8	Union Signal Brown	3765	9.1	27.9	0.0	7.0	10.6	0.3	4.2	0.8
9	Union Signal Brown	3922	15.1	27.9	0.0	10.9	7.5	0.2	1.2	0.6
10	Union Harris A-2	6117	12.6	37.4	0.0	9.0	10.4	0.1	2.1	0.5
11	Union Harris A-2	8013	16.3	45.4	0.0	8.3	7.7	0.1	1.3	0.4
12	Union Harris A-2	8014	11.2	44.0	0.0	10.4	11.0	0.0	1.2	0.2
13	Union Harris A-2	8805	24.6	35.1	0.0	12.4	9.9	0.1	0.7	0.5
14	Union Harris A-2	9512	27.6	33.5	0.0	12.4	8.5	0.0	0.3	1.0
15	Union Harris A-2	9513	15.6	27.1	0.0	12.3	10.2	0.1	1.1	1.0
16	Union Dome 18	9774	24.0	11.3	0.0	8.3	12.7	0.1	0.9	0.6
17	Union Dome 18	9871	2.7	14.3	0.0	8.7	12.8	0.1	1.1	0.6
18	Union Dome 18	10197	3.3	7.6	0.0	7.0	5.3	0.1	1.0	0.9
19	Union Dome 18	10317	12.8	26.2	0.0	7.4	6.5	0.1	0.9	0.6
20	Union Dome 18	10767	13.2	46.7	0.0	9.9	10.6	0.1	1.4	0.4
21	Union Dome 18	10952	14.0	27.2	0.0	12.7	11.1	0.2	1.4	0.8
22	Union Newlove 51	530	7.4	30.2	0.0	5.6	18.7	0.2	2.9	0.3
23	Union Newlove 51	1202	9.0	43.2	0.0	4.8	24.9	0.0	1.6	0.3
24	Union Newlove 51	2037	14.9	24.8	0.0	11.7	24.4	0.1	1.3	0.6
25	Union Newlove 51	2441	2.2	2.7	0.0	7.2	5.5	0.2	1.9	1.2
26	Union Newlove 51	2455	15.2	26.8	0.0	14.2	13.7	0.1	1.2	0.7
27	Union Newlove 51	2788	12.1	26.6	0.0	9.3	23.5	0.1	1.1	0.7
28	Union Newlove 51	3256	11.7	32.3	0.0	9.3	12.5	0.2	2.2	0.7
29	Union Newlove 51	3500	7.3	25.4	0.0	5.7	36.5	0.1	1.7	0.4

Table 5. continued

Sample number	Well	Depth	2-Methyl pentane	3-Methyl pentane	N-Hexane	Methyl cyclopentane	2,2-Dimethyl pentane	Benzene	2,4-Dimethyl pentane	2,2,3-Trimethyl butane
1	Union Annex #1	1398	1.4	4.4	3.0	0.5	0.1	0.3	0.3	0.3
2	Union Annex #1	1826	1.3	44.3	3.1	0.5	0.1	0.3	0.3	0.3
3	Union Annex #1	2609	2.4	4.8	3.8	1.6	0.1	0.2	0.4	0.2
4	Union Annex #1	2753	2.4	4.5	3.2	2.6	0.1	0.1	0.4	0.2
5	Union Annex #1	2928	1.3	3.7	2.5	0.8	0.0	0.1	0.2	0.1
6	Union Signal Brown	3165	1.3	3.4	2.7	0.7	0.1	0.4	0.3	0.3
7	Union Signal Brown	3734	2.7	3.8	4.2	1.0	0.1	0.4	0.4	0.4
8	Union Signal Brown	3765	2.4	3.0	3.5	10.3	0.0	0.3	0.1	0.0
9	Union Signal Brown	3922	3.8	3.1	4.2	3.4	0.1	1.0	0.1	0.0
10	Union Harris A-2	6117	2.4	0.5	3.5	3.4	0.1	0.1	0.2	0.1
11	Union Harris A-2	8013	2.1	2.8	2.5	2.7	0.1	0.2	0.2	0.1
12	Union Harris A-2	8014	2.4	2.1	2.5	3.9	0.0	0.0	0.0	0.0
13	Union Harris A-2	8805	3.0	2.4	2.9	1.7	0.0	0.1	0.1	0.0
14	Union Harris A-2	9512	3.2	2.9	3.1	1.1	0.0	0.1	0.1	0.0
15	Union Harris A-2	9513	5.1	4.0	5.4	3.1	1.1	0.2	0.1	0.0
16	Union Dome 18	9774	5.6	5.3	7.1	7.8	0.0	0.0	0.2	0.0
17	Union Dome 18	9871	5.0	4.7	6.7	7.3	0.1	0.0	0.2	0.0
18	Union Dome 18	10197	5.9	5.8	5.9	8.6	0.1	0.0	0.3	0.0
19	Union Dome 18	10317	3.1	3.0	3.3	4.6	0.1	0.1	0.2	0.0
20	Union Dome 18	10767	2.6	1.8	2.6	3.1	0.0	0.1	0.1	0.0
21	Union Dome 18	10952	4.7	3.3	4.2	4.2	0.1	0.1	0.2	0.0
22	Union Newlove 51	530	1.8	3.0	3.2	6.5	0.1	0.8	0.2	0.1
23	Union Newlove 51	1202	1.6	3.9	3.1	0.9	0.0	0.3	0.3	0.2
24	Union Newlove 51	2037	2.7	2.7	2.7	2.8	0.1	0.2	0.1	0.1
25	Union Newlove 51	2441	6.3	5.4	4.6	11.6	0.1	0.8	0.3	0.0
26	Union Newlove 51	2455	3.9	3.2	3.6	3.5	0.0	0.3	0.1	0.0
27	Union Newlove 51	2788	3.4	3.1	3.4	2.9	0.1	0.2	0.2	0.1
28	Union Newlove 51	3256	3.1	6.1	4.1	2.3	0.1	0.3	0.5	0.2
29	Union Newlove 51	3500	1.7	4.5	3.5	1.8	0.1	0.6	0.6	0.3

Table 5. continued

Sample number	Well	Depth	Cyclo hexane	3,3-Di methyl pentane	1,1-Di methyl cyclo pentane	2-Methyl hexane	2,3-Di methyl pentane	1,CIS-3-Dimethyl cyclo pentane	3-methyl hexane	1,TRANS-3-Dimethyl cyclo pentane
1	Union Annex #1	1398	0.6	0.1	0.1	0.3	0.1	0.1	0.5	0.1
2	Union Annex #1	1826	0.8	0.1	0.1	0.5	0.1	0.1	0.5	0.1
3	Union Annex #1	2609	1.0	0.1	0.4	0.8	0.4	0.8	1.0	0.6
4	Union Annex #1	2753	1.2	0.2	0.4	0.6	0.6	0.8	1.0	0.6
5	Union Annex #1	2928	0.6	0.1	0.1	0.3	0.3	0.2	0.6	0.1
6	Union Signal Brown	3165	0.7	0.1	0.1	0.3	0.4	0.1	0.6	0.1
7	Union Signal Brown	3734	0.8	0.4	0.4	0.6	1.0	0.4	1.0	0.2
8	Union Signal Brown	3765	3.6	0.0	0.4	0.4	0.7	1.8	0.8	1.6
9	Union Signal Brown	3922	3.8	0.1	0.4	1.4	0.6	0.7	1.4	0.7
10	Union Harris A-2	6117	1.2	0.1	0.1	0.6	0.3	1.1	1.0	0.8
11	Union Harris A-2	8013	0.8	0.1	0.1	0.5	0.3	0.8	0.8	0.6
12	Union Harris A-2	8014	0.8	0.0	0.1	0.5	0.2	1.4	0.8	1.0
13	Union Harris A-2	8805	0.5	0.0	0.1	0.7	0.4	0.3	1.0	0.2
14	Union Harris A-2	9512	0.5	0.0	0.1	0.8	0.5	0.2	1.4	0.2
15	Union Harris A-2	9513	2.2	0.0	0.2	1.4	0.7	0.4	2.7	0.4
16	Union Dome 18	9774	2.3	0.0	0.6	1.8	0.8	3.2	2.9	2.8
17	Union Dome 18	9871	2.5	0.0	0.7	2.2	0.5	3.0	3.6	1.8
18	Union Dome 18	10197	3.7	0.1	0.7	3.5	0.9	4.2	4.6	2.9
19	Union Dome 18	10317	2.3	0.0	0.5	1.7	0.8	2.3	2.5	2.0
20	Union Dome 18	10767	1.3	0.0	0.2	0.4	0.2	0.6	0.5	0.5
21	Union Dome 18	10952	3.3	0.1	0.6	1.0	0.4	0.8	1.3	0.8
22	Union Newlove 51	530	3.2	0.1	0.2	0.3	0.4	1.1	0.7	1.1
23	Union Newlove 51	1202	0.7	0.1	0.1	0.2	0.3	0.1	0.6	0.1
24	Union Newlove 51	2037	1.6	0.1	0.2	0.4	0.7	0.7	0.7	0.6
25	Union Newlove 51	2441	8.2	0.1	1.1	2.9	1.0	3.1	5.1	1.3
26	Union Newlove 51	2455	1.5	0.0	0.2	0.9	0.5	0.8	1.4	0.7
27	Union Newlove 51	2788	1.6	0.1	0.3	1.0	0.4	0.7	1.3	0.6
28	Union Newlove 51	3256	1.9	0.1	0.3	0.9	0.5	0.6	1.2	0.5
29	Union Newlove 51	3500	1.1	0.1	0.2	0.4	0.2	0.6	0.7	0.4

Table 5. continued

Sample number	Well	Depth	1,TRANS-2 -Dimethyl cyclo pentane	3-Ethyl pentane	2,2,4-Tri methyl pentane	N- Heptane	1,CIS-2- Dimethyl cyclo pentane	Methyl cyclo hexane	1,1,3- Tri methyl cyclo pentane
1	Union Annex #1 1398		0.5	0.8	0.2	1.0	0.0	0.8	0.0
2	Union Annex #1 1826		0.5	0.8	0.5	1.5	0.1	1.0	0.1
3	Union Annex #1 2609		0.7	0.7	0.4	1.1	0.1	0.7	0.4
4	Union Annex #1 2753		2.0	0.8	0.4	1.2	0.4	1.4	0.4
5	Union Annex #1 2928		0.9	0.6	0.4	0.8	0.1	0.5	0.1
6	Union Signal Brown 3165		0.6	0.6	0.6	0.6	0.1	0.4	0.1
7	Union Signal Brown 3734		0.6	0.8	1.3	1.7	0.2	0.6	0.2
8	Union Signal Brown 3765		4.2	0.1	0.1	1.0	0.7	2.7	0.1
9	Union Signal Brown 3922		1.9	0.2	0.0	2.2	0.2	4.8	0.4
10	Union Harris A-2 6117		2.3	0.9	0.2	1.0	0.4	2.1	0.2
11	Union Harris A-2 8013		2.2	0.5	0.2	0.9	0.3	1.3	0.2
12	Union Harris A-2 8014		3.0	0.1	0.0	0.8	0.4	1.3	0.2
13	Union Harris A-2 8805		0.8	0.1	0.0	1.0	0.2	0.7	0.2
14	Union Harris A-2 9512		0.3	0.1	0.0	1.2	0.1	0.6	0.0
15	Union Harris A-2 9513		0.5	0.2	0.0	2.5	0.2	1.9	0.1
16	Union Dome 18 9774		7.7	0.4	0.0	3.4	1.0	8.2	1.3
17	Union Dome 18 9871		5.4	0.2	0.0	3.6	0.8	9.1	1.6
18	Union Dome 18 10197		11.0	0.5	0.0	4.5	1.7	7.1	0.8
19	Union Dome 18 10317		7.1	0.4	0.0	2.8	1.2	5.1	0.6
20	Union Dome 18 10767		1.2	0.1	0.0	0.7	0.2	1.2	0.2
21	Union Dome 18 10952		1.7	0.1	0.0	1.6	0.2	3.2	0.4
22	Union Newlove 51 530		2.9	0.3	0.1	1.2	0.5	3.0	0.2
23	Union Newlove 51 1202		0.6	0.6	0.2	1.1	0.1	0.6	0.1
24	Union Newlove 51 2037		1.6	0.2	0.1	0.8	0.2	1.5	0.2
25	Union Newlove 51 2441		6.6	0.4	0.0	3.8	0.8	7.8	0.9
26	Union Newlove 51 2455		1.9	0.2	0.1	1.7	0.3	1.8	0.2
27	Union Newlove 51 2788		1.9	0.2	0.1	1.6	0.2	2.1	0.2
28	Union Newlove 51 3256		2.1	1.0	0.3	1.5	0.3	1.9	0.3
29	Union Newlove 51 3500		1.6	0.7	0.3	1.1	0.3	0.8	0.1

Table 5. continued

Sample number	Well	Depth	2,2-Di methyl hexane	Ethyl cyclopentane	Toluene
1	Union Annex #1	1398	0.0	0.0	0.6
2	Union Annex #1	1826	0.1	0.3	1.0
3	Union Annex #1	2609	0.0	0.2	0.5
4	Union Annex #1	2753	0.0	0.2	0.6
5	Union Annex #1	2928	0.0	0.1	0.6
6	Union Signal Brown	3165	0.0	0.1	0.6
7	Union Signal Brown	3734	0.0	0.2	1.9
8	Union Signal Brown	3765	0.0	0.7	1.6
9	Union Signal Brown	3922	0.0	0.3	1.5
10	Union Harris A-2	6117	0.0	0.4	0.4
11	Union Harris A-2	8013	0.0	0.3	0.3
12	Union Harris A-2	8014	0.0	0.3	0.1
13	Union Harris A-2	8805	0.0	0.4	0.1
14	Union Harris A-2	9512	0.0	0.1	0.2
15	Union Harris A-2	9513	0.0	0.4	0.6
16	Union Dome 18	9774	0.0	1.3	0.1
17	Union Dome 18	9871	0.0	0.9	0.0
18	Union Dome 18	10197	0.0	1.8	0.3
19	Union Dome 18	10317	0.0	1.3	0.4
20	Union Dome 18	10767	0.0	0.2	0.1
21	Union Dome 18	10952	0.0	0.3	0.2
22	Union Newlove 51	530	0.0	0.7	2.8
23	Union Newlove 51	1202	0.0	0.1	0.3
24	Union Newlove 51	2037	0.0	0.4	0.6
25	Union Newlove 51	2441	0.0	1.8	5.0
26	Union Newlove 51	2455	0.0	0.4	0.8
27	Union Newlove 51	2788	0.0	0.4	0.6
28	Union Newlove 51	3256	0.0	0.3	0.7
29	Union Newlove 51	3500	0.1	0.2	0.8

Table 5. continued

Sample number	Well	Depth	Iso butane	N- Butane	Neo pentane	Iso pentane	N- pentane	2,2-Di methyl butane	Cyclo pentane	2,3-Di methyl butane
30	SST 25-11	8081	14.4	35.7	0.0	8.4	12.5	0.1	1.3	0.7
31	SST 25-11	8082	9.2	20.8	0.0	12.4	10.4	0.1	1.9	0.6
32	SST 25-11	8587	23.1	34.0	0.0	12.8	10.9	0.0	0.5	0.7
33	SST 25-11	8698	17.2	17.0	0.0	17.5	7.6	0.1	1.5	1.7
34	SST 25-11	8762	22.6	30.4	0.0	13.0	10.8	0.1	0.8	0.6
35	SST 25-11	8795	14.2	27.9	0.0	13.4	12.9	0.1	1.7	0.9
36	SST 25-11	9115	19.1	34.6	0.0	13.4	9.4	0.0	1.7	0.8
37	SST 25-11	9155	16.1	31.7	0.0	13.7	12.4	0.0	0.7	0.8
38	UGO-2B-1B	surface	9.5	33.6	0.0	8.2	14.3	0.1	2.5	0.6
39	UGO-2B-11A	surface	6.8	25.3	0.0	8.8	14.6	0.1	4.1	1.0
40	RIN-K-1	surface	7.9	23.4	0.0	7.5	24.8	0.2	3.3	1.4
41	RIN-K-3	surface	7.4	21.8	0.0	8.4	31.7	0.1	1.9	0.5
42	GE-K-2B	surface	4.9	9.6	0.0	6.4	57.2	0.0	0.9	0.1
43	GE-K-3	surface	4.3	6.9	0.0	4.3	70.7	0.1	0.6	0.1
44	BLK-K-1	surface	21.1	35.2	0.0	10.0	16.7	0.1	1.1	0.3

Table 5. continued

Sample number	Well	Depth	2-Methyl pentane	3-Methyl pentane	N- Hexane	Methyl cyclo pentane	2,2-Di methyl pentane	Benzene	2,4-Di methyl pentane	2,2,3-Tri methyl butane
30	SST 25-11	8081	2.7	3.8	3.1	2.8	0.0	0.3	0.2	0.1
31	SST 25-11	8082	4.9	3.9	4.7	7.4	0.0	0.2	0.1	0.0
32	SST 25-11	8587	3.5	3.0	3.6	1.3	0.0	0.1	0.1	0.0
33	SST 25-11	8698	5.5	5.4	3.2	4.3	0.0	0.5	0.1	0.0
34	SST 25-11	8762	3.5	2.8	3.4	2.2	0.0	0.2	0.1	0.0
35	SST 25-11	8795	4.2	3.7	4.1	4.0	0.0	0.6	0.1	0.0
36	SST 25-11	9115	3.2	2.8	2.6	2.8	0.0	1.2	0.1	0.0
37	SST 25-11	9155	4.4	3.7	4.7	2.1	0.0	0.1	0.1	0.0
38	UGO-2B-1B	surface	2.7	3.9	0.3	4.4	0.0	2.1	0.3	0.0
39	UGO-2B-11A	surface	3.6	3.9	4.3	7.4	0.0	2.2	0.2	0.0
40	RIN-K-1	surface	3.6	3.2	4.1	3.9	0.0	2.6	0.2	0.1
41	RIN-K-3	surface	2.2	2.3	3.3	3.5	0.1	1.7	0.3	0.1
42	GE-K-2B	surface	1.0	1.2	2.3	1.9	0.1	1.6	0.3	0.1
43	GE-K-3	surface	0.6	0.7	1.2	0.8	0.1	0.8	0.1	0.1
44	BLK-K-1	surface	2.0	3.2	2.4	1.0	0.0	0.4	0.2	0.2

Table 5. continued

Sample number	Well	Depth	Cyclo hexane	3,3-Di methyl pentane	1,1-Di methyl cyclo pentane	2-Methyl hexane	2,3-Di methyl pentane	1,CIS-3-Dimethyl cyclo pentane	3-methyl hexane	1,TRANS-3-Dimethyl cyclo pentane
30	SST 25-11	8081	0.8	0.1	0.2	0.9	0.4	1.0	1.2	0.9
31	SST 25-11	8082	2.2	0.0	0.3	0.9	0.8	2.1	1.6	1.9
32	SST 25-11	8587	0.5	0.0	0.0	0.8	0.4	0.2	1.3	0.3
33	SST 25-11	8698	4.0	0.0	0.2	1.1	0.8	0.6	1.9	0.7
34	SST 25-11	8762	1.2	0.0	0.1	1.0	0.3	0.5	1.3	0.4
35	SST 25-11	8795	2.9	0.0	0.1	0.6	0.5	0.5	1.1	0.6
36	SST 25-11	9115	2.0	0.0	0.1	0.5	0.4	0.3	0.8	0.3
37	SST 25-11	9155	1.0	0.0	0.1	1.1	0.4	0.4	1.8	0.6
38	UGO-2B-1B	surface	3.3	0.0	0.1	0.6	0.3	0.6	1.1	0.5
39	UGO-2B-11A	surface	6.5	0.0	0.2	0.4	0.3	0.7	0.8	0.6
40	RIN-K-1	surface	1.9	0.1	0.1	0.6	0.2	0.4	0.6	0.2
41	RIN-K-3	surface	3.2	0.0	0.1	0.3	0.5	0.6	0.8	0.4
42	GE-K-2B	surface	1.3	0.1	0.1	0.4	0.3	0.3	0.6	0.3
43	GE-K-3	surface	0.8	0.1	0.2	0.4	0.2	0.3	0.4	0.2
44	BLK-K-1	surface	0.6	0.2	0.1	0.4	0.3	0.2	0.6	0.2

Table 5. continued

Sample number	Well	Depth	1,TRANS-2 -Dimethyl cyclo pentane	3-Ethyl pentane	2,2,4-Tri methyl pentane	N- Heptane	1,CIS-2- Dimethyl cyclo pentane	Methyl cyclo hexane	1,1,3- Tri methyl cyclo pentane
30	SST 25-11	8081	3.7	0.5	0.1	1.4	0.4	1.4	0.2
31	SST 25-11	8082	5.9	0.2	0.0	2.1	0.8	2.9	0.2
32	SST 25-11	8587	0.3	0.1	0.0	1.2	0.1	0.6	0.0
33	SST 25-11	8698	2.0	0.2	0.0	1.6	0.2	2.6	0.1
34	SST 25-11	8762	1.2	0.1	0.0	1.3	0.1	1.2	0.1
35	SST 25-11	8795	1.3	0.1	0.0	1.3	0.2	1.8	0.1
36	SST 25-11	9115	0.8	0.1	0.0	0.8	0.1	1.0	0.0
37	SST 25-11	9155	0.5	0.1	0.0	1.7	0.1	1.0	0.0
38	UGO-2B-1B	surface	1.8	0.5	0.0	1.6	0.2	2.4	0.3
39	UGO-2B-11A	surface	1.8	0.1	0.0	0.8	0.3	3.0	0.1
40	RIN-K-1	surface	0.9	0.1	0.1	1.4	0.1	2.0	0.4
41	RIN-K-3	surface	1.2	0.3	0.1	1.6	0.2	2.2	0.1
42	GE-K-2B	surface	0.7	0.3	0.1	1.3	0.3	1.3	0.4
43	GE-K-3	surface	0.6	0.4	0.3	1.0	0.2	0.6	0.2
44	BLK-K-1	surface	0.4	0.6	0.1	1.2	0.0	0.4	0.1

Table 5. continued

Sample number	Well	Depth	2,2-DI methyl hexane	Ethyl cyclo pentane	Toluene
30	SST 25-11	8081	0.0	0.5	0.2
31	SST 25-11	8082	0.0	0.8	0.4
32	SST 25-11	8587	0.0	0.2	0.1
33	SST 25-11	8698	0.0	0.8	1.4
34	SST 25-11	8762	0.0	0.3	0.4
35	SST 25-11	8795	0.0	0.5	0.5
36	SST 25-11	9115	0.0	0.4	0.8
37	SST 25-11	9155	0.0	0.4	0.1
38	UGO-2B-1B	surface	0.0	1.1	2.6
39	UGO-2B-11A	surface	0.0	0.7	1.5
40	RIN-K-1	surface	0.0	1.4	3.2
41	RIN-K-3	surface	0.0	0.6	2.3
42	GE-K-2B	surface	0.0	0.9	3.5
43	GE-K-3	surface	0.0	0.2	2.2
44	BLK-K-1	surface	0.0	0.2	0.8

Table 6. Vitrinite reflectance observations (in %) by Geochem Research, Inc. (mean and mode given in Table 4).

Sample Number	Polish Quality	Ease of Selecting First Cycle	Pyrite Abundance	Reflectance Observation	Reflectance Observation	Reflectance Observation	Reflectance Observation	Reflectance Observation
1	Good	Fair	Abundant	0.22	0.35	0.46	-	-
2	Good	Fair	Abundant	0.25	0.26	0.33	0.36	-
3	Good	Fair	Abundant	0.37	-	-	-	0.43
4	Good	Poor	Abundant	-	-	-	-	-
5	Fair	Fair	Common	0.29	0.30	0.37	-	-
6	Good	Poor	Common	-	-	-	-	-
7	Fair	Poor	Common	-	-	-	-	-
8	Fair	Poor	Common	-	-	-	-	-
9	Fair	Poor	Common	-	-	-	-	-
10	Fair	Fair	Common	0.24	0.28	0.33	0.34	0.35
11	Fair	Poor	Abundant	-	-	-	-	0.36
12	Fair	Poor	Common	-	-	-	-	-
13	Fair	Poor	Common	0.28	0.32	0.34	0.36	0.37
14	Fair	Poor	Common	-	-	-	-	-
15	Fair	Fair	Abundant	0.31	0.33	0.34	0.36	0.37
16	Good	Fair	Abundant	0.29	0.30	0.30	0.32	0.35
17	Good	Fair	Abundant	0.29	0.29	0.30	0.30	0.32
18	Good	Fair	Abundant	0.36	0.39	-	-	-
19	Good	Poor	Abundant	-	-	-	-	-
20	Good	Fair	Abundant	0.45	-	-	-	-
21	Good	Fair	Abundant	0.52	0.62	0.63	0.64	-
22	Fair	Fair	Common	0.21	-	-	-	-
23	Good	Fair	Abundant	0.23	0.31	0.35	0.39	0.41
24	Good	Poor	Abundant	-	-	-	-	-
25	Fair	Poor	Abundant	-	-	-	-	-
26	Fair	Poor	Abundant	-	-	-	-	-
27	Fair	Poor	Abundant	0.31	-	-	-	-
28	Fair	Good	Abundant	-	-	-	-	-
29	Good	Poor	Abundant	0.34	0.42	0.48	-	-

Table 6. continued

Sample Number	Polish Quality	Ease of Selecting First Cycle	Pyrite Abundance	Reflectance Observation	Reflectance Observation	Reflectance Observation	Reflectance Observation	Reflectance Observation	Reflectance Observation
30	Good	Poor	Abundant	-	-	-	-	-	-
31	Good	Poor	Abundant	-	-	-	-	-	-
32	Good	Fair	Abundant	0.24	0.30	0.31	0.35	-	-
33	Good	Fair	Common	0.26	0.26	0.28	0.29	0.30	0.30
				0.31	0.31	0.31	0.31	0.33	0.34
				0.35					
34	Good	Fair	Common	0.29	0.33	0.38	-	-	-
35	Good	Good	Common	0.28	0.29	0.30	0.31	0.32	0.32
				0.32	0.32	0.32	0.33	0.33	0.34
				0.34	0.34	0.35	0.35	0.36	0.37
				0.37	0.39				
36	Good	Good	Common	0.33	0.33	0.33	0.33	0.33	0.33
				0.34	0.34	0.34	0.34	0.34	0.35
				0.35	0.35	0.35	0.35	0.35	0.36
				0.36	0.36	0.36	0.36	0.36	0.36
				0.36	0.36	0.36	0.36	0.37	0.37
				0.37	0.37	0.38	0.38	0.38	0.38
				0.38	0.39	0.39	0.39	0.39	0.39
				0.40	0.40	0.40	0.40	0.42	0.42
37	Good	Poor	Aundant	0.38	-	-	-	-	-
38	Good	Poor	Rare	0.18	0.24	-	-	-	-
39	Good	Poor	Common	0.28	-	-	-	-	-
40	Good	Fair	Common	0.22	0.24	0.25	-	-	-
41	Good	Fair	Abundant	0.21	0.23	0.23	0.30	-	-
42	Good	Fair	Common	0.29	0.36	-	-	-	-
43	Good	Poor	Rare	-	-	-	-	-	-
44	Good	Poor	Abundant	-	-	-	-	-	-

Table 7. Abundances of major oxides and carbon (in weight %). Note that these analyses were not performed on material identical to that used in kerogen analyses (see text). "LOI" is loss on ignition at 920°C. Total Fe is reported as Fe₂O₃. Analysts: J.E. Taggart Jr., A.J. Bartel, J.S. Wahlberg, J.W. Baker (oxides and LOI), and S.T. Neil (carbon).

Sample Number	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	TiO ₂	P ₂ O ₅	MnO	LOI	Organic Carbon	Carbonate Carbon
1	72.2	9.21	4.37	1.24	1.25	1.42	1.29	0.43	0.36	<.02	6.71	1.39	0.22
2	67.9	11.3	4.15	1.41	1.23	1.58	1.78	0.56	0.44	<.02	8.91	2.08	0.08
3	71.1	9.64	3.79	1.96	0.80	1.27	1.41	0.48	0.28	<.02	8.23	1.31	0.22
3	82.9	5.58	1.52	0.67	0.58	0.81	0.92	0.28	0.36	<.02	5.61	1.59	0.02
4	75.2	6.21	2.20	0.66	0.34	0.74	1.36	0.34	0.20	<.02	11.8	5.13	0.01
5	61.5	6.26	2.54	0.92	1.27	1.32	1.27	0.37	0.44	<.02	23.2	12.74	0.03
6	79.4	1.94	0.78	0.37	0.66	0.74	0.38	0.14	0.30	<.02	14.1	7.74	0.04
7	8.87	2.00	0.70	13.8	25.6	0.71	0.48	0.14	0.65	<.02	44.5	8.39	9.25
8	32.3	4.97	1.90	1.02	19.4	1.26	1.19	0.30	2.33	<.02	30.3	14.48	2.55
9	69.3	11.3	4.56	1.72	1.75	1.92	1.68	0.55	0.42	<.02	5.94	0.75	0.17
10	79.5	6.97	2.34	1.04	0.43	0.82	1.10	0.35	0.22	<.02	6.25	1.82	0.08
11	69.7	11.1	4.43	1.72	0.63	1.28	1.82	0.52	0.34	<.02	7.71	2.36	0.30
12	71.9	2.34	1.11	2.55	8.65	0.39	0.39	0.12	0.22	<.02	9.99	1.31	2.48
13	68.3	2.60	1.18	4.47	7.78	0.34	0.65	0.18	0.15	<.02	11.5	1.85	2.73
14	26.6	2.34	1.02	12.4	23.0	0.25	0.50	0.15	0.94	<.02	30.0	1.36	8.19
15	37.6	2.08	0.71	10.6	19.2	0.22	0.44	0.11	0.15	<.02	26.2	0.87	7.09
16	73.0	10.8	3.93	1.64	1.04	1.55	1.77	0.51	0.31	<.02	4.79	0.73	0.34
17	68.8	11.8	4.56	1.95	1.78	1.59	1.87	0.56	0.73	0.02	5.27	0.69	0.52
18	74.1	6.26	1.91	2.35	3.45	1.21	1.09	0.30	0.30	<.02	6.29	1.60	1.18
19	73.6	4.51	1.77	2.83	4.55	1.11	0.82	0.28	0.31	<.02	7.74	1.73	1.61
20	69.4	12.3	3.04	1.04	1.12	1.90	2.34	0.66	0.51	<.02	6.81	3.01	0.08
21	72.8	8.34	2.85	1.03	2.64	1.20	1.51	0.44	0.82	<.02	6.66	2.34	0.44
22	56.8	7.17	2.95	1.95	7.17	1.39	0.99	0.36	3.54	<.02	15.8	7.52	0.83
23	67.1	11.4	4.51	1.98	1.76	2.08	1.50	0.58	0.43	0.02	7.87	0.66	0.43
24	67.1	7.79	2.29	1.92	3.90	2.05	1.41	0.43	0.37	<.02	11.2	3.19	0.88
25	48.9	6.53	2.49	2.12	3.55	0.81	1.65	0.37	0.58	<.02	29.0	18.45	0.89
26	18.8	3.15	1.31	11.0	24.6	0.43	0.49	0.19	2.78	<.02	33.7	5.56	7.62
27	50.1	9.46	3.59	5.76	8.85	1.45	1.96	0.46	0.13	0.05	12.4	1.58	3.21
28	51.7	8.90	3.22	2.94	11.30	1.60	1.78	0.44	1.03	<.02	13.1	3.31	2.51
29	64.6	12.4	4.93	2.71	1.91	2.36	2.12	0.67	0.18	0.04	6.94	1.53	0.21

Table 7. continued

Sample Number	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	TiO ₂	P ₂ O ₅	MnO	LOI	Organic Carbon	Carbonate Carbon
30	81.2	3.72	1.31	1.55	2.38	0.71	0.62	0.20	0.28	<.02	5.95	2.09	0.01
31	83.7	5.36	1.40	0.44	0.75	1.01	0.96	0.29	0.37	<.02	5.16	2.11	0.78
32	17.4	1.60	1.28	15.40	25.1	0.29	0.28	0.12	0.34	0.04	36.1	0.89	9.78
33	17.7	2.97	1.12	1.36	38.6	0.32	0.64	0.17	4.09	<.02	30.0	3.77	7.26
34	43.3	7.41	2.67	6.22	15.0	1.34	1.36	0.36	0.39	0.03	17.3	1.15	4.67
35	32.8	1.51	0.66	0.43	33.7	0.23	0.28	0.10	0.76	<.02	27.5	2.41	6.93
36	47.0	5.65	2.33	2.75	16.7	0.69	1.09	0.31	2.41	<.02	16.0	3.96	3.47
37	24.1	4.05	2.00	10.7	24.1	0.66	0.68	0.19	0.60	0.09	29.7	0.99	8.07
38	44.3	7.98	2.84	1.24	11.4	2.80	1.39	0.40	1.48	<.02	24.5	6.28	1.94
39	55.9	3.22	1.30	0.72	5.29	2.41	0.60	0.17	0.40	<.02	28.4	3.45	1.01
40	35.3	6.89	3.08	1.59	19.0	1.45	1.30	0.33	3.46	<.02	22.3	-	-
41	36.0	7.42	2.72	1.05	15.9	1.56	1.39	0.33	0.18	<.02	28.9	-	-
42	31.2	5.56	1.88	0.88	24.8	0.97	1.11	0.27	2.39	<.02	27.6	-	-
43	55.3	2.53	0.91	0.49	16.6	0.77	0.55	0.13	0.16	<.02	21.2	-	-
44	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 8. Abundances of sedimentary components (in weight %) and other derived parameters. Note that these values do not represent material identical to that in kerogen analyses (see text). Values listed in columns 2 through 7 ("Detritus through "Organic matter") have been normalized to sum to 100%. The quantity "sum" represents the pre-normalized sum of components (detritus + silica + apatite + dolomite + calcite + organic matter) derived from data in Table 7 using formulas in Isaacs and others (1989a, b; 1990); this sum is consistently less than 100% due to the presence of H_2O^- . See text for comments on negative values and problems with the calcite-dolomite partition.

Sample Number	Detritus	Silica	Apatite	Dolomite	Calcite	Organic Matter	Sum	Silica/Silica+Carb.	Silica/Detritus
1	54	42	0.2	1.1	0.2	2.1	95.0	0.97	0.44
2	66	30	0.2	0.8	-0.0	3.1	95.7	0.97	0.31
3	57	39	-0.1	4.3	-2.2	2.0	95.2	0.95	0.41
3	32	65	0.4	0.3	-0.3	2.4	97.4	1.00	0.67
4	36	56	0.0	-0.1	-0.2	7.7	95.6	1.01	0.61
5	37	41	0.6	1.1	0.3	19.1	95.6	0.97	0.53
6	11	75	0.6	0.7	-0.0	11.6	96.3	0.99	0.87
7	11	2	1.4	62.4	10.5	12.6	99.4	0.03	0.14
8	28	15	5.2	2.2	27.9	21.7	99.4	0.33	0.35
9	65	31	0.1	2.3	0.2	1.1	96.7	0.93	0.32
10	40	57	-0.0	1.3	-0.9	2.7	97.2	0.99	0.59
11	64	32	-0.0	2.3	-1.7	3.5	97.1	0.98	0.33
12	13	65	0.3	10.6	9.2	2.0	98.7	0.77	0.83
13	15	60	0.2	19.3	3.0	2.8	98.8	0.73	0.80
14	13	18	2.0	55.6	8.6	2.0	99.7	0.22	0.58
15	12	31	0.2	47.9	8.2	1.3	98.9	0.35	0.72
16	62	36	-0.1	2.1	-0.7	1.1	98.0	0.96	0.37
17	68	28	0.9	3.1	-1.0	1.0	97.5	0.93	0.29
18	36	53	0.2	7.7	0.9	2.4	98.4	0.86	0.60
19	26	59	0.4	10.9	1.3	2.6	98.0	0.83	0.70
20	71	27	0.3	-1.5	0.8	4.5	97.6	1.03	0.28
21	48	45	1.3	0.5	2.0	3.5	97.6	0.95	0.48
22	41	33	8.0	5.4	1.2	11.3	97.4	0.83	0.44
23	67	29	0.2	3.5	-0.5	1.0	95.1	0.90	0.30
24	45	41	0.3	5.0	3.0	4.8	96.3	0.84	0.48
25	37	26	0.9	6.5	1.1	27.7	98.6	0.78	0.42
26	18	8	6.3	48.9	10.9	8.3	99.5	0.12	0.31
27	55	18	-0.4	22.3	3.3	2.4	96.6	0.41	0.24
28	51	21	1.8	9.1	12.5	5.0	98.4	0.49	0.29
29	71	22	-0.5	6.3	-1.2	2.3	97.4	0.81	0.23

Table 8. continued

Sample Number	Detritus	Silica	Apatite	Dolomite	Calcite	Organic Matter	Sum	Silica/ Silica+Carb.	Silica/ Silica+Detritus
30	21	69	0.4	5.3	0.5	3.1	98.3	0.92	0.77
31	31	66	0.5	-0.7	0.5	3.2	98.4	1.00	0.68
32	9	12	0.7	70.6	6.3	1.3	98.5	0.13	0.57
33	17	7	9.4	4.7	56.4	5.7	100.3	0.11	0.31
34	43	18	0.4	25.3	12.3	1.7	97.6	0.32	0.30
35	8	27	1.7	1.2	57.6	3.6	100.1	0.32	0.76
36	32	28	5.3	9.9	18.8	5.9	98.3	0.49	0.46
37	23	10	1.1	47.8	16.3	1.5	98.0	0.14	0.30
38	49	18	3.2	1.8	17.1	9.4	90.5	0.49	0.27
39	23	58	0.9	2.2	9.5	5.2	77.6	0.83	0.71
40	41	12	8.1	4.0	24.6	10.1	84.5	0.29	0.22
41	44	11	-0.1	1.1	28.0	15.7	79.4	0.26	0.19
42	32	12	5.4	1.3	38.6	10.5	87.0	0.23	0.27
43	15	48	0.2	1.0	29.3	7.1	90.3	0.61	0.77

Figure 4. TAI and mean vitrinite reflectance values vs. depth (in feet) for Santa Maria subsurface samples.

Figure 5. Tmax and volatile/total hydrocarbon from pyrolysis assay vs. depth (in feet) for Santa Maria subsurface samples. Note that these values were determined by TEA-FID, not by Rock-Eval pyrolysis.

Figure 6. Atomic O/C and H/C values vs. depth (in feet) for Santa Maria subsurface samples.

Figure 7. C₄-C₇ total gasoline range hydrocarbon abundance and organic carbon vs. depth (in feet) for Santa Maria subsurface samples.

Figure 8. Detritus, silica, and proportion of silica in the sum silica + detritus by depth for Santa Maria subsurface samples from Table 8. Note that for some samples these results do not derive from material exactly matching that used for organic analyses (see Table 2 and text).

Figure 9. Proportion of silica in the sum silica + carbonates, calcite, and dolomite by depth for Santa Maria subsurface samples from Table 8. Note that for some samples these results do not derive from material exactly matching that used for organic analyses (see Table 2 and text). For comments on negative values, see text.

Figure 10. Carbonate carbon, apatite, and organic matter abundance by depth for Santa Maria subsurface samples from Table 8. Note that for some samples these results do not derive from material exactly matching that used for organic analyses (see Table 2 and text). For comments on negative values, see text.

Figure 11. Al_2O_3 versus other major oxides for analyzed surface and subsurface samples from Table 7. Correlations were calculated by least-squares linear regression; "r" is the correlation coefficient.

Figure 12. Measured values of carbonate carbon (from Table 7) versus values estimated from oxide analyses of analyzed surface and subsurface samples. Correlations were calculated by least-squares linear regression; "r" is the correlation coefficient.

methods were used on samples reported by Isaacs and others (1989a, b; 1990). Powder splits of most of the XRF samples were also analyzed on dried samples for total carbon and carbonate carbon (organic carbon by difference), by methods described by Jackson and others (1987); identical methods were used on samples reported by Isaacs and others (1989a) and (except for drying) by Isaacs and others (1990).

Major inorganic rock components were estimated from elemental abundances of SiO_2 , Al_2O_3 , CaO , MgO , and P_2O_5 by constants developed for the Monterey Formation in the Santa Barbara coastal area (Isaacs, 1980; Isaacs and others, 1983). Components are silica (both biogenic and diagenetic silica, including opal-A, opal-CT, and diagenetic quartz), detritus (detrital quartz and aluminosilicate minerals, mainly consisting of mixed-layer illite-smectite with minor feldspar and quartz), carbonate minerals (calcite and dolomite), apatite, and organic matter. Minor pyrite is also common, but its abundance has not been estimated. The approximation method is discussed in more detail by Isaacs and others (1989a, b; 1990).

Analytical reproducibility of these methods was studied by Isaacs and others (1989a, b) who showed that for core samples the average standard deviations for blind duplicate splits of powder are 0.5 wt% detritus, 0.4 wt% silica, 0.1 wt% dolomite, 0.2 wt% calcite, 0.01 wt% apatite, and less than 0.1 wt% organic matter. Two problems of accuracy are noted related to the approximation of sedimentary components. First, some components yield negative numbers (see Table 8) due to somewhat inaccurate partitioning of the CaO , MgO , and P_2O_5 into the aluminosilicate fraction; however, inaccuracies are usually less than 1 wt% and thus only significant where values are small. Second, dolomite is generally somewhat more abundant than calculated here due to having CaO in excess of ideal amounts; however, the sum of calcite + dolomite is quite accurate (within 0.03 wt% carbonate carbon) (Isaacs and others, 1989a, b).

Figure 13. Van Krevelen diagram for kerogens reported here. Curves indicate patterns of diagenesis for kerogens of type I, II, and III (from Tissot and Welte, 1978). Open circles represent surface outcrops from the Santa Barbara coastal area.

RESULTS

Data from the organic analyses are presented in Tables 3-6, and data from the inorganic analyses in Tables 7-8. Selected parameters are graphed in Figures 4-10 for subsurface samples, and for all samples in Figures 11-12. Selected values are summarized in Tables 9-11.

Organic Matter Characterization

Organic carbon abundance in the kerogen data set is quite variable, ranging from 0.6% to 14.7% (Table 9). On average, values of organic carbon abundance in Monterey samples from the Santa Maria subsurface (av 3.5%) exceed values from the Sisquoc Formation (av 2.2%), while the small set of samples from the Santa Barbara-Ventura coast (av 6.2%) have much higher organic carbon abundances (Table 9).

Visual kerogen identification indicates that samples on average contain mainly amorphous material (65%), which is generally interpreted as marine-derived material (Table 9). Herbaceous, humic, and inertinite particles (generally interpreted as land-derived material) together comprise the remaining 35% of kerogen (Table 9). The average proportion of nonamorphous material does not vary significantly between Monterey samples and Sisquoc samples from Santa Maria, nor between samples from the Santa Maria Basin and the Santa Barbara-Ventura coast. The high proportion (35%) of nonamorphous material contrasts somewhat with the common view that Monterey organic matter is entirely marine (e.g., Kablanow and Surdam, 1983).

In terms of elemental composition, samples contain immature and marginally mature type I and type II kerogen (Figure 13). The less mature samples (O/C >0.1) are all from the surface (Santa Barbara-Ventura coast) or from the Sisquoc Formation (subsurface Santa Maria) (Table 3).

Table 9. Average abundance of organic carbon (in weight % of rock) and visual kerogen type (in % of kerogen) for the Santa Maria subsurface transect and Santa Barbara-Ventura coastal samples, summarized from Tables 3 and 4. Values for the average and range should not be interpreted as representative of the entire formation from which they were sampled (see text) but only as values for the set of 44 samples reported.

Sample set		Organic carbon	Amorphous	Herbaceous	Humic	Inertinite
Sisquoc Formation (Santa Maria)	- average	2.2	67	19	12	2
	- range	0.6-6.4	36-99	0-40	0-20	0-10
Monterey Formation* (Santa Maria)	- average	3.5	64	22	9	4
	- range	0.7-14.7	36-99	0-44	0-22	0-17
Monterey Formation (S. Barbara-Ventura)	- average	6.2	63	31	7	0
	- range	3.4-10.4	50-80	17-50	0-17	0

* Includes samples from the Point Sal Formation.

Table 10. Indicators of petroleum source-rock potential (in weight fraction) based on pyrolysis assay by TEA-FID for the Santa Maria subsurface transect and Santa Barbara-Ventura coastal samples, summarized from Table 4.

Sample set	Total hydrocarbon, %		Volatile hydrocarbon, ppm	
	average	range	average	range
Sisquoc Formation (Santa Maria)	1.1	0.1-4.8	2,400	200-12,000
Monterey Formation* (Santa Maria)	1.8	0.3-9.8	2,200	400- 9,500
Monterey Formation (S. Barbara-Ventura)	3.0	1.7-5.4	2,700	1000- 7,500

* Includes samples from the Point Sal Formation

Petroleum source-potential

In terms of total organic carbon abundance, over 90% of the samples (and all but 1 Monterey sample) can be characterized as source-rock material (>1% TOC) (Table 9). About 55% of samples have at least good source-rock potential (>2% TOC), and 25% of the samples have excellent source-rock potential (>5% TOC). In terms of total hydrocarbon yield from pyrolysis assay, all but 2 samples (both from the Sisquoc Formation) are source-rock material (values >0.2%), and average values are good (0.6-2%) to excellent (>2%) (Table 10). In terms of volatile hydrocarbon yield from pyrolysis, all samples qualify as source-rock material (values >100 ppm), and average values are all excellent (>1500 ppm).

By these criteria (summarized from Claypool and Magoon, 1988), the sample set has on average good to excellent source-rock potential. However, variability in values is pronounced, and averages for the sample set (Tables 9 and 10) are not necessarily representative of the sequences sampled as a whole.

Thermal Maturity Parameters

In Figures 4 to 7, values of thermal maturity parameters have been plotted against present depth as a rough approximation of thermal exposure. On this basis, TAI (Figure 4) shows a distinct depth-related trend from 1.1 to 2.3, and Tmax (Figure 5) a distinct depth-related trend from about 420°C to about 470°C (except for 2 anomalous Sisquoc samples from the Newlove 51 well). The total abundance of C₄ to C₇ gasoline-range compounds (Figure 7) shows a depth-related threshold increase at about 8000 feet (from <500 to >1000 ppm), and atomic O/C (Figure 6) shows a sharp depth-related decrease at about 2000 feet. Other parameters (atomic H/C, volatile proportion of total hydrocarbon, and vitrinite reflectance (R_o)) show only indistinct (if any) depth-related trends (Figures 4, 5, and 6). (For comparison of the depth-related distribution of organic maturity parameters with sedimentary compositions, Figures 8 to 10 plot the inorganic compositional parameters of each subsurface sample by depth.)

Table 11. Average values of thermal maturity parameters for the Santa Maria subsurface transect (from Table 4), arranged by increasing diagenetic grade (see text). Conventional values for the onset of oil generation, taken from Claypool and Magoon (1988), apply to the exact techniques used in this study.

Well	TAI	Tmax, °C	VHC/HC*	R _o , %	H/C	O/C	Total C ₄ -C ₇ , ppm
Annex 1	1.1	428	0.15	0.31	1.26	0.11	73
Signal Brown 1	1.3	438	0.13	-	1.25	0.08	140
Newlove 51	1.5	444	0.16	0.35	1.30	0.08	190
SST 25-11 + Harris A-2	2.2	459	0.16	0.31	1.21	0.05	21,000
Dome 18	2.3	461	0.14	0.43	1.21	0.05	28,000
Onset of oil generation	2.2	440	0.1	0.6	1.1	-	-
Expected trend with increas- ing maturity	incr	incr	incr	incr	decr	decr	incr

* Volatile proportion of total hydrocarbon determined by TEA-FID.

The distribution of silica phase zones suggests that present burial depth does not correspond perfectly with maximum thermal exposure, due to differences in uplift (Pisciotta, 1978, 1981). Silica diagenetic patterns determined for these wells (Pisciotta, 1978, 1981) show that: (a) the entire Monterey Formation in the Harris A-2 and SST 25-11 wells as well as the entire Monterey Formation underneath the Orcutt frontal fault in the Dome 18 well (including samples analyzed from present-day depths of 8013-10952 ft) is quartzose, (b) the upper part of the Monterey in the Newlove 51 well (including the analyzed sample at a present depth of 2037 ft) is at the boundary between the opal-CT and quartz zones, and (c) the entire Monterey in the Signal Brown 1 well (including analyzed samples at present-day depths of 3734-3922 ft) is in the opal-CT zone. In the Annex 1 well, the transition from the opal-A to opal-CT zones apparently falls between well depths of 900 and 1300 feet.

The wells can be arranged in approximate accordance with silica diagenetic patterns as follows: (1) Annex 1 (opal-A to opal-CT); (2) Signal Brown 1 (opal-CT); (3) Newlove 51 (opal-CT to quartz transition); (4) SST 25-11, Harris A-2, and Dome 18 (quartz). On this basis, average values of thermal maturity parameters show the following trends related to increasing silica diagenesis: TAI increases, Tmax increases, atomic O/C decreases, and total C₄-C₇ gasoline-range hydrocarbon abundance passes a threshold in the quartz zone (Table 11). Values of the volatile proportion of total hydrocarbon and atomic H/C show no marked trend related to silica diagenesis, and values of vitrinite reflectance (R_o) show a slight increase in the quartz zone (Table 11). The set of surface samples from the Santa Barbara-Ventura coast (a set which includes only the upper part of the quartz zone, at Black Canyon) does not show convincing trends related to silica diagenesis - which

increases from Goleta Slough (UGO) to Rincon Point (RIN) to Gaviota East (GE) to Black Canyon (BLK) - except in values of atomic O/C, which decrease with increasing silica diagenetic grade (Table 3).

The conclusion is that in this data set some of the organic maturity parameters (TAI, T_{max} , atomic O/C, total C_4 - C_7 gasoline range hydrocarbon abundance) show distributions consistent with expected maturity trends, whereas other maturity parameters (volatile proportion of total hydrocarbon, atomic H/C, and R_o) show only inconsistent or indistinct trends. In deepest samples, some maturity parameters (TAI, T_{max} , and volatile proportion of hydrocarbons) have values within the range accepted for the onset of oil generation, while others (R_o , H/C) have values indicating immaturity. The study also shows that variations in the analytical results are sufficiently great, even among closely spaced samples, that a large number of samples need to be used in order to establish trends with confidence.

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