

DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

ANALYTICAL REPRODUCIBILITY AND ABUNDANCES OF MAJOR ELEMENTS AND  
SEDIMENTARY COMPONENTS IN CORES FROM THE SISQUOC, MONTEREY, AND POINT  
SAL FORMATIONS, UNION NEWLOVE 51 WELL, ORCUTT OIL FIELD,  
ONSHORE SANTA MARIA BASIN, CALIFORNIA

by

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## ABSTRACT

Abundances of sedimentary components based on chemical analyses of 79 fine-grained core samples from the Union Newlove 51 well indicate an average composition (in weight percent) as follows:

Formation	Detritus	Silica	Carbonate minerals	Apatite	Organic matter
Sisquoc Fm	68	28	4	0	1
Monterey Fm	46	31	22	1	7
Point Sal Fm	68	21	10	1	4

In both the Monterey and Point Sal Formations, fine-grained detritus in the Union Newlove 51 well is generally more abundant than in age-equivalent Monterey strata in the Santa Barbara coastal area or in the Point Conception COST well (OCS-Cal 78-164 No. 1) in the offshore Santa Maria basin.

Analyses of duplicate splits of powders show that the reproducibility of major oxides is excellent. Standard deviations generally represent <2% of analyzed values, except Na<sub>2</sub>O which has an average standard deviation of 3% of analyzed values (0.04 wt% Na<sub>2</sub>O). Reproducibility of sedimentary components based on major oxide analyses is excellent, with average standard deviations of 0.5 wt% detritus, 0.4 wt% silica, 0.1 wt% dolomite, 0.2 wt% calcite, and 0.01 wt% apatite. Reproducibility of carbon analyses is less good, with average standard deviations of duplicate powder splits 0.1 wt% total carbon, 0.5 wt% organic carbon, and 0.4 wt% carbonate carbon. Average standard deviations of organic matter abundance are thus about 0.7 wt% organic matter.

## INTRODUCTION

The Union Newlove 51 well is located in the Orcutt oil field in the on-shore Santa Maria basin (Figure 1). Located on the south side of the Orcutt fault bordering the north end of the field (Figure 2), the well was drilled in 1932 by Union Oil Company, penetrating 4114 feet of section, and was extensively cored. As originally reported by the operator, the drilled sequence includes the Careaga Formation (0-90 ft), the Foxen Mudstone (90-462 ft), the Sisquoc Formation (462-1884 ft), the Monterey Formation (1884-4014 ft), and the Lospe Formation (4014-4114 ft). Within the Monterey Formation, the original operator reports identify the arenaceous zone (1884-1918 ft), cherty zone (1918-2154 ft), bentonitic-brown zone (2154-2309 ft), buff and brown zone (2309-2515 ft), dark brown zone (2515-2841 ft), oil sand zone (2841-3132 ft), and siltstone and shell zone (3132-4014 ft). Subsequently Canfield (1939) proposed the name "Point Sal Formation" for the siltstone and shell zone, and Woodring and Bramlette (1950) formally adopted the proposal. Common current usage is to include the oil sand zone in the Point Sal Formation as well, and this scheme is used here.

The purpose of this report is to present analytical results on 83 core samples from the Union Newlove 51 well, including 79 fine-grained samples from the lower part of the Sisquoc Formation, the Monterey Formation, and the Point Sal Formation. 4 additional samples analyzed include 3 sandstones from the Point Sal Formation and 1 sample (at 530 feet) from the upper part of the

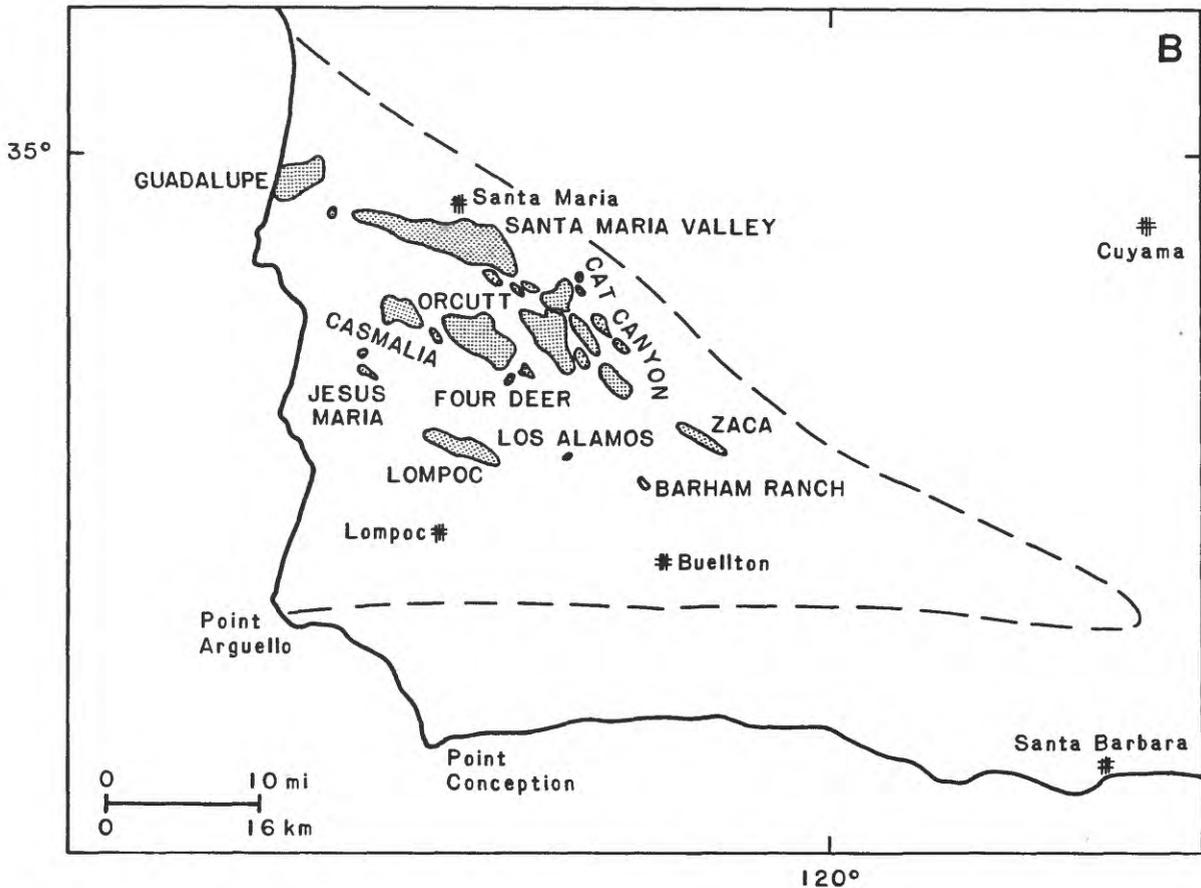
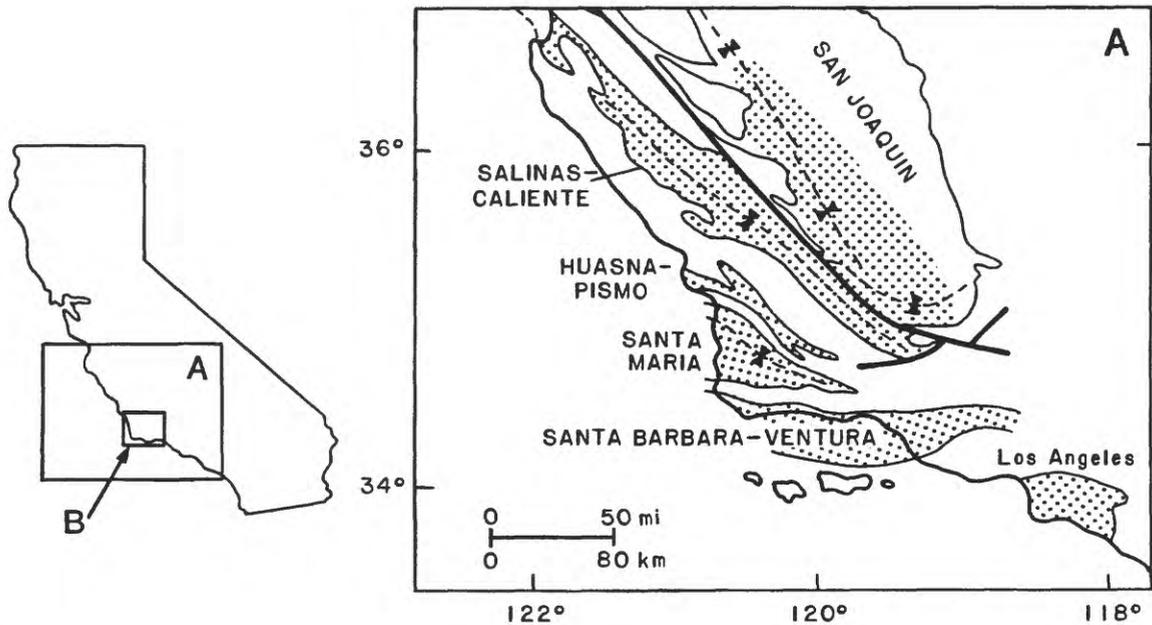


Figure 1. Locality map showing Neogene basins of south-central California (above) and oil fields in the onshore Santa Maria basin (below). Neogene basins are from Blake and others (1978), dotted pattern indicates original distribution of Monterey deposits. Oil fields are from California Division of Oil and Gas (1974).

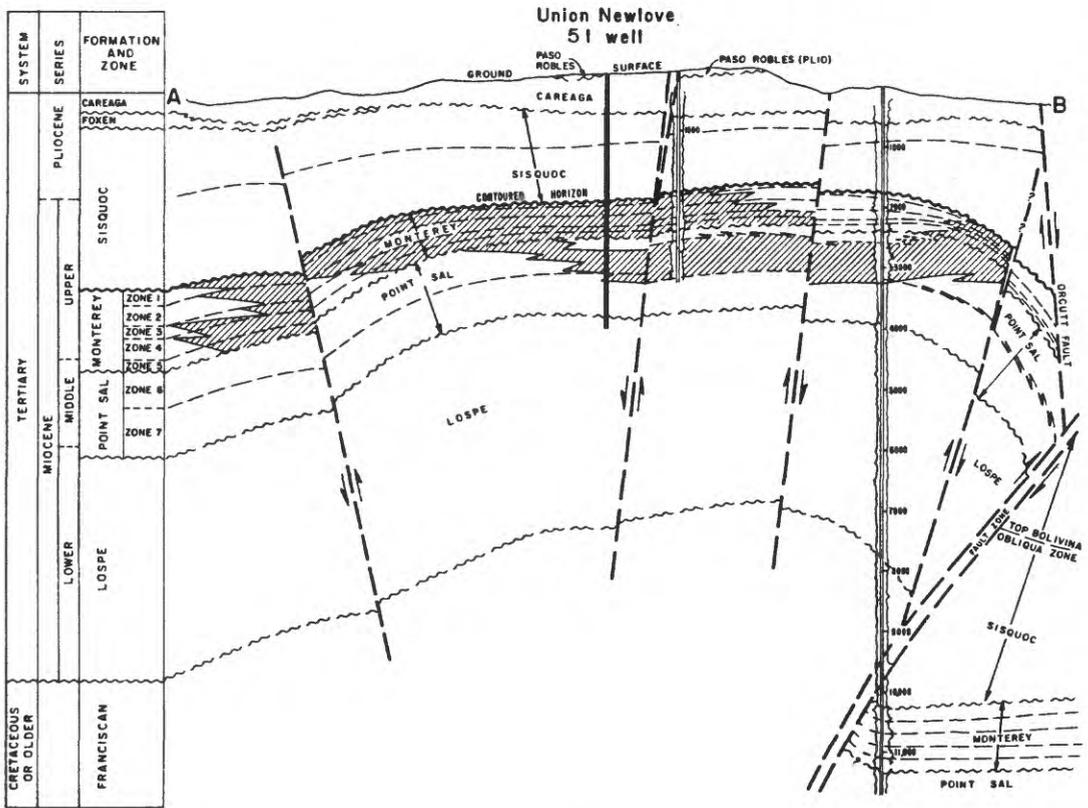
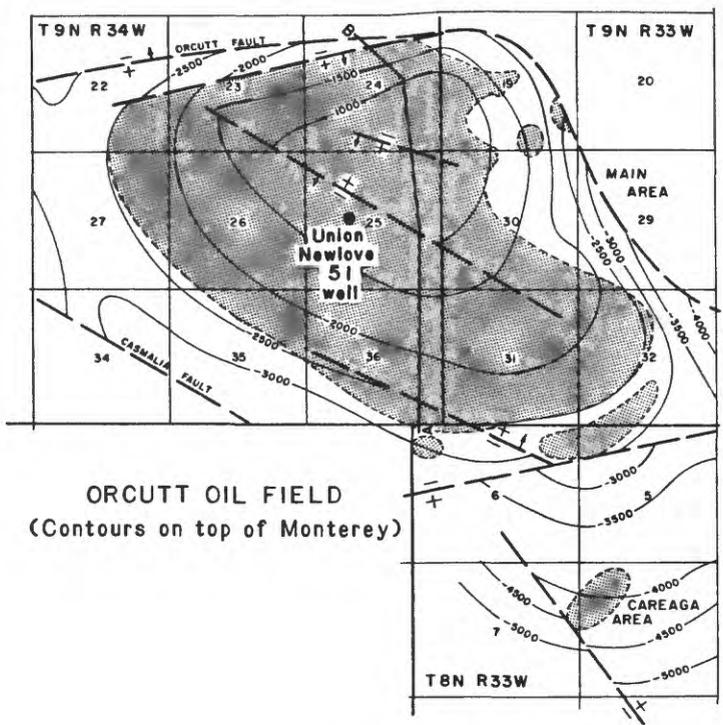


Figure 2. Map and cross section of the Orcutt oil field showing location of the Union Newlove 51 well. From California Division of Oil and Gas (1974).

Sisquoc Formation, lithologically unlike all other samples from the Sisquoc Formation.

Values were determined for the abundances of major elements ( $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{Fe}_2\text{O}_3$ ,  $\text{Na}_2\text{O}$ ,  $\text{K}_2\text{O}$ ,  $\text{CaO}$ ,  $\text{MgO}$ ,  $\text{TiO}_2$ ,  $\text{P}_2\text{O}_5$ , and  $\text{MnO}$ ), organic carbon, and carbonate carbon. These values have been converted, by analytical constants, to estimated abundances of sedimentary components--namely (biogenic and diagenetic) silica, (fine-grained terrigenous) detritus, calcite, dolomite, apatite, and organic matter. Preliminary compositional results were previously summarized in terms of lithostratigraphic correlation and depositional controls by Isaacs and others (1983).

## METHODS

### Sample Preparation

Prior to analysis, samples were cut either with a water saw or a dry saw into matched pieces for porosity determination and analytical determination. The latter piece, about 10-15 g by weight, was ground first with a steel mortar and then with a mullite mortar to <100 mesh. Powders were then split into portions for X-ray diffraction, major element analysis, and (in most cases) carbon analysis.

### Analytical Techniques - Major Oxides

Samples were analyzed for major oxides by X-ray fluorescence spectroscopy. For this analysis, 0.8 g of sample powder (ground to <100 mesh) was weighed into a tared platinum-gold (95:5) crucible and ignited for 45 minutes at 925°C, after which it was reweighed to determine loss on ignition (LOI). An 8 g charge (dry basis) of lithium tetraborate was then added to the crucible, physically mixed with the sample, and then fused at 1130°C for 25 minutes (Taggart and Wahlberg, 1980a) after which it was cast in a platinum-gold mold (Taggart and Wahlberg, 1980b) and allowed to cool. The disc was then presented to a Phillips PW1600 simultaneous X-ray spectrometer using an on-line Digital Equipment Corporation PDP 11/04 computer to perform a de Jongh matrix correction program for analysis (Taggart and others, 1981).

Note that  $\text{H}_2\text{O}^-$  (adsorbed water) was present in the samples and duplicates analyzed. Amounts of  $\text{H}_2\text{O}^-$  probably range from about 1% to as much as 5% in clay-rich Sisquoc samples (Isaacs, 1980, appendix A).

### Analytical Techniques - Carbon

The abundance of organic carbon was measured by difference between total carbon and carbonate carbon. Total carbon abundances were measured by dry combustion with a LECO WR12 apparatus which combusts the sample in oxygen at 1200°C, converting carbon to  $\text{CO}_2$ ;  $\text{CO}_2$  was then measured by a thermal conductivity detector (Leventhal and Shaw, 1980). Carbonate carbon (the acid-soluble fraction) was determined by a gasometric procedure (Rader and Grimaldi, 1961; Leventhal and Shaw, 1980).

In contrast to techniques used for major oxides, powders analyzed for carbon were dried for 4-24 hours prior to analysis.

## Determination of Sedimentary Components

Abundances of silica and detritus were estimated from elemental abundances of  $\text{SiO}_2$  and  $\text{Al}_2\text{O}_3$  by constants developed for the Monterey Formation in adjacent onshore areas (Table 1). Resulting values are for the most part reliable for Monterey strata but probably underestimate the amount of aluminosilicate material where mica or chlorite is abundant; values also may underestimate detrital quartz (and thus overestimate biogenous and diagenetic silica) in highly terrigenous samples. Abundances of silica and detritus for non-Monterey strata should therefore be regarded as approximations.

Abundances of calcite, dolomite, and apatite were estimated from abundances of  $\text{CaO}$ ,  $\text{MgO}$ , and  $\text{P}_2\text{O}_5$  after adjustment of these values for average abundances in the aluminosilicate fraction (Table 1). Samples were also evaluated by X-ray diffraction analysis for bulk mineralogy. Abundances of organic matter were estimated from the abundance of total organic carbon (Table 1).

A problem with this set of samples is that organic carbon was not measured in all samples. In addition, powders that were analyzed for major oxides contained adsorbed water ( $\text{H}_2\text{O}^-$ ) whereas powders analyzed for carbon did not. As a result, in order to make values easier to compare, abundances of silica, terrigenous detritus, calcite, dolomite and apatite were normalized to 100% on an organic-matter-free basis. These abundances are thus similar to the kind of values widely reported from X-ray diffraction analysis.

### ANALYTICAL REPRODUCIBILITY

During this study, a number of duplicate splits of powders were analyzed to test the reproducibility of the analytical methods. These duplicates were "blind" tests in the sense that they were submitted for analytical determination with different numbers and without the knowledge of the analysts, in some cases in the same lot and in other cases in separate lots as much as two years apart.

#### Major oxides

For major oxides, duplicate splits were analyzed in the same laboratory by identical methods over a period of one year. Table 2a presents the analytical results of a total of 15 analyses of 4 powders. For the most part, standard deviations represent <2.0% of analyzed values. An exception is  $\text{Na}_2\text{O}$ , which has an average standard deviation of 0.04 wt%  $\text{Na}_2\text{O}$  or about 3% of measured values.

Sedimentary components calculated from major oxide analyses of duplicate splits are presented in Table 2b. These data show that detritus is reproducible to within 1 wt% in the range 10-70% detritus, with an average standard deviation of 0.5 wt% detritus. Other parameters are even more closely reproducible. Dolomite, for example, is reproducible to within 0.5 wt% in the range 1-60% dolomite, with an average standard deviation of 0.1 wt% dolomite. These data show that analytical reproducibility is so excellent that variability introduced by the analytical method is negligible for most practical purposes.

Table 1. Formulas used to convert elemental abundances to approximate mineral abundances. Formulas for detritus and silica contents and average abundance of major elements in detritus are derived from the evaluation in Isaacs (1980, appendix B) for the Monterey Formation in the western Santa Barbara coastal area. CaO and P<sub>2</sub>O<sub>5</sub> abundances in apatite are based on published references (see Isaacs, 1980, p. 228), and calculations for calcite and dolomite are based on their molecular formulas. Because most dolomite in the Monterey Formation contains excess CaO, dolomite abundances are generally underestimated and calcite abundances overestimated.

Quantity	Explanation	Formula
Detritus	Equals aluminosilicates + detrital quartz	$5.6 \times \text{Al}_2\text{O}_3$
Aluminosilicates	Based on Al <sub>2</sub> O <sub>3</sub> content	$4.2 \times \text{Al}_2\text{O}_3$
Detrital quartz	Based on a proportion of aluminosilicates	Aluminosilicates ÷ 3
Silica (biogenic and diagenetic)	Based on SiO <sub>2</sub> content adjusted for amounts in detritus	$\text{SiO}_2 - (3.5 \times \text{Al}_2\text{O}_3)$
Apatite	Based on P <sub>2</sub> O <sub>5</sub> content adjusted for 0.7% P <sub>2</sub> O <sub>5</sub> in aluminosilicates and assuming 42.4% P <sub>2</sub> O <sub>5</sub> in apatite	$[\text{P}_2\text{O}_5 - (0.032 \times \text{Al}_2\text{O}_3)] \div 0.424$
Dolomite	Based on MgO content adjusted for 2.6% MgO in aluminosilicates and assuming 21.9% MgO in dolomite	$[\text{MgO} - (0.11 \times \text{Al}_2\text{O}_3)] \div 0.219$
Calcite	Based on CaO content adjusted for 1.9% CaO in aluminosilicates, 55.5% CaO in apatite, and 30.4% CaO in dolomite, and assuming 56.0 % CaO in calcite	$[\text{CaO} - (0.08 \times \text{Al}_2\text{O}_3 - (0.555 \times \text{apatite}) - (0.304 \times \text{dolomite}))] \div 0.56$
Organic matter	Based on organic carbon content	(Organic carbon) x 1.5

Table 2a. Major oxide analyses of duplicate powder splits of samples from the Union Newlove 51 well.  
(Weight %)

Sample number	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	MgO	CaO	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO	LOI
1497(4B)											
Split											
1	63.9	12.2	4.32	1.66	2.21	2.35	1.96	0.58	0.67	<0.02	8.87
2	63.6	12.2	4.31	1.64	2.22	2.36	1.94	0.59	0.66	0.02	8.77
3	64.3	12.3	4.35	1.68	2.25	2.39	1.99	0.58	0.67	0.02	8.41
4	63.9	12.4	4.31	1.67	2.21	2.27	1.96	0.59	0.67	0.02	8.83
5	63.5	12.2	4.30	1.64	2.19	2.31	1.94	0.58	0.66	<0.02	8.66
Mean	63.8	12.3	4.32	1.66	2.22	2.34	1.96	0.58	0.67	-	8.71
Standard Deviation	0.3	0.09	0.02	0.02	0.02	0.05	0.02	0.005	0.005	-	0.18
% Standard Deviation	0.5%	0.7%	0.4%	1.1%	1.0%	2.0%	1.0%	1.0%	0.8%	-	2.1%
2037(5B)											
Split											
1	45.8	4.65	1.53	1.97	15.4	1.03	0.91	0.22	0.50	<0.02	24.2
2	45.7	4.65	1.54	1.97	15.5	0.99	0.92	0.22	0.50	<0.02	24.0
3	45.7	4.65	1.53	1.99	15.4	0.96	0.91	0.22	0.50	<0.02	24.1
4	45.7	4.68	1.53	1.98	15.4	0.99	0.92	0.22	0.50	<0.02	24.5
5	45.7	4.77	1.53	1.94	15.4	0.93	0.92	0.22	0.50	<0.02	24.1
Mean	45.7	4.68	1.53	1.97	15.4	0.98	0.92	0.22	0.50	<0.02	24.2
Standard Deviation	0.04	0.05	0.004	0.02	0.04	0.04	0.005	0.000	0.000	-	0.2
% Standard Deviation	0.1%	1.1%	0.3%	0.9%	0.3%	3.8%	0.6%	0.0%	0.0%	-	0.8%
2651(7A)											
Split											
1	21.8	2.29	0.92	13.3	23.8	0.33	0.45	0.09	0.38	0.03	34.1
2	21.9	2.12	0.92	13.2	24.0	0.28	0.44	0.09	0.37	0.03	34.3
Mean	21.9	2.21	0.92	13.3	23.9	0.31	0.45	0.09	0.38	0.03	34.2
Standard deviation	0.07	0.12	0.000	0.07	0.1	0.04	0.007	0.000	0.007	0.000	0.1
% Standard deviation	0.3%	5.4%	0.0%	0.5%	0.6%	11.6%	1.6%	0.0%	1.9%	0.0%	0.4%

Table 2a. Continued

2687 (5B)	Split		Batch*		Batch A (Sep 1981), Batch B (Sep 1981), Batch C (Mar 1982), Batch D (Sep 1982), Batch E (Mar 1982), and Batch F (Sep 1982).		Batch C (Mar 1982), Batch D (Sep 1982)				
	1	2	A	C	F	Mean	Standard deviation	% standard deviation			
	66.7	9.02	3.81	1.78	2.01	1.40	1.85	0.45	0.09	0.02	10.5
	66.9	9.07	3.83	1.82	2.01	1.36	1.88	0.45	0.09	<0.02	10.6
	67.8	9.13	3.90	1.82	2.06	1.35	1.89	0.48	0.09	0.02	9.80
Mean	67.1	9.07	3.85	1.81	2.03	1.37	1.87	0.46	0.09	-	10.3
Standard deviation	0.6	0.06	0.05	0.02	0.03	0.03	0.02	0.02	0.000	-	0.44
% standard deviation	0.9%	0.6%	1.2%	1.3%	1.4%	1.9%	1.1%	3.8%	0.0%	-	4.2%
Average	49.6	7.1	2.66	4.7	10.9	1.25	1.30	0.34	0.41	-	19.4
Av standard deviation	0.3	0.08	0.02	0.03	0.06	0.04	0.01	0.006	0.003	-	0.2
% standard deviation	0.5%	1.1%	0.7%	0.7%	0.5%	2.9%	1.0%	1.6%	0.7%	-	1.2%

Table 2b. Abundance of sedimentary components (in weight %) of duplicate powder splits of samples from the Union Newlove 51 well No. 1 based on data in Table 2a. See text for calculation method.

Sample number		Detritus	Silica	Dolomite	Calcite	Apatite	
1497(4B)							
	<u>Split</u>	<u>Batch</u>					
	1	A	68.3	21.2	1.5	0.8	0.66
	2	B	68.3	20.9	1.4	0.9	0.64
	3	C	68.9	21.3	1.5	0.8	0.65
	4	D	69.4	20.5	1.4	0.8	0.64
	5	B	68.3	20.8	1.4	0.8	0.64
	Mean		<u>68.7</u>	<u>20.9</u>	<u>1.4</u>	<u>0.8</u>	<u>0.65</u>
	Standard deviation		0.5	0.3	0.06	0.03	0.01
	% standard deviation		0.7%	1.5%	4.1%	4.3%	1.6%
2037(5B)							
	<u>Split</u>	<u>Batch</u>					
	1	A	26.0	29.5	6.7	22.4	0.83
	2	A	26.0	29.4	6.7	22.6	0.83
	3	A	26.0	29.4	6.8	22.3	0.83
	4	B	26.2	29.3	6.7	22.4	0.83
	5	D	26.7	29.0	6.5	22.5	0.82
	Mean		<u>26.2</u>	<u>29.3</u>	<u>6.6</u>	<u>22.4</u>	<u>0.83</u>
	Standard deviation		0.3	0.2	0.1	0.09	0.004
	% standard deviation		1.1%	0.7%	1.6%	0.4%	0.5%
2651(7A)							
	<u>Split</u>	<u>Batch</u>					
	1	D	12.8	13.8	59.6	9.1	0.72
	2	E	11.9	14.5	59.2	9.7	0.71
	Mean		<u>12.3</u>	<u>14.1</u>	<u>59.4</u>	<u>9.4</u>	<u>0.72</u>
	Standard deviation		0.7	0.5	0.3	0.4	0.01
	% Standard deviation		5.5%	3.5%	0.4%	4.5%	1.1%
2687 (5B)							
	<u>Split</u>	<u>Batch</u>					
	1	A	50.5	35.1	3.6	0.8	-0.47
	2	C	50.8	35.2	3.8	0.7	-0.47
	3	F	51.1	35.8	3.7	0.8	-0.48
	Mean		<u>50.7</u>	<u>35.4</u>	<u>3.7</u>	<u>0.8</u>	<u>-0.47</u>
	Standard deviation		0.51	0.41	0.08	0.06	0.004
	% standard deviation		1.0%	1.1%	2.3%	7.0%	0.9%
Average value			39.5	24.9	17.8	8.4	0.43
Av standard deviation			0.5	0.4	0.1	0.2	0.007
% standard deviation			1.3%	1.4%	0.7%	1.8%	1.5%

Table 3. Carbon analyses (in weight %) of duplicate powder splits of samples from the Union Newlove 5l well. Note that analyses were performed in 3 separate laboratories over a period of 2 years (1981-1983).

Sample number	Total carbon	Organic carbon	Carbonate carbon
2178(1A) <u>Split</u> <u>Batch*</u>			
1            A	9.06	7.37	1.69
2            B	9.12	6.13	2.99
3            C	9.08	7.38	1.70
4            C	<u>9.10</u>	<u>7.72</u>	<u>1.38</u>
Mean (LECO)	9.09	7.15	1.94
Standard deviation	0.03	0.70	0.72
% Standard Deviation	0.3%	9.8%	36.9%
5            F	-	6.19	-
6            F	-	6.10	-
7            F	-	<u>6.58</u>	-
Mean (wet oxidation)		6.29	
Standard deviation		0.26	
% Standard deviation		4.1%	
2227(8A) <u>Split</u> <u>Batch*</u>			
1            B	4.90	4.90	<0.01
2            B	5.01	4.95	0.06
3            B	4.85	4.77	0.08
4            D	<u>4.73</u>	<u>4.67</u>	<u>0.07</u>
Mean (LECO)	4.87	4.82	0.05
Standard Deviation	0.12	0.13	0.04
% Standard Deviation	2.4%	2.6%	68.5%
5            F	-	4.07	-
2651(7A) <u>Split</u> <u>Batch*</u>			
1            A	11.13	2.81	8.32
2            B	11.10	3.04	8.06
3            E	<u>10.67</u>	<u>1.93</u>	<u>8.74</u>
Mean (LECO)	10.97	2.59	8.37
Standard Deviation	0.26	0.59	0.34
% Standard Deviation	2.3%	22.6%	4.1%
Average value (LECO)	8.31	4.85	3.45
Av standard deviation	0.13	0.47	0.37
% standard deviation	1.6%	9.7%	10.6%

\* Batch A (Nov 1981): U.S. Geological Survey, Denver Lab; Batches B (Dec 1981), C (Dec 1981), D (Jun 1983) and E (Jul 1983): U.S. Geological Survey, Menlo Park Lab; Batch F (Mar 1982): Rinehart Laboratories, Wheatridge CO.

## Carbon

For total carbon and carbonate carbon, duplicate splits were analyzed in 2 different U.S. Geological Survey laboratories by a similar method over a period of 2 years. Some splits (but not other samples) were also analyzed for organic carbon in a third laboratory (Rinehart Laboratories) by a different method; these analyses were measured by the direct organic carbon wet-oxidation method after drying at 110°C for 4-24 hours and storage over P<sub>2</sub>O<sub>5</sub> in a vacuum desiccator.

Table 3 presents results for a total of 10 analyses on 3 powders by the U.S. Geological Survey laboratories as well as a total of 4 analyses on 2 of the same powders by Rinehart Laboratories. Reproducibility of total carbon abundances is generally good, with an average standard deviation of 0.1 wt% carbon. Reproducibility of the abundance of carbonate carbon (and of organic carbon by difference), however, is only fair, with average standard deviations of 0.4 wt% (and 0.5 wt%) carbon respectively. Note also that samples analyzed by the LECO method have consistently different values than samples analyzed by the wet oxidation method.

## RESULTS

### Major Oxides

Core samples from the Union Newlove 51 well show a wide range of major oxide and carbon abundances, particularly within the Monterey Formation (Table 4; data in Appendix Table 1). Al<sub>2</sub>O<sub>3</sub>, Na<sub>2</sub>O, K<sub>2</sub>O, and TiO<sub>2</sub> mainly reflect detritus abundance, Fe<sub>2</sub>O<sub>3</sub> reflects both detritus and pyrite, CaO reflects mainly calcite (also apatite and detritus), MgO reflects mainly dolomite (also detritus), and P<sub>2</sub>O<sub>5</sub> reflects mainly apatite (also detritus) (Isaacs, 1980, appendix B). The average ratios between Al<sub>2</sub>O<sub>3</sub> and Fe<sub>2</sub>O<sub>3</sub>, Na<sub>2</sub>O, and TiO<sub>2</sub> are generally about the same within all three formations. However, Sisquoc samples from the Union Newlove 51 well have a distinctly smaller ratio of K<sub>2</sub>O/Al<sub>2</sub>O<sub>3</sub> than other samples from this well (Figure 3).

### Sedimentary Components

Sedimentary components estimated from major oxide and carbon abundances are presented in Appendix Table 2. The presence of some negative numbers in this table indicates that the conversion parameters (Table 1) are somewhat inaccurate. Note that the reproducibility of the negative values from replicate analyses (Table 2b, sample 2687(5B)) is excellent. The inaccuracy is thus probably due to partitioning slightly too much CaO, MgO, and P<sub>2</sub>O<sub>5</sub> into the aluminosilicate fraction. These inaccuracies are generally less than 1 wt% and thus are only significant where values are small.

A more serious inaccuracy results from the partitioning of CaO into calcite and dolomite. Many of the samples listed in Appendix Table 2 as having calcite do not have any calcite detectable by bulk X-ray diffraction analysis (e.g., sample 3057 (3a) listed as having 8% calcite). However, Isaacs and others (in press) show that total measured carbonate averages within 0.02 wt% of the carbonate carbon calculated from the sum of calcite + dolomite based on major oxides. The total of carbonate minerals is thus reasonably accurate, and this value has been used for averages.

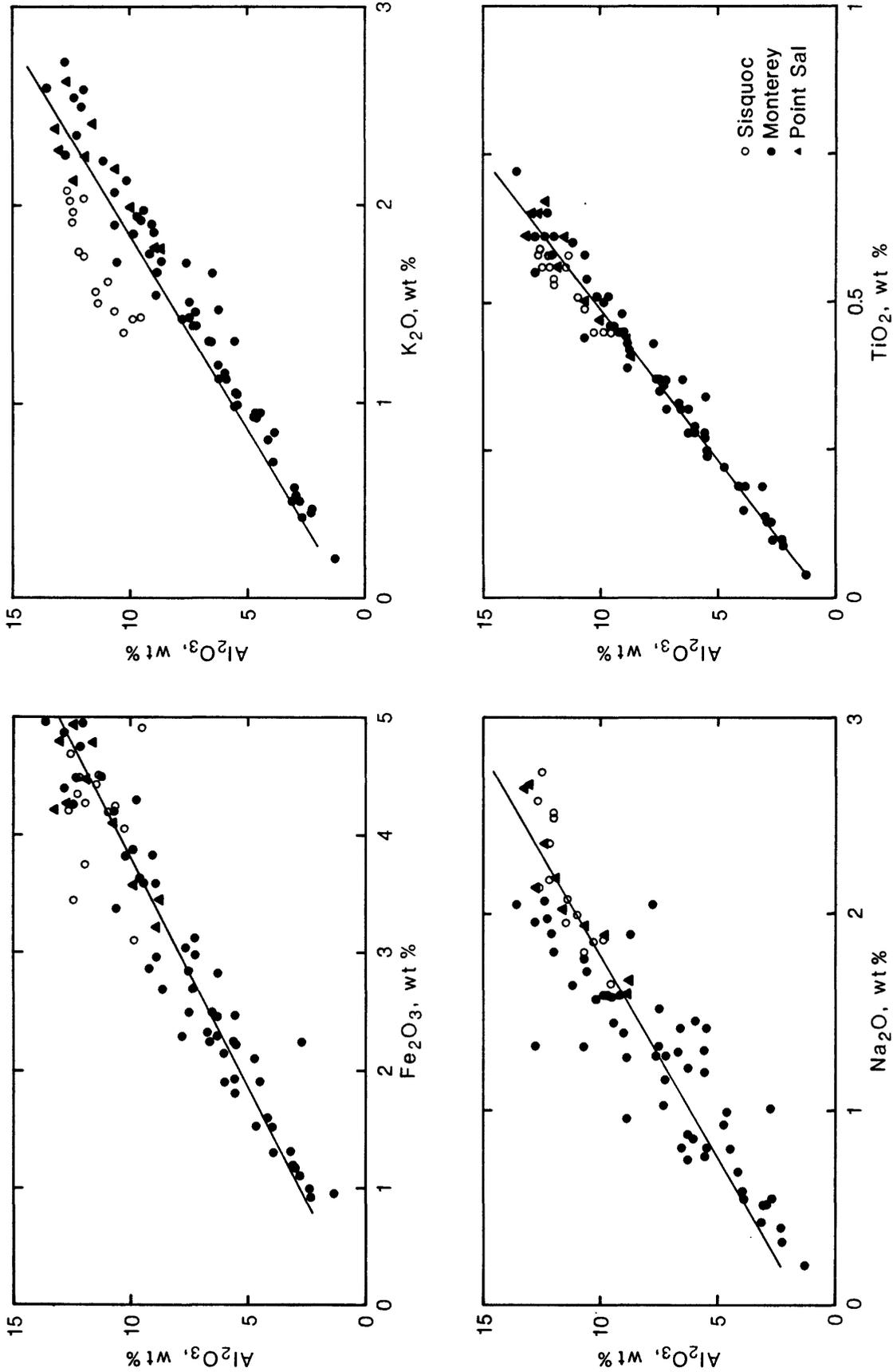


Figure 3.  $Al_2O_3$  versus  $Fe_2O_3$ ,  $Na_2O$ ,  $K_2O$ , and  $TiO_2$  in fine-grained samples analyzed from the Union Newlove 51 well. Includes all samples analyzed except the 3 sandstones from the Point Sal Formation and the sample at 530 feet from the upper part of the Sisquoc Formation.

Table 4. Average abundance (in weight %) of sedimentary components in the Union Newlove 51 well, Orcutt oil field, onshore Santa Maria basin. Values here (except organic matter) have been normalized to 100% on an organic-matter-free basis and are not directly comparable to values in Figure 4. Values exclude samples 530, 3057 (3A), 3256 (4A), and 3383 (2A). Standard deviations assume a normal distribution of values.

Formation	Detritus	Silica	Carbonate minerals	Apatite	Organic matter
Sisquoc Formation (14 samples):					
Range	56-76	22-40	1-14	0.0-0.7	1.0-1.4
Average	68	28	4	0.2	1.2
Std dev	6	6	3	0.3	0.1
Monterey Formation (55 samples):					
Range	7-91	2-72	0-91	0.0-11.3	1.5-27.7
Average	46	31	22	1.3	7.2
Std dev	21	17	23	2.3	4.8
Point Sal Formation (10 samples):					
Range	53-81	15-29	0-24	0.0-6.1	1.1-6.1
Average	68	21	10	1.2	4.0
Std dev	10	4	9	2.1	1.8

abundances are summarized by formation in Table 4. Note that abundances range widely within the Monterey Formation and more moderately in the Sisquoc and Point Sal Formations (Table 4; data in Appendix Table 2). Another interesting feature of the data in Table 4 is that the average silica abundance of the 55 samples from the Monterey Formation is only 31%, barely above the average 28% shown for the Sisquoc Formation. Data from the Union Newlove 51 well have also been averaged according to Canfield's (1939) zones, as originally defined by the operator (Figure 4), but sample numbers are not adequate to be confident of the differences shown in any detail.

Compared to correlative strata in the Santa Barbara coastal area (Isaacs and others, 1983), samples from the Union Newlove 51 well have a greater average abundance of fine terrigenous detritus, particularly in the Point Sal Formation. The average detritus abundance in all lithologic units from the Union Newlove 51 well is also greater than in correlative strata from the Point Conception COST well in the offshore Santa Maria basin (Isaacs and others, 1983).

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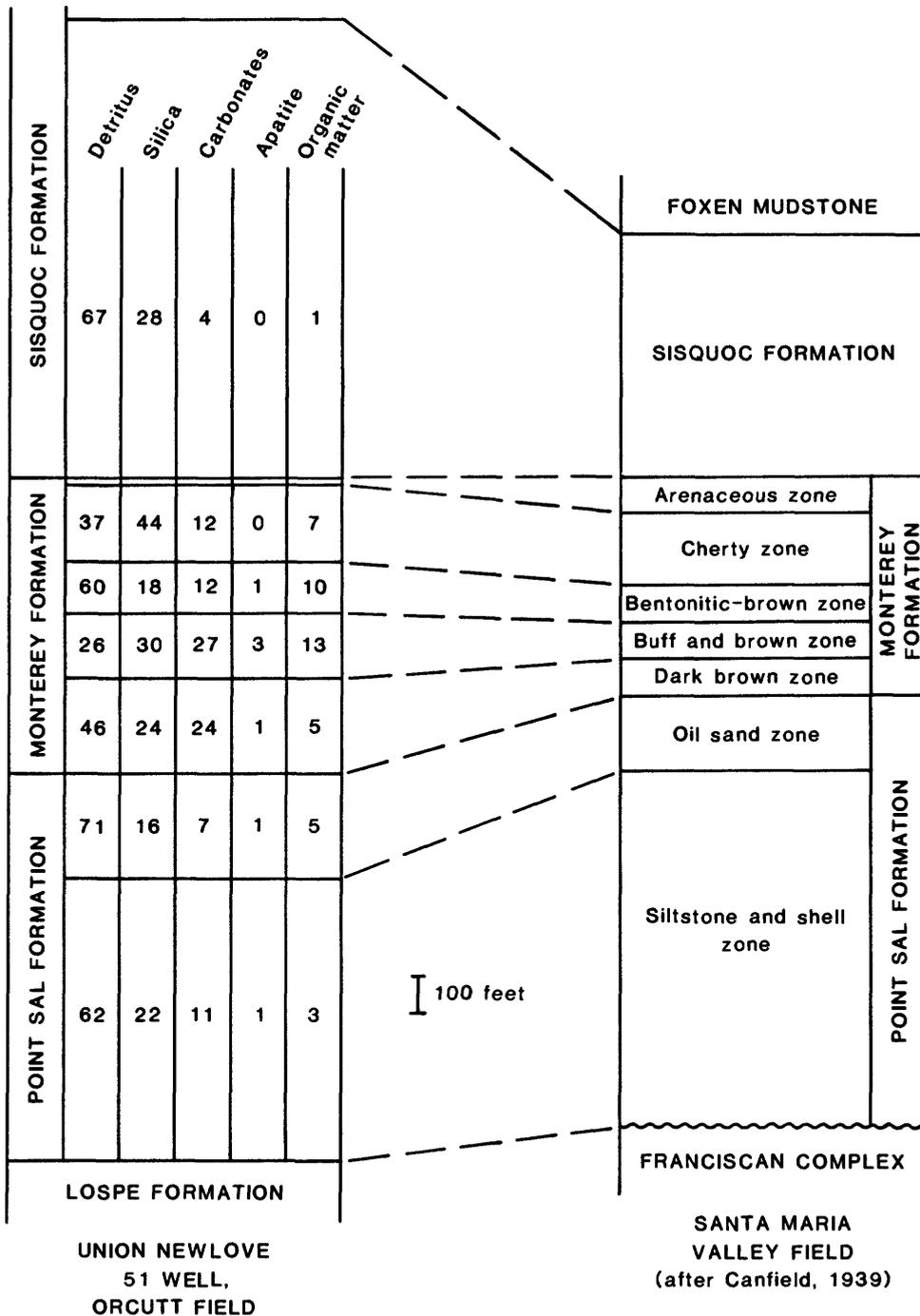


Figure 4. Lithostratigraphic units of the Monterey Formation and adjacent formations in the Santa Maria Valley field area and the Union Newlove 51 well, showing mean composition of samples from each unit. Formations represent common current usage, but correlation lines are based on zones from original operator reports on the Union Newlove 51 well. Note that the oil sand zone in the Santa Maria Valley field is not today regarded as comparable to the sandstone-bearing strata at the top of the Point Sal Formation in the Orcutt oil field (Gregg H. Blake, personal communication, 1989).

grinding the samples and running bulk X-ray diffraction analyses. For major element determinations, project leaders were Joseph E. Taggart, Jr. and James S. Wahlberg; analysts were James W. Baker, Ardith J. Bartel, Kathleen C. Stewart, Joseph E. Taggart, Jr., and James S. Wahlberg. For carbon determinations, project leaders were Larry L. Jackson, James L. Seeley, and William Updegrave; analysts were Georgia Mason, Sarah T. Neil, and Van E. Shaw. Martin B. Lagoe and Margaret A. Keller reviewed preliminary versions of the manuscript.

#### REFERENCES

- Blake, M. C., Jr., Campbell, R. H., Dibblee, T. W., Jr., Howell, D. G., Nilsen, T. H., Normark, W. R., Vedder, J. G., and Silver, E. A., 1978, Neogene basin formation in relation to plate-tectonic evolution of the San Andreas Fault System, California: American Association of Petroleum Geologists Bulletin, v. 62, p. 344-372.
- California Division of Oil and Gas, 1974, California oil and gas fields, south, central coastal, and offshore California: State of California, Sacramento, California, v. 2.
- Canfield, C. R., 1939, Subsurface stratigraphy of Santa Maria Valley oil field and adjacent parts of Santa Maria Valley, California: American Association of Petroleum Geologists Bulletin, v. 23, p. 45-81.
- Isaacs, C. M., 1980, Diagenesis in the Monterey Formation examined laterally along the coast near Santa Barbara, California: Stanford University unpublished Ph.D. thesis, 329 p.
- Isaacs, C. M., Jackson, L. L., Stewart, K. C., and Scott, N., III, in press, Analytical reproducibility and abundances of major oxides, total carbon, organic carbon, and sedimentary components of Miocene and early Pliocene cuttings from the Point Conception Deep Stratigraphic Test Well, OCS-Cal 78-164 No. 1, offshore Santa Maria basin, southern California: U.S. Geological Survey Open-File Report 87-75 (in press).
- Isaacs, C. M., Keller, M. A., Gennai, V. A., Stewart, K. C., and Taggart, J. E., Jr., 1983, Preliminary evaluation of Miocene lithostratigraphy in the Point Conception COST well OCS-Cal 78-164 No. 1, off Southern California, in Isaacs, C. M., and Garrison, R. E., eds., Petroleum generation and occurrence in the Miocene Monterey Formation, California: Society of Economic Paleontologists and Mineralogists Pacific Section Book 33, p. 99-110.
- Leventhal, J. S., and Shaw, V. E., 1980, Organic matter in Appalachian Devonian black shale: I. Comparison of techniques to measure organic carbon, II. Short Range organic carbon content variations: Journal of Sedimentary Petrology, v. 50, p. 77-81.
- Rader, L. F., and Grimaldi, F. S., 1961, Chemical analyses for selected minor elements in Pierre Shale: U.S. Geological Survey Professional Paper 391-A, 45 p.
- Taggart, J. E., Jr., and Wahlberg, J. S., 1980a, A new in-muffle automatic fluxer design for casting glass discs for X-ray fluorescence analysis: Federation of Analytical Chemists and Spectroscopy Societies Meeting, Philadelphia, Pa., September 1980.
- Taggart, J. E., Jr., and Wahlberg, J. S., 1980b, New mold design for casting fused samples, in Rhodes, J. R., ed., Twenty-eighth annual conference on applications of X-ray analysis: Advances in X-ray analysis, v. 23, p. 257-261.

- Taggart, J. E., Jr., Lichte, F. E., and Wahlberg, J. S., 1981, Methods of analysis of samples using X-ray fluorescence and induction-coupled plasma spectroscopy, in Lipman, P. W., ed., The 1980 eruptions of Mount St. Helens, Washington: U.S. Geological Survey Professional Paper 1250, p. 683-687.
- Woodring, W. P., and Bramlette, M. N., 1950, Geology and Paleontology of the Santa Maria district, California: U.S. Geological Survey Professional Paper 222, 142 p.

Appendix - Table 1. Elemental abundances (in weight %) in samples from the Union Newlove 51 well. Sample numbers represent the average depth of the cored interval (see Appendix Table 3 for exact limits of each core) followed (in parentheses) by tray number; letters differentiate various samples from the same tray.

Sample number	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	MgO	CaO	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO	LOI	Org carb	Carb'te carb
<b>SISQUOC FORMATION:</b>													
530	56.8	7.17	2.95	1.95	7.17	1.39	0.99	0.36	3.54	<0.02	15.8	7.52	0.83
910 (2A)	63.9	12.5	3.45	1.40	2.10	2.73	1.91	0.56	0.29	<0.02	9.71	-	-
961 (A)	67.4	12.0	3.75	1.71	2.07	2.52	2.03	0.53	0.29	0.02	7.07	-	-
1060 (1A)	68.1	12.0	4.28	1.89	2.33	2.49	1.74	0.54	0.39	0.02	5.14	-	-
1118 (2A)	67.4	12.2	4.49	1.96	2.10	2.18	1.76	0.56	0.50	0.03	5.84	-	-
1180 (5A)	60.8	10.3	4.06	1.57	7.59	1.86	1.35	0.45	0.34	0.06	8.88	-	-
1202 (A)	67.4	11.5	4.43	2.08	2.66	1.96	1.56	0.56	0.48	0.03	5.94	0.81	0.60
1202 (B)	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
1202 (C)	65.7	10.7	4.25	1.97	1.95	1.81	1.46	0.49	0.49	0.02	9.49	0.74	0.48
1229 (7A)	72.6	9.89	3.11	1.22	1.26	1.87	1.42	0.45	0.35	<0.02	6.48	-	-
1254 (7A)	70.3	11.0	4.20	1.84	1.77	2.00	1.61	0.51	0.42	0.02	5.51	-	-
1341 (A)	66.0	12.6	4.69	2.09	1.67	2.14	2.02	0.59	0.44	<0.02	6.35	0.93	0.16
1453 (5A)	71.0	9.56	4.91	2.20	1.49	1.65	1.43	0.45	0.34	0.03	6.13	0.81	0.54
1497 (4A)	67.6	12.7	4.21	1.63	2.15	2.58	2.07	0.58	0.59	<0.02	5.52	-	-
1497 (4B)	63.8*	12.3*	4.32*	1.66*	2.22*	2.34*	1.96*	0.58*	0.67*	-*	8.71*	-	-
<b>MONTEREY FORMATION, Cherty zone:</b>													
1921 (A)	71.7	8.68	2.70	1.06	1.57	1.90	1.71	0.42	0.48	<0.02	9.35	-	-
1946 (A)	75.9	2.79	1.10	0.60	5.49	1.01	0.49	0.13	0.20	<0.02	10.1	-	-
1968 (1A)	77.3	5.98	1.90	0.89	1.84	1.46	1.11	0.28	0.24	<0.02	8.20	-	-
1968 (2A)	71.9	5.52	1.80	0.69	5.15	1.42	1.03	0.25	0.31	<0.02	9.99	3.23	0.68
1968 (2B)	55.9	6.62	2.24	1.33	11.3	1.42	1.30	0.32	0.38	<0.02	14.9	5.47	1.52
1991 (2A)	73.0	5.60	2.24	1.73	3.52	1.31	0.97	0.28	0.27	<0.02	9.69	-	-
2010 (2A)	66.6	9.20	2.86	1.52	2.76	1.59	1.74	0.45	0.32	0.03	10.9	4.40	0.32
2010 (6A)	61.1	6.70	2.32	1.35	8.56	1.30	1.30	0.33	0.34	<0.02	14.3	-	-
2026 (A)	67.2	7.51	2.49	1.36	4.64	1.52	1.42	0.37	0.32	<0.02	11.7	-	-
2037 (4A)	67.1	7.79	2.29	1.92	3.90	2.05	1.41	0.43	0.37	<0.02	11.2	3.19	0.88
2037 (5A)	54.2	5.58	1.92	2.75	11.3	1.20	1.04	0.27	0.40	0.03	18.9	6.67	2.30
2037 (5B)	45.7*	4.68*	1.53*	1.97*	15.4*	0.98*	0.92*	0.22*	0.50*	<0.02*	24.2*	-	-

Appendix - Table 1. continued

MONTEREY FORMATION, Bentonitic brown zone:													
2178 (1A)	49.8	7.33	2.69	1.66	10.9	1.03	1.38	0.36	0.65	0.03	19.9	7.15*	1.94*
2178 (6A)	37.6	6.02	2.14	1.70	18.5	0.86	1.14	0.29	0.48	0.02	27.6	10.79	2.97
2202 (1A)	66.0	10.6	3.37	1.31	0.99	1.71	1.70	0.54	0.33	<0.02	12.7	-	-
2227 (6A)	55.2	13.6	4.96	1.50	1.03	2.05	2.58	0.72	0.39	0.03	17.1	4.98	<0.01
2227 (8A)	56.1	12.3	4.48	1.73	2.12	1.98	2.34	0.65	0.18	0.03	16.3	4.82*	0.65*
2254 (2A)	50.7	11.2	4.49	2.86	6.06	1.64	2.21	0.60	1.64	0.04	15.7	6.18	0.41
MONTEREY FORMATION, Buff and brown zone:													
2395 (A)	52.0	6.28	2.29	4.43	7.86	0.75	1.46	0.32	0.67	<0.02	19.6	-	-
2408 (A)	77.3	3.89	1.30	1.14	1.99	0.55	0.84	0.19	0.31	<0.02	10.8	5.68	0.39
2439 (A)	45.1	5.57	2.46	3.86	8.91	0.77	1.30	0.34	1.79	<0.02	24.4	-	-
2441 (3)	48.9	6.53	2.49	2.12	3.55	0.81	1.65	0.37	0.58	<0.02	29.0	18.45	0.89
2455 (5)	18.8	3.15	1.31	11.0	24.6	0.43	0.49	0.19	2.78	<0.02	33.7	5.56	7.62
2487 (A)	36.4	2.96	1.17	8.38	18.3	0.52	0.52	0.13	2.69	<0.02	26.4	-	-
2487 (B)	40.7	3.05	1.19	8.34	16.9	0.52	0.56	0.14	1.93	<0.02	24.5	3.87	5.58
MONTEREY FORMATION, Dark brown zone:													
2634 (A)	36.1	2.34	0.99	9.28	19.2	0.40	0.43	0.10	1.90	<0.02	26.9	4.36	5.67
2651 (7A)	21.9*	2.21*	0.92*	13.3*	23.9*	0.31*	0.45*	0.09*	0.38*	0.03*	34.2*	2.59*	8.37*
2667 (A)	71.5	4.48	1.90	1.69	3.72	0.81	0.94	0.22	0.86	<0.02	10.5	5.53	0.48
2669 (1A)	57.5	4.15	1.59	5.14	9.74	0.69	0.80	0.19	0.69	<0.02	16.9	-	-
2669 (4A)	65.2	10.7	5.13	1.56	1.30	1.33	2.17	0.58	0.10	0.03	10.6	2.52	0.32
2669 (6A)	61.9	12.8	4.39	0.83	0.24	1.33	2.24	0.55	0.11	<0.02	14.8	-	-
2687 (2A)	63.0	7.65	3.04	2.71	4.56	1.28	1.70	0.37	0.49	<0.02	10.6	-	-
2687 (3A)	54.8	8.90	2.96	3.65	6.99	0.96	1.53	0.39	0.95	<0.02	12.9	-	-
2687 (4A)	65.8	10.2	3.82	1.04	1.20	1.57	2.11	0.51	0.64	<0.02	12.4	3.52	<0.01
2687 (5A)	61.7	8.89	3.59	1.54	4.6	1.27	1.65	0.43	2.24	<0.02	12.4	-	-
2687 (5B)	67.1*	9.07*	3.85*	1.81*	2.03*	1.37*	1.87*	0.46*	0.09*	-*	10.3*	-	-
2687 (6A)	59.0	7.25	3.12	3.21	6.01	1.16	1.45	0.37	0.94	0.02	13.1	-	-
2687 (7A)	23.2	3.95	1.51	11.7	22.0	0.59	0.69	0.15	1.13	0.06	31.3	5.14	5.62
2705 (2A)	65.8	9.71	4.30	1.57	1.48	1.59	1.93	0.51	0.09	0.02	11.1	3.48	0.29
2705 (2B)	65.9	10.7	4.20	1.40	1.59	1.77	1.89	0.44	0.23	<0.02	9.85	-	-
2705 (4A)	25.8	5.47	2.22	11.9	19.4	0.81	0.98	0.24	0.23	0.07	28.1	1.89	7.12
2705 (5A)	61.6	12.0	4.94	1.12	0.42	1.81	2.57	0.61	0.15	0.02	13.5	-	-
2722 (2A)	6.33	1.30	0.95	17.0	29.7	0.21	0.20	0.04	0.10	0.08	41.5	1.17	11.14

Appendix - Table 1. continued

2722 (3A)	64.4	7.23	2.97	2.56	3.74	1.28	1.38	0.32	0.21	<0.02	12.7	5.31	0.46
2722 (6A)	56.5	6.29	2.45	4.66	7.63	1.22	1.18	0.28	0.25	0.02	14.0	3.85	2.57
2743 (2A)	33.7	6.26	2.82	9.61	16.2	0.88	1.11	0.28	0.55	0.07	22.9	-	-
2758 (2A)	60.8	12.8	4.86	1.26	0.51	1.96	2.71	0.61	0.23	0.02	12.8	2.49	0.06
2788 (2A)	61.9	12.1	4.74	1.69	1.75	1.90	2.48	0.58	0.75	0.02	10.6	-	-
2788 (A)	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
2810 (A)	32.3	4.72	2.09	9.46	18.0	0.90	0.94	0.22	1.19	0.06	26.2	4.03	5.69
2824 (A)	37.1	7.51	2.84	7.45	15.5	1.33	1.50	0.35	2.39	0.06	19.7	-	-
2824 (B)	11.8	2.70	2.23	14.7	27.3	0.55	0.41	0.10	0.09	0.12	37.6	0.97	10.14
2824 (C)	46.4	9.89	3.87	5.83	9.29	1.59	1.84	0.50	0.32	0.07	14.6	-	-
2824 (5A)	61.2	12.4	4.25	1.57	0.69	2.07	2.53	0.61	0.23	0.02	13.3	4.53	0.04
2837 (2A)	47.2	9.58	3.63	3.02	10.3	1.58	1.91	0.46	4.56	0.02	14.1	5.18	1.51

POINT SAL FORMATION, Oil sand zone:

2850 (3A)	64.5	13.2	4.21	1.39	0.36	2.64	2.38	0.61	0.20	<0.02	9.33	-	-
2867 (2A)	51.1	10.7	4.09	4.75	7.65	1.94	2.05	0.50	0.14	0.08	11.2	2.08	2.06
3040 (3A)	54.1	11.6	4.78	2.27	5.67	2.03	2.40	0.61	2.67	0.02	11.6	4.09	0.23
3040 (4A)	60.5	12.7	4.26	1.98	1.81	2.15	2.62	0.65	0.73	0.02	10.9	4.00	0.04
3057 (3A)	48.7	6.65	1.77	6.62	12.8	2.20	0.83	0.18	0.14	0.09	16.8	1.25	4.50

POINT SAL FORMATION, Siltstone and shell zone:

3137 (3A)	49.3	8.77	3.45	5.01	9.51	1.67	1.77	0.41	1.21	0.05	13.9	3.02	2.77
3156 (B)	61.5	9.98	3.58	1.42	5.60	1.89	2.01	0.47	0.99	<0.02	10.6	-	-
3256	51.7	8.90	3.22	2.94	11.3	1.60	1.78	0.44	1.03	0.02	13.1	3.31	2.51
3256 (4A)	38.3	6.21	1.77	1.13	26.8	1.83	0.83	0.21	0.15	0.05	20.6	0.66	5.38
3383 (2A)	71.9	11.0	2.91	1.38	1.85	3.29	1.79	0.39	0.10	0.03	2.86	0.25	0.14
3383 (2B)	62.5	11.9	4.47	2.08	3.62	2.19	2.24	0.56	0.88	0.03	7.80	2.39	0.27
3500 (3)	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
3524 (2)	66.2	13.0	4.79	2.72	1.21	2.67	2.27	0.65	0.17	0.04	5.18	0.74	0.10

\* Mean values of duplicate analyses (see text Tables 2a and 3).

Appendix - Table 2. Approximate mineral abundances (in weight %) in samples from the Union Newlove 51 well based on data in Appendix Table 1. See text for calculation method, comments on negative values, and problems with the accuracy of the calcite-dolomite partition.

Sample Number	Detritus	Silica	Dolomite	Calcite	Apatite	Organic matter
<b>SISQUOC FORMATION:</b>						
530*						
910 (2A)	47	37	6	1	9.1	11.3
961 (A)	76	22	0	2	-0.3	-
1060 (1A)	70	27	2	1	-0.2	-
1118 (2A)	69	27	3	1	0.0	-
1180 (5A)	71	26	3	0	0.3	-
1202 (A)	60	26	2	12	0.0	-
1202 (B)	67	28	4	1	0.3	1.2
1202 (C)	68	29	4	0	0.1	1.0
1229 (7A)	65	31	4	0	0.4	1.1
1254 (7A)	59	40	1	0	0.1	-
1341 (A)	64	33	3	0	0.2	-
1453 (5A)	74	23	3	-1	0.1	1.4
1497 (4A)	56	40	6	-2	0.1	1.2
1497 (4B)	73	24	1	1	0.4	-
	74	22	2	1	0.7	-
<b>MONTEREY FORMATION, Cherty zone:</b>						
1921 (A)	53	45	1	1	0.5	-
1946 (A)	17	72	1	9	0.3	-
1968 (1A)	36	61	1	2	0.1	-
1968 (2A)	34	57	0	9	0.3	4.8
1968 (2B)	41	36	3	19	0.4	8.2
1991 (2A)	34	58	5	3	0.2	-
2010 (2A)	57	38	3	3	0.1	6.6
2010 (6A)	41	41	3	14	0.3	-
2026 (A)	46	45	3	6	0.2	-
2037 (4A)	48	44	5	3	0.3	4.8
2037 (5A)	35	39	11	15	0.6	10.0
2037 (5B)	31	34	8	26	1.0	-

Appendix - Table 2. continued

MONTEREY FORMATION, Bentonitic brown zone:									
2178 (1A)	48	28	5	18	1.1	10.7			
2178 (6A)	40	20	6	34	0.8	16.2			
2202 (1A)	67	33	1	0	0.0	-			
2227 (6A)	91	9	0	0	-0.1	7.5			
2227 (8A)	81	15	2	2	-0.6	7.2			
2254 (2A)	72	13	9	3	3.5	9.3			
MONTEREY FORMATION, Buff and brown zone:									
2395 (A)	41	35	20	3	1.3	-			
2408 (A)	24	71	4	1	0.5	8.5			
2439 (A)	40	33	19	4	4.8	-			
2441 (3)	52	37	9	2	1.2	27.7			
2455 (5)	19	9	53	12	6.9	8.3			
2487 (A)	18	28	40	7	6.7	-			
2487 (B)	18	32	39	6	4.6	5.8			
MONTEREY FORMATION, Dark brown zone:									
2634 (A)	14	30	44	8	4.6	6.5			
2651 (7A)	13	15	62	10	0.8	3.9			
2667 (A)	28	62	6	2	1.9	8.3			
2669 (1A)	25	46	23	4	1.4	-			
2669 (4A)	67	31	2	0	-0.6	3.8			
2669 (6A)	83	20	-3	1	-0.8	-			
2687 (2A)	48	40	9	2	0.6	-			
2687 (3A)	55	26	14	3	1.7	-			
2687 (4A)	65	34	0	0	0.8	5.3			
2687 (5A)	56	35	3	1	5.1	-			
2687 (5B)	56	39	4	1	-0.5	-			
2687 (6A)	46	38	12	2	1.9	-			
2687 (7A)	24	10	55	9	2.5	7.7			
2705 (2A)	61	36	3	1	-0.6	5.2			
2705 (2B)	66	32	1	1	-0.3	-			
2705 (4A)	32	7	54	6	0.1	2.8			
2705 (5A)	79	23	-1	0	-0.6	-			
2722 (2A)	7	2	79	11	0.1	1.8			

Appendix - Table 2. continued

2722 (3A)	46	44	9	1	-0.1	8.0
2722 (6A)	39	38	20	3	0.1	5.8
2743 (2A)	37	13	44	5	0.9	-
2758 (2A)	83	19	-1	0	-0.5	3.7
2788 (2A)	76	22	2	0	1.0	-
2788	56	18	23	3	-0.4	2.4
2810 (A)	29	17	44	7	2.7	6.0
2824 (A)	45	12	32	6	5.4	-
2824 (B)	16	2	69	13	0.0	1.5
2824 (C)	60	13	23	4	0.0	-
2824 (5A)	80	20	1	-1	-0.5	6.8
2837 (2A)	61	15	10	2	11.3	7.8
POINT SAL FORMATION, Oil sand zone:						
2850 (3A)	81	20	0	-1	-0.6	-
2867 (2A)	64	15	18	4	-0.5	3.1
3040 (3A)	73	15	5	1	6.1	6.1
3040 (4A)*	79	18	3	-1	0.9	6.0
3057 (3A)*	38	26	28	8	-0.2	1.9
POINT SAL FORMATION:						
3137 (3A)	53	20	20	4	2.4	4.5
3156 (B)	61	29	2	7	1.7	-
3256	53	22	10	13	1.9	5.0
3256 (4A)*	35	17	2	46	-0.1	1.0
3383 (2A)*	63	34	1	2	-0.6	0.4
3383 (2B)	71	22	4	2	1.3	3.6
3500 (3)	73	22	6	-1	-0.5	2.3
3524 (2)	75	21	6	-2	-0.6	1.1

\* These samples are not included in figures and mean calculations. Sample 530 is from the upper part of the Sisquoc Formation; the other three samples are sandstones.

Appendix - Table 3. Depth intervals represented by sample numbers (Appendix Tables 1 and 2) from the Union Newlove 51 well.

Sample No.	Depth interval	Sample No.	Depth interval
530	520-540	2439	2435-2443
910	897-923	2455	2447-2463
961	948-974	2487	2480-2495
1060	1049-1070	2634	2625-2641
1118	1113-1123	2651	2641-2660
1180	1168-1191	2669	2660-2677
1202	1191-1216	2687	2677-2696
1229	1216-1241	2705	2696-2714
1254	1241-1266	2722	2714-2730
1341	1328-1354	2743	2736-2750
1453	1444-1462	2758	2750-2766
1497	1487-1506	2788	2785-2790
1921	1913-1937	2810	2804-2816
1946	1937-1955	2824	2816-2832
1968	1955-1980	2837	2832-2841
1991	1980-2002	2850	2841-2859
2010	2002-2018	2867	2859-2875
2026	2018-2033	3040	3030-3050
2037	2033-2041	3057	3050-3064
2178	2165-2190	3137	3129-3146
2202	2190-2213	3156	3146-3165
2227	2215-2218	3256	3247-3265
2254	2240-2267	3383	3373-3393
2395	2387-2404	3500	3491-3509
2408	2404-2413	3524	3515-3533