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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

by

Caroline M. Isaacs[1]
Larry L. Jackson[2]
Kathleen C. Stewart[2]
Norman Scott, III[1]

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[1]U.S. Geological Survey
345 Middlefield Road, MS 999
Menlo Park, California 94025

[2]U.S. Geological Survey
Federal Center, Box 25046
Denver, Colorado 80225

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ABSTRACT

Bulk cuttings samples from 64 30-foot intervals were analyzed from the sequence of the Miocene Monterey Formation and the late Miocene to early Pliocene Sisquoc Formation in the Point Conception Deep Stratigraphic Test (DST) well. These samples do not represent the complete sequence, but only each third 30-foot interval. Based on these analyses, the Monterey Formation averages 38% detritus (range of 30-foot interval averages, 11-52%), 39% silica (range 20-71%), 23% carbonate minerals (range 6-44%), <1% apatite (range 0-3%), and 2.9% organic matter (range 1.5-5.9%). By contrast, the Sisquoc Formation is more detritus-rich (av 57%, range 45-68%), less siliceous (av 32%, range 20-41%), less rich in carbonate minerals (av 11%, range 5-23%), and more organic-rich (av 3.9%, range 2.4-8.2%).

Analyses of duplicate splits show that compared to powder samples (which have an average standard deviation <1% of measured values), some additional variability is introduced to the reproducibility of cuttings samples (av standard deviation 2-3% of measured values), probably as a result of bias introduced by the large size of some individual cuttings. Average standard deviations of sedimentary components in duplicate bulk (unpowdered) cuttings are 0.7 wt% detritus, 0.7 wt% silica, 0.5 wt% dolomite, 0.1 wt% calcite, 0.01 wt% apatite, and 0.1 wt% organic matter. Additional variability was also introduced by prior handling, such as inexact splitting of separately bagged sets of cuttings, and such variability is probably commonly introduced by the handling of cuttings. Standard deviations of sedimentary components in separately bagged samples from the same depth interval are nevertheless reasonably small, averaging 1.4 wt% detritus, 1.7 wt% silica, 0.8 wt% dolomite, 0.6 wt% calcite, 0.05 wt% apatite, and 0.1 wt% organic matter.

INTRODUCTION

The Point Conception Deep Stratigraphic Test Well OCS-Cal 78-164 No. 1, informally known as the Point Conception COST well, was drilled in 1978 about 10 miles southwest of Point Arguello at 120°47'0" W longitude and 34°28'56.6" N latitude. Water depth was 1428 feet, and total drilled depth 10,571 feet. A variety of studies of this well were published by the U.S. Geological Survey in 1979, including biostratigraphy (Bukry, 1979; McDougall and others, 1979), geochemistry of selected intervals (Piper and Fowler, 1979), mineralogy of selected intervals (Hein and others, 1979), and a stratigraphic summary (McCulloch and others, 1979).

Since publication of the 1979 U.S. Geological Survey Open-File Report 79-1218 (Cook, 1979), the Point Conception DST (Deep Stratigraphic Test) well has become extremely important as a source of information about Miocene strata in the offshore area because of its proximity to the Point Arguello oil field (Fig. 1) which contains estimated recoverable oil in excess of 300 million barrels (Crain and others, 1984, 1985).

A preliminary evaluation of Miocene lithostratigraphy in the Point Conception DST well was previously presented (Isaacs and others, 1983). Data for that evaluation were major elemental abundances of bulk cuttings in the interval 4585-9895 feet (cuttings were collected over 30-foot intervals and each third sample was analyzed); also analyzed were 61 individual cuttings. Additional data presented here include: (1) organic-carbon and carbonate-carbon analyses of all bulk cuttings previously reported by Isaacs and others (1983), and (2) analytical data on bulk cuttings from the intervals 4255, 4345, 4405, 5125, 5755, 6745, 7105, and 7465 feet. Each sample represents cuttings from 30-foot intervals (from 15 feet above to 15 feet below the depth reported), and reported depths represent well depths measured from the derrick floor, which was 1465 feet above the seafloor. Stratigraphic thicknesses are somewhat smaller than values indicated by depth differences due to small dips ranging from 1-6° in the uppermost (4200-4800 feet) interval analyzed to 18-22° in the lowermost (9520-9600 feet) interval analyzed (Prensky, 1979).

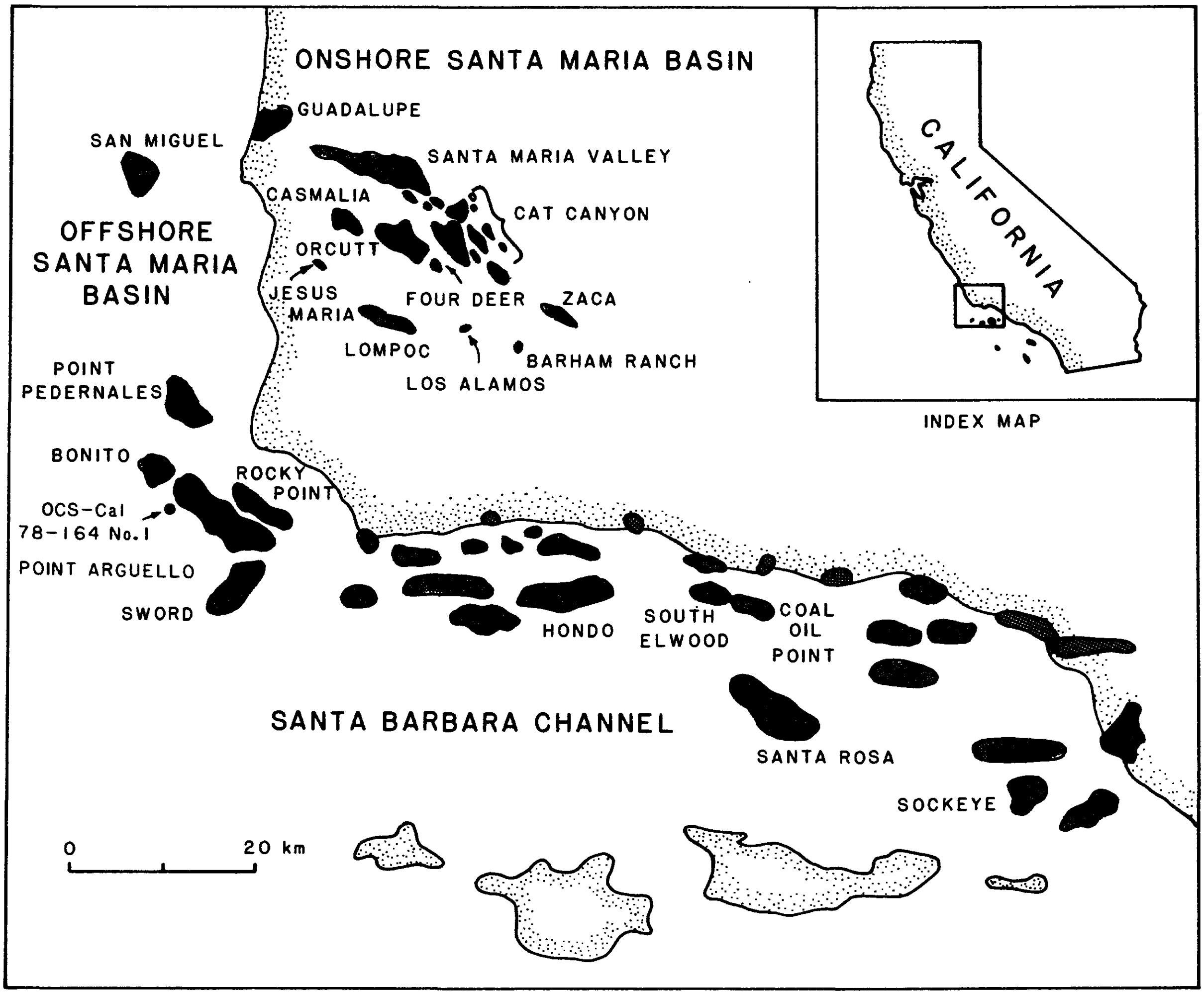

Figure 1. Location map showing position of the Point Conception DST well and oil and gas fields in the Santa Maria and Santa Barbara-Ventura areas, California. Labeled fields have significant production or potential from Monterey Formation fractured reservoirs. Adapted from California Division of Oil and Gas (1974) and Williams (1985).

METHODS

Sample Storage and Preparation

Bulk cuttings were washed, and split with a riffle splitter as part of the U.S. Geological Survey study published in 1979. The set of samples used for the present study was stored in paper envelopes, in some cases in as many as 4 envelopes per depth interval. Because of this prior handling, each envelope was treated as a separate sample (see "Reproducibility of Cuttings Analyses" below). Samples were split in mid-1982 with a riffle splitter, and submitted for grinding to the U.S. Geological Survey Branch of Analytical Chemistry.

Analytical Techniques - Major Oxides

Samples were analyzed for major elements by X-ray fluorescence spectroscopy, using methods described by Taggart and Wahlberg (1980a, b) and Taggart and others (1981, 1987). Identical methods were used on samples reported in Isaacs and others (1989). For this analysis, 0.8 g of sample (ground to <100 mesh) was weighed into a tared platinum-gold (95:5) crucible and ignited for 45 minutes at 920°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 40 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 (Taggart and others, 1981).

Note that samples were not dried prior to analysis and included H_2O^- (adsorbed water). Amounts of H_2O^- probably range from about 1 wt% to as much as 5 wt% in clay-rich samples (Isaacs, 1980, appendix A).

Analytical Techniques - Carbon

Carbon was measured by methods described by Jackson and others (1987), somewhat different from methods used on samples in previous reports (e.g., Isaacs and others, 1989). Total carbon abundance was measured by dry combustion with a LECO CR12 automated carbon analyzer. Carbonate carbon was measured by automated coulometric titration of perchloric acid-evolved CO_2 (Engleman and others, 1985). Organic carbon was then determined by difference between total carbon and carbonate carbon.

In contrast to procedures for major oxide analyses, most samples were dried for 4-24 hours prior to analysis for carbon. Exceptions are samples 4255, 4345, 4405, 5125, 5755, 6745, 7105, and 7465 which were not dried prior to carbon analysis.

Determination of Sedimentary Components

The major sedimentary components in the Monterey Formation are termed silica (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. Abundances of silica and detritus were estimated from elemental abundances of SiO_2 and Al_2O_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 CaO, MgO, and P_2O_5 after adjustment of these values for average abundances in the aluminosilicate fraction (Table 1). Because not all abundance values were confirmed by X-ray diffraction analysis, they are preliminary estimates only. Abundances of organic matter were estimated from the abundances of total organic carbon (Table 1).

Dolomite has probably been underestimated relative to calcite (see below under "Results and Discussion") because dolomite in the Monterey Formation tends to have CaO in excess of the ideal values used here (Table 1) and may also have significant Fe (Murata and others, 1972). For comparison, the abundances of carbonate carbon represented by dolomite + calcite as estimated above (0.13 x dolomite + 0.12 x calcite) was compared with the analytical determination of carbonate carbon. The average difference between these sets of values is 0.03 wt% carbonate carbon (about 0.3 wt% carbonate minerals), and the maximum difference is 0.33 wt% carbonate carbon (about 2.5-2.7 wt% carbonate minerals) (Table 2). These comparisons show that the total abundance of carbonate minerals can be reliably estimated from major oxide analyses.

A minor problem with this set of samples is that powders were analyzed for major oxides with adsorbed water (H_2O^-) whereas they were analyzed for carbon after drying, so that the two sets of values are not exactly comparable. Because of this difference, and in order to conform to previous reports (e.g., Isaacs and others, 1989), 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.

REPRODUCIBILITY OF CUTTINGS ANALYSES

Variability Due to Bulk Pieces

Because some cutting samples included individual pieces that are large (2-5 g) relative to sample size (10-15 g), some bias and (or) variability may have been introduced into analytical results by splitting. The overall magnitude of this variability was investigated by analyzing several pairs of samples representing duplicate splits from the same envelope.

A previous study (Isaacs and others, 1989) showed that for duplicate powder splits analyzed by the techniques used here, the relative standard deviation is generally less than 1% of major oxide values (av 0.9%) . That is to say, for oxide abundances of 30 wt% and 60 wt%, standard deviations are less than 0.3 wt% and 0.6 wt% oxide respectively (a relative standard deviation less than 1%). Additional variability introduced by the inhomogeneous character of cuttings is shown by larger average relative standard deviations - in the range 1.0-2.6% (av. 1.9%) - of major oxides analyzed here among duplicate splits of the same bulk (unpowdered) cuttings

Table 1. Formulas used to convert elemental abundances to approximate abundances of sedimentary components. Formulas for detritus and silica abundance and the 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_2O_5 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 may be slightly underestimated and calcite abundances slightly overestimated.

Quantity	Explanation	Formula
Detritus	Equals aluminosilicates + detrital quartz	$5.6 \times Al_2O_3$
Aluminosilicates	Based on Al_2O_3 content	$4.2 \times Al_2O_3$
Detrital quartz	Based on a proportion of aluminosilicates	Aluminosilicates ÷ 3
Silica (biogenic and diagenetic)	Based on SiO_2 content adjusted for amounts in detritus	$SiO_2 - (3.5 \times Al_2O_3)$
Apatite	Based on P_2O_5 content adjusted for 0.7% P_2O_5 in aluminosilicates and assuming 42.4% P_2O_5 in apatite	$[P_2O_5 - (0.032 \times Al_2O_3)] \div 0.424$
Dolomite	Based on MgO content adjusted for 2.6% MgO in aluminosilicates and assuming 21.9% MgO in dolomite	$[MgO - (0.11 \times Al_2O_3)] \div 0.219$
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	$[CaO - (0.08 \times Al_2O_3 - (0.555 \times \text{apatite}) - (0.304 \times \text{dolomite})] \div 0.56$
Organic matter	Based on organic carbon content	(Organic carbon) x 1.5

Table 2. Comparison of measured values of carbonate carbon with values calculated from dolomite and calcite abundances estimated from the abundances of major oxides (as described in Table 1). Carbon values estimated from oxides are based on abundances of carbonate minerals calculated from actual oxide analyses (Tables 3a, 4a, and 5), not from normalized values given in Table 7. (Weight %).

Sample number	Carbonate carbon (estimated from oxides)	Carbonate carbon (measured)	Difference (measured less estimated)
4255	5.52	5.69	0.17
4345	4.26	4.21	-0.05
4405	4.12	4.18	0.06
4495	0.50	0.58	0.08
4585	1.52	1.66*	0.14
4675	1.24	1.36*	0.12
4765	1.12	1.35*	0.23
4855	1.49	1.78*	0.29
4945	1.39	1.65*	0.26
5035	0.63	0.84*	0.21
5125	1.31	1.57	0.26
5215-2	1.31	1.50*	0.19
5215-4	1.06	1.26*	0.20
5305-3a	0.64	0.83*	0.19
5305-3b	0.70	0.89*	0.19
5395	0.72	0.92*	0.20
5482	2.64	2.74*	0.10
5575-2	2.24	2.03*	-0.21
5575-3	2.20	1.94*	-0.26
5665-2	0.59	0.64*	0.05
5665-3	1.05	0.98*	-0.07
5755	1.33	1.45	0.12
5845-2a	1.09	1.34*	0.25
5845-2b	0.94	1.16*	0.22
5845-3	0.93	1.12*	0.19
5935-2	2.05	2.35*	0.30
5935-3	1.84	2.11*	0.27
6025	1.05	1.28*	0.23
6115	0.75	0.97*	0.22
6205	1.18	1.38*	0.20
6295-2a	1.78	2.01*	0.23
6295-2b	1.76	1.96*	0.20
6385	0.69	0.84*	0.15
6475	0.75	0.91*	0.16
6565	1.33	1.42*	0.09
6655-2a	0.80	0.89*	0.09
6655-2b	0.95	1.05*	0.10
6745	1.02	1.08	0.06
6835-2	1.57	1.59*	0.02
6835-3	1.75	1.79*	0.04

Table 2. continued

6925-2	2.11	2.07*	-0.04
6925-3	1.90	1.88*	-0.02
7015-1	2.16	2.10*	-0.06
7015-3	2.12	2.11*	-0.01
7015-4	2.05	2.01*	-0.04
7105	2.89	2.93	0.04
7195	2.56	2.54*	-0.02
7285	4.59	4.58*	-0.01
7375	4.29	4.42*	0.13
7465	4.90	4.94	0.04
7555-1	5.41	5.52*	0.11
7555-2	5.08	5.15*	0.07
7555-3	5.02	5.06*	0.04
7645-2a	5.33	5.38*	0.05
7645-2b	5.31	5.38*	0.07
7735	2.86	2.72*	-0.14
7825	5.08	5.20*	0.12
7915	4.95	4.92*	-0.03
8005-2a	2.55	2.43*	-0.12
8005-2b	2.55	2.41*	-0.14
8095	3.64	3.58*	-0.06
8185	2.69	2.49*	-0.20
8275	2.88	2.84*	-0.04
8365	2.95	2.88*	-0.07
8455	2.51	2.50*	-0.01
8545	2.77	2.71*	-0.06
8635	2.81	2.80*	-0.01
8725	3.22	3.38*	0.16
8815-2	2.66	2.75*	0.09
8815-3	2.26	2.29*	0.03
8905-2a	2.99	3.10*	0.11
8905-2b	3.11	3.15*	0.04
8995	3.65	3.77*	0.12
9085-3a	3.60	3.60*	0.00
9085-3b	3.43	3.32*	-0.11
9175	3.53	3.50*	-0.03
9265	3.68	3.43*	-0.25
9355	4.20	3.90*	-0.30
9445	3.16	2.84*	-0.32
9535	1.78	1.47*	-0.31
9625	1.76	1.51*	-0.25
9715	1.28	0.95*	-0.33
9805-2	1.64	1.35*	-0.29
9805-3	1.44	1.20*	-0.24
9895	1.77	1.52*	-0.25
Average	2.39	2.42	0.03
Stand deviation	1.40	1.37	0.16

* Carbonate values measured on powders dried 4-24 hours before analysis. All other carbonate values and all oxide values were measured on powders not dried before analysis.

Table 3a. Comparison of elemental abundances in duplicate splits of bulk cuttings from the Point Conception DST well OCS-Cal 78-164 No. 1. (Weight %).

Sample number	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	LOI	Org carb	Carbonate carbon
5305-3a	67.7	8.55	3.61	2.02	2.31	1.43	1.46	0.44	0.36	<0.02	9.86	2.03	0.83
5305-3b	66.1	8.88	3.77	2.14	2.46	1.50	1.56	0.44	0.37	<0.02	10.3	2.23	0.89
Average	66.9	8.72	3.69	2.08	2.39	1.47	1.51	0.44	0.37	<0.02	10.1	2.13	0.86
Std. Dev.	1.1	0.23	0.11	0.08	0.11	0.05	0.07	0.00	0.01	-	0.3	0.14	0.04
% Std. Dev.	1.7%	2.7%	3.1%	4.1%	4.4%	3.4%	4.7%	0.0%	1.9%	-	3.1%	6.6%	4.9%
5845-2a	69.5	7.40	2.99	2.32	3.64	1.29	1.54	0.33	0.28	<0.02	7.87	1.39	1.34
5845-2b	71.0	7.11	2.87	2.06	3.23	1.26	1.49	0.32	0.26	<0.02	7.29	1.41	1.16
Average	70.3	7.26	2.93	2.19	3.44	1.28	1.52	0.33	0.27	<0.02	7.58	1.40	1.25
Std. Dev.	1.1	0.21	0.08	0.18	0.29	0.02	0.04	0.01	0.01	-	0.41	0.01	0.13
% Std. Dev.	1.5%	2.8%	2.9%	8.4%	8.4%	1.7%	2.3%	2.2%	5.2%	-	5.4%	1.0%	10.2%
6295-2a	62.8	7.32	3.84	3.60	5.17	1.29	1.16	0.38	0.33	0.02	11.0	1.61	2.01
6295-2b	63.5	7.34	3.70	3.58	5.09	1.32	1.15	0.39	0.34	<0.02	10.8	1.64	1.96
Average	63.2	7.33	3.77	3.59	5.13	1.31	1.16	0.39	0.34	-	10.9	1.63	1.99
Std. Dev.	0.5	0.01	0.10	0.01	0.06	0.02	0.01	0.01	0.01	-	0.1	0.02	0.04
% Std. Dev.	0.8%	0.2%	2.6%	0.4%	1.1%	1.6%	0.6%	1.8%	2.1%	-	1.3%	1.3%	1.8%
6655-2a	66.2	8.46	3.94	2.32	2.65	1.40	1.43	0.43	0.39	<0.02	10.5	3.17	0.89
6655-2b	65.8	8.21	3.83	2.51	3.03	1.38	1.38	0.42	0.38	<0.02	10.1	3.10	1.05
Average	66.0	8.34	3.89	2.42	2.84	1.39	1.41	0.43	0.39	<0.02	10.3	3.14	0.97
Std. Dev.	0.3	0.18	0.08	0.13	0.27	0.01	0.04	0.01	0.01	-	0.3	0.05	0.11
% Std. Dev.	0.4%	2.1%	2.0%	5.6%	9.5%	1.0%	2.5%	1.7%	1.8%	-	2.7%	1.6%	11.7%
7645-2a	43.7	4.68	2.63	8.77	13.9	1.13	0.72	0.25	0.20	0.05	20.2	1.04	5.38
7645-2b	43.9	4.83	2.61	8.80	13.8	1.15	0.75	0.27	0.21	0.05	20.0	1.02	5.38
Average	43.8	4.76	2.62	8.79	13.9	1.14	0.74	0.26	0.21	0.05	20.1	1.03	5.38
Std. Dev.	0.1	0.11	0.01	0.02	0.1	0.01	0.02	0.01	0.01	0.00	0.1	0.01	0.00
% Std. Dev.	0.3%	2.2%	0.5%	0.2%	0.5%	1.2%	2.9%	5.4%	3.4%	0.0%	0.7%	1.4%	0.0%

Table 3a. continued.

8005-2a	59.2	7.52	3.88	5.14	6.52	1.55	1.23	0.43	0.21	0.04	10.6	1.48	2.43
8005-2b	58.8	7.52	3.85	5.09	6.55	1.54	1.23	0.41	0.21	0.05	10.9	1.39	2.41
Average	59.0	7.52	3.87	5.12	6.54	1.55	1.23	0.42	0.21	0.05	10.8	1.44	2.42
Std. Dev.	0.3	0.00	0.02	0.04	0.02	0.01	0.00	0.01	0.00	0.01	0.2	0.06	0.01
% Std. Dev.	0.5%	0.0%	0.5%	0.7%	0.3%	0.5%	0.0%	3.4%	0.0%	15.7%	2.0%	4.4%	0.6%
8905-2a	55.8	6.83	3.64	5.19	8.42	1.35	1.24	0.41	0.27	0.04	13.7	1.81	3.10
8905-2b	55.0	6.69	3.61	5.45	8.64	1.39	1.24	0.41	0.28	0.04	13.9	1.97	3.15
Average	55.4	6.76	3.63	5.32	8.53	1.37	1.24	0.41	0.28	0.04	13.8	1.89	3.13
Std. Dev.	0.6	0.10	0.02	0.18	0.16	0.03	0.00	0.00	0.01	0.00	0.1	0.11	0.04
% Std. Dev.	1.0%	1.5%	0.6%	3.5%	1.8%	2.1%	0.0%	0.0%	2.6%	0.0%	1.0%	6.0%	1.1%
9085-3a	54.6	5.62	2.69	6.02	9.90	1.22	1.02	0.34	0.28	0.03	15.4	1.80	3.60
9085-3b	55.9	5.80	2.81	5.79	9.48	1.26	1.04	0.36	0.28	0.03	14.7	1.96	3.32
Average	55.3	5.71	2.75	5.91	9.69	1.24	1.03	0.35	0.28	0.03	15.1	1.88	3.46
Std. Dev.	0.9	0.13	0.08	0.16	0.30	0.03	0.01	0.01	0.00	0.00	0.5	0.11	0.20
% Std. Dev.	1.7%	2.2%	3.1%	2.8%	3.1%	2.3%	1.4%	4.0%	0.0%	0.0%	3.3%	6.0%	5.7%
Average	60.0	7.05	3.39	4.43	6.56	1.34	1.23	0.38	0.29	-	12.3	1.82	2.43
Av std dev	0.6	0.12	0.06	0.10	0.16	0.02	0.02	0.01	0.01	-	0.3	0.06	0.07
% std dev	1.0%	1.7%	1.8%	2.3%	2.5%	1.7%	1.9%	2.0%	2.6%	-	2.0%	3.5%	2.9%

Table 3b. Comparison of the abundances of sedimentary components in duplicate splits of bulk cuttings from the Point Conception DST well OCS-Cal 78-164 No. 1. Values derived from analyses in Table 3a by using formulas in Table 1. (Weight %).

Sample number	Detritus	Silica	Dolomite	Calcite	Apatite	Organic matter
5305-3a	47.9	37.8	4.9	0.03	0.20	3.0
5305-3b	49.7	35.0	5.3	0.04	0.20	3.3
Average	48.8	36.4	5.1	0.03	0.20	3.2
Std. Dev.	1.3	1.9	0.3	0.01	0.001	0.2
% Std. Dev.	2.7%	5.4%	5.3%	31%	0.5%	6.6%
5845-2a	41.4	43.6	6.9	1.6	0.10	2.1
5845-2b	39.8	46.1	5.8	1.5	0.08	2.1
Average	40.6	44.9	6.4	1.6	0.09	2.1
Std. Dev.	1.1	1.8	0.7	0.07	0.02	0.02
% Std. Dev.	2.8%	4.0%	12%	4.6%	20%	1.0%
6295-2a	41.0	37.2	12.8	1.0	0.23	2.4
6295-2b	41.1	37.8	12.7	0.9	0.25	2.5
Average	41.0	37.5	12.7	1.0	0.24	2.4
Std. Dev.	0.08	0.4	0.07	0.08	0.02	0.03
% Std. Dev.	0.2%	1.2%	0.6%	8.1%	6.6%	1.3%
6655-2a	47.4	36.6	6.3	-0.2	0.28	4.8
6655-2b	46.0	37.1	7.3	0.0	0.28	4.7
Average	46.7	36.8	6.8	-0.1	0.28	4.7
Std. Dev.	1.0	0.3	0.7	0.1	0.003	0.07
% Std. Dev.	2.1%	0.9%	10%	120%	1.2%	1.6%
7645-2a	26.2	27.3	37.7	3.6	0.12	1.6
7645-2b	27.0	27.0	37.8	3.3	0.13	1.5
Average	26.6	27.2	37.7	3.4	0.12	1.5
Std. Dev.	0.6	0.2	0.04	0.2	0.01	0.02
% Std. Dev.	2.2%	0.8%	0.1%	5.0%	7.0%	1.4%

Table 3b. continued

8005-2a	42.1	32.9	19.7	-0.1	-0.07	2.2
8005-2b	42.1	32.5	19.5	0.1	-0.07	2.1
Average	42.1	32.7	19.6	0.0	-0.07	2.2
Std. Dev.	0.0	0.3	0.2	0.1	0.0	0.1
% Std. Dev.	0.0%	0.9%	0.8%	330%	0.0%	4.4%
8905-2a	38.2	31.9	20.3	2.9	0.12	2.7
8905-2b	37.5	31.6	21.5	2.6	0.16	3.0
Average	37.9	31.7	20.9	2.8	0.14	2.8
Std. Dev.	0.6	0.2	0.9	0.2	0.02	0.2
% Std. Dev.	1.5%	0.7%	4.3%	7.7%	17%	6.0%
9085-3a	31.5	34.9	24.7	3.3	0.24	2.7
9085-3b	32.5	35.6	23.5	3.1	0.22	2.9
Average	32.0	35.3	24.1	3.2	0.23	2.8
Std. Dev.	0.7	0.5	0.8	0.1	0.01	0.2
% Std. Dev.	2.2%	1.3%	3.3%	3.2%	4.2%	6.0%
Average	39.5	35.3	16.7	1.5	0.15	2.7
Av Std. Dev.	0.7	0.7	0.5	0.1	0.01	0.1
% Std. Dev.	1.7%	2.0%	2.8%	7.6%	6.5%	3.6%

Table 4a. Comparison of elemental abundances in bulk cuttings from various envelopes from the same interval in the Point Conception DST well OCS-Cal 78-164 No. 1. (Weight %).

Sample number	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	LOI	Org carb	Carbonate carbon
5215-2	64.4	7.85	3.51	3.10	3.70	1.23	1.39	0.39	0.28	<0.02	10.8	1.94	1.50
5215-4	65.6	7.86	3.61	2.74	3.07	1.35	1.38	0.41	0.30	<0.02	10.6	1.98	1.26
Average	65.0	7.86	3.56	2.92	3.39	1.29	1.39	0.40	0.29	<0.02	10.7	1.96	1.38
Std. Dev.	0.85	0.01	0.07	0.25	0.45	0.08	0.01	0.01	0.01	-	0.1	0.03	0.17
% Std. Dev.	1.3%	0.1%	2.0%	8.7%	13.2%	6.6%	0.5%	3.5%	4.9%	-	1.3%	1.4%	12.3%
5575-2	56.5	7.33	4.34	2.94	8.85	1.28	1.19	0.37	0.81	0.03	12.6	1.64	2.03
5575-3	56.6	7.34	4.29	2.68	9.03	1.39	1.18	0.36	0.83	0.03	12.2	1.62	1.94
Average	56.6	7.34	4.32	2.81	8.94	1.34	1.19	0.37	0.82	0.03	12.4	1.63	1.99
Std. Dev.	0.1	0.01	0.04	0.18	0.13	0.08	0.01	0.01	0.01	0.00	0.3	0.01	0.06
% Std. Dev.	0.1%	0.1%	0.8%	6.5%	1.4%	5.8%	0.6%	1.9%	1.7%	0.0%	2.3%	0.9%	3.2%
5665-2	66.3	9.09	4.04	1.53	3.13	1.56	1.51	0.45	0.58	<0.02	9.37	1.99	0.64
5665-3	62.9	9.12	4.15	1.70	5.07	1.54	1.50	0.47	0.59	<0.02	10.0	1.98	0.98
Average	64.6	9.11	4.10	1.62	4.10	1.55	1.51	0.46	0.59	<0.02	9.7	1.99	0.81
Std. Dev.	2.4	0.02	0.08	0.12	1.37	0.01	0.01	0.01	0.01	-	0.4	0.01	0.24
% Std. Dev.	3.7%	0.2%	1.9%	7.4%	33.5%	0.9%	0.5%	3.1%	1.2%	-	4.6%	0.4%	29.7%
5845-2*	70.3	7.26	2.93	2.19	3.44	1.28	1.52	0.33	0.27	<0.02	7.58	1.40	1.25
5845-3	71.2	7.18	2.85	2.05	3.24	1.37	1.49	0.32	0.28	<0.02	7.10	1.42	1.12
Average	70.8	7.22	2.89	2.12	3.34	1.33	1.51	0.33	0.28	<0.02	7.34	1.41	1.19
Std. Dev.	0.6	0.06	0.06	0.10	0.14	0.06	0.02	0.01	0.01	-	0.34	0.01	0.09
% Std. Dev.	0.9%	0.8%	2.0%	4.7%	4.2%	4.8%	1.4%	2.2%	2.6%	-	4.6%	1.0%	7.8%
5935-2	59.6	8.65	3.44	4.06	6.05	1.05	1.22	0.37	0.35	<0.02	12.6	1.86	2.35
5935-3	61.9	7.52	3.45	3.73	5.37	1.16	1.32	0.36	0.38	<0.02	12.1	1.97	2.11
Average	60.8	8.09	3.45	3.90	5.71	1.11	1.27	0.37	0.37	<0.02	12.4	1.92	2.23
Std. Dev.	1.6	0.80	0.01	0.23	0.48	0.08	0.07	0.01	0.02	-	0.4	0.08	0.17
% Std. Dev.	2.7%	9.9%	0.2%	6.0%	8.4%	7.0%	5.6%	1.9%	5.8%	-	2.9%	4.1%	7.6%
6835-2	66.3	5.96	2.61	2.32	5.80	1.06	1.02	0.30	0.43	<0.02	10.4	3.36	1.59
6835-3	65.7	5.43	2.40	2.30	6.65	1.03	0.95	0.28	0.48	<0.02	11.1	3.38	1.79
Average	66.0	5.70	2.51	2.31	6.23	1.05	0.99	0.29	0.46	<0.02	10.8	3.37	1.69
Std. Dev.	0.4	0.37	0.15	0.01	0.60	0.02	0.05	0.01	0.03	-	0.5	0.01	0.14
% Std. Dev.	0.6%	6.6%	5.9%	0.6%	9.7%	2.0%	5.0%	4.9%	7.8%	-	4.6%	0.4%	8.4%

Table 4a. continued

6925-2	73.6	2.47	1.09	3.34	6.01	0.51	0.41	0.13	0.25	<0.02	9.82	1.86	2.07
6925-3	74.4	2.57	1.21	3.05	5.45	0.51	0.45	0.15	0.25	<0.02	9.23	1.86	1.88
Average	74.0	2.52	1.15	3.20	5.73	0.51	0.43	0.14	0.25	<0.02	9.53	1.86	1.98
Std. Dev.	0.6	0.07	0.08	0.21	0.40	0.00	0.03	0.01	0.00	-	0.42	0.00	0.13
% Std. Dev.	0.8%	2.8%	7.4%	6.4%	6.9%	0.0%	6.6%	10.1%	0.0%	-	4.4%	0.0%	6.8%
7015-1	75.6	1.55	0.79	3.39	6.34	0.35	0.26	0.10	0.49	<0.02	9.41	1.37	2.10
7015-3	75.2	1.69	0.88	3.36	6.11	0.38	0.30	0.10	0.41	<0.02	9.51	1.57	2.11
7015-4	74.2	2.24	1.08	3.32	6.01	0.45	0.39	0.12	0.47	<0.02	9.49	1.75	2.01
Average	75.0	1.83	0.92	3.36	6.15	0.39	0.32	0.11	0.46	<0.02	9.47	1.56	2.07
Std. Dev.	0.7	0.36	0.15	0.04	0.17	0.05	0.07	0.01	0.04	-	0.05	0.19	0.06
% Std. Dev.	1.0%	20.0%	16.2%	1.0%	2.8%	13.0%	21.0%	10.8%	9.1%	-	0.6%	12.2%	2.7%
7555-1	44.2	4.41	1.96	8.93	14.1	0.98	0.67	0.25	0.26	0.03	20.8	1.13	5.52
7555-2	46.3	4.35	2.00	8.41	13.3	1.00	0.67	0.25	0.29	0.03	19.6	1.38	5.15
7555-3	47.5	4.27	1.94	8.30	13.1	1.01	0.66	0.24	0.26	0.03	19.2	1.35	5.06
Average	46.0	4.34	1.97	8.55	13.5	1.00	0.67	0.25	0.27	0.03	19.9	1.29	5.24
Std. Dev.	1.7	0.07	0.03	0.34	0.53	0.02	0.01	0.01	0.02	0.00	0.8	0.14	0.24
% Std. Dev.	3.6%	1.6%	1.6%	3.9%	3.9%	1.5%	0.9%	2.3%	6.4%	0.0%	4.2%	10.6%	4.7%
8815-2	57.9	7.08	3.71	4.73	7.58	1.42	1.33	0.45	0.28	0.04	12.5	1.85	2.75
8815-3	59.3	7.75	3.86	4.24	6.53	1.57	1.41	0.48	0.29	0.04	10.9	1.93	2.29
Average	58.6	7.42	3.79	4.49	7.06	1.50	1.37	0.47	0.29	0.04	11.7	1.89	2.52
Std. Dev.	1.0	0.47	0.11	0.35	0.74	0.11	0.06	0.02	0.01	0.00	1.1	0.06	0.33
% Std. Dev.	1.7%	6.4%	2.8%	7.7%	10.5%	7.1%	4.1%	4.6%	2.5%	0.0%	9.7%	3.0%	12.9%
9805-2	56.4	12.2	5.98	3.28	5.72	2.30	1.61	0.70	0.21	0.09	8.87	1.27	1.35
9805-3	60.1	11.4	5.29	3.10	4.93	2.18	1.62	0.62	0.24	0.07	8.33	1.50	1.20
Average	58.3	11.8	5.64	3.19	5.33	2.24	1.62	0.66	0.23	0.08	8.60	1.39	1.28
Std. Dev.	2.6	0.6	0.49	0.13	0.56	0.08	0.01	0.06	0.02	0.01	0.38	0.16	0.11
% Std. Dev.	4.5%	4.8%	8.7%	4.0%	10.5%	3.8%	0.4%	8.6%	9.4%	17.7%	4.4%	11.7%	8.3%
Average	63.2	6.66	3.12	3.50	6.32	1.21	1.12	0.35	0.39	-	11.2	1.84	2.03
Av Std. Dev.	1.1	0.26	0.12	0.18	0.51	0.05	0.03	0.02	0.02	-	0.4	0.06	0.16
% Std. Dev.	1.8%	3.9%	3.7%	5.1%	8.0%	4.4%	2.9%	4.4%	4.2%	-	3.9%	3.5%	7.8%

* Average of duplicate splits from Table 3a.

Table 4b. Comparison of the abundances of sedimentary components in bulk cuttings from various envelopes from the same interval in the Point Conception DST well OCS-Cal 78-164 No. 1. Values derived from analyses in Table 4a by using formulas in Table 1. (Weight %).

Sample number	Detritus	Silica	Dolomite	Calcite	Apatite	Organic matter
5215-2	44.0	36.9	10.2	-0.1	0.07	2.9
5215-4	44.0	38.1	8.6	-0.4	0.11	3.0
Average	44.0	37.5	9.4	-0.3	0.09	2.9
Std. Dev.	0.04	0.8	1.2	0.2	0.03	0.04
% Std. Dev.	0.09%	2.2%	12%	74%	36%	1.4%
5575-2	41.0	30.8	9.7	8.1	1.4	2.5
5575-3	41.1	30.9	8.6	9.0	1.4	2.4
Average	41.1	30.9	9.1	8.6	1.4	2.4
Std. Dev.	0.04	0.05	0.8	0.7	0.03	0.02
% Std. Dev.	0.1%	0.1%	9.2%	7.6%	2.4%	0.9%
5665-2	50.9	34.5	2.4	2.3	0.7	3.0
5665-3	51.1	31.0	3.2	5.3	0.7	3.0
Average	51.0	32.7	2.8	3.8	0.7	3.0
Std. Dev.	0.1%	2.5	0.5	2.1	0.02	0.01
% Std. Dev.	0.2%	7.6%	19%	56%	2.2%	0.4%
5845-2	40.7	44.9	6.4	1.6	0.09	2.1
5845-3	40.2	46.1	5.8	1.5	0.12	2.1
Average	40.4	45.5	6.1	1.5	0.10	2.1
Std. Dev.	0.3	0.8	0.4	0.04	0.02	0.02
% Std. Dev.	0.8%	1.8%	7.0%	2.3%	20%	1.0%
5935-2	48.4	29.3	14.2	1.7	0.2	2.8
5935-3	42.1	35.6	13.3	1.0	0.3	3.0
Average	45.3	32.5	13.7	1.3	0.3	2.9
Std. Dev.	4.5	4.4	0.7	0.5	0.1	0.1
% Std. Dev.	9.9%	14%	4.8%	37%	44%	4.1%
6835-2	33.4	45.4	7.6	4.8	0.6	5.0
6835-3	30.4	46.7	7.8	6.2	0.7	5.1
Average	31.9	46.1	7.7	5.5	0.6	5.1
Std. Dev.	2.1	0.9	0.1	0.9	0.11	0.02
% Std. Dev.	6.6%	1.9%	1.6%	17%	17%	0.4%

Table 4b. continued

6925-2	13.8	65.0	14.0	2.4	0.4	2.8
6925-3	14.4	65.4	12.6	2.1	0.4	2.8
Average	14.1	65.2	13.3	2.2	0.4	2.8
Std. Dev.	0.4	0.3	1.0	0.2	0.01	0.00
% Std. Dev.	2.8%	0.5%	7.3%	8.2%	1.3%	0.0%
7015-1	8.7	70.2	14.7	2.1	1.0	2.1
7015-3	9.5	69.3	14.5	2.0	0.8	2.4
7015-4	12.5	66.4	14.0	1.9	0.9	2.6
Average	10.2	68.6	14.4	2.0	0.9	2.3
Std. Dev.	2.0	2.0	0.3	0.1	0.1	0.3
% Std. Dev.	20%	2.9%	2.4%	5.8%	11%	12%
7555-1	24.7	28.8	36.6	3.3	0.3	1.7
7555-2	24.4	31.1	36.2	3.1	0.4	2.1
7555-3	23.9	32.6	35.8	3.1	0.3	2.0
Average	24.3	30.8	36.8	3.2	0.3	1.9
Std. Dev.	0.4	1.9	1.5	0.1	0.04	0.20
% Std. Dev.	1.6%	6.2%	4.1%	4.3%	13%	11%
8815-2	39.6	33.1	18.0	2.6	0.1	2.8
8815-3	43.4	33.2	15.5	2.1	0.1	2.9
Average	41.5	32.6	16.8	2.3	0.1	2.8
Std. Dev.	2.7	0.7	1.8	0.4	0.02	0.08
% Std. Dev.	6.4%	2.0%	11%	17%	17%	3.0%
9805-2	68.3	13.7	8.8	4.1	-0.4	1.9
9805-3	63.8	20.2	8.4	2.9	-0.3	2.3
Average	66.1	17.0	8.6	3.5	-0.4	2.1
Std. Dev.	3.2	4.6	0.3	0.8	0.09	0.2
% Std. Dev.	4.8%	27%	3.4%	24%	26%	12%
Average	37.3	39.9	12.6	3.1	0.4	2.8
Av Std. Dev.	1.4	1.7	0.8	0.6	0.05	0.10
% Std. Dev.	3.8%	4.3%	6.3%	18%	13%	3.5%

Table 5. Elemental abundances (wt %) in bulk cuttings from the Point Conception DST well OCS-Cal 78-164 No. 1.

Sample number	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	LOI	Org carbon	Carbonate carbon
4255	33.2	6.64	3.40	9.32	14.7	1.43	1.24	0.29	0.42	0.06	24.7	3.15*	5.69*
4345	38.8	7.99	3.71	7.69	11.4	1.64	1.45	0.37	0.48	0.04	22.5	4.16*	4.21*
4405	40.0	8.03	3.53	7.63	10.8	1.60	1.46	0.38	0.45	0.04	21.9	4.14*	4.18*
4495	60.8	9.87	3.95	1.96	2.18	1.98	1.79	0.47	0.51	<0.02	14.0	5.48*	0.58*
4585	57.0	8.43	3.53	3.46	4.70	1.78	1.55	0.43	0.59	0.03	14.8	4.66	1.66
4675	59.1	8.48	3.51	3.05	3.80	1.64	1.63	0.42	0.46	0.02	14.0	3.88	1.36
4765	58.5	10.6	4.20	3.16	3.43	1.70	2.09	0.47	0.42	0.03	13.0	2.85	1.35
4855	56.3	11.0	4.68	3.89	4.09	1.60	2.04	0.50	0.31	0.03	12.8	1.96	1.78
4945	58.1	10.3	4.68	3.72	3.72	1.56	1.67	0.51	0.32	0.02	12.8	1.81	1.65
5035	63.7	9.70	4.08	2.21	2.39	1.82	1.65	0.50	0.49	<0.02	11.2	2.55	0.84
5125	60.9	9.22	4.11	3.31	3.87	1.73	1.64	0.44	0.44	0.02	10.4	2.18*	1.57*
5215**	65.0	7.86	3.56	2.92	3.39	1.29	1.39	0.40	0.29	<0.02	10.7	1.96	1.38
5305**	66.9	8.72	3.69	2.08	2.39	1.47	1.51	0.44	0.37	<0.02	10.1	2.13	0.86
5395	65.0	9.29	3.86	2.20	2.60	1.62	1.65	0.48	0.41	<0.02	10.8	2.16	0.92
5482	53.1	7.69	3.60	4.60	8.09	1.55	1.49	0.39	0.52	<0.02	14.9	1.85	2.74
5575**	56.6	7.34	4.32	2.81	8.94	1.34	1.19	0.37	0.82	0.03	12.4	1.63	1.99
5665**	64.6	9.11	4.10	1.62	4.10	1.55	1.51	0.46	0.59	<0.02	9.7	1.99	0.81
5755	61.7	9.06	4.29	2.68	4.85	1.55	1.45	0.42	0.46	0.03	9.65	1.89*	1.45*
5845**	70.8	7.22	2.89	2.12	3.34	1.33	1.51	0.33	0.28	<0.02	7.34	1.41	1.19
5935**	60.8	8.09	3.45	3.90	5.71	1.11	1.27	0.37	0.37	<0.02	12.4	1.92	2.23
6025	69.5	7.07	3.10	2.41	3.27	1.13	1.11	0.36	0.29	<0.02	8.85	1.76	1.28
6115	70.9	7.57	3.24	2.04	2.52	1.16	1.17	0.38	0.31	<0.02	8.16	1.73	0.97
6205	67.0	7.57	3.52	2.65	3.72	1.22	1.18	0.38	0.34	<0.02	9.25	1.89	1.38
6295**	63.2	7.33	3.77	3.59	5.13	1.31	1.16	0.39	0.34	<0.02	10.9	1.63	1.99
6385	70.7	7.85	3.57	2.08	2.27	1.34	1.23	0.40	0.34	<0.02	8.22	1.69	0.84
6475	69.7	7.72	3.48	2.17	2.39	1.27	1.23	0.40	0.32	<0.02	9.11	2.29	0.91
6565	64.8	7.37	3.62	2.97	3.96	1.31	1.24	0.39	0.36	0.02	11.2	2.83	1.42
6655**	66.0	8.34	3.89	2.42	2.84	1.39	1.41	0.43	0.39	<0.02	10.3	3.14	0.97
6745	64.9	7.71	3.45	2.43	3.42	1.32	1.36	0.36	0.43	<0.02	10.8	3.90*	1.08*
6835**	66.0	5.70	2.51	2.31	6.23	1.05	0.99	0.29	0.46	<0.02	10.8	3.37	1.69
6925**	74.0	2.52	1.15	3.20	5.73	0.51	0.43	0.14	0.25	<0.02	9.53	1.86	1.98

Table 5. continued

7015**	75.0	1.83	0.92	3.36	6.15	0.39	0.32	0.11	0.46	<0.02	9.47	1.56	2.07
7105	67.4	2.37	0.97	4.59	7.95	0.43	0.38	0.09	0.26	<0.02	12.9	1.72*	2.93*
7195	63.2	3.31	1.56	4.19	8.19	0.55	0.63	0.18	1.09	<0.02	13.8	3.72	2.54
7285	51.0	2.53	1.24	7.42	12.9	0.43	0.52	0.15	0.95	<0.02	19.8	2.99	4.58
7375	56.1	1.86	1.03	6.98	11.2	0.31	0.38	0.10	0.36	<0.02	18.6	3.00	4.42
7465	44.4	4.85	2.17	8.26	13.4	0.98	0.79	0.23	0.79	<0.02	20.3	2.19*	4.94*
7555**	46.0	4.34	1.97	8.55	13.5	1.00	0.67	0.25	0.27	0.03	19.9	1.29	5.24
7645**	43.8	4.76	2.62	8.79	13.9	1.14	0.74	0.26	0.21	0.05	20.1	1.03	5.38
7735	57.0	7.48	3.71	5.59	7.35	1.53	1.24	0.42	0.22	0.05	12.1	1.26	2.72
7825	41.6	6.42	3.38	8.72	13.2	1.39	1.00	0.34	0.25	0.06	19.7	1.24	5.20
7915	42.1	6.72	3.93	8.65	12.7	1.42	1.07	0.38	0.22	0.07	18.8	1.24	4.92
8005**	59.0	7.52	3.87	5.12	6.54	1.55	1.23	0.42	0.21	0.05	10.8	1.44	2.42
8095	50.4	7.15	4.18	6.62	9.48	1.48	1.20	0.41	0.22	0.06	14.9	1.42	3.58
8185	56.8	8.14	4.12	5.36	6.99	1.66	1.37	0.45	0.22	0.06	12.1	1.55	2.49
8275	55.7	7.72	4.10	4.80	8.54	1.52	1.28	0.43	0.22	0.06	12.7	1.58	2.84
8365	54.3	7.87	4.30	5.15	8.47	1.72	1.30	0.44	0.25	0.06	12.8	1.52	2.88
8455	58.8	7.33	3.88	4.02	7.89	1.47	1.19	0.42	0.25	0.04	11.6	2.08	2.50
8545	58.5	6.61	3.47	3.53	9.68	1.39	1.13	0.40	0.27	0.04	12.4	1.83	2.71
8635	57.7	6.58	3.38	3.78	9.54	1.42	1.16	0.41	0.30	0.04	12.8	1.94	2.80
8725	54.4	6.65	3.63	4.83	9.98	1.37	1.18	0.41	0.28	0.04	14.2	1.33	3.38
8815**	58.6	7.42	3.79	4.49	7.06	1.50	1.37	0.47	0.29	0.04	11.7	1.89	2.52
8905**	55.4	6.76	3.63	5.32	8.53	1.37	1.24	0.41	0.28	0.04	13.8	1.89	3.13
8995	52.1	6.19	3.37	6.15	10.1	1.28	1.13	0.39	0.30	0.04	15.9	2.04	3.77
9085**	55.3	5.71	2.75	5.91	9.69	1.24	1.03	0.35	0.28	0.03	15.1	1.88	3.46
9175	51.5	7.13	3.53	5.66	10.4	1.44	1.21	0.43	0.29	0.04	15.2	1.72	3.50
9265	50.2	7.34	3.69	5.25	11.7	1.60	1.21	0.47	0.30	0.05	15.3	1.94	3.43
9355	46.5	7.48	3.78	6.21	12.8	1.56	1.20	0.47	0.28	0.06	17.0	1.63	3.90
9445	52.2	8.57	4.36	4.80	10.1	1.81	1.36	0.53	0.27	0.06	12.8	1.51	2.84
9535	63.1	8.84	4.16	3.68	5.21	1.86	1.34	0.53	0.25	0.05	8.51	1.31	1.47
9625	59.5	10.2	4.75	3.89	5.07	2.16	1.58	0.62	0.24	0.05	8.85	1.63	1.51
9715	61.2	11.5	5.40	3.18	4.10	2.41	1.58	0.69	0.27	0.05	7.35	1.57	0.95
9805**	58.3	11.8	5.64	3.19	5.33	2.24	1.62	0.66	0.23	0.08	8.60	1.39	1.28
9895	55.6	11.8	6.09	3.35	6.29	2.28	1.44	0.67	0.33	0.08	9.40	1.53	1.52

* Measured on powders not dried before analysis; all other carbon and carbonate analyses were measured on powders dried 4-24 hours before analysis.

** Mean values of duplicate analyses (from Tables 3a and 4a).

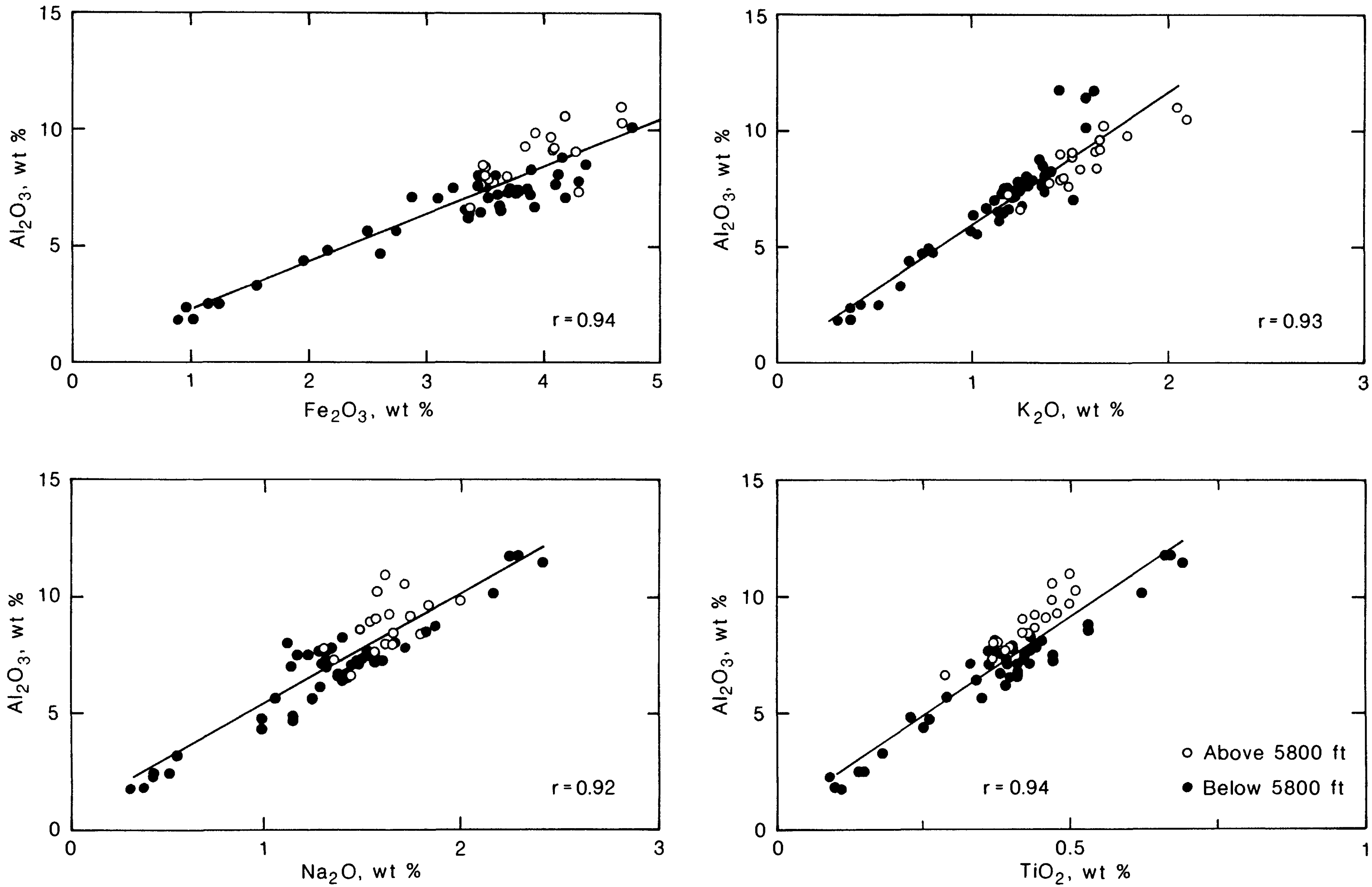

Figure 2. Al_2O_3 versus other major oxides in bulk cuttings from the Point Conception DST well. Correlations were calculated by least-squares linear regression; "r" is the correlation coefficient.

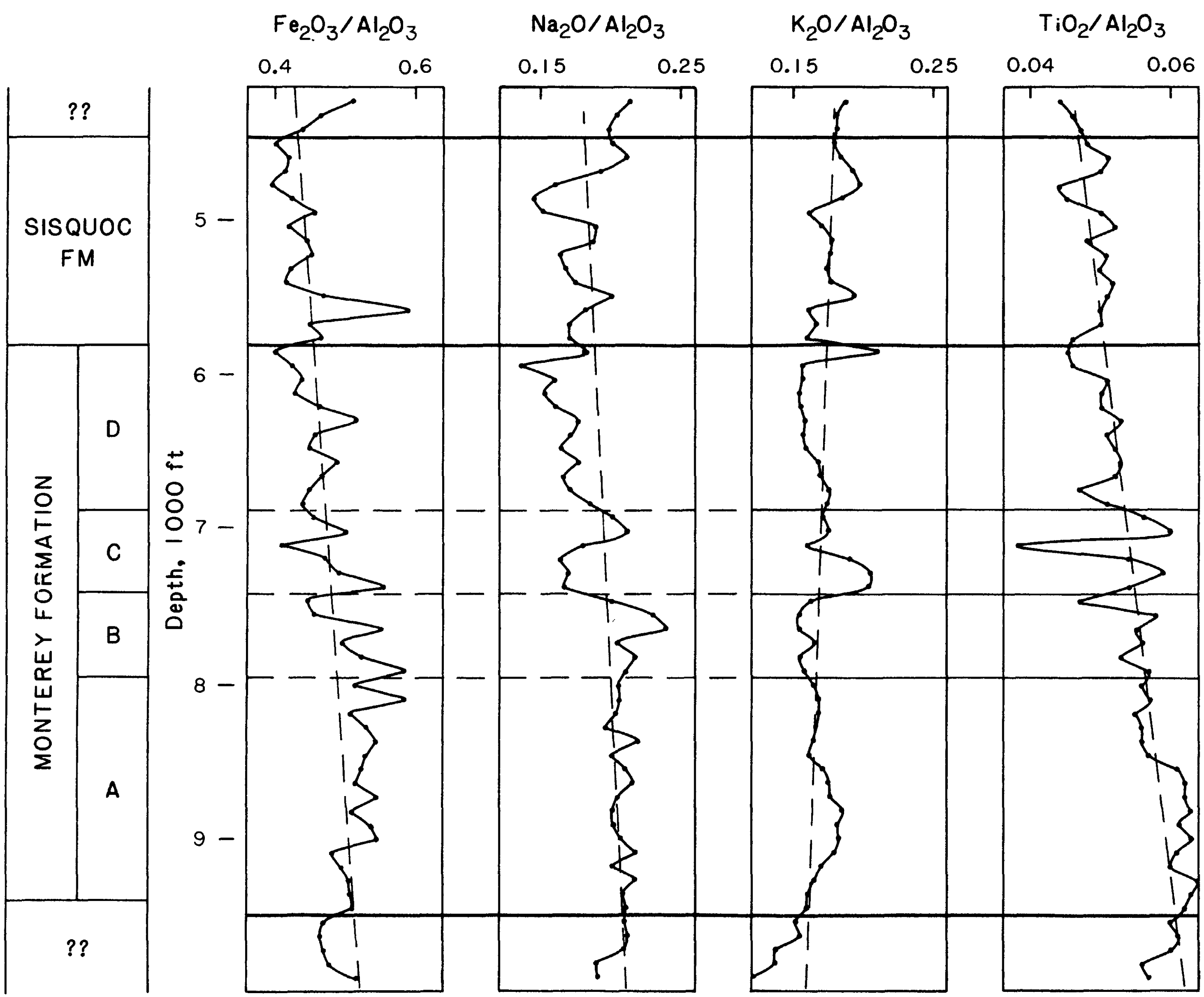

Figure 3. Selected oxide ratios versus depth in bulk cuttings from the Point Conception DST well.

Table 6. Oxide ratios in bulk cuttings from the Point Conception DST well OCS-Cal 78-164 No. 1. Values are derived from data in Table 5.

Sample number	Fe_2O_3/Al_2O_3	Na_2O/Al_2O_3	K_2O/Al_2O_3	TiO_2/Al_2O_3	Sample number	Fe_2O_3/Al_2O_3	Na_2O/Al_2O_3	K_2O/Al_2O_3	TiO_2/Al_2O_3
4255	0.512	0.215	0.187	0.044	7105	0.409	0.181	0.160	0.038
4345	0.464	0.205	0.181	0.046	7195	0.471	0.166	0.190	0.054
4405	0.440	0.199	0.182	0.047	7285	0.490	0.170	0.206	0.059
4495	0.400	0.201	0.181	0.048	7375	0.554	0.167	0.204	0.054
4585	0.419	0.211	0.184	0.051	7465	0.447	0.202	0.163	0.047
4675	0.414	0.193	0.192	0.050	7555	0.454	0.230	0.154	0.058
4765	0.396	0.160	0.197	0.044	7645	0.550	0.239	0.155	0.055
4855	0.425	0.145	0.185	0.045	7735	0.496	0.205	0.166	0.056
4945	0.454	0.151	0.162	0.050	7825	0.526	0.217	0.156	0.053
5035	0.421	0.188	0.170	0.052	7915	0.585	0.211	0.159	0.057
5125	0.446	0.188	0.178	0.048	8005	0.515	0.206	0.164	0.056
5215	0.453	0.164	0.177	0.051	8095	0.585	0.207	0.168	0.057
5305	0.423	0.169	0.173	0.050	8185	0.506	0.204	0.168	0.055
5395	0.416	0.174	0.178	0.052	8275	0.531	0.197	0.166	0.056
5482	0.468	0.202	0.194	0.051	8365	0.546	0.219	0.165	0.056
5575	0.589	0.183	0.162	0.050	8455	0.529	0.201	0.162	0.057
5665	0.450	0.170	0.166	0.050	8545	0.525	0.210	0.171	0.061
5755	0.474	0.171	0.160	0.046	8635	0.514	0.216	0.176	0.062
5845	0.400	0.183	0.208	0.045	8725	0.546	0.206	0.177	0.062
5935	0.426	0.137	0.157	0.046	8815	0.511	0.202	0.185	0.063
6025	0.438	0.160	0.157	0.051	8905	0.536	0.203	0.183	0.061
6115	0.428	0.153	0.155	0.050	8995	0.544	0.207	0.183	0.063
6205	0.465	0.161	0.156	0.050	9085	0.482	0.217	0.180	0.061
6295	0.514	0.178	0.158	0.053	9175	0.495	0.202	0.170	0.060
6385	0.455	0.171	0.157	0.051	9265	0.503	0.218	0.165	0.064
6475	0.451	0.165	0.159	0.052	9355	0.505	0.209	0.160	0.063
6565	0.491	0.178	0.168	0.053	9445	0.509	0.211	0.159	0.062
6655	0.466	0.167	0.169	0.052	9535	0.471	0.210	0.152	0.060
6745	0.447	0.171	0.176	0.047	9625	0.466	0.212	0.155	0.061
6835	0.440	0.184	0.174	0.051	9715	0.470	0.210	0.137	0.060
6925	0.456	0.202	0.171	0.056	9805	0.478	0.190	0.137	0.056
7015	0.503	0.213	0.175	0.060	9895	0.516	0.193	0.122	0.057

Table 7. Approximate abundances of sedimentary components in bulk cuttings from the Point Conception DST well OCS-Cal 78-164 No. 1 (in wt%). Except for organic matter, values are normalized on an organic-matter-free basis to 100%. See text (and Table 1) 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	SILICA / SIL + CARB	SILICA / SIL + DET
4255	41	11	43	4	0.5	4.7	19	21
4345	50	12	35	2	0.6	6.2	25	19
4405	50	13	35	1	0.5	6.2	27	21
4495	64	31	5	0	0.5	8.2	87	32
4585	54	32	13	0	0.9	7.0	70	37
4675	55	34	11	0	0.5	5.8	75	38
4765	66	24	10	-1	0.2	4.3	71	27
4855	68	20	13	-1	-0.1	2.9	61	22
4945	64	24	13	-1	0.0	2.7	68	28
5035	61	33	6	0	0.5	3.8	86	35
5125	57	32	12	0	0.4	3.3	74	36
5215	49	41	10	0	0.1	2.9	80	46
5305	54	40	6	0	0.2	3.2	88	43
5395	58	36	6	0	0.3	3.2	86	38
5482	48	29	19	4	0.7	2.8	56	38
5575	45	34	10	9	1.5	2.4	64	43
5665	56	36	3	4	0.8	3.0	83	39
5755	55	33	8	3	0.4	2.8	74	37
5845	43	49	6	2	0.1	2.1	86	53
5935	49	35	15	1	0.3	2.9	68	42
6025	43	48	8	1	0.2	2.6	85	53
6115	46	48	6	0	0.2	2.6	88	51
6205	46	44	9	1	0.3	2.8	82	49
6295	44	41	14	1	0.3	2.4	73	48
6385	47	47	6	0	0.2	2.5	89	50
6475	47	46	7	0	0.2	3.4	88	50
6565	45	43	11	0	0.3	4.2	79	49
6655	52	41	8	0	0.3	4.7	85	44
6745	48	42	8	1	0.5	5.9	83	47
6835	35	50	8	6	0.7	5.1	78	59
6925	15	68	14	2	0.4	2.8	81	82

Table 7. continued

7015	11	71	15	2	1.0	2.3	81	87
7105	14	62	21	3	0.5	2.6	72	82
7195	20	56	19	3	2.5	5.6	72	74
7285	15	45	35	3	2.2	4.5	54	75
7375	11	53	33	2	0.8	4.5	60	83
7465	29	29	38	3	1.6	3.3	42	50
7555	25	32	39	3	0.3	1.9	43	56
7645	28	29	40	4	0.1	1.5	40	50
7735	44	33	23	0	0.0	1.9	58	42
7825	38	20	39	3	0.1	1.9	33	35
7915	40	20	38	2	0.0	1.9	33	33
8005	45	35	21	0	-0.1	2.2	62	44
8095	43	27	28	2	0.0	2.1	47	39
8185	48	30	22	0	-0.1	2.3	58	38
8275	46	30	19	5	-0.1	2.4	56	40
8365	47	29	21	4	0.0	2.3	54	38
8455	44	35	16	5	0.0	3.1	63	45
8545	39	37	14	10	0.1	2.7	62	49
8635	39	37	15	9	0.2	2.9	61	48
8725	40	33	20	7	0.2	2.0	55	46
8815	44	35	18	2	0.1	2.8	63	44
8905	41	34	22	3	0.1	2.8	57	46
8995	37	32	27	4	0.3	3.1	52	47
9085	34	37	25	3	0.2	2.8	56	52
9175	42	28	24	6	0.2	2.6	49	40
9265	43	26	21	9	0.2	2.9	46	37
9355	44	21	26	9	0.1	2.4	38	33
9445	50	23	19	8	0.0	2.3	47	32
9535	52	34	13	1	-0.1	2.0	70	39
9625	61	25	13	1	-0.2	2.4	64	29
9715	68	22	9	1	-0.2	2.4	68	25
9805	70	18	9	4	-0.4	2.1	58	20
9895	70	15	10	5	-0.1	2.3	51	18

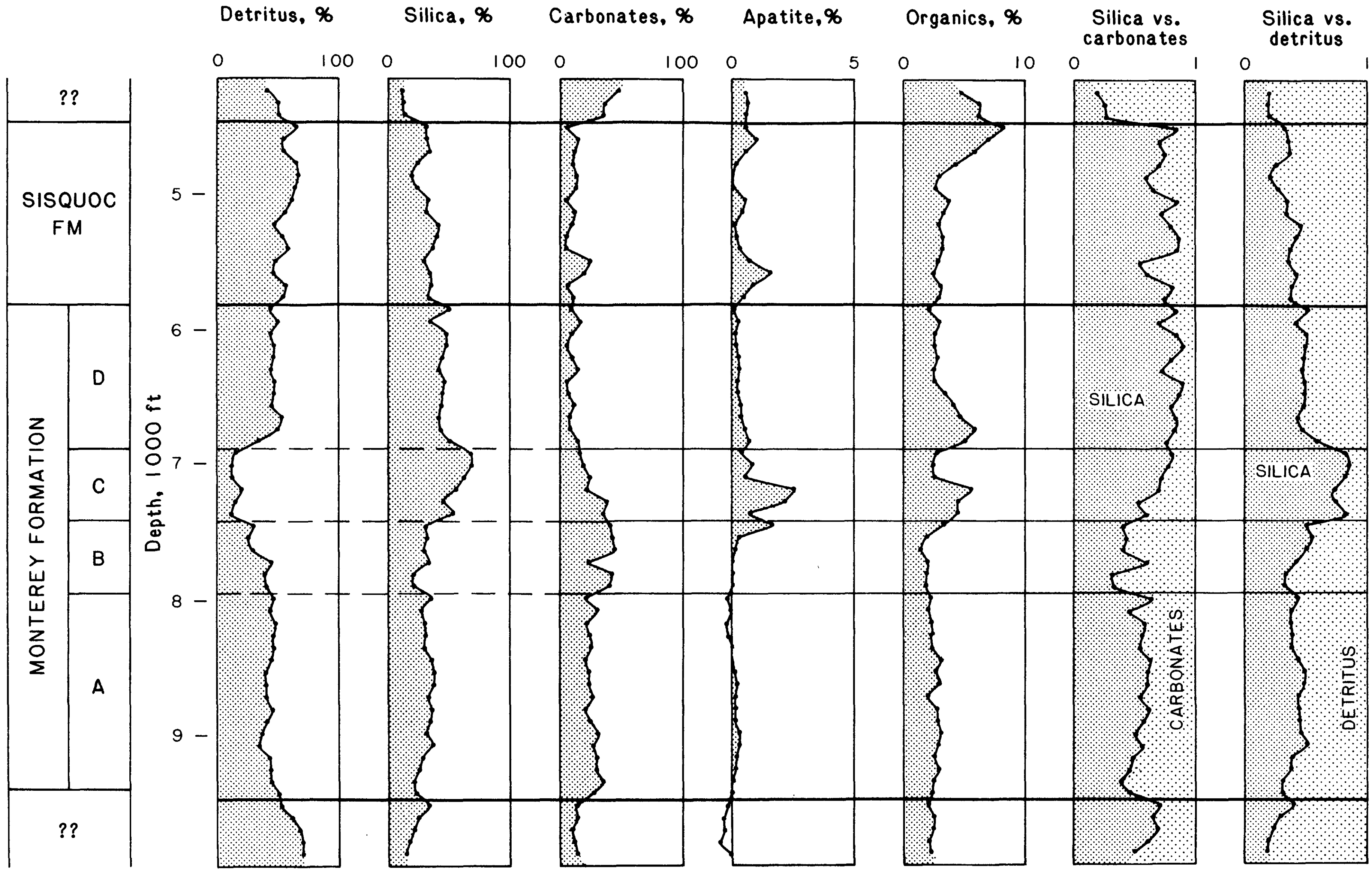

Figure 4. Sedimentary components and selected parameters versus depth in bulk cuttings from the Point Conception DST well.

materials (Table 3a). Sedimentary components calculated from major oxides in these duplicate bulk cuttings splits have average standard deviations of 0.7 wt% detritus, 0.7 wt% silica, 0.5 wt% dolomite, 0.1 wt% calcite, and 0.01 wt% apatite (Table 3b).

Carbon values (total carbon, carbonate carbon, and organic carbon) analyzed by the techniques used here were not previously tested for reproducibility of powder splits. Among duplicate splits of the same bulk (unpowdered) cuttings material, however, the average standard deviation is 0.06 wt% organic carbon (3.5% of average values) and 0.07 wt% carbonate carbon (2.9% of average values) (Table 3a). The average standard deviation for organic matter is thus 0.09 wt% (Table 3b), showing that the techniques used here have exceedingly good reproducibility.

Variability Due to Other Handling

Another possible source of additional variability for the Point Conception DST well cuttings is prior handling of the samples. The cuttings stored in separate envelopes were not split precisely from the original sample, and cuttings in some envelopes may have been used for previous studies. These kinds of sources of variability probably apply to bulk cuttings generally.

To test the amount of variability introduced by these factors, cuttings in each envelope were treated as separate samples, and variability was investigated by analysis of splits of several sets of samples from the same interval stored in separate envelopes. Separately stored samples from the same depth interval show average relative standard deviations for major oxides in the range 2-8% (av. 4.3%), for organic carbon 3.5%, and for carbonate carbon 7.8% (Table 4a). Sedimentary components derived from these analyses show average standard deviations of 1.4 wt% detritus, 1.7 wt% silica, 0.8 wt% dolomite, 0.6 wt% calcite, 0.05 wt% apatite, and 0.1 wt% organic matter (Table 4b). Although clearly more variable than powder splits or bulk cuttings splits, therefore, separately stored cuttings samples still have average reproducibility well within geologically significant limits.

RESULTS AND DISCUSSION

Major Oxides

Major oxide abundances of cuttings samples from the Point Conception DST well are presented in Table 5. Al_2O_3, Na_2O, K_2O, and TiO_2 mainly reflect detritus abundance, Fe_2O_3 reflects both detritus and pyrite, CaO reflects mainly calcite (also apatite and detritus), MgO reflects mainly dolomite (and, to a lesser extent, detritus), and P_2O_5 reflects mainly apatite (and, to a lesser extent, detritus) (Appendix B in Isaacs, 1980).

With respect to oxides mainly in the detritus fraction, Figure 2 illustrates Al_2O_3 plotted against Fe_2O_3, Na_2O, K_2O, and TiO_2 in all samples, and Figure 3 illustrates the ratios of these oxides to Al_2O_3 plotted against depth. The abundance of TiO_2 relative to Al_2O_3 shows a distinct (r=0.79) decrease upsequence (TiO_2/Al_2O_3 changes from 0.062 to 0.046) (Figure 3, Table 6). Other oxides have less distinct (r=0.43 to 0.58) slight trends upsequence (Figure 3). In comparison to Monterey sequences in adjacent onshore areas, Fe_2O_3/Al_2O_3 and Na_2O/Al_2O_3 ratios have somewhat higher values and K_2O/Al_2O_3 ratios slightly lower values in the Point Conception DST well (cf. Isaacs and others, 1989).

Sedimentary Components

Sedimentary components estimated from major oxide and carbon abundances are presented in Table 7 and illustrated in Figure 4. The presence of some negative numbers in this table indicates that the conversion parameters (Table 1) are somewhat inaccurate. As noted by Isaacs and others (1989), however, the reproducibility of the negative values from replicate analyses is excellent (see also Table 3b, sample 8005 and Table 4b, sample 9805). The negative values are thus probably due to partitioning slightly too much CaO, MgO, and P_2O_5 into the aluminosilicate fraction. These inaccuracies are generally less than 1 wt% and thus only significant where values are small.

A more serious inaccuracy results from the partitioning of CaO into calcite and dolomite. Isaacs and others (1989) noted that a number of samples estimated by the conversion parameters (Table 1) as having calcite had no calcite detectable by bulk X-ray diffraction. However, the total measured carbonate averages within 0.03 wt% of the carbonate carbon calculated from the sum of calcite + dolomite based on major oxides (Table 2). This relation shows that the total of carbonate minerals is reasonably accurate, and suggests that dolomite is underestimated due to excess CaO, as reported by Murata and others (1972).

Compositional Sequence

Vertical variations in the abundance of sedimentary components show the following characteristics (Figure 4):

1. Detritus. Generally, the abundance of detritus is 50 wt% or more above 5900 feet and below 9400 feet, and 50 wt% or less in the interval between. Detritus is particularly sparse (<25 wt%) in the interval 6925-7375 feet.
2. Silica (biogenic and diagenetic silica). Silica exceeds 20 wt% throughout most of the sequence (4495-9715 feet) but exceeds 40 wt% mainly in the interval 5845-7375 feet. Silica is particularly abundant (>50 wt%) in the interval 6835-7375 feet, with a maximum in the range 60-70 wt% in the interval 6925-7105 feet.
3. Carbonate minerals. Carbonates exceed 20 wt% in the uppermost analyzed interval (4255-4405 feet) and in most of the lower half of the sequence (7105-9445 feet), but are most abundant (40-45 wt%) only in the interval 7555-7915 feet. Dolomite predominates over calcite in all but one sample in the entire sequence.
4. Apatite. Apatite is generally less than 0.5 wt% and exceeds 1 wt% only in the intervals 5575 feet, 7195-7285 feet, and 7465 feet.
5. Organic matter. Organic matter is generally in the range 1.5-3.0 wt% (1.0-2.0 wt% TOC). Higher-than-average organic matter (>3 wt% organic matter or >2 wt% TOC) is present only in the intervals 4225-4765 feet, 6455-6835 feet, and 7195-7465 feet.
6. Silica vs. carbonate minerals. Silica consistently predominates over carbonates in the interval 4495-7375 feet. In underlying strata, carbonate in general slightly exceeds silica in the interval 7465-7915 feet whereas silica in general slightly exceeds carbonate in the interval 8005-9100 feet.
7. Silica vs. detritus (a major influence on physical properties, with higher values indicating greater fracturability). Silica exceeds detritus mainly in the interval 6835-7645 feet.

Table 8. Average abundance (in wt%) of major sedimentary components in bulk cuttings from the Point Conception DST well. Except for organic matter, values are normalized on an organic-free basis to 100%. Stratigraphic units follow tentative divisions by Isaacs and others (1983). Units designated "??" seem likely to represent formations other than the Sisquoc or Monterey Formation.

Onshore correlative	Depth interval (feet)	Detritus	Silica	Carbonate minerals	Apatite	Organic matter
??	4255-4405	47	12	40	0.5	5.7
Sisquoc Fm	4495-5755	57	32	11	0.5	3.9
Monterey Fm						
D	5845-6835	45	44	10	0.3	3.4
C	6925-7375	14	59	25	1.2	3.7
B	7465-7915	34	27	38	0.4	2.1
A	8005-9445	43	31	26	0.1	2.6
??	9535-9895	64	23	13	0.0	2.2

Average sedimentary components in the Point Conception Deep Stratigraphic Test (DST) well, divided into the preliminary stratigraphic units described by Isaacs and others (1983), are summarized in Table 8.

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