2003

Deposition and provenance of modern coarse sediment in Monterey submarine canyon

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DEPOSITION AND PROVENANCE OF MODERN
COARSE SEDIMENT IN MONTEREY SUBMARINE CANYON

A Thesis Presented to
The Faculty of Moss Landing Marine Laboratories
and San José State University

In Partial Fulfillment of the
Requirements for the Degree
Master of Science

by
Patrick John Mitts
August 2003

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ABSTRACT

DEPOSITION AND PROVENANCE OF MODERN COARSE SEDIMENT IN MONTEREY SUBMARINE CANYON

By Patrick J. Mitts

Submarine canyons are major sediment transport conduits that carry coarse material from the continent to the deep-sea, yet few sediment samples collected from submarine canyons exist. A vibracoring system developed at Monterey Bay Aquarium Research Institute (MBARI) was used to collect coarse sediment from Monterey Canyon and has provided the largest collection of modern sediment from a submarine canyon to date.

Grain-size data, quartz-feldspar-lithic ratios, lithologic identification, and facies analysis are the foundation of this thesis. Sand is the predominant material in the channel on Monterey Canyon's floor, with the largest grain sizes occurring at water depths between 1,000 m and 1,500 m. The sand is derived from terrestrial watersheds within the Monterey Bay region, not from the canyon flanks or continental shelf. This study concludes that upper Monterey Canyon (< 1,500 m) is an active conduit of coarse-grained material from the shoreline to the lower canyon.

ACKNOWLEDGEMENTS AND THESIS DEDICATION

I must acknowledge those whose help was invaluable along the way. To my family and friends thank you for helping support this mid-life crisis...I love you!

To Gary Greene and Charlie Paull: I thank you for the guidance, information, assistance, and patience that you have provided. I enjoyed all the geology projects, field trips, and many incomparable hours at sea. The emotions I experienced while observing under sea images that had never been seen before is indescribable! You have given me more joy, world travel, and work exposure than I ever could have dreamed of, or much less deserved, while at MLML. You are both inspirations to those whose lives you have touched. May you always have good food, good coffee, good wine, and most of all good friends!

To Bill Ussler, Bob Garrison, Cal Stevens, Tracy Vallier, and Norm Maher: Thank you all for your help, the knowledge you shared, and your enthusiasm for geology.

To the captains, crews, ROV pilots, and engineers at MBARI: I am grateful for your long hours of hard work, persistent diligence, and level of professionalism. Without the financial support of the Packard Foundation this project would have been impossible.

Finally, I dedicate this thesis to the memory of Stuart Stratton. Stuart, an ROV pilot at MBARI, was critical in designing the vibracoring system on the ROV *Ventana*. Stuart lost his life on October, 19, 2001 in Daytona Beach, Florida fulfilling his life's passion: motorcycle racing. Thank you for contributing so much to this project and thesis. You and your passion are sorely missed by everyone at MBARI and MLML.

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INTRODUCTION

This thesis examines the composition, grain-size, mineralogy, provenance, and depositional settings of modern coarse sediment in Monterey Canyon. The term “coarse-grained” is used in this thesis to indicate sediment with grain sizes that range from fine sand to cobbles. Previous attempts to retrieve and identify coarse-grained sediment deposits from active submarine canyon channels, including Monterey Canyon, have been incomplete. Documenting sediment deposits and transport processes in active submarine canyons were restricted in past studies by the limitations of traditional wire line core sampling techniques from surface ships (Pickering et al., 1989; Clark and Pickering 1996).

The focus of this study is to determine the properties of coarse-grained sediment (i.e., sand, gravel, cobbles, and pebbles) collected in sediment cores from the Monterey Canyon channel. The coarse-grained sediment collected by MBARI and Moss Landing Marine Laboratories, and made available for this study, are the foundation of this thesis. The sediment cores represent the most extensive collection of coarse-grained sediment samples yet recovered from any submarine canyon channel.

This study addresses four primary questions: 1) what type of sediment is in the canyon axis; 2) what is the provenance of the sediment within the canyon axis; 3) what changes in sediment occur in the varied depositional environments of the Monterey Canyon system; 4) is Monterey Canyon an active conduit of sediment from the continental shelf to the lower canyon?

From May 5, 1999 to June 6, 2002, the Monterey Bay Aquarium Research Institute (MBARI) collected core samples on the Monterey Canyon channel floor. Retrieval of coarse-grained sediment in the canyon was done using remotely operated vehicles (ROV's). Sediment was collected in 193 vibracores and 134 push cores from seawater depths of 12 m at the head of the canyon to 3,884 m in the canyon channel. The core locations are listed in Appendix Ia and Ib and shown in Figure 1, whereas the Monterey Canyon system and its tributaries are shown in Figure 2. Forty-five hand cores were also collected for this study along the shoreline, from paleo-marine deposits, and from rivers that debauch into Monterey Bay to supplement the data set from the cores collected offshore (Appendix Ic).

Vibracores are the primary source of offshore data for this study because they contain significantly thicker layers of sediment. Push cores are only capable of retrieving 25 cm of sediment thicknesses and were used in this study primarily to supplement data sets from areas where no vibracores were collected. The majority of push cores collected during this study were used for analysis of DDT levels in fine-grained sediment. The levels of DDT, and its breakdown products DDE and DDD, were used to trace recent sediment transport through Monterey Canyon (Paull et. al., 2002). Data from that study show that pesticide concentrations were highest in the canyon axis and confirmed that fine-grained sediment has been transported through Monterey Canyon during the last 50 years. However, the data from that study did not resolve questions related to transport of modern coarse-grained material.

Fig. 1: Location map of core sites for this study. Vibracores (white circles), push cores (red circles), and onshore hand cores (orange squares) are shown on the map. Offshore shaded relief gray scale multibeam data from MBARI Mapping Team Digital Data Series No. 3 ©, onshore shaded relief digital elevation model (DEM) from California Division of Mines and Geology (CDMG), and 100 m bathymetry from National Oceanic and Atmospheric Administration (NOAA).

Fig. 2: Map of Monterey Canyon system and its tributary canyons. Map is modified from MBARI Mapping Team Digital Data Series No. 3 © (2000).

Sediment Grain-Size Analysis

Sediment grain-size analysis is a primary source of data for this thesis. Grain-size statistics have been used for over a century to establish the composition of sediment (Boggs, 2001). Grain-size data are reported in phi units using the Wentworth classification scheme (Table 1).

Table 1: Wentworth Grain-size Classification, from Boggs (2001).

		U.S. Standard sieve mesh	Millimeters	Phi (ϕ) units	Wentworth size class
GRAVEL			4096	-12	
			1024	-10	Boulder
			256	-8	
			64	-6	Cobble
			16	-4	Pebble
			4	-2	
	5			-1.75	
	6			-1.5	Granule
	7			-1.25	
SAND	8			-1.0	
	10		2	-0.75	
	12			-0.5	Very coarse sand
	14			-0.25	
	16			0.0	
	18		1	0.25	
	20			0.5	Coarse sand
	25			0.75	
	30			1.0	
	35		1/2	1.25	
	40			1.5	Medium sand
	45			1.75	
	50			2.0	
	60		1/4	2.25	
	70			2.5	Fine sand
	80			2.75	
	100			3.0	
	120		1/8	3.25	
	140			3.5	Very fine sand
	170			3.75	
MUD	200			4.0	
	230		1/16	4.25	
	270			4.5	Coarse silt
	325			4.75	
				5.0	
			1/32	6.0	Medium silt
			1/64	7.0	Fine silt
			1/128	8.0	Very fine silt
			1/256	9.0	
				10.0	Clay
				11.0	
				12.0	
CLAY				13.0	
				14.0	

The grain-size data statistics are combined with visual and stratigraphic descriptions of the sediment collected to identify the depositional settings within the canyon system. The grain-size data are combined with quartz-feldspar-lithic (QFL) ratios and accessory mineral compositions to identify the provenance of the sediment and determine changes in sediment composition down the Monterey Canyon channel. The QFL ratios of sand collected from the canyon axis are compared with previous QFL studies to determine if the sediment in Monterey Canyon axis is re-worked from the flanks of the canyon. Cobbles were also collected from the canyon, continental shelf, and fluvial watersheds that empty into Monterey Bay and supplement the provenance study.

Submarine Canyons as Sediment Transport Conduits

Large volumes of terrigenous sediment are found in deep sea fans (Piper and Normark, 2001). Sand of terrigenous origin has been collected from the Monterey Fan during previous studies (Shepard and Dill, 1966; Piper and Normark, 2001). Submarine canyons are the primary conduits through which terrigenous and continental shelf materials are transported to the fans (Normark and Piper, 1991).

Sediment Transport to Monterey Canyon

Sediment derived from onshore sources is delivered to the head of Monterey Canyon before being transported down the canyon channel to the fan (Best and Griggs, 1991; Normark and Piper, 1991; Greene et al., 2002). Coarse-grained sediment is provided to

the head of Monterey Canyon by three primary methods: 1) fluvial transport of eroded detrital grains (Griggs, 1987); 2) wave erosion of shoreline deposits (Griggs, 1982); 3) longshore drift with terminus of littoral cells at the head of Monterey Canyon (Best and Griggs, 1991).

Best and Griggs (1991) estimated that the total amount of sediment delivered to the head of Monterey Canyon is $\sim 2.0\text{-}2.5 \times 10^5 \text{ m}^3/\text{yr}$. They report that approximately 75% of suspended sediment delivered to Monterey Bay arrives as fluvial detrital grains. This implies that the bulk of sediment delivered to Monterey Bay arrives as suspended load during periods of high fluvial discharge, the result of major winter storms in the region (Best and Griggs, 1991). Other regional sediment sources include erosion of sedimentary deposits along the shoreline, accounting for 20% of the sediment budget, and an additional 5% of the sediment derived from dune deflation and eolian processes.

Fluvial Watersheds. Griggs and Hein (1980) reported that four rivers contribute the bulk of sediment to the Monterey Bay: the San Lorenzo, Pajaro, Salinas, and Carmel rivers. Two additional sources of sediment from the Santa Cruz Mountains were investigated for this study: Aptos and Soquel creeks. The fluvial watersheds are shown in Figure 3.

Fig. 3: Location map of regional watersheds. Image data for base map from Figure 1, rivers and watershed boundaries drawn by this author

Shoreline Erosion. Shoreline erosion occurs primarily during episodic periods of large waves and high storm surge (Griggs and Johnson, 1983). The largest sources of wave-eroded material in Monterey Bay are from the erosion of bedrock cliffs and deflation of sand dunes along the coastline. In the northern Monterey Bay, near Santa Cruz, the shoreline consists of tectonically uplifted marine terraces containing Miocene to Pleistocene marine and near-shore sediment deposits (Dupré, 1990; Fig. 4).

To the south, along the coastline between Santa Cruz and Monterey, beach deposits are composed of fine- to coarse-grained lithic arenite sand (Fig. 4; Combellick and Osborne, 1977; Wolf, 1970). Aeolian sand dunes dominate the topography above the backshore and berms above the beaches along the central Monterey Bay (Dupré, 1990).

Granodiorite, the basement rock of the Monterey Peninsula, bounds the southern end of Monterey Bay forming a headland at Point Piños. The shoreline between the Monterey Peninsula and Carmel is dominated by granodiorite outcrops interspersed with pocket beaches up to 1 km long (Storlazzi and Field, 2000; Fig. 5). Pocket beach deposits along the southern Monterey Bay are composed of fine- to coarse-grained quartz arenite sand.

Littoral Drift. Sand, delivered from streams or eroded from the beaches and cliffs, is transported by littoral drift to the head of Monterey Canyon (Best and Griggs, 1991). The predominant wave direction in the northern Monterey Bay is from the northwest, producing a southerly littoral drift that terminates at Monterey Canyon head (Oradiwe, 1986; Best and Griggs, 1991). Conversely, on the southern shelf sediment is transported

northward to the canyon head by littoral drift and surface currents in the southern Monterey Bay (Wolf, 1970; Fig. 6).

Fig. 4: Location map of Quaternary marine terraces (between points A and B), Quaternary dune sand (points B to C), and interspersed pocket beaches (points C to D) on Monterey Bay shoreline. Shaded relief DEM of offshore multibeam data from MBARI Mapping Team Digital Data Series 3 ©; terrestrial image modified from Landsat data.

Fig. 5: Pocket beaches near Cypress Point. Photo by Adelman © (2002)

Sediment Transport in Submarine Canyons

After delivery to upper Monterey Canyon, transport of sediment to the fan probably occurs during periodic events that occur from hundreds to thousands of years (Greene et al., 2002; Paull et al., 2003a). In order to transport large volumes of coarse-grained material from the shelf to deep-sea fans, high-energy flows are necessary. After sediment is deposited it can be re-mobilized by several mechanisms including: 1) sediment-gravity flows (Normark and Piper, 1991; Greene et al., 2002); 2) mass wasting (Middleton and Hampton, 1976; Greene et al., 2002); and 3) grain flows (Middleton and Hampton, 1973).

Fig. 6: Regional sediment transport direction showing shoreline littoral drift (black arrows), surface currents, (blue arrows) and down canyon sediment flow (ochre arrows in submarine canyons). Sediment transport, littoral drift, and surface current arrows from data reported by Wolf (1970), Best and Griggs (1991), Breaker and Broenkow (1996), Greene et al. (2002), Eittreim et al. (2002a; b), and Paull et al. (2002; 2003a). Map image data from Figure 4.

Sediment-Gravity Flows. Sediment-gravity flows may be the primary transport mechanisms of coarse-grained sediment from the continental shelf through the modern Monterey Canyon axis (Paull et al., 2003a, b). Sediment-gravity flows are energetic enough to incorporate large cobbles and coarse sand into the flows. Well-rounded cobbles, large angular granodiorite blocks, and cobble-sized mud rip-ups in Eocene submarine canyon deposits at Point Lobos, California suggest that the coarse-grained

cobble conglomerate deposits there were emplaced by sediment-gravity flows (Clifton, 1984).

The frequency and mechanisms that trigger sediment-gravity flows have been difficult to accurately document in submarine canyons, including the well-studied Monterey Canyon (Inman et al., 1976; Paull et al., 2003b). Greene et al. (1991) reported that mass wasting at the canyon head had occurred during the 7.1 magnitude Loma Prieta earthquake in 1989. Kinoshita and Noble (1995) also recorded another possible Monterey Canyon turbidity event on February 8, 1994.

Six sediment-gravity flows have now been documented by MBARI during an eighteen-month period from 12-19-01 to 6-19-03 (Paull, personal communication, 2003). The first of those events occurred six hours after deployment of an equipment package with ROV *Tiburon* and was reported by Paull et al. (2003b).

Mass Wasting. Mass wasting events (Shepard and Dill, 1966; Clark and Pickering, 1996) are also a source of coarse-grained material in the Monterey Canyon channel axis (Martin and Emory, 1967; Greene et al., 2002). Large blocks, slabs, or sheets of material are moved down slope into the canyon axis during mass-wasting events (Middleton and Hampton, 1973). Debris slumps, one form of mass wasting, often contain poorly sorted deposits with large angular blocks of material. Slump deposits may exhibit internal deformation and produce bi-modal or multi-modal grain-size distribution curves when clay and fine-grained sediment are entrained with coarse-grained sediment (Middleton and Hampton, 1973).

Grain Flows. Grain flows are another method of coarse sediment remobilization. Middleton and Hampton (1973) described grain flows as concentrations of cohesionless sediment that move down-slope by grain-to-grain saltation in a dispersed state. Grain-flow deposits may be distinguished by thin- to thick-bedded sand units, slight variation in grain-sizes, uni-modal clast distribution, and moderately to poorly sorted sand.

TECTONIC HISTORY, PHYSIOGRAPHY, AND GEOLOGY OF THE MONTEREY BAY REGION

Tectonic History

The present geology of the Monterey Bay region is the result of tectonic evolution over the past 65 Ma (Greene, 1990). Active plate subduction along a convergent plate boundary, west of the paleo-California coast, was the dominant tectonic process from the Cretaceous through middle Tertiary. During this period, the Farallon Plate was subducted eastward under the North American plate (Atwater, 1970; Atwater and Molnar, 1973).

Plate subduction ended in the Monterey Bay region during the early Miocene (~21 Ma) and switched to a transform plate boundary with formation of the San Andreas Fault system (Dickenson, 1981). The northwest-southeast-trending mountain ranges and valleys of the Monterey Bay region are the result of ongoing transpressional tectonic forces acting on the Salinian Block over the past ~21 Ma (Howell et al., 1985).

The basement rocks now exposed in the Monterey Bay region were created as the result of plate subduction processes (Ernst, 1993a, b; Compton, 1966). Blocks of oceanic crust (basalt) and overlying sediments were fragmented or mixed within the subduction zone forming a tectonic melange, characteristic of Franciscan Complex deposits. The formation of blueschist facies rocks produced a distinct suite of rocks: jadeite, serpentine, glaucophane-lawsonite schists, slates, chert, and greywacke (Mason, 1990; Peacock, 1992).

Subduction also resulted in the formation of igneous complexes inshore of the plate boundary (Kirby et al., 1996). The Sierra Nevada batholith and the Salinian Block, a tectonostratigraphic block of granite/granodiorite that formed to the south of its present location, were created during subduction of the Farallon Plate.

A different tectonic process began affecting the geology of the Monterey Bay region ~21 Ma. Subduction of the Farallon Plate ceased and was replaced by northwest movement of the Pacific Plate and the Salinian Block, along right-lateral strike-slip faults after the formation of the San Andreas Fault system. Transpressional tectonics was responsible for the uplifted fault blocks and subsidence of depositional basins that formed in, and near, the Salinian Block during the Neogene (Vedder et al., 1982).

Offshore Physiography

Monterey Bay is a crescent-shaped embayment on the Central California coast located 115 km south of San Francisco. The floor of the Monterey Bay is bisected by Monterey Canyon (Fig. 7). The canyon channel originates at four submarine canyon heads that incise the continental shelf 30 to 100 m offshore of the Moss Landing harbor mouth (Fig. 8). The Monterey Canyon channel meanders across the continental margin and reaches depths over 3,900 m at the base of the continental rise more than 90 km from the shoreline (Greene, 1990; Fig. 7). Two tributary channels empty into the upper thalweg. They are: 1) Soquel Canyon, which intersects Monterey Canyon as a hanging valley from the north at ~ 1000 m water depth (Greene and Hicks, 1990; Greene, et al.,

2002); and 2) Carmel Canyon, which enters Monterey Canyon from the south in a stepped chute at a water depth of $\sim 2,000$ m (Greene and Hicks, 1990; Greene et al., 2002; Fig.2).

Fig. 7: Map of the Monterey Bay region. Image data on map from Figure 4.

Fig. 8: Monterey Canyon heads located off the Moss Landing Harbor mouth. DEM of high-resolution multibeam data from CSU Monterey Bay Seafloor Mapping Project (modified from Okey, 2003).

In the lower Monterey Canyon, the Ascension Canyon system of Greene et al. (2001) intersects the Monterey Sea Valley of Shepard and Dill (1966) northwest of Shepard's meander (Fig. 2). The Sur-Lucia Canyon system of Greene and Hicks (1990) and Greene et al., (2002) joins Monterey Sea Valley near the Davidson Seamount (Fig. 2).

Two fault systems, the Palo Colorado-San Gregorio fault zone of Greene (1990), and the Monterey Bay fault zone of Greene (1977) bisect the continental shelf in Monterey Bay and control the geomorphology of meanders within the Monterey Canyon (Greene, 1990; Greene et al., 2002; Fig. 9).

Fig. 9: Faults of the Monterey Bay Region showing onshore and offshore faults in the Monterey Bay trend northwest-southeast sub-parallel to the San Andreas Fault. Fault data from California Division of Mines and Geology, Greene et al. (2002), and Wagner et al. (2001). Image data from Figure 4.

Onshore Physiography

The major onshore topographic features of the region trend southeast-northwest sub-parallel to the San Andreas Fault system. The mountains of the Coast Ranges dominate the onshore physiography of the Monterey Bay region. The Santa Lucia Range, Santa Cruz Mountains, Diablo Range, and Gabilan Range are uplifted features that follow this trend (Fig. 10)

Fig. 10: Monterey Canyon and onshore geomorphic features of Monterey Bay Region. Salinian Block boundary drawn from fault data modified from CDMG, Wagner et al. (2001), and Greene et al. (2002). Image data of base map from Figure 1.

The Salinas Valley is a topographic low between the Santa Lucia and Gabilan Ranges (Fig. 10) and is the primary drainage basin of the Salinas River system. Moss Landing harbor mouth, in the center of Monterey Bay, is the predominant outlet of Salinas River and is the outlet of Elkhorn Slough. The Salinas River mouth is blocked by a beach berm during much of the year. The Salinas River utilizes Moss Landing harbor as an outlet when flows are low (Greene et al., 1991). The Salinas River flows out through the river mouth only during high-energy winter flood events that break through the berm.

Provenance Geology

For the purposes of this study, the regional onshore geology is divided into three major provenances: 1) the Salinian Block, an area of Cretaceous granodiorite basement rock west of the San Andreas Fault (Page, 1970; Howell et al., 1985) overlain by pre-Cretaceous high grade metamorphic and carbonate rock of the Sur Series of Trask (1926) on some of the ridge tops and peaks of the Santa Lucia and Gabilan Ranges (Clark and Rietman, 1973); 2) the high-pressure/low-temperature metamorphic deposits of the Franciscan Complex, located east of the San Andreas Fault (Ernst, 1993a); and 3) Paleocene to Quaternary sedimentary deposits overlying the regional basement (Compton, 1966; Greene, 1977; Ernst, 1993a). The geologic deposits in the Monterey Bay region are shown in Figure 11.

Fig. 11: Regional geologic map with watershed boundaries from Figure 3 shown in white, (modified from Feray, Oetking, and Renfro, 1968).

Salinian Block. In the Monterey Bay region, the Salinian Block is wedged between the San Andreas Fault zone to the east and the Palo Colorado-San Gregorio-Sur-Nacimiento Fault zone to the west (Page, 1970; Greene, 1977; Howell et al., 1985; Fig.10). Greene (1977) first described the western boundary of the Salinian block in the Monterey Bay region.

Pre-Cretaceous metamorphic quartzite, gneiss, marble schist, and limestone roof pendants cap the crests of some peaks in the Santa Lucia and Gabilan Ranges (Trask, 1926; Compton, 1966; Fiedler, 1944). One exception is the Miocene andesite and rhyolite tuff of Matthews (1976) within the Pinnacles National Monument near Soledad (Fig.11).

Franciscan Complex/Great Valley Group and Quien Sabe Volcanics. Late Jurassic-Mid Cretaceous high pressure/low-temperature metamorphic rocks, located east of the San Andreas Fault in the Diablo Range, represent the largest exposed tract of Franciscan Complex rocks in the state of California (Ernst, 1993b). The Miocene Quien Sabe Formation basalts and andesites cap peaks in the Diablo Range northeast of Hollister (Leith, 1949).

Tertiary to Quaternary Sedimentary Deposits. Paleocene to Quaternary siliciclastic marine and non-marine sedimentary sequences overlie the basement rock in many areas of the Monterey Bay Region. A stratigraphic column of the geologic sequence in the central Santa Cruz Mountains is shown in Figure 12. The sequence of Paleocene to

Quaternary marine deposits in the Monterey Bay region indicates that the regional topography has undergone both transgressive depression and regressive uplift over geologic time due to oblique transpressional tectonic forces related to plate motion.

SERIES	SEDIMENTARY SEQUENCE	FORAMINIFERAL STAGE	FORMATION	LITHOLOGY	THICKNESS METERS	DESCRIPTION	
MIOCENE	Pliocene		Purisima Formation		150+	Very thick-bedded yellowish-gray tuffaceous and diatomaceous siltstone with thick interbeds of bluish-gray semifriable andesitic sandstone	
			Upper Miocene to Pliocene		Santa Cruz Mudstone	0-2700	Medium- to thick-bedded and faintly laminated pale-yellowish-brown siliceous mudstone with scattered spheroidal dolomite concretions; locally grades to sandy siltstone
					Santa Margarita Sandstone	0-130	Very thick-bedded and thickly crossbedded yellowish-gray to white friable arkosic sandstone
	Middle Miocene	Luisian	Monterey Formation		810	Medium- to thick-bedded and laminated olive-gray subsiliceous organic mudstone and sandy siltstone with few thick dolomite interbeds	
			Lompico Sandstone		60-240	Thick-bedded to massive yellowish-gray arkosic sandstone	
	Oligocene	Sarcinian	Unconformable on Butano and underlying rocks				
			Lambert Shale		185	Thin- to medium-bedded and faintly laminated olive-gray to dusky-yellowish-brown organic mudstone	
		Zemurian	Vaqueros Sandstone		350+	Thick-bedded to massive yellowish-gray arkosic sandstone; contains a unit, as much as 60 m thick, of pillow-basalt flows	
			Zayante Sandstone		550	Thick- to very thick-bedded yellowish-orange arkosic sandstone with thin interbeds of green and red siltstone and lenses and thick interbeds of pebble and cobble conglomerate	
		Eocene	Refugian(?)		San Lorenzo Fm.		275
Two-bar Shale Member	60			Very thin-bedded olive-gray shale			
Narizian	Butano Sandstone		Upper sandstone member	980	Thin- to very thick-bedded medium-gray arkosic sandstone with thin interbeds of medium-gray siltstone		
			Middle siltstone member	75-230	Thin- to medium-bedded nodular olive-gray pyritic siltstone		
Paleocene		Ynezian	Lower sandstone member	460+	Very thick-bedded to massive yellowish-gray arkosic sandstone with thick to very thick interbeds of sandy pebble conglomerate in lower part		
	Not in contact within area						
			Locatelli Formation	270	Nodular olive-gray to pale-yellowish-brown micaceous siltstone; massive arkosic sandstone locally at base		
Unconformable on crystalline complex of Ben Lomond Mountain							

Fig. 12: Stratigraphic column for central Santa Cruz Mountains from Clark (1981).

Previous Studies of Accessory Mineral Provenance

Yancey (1968) identified four heavy mineral provinces along the Monterey Bay shoreline. Five primary accessory minerals were used to identify provenance: hornblende, augite, hypersthene, garnet, and glaucophane (Fig. 13). Accessory minerals are delivered to the shoreline from onshore source areas by fluvial streams in the region (Yancey, 1968).

Fig. 13: Accessory mineral depositional provinces in Monterey Bay. Map modified from Yancey (1968).

Yancey and Lee (1972) identified the major source areas for the accessory minerals of Yancey's (1968) study. Four source areas are primary contributors of accessory minerals to Monterey Bay: 1) the La Panza Range in the southern Salinas River drainage is the source of hornblende/sphene; 2) the Santa Lucia Range is the source of hornblende/garnet; 3) the Diablo Range is the source of glaucophane/jadeite and lawsonite; 4) the northern Santa Cruz Mountains is a primary province of augite; and 5) flows into San Francisco Bay via the Sacramento/San Joaquin Delta may contribute hornblende-augite-hypersthene through littoral drift from the north. The first four provinces listed above contribute the bulk of sediment to Monterey Bay and are the primary sources of coarse sediment for Monterey Canyon. The provinces are shown in Figure 14.

Fig. 14: Accessory mineral source provinces. Map modified from Yancey and Lee (1972).

METHODS

Sampling with piston and gravity cores in sand and conglomerate deposits that are common in active submarine canyons is difficult (Pickering et al., 1989; Whitaker, 1976). Until recently, precise targeting and retrieval of core samples within submarine canyons axes was difficult utilizing standard gravity-coring systems on surface ships, because of the narrowness and great depths of canyon channels and the inability of gravity cores to successfully penetrate and retrieve unconsolidated coarse-grained sediment.

The development of a mounted vibracoring system at MBARI for use on remotely operated vehicles (ROV's) allows retrieval of sediment cores up to 2.4 m in length from coarse-grained sediments in submarine-canyon channels for the first time (Paull et al., 2001). Precise sites for sample collection within submarine canyons may now be chosen with extreme accuracy. Sampling with such precision can detect subtle changes in grain-size and lithology and relate that information to the canyon channel morphology.

MBARI's Remotely Operated Vehicles

The development and use of the vibracoring systems on the ROV's at MBARI was the critical component of this project because it allowed sites to be chosen where GPS navigation systems, ROV sonar capabilities, and high-resolution cameras could precisely pin-point targets in the canyon channel. Surgical-like core retrieval is now available for the first time for sea-floor core sampling. High-resolution cameras onboard the ROV's also allowed scientists to assess the seafloor sediment and lithologies of outcrops on the

canyon flanks for the purposes of determining if sediment in the canyon axis is from the adjacent outcrops or transported through the canyon axis from elsewhere (Figs. 15 and 16).

Fig. 15: Cobbles and granite outcrop in the axis of Monterey Canyon, field of view approximately 4 m. This site could be sampled with the ROV vibracore although penetration might be limited by the cobble sizes. It would be impossible to sample this area with standard shipboard wire line gravity cores. Photograph from MBARI © 2002.

Fig. 16: Sedimentary rock outcrop (Monterey Formation diatomite) from the flanks Monterey Canyon, field of view approximately 3 m. Photograph from MBARI © 2002.

ROV *Ventana*

The ROV *Ventana* (Fig. 17) is deployed aboard the 31 m research vessel *Point Lobos* (Fig. 20). The vehicle is 3.1 m long, 2.6 m wide, and 3.4 m tall, with a weight in air of 2,338 kg. *Ventana* is an electrical-hydraulic vehicle powered by an 8-kW electrical system that runs the lighting, systems operation, and science tools during the dive. *Ventana* operates over the side of the R/V *Point Lobos* at a maximum water depth of 1,500 m and can retrieve only one vibracore per dive. *Ventana*'s vibracoring system has a 3.5-m aluminum frame topped with a vibrating motor (Fig. 18). The weight of the motor combined with vibration allows cores to be inserted into coarse-grained sediment. Core penetration is facilitated by sediment liquefaction created by vibration of the motor, and

by the downward pull of gravity from the weighted motor at the top of the core liner. The 7.62-cm-diameter aluminum core liners contain a rubber piston and metal core catcher at the base to help facilitate sediment retention during core extraction.

ROV *Tiburon*

The ROV *Tiburon* is deployed from a moon-pool in the center of the R/V *Western Flyer*, a 35.7-m-long by 16.2 m-wide small water-plane area twin hull (SWATH) ship. *Tiburon* is an all-electric vehicle that has slightly larger dimensions than *Ventana*, but has similar scientific capabilities. *Tiburon* is deployed for deep-water research with a maximum dive capability of 4,000 m. *Tiburon* has a smaller mounted version of the vibracoring system or can be equipped with a vibraclaw for use with the manipulator arm of the ROV. The vibraclaw is a tool for the ROV that works well in unconsolidated sediment. The ROV pilots vibrate the manipulator arm on the vehicle while the core barrel is penetrating sediment on the canyon floor. The vibration causes liquefaction in the unconsolidated sediment and eases penetration of the core barrel. Vibracoring with *Tiburon* is assisted by the use of an elevator-mounted quiver capable of holding 8-20 core liners (Fig. 19). The quiver is fitted with a detachable weight and dropped to the sea floor from the stern of the R/V *Western Flyer*. After elevator deployment, *Tiburon* locates the quiver via a homing beacon placed on the elevator, commonly using the site as a base of operations and traveling outward from the elevator to collect the cores. The ROV can collect two cores per transit, return the cores to the quiver and replace them on the ROV with two empty liners, and then repeat the process. After cores are collected, the weights

holding the elevator on the bottom are detached and the system floats to the surface. The ship's crew collects the elevator after it arrives on the surface, using a zodiac to tow it back to the ship for hoisting aboard.

Fig. 17: ROV *Ventana* being launched from R/V *Point Lobos*.

Fig. 18: ROV *Ventana* aboard R/V *Point Lobos* with bent vibracore barrel.

Fig. 19: Core elevator quiver being launched .

Core Retrieval

In Monterey Canyon, the ROV *Ventana* collected 85 vibracores up to 240 cm long and 28 push cores up to 25 cm long from water of 1,500 m and shallower (Fig. 1; Appendix Ia; Ib). The ROV *Tiburon* collected 108 vibracores up to 150 cm long and 106 push cores up to 25 cm in length from deep-water sites between water depths of 1,500 m and 3,884 m (Fig. 1; Appendix Ia; Ib). Other samples used for this study include: one hand-held dive collected from 20 m water depth (Fig 20); two Smith-Mac grabs from Moss Landing Marine Laboratories' R/V *John Martin* collected from the Monterey Canyon axis (Fig. 20); and 45 hand-held PVC push cores collected from beaches, river sites, and pre-Holocene deposits in the Monterey Bay region (Fig. 1; Appendix Ic).

Fig. 20: Location map of two sample sites from the R/V *John Martin* and one core site near the Moss Landing Harbor mouth where a hand-held diver core was collected.

Core Processing

Push cores collected by the ROV pilots were extruded from their core liners using a plastic plug and a PVC pipe to push the sediment through the core liner onto a tray. Cores were described, photographed, and ninety-one sub-samples of sediment weighing 20-50 g were selected from sand and coarse-silt horizons in the push cores for grain-size analysis. The sub-samples were placed in whirl-pack bags and refrigerated prior to analysis.

Vibracores were collected from the ROV's or elevator when they arrived aboard ship and sealed with plastic caps and electrical tape. The aluminum core liners were horizontally split with electric shears. A wire garotte was run down the length of the core to divide the core into halves. The cores were then photographed and described. The percent of various sedimentary components within the cores were calculated from the different stratigraphic layers observed in the cores (Appendix II).

Sub-samples of coarse-grained sediment weighing 20-50 g each were selected for grain-size analysis from coarse-grained horizons, massively bedded sands, and gravelly muds in 84 of the vibracores. Sub-samples were preferentially selected from coarse-grained sediment layers. The coarse-grained sediment was the primary interest of this study because it is the best indicator of high-energy sediment transport processes and the provenance of the sediment in the canyon's axis.

Grain-Size Samples

A total of eight-hundred-ninety-one sub-samples were analyzed for grain size during this study from eighty-four vibracores and fifty-three push cores (Fig. 21). Mean grain sizes of the sub-samples are reported in Appendix III in both mm and phi units based on the Wentworth grain-size classification scale (Table 1). The additional statistics generated from grain-size analysis (standard deviation, skewness, and kurtosis), as well as the calculated percentages of gravel, sand, and mud from each of the sub-samples, are also reported (Appendix III).

Samples that had mean grain sizes greater than 6 phi are reported in Appendix III, but were not used for this study. The median grain sizes of the sediment in those samples are smaller than the smallest screen size of the Ro-Tap used for analysis and the data from those samples do not accurately reflect the distribution of the very fine silt and clay particles in those samples. The procedures and protocol used for the samples are described by Folk (1974). Samples were weighed in pre-tarred 100-ml glass beakers. Sediment sub-samples were then dried at 60° C in a drying oven for at least 24 hours or until completely dry. Sub-samples were placed in a vacuum desiccator with Drierite ® to allow the samples to cool to room temperature without re-absorbing water. The sub-samples were re-weighed to determine the weight of the dry sediment.

Fig. 21: Location map of cores selected for grain-size analysis: vibracores (white circles), push cores (red circles), and onshore hand cores (orange squares). Image data for base map from Figure 1.

Sediment containing mud was additionally processed by adding 50 ml of de-ionized water and a 10-ml solution of 50 g/L Calgon TM to facilitate de-flocculation of clays in the samples. The sub-samples were placed on a rotary table at 110 rpm for 24 hours to help disaggregate the samples. Sediment was then wet sieved through a 38 μ m (6 ϕ) screen allowing grains smaller than the screen to be removed and drained from the samples. The remaining fraction larger than 38 μ m was dried in the oven again, cooled in the desiccator, and re-weighed. The weight of the sediment smaller than 38 μ m removed by wet sieving was calculated by subtracting the second dry weight total from the first dry weight total.

Screen sieves in a roto-tap separated the samples of dry sediment. Sets of incrementally finer sieves were used to separate the sediment. Seven sieve sizes: 1) >2 mm (-1 ϕ); 2) >1mm (0 ϕ); 3) >500 μ m (1 ϕ); 4) >250 μ m (2 ϕ); 5) >125 μ m (3 ϕ); 6) >63 μ m (4 ϕ); 7) >38 μ m (6 ϕ) and a catch tray for sediment <38 μ m (6 ϕ) were used. The sediment sub-samples were placed in the coarsest screen at the top of the stack and separated by running the machine for 15 minutes per sample, as recommended by Folk (1974).

Method of Grain-Size Analysis

Sediment collected in each of the seven screens and the bottom catchment tray were placed in pre-tarred glass vials. Each of the eight grain-size fractions were then weighed and data recorded in a spreadsheet for statistical analysis. To generate the statistical data for this study, the method of moments technique was chosen to calculate grain-size

statistics because it works well for samples that contain coarse- and fine-grained tails and it allows rapid calculation of a large number of sub-samples (Krumbein and Pettijohn, 1938). Weight percentage of each grain-size fraction (f) was calculated by dividing the weight of each of the eight bin fractions (g_f) by the total weight of the sample (g_t) and multiplying by 100 [i.e. $f = (g_f/g_t) \times 100$]. Additional statistical parameters were calculated for sediment sub-samples including: statistical mean (x_ϕ); ($x_\phi = \sum fm/n$), standard deviation (σ_ϕ) ($\sigma_\phi = \sqrt{\sum f(m-x_\phi)^2/100}$), skewness (Sk_ϕ) ($Sk_\phi = \sum f(m-x_\phi)^3/100\sigma_\phi^3$), and kurtosis (K_ϕ) ($K_\phi = \sum f(m-x_\phi)^4/100\sigma_\phi^4$) of each sub-sample, where f = weight percent of each grain-size fraction, m = the mid-point of each grain-size fraction in phi units, and $n = 100$ because f is in weight percentage.

Beach, Dune, and River Sand Grain-Size Data

One of the crucial issues addressed in this study was identification of differences in the sand using grain-size statistics from: 1) the fluvial watersheds; 2) the beaches along the coast; 3) the dunes above the coastal beaches; and 4) the canyon axis. Grain size statistics were used to resolve the sources of the sand. Standard deviation versus skewness plots were used in this study to identify differences in source areas and depositional settings. Friedman (1967) analyzed 180 river sands and 155 beach sands and compared the skewness and standard deviations values of beach and river sands from around the world. Friedman (1967) drew a line separating the two sediment populations in his study (Fig. 22). Lower standard deviations and skewness characterize beach sands, whereas river sands have higher values (Fig. 22).

Fig. 22: Friedman (1967) diagram showing skewness versus standard deviation to distinguish beach versus river sand.

QFL Analysis

Samples of medium- to coarse-grained sand were chosen from onshore and offshore sites for identifying the amount of monocrystalline quartz (Q_m), total feldspar (F_t), and total lithic rock fragments (L_t) (QFL) in each sample (Appendix IV). The samples were selected from: 1) cores collected in the axis of the canyon channel to detect changes in

sand composition down the canyon axis; 2) from hand cores collected along the shoreline between the Salinas and Pajaro River mouths to examine the composition of beach sand near the head of the canyon; and 3) from rivers that terminate in Monterey Bay (Fig. 23; Appendix IVa).

One-gram vials of selected samples were sent to Rocktell Laboratories, Alberta, Canada for grain mounts. Samples were mounted and ground to 30 μm thickness for identification of the minerals with a petrographic microscope. The QFL compositions from each slide were calculated by counting the total number of each grain type from a 300-grain count using a petrographic microscope and digital counter. To obtain a statistically significant representation of the grain population, a minimum of 300 grains from each slide were analyzed.

The QFL ratios were calculated on fifty grain-mount samples. Thirty-five sub-samples were counted from 20 offshore sites and 15 sub-samples were counted from onshore locations, including three Tertiary sand deposits (Fig. 23; Appendix IVa). The QFL data were plotted by grouping them into upper canyon samples (water depths of 0-2,000 m) and lower canyon samples (water depths of 2,000-3,884 m) to determine the changes in sand composition from the upper canyon to the lower canyon.

Data were also obtained for beach samples collected at three locations south of Moss Landing Jetty and three to the north of Moss Landing Jetty (Fig. 24) to detect any differences in composition of the sand near the head of the canyon. Samples from the Salinas River watershed and Pajaro River watershed (Fig. 23) were also examined to establish the difference in sand composition coming into Monterey Bay from the two provinces.

Fig. 24: Location map of cores collected onshore near the Moss Landing Harbor (orange triangles). Image data for base map from Figure 4.

The QFL ratios were also determined for a massive sand layer in VC-16 collected in 693-m water depths from Monterey Canyon axis (Fig. 25). The core was chosen for

analysis of the QFL ratios to determine if the sand is homogenous over a range of grain-sizes and within the bed. Samples were selected from three intervals in VC-16 to calculate the QFL ratios of the sand: 1) 9-11 cm; 2) 89-91 cm; and 3) 169-171 cm. The depths were selected because they were near the top, middle and bottom of the vibracore. Three distinct grain-sizes were separated and sampled from each of the three depth intervals. These samples were composed of: 1) coarse sand (1ϕ fraction); 2) medium sand (2ϕ fraction); and 3) fine sand (3ϕ fraction).

Fig. 25: Location map of three vibracores collected near 700 m water depth of Monterey Canyon channel axis. Image data for base map from Figure 4, 100 m bathymetry from MBARI Mapping Team Data Series No. 3 ©.

Accessory Mineral Analysis

Accessory minerals were examined in 25 samples of very fine sand from cores collected in the Monterey Canyon axis from 20 m to 3,884 m water depths (Appendix Va; Fig. 26). Samples were also examined from 8 onshore locations (Appendix Va; Fig. 26). The samples sites were chosen for two purposes: 1) to help identify the provenance of sand from beaches near the head of the canyon and in the canyon channel; 2) to identify any changes in the composition of accessory minerals associated with transport through the canyon axis. Optical properties used to identify the fifteen primary minerals of this study are listed in Appendix Vb. Point counts were tabulated from the grain mounts and data are reported in Appendix Vc.

Four of the eight shoreline samples selected for accessory mineral analysis were chosen from cores collected between the Moss Landing Harbor mouth and the Pajaro River, three samples were selected from cores collected between the harbor mouth and the Salinas River, and one from the sample was collected on the beach at the Carmel River mouth (Fig. 27).

Fig. 26: Location map of samples selected for accessory mineral analysis. Samples from offshore sites (white triangles) and onshore sites (orange triangles) are shown. Image data for base map from Figure 1.

Fig. 27: Location map of seven onshore sites selected for accessory mineral analysis (orange triangles) Six samples were analyzed from central Monterey Bay and one sample from Carmel Bay. Image data for base map from Figure 4.

Thirty-four samples of very fine sand ($63\mu\text{m}$ - $125\mu\text{m}$ or 3ϕ - 4ϕ) were selected from the shoreline and canyon and sent to Roger Lewis at the United States Geological Survey (USGS) at Menlo Park, California for separation of accessory minerals. Minerals with densities $> 2.90\text{ g/cm}^3$ were separated from the sand samples. The samples were rinsed with de-ionized water and dried at 60°C in an oven prior to separation. Samples were placed in a separation funnel with a closed stopcock containing 250 ml of tetrabromomethane with a specific gravity of 2.90. The sediments were swirled in the funnel to separate aggregates. Grains were allowed to settle by density differentiation for 45 minutes. The sediment grains were collected by passing the liquid and sediments through two 10-cm-diameter paper filters. By passing the liquid and sediment at the bottom of the funnel through one filter first and then the rest of the liquid and sediment through a second filter, the accessory minerals were separated from the lighter siliciclastic mineral grains in the samples. The accessory minerals were subsequently rinsed with acetone and allowed to dry under a fume hood.

Thirty-four samples containing accessory minerals were also sent to Rocktell Laboratories, Alberta, Canada for grain mounts, which were ground to $30\mu\text{m}$ thickness for identification of the minerals with a petrographic microscope.

Three hundred grains were counted on each of the slides. Percent compositions of the key accessory minerals are reported in Appendix Vd. Photomicrographs of the key accessory mineral samples collected in this study, in addition quartz and feldspar clasts, are shown in Figure 28.

Fig. 28: Photomicrographs of key mineral grains of this study. Minerals are shown in plain polarized light (ppl) and crossed-polarized light (xpl). Field of view ~ 0.075 mm.

Gravel Analysis

Forty-one vibracores collected in the canyon's channel and on the shelf contained pebbles and cobbles (Appendix VIa; Fig. 29). The largest cobbles collected during this study were restricted to the diameter of the cores (7.62 cm for the vibracores); however, core penetration would stop when cobbles larger than the diameter of the core were encountered.

Gravel was also collected from 12 onshore sites in watersheds that have public access, contain sufficient quantities of gravel, and are in the main channel or tributaries of the streams that enter Monterey Bay (Appendix VIa). Onshore sites were chosen from four locations in the Salinas River watershed: Nacimiento River, San Antonio River, Arroyo Seco River, and Salinas River; four sites in the Pajaro River watershed: Pacheco Creek, Tres Pinos Creek, San Benito River, and Pajaro River; the San Lorenzo River in Santa Cruz; Soquel Creek in Soquel; and Aptos Creek in Aptos (Fig. 29).

Twenty-five gravel clasts were large enough for thin sections and cut with a rock saw into 3 mm x 45 mm x 25 mm rectangles and ground for slide production. The minerals were identified using a petrographic microscope.

Point counts were tabulated from the core samples to identify the types of lithologies in the cobbles and categorizing them into seven lithic types (Appendix VIb). The lithologies are: 1) granodiorite (plutonic igneous rock); 2) sandstone (lithified rocks composed of individual siliciclastic detrital grains cemented by silica or calcite); 3) high grade metamorphic rocks (high-pressure/high-temperature metamorphic rocks including gneiss, quartzite, amphibolite schist, and marbled limestone); 4) Franciscan Complex

(rocks formed in high-pressure/low temperature subduction zones including slates, glaucophane-lawsonite schists, jadeite, serpentine, metamorphic ultra-mafics, and other altered meta-sedimentary and meta-volcanic clasts); 5) Monterey Formation (lithified diatomaceous marine sediments); 6) volcanic rocks (all extrusive igneous rocks); and 7) chert (microcrystalline meta-sedimentary deposits generally composed of opalized amorphous silica or altered radiolarians and biogenic silica). Gravel/cobble samples were identified by visual inspection with a hand lens, dissecting microscope, or by inspection of thin sections with a petrographic microscope. Samples collected in Monterey Canyon were identified, grouped into the seven lithic categories selected for this study, and percent compositions were calculated for each of the lithic categories (Appendix VIc). Additional point counts were tabulated from gravel/cobble samples from fluvial systems, by identifying and categorizing 300 gravel/cobble samples from each site (Appendix VIId). Percent compositions were also calculated for the samples by clast type (Appendix VIe). The data obtained from onshore samples supplement the gravel/cobble data set from the Monterey Canyon and helped to determine the provenance of gravel in the canyon axis.

Fig. 29: Map of sites where gravel/cobbles were collected. The offshore locations are shown as white circles and cores collected onshore are shown as orange squares. Image data for base map from Figure 1.

RESULTS OF SEDIMENT ANALYSES

Core Descriptions

The first level of core analysis after splitting was photography and description. The descriptions of the cores allowed the percent composition of the various sedimentary components to be calculated. The sedimentary divisions used for this study are: mud, mud (clay) balls, silt, sand, gravel, mixed sand and gravel, mixed mud and cobbles, interbedded silt and clay, and shell coquinas. The percentage of each sediment type was calculated by dividing the sum of each type by the total length of the core, multiplied by 100, (i.e. $F_i/C_t \times 100$) where F_i is the total length of all intervals of one particular sediment type and C_t is total length of the core. Data are reported in Appendix II.

Visual inspection of the cores allowed the author to differentiate four distinct depositional environments within the Monterey Canyon system. They are: 1) canyon channel; 2) over-bank levee/channel edge; 3) canyon flanks; 4) Monterey Bay shelf (Fig. 30).

Fig. 30: Map of upper canyon core sites by depositional settings listed on previous page. Depositional environments are: 1) canyon channel (white circles); 2) over-bank levee/channel edge (dark red circles in canyon channel); 3) canyon flanks (dark green circles in Monterey Canyon, and light green circles in Sequel Canyon); and 4) continental shelf (bright red circles). Data for base map from Figure 4.

Depositional Settings

Canyon Channel

The deposits in cores collected in the canyon channel contain a variety of compositions ranging from a mixed-slurry of mud and gravel to competent layers of homogenous sand or gravel. Canyon channel cores contain five distinct sediment types: 1) massively bedded sand; 2) mixed sand and gravel; 3) mixed sand and mud/clay balls; 4) gravel and pebble conglomerate; and 5) mixed sand, gravel, and mud/clay balls in a muddy matrix.

Massively Bedded Sand. Massively bedded sand cores occur near the head of the canyon (in water depths from 86 m to ~200 m) and in three cores (VC-16, VC-19, VC-27) collected near 700 m in the canyon axis (Fig. 31). The deposits contain poorly sorted, sub-rounded, fine- to medium-grained sand (Fig. 32). Some of the sand contained scattered small clay rip-up clasts (less than 1 cm in diameter) or coarse-grained sand and pebbles.

Mixed Sand and Gravel. Mixed sand and gravel deposits contain thin to massively bedded, poorly sorted, fine to coarse sand mixed with pebbles and cobbles (Fig. 33). The deposits are common throughout the canyon. Mixed sand and gravel occurs in cores from the shelf break north of the Monterey Canyon head to the lower canyon at 3,883 m water depths.

Fig. 31: Map of core sites reported in results section of this thesis. Data for base map from Figure 4.

Fig. 32: Photograph of massive sand layer in VC-55 from 28-64 cm below top of core (see Figure 31 for location).

Fig. 33: Photograph of mixed sand and gravel in VC-89 from 28-64 cm below top of core (see Figure 31 for location).

Mixed Sand and Mud/Clay Balls. Sediment composed of mixed sand and mud/clay balls are common in the canyon axis. The mixed sand and mud/clay ball layers contain thin- to thick-bedded, poorly sorted, fine- to coarse-sand matrix supporting small to large mud/clay balls 1 cm to 7.5 cm in diameter (Fig. 34).

Gravel and Pebble Conglomerate. Gravel and pebble conglomerate are clast-supported and consist of thick to massive beds of pebbles and cobbles with a minor percentage (< 5%) of very coarse sand (Fig. 35). Only two vibracores were dominantly gravel and pebble conglomerate deposits. Vibracores VC-23 and VC-24 were collected at water depths near ~ 1,150 m (Fig. 31).

Mixed Sand, Gravel, and Mud/Clay Balls in a Muddy Matrix. These deposits are clast supported, thick to massive, and composed of mixed sand, gravel and mud/clay balls that are entrained with liquefied to semi-consolidated mud. They typically range from an unconsolidated slurry of silt, sand, mud, and gravel to semi-consolidated, matrix-supported, muddy cobble conglomerate (Fig. 36).

Fig. 34: Photograph of mixed sand and mud/clay balls in VC-22 from 17-55 cm below top of core (see Figure 31 for location).

Fig. 35: Photograph of gravel and pebble conglomerate in VC-23 from 25-50 cm below top of core (see Figure 31 for location).

Fig. 36: Photograph of gravel slurry in VC-94 from 142-175 cm below top of core (see Figure 31 for location).

Overbank Levee/Channel Edge

Overbank levee/channel edge cores were collected from overbank or channel levees or from the edge of the canyon channel where the transition from the channel to the levee or flank occurs. The sediment consists of very thin to medium beds of very fine sand, silt, and clay (Fig. 37). The individual layers contain fining upward sequences composed of fine-grained sediment (i.e., very fine sand, silt, and clay).

Fig. 37: Photograph of interlayered silt, sand, and clay in VC-33 from 88-124 cm below top of core (see Figure 31 for location).

Canyon Flank

These cores are composed of thin- to thickly-bedded fine-grained silt and organic-rich clay. Some cores contained thin shell coquinas and bioturbation (Fig. 38). The cores collected in Soquel Canyon were placed in this category because the sediment in the cores collected from this canyon is composed entirely of very fine-grained mud and clay (Fig. 39). Although the cores were collected on the floor of the Soquel Canyon channel axis, no evidence of any recent coarse-grained sediment transport through the canyon was found in the cores (Fig. 39).

Fig. 38: Photograph of silty mud and shell coquina in VC-40 from 0-34 cm below top of core (see Figure 31 for location).

Fig. 39: Photograph of silty clay in VC-61 from 0-35 cm below top of core (see Figure 31 for location).

Continental Shelf Cores

Cores from the continental shelf contain homogenous, massively bedded, very fine sand, silt, and clay with few noticeable bedding planes and some bioturbation in the cores collected for this study. Cores on the inner shelf (less than 30 m water depths) are composed of muddy fine sand and silt (Fig. 40), whereas cores collected on the outer shelf near the shelf/canyon break are dominated by fine silty clay (Fig. 41).

Fig. 40: Photograph of silty sand in VC-81 from 0-35 cm below top of core (see Figure 31 for location).

Fig. 41: Photograph of silty clay in VC-7 from 0-35 cm (see Figure 31 for location).

Grain-Size Analysis

Grain-size data from the cores were used to characterize the sediment types in the canyon axis. Grain-size distribution is a property that can be measured directly and is the result of the energy of the flow processes that transported the sediment (Lewis and McConchie, 1994). The correlative relationship between flow rates and clast size establishes the minimum force necessary to transport coarse material in the canyon axis.

Grain-Size Frequency Distribution Curves

Grain-size frequency distribution curves were produced for sand collected in onshore samples and from vibracores collected down the canyon axis and on the shelf (Figs. 42-48). The modality of the normal clast distribution curves of the beach and dune sand (Figs. 42 and 43) is compared with the modalities of the clast distribution curves from the canyon and from shelf deposits in Figures 44-48.

Fig. 42: Grain-size frequency distribution curves of beach sand samples with sites shown on the right side of the graph. Note that these samples all have uni-modal distributions. Core locations are shown in Figure 49.

Fig. 43: Grain-size frequency distribution curves of dune sand samples. Core sites shown on the right of graph. Note that these samples all have uni-modal distributions. Core locations are shown in Figure 49.

Fig. 44: Grain-size frequency distribution curves massive sand deposits in VC-16. Sample intervals shown at cm depth below core top on the right side of graph. Note that most of these samples have uni-modal distributions. Core location is shown in Figure 31.

Fig. 45: Grain-size frequency distribution curves of mixed sand and gravel deposit in VC-89. Sample intervals are shown at cm depth below core top on the right side of graph. Note that these samples have bi-modal distributions. Core location is shown in Figure 31.

Fig. 46: Grain-size frequency distribution curves of gravel deposits in VC-23 and VC-24. Sample intervals are shown at cm depth below core top on the right side of graph, except core catcher (cc) at base of core. Note that these samples all have uniformal distributions. Core locations are shown in Figure 31.

Fig. 4-7: Grain-size frequency distribution curves of mixed sand, gravel, and clay in a muddy matrix in VC-50. Sample intervals are shown at cm depth below core top on the right side of graph. Note that these samples all have tri-modal distributions. Core location is shown in Figure 31.

Fig. 48: Grain-size frequency distribution curves of deposits in VC-78 from Monterey Bay shelf. Sample intervals are shown at cm depth below core top on the right side of graph. Fine tails in these curves are artifacts of grain-size calculation method rather than real data. Note that these samples have uni-modal distributions. Core location is shown in Figure 31.

Fig. 49: Map showing 14 location sites where dune samples were collected (dark blue circles) and 13 of 14 locations where beach sand was collected (brown hexagons). Beach sand collected at Julia Pfeiffer Burns State Beach south of Big Sur not shown here. The site is shown as an orange square on the coastline ~ 35 km south of Monterey in Figure 21. Data for base map from Figure 4.

Grain-Size Statistics

Statistical data were calculated for the mean grain size, standard deviation, and skewness. In this section the data are reported and sub-divided into several categories. Statistical data from beach, dune, and river sand samples are compared to detect differences in the three sediment populations. Samples from the canyon axis are also divided into four subsets by water depth: 1) 0 m - 500 m; 2) 500 m - 1,000 m; 3) 1,000 m - 2,000 m; and 4) 2,000 m - 3,884 m. This was done to analyze the changes in clast

composition within the axis of the upper canyon (water depths of 0 m – 2,000 m) and in the axis of the lower canyon (water depths 2,000 m - 3,884 m).

The data from the canyon flank, levee/channel edge, and the shelf were separated and further examined to quantify compositional differences in the cores collected from those locations. The sediment in those cores are also compared to the sediment in the canyon channel. The push cores primarily contained fine-grained sediment and data are reported separately from the canyon vibracore data. The maximum, minimum, median, and standard deviation values of the mean grain-sizes from the samples are grouped by the categories mentioned above (Table 2).

Table 2: Maximum, Minimum, and Median Grain-Sizes

	Mean Grain-Size (ϕ)
Beach Sand Samples n=14	
Maximum Value	3.2
Minimum Value	1.4
Median Value	2.8 ± 0.6
Dune Sand Samples n=14	
Maximum Value	2.9
Minimum Value	2.0
Median Value	2.4 ± 0.3
River Samples n=14	
Maximum Value	3.2
Minimum Value	0.7
Median Value	1.9 ± 0.6
Canyon Axis Samples (0-500 m) n=308	
Maximum Value	5.3
Minimum Value	-0.3
Median Value	2.6 ± 1.1
Canyon Axis Samples (500-1,000 m) n=207	
Maximum Value	4.6
Minimum Value	0.0
Median Value	3.0 ± 1.0
Canyon Axis Samples (1,000-2,000 m) n= 73	
Maximum Value	4.7
Minimum Value	-0.4
Median Value	1.0 ± 1.2
Canyon Axis Samples (2,000-3,884 m) n=168	
Maximum Value	6.0
Minimum Value	-0.4
Median Value	3.0 ± 1.3
Push Core Samples n=61	
Maximum Value	5.9
Minimum Value	1.0
Median Value	3.8 ± 1.0
Levee/ Channel Edge Core Samples n=5	
Maximum Value	7.5
Minimum Value	3.9
Median Value	3.9 ± 1.6
Shelf Core Samples n=27	
Maximum Value	5.6
Minimum Value	0.9
Median Value	3.6 ± 1.1

Table 2 shows that beach sands have a median grain-size of $2.8 \phi \pm 0.6 \phi$ and dune sands have a median grain-size of $2.4 \phi \pm 0.3 \phi$. The sediment samples collected in the canyon axis from 0-500 m have a median grain-size of $2.6 \phi \pm 1.2 \phi$ and samples collected from 500-1,000 m have a median grain-size of $3.0 \phi \pm 1.0 \phi$.

The data also show that the coarsest sediments in the canyon axis occur from 1,000 m to 2,000 m. The median grain-size of the sediments collected from 1,000 m to 2,000 m water depths is $1.0 \phi \pm 1.2 \phi$. In the lower canyon samples collected from 2,000 m to 3,884 m water depths have a median grain-size of $3.0 \phi \pm 1.3 \phi$.

In the upper canyon, sand samples have standard deviation values that range from 4.4ϕ to 1.2ϕ for 0-500 m water depths, 5.2ϕ to 1.2ϕ for 500-1,000 m water depths, and 4.3ϕ to 1.1ϕ for 1,000-2,000 m water depths (Appendix III). In the upper canyon axis, the samples that have standard deviations that plot above 2.5ϕ are outliers. These are from cores containing mixtures of sand, gravel, and mud, or are from very fine sand/coarse silt horizons. From 2,000-3,884 m water depths, sand samples in the lower canyon have standard deviation values that range from 3.9ϕ to 1.2ϕ .

Mean Grain-Size Data from Upper Canyon Vibracores. The median grain-size of samples collected in 13 individual cores in the upper canyon is shown with the median grain-size of beach sand (Fig. 50). The range of mean grain-size values indicate that the samples from 0-1,500 m water depths are fine- to coarse-grained sand. The data also show that the sediment in the vibracores generally display fining upward sequences (Fig. 50). The locations from which the cores were recovered from are shown in Figure 51.

Fig. 50: Graph of twelve grain-size plots of vibracores from Monterey Canyon axis. Sites shown with water depth in the canyon axis on the right side of the graph.

Fig. 51: Location map of the Monterey Canyon axis showing 12-vb core sites from Figure 50. Image data for base map from Figure 4.

Mean Grain Size Versus Standard Deviation. Sorting versus change in grain size of the sub-samples from the Monterey Canyon axis and from onshore cores is compiled from Appendix III and shown in Figure 52. Minimum standard deviation values (maximum sorting) occur in two phi-size ranges: -0.5ϕ to 0ϕ and 1.5ϕ to 3.0ϕ (Fig. 40). Grain size versus standard deviation plots for samples collected down the axis of the canyon are repeated in Figures 53 and 54. The graphs show that the mean grain sizes increase with water depth to 1,500 m in the upper canyon and that mean grain sizes decrease and the standard deviations increase in the lower canyon (Figs. 53 and 54). Locations of the core sampling sites are shown in Figure 55.

Fig. 52: Graph of grain size versus standard deviation plots from onshore and canyon channel cores. Onshore sites are shown on Figures 49 and 55 and canyon channel sites shown in Figure 55.

Fig. 53: Graphs of mean grain size versus standard deviation of canyon channel cores from water depths of 0-500 m (A) and 500-1,000 m (B).

Fig. 54: Graphs of mean grain size versus standard deviation of canyon channel cores from water depths of 1,000-2,000 m (C) and 2,000-3,884 m (D).

Fig. 55: Location map of canyon channel vibracore sites (white circles) and onshore sites (orange squares) selected for grain-size analysis. Image data for base map from Figure 1.

Mean Grain Size Versus Skewness. Another set of statistics that were plotted for the onshore and canyon axis samples was mean grain size versus skewness data (Fig. 56). The statistics were plotted to examine if there were systematic changes in the skewness of the samples. Negatively skewed samples have coarse-grained tails and positively skewed samples have fine-grained tails. The majority of the samples from onshore and the canyon axis plot negatively (coarsely) skewed regardless of mean grain size (Fig. 56). Data are reported from Appendix III.

Fig. 56: Mean grain-size versus skewness plots of canyon channel and onshore samples.

Standard Deviation Versus Skewness. Plots of the standard deviation versus skewness values from beach, dune, and river sand samples show that there is a distinction between the river sand and the beach and dune sand that were analyzed in this study (Fig. 57). Data are reported from Appendix III. The beach and dune sand are interspersed on the graph, and it shows that they are derived from the same population (Fig. 57). The river sands have higher skewness values and standard deviations (they contain more fine-grained material and are more poorly sorted) than the beach and dune sand.

Standard deviation versus grain-size plots are graphed by water depth down the canyon axis and shown in Figures 58 and 59. The graphs include the line separating the beach and dune sand from the river sand to compare with the sand in the canyon axis.

Fig. 58: Skewness versus standard deviation plots from samples in Monterey Canyon collected from water depths of 0–500 m (A) and 500–1,000 m (B). The dotted line is that separating the beach and dune sand from the river sand in Figure 57.

Fig. 59: Skewness versus standard deviation plots from samples in Monterey Canyon collected from water depths of 1,000-2,000 m (C) and 2,000-3,884 m (D). The dotted line is that separating the beach and dune sand from the river sand in Figure 57.

QFL Point Counts

The data from the QFL analysis were grouped into several categories by locations from which they were collected. These include: 1) upper Monterey Canyon (0-2,000 m); 2) lower Monterey Canyon (2,000-3,884 m); 3) three locations on the beach south of Moss Landing Jetty; 4) three locations on the beach north of Moss Landing Jetty; 5) Salinas River watershed; and 6) Pajaro River watershed. The QFL data from this study are reported in Appendix IVc, summarized in Table 3, and plotted in Figure 60. The comparisons between data sets reported here are examined in more detail in the discussion section of this thesis.

Table 3: Maximum, Minimum, and Median QFL Counts

Sample Locations	% Quartz	% Feldspar	% Lithic Fragments
Minimum Value (0-2,000 m sites) n= 16	36	11	35
Maximum Value (0-2,000 m sites)	51	22	46
Median Value (0-2,000 m sites)	43 $\pm$ 4	19 $\pm$ 3	38 $\pm$ 3
Minimum Value (2,000-3,884 m sites) n= 11	28	10	45
Maximum Value (2,000-3,884 m sites)	44	14	60
Median Value (2,000-3,884 m sites)	36 $\pm$ 5	12 $\pm$ 1	51 $\pm$ 5
Minimum Value South of Jetty Beach n= 3	43	15	33
Maximum Value South of Jetty Beach	48	19	42
Median Value South of Jetty Beach	44 $\pm$ 3	18 $\pm$ 2	39 $\pm$ 4
Minimum Value North of Jetty Beach n= 3	40	17	35
Maximum Value North of Jetty Beach	46	24	39
Median Value North of Jetty Beach	41 $\pm$ 3	20 $\pm$ 3	36 $\pm$ 2
Minimum Value Salinas River watershed n= 5	47	17	31
Maximum Value Salinas River watershed	52	22	33
Median Value Salinas River watershed	48 $\pm$ 2	19 $\pm$ 2	32 $\pm$ 1
Minimum Value Pajaro River watershed n= 3	31	14	50
Maximum Value Pajaro River watershed	36	15	54
Median Value Pajaro River watershed	32 $\pm$ 2	14 $\pm$ 0.4	53 $\pm$ 2
Carmel River Beach n= 1	19	40	41

Fig. 60: QFL point count data plots from this study. Sample locations shown in Figures 23 and 24.

Sediment in the upper canyon axis has QFL with a median composition of 43% quartz, 20% feldspar, and 38% lithic clasts (Table 5). Sediment in the lower canyon has a median composition of 36% quartz, 12% feldspar, and 51% lithic clasts (Table 5). The data show that an increase in lithic clasts occurs with depth in the canyon axis. The QFL composition measured within the massive sand layer in VC-16 (693 m water depth, Fig. 31) yielded median QFL values of quartz $42\% \pm 3\%$, feldspar $20\% \pm 1\%$, and lithic clasts $37\% \pm 4\%$ (Appendix IV).

Accessory Mineral Point Counts

Yancey (1968) and Yancey and Lee (1972) indicated that five minerals are primary indicators of sediment provenance in the Monterey Bay region. They are: 1) hornblende; 2) hypersthene; 3) garnet; 4) augite, and 5) glaucophane. The percent composition of the five minerals is shown in four categories in Table 4. The minerals are separated here to help establish their provinces and to identify the change in accessory mineral composition down the canyon axis. Additionally, opaque minerals (e.g. magnetite, ilmenite, and pyrite) are the most abundant accessory minerals on the beach near the Moss Landing Jetty (Appendix Vd). However, the percent of opaque minerals decreases with depth in the canyon axis (Table 4; Appendix Vd). The data are graphed in Figure 61. The sample locations are shown in Figure 26 and the individual point count data are reported by individual sites in Appendix Vc and shown in Figure 62.

Table 4: Opaque and Provenance Accessory Mineral Data

	Opakes	Hornblende/Biotite	Hypersthene	Garnet	Augite	Glaucophane
Carmel River Beach n=1	28%	37%	4%	11%	6%	0%
Beach North of Jetty n=4	45 ± 13%	15 ± 7%	12 ± 6%	1 ± 0.7%	12 ± 1%	2 ± 0.2%
Beach South of Jetty n=3	42 ± 6%	22 ± 6%	4 ± 1%	11 ± 11%	8 ± 1%	0.4 ± 0.2%
Upper Canyon n=18	20 ± 4%	39 ± 4%	15 ± 2%	2 ± 2%	8 ± 2%	2 ± 2%
Lower Canyon n=7	9 ± 3%	45 ± 1%	14 ± 1%	6 ± 1%	7 ± 1%	2 ± 0.4%

Fig. 61: Opaque and provenance accessory minerals graphed from Table 4.

Fig. 62: Accessory minerals in very fine-grained sand in Monterey Canyon axis. Sample locations are shown in Figure 26.

From the shoreline to the lower Monterey Canyon the amount of opaque minerals decreases substantially in sediment samples, whereas the amount of biotite and hornblende increases from the shoreline to the lower canyon (Fig. 61). In general, the ratios of accessory minerals remain almost constant down the canyon axis (Fig. 62). However, three subtle changes in accessory mineral composition within the canyon are suggested by the data. These changes are: 1) dense opaque minerals decrease in the lower canyon; 2) hornblende/biotite increases with depth; and 3) garnet clasts become more numerous in the lower canyon.

Gravel/Cobble Lithologies

The compositions of 1,648 gravel clasts were tabulated from 32 dives (Fig. 29; Appendix VIb) and 3,768 gravel clasts were tabulated from 12 onshore sites (Fig 29; Appendix VIId). The pebble/cobble counts were tabulated from the samples and grouped into the seven categories shown in Table 5 and are reported in Appendix VIc and VIe. The cobble data are shown as clast count totals in the upper half of Table 5, and as percent compositions in the lower half of Table 5. Examples of some of the gravel clasts collected during this study are shown in Figures 63 and 64.

Table 5: Classification of Gravel/Cobble Data by Rock Clast Types

Location	#Granite	# Sandstone	# HG Metamorphic	# Franciscan	# Monterey	# Volcanic	#Chert
<i>Tres Pinos Creek</i>	23	107	18	130	0	30	15
<i>San Benito River</i>	25	65	15	148	0	45	18
<i>Pacheco Creek</i>	20	65	0	165	0	55	12
<i>Pajaro River</i>	28	74	25	138	0	25	22
<i>Salinas River</i>	95	10	85	0	96	15	3
<i>Arroyo Seco River</i>	115	33	88	0	70	0	4
<i>Nacimiento River</i>	153	0	172	0	0	0	0
<i>San Antonio River</i>	180	36	90	0	0	0	0
<i>Carmel River</i>	250	0	15	0	45	0	0
<i>San Lorenzo River</i>	160	36	45	0	73	0	4
<i>Soquel Creek</i>	63	249	0	0	0	0	0
<i>Aptos Creek</i>	45	270	0	0	0	0	0
Location	% Granite	% Sandstone	% HG Metamorphic	% Franciscan	% Monterey	% Volcanic	% Chert
<i>Tres Pinos Creek</i>	7	33	6	40	0	9	5
<i>San Benito River</i>	8	21	5	47	0	14	6
<i>Pacheco Creek</i>	6	21	0	52	0	17	4
<i>Pajaro River</i>	9	24	8	44	0	8	7
<i>Salinas River</i>	31	3	28	0	32	5	1
<i>Arroyo Seco River</i>	37	11	28	0	23	0	1
<i>Nacimiento River</i>	47	0	53	0	0	0	0
<i>San Antonio River</i>	59	12	29	0	0	0	0
<i>Carmel River</i>	81	0	5	0	15	0	0
<i>San Lorenzo River</i>	50	11	14	0	23	0	1
<i>Soquel Creek</i>	20	80	0	0	0	0	0
<i>Aptos Creek</i>	14	66	0	0	0	0	0

Fig. 63: Photograph of pebbles and cobbles from V-1874 VC-23 (ruler scale in cm). Core location is shown in Figure 31.

Fig. 64: Photograph of pebbles and cobbles from Tres Pinos Creek (ruler scale in cm). Core location is shown north of Hollister in Figure 29.

DISCUSSION AND SUMMARY OF DATA

An important component of geologic observations and analyses is the synthesis of observations from the field with the data developed in the laboratory. In this section, observations from ROV dives in Monterey Canyon, field observations onshore, and visual inspection of the sediment cores are combined with the various analytical data sets to develop several hypotheses concerning sedimentation in Monterey Canyon. The discussion of those hypotheses in this section will attempt to resolve unanswered questions that are the primary goals of this thesis: 1) to identify what sediment is in Monterey Canyon; 2) to determine the provenance of the sediment; 3) to identify the changes in sediment composition and depositional settings in the canyon; and 4) to determine if Monterey Canyon is an active transport conduit.

Facies Classifications

Sediment collected in vibracores from different depositional settings indicate that four distinct facies occur in the Monterey Canyon system.

1) Fine sediment facies: This sediment is composed of suspended fine particles derived from the overlying water column. Soquel Canyon cores are placed in this group because they contain only fine silt and clay. Thus, Soquel Canyon shows no sign of recent transport of coarse-grained sediment down its channel axis, and the sediment in Soquel Canyon is primarily composed of hemi-pelagic, fine-grained particulates that have settled out of suspension.

2) Shelf facies: Three depositional environments occur on the shelf near Monterey Canyon. These are: 1) inner shelf (< 50 m water depths); 2) mid-shelf (50 m to ~100 m water depths); and shelf edge (~ 100 m). Cores were collected in the inner shelf and the shelf break for this study. Inner shelf cores contain muddy thin- to massive-bedded silt and very fine-grained sand. The cores collected near the shelf break contain fine-grained muddy silt and silty clay. Additionally, some of the cores contain thin shell coquinas. Near the shelf break, sediment may be slightly re-worked fine-grained relict deposits that were exposed near the shelf edge (Paull, personal communication, 2003). No cores were collected in the mid-shelf area for this study, but the United States Geological Survey collected a series of gravity cores in 1995 and 1997 on the northern Monterey Bay shelf (Edwards, 2002). The sediment collected in the gravity cores indicates that a mid-shelf mud belt occurs on the continental shelf north of Monterey Canyon (Edwards, 2002; Eittreim et al., 2002b).

3) Overbank levee/channel edge facies: These deposits contain thin to thick, interlayered silt and clay. This sediment was transported onto the levees or to the outer edge of the channel during passage of sediment-gravity flows through the channel axis.

4) Canyon channel facies: These are high-energy deposits representing both bed load and suspended load. Fine- to medium-grained sand is the most abundant sediment in the cores, although most of the cores in the canyon channel also contain pebbles and cobbles.

The canyon channel facies are further subdivided into five distinct sub-facies:

A) Massively bedded sand sub-facies: Massively bedded, fine- to coarse-grained,

moderately- to poorly-sorted sands. The deposits have uni-modal normal clast frequency distribution curves.

B) Mixed sand and gravel sub-facies: Deposits are thin to massively bedded, fine- to coarse-grained sands interspersed with gravel clasts or contain gravel layers. The deposits have bi-modal normal clast frequency distribution curves, with coarse- and medium-grained tails.

C) Mixed sand and mud/clay balls sub-facies: These deposits represent the sediment entrained from the semi-lithified to lithified mud in the canyon walls and floor into the body of a sediment-gravity flow during transit down the canyon axis. The deposits have bi-modal clast-frequency distribution curves.

D) Gravel and pebble conglomerate sub-facies: These are high-energy deposits that contain granule- to cobble-size clasts and have low sand content (<5%). The deposits have coarse-tailed uni-modal normal clast-frequency distribution curves.

E) Mixed sand, mud/clay balls, and gravel in a muddy matrix sub-facies: These deposits may contain a mixture of debris-flow and liquefied-flow deposits that entrained a variety of available sediment from the channel axis and flanks. The deposits have tri-modal or multi-modal clast-frequency distribution curves, with coarse-, medium-, and fine-grained tails.

Grain-Size Analysis

Grain-size analysis shows that the beach and dune sands are derived from the same population. The standard deviation versus skewness data show that sand from fluvial watersheds can be differentiated from the beach and dune sand. Grain-size analyses of the samples in this study (Fig. 57) agree with the findings of Friedman (1967; Fig. 22). Friedman's (1967) sample data showed that the plots are the result of the different sorting mechanics and transport systems in the two depositional environments (Fig. 22). Beach and dune sand are well sorted by oscillatory wave motion along the shoreline and by aeolian sorting, which is especially characteristic of the Monterey Bay area (Best and Griggs, 1991). The waves in the breaker zone sort coarse-grained material by saltation and transport it toward the shoreline. Fine sediment is winnowed out by suspension and transported toward the shelf (Friedman, 1967).

In contrast, river sands are deposited by unidirectional flow, (i.e., the fine-grained suspended particles travel parallel to larger sediment clasts which are moved by saltation and bed load). Three types of clasts are typical of river deposits: cobbles and gravel deposited by rolling and sliding, sand deposited by saltation and suspension, and fine particles transported by suspension and deposited into inter-clast void spaces.

Grain-size data also verified visual observations that sand is the most abundant coarse sediment in the axis of the canyon. Grain-size analysis indicates that the bulk of clastic material in the upper Monterey Canyon is composed of moderately sorted, fine- to medium-grained sand (Appendix III). The data plotted in Figures 53 and 54 indicate that

the range of median-grain sizes of clastic material in the canyon axis is composed of sand similar to that of sand found on the beaches along Monterey Bay (Table 2).

The data from Table 2 and Figures 53 and 54 also show that the mean grain size of the sediment in the Monterey Canyon axis increases from shallow water depths to water depths of ~ 1,500 m. The standard deviation versus skewness data indicates that in the lower Monterey Canyon axis sediment deposits become finer grained and more poorly sorted down the canyon (Figs. 58 and 59).

Shelf Cores

Shelf sediment consists of very fine-grained sand, silt, and clay. The standard deviation versus skewness plots of sediment in the shelf cores show that the samples plot both above and below the line separating beach and river sand (Fig. 65). This suggests that the clastic material being deposited on the shelf is not beach sand. Shelf sediment (Fig. 65) is derived from a combination of sources including: 1) fine-grained shoreline deposits (Best and Griggs, 1991; Eittreim, et al., 2002b); 2) suspended fine silt and clay moved to the shelf by wave and current processes (Friedman, 1967; Griggs and Hein, 1980; Edwards, 2002); and 3) fluvial input during winter flood events (Griggs and Hein, 1980; Eittreim et al., 2002b).

Fig. 65: Standard deviation versus skewness plots of samples from the Monterey Bay shelf cores.

Push Cores

Push cores were used to supplement data from areas where no vibracores were collected, or to provide material to make grain mounts for accessory mineral analysis. The push cores contain finer sediment than the majority of the vibracore samples collected in the canyon axis (Table 4). The push cores from the floor of Monterey Canyon are typically covered with a thin veneer of organic rich mud (~ 5-12 cm thick) representing the uppermost depositional sequences on the bottom of the canyon. These are the most recent deposits that are either the last material to settle out from sediment-gravity flows, or are organic particulates that have settled during normal conditions.

QFL Data

Three samples of Tertiary sands were collected from onshore sites in Pacific Grove, Toro Road, and Scotts Valley (Fig 66). They were collected from locations where sand had previously been sampled and analyzed by Stakes et al. (1999). The QFL ratios from the three sites were compared with the QFL data from Stakes et al. (1999) to see if the plots were similar. This comparison was used as tool to detect whether or not the data from this study could be compared with other data from Stakes et al. (1999). The three data points from this study (Subaerial Tertiary sand Fig. 59) plot in the same region on the QFL diagram as the Tsm petrofacies 2 field (Fig. 67) of Stakes et al. (1999). Tsm 2 petrofacies is the Miocene Santa Margarita Formation. The Santa Margarita Formation is composed of quartz-rich, arkosic, shallow-marine sand (Clark, 1981). A brief description of the sediment and geochronology of the Santa Margarita Formation is shown on the stratigraphic column in Figure 12.

The analysis of QFL compositions had four purposes. These are to: 1) distinguish the differences in composition between modern sand and paleo sand deposits in Monterey Canyon; 2) determine whether or not modern sand in Monterey Canyon has been eroded and re-worked from the canyon walls; 3) establish the provenance of sand in Monterey Canyon; and 4) determine if there are differences in sand composition in the upper and lower canyon.

Fig. 66: Location of three Tertiary sands selected for QFL analysis. Image data for base map from Figure 1.

Fig. 67: QFL diagram modified from Stakes et al. (1999) showing their three petrofacies classifications: 1) upper Oligocene Vaqueros sands [Tv petrofacies (1)], 2) upper Miocene Santa Margarita sands [Tsm petrofacies (2)], and 3) pre- and post-Monterey Formation sands from Monterey Canyon [Tpm petrofacies (3)]. Data from Stakes et al. (1999) except red circles in Tv petrofacies (1) from Taylor (1988) and reported by Stakes et al. (1999).

QFL Ratios from the Canyon Flanks

Two Tertiary deposits crop out in the upper Monterey Canyon flanks: the Miocene Santa Margarita Sandstone and the Pliocene Purisima Formation (Greene, 1977; Stakes et al., 1999; Greene et al., 2002). Stakes et al. (1999) plotted QFL data from the Tertiary sandstone, shown as Tpm petrofacies in Figure 67, that they collected from the Monterey

Canyon walls. Additionally, Gavigan (1984) plotted the QFL composition of the Pliocene/Pleistocene Purisima Formation, including two samples collected from the flanks of the canyon during Greene's (1977) study. Gavigan's data are shown in Figure 68.

Fig. 68: QFL plots of Purisima Formation samples from Gavigan (1984).

The data from the QFL plots of the samples from this study (Fig. 60) with the plots of Stakes et al. (Fig. 67) and Gavigan (Fig. 68) shows that the modern sands in Monterey Canyon axis are not solely derived from the Santa Margarita Sandstone, or the Purisima Formation, on the flanks of the canyon (Figs. 67 and 68). Undoubtedly some Tertiary clasts on the floor of the canyon are from canyon walls. However, it is not adequate

quantities significant to substantially alter the composition of sand in the canyon. The Santa Margarita Formation and Purisima Formation onshore do contribute detrital sediment to the overall sediment budget for Monterey Canyon, but the QFL data from Monterey Canyon do not plot between the data clusters of the two Tertiary deposits shown in Figures 67 and 68. This indicates that the sand in the canyon is not primarily composed of Tertiary sand. The QFL data in Figure 60 show that the sand in the Monterey Canyon axis is similar in composition to sand on the beach and that the most likely source of sand on the canyon floor is littoral input of beach sand from the Monterey Bay shoreline. No evidence was found indicating that substantial quantities of the sand on the canyon floor is supplied from the flanks of the canyon, from the shelf overlying the canyon, or from mass-wasting events (Paull et al., 2003a).

Fluvial and Shoreline QFL Plots

As shown in Figure 60, the samples from the Pajaro River watershed contain a higher percentage of lithic clasts (median 53%) than the Salinas River watershed samples (median 32%). Detrital sediment in the Pajaro River watershed is derived primarily from metamorphic Franciscan Complex rocks in the Diablo Range, whereas the most active tributaries in Salinas River watershed are entirely within the Salinian Block. Higher concentrations of lithic fragments would be anticipated in the Pajaro River watershed due to the different source rocks in the Diablo Range.

After sediment reaches the shoreline, littoral drift moves the sand toward Monterey Canyon. The QFL plots from Figure 60 show that the beach samples lie between the

QFL plots of the two watersheds, indicating that the sediment population derived from the two fluvial sources become mixed near the canyon head (Fig. 60).

Canyon QFL Plots

In the upper canyon (water depths shallower than ~ 1500 m), the QFL plots of the sand in the canyon floor group near the QFL plots of the beach sand. However, in the lower canyon the sand becomes more enriched in lithic clasts. Fe-enriched micas, primarily biotite, are dominant among the lithic clasts in the sand, whereas muscovite is not present in any substantial quantities. Flat mica platelets and platy accessory mineral fragments are more numerous in the lower canyon because they are more easily entrained and remobilized in suspension from unconsolidated deposits on the canyon floor and can be transported farther down the canyon axis than other more dense, oblate minerals. Although micas are difficult to remobilize from consolidated clay, they may be removed from coarse-grained deposits by successive sediment-gravity flows that pass through the canyon axis.

Accessory Minerals

The accessory mineral data show that opaque minerals are the most numerous accessory minerals along the Monterey Bay shoreline near the Monterey Canyon head. Garnet and hornblende populations are highest on the beaches south of Moss Landing Harbor, whereas hypersthene, glaucophane, and augite populations are highest north of the harbor mouth (Fig. 61).

The accessory mineral composition is almost constant down the canyon axis (Fig.62) with three slight variations: 1) opaque metallic minerals, although predominant on the shoreline, decrease in composition with depth in the canyon. These are dense metallic minerals that are probably entrained and deposited first by sediment-gravity flows down the canyon; 2) hornblende and biotite increase with depth. Biotite to hornblende ratios increase from ~ 1:3 near the head of the canyon to ~ 4:1 in the lower canyon. This supports the QFL data that show that there is an increase in lithic components in the lower canyon axis; and 3) the amount of garnet composition in the lower Monterey Canyon increases below 1,500 m water. Additional garnets are probably delivered to Monterey Canyon from the Carmel Canyon system. Carmel Canyon may also deliver additional hornblende and biotite to lower Monterey Canyon. The changes in opaque minerals and hornblende/biotite in samples from the shoreline to the lower canyon are shown in Figures 68 and 69.

Fig. 69: Accessory minerals from the beach south of Moss Landing Jetty (field of view 3 mm wide). Location of sample site is shown in Figure 71.

Fig. 70: Accessory minerals from T-217 PC-21 at 2,810 m depth (field of view 3 mm wide). Location of core shown in Figure 71.

Fig. 71: Location map of sites where the samples T217 PC-12 and the Beach South of Moss Landing Jetty were collected for analysis of accessory mineral composition. Image data for base map from Figure 1.

Data from the accessory mineral study, combined with the findings of Yancey and Lee (1972), indicate that both littoral drift and fluvial input contribute sediment to the Monterey Canyon system. Augite from the northern Santa Cruz Mountains is delivered to Monterey Canyon via the southward littoral drift. Garnet is supplied to Monterey Bay from the Salinas River and transported to the head Monterey Canyon near Moss Landing harbor mouth by northward littoral drift of sediment. Glaucophane, lawsonite, and serpentine are supplied to the canyon via the Pajaro River watershed.

Garnet, which is primarily delivered to Monterey Bay from the Salinas River system, was found on the beach both north and south of the Moss Landing Jetty. Augite and glaucophane (delivered from fluvial systems north of the canyon head) also occurs on the beach both south and north of the jetty. This suggests that some of the sand that moves north or south bypasses the canyon head, at least temporarily. Supplemental garnet, and perhaps additional hornblende and biotite, are provided to the lower Monterey Canyon via the Carmel Canyon.

Gravel/Cobble Analysis

One method of comparing the composition of cobbles in the canyon to cobbles in the fluvial watersheds was to plot the data from Table 5 on two ternary diagrams (Fig. 72). Lithologies are divided into three categories for each diagram (Figure 72). The categories on left diagram (QGV) in Figure 72 compares: 1) Sandstone, diatomite, and chert; 2) Granite/granodiorite and high-grade metamorphic cobbles; and 3) Volcanic cobbles, the primary lithologies of the Salinian Block.

The Q(C+F) I diagram on the right side of Figure 72 compares: 1) Sandstone, and diatomite; 2) Chert and low-grade metamorphic rock; and 3) Volcanic and granitic rocks. This diagram compares the composition of Franciscan and volcanic cobbles (lithologies primarily derived from the Franciscan Complex, Great Valley Group, and Quien Sabe volcanic rocks in the Diablo Range) with sedimentary cobbles. In Figure 72, the cobble plots are grouped by: 1) Salinas River watersheds; 2) Pajaro River

watershed; 3) Santa Cruz watersheds (San Lorenzo River, Soquel Creek, and Aptos Creek); and 4) Monterey Canyon cobbles (Fig. 29).

Fig. 72: QGV and Q(C+F)I ternary diagrams for onshore and offshore cobbles.

Cobble compositions in the canyon plot between the fluvial groups, indicating that the watersheds have contributed cobbles to the canyon. However, the canyon plots are not located in areas of the diagrams that would reflect a composition intermediate for all the streams in the study. Three factors may affect the plots: 1) the streams did not contribute equal amounts of cobbles to Monterey Canyon during deposition; 2) the samples collected in this study do not represent the true distribution of cobble composition in the canyon; and 3) the streams are not the sole source of cobbles in the canyon.

There is little evidence to suggest recent input of cobbles to the canyon from the fluvial systems. There are no large cobble deposits along the shoreline or evidence of cobble-size material in lags or trails from the Salinas or Pajaro River mouths to the canyon head. Additionally, cobbles do not occur in significant quantities in the lower sections of the rivers, or near their mouths on the Monterey Bay coast.

There are no significant quantities of very angular cobbles in Monterey Canyon, an indicator of rock eroded from solid outcrops, such as granite, on the canyon flanks. The majority of large cobbles collected or observed in Monterey Canyon axis are very well rounded. Cobbles were photographed during *Ventana* dive 1733 (Fig. 73), cobble conglomerates were observed cropping out above the canyon floor during *Ventana* dive 2033 on March 10, 2003 by the author (Fig. 74), and cobbles were most recently seen on the canyon floor near the head of the canyon during MBARI ROV operations (Paull, personal communication, 2003). Cobbles might be easily remobilized and incorporated into sediment-gravity flows from conglomerate deposits just above the canyon floor or from the cobbles observed on the canyon floor.

Fig. 73: Well-rounded cobbles on the floor of Monterey Canyon axis (see Figure 74 for location; photo modified from Paull et al., 2003a, MBARI © 2003).

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Fig. 75: Pebble and cobbles found in V-2127-VC-83. Photo shows sediment interval from 60 to 84 cm below core top from left to right on the photograph. Location is shown in Figure 73.

There are other areas on the shelf that may supply cobbles to Monterey Canyon. Malone (1970) reported gravel in samples collected from the continental shelf in Monterey Bay, as did Greene (1977), who described relic beach deposits located along the shelf break at the top of Monterey Canyon. Coarse-grained sand and gravel on the outer shelf above Monterey Canyon were also mapped by Greene (1977; 1990), Wagner et al. (2001), and Eittreim et al. (2002a). However, in this study there is no evidence that any coarse-grained material was supplied to the canyon axis from the flanks or outer shelf. Therefore, the source of gravels in the canyon axis remains inconclusive.

Structural Control of Sediment-Gravity Flows

The meanders of the canyon axis may act as structural impediments to sediment transport to the lower canyon, and may also control deposition of sediment from gravity flows as they move through the canyon (Greene, 1990; Greene et al., 2002). Greene et al.

(2002) reported that several slump-like features appear to have dammed Monterey Canyon axis in the past, diverting or damming the channel thalweg. Near ~ 1,300 m water depths the canyon channel narrows to a 45-m-wide constriction between sheer granodiorite walls (Fig. 76). The constriction passes along the side of the Navy Slump Block of Greene et al. (2002; Fig. 76), and may be a primary factor that restricts or controls sediment transport (Greene et al., 2002).

Fig. 76: Map of constriction in Monterey Canyon and the vibracore sites collected near it. Red area shows the canyon channel floor. Image data from Figure 4.

The coarsest mean grain sizes occur from 1,000–1,500 m water depths near the canyon constriction (Table 2). If the constriction is partially damming sediment, or restricting sediment transport, it may explain why the coarsest sediment is observed in that segment of the canyon. Examples of the coarse-grained sub-facies that are deposited between 1,000 and 1,500 m water depths in the canyon axis are shown in Figure 77.

Greene et al. (2002) and Paull et al. (2003a) also reported that sediment that are supplied to the canyon head is accumulating in the upper canyon and is not currently being carried in substantial amounts to the Monterey Fan. They believed that the large events that supply sediment to the fan occur over periods ranging from 10^3 to 10^5 years (Paull et al., 2003a).

Lower Canyon Cores

Vibracore photos and descriptions show that upper Monterey Canyon (water depths greater than 2,000 m) contains thicker deposits of coarse-grained sediment than the lower Monterey Canyon. In the lower canyon, very few large cobbles were seen on the canyon floor during ROV dives. However, some pebbles and cobbles were collected in cores from the lower canyon. Images of the vibracores collected in the lower canyon are shown in Figures 78 and 79 and their locations shown in Figure 80.

Fig. 77: Photographs of coarse-grained deposits in vibracores collected near the 1,300-m-constriction of Monterey Canyon.

Fig. 78: Coarse sand and pebbles in T-388-VC-11 (0-38 cm interval) from water depth of 3,163 m in lower Monterey Canyon. Location of core site shown in Figure 80.

Fig. 79: Cobbles and pebbles near the bottom of T-405-VC-41 (0-34 cm interval) from water depth of 3,448 m in lower Monterey Canyon. Location of core site shown in Figure 80.

A change in the composition of the sediment in the canyon axis occurs below ~ 1,500 m in the canyon. The thickness of coarse-grained sediment and median-grain sizes of the sediment decreases with depth in the lower canyon axis, verified both by observation (Figs. 81 and 82) and grain-size analysis (Table 2; Appendix III). Additionally, there is an increase in the number of mud layers and organic-rich clay layers in the vibracores from the lower canyon axis. The layers of mud and organic-rich clay suggest quiescent periods when sedimentation is dominated by particles that settle out of suspension from the overlying water column. This suggests that there are fewer sediment- gravity-flow events and longer time intervals between the flows in the lower

Monterey Canyon than in the highly active upper canyon. This agrees with the findings of Greene et al. (2002) and Paull et al. (2003a).

Fig. 80: Map of the lower canyon vibracore sites T-388-VC-11 (3,163 m) and T-405 VC-41 (3,884 m). Image data for base map from Figure 1.

Fig. 81: Vibracores from the upper canyon. Note the coarse-grained sediment in all cores and firm mud (clay) balls in cores VC-68 and VC-92, locations shown in Figure 83.

Fig. 82: Vibracores from the lower canyon. Note thin beds of coarse sediment and multiple semi-firm clay layers compared to upper canyon cores. Locations are shown in Figure 83.

Fig. 83: Location map of eight vibracore sites from Figures 81 and 82 in the upper and lower Monterey Canyon. Image data for base map from Figure 1.

The lower Monterey Canyon channel widens below 2,000 m and the channel gradient decreases (Greene et al., 2002; Paull et al., 2003a). Cobbles may be more difficult to entrain in sediment-gravity flows nearer a proximal fan/distal canyon area because of decreased energy or the reduction in the amount of coarse clastic material from the upper canyon.

The observations indicate that upper Monterey Canyon is very active and sediment transport through the canyon channel occurs frequently. The flanks appear to be

accumulating sediment from suspension, but the depositional rates are very low compared to the canyon floor. The flanks do contribute sediment to the channel during periodic mass-wasting events (slumps) and during sediment-gravity-flow events. In the upper canyon, the mixed muddy slurry deposits in core VC-94 have the appearance of slump deposits. Small to large mud/clay rip-ups or balls are periodically stripped off the canyon walls and floor by sediment-gravity flows and incorporated into sediment deposits in the canyon channel axis.

A change in sedimentary processes occurs in lower Monterey Canyon, with the transition occurring down channel of the canyon constriction/Navy Slump Block of Greene et al. (2002), below the lower leg of the San Gregorio Meander of Greene et al. (2002; Fig. 76). The thicknesses of interlayered coarse-grained deposits and organic-rich clay below 2,000 m water depths in the lower Monterey Canyon axis show that sediment-gravity flows have lower energies and occur less frequently than in the upper Monterey Canyon axis. The thicker layers of organic-rich clay also indicate longer periods of quiescence between sediment-gravity-flow events in lower Monterey Canyon. Additionally, Greene et al. (2002) believed that mass wasting might be a primary factor of sedimentation in Monterey Canyon, occasionally contributing large sediment pulses to the Monterey Fan with periodicities of perhaps thousands of years.

CONCLUSIONS

This study involves the most comprehensive collection of coarse-grained sediment yet retrieved in a submarine canyon. The observations recorded during the course of this study and the data reported in this thesis show that the upper Monterey Canyon is an active sediment conduit, with frequent sediment transport events occurring in the upper canyon channel.

The grain-size data, QFL analysis, and accessory mineral data from the sediment samples indicate that modern coarse sediment arrives in Monterey Bay from onshore watersheds. The basement rocks of the Salinian Block are the predominant source of lithic arenite in Monterey Canyon, whereas the Diablo Range is the primary source of Franciscan-type clasts that are supplied from the Pajaro River watershed.

Grain-size data indicate that the beach and dune sand along Monterey Bay are derived from the same population and are the primary source of clastic material transported to Monterey Canyon. Apparently sediment is transported by littoral drift along the shoreline of Monterey Bay to the head of Monterey Canyon where it enters a transport conduit system that eventually delivers it from the canyon head to the abyssal Monterey Fan.

No evidence indicates that large quantities of sand are presently being supplied to the canyon axis from the continental shelf or from the flanks of Monterey Canyon. However, the flanks do contribute some fine-grained sediment to the canyon channel during periodic mass-wasting events (slumps) or as small (~1 cm) to large (> 10 cm)

mud/clay rip-ups or balls stripped from the canyon walls or floor by sediment-gravity flows.

Grain-size data show that the vibracores collected between 1,200 m and 1,500 m water depths contain the coarsest-grained clasts sampled in the canyon, implying that coarse-grained sediment is probably accumulating, or its transport is being restricted, in the more sinuous or meandering parts of the upper Monterey Canyon.

Below ~ 2,000 m water depths in the canyon axis, decreased thickness of sand layers and increased thickness of clay layers were detected in cores collected in the lower canyon. This suggests that a change in sedimentary processes occurs from the upper to lower Monterey Canyon. Sediment-gravity flows in the lower Monterey Canyon axis occur less frequently than in the upper canyon and are probably less energetic.

The development and use of vibracoring systems on the ROV's at MBARI was the critical component of this project, because it allowed sites to be selected within the Monterey Canyon channel axis where GPS navigation systems, ROV sonar, and high-resolution cameras could be combined to precisely pin-point coring targets. High-resolution cameras onboard the ROV's also allowed direct *in situ* observations to characterize potential target sites and adjacent outcrops prior to coring, adding a dimensionality to sea floor sampling that was not previously possible.

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APPENDIX I: THESIS SAMPLE LOCATIONS

Appendix Ia: Monterey Canyon Vibracore Sites

Dive and Core	Date	Time (GMT)	Depth (m)	Longitude	Latitude	Length (cm)
V-1708 VC-1	1/27/2000	18:20	441	121.88982	36.79657	70
V-1711 VC-2	1/27/2000	21:48	425	121.88201	36.79544	62
V-1729 VC-3	3/20/2000	17:35	383	121.88778	36.79050	214
V-1730 VC-4	3/20/2000	19:32	444	121.89059	36.79552	85
V-1739 VC-5	4/6/2000	17:50	429	121.88326	36.79572	52
V-1741 VC-6	4/6/2000	19:36	424	121.88366	36.79538	45
V-1742 VC-7	4/6/2000	21:00	375	121.88494	36.79432	187
V-1743 VC-8	4/6/2000	22:16	412	121.88441	36.79504	150
V-1744 VC-9	4/7/2000	16:33	427	121.88271	36.79581	94
V-1745 VC-10	4/7/2000	17:08	404	121.88206	36.79635	160
V-1746 VC-11	4/7/2000	18:31	423	121.88266	36.79620	96
V-1747 VC-12	4/7/2000	19:55	349	121.88024	36.79797	192
V-1848 VC-13	10/19/2000	15:55	518	121.90429	36.78997	60
V-1849 VC-14	10/20/2000	16:03	466	121.90131	36.78972	195
V-1850 VC-15	10/20/2000	19:45	1,169	122.02708	36.75633	126
V-1851 VC-16	10/20/2000	21:32	693	121.93409	36.78263	219
V-1854 VC-17	10/23/2000	19:32	692	121.93355	36.78285	20
V-1869 VC-18	11/17/2000	16:41	291	121.84579	36.79397	86
V-1870 VC-19	11/17/2000	19:10	690	121.93368	36.78436	180
V-1871 VC-20	11/17/2000	20:49	700	121.93334	36.78211	120
V-1872 VC-21	11/17/2000	22:34	519	121.90305	36.79083	44
V-1873 VC-22	11/20/2000	16:12	292	121.84618	36.79316	92
V-1874 VC-23	11/20/2000	18:48	1,159	122.03964	36.76075	64
V-1875 VC-24	11/20/2000	21:01	1,165	122.03732	36.76145	48
V-1876 VC-26	11/21/2000	17:15	488	121.90473	36.78961	125
V-1877 VC-27	11/21/2000	19:18	692	121.93453	36.78263	150
V-1878 VC-28	11/21/2000	21:03	296	121.84601	36.79358	65
V-1898 VC-29	1/26/2001	17:03	237	121.84576	36.79672	242
V-1899 VC-30	1/26/2001	19:06	677	121.93748	36.78287	162
V-1900 VC-31	1/26/2001	20:32	443	121.89063	36.79615	173
V-1901 VC-32	1/29/2001	20:55	1,126	122.03998	36.76145	56
V-1902 VC-33	1/29/2001	23:16	284	121.84554	36.79431	176
V-1903 VC-34	1/30/2001	19:35	1,553	122.12018	36.68117	148
V-1905 VC-35	1/30/2001	23:15	201	121.82188	36.79632	165
V-1906 VC-36	1/30/2001	23:58	202	121.82204	36.79646	146
V-1929 VC-37	3/21/2001	18:13	526	121.90321	36.78926	119
V-1930 VC-38	3/21/2001	19:48	238	121.88275	36.80223	214
V-1931 VC-39	3/21/2001	20:36	85	121.88346	36.80824	89
V-1932 VC-40	3/21/2001	21:22	113	121.87722	36.78144	165
V-1933 VC-41	3/21/2001	22:14	328	121.85600	36.80059	92
V-1934 VC-42	3/21/2001	23:08	316	121.88081	36.78874	184
V-1935 VC-43	3/22/2001	16:36	489	121.90124	36.79773	211
V-1936 VC-44	3/22/2001	19:17	89	121.94125	36.81007	19
V-1937 VC-45	3/22/2001	20:00	209	121.93801	36.80082	62
V-1938 VC-46	3/22/2001	21:02	346	121.93529	36.79175	182
V-1939 VC-47	3/22/2001	22:03	497	121.93157	36.77648	105
V-1940 VC-48	3/22/2001	23:13	355	121.93115	36.76910	168
V-1941 VC-49	3/23/2001	16:00	82	121.89122	36.81297	76
V-1942 VC-50	3/23/2001	17:20	552	121.90426	36.78040	144
V-1943 VC-51	3/23/2001	18:22	100	121.92665	36.75532	54
V-1944 VC-52	3/23/2001	19:55	533	121.90311	36.78531	240
V-1945 VC-53	3/23/2001	22:03	207	121.87898	36.78540	126
V-1946 VC-54	3/23/2001	22:40	95	121.87356	36.77703	124
V-1947 VC-55	3/23/2001	23:32	86	121.79857	36.80521	216
V-1974 VC-56	5/9/2001	15:53	156	121.83961	36.80917	243
V-1975 VC-57	5/9/2001	18:19	1,008	122.01294	36.78063	172
V-1976 VC-58	5/9/2001	20:43	610	121.99274	36.80569	228
V-1977 VC-59	5/9/2001	22:28	381	121.86583	36.79529	76
V-1978 VC-60	5/10/2001	15:55	478	121.98757	36.82233	183

Appendix Ia: Monterey Canyon Vibracore Sites (cont.)

Dive and Core	Date	Time (GMT)	Depth (m)	Longitude	Latitude	Length (cm)
V-1979 VC-61	5/10/2001	17:23	413	121.97564	36.82794	248
V-1980 VC-62	5/10/2001	18:22	330	121.96849	36.83695	180
V-1981 VC-63	5/10/2001	19:13	217	121.96209	36.85170	252
V-1985 VC-65	5/11/2001	14:51	84	121.83103	36.78210	104
V-1986 VC-66	5/11/2001	15:34	226	121.82752	36.78957	97
V-1987 VC-67	5/11/2001	17:41	887	121.98614	36.76423	54
V-1988 VC-68	5/11/2001	19:30	802	121.96289	36.77221	102
V-1989 VC-69	5/11/2001	21:13	632	121.91731	36.77917	120
V-2120 VC-76	2/26/2002	10:18	1,356	122.01751	36.72836	113
V-2121 VC-77	2/26/2002	12:51	1,392	122.01529	36.72516	120
V-2122 VC-78	2/26/2002	15:27	19	121.80728	36.78852	181
V-2123 VC-79	2/27/2002	10:22	1,466	122.01624	36.71038	67
V-2124 VC-80	2/27/2002	13:07	1,297	122.01720	36.73243	178
V-2125 VC-81	2/27/2002	15:32	15	121.80564	36.79371	235
V-2126 VC-82	2/28/2002	16:37	1,054	122.02781	36.78117	57
V-2127 VC-83	2/28/2002	12:01	19	121.80322	36.81363	86
V-2128 VC-84	2/28/2002	12:37	19	121.81011	36.81993	92
V-2129 VC-85	2/28/2002	13:45	151	121.81072	36.80124	57
V-2130 VC-86	2/28/2002	14:34	150	121.81040	36.80134	197
V-2131 VC-87	2/28/2002	15:10	135	121.81114	36.80168	239
V-2132 VC-88	2/28/2002	15:49	31	121.81403	36.79051	235
V-2174 VC-89	6/5/2002	20:28	288	121.84478	36.79278	105
V-2175 VC-90	6/5/2002	22:10	537	121.90353	36.78441	70
V-2176 VC-91	6/6/2002	15:48	531	121.90254	36.78414	168
V-2177 VC-92	6/6/2002	17:35	517	121.90302	36.78450	123
V-2178 VC-93	6/6/2002	19:34	524	121.90299	36.79014	104
V-2179 VC-94	6/6/2002	21:16	534	121.90214	36.78348	227
T-372 VC-2	11/5/2001	16:44	1,784	122.07771	36.70104	42
T-372 VC-3	11/5/2001	16:44	1,784	122.07771	36.70104	82
T-373 VC-1	11/6/2001	18:45	383	121.73371	36.18296	70
T-374 VC-5	11/6/2001	20:54	375	121.73302	36.18290	78
T-375 VC-6	11/7/2001	1:19	342	121.71915	36.16957	34
T-377 VC-8	11/8/2001	15:32	1,044	122.45539	36.93715	84
T-377 VC-9	11/8/2001	15:47	1,054	122.45564	36.93744	82
T-377 VC-11	11/8/2001	16:42	1,064	122.45591	36.93773	81
T-378 VC-13	11/9/2001	0:14	748	122.43403	36.96998	93
T-378 VC-14	11/9/2001	0:53	749	122.43435	36.96999	98
T-378 VC-16	11/9/2001	1:24	751	122.43464	36.97031	98
T-378 VC-15	11/9/2001	2:48	549	122.44011	36.97134	93
T-379 VC-7	11/9/2001	15:45	800	122.38607	36.94450	90
T-379 VC-8	11/9/2001	15:59	784	122.38524	36.94410	43
T-379 VC-16	11/9/2001	17:49	810	122.38744	36.94444	62
T-388 VC-12	12/13/2001	3:02	3,130	122.62510	36.49925	70
T-388 VC-13	12/13/2001	3:27	3,157	122.62549	36.49955	82
T-388 VC-14	12/13/2001	4:38	3,159	122.62478	36.49825	88
T-388 VC-15	12/13/2001	5:11	3,160	122.62487	36.49650	84
T-388 VC-16	12/13/2001	5:38	3,162	122.62250	36.49643	77
T-388 VC-21	12/13/2001	7:47	3,172	122.62059	36.49664	28
T-388 VC-22	12/13/2001	8:15	3,172	122.61597	36.49392	50
T-388 VC-8	12/13/2001	9:54	3,167	122.61197	36.49392	32
T-388 VC-9	12/13/2001	10:21	3,166	122.61197	36.49392	26
T-388 VC-10	12/13/2001	10:45	3,164	122.61206	36.49390	83
T-388 VC-11	12/13/2001	11:05	3,163	122.61206	36.49390	38
T-389 VC-41	12/13/2001	22:24	2,071	122.11299	36.65560	110
T-389 VC-40	12/13/2001	23:24	2,093	122.11406	36.65600	110
T-389 VC-39	12/13/2001	23:38	2,102	122.11430	36.65609	65
T-389 VC-38	12/14/2001	0:07	2,102	122.11419	36.65708	34

Appendix Ia: Monterey Canyon Vibracore Sites (cont.)

Dive and Core	Date	Time (GMT)	Depth (m)	Longitude	Latitude	Length (cm)
T-389 VC-36	12/14/2001	1:01	2,098	122.11555	36.65853	29
T-389 VC-35	12/14/2001	1:18	2,100	122.11501	36.65814	50
T-389 VC-34	12/14/2001	1:50	2,101	122.11662	36.65914	27
T-389 VC-33	12/14/2001	2:03	2,097	122.11628	36.65905	28
T-389 VC-30	12/14/2001	3:30	2,099	122.11642	36.65766	23
T-389 VC-29	12/14/2001	3:52	2,104	122.11506	36.65667	72
T-399 VC-27	3/5/2002	23:23	3,116	122.62593	36.49913	86
T-399 VC-5	3/6/2002	0:00	3,119	122.62635	36.49955	104
T-399 VC-2	3/6/2002	0:05	3,118	122.62514	36.49933	95
T-399 VC-19	3/6/2002	0:40	3,118	122.62595	36.49948	109
T-400 VC-A1	3/6/2002	16:36	3,575	123.14759	36.20806	111
T-400 VC-A2	3/6/2002	17:13	3,581	123.15007	36.20909	112
T-400 VC-A3	3/6/2002	17:47	3,583	123.15161	36.21072	89
T-400 VC-A4	3/6/2002	18:16	3,586	123.15258	36.21225	102
T-400 VC-A5	3/6/2002	18:45	3,589	123.15244	36.21252	85
T-400 VC-A6	3/6/2002	19:15	3,594	123.15348	36.21392	83
T-400 VC-A7	3/6/2002	19:37	3,601	123.15477	36.21493	45
T-400 VC-A8	3/6/2002	20:10	3,610	123.15487	36.21545	79
T-400 VC-A9	3/6/2002	20:46	3,610	123.15636	36.21720	51
T-400 VC-A19	3/6/2002	21:37	3,612	123.15767	36.21774	58
T-400 VC-A20	3/6/2002	22:01	3,612	123.15842	36.21904	82
T-400 VC-A23	3/6/2002	22:17	3,610	123.15779	36.21861	55
T-400 VC-A24	3/6/2002	22:34	3,605	123.15879	36.21922	56
T-400 VC-A25	3/6/2002	22:50	3,606	123.15811	36.21830	113
T-400 VC-A17	3/6/2002	23:08	3,603	123.15827	36.21925	106
T-400 VC-A28	3/7/2002	0:37	3,530	123.15928	36.22027	107
T-401 VC-30	3/7/2002	17:11	3,865	123.00642	35.54412	105
T-401 VC-31	3/7/2002	18:00	3,846	123.00769	35.54383	165
T-401 VC-32	3/7/2002	19:27	3,867	123.00703	35.54353	91
T-401 VC-33	3/7/2002	19:51	3,870	123.00514	35.54354	98
T-401 VC-34	3/7/2002	20:08	3,875	123.00400	35.54371	91
T-401 VC-35	3/7/2002	20:28	3,877	123.00368	35.54293	53
T-401 VC-36	3/7/2002	21:15	3,872	123.00054	35.54300	63
T-401 VC-38	3/7/2002	22:02	3,883	122.99856	35.54305	62
T-401 VC-39	3/7/2002	22:20	3,884	122.99842	35.54287	65
T-402 VC-A21	3/8/2002	16:06	333	121.91798	36.24707	76
T-402 VC-A50	3/8/2002	16:37	321	121.91847	36.24628	66
T-404 VC-3	3/9/2002	2:53	342	121.71876	36.16927	78
T-404 VC-4	3/9/2002	3:10	325	121.71914	36.16977	104
T-405 VC-37	3/9/2002	16:41	3,418	122.87662	36.22745	109
T-405 VC-38	3/9/2002	17:13	3,431	122.87793	36.22657	93
T-405 VC-39	3/9/2002	17:37	3,441	122.88123	36.22664	56
T-405 VC-40	3/9/2002	18:02	3,445	122.88160	36.22593	37
T-405 VC-41	3/9/2002	18:29	3,448	122.88271	36.22610	34
T-405 VC-42	3/9/2002	18:58	3,454	122.88380	36.22545	68
T-405 VC-45	3/9/2002	20:10	3,456	122.88469	36.22414	50
T-405 VC-46	3/9/2002	20:35	3,446	122.88512	36.22444	59
T-405 VC-48	3/9/2002	21:12	3,348	122.88674	36.22323	111
T-405 VC-50	3/10/2002	2:04	3,295	122.88614	36.21704	79
T-406 VC-53	3/10/2002	20:12	2,897	122.43573	36.61240	93
T-406 VC-59	3/10/2002	22:00	2,889	122.43534	36.60908	49
T-406 VC-60	3/10/2002	22:14	2,888	122.43580	36.60894	60
T-406 VC-62	3/10/2002	23:47	2,881	122.43588	36.60814	42

Appendix Ib: Monterey Canyon Push Core Sites

Dive #	Core#	Latitude	Longitude	Water Depth
V-1759	PC-29	36.76137	122.03883	1,160
V-1759	PC-31	36.76197	122.03722	1,160
V-1759	PC-34	36.76183	122.03877	1,158
V-1759	PC-35	36.76116	122.03947	1,161
V-1759	PC-40	36.76158	122.03988	1,161
V-1773	PC-72	36.79385	121.87374	398
V-1773	PC-75	36.79057	121.90308	522
V-1773	PC-76	36.79068	121.90382	521
V-1773	PC-78	36.79291	121.87412	398
V-1774	PC-80	36.79361	121.84516	290
V-1775	PC-29	36.75960	121.98017	853
V-1775	PC-30	36.75940	121.98390	874
V-1775	PC-33	36.75960	121.98017	853
V-1775	PC-67	36.75933	121.98390	874
V-1775	PC-79	36.75960	121.98150	853
V-1779	PC-68	36.71020	121.98636	355
V-1779	PC-67	36.71246	121.98428	258
V-1819	PC-1	36.78829	121.92751	663
V-1819	PC-67	36.78837	121.92748	666
V-1819	PC-14	36.78669	121.92615	674
V-1819	PC-15	36.78773	121.92568	663
V-2077	PC-22	36.72797	122.01839	1,361
V-2077	PC-13	36.72750	122.01644	1,367
V-2146	PC-1	36.78433	121.90379	539
T-160	PC-21	36.61756	122.32974	2,734
T-160	PC-41	36.61903	122.32898	2,742
T-160	PC-45	36.61969	122.32924	2,732
T-160	PC-50	36.61996	122.33017	2,744
T-160	PC-52	36.61699	122.32836	2,724
T-167	PC-42	36.68171	122.10456	1,951
T-167	PC-43	36.68032	122.10970	1,900
T-167	PC-49	36.68510	122.09413	1,867
T-167	PC-50	36.68044	122.10615	1,916
T-167	PC-54	36.68190	122.10476	1,952
T-167	PC-56	36.68190	122.10401	1,951
T-167	PC-60	36.68476	122.09713	1,899
T-167	PC-77	36.60325	122.30534	2,702
T-212	PC-56	36.60154	122.30795	2,690
T-212	PC-52	36.60449	122.30414	2,703
T-212	PC-53	36.60325	122.30534	2,702
T-212	PC-73	36.57097	122.18743	2,432
T-212	PC-79	36.57097	122.18743	2,432
T-217	PC-9	36.61817	122.38268	2,811
T-217	PC-21	36.61850	122.38344	2,810
T-217	PC-30	36.61834	122.38306	2,810
T-232	PC-57	36.58176	122.04872	1,098
T-400	PC-56	36.21699	123.15631	3,610
T-355	PC-59	36.63821	122.41752	2,344
T-355	PC-60	36.63835	122.41671	2,346
T-356	PC-50	36.49840	122.62483	3,148
T-356	PC-77	36.49916	122.62550	3,148
T-356	PC-73	36.49899	122.62566	3,148
T-357	PC-42	36.64035	122.41193	2,306
T-357	PC-59	36.64000	122.41231	2,306
T-357	PC-80	36.64087	122.40789	2,264
T-357	PC-61	36.63810	122.40504	2,222
T-357	PC-58	36.63812	122.40488	2,222
T-357	PC-54	36.63787	122.40532	2,222
T-357	PC-57	36.63884	122.40428	2,223
T-357	PC-75	36.63907	122.40400	2,223

Appendix Ib: Monterey Canyon Push Core Sites (cont.)

Dive #	Core#	Latitude	Longitude	Water Depth
T-357	PC-73	36.63791	122.40331	2,256
T-357	PC-65	36.63636	122.40019	2,191
T-358	PC-57	36.60785	122.48525	2,903
T-358	PC-45	36.60772	122.48551	2,903
T-359	PC-50	36.55627	122.36143	1,714
T-359	PC-59	36.55568	122.36176	1,714
T-360	PC-65	36.63032	122.41312	2,463
T-360	PC-75	36.63083	122.41286	2,463
T-372	PC-54	36.70280	122.07515	1,780
T-373	PC-57	36.18292	121.73392	387
T-373	PC-54	36.18294	121.73397	387
T-374	PC-78	36.18260	121.73325	375
T-374	PC-43	36.18424	121.73203	369
T-374	PC-47	36.18521	121.73256	331
T-375	PC-50	36.17003	121.71938	331
T-375	PC-54	36.16948	121.71917	342
T-375	PC-53	36.16906	121.71972	348
T-375	PC-42	36.16917	121.72054	299
T-376	PC-50	36.06737	122.32910	2,755
T-376	PC-78	36.06665	122.32892	2,755
T-376	PC-54	36.06630	122.32780	2,751
T-376	PC-77	36.06713	122.32735	2,751
T-376	PC-80	36.06811	122.32809	2,758
T-376	PC-45	36.07110	122.33077	2,630
T-376	PC-80	36.07817	122.33144	2,188
T-377	PC-78	36.93725	122.45563	1,055
T-377	PC-77	36.93749	122.45571	1,055
T-377	PC-53	36.93866	122.45557	1,077
T-377	PC-79	36.93897	122.45538	1,070
T-378	PC-43	36.97036	122.43443	749
T-378	PC-47	36.97021	122.43387	746
T-378	PC-50	36.97012	122.43558	743
T-379	PC-78	36.94463	122.38591	799
T-379	PC-77	36.94428	122.38743	810
T-379	PC-52	36.94394	122.38879	817
T-379	PC-53	36.94788	122.38667	713
T-379	PC-79	36.94779	122.38667	713
T-379	PC-45	36.94768	122.38659	713
T-379	PC-42	36.94764	122.38657	713
T-379	PC-54	36.94869	122.38700	656
T-388	PC-56	36.49392	122.61197	3,166
T-388	PC-59	36.49278	122.60869	3,163
T-388	PC-60	36.49254	122.60977	3,163
T-400	PC-44	36.21055	123.15160	3,583
T-400	PC-53	36.21196	123.15239	3,586
T-400	PC-60	36.21270	123.15261	3,594
T-400	PC-77	36.21583	123.15543	3,610
T-400	PC-56	36.21699	123.15631	3,610
T-400	PC-52	36.21897	123.15853	3,610
T-400	PC-70	36.22006	123.15858	3,601
T-400	PC-61	36.22379	123.16406	3,394
T-401	PC-58	35.54301	123.00720	3,865
T-401	PC-56	35.54381	123.00727	3,865
T-401	PC-70	35.54238	123.00789	3,862
T-401	PC-53	35.54431	123.00660	3,846
T-401	PC-60	35.54309	123.00282	3,877
T-401	PC-61	35.54349	122.99769	3,883
T-402	PC-56	36.24561	121.91854	333
T-403	PC-53	36.17720	121.73616	483
T-405	PC-52	36.22742	122.87843	3,431

Appendix Ib: Monterey Canyon Push Core Sites (cont.)

Dive #	Core#	Latitude	Longitude	Water Depth
T-405	PC-44	36.22589	122.88176	3,445
T-405	PC-53	36.22501	122.88354	3,454
T-405	PC-60	36.22515	122.88329	3,454
T-405	PC-61	36.22428	122.88452	3,455
T-405	PC-77	36.22550	122.88522	3,454
T-405	PC-56	36.22144	122.88634	3,246
T-405	PC-70	36.21727	122.88525	3,295
T-406	PC-60	36.61327	122.43471	2,896
T-406	PC-61	36.61344	122.43431	2,896
T-406	PC-53	36.61333	122.43569	2,896
T-406	PC-77	36.61337	122.43508	2,895

Appendix Ic: Onshore Sample Sites

Location	Core Type	Latitude	Longitude
MBARI	hand core	36.80157	121.78869
Manresa State Beach	hand core	36.92949	121.85994
Monterey Hotel Beach	hand core	36.61222	121.85865
Carmel Beach	hand core	36.53806	121.92861
New Brighton Beach	hand core	36.97842	121.93466
Pajaro Dunes Beach	hand core	36.86517	121.81875
Zmudowski State Beach	hand core	36.83667	121.80250
Moss Landing Beach North	hand core	36.81506	121.79163
ML Jetty North Beach	hand core	36.80788	121.78971
ML Jetty South Beach	hand core	36.80579	121.78884
Portrero Road Beach	hand core	36.79130	121.79308
Salinas River Beach	hand core	36.77553	121.79783
Seaside Beach	hand core	36.61578	121.85494
Pfeiffer Big Sur Beach	hand core	36.23791	121.81513
Sand City Dunes	hand core	36.62515	121.84211
Seaside Dunes	hand core	36.61458	121.85303
Costco Plaza Dune	hand core	36.62141	121.84720
Marina South Dune	hand core	36.68108	121.81003
Marina Beach Dune	hand core	36.69850	121.80884
Marina North Dune	hand core	36.73167	121.80395
Scotts Valley	hand core	37.06182	122.01777
Pacific Grove Highway 68	hand core	36.58929	121.92196
Toro Road	hand core	36.55422	121.74945
Salinas River	hand core	36.63139	121.67306
Pajaro River	hand core	36.89944	121.59501
Salinas River Gonzales	hand core	36.48710	121.46582
Arroyo Seco River	hand core	36.28222	121.32389
Nacimiento River	hand core	36.00390	121.39591
San Antonio River	hand core	36.06901	121.32251
Tres Pinos Creek	hand core	36.78281	121.31320
San Benito River	hand core	36.85222	121.43083
Pacheco Creek	hand core	36.98968	121.37812
Carmel River	hand core	36.48144	121.74225
San Lorenzo River	hand core	36.97528	122.02342
Soquel Creek	hand core	36.98525	121.95722
Aptos Creek	hand core	37.00222	121.90450

APPENDIX II: VIBRACORE COMPOSITIONS

Appendix II: Vibracore Compositions

Core #	Depth (m)	Latitude	Longitude	Lgth. (cm)	% Mud	% Clay Balls	% Silt	% Sand	% Sand & Gravel	% Gravel	% Layered Snd & Silt	% Mddy Cobbles	% Shell Coquina
V-1710 VC-1	441	36.79657	121.88982	112	0	0	0	100	0	0	0	0	0
V-1711 VC-2	425	36.79544	121.88201	70	14	0	0	86	0	0	0	0	0
V-1729 VC-3	445	36.79050	121.88778	214	93	0	1	6	0	0	0	0	0
V-1730 VC-4	444	36.79552	121.89059	85	0	39	0	61	0	0	0	0	0
V-1740 VC-5	429	36.79572	121.88326	52	0	40	0	0	60	0	0	0	0
V-1741 VC-6	424	36.79538	121.88366	45	9	22	0	56	13	0	0	0	0
V-1742 VC-7	375	36.79432	121.88494	187	98	0	2	0	0	0	0	0	0
V-1743 VC-8	412	36.79504	121.88441	150	0	0	0	0	0	0	100	0	0
V-1744 VC-9	427	36.79581	121.88271	94	0	0	0	17	0	0	83	0	0
V-1745 VC-10	404	36.79635	121.88206	160	19	0	0	6	0	0	75	0	0
V-1746 VC-11	423	36.79620	121.88266	96	3	0	0	0	0	0	97	0	0
V-1747 VC-12	349	36.79797	121.88024	192	100	0	0	0	0	0	0	0	0
V-1848 VC-13	518	36.78997	121.90429	60	3	53	0	37	7	0	0	0	0
V-1849 VC-14	400	36.78972	121.90131	195	97	0	3	0	0	0	0	0	0
V-1850 VC-15	1,169	36.78633	122.02708	126	95	0	5	0	0	0	0	0	0
V-1851 VC-16	693	36.78263	121.93409	219	0	7	0	93	0	0	0	0	0
V-1854 VC-17	692	36.78285	121.93355	20	0	0	0	100	0	0	0	0	0
V-1869 VC-18	291	36.79397	121.84579	86	0	2	0	98	0	0	0	0	0
V-1870 VC-19	690	36.78436	121.93368	180	0	2	0	98	0	0	0	0	0
V-1871 VC-20	700	36.78211	121.93334	120	0	92	0	8	0	0	0	0	0
V-1872 VC-21	519	36.79083	121.90305	44	7	0	0	68	25	0	0	0	0
V-1873 VC-22	292	36.79316	121.84618	92	4	33	0	26	17	20	0	0	0
V-1874 VC-23	1,159	36.76075	122.03964	64	0	0	0	0	0	100	0	0	0
V-1875 VC-24	1,165	36.76145	122.03732	48	0	0	0	0	0	100	0	0	0
V-1876 VC-26	468	36.78961	121.90473	125	0	0	0	0	0	0	100	0	0
V-1877 VC-27	692	36.78263	121.93453	150	0	3	0	97	0	0	0	0	0
V-1878 VC-28	296	36.79358	121.84601	65	6	0	0	52	42	0	0	0	0
V-1898 VC-29	237	36.79672	121.84576	242	98	0	2	0	0	0	0	0	0
V-1899 VC-30	677	36.78287	121.93748	162	3	0	0	0	0	0	98	0	0
V-1900 VC-31	443	36.79615	121.89063	173	0	23	0	28	49	0	0	0	0
V-1901 VC-32	1,126	36.76145	122.03998	56	50	0	0	0	0	0	50	0	0
V-1902 VC-33	284	36.79431	121.84554	148	0	0	0	0	0	0	100	0	0
V-1904 VC-35	201	36.79632	121.82188	165	30	0	0	46	24	0	0	0	0
V-1905 VC-36	202	36.79646	121.82204	146	0	14	0	40	47	0	0	0	0
V-1929 VC-37	526	36.78926	121.90321	119	0	0	0	23	0	0	0	77	0
V-1930 VC-38	238	36.80223	121.88275	214	100	0	0	0	0	0	0	0	0
V-1931 VC-39	85	36.80824	121.88346	89	0	0	0	78	0	0	0	0	23
V-1932 VC-40	113	36.78144	121.87722	165	0	0	37	0	0	0	50	0	13

Appendix II: Vibracore Compositions (cont.)

Core #	Depth (m)	Latitude	Longitude	Lgth. (cm)	% Mud	% Clay Balls	% Silt	% Sand	% Sand & Gravel	% Gravel	% Layered Sand & Silt	% Mddy Cobbles	% Shell Coquina
V-1933 VC-41	328	36.80059	121.85600	92	0	23	0	0	77	0	0	0	0
V-1934 VC-42	316	36.78874	121.88081	184	97	0	3	0	0	0	0	0	0
V-1935 VC-43	489	36.79773	121.90124	211	0	13	0	63	0	6	19	0	0
V-1936 VC-44	89	36.81007	121.94125	19	84	0	16	0	0	0	0	0	0
V-1937 VC-45	209	36.80082	121.93801	62	36	0	65	0	0	0	0	0	0
V-1938 VC-46	346	36.79175	121.93529	182	100	0	0	0	0	0	0	0	0
V-1939 VC-47	497	36.77648	121.93157	105	88	0	0	12	0	0	0	0	0
V-1940 VC-48	355	36.76910	121.93115	168	90	0	0	10	0	0	0	0	0
V-1941 VC-49	82	36.81297	121.89122	76	0	0	0	55	0	0	0	0	45
V-1942 VC-50	552	36.78040	121.90426	144	0	36	5	15	22	0	0	22	0
V-1943 VC-51	100	36.75532	121.92665	54	0	0	17	0	41	9	0	0	33
V-1944 VC-52	533	36.78531	121.90311	240	0	52	0	16	20	0	0	13	0
V-1945 VC-53	207	36.78540	121.87898	126	100	0	0	0	0	0	0	0	0
V-1946 VC-54	95	36.77703	121.87356	124	66	0	19	0	0	0	0	0	15
V-1947 VC-55	86	36.80521	121.79857	216	0	9	0	59	32	0	0	0	0
V-1974 VC-56	156	36.80917	121.83961	243	100	0	0	0	0	0	0	0	0
V-1957 VC-57	1,008	36.78063	122.01294	172	16	15	0	16	0	0	20	33	0
V-1976 VC-58	610	36.80569	121.99274	228	98	0	2	0	0	0	0	0	0
V-1977 VC-59	381	36.79529	121.86583	76	0	1	0	0	13	86	0	0	0
V-1978 VC-60	478	36.82233	121.98757	183	100	0	0	0	0	0	0	0	0
V-1979 VC-61	413	36.82794	121.97564	248	100	0	0	0	0	0	0	0	0
V-1980 VC-62	330	36.83695	121.96849	180	100	0	0	0	0	0	0	0	0
V-1981 VC-63	217	36.85170	121.96209	252	100	0	0	0	0	0	0	0	0
V-1985 VC-65	84	36.78210	121.83103	104	19	10	0	0	71	0	0	0	0
V-1986 VC-66	226	36.78957	121.82752	97	5	0	7	88	0	0	0	0	0
V-1987 VC-67	887	36.76423	121.98614	54	7	0	0	80	0	0	13	0	0
V-1988 VC-68	802	36.77221	121.96289	102	0	19	0	12	0	32	0	37	0
V-1989 VC-69	632	36.77917	121.91731	120	0	15	0	19	54	12	0	0	0
V-2120 VC-76	1,356	36.72836	122.01751	113	0	12	4	55	11	19	0	0	0
V-2121 VC-77	1,392	36.72516	122.01529	120	0	0	0	4	96	0	0	0	0
V-2122 VC-78	19	36.78852	121.80728	181	0	0	100	0	0	0	0	0	0
V-2123 VC-79	1,466	36.71038	122.01624	67	12	33	6	24	25	0	0	0	0
V-2124 VC-80	1,297	36.73243	122.01720	178	5	0	0	0	66	0	29	0	0
V-2125 VC-81	15	36.79371	121.80564	235	0	0	100	0	0	0	0	0	0
V-2126 VC-82	1,054	36.78117	122.02781	57	0	0	11	0	23	0	26	40	0
V-2127 VC-83	19	36.81363	121.80322	86	0	0	0	58	11	31	0	0	0
V-2128 VC-84	19	36.81993	121.81011	92	0	13	0	63	24	0	0	0	0
V-2129 VC-85	151	36.80124	121.81072	57	0	21	0	0	79	0	0	0	0

Appendix II: Vibracore Compositions (cont.)

Core #	Depth (m)	Latitude	Longitude	Lgth. (cm)	% Mud	% Clay Balls	% Silt	% Sand	% Sand & Gravel	% Gravel	% Layred Snd & Silt	% Mddy Cobbles	% Shell Coquina
V-2130 VC-86	150	36.80134	121.81040	197	0	10	0	52	38	0	0	0	0
V-2131 VC-87	135	36.80168	121.81114	239	0	0	0	0	0	0	100	0	0
V-2132 VC-88	31	36.79051	121.81403	235	0	0	97	0	0	0	0	0	3
V-2174 VC-89	288	36.79278	121.84478	105	2	0	0	17	81	0	0	0	0
V-2175 VC-90	537	36.78441	121.90353	70	1	6	0	42	51	0	0	0	0
V-2176 VC-91	532	36.78414	121.90254	168	0	0	0	6	0	0	94	0	0
V-2177 VC-92	517	36.78450	121.90302	123	0	16	0	37	46	0	0	0	0
V-2178 VC-93	525	36.79014	121.90299	104	0	21	0	14	64	0	0	0	0
V-2179 VC-94	534	36.78348	121.90214	227	13	4	0	0	9	0	0	74	0
T-372 VC-2	1,785	36.70106	122.07795	42	52	0	0	10	0	38	0	0	0
T-372 VC-3	1,785	36.70106	122.07795	82	0	15	0	61	0	24	0	0	0
T-373 VC-1	383	36.18296	121.73371	70	3	0	0	97	0	0	0	0	0
T-373 VC-4	383	36.18296	121.73371	15	0	0	0	0	0	100	0	0	0
T-374 VC-5	375	36.18290	121.73302	78	83	0	17	0	0	0	0	0	0
T-375 VC-6	342	36.16957	121.71915	34	38	0	0	62	0	0	0	0	0
T-377 VC-8	1,045	36.93715	122.45539	84	100	0	0	0	0	0	0	0	0
T-377 VC-9	1,055	36.93744	122.45564	82	99	0	1	0	0	0	0	0	0
T-377 VC-11	1,065	36.93773	122.45591	81	95	0	5	0	0	0	0	0	0
T-378 VC-13	748	36.96998	122.43403	93	100	0	0	0	0	0	0	0	0
T-378 VC-14	749	36.96999	122.43435	98	89	0	0	0	0	0	0	0	11
T-378 VC-16	751	36.97031	122.43464	98	100	0	0	0	0	0	0	0	0
T-379 VC-15	549	36.97134	122.44011	93	100	0	0	0	0	0	0	0	0
T-379 VC-7	800	36.94450	122.38607	90	100	0	0	0	0	0	0	0	0
T-379 VC-8	785	36.94410	122.38524	43	81	0	0	0	0	0	0	0	19
T-379 VC-16	811	36.94444	122.38744	62	97	0	3	0	0	0	0	0	0
T-388 VC-12	3,130	36.49925	122.62510	70	100	0	0	0	0	0	0	0	0
T-388 VC-13	3,158	36.49955	122.62549	82	91	0	0	9	0	0	0	0	0
T-388 VC-14	3,159	36.49825	122.62478	88	67	7	5	22	0	0	0	0	0
T-388 VC-15	3,160	36.49650	122.62487	84	17	39	4	41	0	0	0	0	0
T-388 VC-16	3,163	36.49643	122.62250	77	62	0	0	38	0	0	0	0	0
T-388 VC-21	3,172	36.49664	122.62059	28	32	0	0	68	0	0	0	0	0
T-388 VC-22	3,172	36.49392	122.61597	50	17	0	0	83	0	0	0	0	0
T-388 VC-8	3,167	36.49392	122.61197	32	13	0	0	22	0	66	0	0	0
T-388 VC-9	3,166	36.49392	122.61197	26	31	54	0	0	15	0	0	0	0
T-388 VC-10	3,164	36.49390	122.61206	83	5	43	8	22	22	0	0	0	0
T-388 VC-11	3,163	36.49390	122.61206	38	61	0	0	0	40	0	0	0	0
T-389 VC-41	2,071	36.65560	122.11299	110	96	0	4	0	0	0	0	0	0
T-389 VC-40	2,093	36.65560	122.11406	110	96	0	4	0	0	0	0	0	0

Appendix II: Vibracore Compositions (cont.)

Core #	Depth (m)	Latitude	Longitude	Lgth. (cm)	% Mud	% Clay Balls	% Silt	% Sand	% Sand & Gravel	% Gravel	% Layered Snd & Silt	% Mddy Cobbles	% Shell Coquina
T-389 VC-39	2.102	36.65609	122.11430	65	97	0	3	0	0	0	0	0	0
T-389 VC-38	2.102	36.65708	122.11419	34	35	59	0	0	6	0	0	0	0
T-389 VC-36	2.098	36.65853	122.11555	30	100	0	0	0	0	0	0	0	0
T-389 VC-35	2.101	36.65814	122.11501	50	61	0	0	39	0	0	0	0	0
T-389 VC-34	2.095	36.65914	122.11662	27	100	0	0	0	0	0	0	0	0
T-389 VC-33	2.097	36.65905	122.11628	17	100	0	0	0	0	0	0	0	0
T-389 VC-30	2.107	36.65766	122.11642	23	100	0	0	0	0	0	0	0	0
T-389 VC-29	2.104	36.65667	122.11506	72	42	0	0	43	15	0	0	0	0
T-399 VC-27	3.116	36.49913	122.62593	86	100	0	0	0	0	0	0	0	0
T-399 VC-5	3.119	36.49955	122.62635	104	87	0	0	0	0	0	0	0	14
T-399 VC-2	3.118	36.49933	122.62514	95	100	0	0	0	0	0	0	0	0
T-399 VC-19	3.118	36.49948	122.62595	109	100	0	0	0	0	0	0	0	0
T-400 VC-A1	3.575	36.20806	123.14759	95	84	0	0	16	0	0	0	0	0
T-400 VC-A2	3.581	36.20909	123.15007	97	78	0	0	22	0	0	0	0	0
T-400 VC-A3	3.583	36.21072	123.15161	73	86	0	0	14	0	0	0	0	0
T-400 VC-A4	3.586	36.21225	123.15258	87	91	0	0	9	0	0	0	0	0
T-400 VC-A5	3.589	36.21252	123.15244	70	66	0	0	31	0	0	0	0	0
T-400 VC-A6	3.594	36.21392	123.15348	83	77	0	0	21	0	2	0	0	0
T-400 VC-A7	3.601	36.21493	123.15477	30	43	0	0	57	0	0	0	0	0
T-400 VC-A8	3.610	36.21545	123.15487	69	10	0	0	90	0	0	0	0	0
T-400 VC-A9	3.610	36.21720	123.15636	36	17	0	0	83	0	0	0	0	0
T-400 VC-A19	3.612	36.21774	123.15767	43	2	0	0	98	0	0	0	0	0
T-400 VC-A20	3.612	36.21904	123.15842	67	21	0	0	79	0	0	0	0	0
T-400 VC-A23	3.610	36.21861	123.15779	55	31	0	0	69	0	0	0	0	0
T-400 VC-A24	3.605	36.21922	123.15879	71	37	0	0	63	0	0	0	0	0
T-400 VC-A25	3.606	36.21830	123.15811	98	93	0	0	7	0	0	0	0	0
T-400 VC-A17	3.603	36.21925	123.15827	91	51	0	0	37	0	12	0	0	0
T-400 VC-A28	3.530	36.22027	123.15928	92	98	0	0	2	0	0	0	0	0
T-401 VC-30	3.865	35.54412	123.00642	90	81	0	0	13	0	0	6	0	0
T-401 VC-31	3.846	35.54383	123.00769	134	100	0	0	0	0	0	0	0	0
T-401 VC-32	3.867	35.54353	123.00703	76	78	0	0	15	0	0	7	0	0
T-401 VC-33	3.870	35.54354	123.00514	83	71	0	13	16	0	0	0	0	0
T-401 VC-34	3.875	35.54371	123.00400	76	16	0	71	13	0	0	0	0	0
T-401 VC-35	3.877	35.54293	123.00368	38	0	0	0	0	0	0	100	0	0
T-401 VC-36	3.872	35.54300	123.00054	48	0	0	0	15	21	0	65	0	0
T-401 VC-38	3.883	35.54305	122.99856	47	26	0	4	43	28	0	0	0	0
T-401 VC-39	3.884	35.54287	122.99842	65	15	0	0	0	0	0	85	0	0

Appendix II: Vibracore Compositions (cont.)

Core #	Depth (m)	Latitude	Longitude	Lgth. (cm)	% Mud	% Clay Balls	% Silt	% Sand	% Sand & Gravel	% Gravel	% Layered Sand & Silt	% Mddy Cobbles	% Shell Coquina
T-402 VC-A21	333	36.24707	121.91798	76	0	0	100	0	0	0	0	0	0
T-402 VC-A50	321	36.24628	121.91847	66	0	0	100	0	0	0	0	0	0
T-403 VC-36	507	36.17500	121.73778	53	0	0	0	100	0	0	0	0	0
T-403 VC-35	502	36.17532	121.73821	39	0	0	0	100	0	0	0	0	0
T-404 VC-3	342	36.16927	121.71876	78	13	0	6	28	32	21	0	0	0
T-404 VC-4	325	36.16977	121.71914	106	0	0	100	0	0	0	0	0	0
T-405 VC-37	3418	36.22745	122.87662	94	68	3	0	6	23	0	0	0	0
T-405 VC-38	3431	36.22657	122.87793	93	22	0	0	38	0	0	41	0	0
T-405 VC-39	3441	36.22664	122.88123	56	29	0	0	71	0	0	0	0	0
T-405 VC-40	3445	36.22593	122.88160	37	27	0	0	27	46	0	0	0	0
T-405 VC-41	3448	36.22610	122.88271	34	44	0	0	32	0	24	0	0	0
T-405 VC-42	3454	36.22545	122.88380	67	18	0	0	45	10	0	0	27	0
T-405 VC-45	3456	36.22414	122.88469	35	26	0	74	0	0	0	0	0	0
T-405 VC-46	3446	36.22444	122.88512	43	58	0	42	0	0	0	0	0	0
T-405 VC-48	3348	36.22323	122.88674	96	100	0	0	0	0	0	0	0	0
T-405 VC-50	3295	36.21704	122.88614	79	71	0	0	29	0	0	0	0	0
T-406 VC-53	2897	36.61189	122.43539	93	40	0	0	60	0	0	0	0	0
T-406 VC-59	2889	36.60908	122.43534	46	0	0	100	0	0	0	0	0	0
T-406 VC-60	2888	36.60894	122.43581	45	0	0	100	0	0	0	0	0	0
T-406 VC-62	2884	36.60814	122.43588	42	0	0	0	100	0	0	0	0	0

APPENDIX III: GRAIN-SIZE DATA

Appendix III: Grain Size Data

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
V-1600	SB-11	0	0	50	50	0.01	6.7	4.0	-0.6	1.4
V-1600	SB-12	0	2	59	39	0.03	5.3	4.3	-0.2	1.2
V-1600	SB-13	0	0	45	55	0.01	6.7	4.2	-0.7	1.4
V-1600	SB-14	0	0	14	86	0.00	9.0	3.0	-2.2	5.6
V-1601	SB-12	0	0	42	58	0.01	6.9	4.2	-0.8	1.5
V-1602	SB-1	0	0	5	95	0.00	9.7	2.1	-3.1	10.5
V-1602	SB-2	0	0	44	56	0.01	6.8	4.3	-0.7	1.5
V-1602	SB-3	0	0	20	80	0.00	8.8	3.0	-1.8	3.8
V-1602	SB-4	0	0	34	66	0.01	7.5	4.1	-1.0	2.0
V-1602	SB-5	0	0	44	56	0.01	6.7	4.3	-0.7	1.4
V-1602	SB-6	0	0	14	86	0.00	9.1	2.9	-2.2	5.5
V-1602	SB-11	0	0	24	76	0.00	8.5	3.4	-1.5	2.8
V-1602	SB-12	0	0	19	81	0.00	8.8	3.2	-1.7	3.7
V-1602	SB-13	0	0	6	94	0.00	9.6	2.1	-3.2	11.0
V-1602	SB-14	0	0	8	92	0.00	9.5	2.3	-2.9	9.5
V-1602	SB-15	0	0	2	98	0.00	9.9	1.4	-4.9	25.9
V-1602	SB-16	0	0	11	89	0.00	9.3	2.7	-2.5	6.9
V-1759	PC-29	(0-5)	13	12	75	0.00	7.9	4.2	-1.6	3.5
V-1759	PC-31	(0-5)	0	20	79	0.00	8.8	3.1	-1.7	3.5
V-1759	PC-31	(17-22)	0	7	93	0.00	9.6	2.1	-2.8	8.4
V-1759	PC-34	(0-2)	31	31	38	0.05	4.4	5.1	-0.2	1.2
V-1759	PC-34	(2-7)	53	32	16	0.24	2.1	4.1	0.6	2.3
V-1759	PC-35	(7-10)	64	29	7	0.51	1.0	3.2	1.3	4.7
V-1759	PC-35	(10-13)	55	30	15	0.29	1.8	4.0	0.8	2.7
V-1759	PC-40	(13-15)	17	20	62	0.01	6.9	4.7	-1.1	2.1
V-1759	PC-40	(0-3)	0	61	39	0.01	6.3	3.6	-0.3	1.1
V-1759	PC-72	(3-5)	0	77	23	0.02	5.4	3.0	0.2	1.5
V-1759	PC-72	(1-3)	0	70	30	0.02	5.9	3.3	-0.2	1.3
V-1759	PC-72	(3-6)	0	47	53	0.01	7.2	3.7	-0.7	1.4
V-1759	PC-72	(11-14)	0	98	2	0.07	3.8	1.5	0.5	5.9
V-1773	PC-72	(0-1)	0	99	1	0.09	3.5	1.4	-0.4	5.3
V-1773	PC-75	(9-10)	0	100	0	0.11	3.2	1.2	-0.8	3.8
V-1773	PC-75	(13-14)	0	99	0	0.14	2.8	1.3	-1.1	4.3
V-1773	PC-76	(16-17)	4	96	0	0.19	2.4	1.6	-1.2	4.3
V-1773	PC-76	(20-21)	24	75	1	0.29	1.8	2.1	-0.6	3.8
V-1773	PC-78	(2-4)	0	100	0	0.09	3.5	1.2	-0.7	3.7
V-1773	PC-78	(10-12)	0	100	0	0.11	3.2	1.2	-1.1	3.6
V-1773	PC-34	(0-1)	0	99	1	0.15	2.8	1.4	0.0	6.7
V-1773	PC-34	(19-20)	0	100	0	0.10	3.3	1.3	-0.8	4.1
V-1773	PC-34	(0-1)	0	95	5	0.06	4.0	2.0	0.7	4.4
V-1773	PC-40	(18-19)	0	99	1	0.09	3.5	1.4	-0.1	5.8
V-1774	PC-80	(2-4)	0	59	40	0.01	6.4	3.6	-0.5	1.3
V-1774	PC-80	(10-12)	5	95	1	0.14	2.9	1.8	-1.6	3.7
V-1775	PC-29	(0-1)	0	7	93	0.00	9.6	2.3	-2.5	6.6
V-1775	PC-29	(1-3)	0	72	28	0.02	5.9	3.0	-0.3	1.3
V-1775	PC-30	(6-7)	1	98	1	0.07	3.9	1.5	-0.8	4.9
V-1775	PC-33	(1-2)	0	97	3	0.06	4.1	1.6	-0.8	3.2
V-1775	PC-33	(8-10)	0	44	56	0.01	7.4	3.6	-0.8	1.5

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
V-1775	PC-67	(0-2)	0	88	12	0.05	4.2	2.6	0.7	2.9
V-1775	PC-79	(5-6)	0	96	5	0.05	4.4	1.7	-0.5	3.1
V-1779	PC-67	(8-10)	0	88	12	0.05	4.3	2.8	0.2	2.7
V-1779	PC-68	(5-7)	5	27	68	0.00	7.9	3.8	-1.4	2.9
T-160	PC-21	(5-10)	0	6	94	0.00	9.7	2.0	-3.0	9.3
T-160	PC-21	(10-14)	0	23	77	0.00	8.7	3.2	-1.5	2.6
T-160	PC-41	(6-8)	0	44	56	0.01	7.3	3.7	-0.7	1.4
T-160	PC-41	(8-10)	0	78	22	0.03	5.1	3.0	0.1	1.7
T-160	PC-45	(11-12)	0	67	33	0.01	6.3	3.2	-0.4	1.2
T-160	PC-50	(5-14)	0	97	3	0.07	3.8	1.6	0.6	5.7
T-160	PC-52	(10-13)	0	41	59	0.00	7.8	3.5	-1.0	1.6
T-160	PC-52	(14-15)	0	86	14	0.03	5.0	2.4	-0.2	2.3
T-167	PC-42	(19-23)	0	31	69	0.00	8.3	3.5	-1.2	1.8
T-167	PC-43	(0-2)	0	1	99	0.00	9.9	1.2	-4.9	24.4
T-167	PC-49	(0-2)	0	5	95	0.00	9.7	1.8	-3.5	12.6
T-167	PC-50	(0-2)	0	1	99	0.00	10.0	1.1	-5.4	30.3
T-167	PC-54	(0-2)	0	2	99	0.00	9.9	1.2	-5.3	29.6
T-167	PC-56	(0-2)	0	5	95	0.00	9.7	2.0	-3.1	10.0
T-167	PC-56	(19-21)	1	92	8	0.06	4.2	2.0	-0.7	3.2
T-167	PC-60	(0-2)	0	4	96	0.00	9.8	1.7	-3.5	12.5
T-167	PC-77	(18-20)	0	44	56	0.01	7.4	3.6	-0.8	1.4
T-212	PC-56	(12-14)	0	96	5	0.11	3.2	2.1	0.8	5.3
T-212	PC-52	(16-18)	0	87	13	0.03	4.9	2.1	-0.6	2.1
T-212	PC-53	(7-10)	2	93	6	0.07	3.8	1.9	-0.3	4.4
T-212	PC-53	(10-13)	0	98	2	0.07	3.8	1.3	-0.9	2.3
T-212	PC-79	(12-14)	0	31	69	0.00	8.2	3.6	-1.2	1.7
T-212	PC-79	(14-16)	0	87	13	0.03	4.9	2.2	-0.5	2.2
T-212	PC-73	(16-18)	0	93	7	0.05	4.2	1.8	-0.8	2.5
T-212	PC-73	(18-20)	2	94	5	0.07	3.8	1.7	-1.3	3.7
T-212	PC-9	(13-16)	0	36	64	0.00	7.9	3.6	-1.1	1.6
T-212	PC-30	(16-18)	0	91	10	0.05	4.4	1.9	-0.5	2.4
T-212	PC-79	(18-19)	0	91	9	0.05	4.4	1.9	-0.7	2.4
T-212	PC-73	(19-20)	0	60	40	0.01	6.4	3.3	-0.7	1.3
T-217	PC-73	bottom	0	99	1	0.22	2.2	1.4	-0.4	5.2
T-217	PC-79	(10-12)	0	85	15	0.07	3.8	2.8	0.4	2.6
T-217	PC-21	bottom	2	98	1	0.20	2.3	1.4	-0.9	5.0
T-217	PC-30	(11-12)	0	52	47	0.01	6.3	3.9	-0.7	1.4
T-232	PC-57	(14-16)	0	100	0	0.12	3.0	1.3	-1.1	2.7
V-1819	PC-1	(5-8)	0	99	1	0.09	3.5	1.3	-1.0	2.6
V-1819	PC-1	(8-11)	0	96	4	0.07	3.9	1.5	-0.6	3.2
V-1819	PC-1	(11-14)	0	35	65	0.00	8.0	3.4	-1.1	1.9
V-1819	PC-14	(2-5)	1	45	54	0.01	7.3	3.7	-0.9	1.7
V-1819	PC-14	(5-7)	0	93	7	0.05	4.3	1.7	-0.8	2.6
V-1819	PC-14	(7-10)	0	95	5	0.06	4.1	1.6	-0.8	2.7
V-1819	PC-14	(10-12)	1	97	2	0.07	3.8	1.4	-1.1	3.9
V-1819	PC-15	(3-5)	0	75	25	0.02	5.6	3.0	0.0	1.4
V-1819	PC-15	(5-7)	0	76	24	0.03	5.2	3.2	0.2	1.5
V-1819	PC-15	(7-9)	0	81	19	0.03	5.2	2.8	0.1	1.8

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
V-1819	PC-15	(9-11)	0	99	1	0.08	3.6	1.3	-0.8	3.0
V-1819	PC-15	(11-13)	0	99	1	0.10	3.4	1.3	-0.7	4.1
V-1819	PC-15	(14-17)	0	32	68	0.00	8.1	3.5	-1.2	2.1
V-1819	PC-67	(5-7)	0	20	80	0.00	8.9	3.0	-1.6	3.2
V-1819	PC-67	(7-9)	0	90	10	0.05	4.5	1.9	-0.6	2.4
V-1819	PC-67	(9-12)	0	98	3	0.08	3.6	1.4	-0.7	3.1
V-1819	PC-67	(12-14)	0	100	1	0.10	3.4	1.2	-1.0	3.0
V-2077	PC-13	(14-16)	0	100	0	0.20	2.3	1.4	-0.8	4.2
V-2077	PC-22	(6-8)	1	97	2	0.11	3.2	1.9	0.1	5.1
V-2146	PC-1	(0-2)	0	97	3	0.06	4.0	1.5	-0.8	2.9
V-2146	PC-1	(10-12)	0	99	1	0.08	3.6	1.4	-1.1	3.1
V-2146	PC-1	(17-19)	0	100	0	0.10	3.3	1.2	-1.1	3.6
V-1710	VC-1	-102	4	96	1	0.18	2.5	1.6	-1.2	4.4
V-1710	VC-1	(5-7)	5	94	1	0.13	3.0	1.6	-1.5	5.5
V-1710	VC-1	(10-12)	3	97	0	0.13	2.9	1.4	-1.4	4.9
V-1710	VC-1	(15-17)	1	99	0	0.13	2.9	1.4	-1.2	4.2
V-1710	VC-1	(20-22)	0	99	0	0.14	2.9	1.4	-1.1	3.9
V-1710	VC-1	(25-27)	2	98	0	0.16	2.6	1.5	-1.3	4.0
V-1710	VC-1	(30-32)	3	97	1	0.19	2.4	1.6	-1.2	3.9
V-1710	VC-1	(35-37)	4	96	0	0.20	2.3	1.6	-1.4	3.5
V-1710	VC-1	(40-42)	4	96	0	0.16	2.6	1.7	-1.4	3.9
V-1710	VC-1	(45-47)	6	94	0	0.16	2.6	1.7	-1.6	4.1
V-1710	VC-1	(50-52)	4	96	0	0.16	2.7	1.6	-1.5	4.4
V-1710	VC-1	(55-57)	5	95	0	0.17	2.6	1.6	-1.5	4.2
V-1710	VC-1	(60-67)	2	98	0	0.17	2.6	1.5	-1.3	4.0
V-1710	VC-1	(65-67)	5	95	0	0.19	2.4	1.6	-1.5	3.7
V-1710	VC-1	(70-72)	8	92	0	0.21	2.3	1.7	-1.4	3.7
V-1710	VC-1	(80-82)	8	92	0	0.18	2.5	1.7	-1.6	4.1
V-1710	VC-1	(85-87)	2	97	0	0.14	2.8	1.5	-1.2	5.0
V-1710	VC-1	(90-92)	14	86	0	0.21	2.2	1.8	-1.6	3.5
V-1710	VC-1	(95-97)	48	52	0	0.48	1.1	2.0	-0.9	1.8
V-1710	VC-1	(97-99)	5	94	1	0.13	3.0	1.6	-1.5	5.5
V-1711	VC-2	cc	1	47	52	0.01	7.0	3.9	-0.7	1.5
V-1729	VC-3	(30-34)	0	5	95	0.00	9.7	1.8	-4.5	21.3
V-1729	VC-3	(68-70)	0	54	46	0.01	6.9	3.6	-0.5	1.1
V-1729	VC-3	(73-75)	0	97	3	0.08	3.6	1.6	-0.5	4.3
V-1729	VC-3	(83-85)	0	73	28	0.01	6.3	3.2	-0.1	1.1
V-1729	VC-3	(110-112)	0	3	97	0.00	9.8	1.2	-5.6	32.7
V-1729	VC-3	(180-184)	0	9	92	0.00	9.5	1.9	-3.2	11.0
V-1730	VC-4	cc	9	54	37	0.03	5.3	4.4	-0.3	1.4
V-1730	VC-4	(0-2)	1	68	31	0.03	5.3	3.5	-0.4	1.6
V-1730	VC-4	(5-7)	0	99	1	0.07	3.8	1.4	-1.0	3.0
V-1730	VC-4	(10-12)	0	99	1	0.08	3.8	1.4	-1.0	3.1
V-1730	VC-4	(15-17)	0	99	1	0.08	3.6	1.3	-1.1	2.9
V-1730	VC-4	(20-22)	0	99	1	0.08	3.6	1.4	-1.0	3.5
V-1730	VC-4	(25-27)	0	99	1	0.12	3.1	1.5	-1.2	4.0
V-1730	VC-4	(30-32)	0	99	1	0.10	3.4	1.3	-1.3	3.1
V-1730	VC-4	(35-37)	0	100	0	0.11	3.1	1.3	-1.5	3.3

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
V-1730	VC-4	(40-42)	5	95	0	0.26	1.9	1.6	-1.3	2.6
V-1730	VC-4	(45-47)	8	92	0	0.28	1.8	1.7	-1.2	2.7
V-1730	VC-4	(50-52)	3	97	0	0.21	2.3	1.6	-1.3	3.2
V-1730	VC-4	(60-62)	0	65	35	0.02	6.0	3.6	-0.2	1.2
V-1730	VC-4	(70-72)	0	50	50	0.01	6.3	4.2	-0.4	1.1
V-1740	VC-5	cc	2	17	81	0.00	8.7	3.4	-1.8	4.2
V-1740	VC-5	(2-4)	0	100	0	0.11	3.2	1.2	-1.4	3.0
V-1740	VC-5	(7-9)	0	100	0	0.12	3.1	1.3	-1.2	3.5
V-1740	VC-5	(12-14)	0	100	0	0.11	3.2	1.3	-1.2	3.4
V-1740	VC-5	(18-20)	0	100	0	0.12	3.1	1.3	-1.2	3.3
V-1740	VC-5	(23-25)	0	100	0	0.11	3.2	1.2	-1.1	3.2
V-1740	VC-5	(28-30)	0	100	0	0.12	3.0	1.3	-1.1	3.8
V-1740	VC-5	(33-35)	9	90	1	0.19	2.4	1.9	-0.8	4.9
V-1740	VC-5	(75-77)	7	92	0	0.19	2.4	1.7	-1.4	4.2
V-1741	VC-6	(5-7)	0	95	5	0.06	4.1	1.8	0.2	3.9
V-1741	VC-6	(10-12)	0	99	2	0.08	3.7	1.5	0.2	5.4
V-1741	VC-6	(14-16)	0	99	1	0.11	3.2	1.4	-0.3	5.5
V-1741	VC-6	(20-21)	0	91	9	0.05	4.2	2.1	-0.1	3.0
V-1741	VC-6	(25-29)	63	33	5	0.42	1.3	2.8	0.4	3.5
V-1741	VC-6	(43-45)	59	30	12	0.28	1.9	3.6	0.5	2.7
V-1742	VC-7	cc	0	5	95	0.00	9.7	1.7	-3.7	14.7
V-1742	VC-7	(5-17)	0	5	95	0.00	9.8	1.7	-3.5	13.0
V-1744	VC-9	(2-4)	0	99	1	0.07	3.8	1.5	0.1	5.2
V-1744	VC-9	(10-12)	0	99	1	0.09	3.5	1.4	-0.5	4.9
V-1744	VC-9	(15-17)	0	99	1	0.08	3.7	1.5	0.1	5.8
V-1744	VC-9	(54-56)	0	98	2	0.07	3.9	1.5	0.3	5.1
V-1745	V-10	cc	0	34	66	0.01	7.5	4.1	-1.0	1.9
V-1745	V-10	(53-54)	0	92	8	0.05	4.3	2.4	0.5	3.1
V-1745	V-10	(155-157)	0	95	5	0.07	3.9	2.0	0.8	4.5
V-1748	VC-13	(10-14)	0	98	1	0.16	2.7	1.5	-0.4	4.9
V-1848	VC-13	(14-17)	1	97	3	0.14	2.8	1.8	0.4	6.1
V-1848	VC-13	(17-20)	1	95	5	0.12	3.0	2.0	0.4	4.9
V-1851	VC-16	(0-2)	0	81	19	0.04	4.6	2.4	-0.9	2.2
V-1851	VC-16	(4-6)	2	96	2	0.10	3.4	1.7	-0.4	5.9
V-1851	VC-16	(9-11)	1	98	1	0.11	3.3	1.4	-1.0	5.5
V-1851	VC-16	(14-16)	0	99	1	0.11	3.2	1.3	-0.8	4.5
V-1851	VC-16	(19-21)	1	98	1	0.11	3.2	1.4	-0.8	5.4
V-1851	VC-16	(24-26)	0	99	1	0.12	3.1	1.3	-0.9	4.4
V-1851	VC-16	(29-31)	1	98	1	0.11	3.1	1.4	-0.9	5.3
V-1851	VC-16	(34-36)	0	99	1	0.12	3.1	1.3	-0.7	4.6
V-1851	VC-16	(39-41)	3	97	1	0.12	3.0	1.4	-1.3	5.5
V-1851	VC-16	(44-46)	0	99	1	0.12	3.1	1.3	-0.9	4.2
V-1851	VC-16	(49-51)	1	98	1	0.14	2.9	1.4	-0.6	4.8
V-1851	VC-16	(54-56)	0	100	0	0.12	3.0	1.3	-1.0	4.0
V-1851	VC-16	(59-61)	1	99	1	0.12	3.1	1.4	-1.0	4.7
V-1851	VC-16	(64-66)	0	100	1	0.12	3.0	1.3	-0.9	4.1
V-1851	VC-16	(69-71)	0	99	1	0.12	3.1	1.3	-0.8	4.4
V-1851	VC-16	(74-76)	0	100	0	0.13	3.0	1.3	-0.9	4.2

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
V-1851	VC-16	(79-81)	1	99	1	0.12	3.1	1.4	-0.9	4.5
V-1851	VC-16	(84-86)	0	99	1	0.12	3.0	1.3	-1.1	3.5
V-1851	VC-16	(89-91)	0	99	1	0.12	3.0	1.3	-0.8	4.2
V-1851	VC-16	(94-96)	0	99	1	0.12	3.0	1.4	-0.8	4.4
V-1851	VC-16	(99-101)	0	99	1	0.13	3.0	1.4	-0.8	4.6
V-1851	VC-16	(104-106)	0	100	0	0.13	3.0	1.3	-0.9	3.9
V-1851	VC-16	(109-111)	0	100	1	0.13	3.0	1.4	-0.9	4.1
V-1851	VC-16	(114-116)	0	99	1	0.12	3.1	1.3	-0.6	5.1
V-1851	VC-16	(119-121)	0	99	1	0.12	3.0	1.3	-0.9	4.2
V-1851	VC-16	(124-126)	0	100	0	0.13	3.0	1.3	-1.0	4.0
V-1851	VC-16	(129-131)	0	99	1	0.13	3.0	1.4	-0.9	4.2
V-1851	VC-16	(134-136)	0	99	1	0.13	3.0	1.4	-0.9	4.4
V-1851	VC-16	(139-141)	0	99	1	0.13	3.0	1.4	-0.9	4.4
V-1851	VC-16	(144-146)	0	100	1	0.11	3.2	1.3	-1.0	3.9
V-1851	VC-16	(149-151)	0	99	1	0.10	3.3	1.3	-0.9	3.8
V-1851	VC-16	(154-156)	0	97	3	0.08	3.6	1.5	-0.9	3.3
V-1851	VC-16	(159-161)	0	100	1	0.10	3.3	1.2	-0.9	3.7
V-1851	VC-16	(164-166)	0	100	0	0.12	3.0	1.3	-0.9	4.1
V-1851	VC-16	(169-171)	7	87	6	0.10	3.3	2.2	-0.4	4.8
V-1851	VC-16	(174-176)	0	100	0	0.14	2.8	1.3	-1.1	3.7
V-1851	VC-16	(179-181)	0	100	0	0.14	2.9	1.4	-1.0	4.0
V-1851	VC-16	(184-186)	0	100	0	0.15	2.7	1.4	-1.2	3.6
V-1851	VC-16	(189-191)	0	100	0	0.15	2.7	1.4	-1.1	3.6
V-1851	VC-16	(194-196)	0	100	0	0.16	2.7	1.3	-1.0	3.7
V-1851	VC-16	(199-201)	5	94	1	0.16	2.7	1.6	-1.3	5.0
V-1851	VC-16	(204-206)	10	77	13	0.09	3.5	2.8	-0.1	3.0
V-1854	VC-17	cc	0	99	1	0.11	3.1	1.4	-1.1	3.7
V-1854	VC-17	above cc	1	98	2	0.10	3.3	1.5	-0.8	4.7
V-1869	VC-18	(2-4 cm)	5	95	1	0.15	2.7	1.6	-1.3	5.0
V-1869	VC-18	(8-10)	3	97	1	0.15	2.8	1.5	-1.2	5.0
V-1869	VC-18	(20-22)	0	95	5	0.08	3.6	1.8	-0.2	4.1
V-1869	VC-18	(28-30)	1	98	1	0.14	2.8	1.6	-0.7	4.8
V-1869	VC-18	(38-40)	0	98	2	0.10	3.3	1.5	-0.3	5.4
V-1869	VC-18	(41-43)	1	98	2	0.12	3.1	1.6	-0.1	5.8
V-1869	VC-18	(46-48)	0	99	1	0.15	2.7	1.6	-0.6	5.0
V-1869	VC-18	(51-53)	1	91	8	0.07	3.8	2.2	-0.4	3.4
V-1869	VC-18	(56-58)	0	94	6	0.07	3.8	1.9	-0.3	3.7
V-1869	VC-18	(61-63)	0	95	5	0.08	3.7	1.9	0.4	4.7
V-1869	VC-18	(66-68)	3	96	1	0.17	2.6	1.7	-1.2	4.2
V-1869	VC-18	(71-73)	0	99	0	0.13	3.0	1.5	-1.3	4.1
V-1869	VC-18	(76-78)	0	100	0	0.14	2.9	1.4	-1.1	4.3
V-1869	VC-18	(81-83)	0	98	2	0.13	3.0	1.6	0.0	5.6
V-1870	VC-19	(6-8)	1	98	1	0.09	3.4	1.5	-1.3	5.1
V-1870	VC-19	(11-13)	0	100	0	0.10	3.4	1.2	-1.1	3.3
V-1870	VC-19	(16-18)	0	99	0	0.09	3.4	1.3	-0.8	5.1
V-1870	VC-19	(21-23)	1	99	1	0.09	3.5	1.4	-1.1	5.5
V-1870	VC-19	(26-28)	1	99	0	0.11	3.2	1.3	-1.1	5.0
V-1870	VC-19	(31-33)	0	100	0	0.11	3.2	1.3	-1.1	3.8

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
V-1870	VC-19	(36-38)	0	100	0	0.11	3.2	1.3	-0.8	4.5
V-1870	VC-19	(41-43)	0	100	0	0.11	3.1	1.3	-1.0	3.8
V-1870	VC-19	(46-48)	0	99	0	0.12	3.1	1.3	-0.8	5.1
V-1870	VC-19	(51-53)	0	100	0	0.12	3.1	1.2	-1.0	3.4
V-1870	VC-19	(56-58)	0	99	0	0.12	3.1	1.3	-0.9	4.7
V-1870	VC-19	(61-63)	0	100	0	0.12	3.0	1.3	-1.0	3.7
V-1870	VC-19	(66-68)	0	100	0	0.13	3.0	1.3	-1.0	4.1
V-1870	VC-19	(71-73)	0	100	0	0.13	3.0	1.3	-1.1	3.4
V-1870	VC-19	(76-78)	0	100	0	0.12	3.0	1.3	-0.9	4.3
V-1870	VC-19	(81-83)	0	100	0	0.12	3.1	1.3	-0.8	4.2
V-1870	VC-19	(86-88)	0	99	0	0.13	3.0	1.3	-1.0	4.3
V-1870	VC-19	(91-93)	0	100	0	0.12	3.0	1.3	-1.1	3.6
V-1870	VC-19	(96-98)	0	100	0	0.14	2.9	1.3	-1.1	4.0
V-1870	VC-19	(101-103)	0	100	1	0.11	3.1	1.3	-0.8	4.5
V-1870	VC-19	(106-108)	0	100	0	0.12	3.0	1.3	-0.9	4.4
V-1870	VC-19	(111-113)	0	100	0	0.13	2.9	1.3	-1.0	3.8
V-1870	VC-19	(116-118)	0	100	0	0.13	2.9	1.3	-1.0	4.2
V-1870	VC-19	(121-123)	0	100	0	0.13	3.0	1.3	-1.0	4.0
V-1870	VC-19	(126-128)	0	100	0	0.12	3.0	1.3	-0.8	4.5
V-1870	VC-19	(131-133)	0	100	0	0.14	2.9	1.3	-1.0	4.0
V-1870	VC-19	(136-138)	0	99	0	0.14	2.9	1.4	-0.9	4.7
V-1870	VC-19	(141-143)	0	100	0	0.13	2.9	1.3	-0.9	4.2
V-1870	VC-19	(146-148)	0	99	0	0.13	2.9	1.3	-1.1	4.0
V-1870	VC-19	(151-153)	1	99	1	0.13	3.0	1.4	-0.9	4.9
V-1869	VC-18	(71-73)	0	99	0	0.13	3.0	1.5	-1.3	4.1
V-1869	VC-18	(76-78)	0	100	0	0.14	2.9	1.4	-1.1	4.3
V-1869	VC-18	(81-83)	0	98	2	0.13	3.0	1.6	0.0	5.6
V-1870	VC-19	(6-8)	1	98	1	0.09	3.4	1.5	-1.3	5.1
V-1870	VC-19	(11-13)	0	100	0	0.10	3.4	1.2	-1.1	3.3
V-1870	VC-19	(16-18)	0	99	0	0.09	3.4	1.3	-0.8	5.1
V-1870	VC-19	(21-23)	1	99	1	0.09	3.5	1.4	-1.1	5.5
V-1870	VC-19	(26-28)	1	99	0	0.11	3.2	1.3	-1.1	5.0
V-1870	VC-19	(31-33)	0	100	0	0.11	3.2	1.3	-1.1	3.8
V-1870	VC-19	(36-38)	0	100	0	0.11	3.2	1.3	-0.8	4.5
V-1870	VC-19	(41-43)	0	100	0	0.11	3.1	1.3	-1.0	3.8
V-1870	VC-19	(46-48)	0	99	0	0.12	3.1	1.3	-0.8	5.1
V-1870	VC-19	(51-53)	0	100	0	0.12	3.1	1.2	-1.0	3.4
V-1870	VC-19	(56-58)	0	99	0	0.12	3.1	1.3	-0.9	4.7
V-1870	VC-19	(61-63)	0	100	0	0.12	3.0	1.3	-1.0	3.7
V-1870	VC-19	(66-68)	0	100	0	0.13	3.0	1.3	-1.0	4.1
V-1870	VC-19	(71-73)	0	100	0	0.13	3.0	1.3	-1.1	3.4
V-1870	VC-19	(76-78)	0	100	0	0.12	3.0	1.3	-0.9	4.3
V-1870	VC-19	(81-83)	0	100	0	0.12	3.1	1.3	-0.8	4.2
V-1870	VC-19	(86-88)	0	99	0	0.13	3.0	1.3	-1.0	4.3
V-1870	VC-19	(91-93)	0	100	0	0.12	3.0	1.3	-1.1	3.6
V-1870	VC-19	(96-98)	0	100	0	0.14	2.9	1.3	-1.1	4.0
V-1870	VC-19	(101-103)	0	100	1	0.11	3.1	1.3	-0.8	4.5
V-1870	VC-19	(106-108)	0	100	0	0.12	3.0	1.3	-0.9	4.4

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
V-1870	VC-19	(111-113)	0	100	0	0.13	2.9	1.3	-1.0	3.8
V-1870	VC-19	(116-118)	0	100	0	0.13	2.9	1.3	-1.0	4.2
V-1870	VC-19	(121-123)	0	100	0	0.13	3.0	1.3	-1.0	4.0
V-1870	VC-19	(126-128)	0	100	0	0.12	3.0	1.3	-0.8	4.5
V-1870	VC-19	(131-133)	0	100	0	0.14	2.9	1.3	-1.0	4.0
V-1870	VC-19	(136-138)	0	99	0	0.14	2.9	1.4	-0.9	4.7
V-1870	VC-19	(141-143)	0	100	0	0.13	2.9	1.3	-0.9	4.2
V-1870	VC-19	(146-148)	0	99	0	0.13	2.9	1.3	-1.1	4.0
V-1870	VC-19	(151-153)	1	99	1	0.13	3.0	1.4	-0.9	4.9
V-1870	VC-19	(156-158)	1	99	1	0.13	3.0	1.4	-0.8	5.4
V-1870	VC-19	(161-163)	2	97	1	0.13	2.9	1.5	-0.9	6.1
V-1870	VC-19	(166-168)	4	95	1	0.14	2.8	1.5	-1.2	5.9
V-1870	VC-19	(171-173)	5	94	1	0.15	2.7	1.6	-0.8	6.1
V-1870	VC-19	(176-178)	15	85	1	0.19	2.4	1.9	-1.2	4.9
V-1871	VC-20	(0-2)	1	98	0	0.17	2.6	1.5	-1.4	3.8
V-1871	VC-20	(2-4)	1	99	0	0.17	2.6	1.5	-1.5	3.5
V-1871	VC-20	(4-6)	2	98	0	0.18	2.5	1.5	-1.5	3.7
V-1871	VC-20	(6-8)	0	100	0	0.13	2.9	1.4	-1.3	3.7
V-1871	VC-20	(8-10 cm)	0	99	0	0.13	3.0	1.4	-1.1	4.4
V-1872	VC-21	(9-11 cm)	0	98	1	0.09	3.5	1.4	-0.8	4.2
V-1872	VC-21	(19-21)	2	97	1	0.12	3.1	1.6	-1.1	5.2
V-1872	VC-21	(29-31)	30	68	2	0.27	1.9	2.3	-0.7	3.4
V-1872	VC-21	(39-41)	56	43	2	0.54	0.9	2.2	0.2	3.9
V-1873	VC-22	(5-7)	0	100	1	0.11	3.2	1.3	-0.9	4.0
V-1873	VC-22	(11-13)	0	100	1	0.12	3.1	1.3	-0.8	4.2
V-1873	VC-22	(17-19)	0	100	1	0.11	3.2	1.3	-0.8	4.0
V-1873	VC-22	(40-42)	3	97	1	0.20	2.3	1.7	-0.8	4.4
V-1873	VC-22	(52-54)	8	92	1	0.19	2.4	1.8	-1.4	3.9
V-1873	VC-22	(57-59)	20	80	0	0.25	2.0	1.9	-1.3	3.1
V-1873	VC-22	(62-64)	15	85	0	0.22	2.2	1.9	-1.5	3.4
V-1873	VC-22	(67-69)	9	91	0	0.18	2.5	1.8	-1.4	4.3
V-1873	VC-22	(72-74)	31	68	1	0.30	1.7	2.2	-0.7	3.2
V-1873	VC-22	(77-79)	33	66	1	0.41	1.3	2.0	-0.6	3.0
V-1873	VC-22	(84-86)	51	49	0	0.59	0.8	1.8	-0.8	1.4
V-1874	VC-23	(17-19)	83	17	0	1.16	-0.2	1.3	-0.4	3.6
V-1874	VC-23	(32-34)	92	8	0	1.31	-0.4	1.1	-0.8	1.7
V-1874	VC-23	(47-49)	64	36	0	0.88	0.2	1.6	-0.1	4.2
V-1874	VC-23	(62-64)	85	15	0	1.22	-0.3	1.2	-0.1	6.4
V-1874	VC-23	68	64	35	0	0.88	0.2	1.6	0.1	5.2
V-1874	VC-23	(cc)	72	28	0	1.07	-0.1	1.3	-0.1	6.5
V-1874	VC-23	cc	32	68	1	0.38	1.4	2.0	0.9	2.6
V-1875	VC-24	(10-12)	70	30	1	0.95	0.1	1.6	0.3	6.1
V-1875	VC-24	(20-22)	78	22	0	1.06	-0.1	1.4	0.1	5.8
V-1875	VC-24	(30-32)	67	32	1	0.88	0.2	1.7	0.3	5.5
V-1875	VC-24	cc	90	10	0	1.26	-0.3	1.2	-0.2	5.3
V-1877	VC-27	(2-4)	0	99	1	0.10	3.3	1.4	-0.7	5.1
V-1877	VC-27	(12-14)	0	99	1	0.10	3.3	1.3	-0.8	4.3
V-1877	VC-27	(22-24)	0	99	1	0.11	3.2	1.3	-0.7	4.6

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
V-1877	VC-27	(32-24)	0	99	1	0.11	3.2	1.3	-0.8	4.3
V-1877	VC-27	(42-44)	0	99	1	0.11	3.2	1.4	-0.6	4.8
V-1877	VC-27	(52-54)	0	99	1	0.11	3.2	1.4	-0.7	4.6
V-1877	VC-27	(62-64)	0	99	1	0.11	3.1	1.4	-0.7	4.7
V-1877	VC-27	(72-74)	0	99	1	0.11	3.2	1.3	-0.8	4.3
V-1877	VC-27	(82-84)	0	100	1	0.11	3.2	1.3	-0.8	4.0
V-1877	VC-27	(92-94)	0	100	1	0.10	3.3	1.3	-0.8	4.0
V-1877	VC-27	(102-104)	0	99	1	0.10	3.3	1.3	-0.8	4.5
V-1877	VC-27	(112-114)	1	99	1	0.10	3.3	1.3	-0.8	4.8
V-1877	VC-27	(122-124)	0	99	1	0.10	3.3	1.4	-0.2	5.8
V-1877	VC-27	(132-134)	0	100	1	0.11	3.2	1.3	-0.9	4.0
V-1877	VC-27	(142-144)	0	100	0	0.12	3.0	1.3	-1.1	3.6
V-1878	VC-28	(4-6)	0	92	8	0.06	4.1	2.1	0.3	3.6
V-1878	VC-28	(10-12)	0	99	1	0.09	3.5	1.3	-0.8	4.1
V-1878	VC-28	(20-22)	0	99	1	0.11	3.2	1.4	-0.7	4.8
V-1878	VC-28	(30-32)	0	96	4	0.11	3.2	2.0	0.8	5.8
V-1878	VC-28	(40-42)	78	22	0	0.91	0.1	1.7	-0.2	2.1
V-1900	VC-31	(0-2)	0	99	1	0.09	3.5	1.5	-0.5	4.5
V-1900	VC-31	(5-7)	0	97	3	0.09	3.6	1.7	0.6	5.6
V-1900	VC-31	(10-12)	0	99	1	0.10	3.3	1.4	-0.4	4.9
V-1900	VC-31	(15-17)	0	99	1	0.12	3.0	1.4	-0.8	4.7
V-1900	VC-31	(20-22)	0	99	1	0.12	3.0	1.4	-0.7	4.7
V-1900	VC-31	(25-27)	0	99	1	0.13	3.0	1.5	-0.8	4.9
V-1900	VC-31	(30-32)	1	99	1	0.14	2.9	1.5	-0.9	4.7
V-1900	VC-31	(35-37)	3	96	1	0.16	2.6	1.6	-1.2	4.5
V-1900	VC-31	(40-42)	4	96	0	0.14	2.9	1.8	-1.4	3.7
V-1900	VC-31	(45-47)	4	96	1	0.20	2.4	1.7	-1.1	4.0
V-1900	VC-31	(50-52)	9	91	1	0.23	2.1	1.8	-1.1	3.9
V-1900	VC-31	(55-57)	17	83	0	0.28	1.9	1.9	-1.1	3.2
V-1900	VC-31	(60-62)	18	82	0	0.29	1.8	1.9	-1.0	3.3
V-1900	VC-31	(65-67)	37	62	1	0.45	1.2	2.0	-0.5	3.3
V-1900	VC-31	(110-112)	37	63	1	0.41	1.3	2.0	-0.7	2.8
V-1900	VC-31	(120-122)	6	93	1	0.22	2.2	1.8	-0.8	4.4
V-1900	VC-31	(150-152)	24	75	1	0.30	1.7	2.0	-0.8	3.4
V-1904	VC-33	(18-20)	14	64	22	0.07	3.9	4.0	0.2	1.8
V-1929	VC-37	(5-7)	0	96	3	0.10	3.4	1.8	-0.2	4.8
V-1929	VC-37	(21-23)	62	38	1	0.62	0.7	2.0	-0.3	2.7
V-1929	VC-37	(32-34)	77	21	2	0.81	0.3	2.1	1.0	6.4
V-1931	VC-39	(8-10)	0	97	3	0.07	3.9	1.6	0.0	4.4
V-1931	VC-39	(32-34)	1	90	9	0.05	4.4	2.0	-0.4	3.4
V-1933	VC-41	(5-7)	0	100	0	0.12	3.0	1.3	-0.8	4.2
V-1933	VC-41	(10-12)	15	85	1	0.21	2.3	1.8	-1.4	4.5
V-1933	VC-41	(15-17)	5	95	0	0.19	2.4	1.6	-1.5	4.1
V-1933	VC-41	(20-22)	4	96	1	0.20	2.3	1.6	-0.9	4.9
V-1933	VC-41	(38-40)	13	86	1	0.30	1.7	1.8	-0.7	4.0
V-1933	VC-41	(55-57)	18	81	1	0.27	1.9	1.9	-1.0	4.0
V-1933	VC-41	(60-62)	9	89	2	0.20	2.4	2.0	-0.3	4.8
V-1933	VC-41	(65-67)	19	80	1	0.30	1.8	1.9	-0.9	3.5

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
V-1933	VC-41	(70-72)	38	61	0	0.45	1.2	1.9	-0.8	2.6
V-1933	VC-41	(75-77)	18	82	0	0.36	1.5	1.8	-0.9	3.1
V-1933	VC-41	(80-82)	27	72	1	0.33	1.6	2.0	-0.8	3.3
V-1933	VC-41	(85-87)	12	87	1	0.21	2.3	1.8	-1.2	4.0
V-1933	VC-41	cc	4	95	1	0.17	2.6	1.7	-0.7	5.2
V-1935	VC-43	(5-7)	0	99	1	0.07	3.8	1.4	-0.9	3.5
V-1935	VC-43	(10-12)	0	99	1	0.08	3.6	1.4	-0.8	4.1
V-1935	VC-43	(15-17)	0	98	2	0.08	3.6	1.4	-0.5	4.2
V-1935	VC-43	(20-22)	0	99	1	0.09	3.5	1.4	-0.5	4.4
V-1935	VC-43	(25-27)	0	99	1	0.11	3.3	1.4	-0.5	4.5
V-1935	VC-43	(30-32)	0	98	2	0.11	3.2	1.6	-0.4	4.9
V-1935	VC-43	(40-42)	0	94	5	0.06	4.2	1.8	-0.5	3.4
V-1935	VC-43	(45-47)	0	95	5	0.06	4.2	1.8	-0.7	3.5
V-1935	VC-43	(50-52)	0	96	4	0.06	4.1	1.7	-0.8	3.5
V-1935	VC-43	(55-57)	1	96	4	0.06	4.2	1.7	-0.9	3.6
V-1935	VC-43	(60-62)	2	98	1	0.09	3.5	1.5	-1.3	4.8
V-1935	VC-43	(65-67)	1	98	0	0.13	2.9	1.6	-1.4	4.1
V-1935	VC-43	(70-72)	1	99	1	0.10	3.3	1.4	-1.3	4.4
V-1935	VC-43	(75-77)	1	99	0	0.11	3.2	1.4	-1.4	4.6
V-1935	VC-43	(80-82)	1	98	1	0.12	3.0	1.5	-1.3	4.5
V-1935	VC-43	(85-87)	9	91	0	0.23	2.1	1.8	-1.3	3.1
V-1935	VC-43	(90-92)	8	92	0	0.32	1.7	1.7	-1.0	2.6
V-1935	VC-43	(95-97)	11	89	0	0.34	1.6	1.7	-1.1	2.3
V-1935	VC-43	(100-102)	7	93	0	0.28	1.8	1.7	-1.2	2.5
V-1935	VC-43	(105-107)	7	93	0	0.29	1.8	1.7	-1.1	2.8
V-1935	VC-43	109	9	91	0	0.27	1.9	1.8	-1.2	2.8
V-1935	VC-43	(110-112)	5	95	0	0.27	1.9	1.6	-1.2	3.2
V-1935	VC-43	(115-117)	0	99	0	0.15	2.7	1.4	-1.2	4.2
V-1935	VC-43	(120-122)	0	99	0	0.14	2.8	1.4	-1.2	4.0
V-1935	VC-43	(125-127)	1	98	1	0.13	3.0	1.5	-1.2	4.8
V-1935	VC-43	(130-132)	3	97	1	0.16	2.7	1.6	-0.9	5.4
V-1936	VC-44	(50-52)	47	52	1	0.55	0.9	1.9	-0.5	2.7
V-1937	VC-45	(13-15)	0	56	44	0.01	6.8	3.5	-0.5	1.2
V-1937	VC-45	(28-30))	0	59	41	0.01	6.6	3.5	-0.4	1.2
V-1938	VC-46	(10-12)	2	92	6	0.13	3.0	2.3	0.7	4.7
V-1938	VC-46	(20-22))	2	92	6	0.14	2.8	2.3	0.6	4.7
V-1938	VC-46	(30-32))	0	67	34	0.03	5.3	3.9	0.0	1.2
V-1940	VC-48	(0-2)	0	74	25	0.04	4.7	3.7	0.2	1.6
V-1941	VC-49	(6-8)	0	98	2	0.08	3.6	1.6	0.3	5.5
V-1941	VC-49	(33-35)	0	91	9	0.06	4.2	2.1	-0.2	3.4
V-1941	VC-49	(38-40)	0	93	7	0.06	4.1	1.9	-0.1	3.7
V-1941	VC-49	(43-45)	0	97	3	0.06	4.1	1.6	-0.3	3.6
V-1941	VC-49	(48-50)	1	88	11	0.05	4.4	2.2	-0.5	3.1
V-1941	VC-49	(53-55)	1	91	9	0.05	4.3	2.0	-0.3	3.3
V-1942	VC-50	(9-11)	0	99	1	0.10	3.3	1.5	-1.1	3.9
V-1942	VC-50	(19-21)	0	99	1	0.10	3.4	1.4	-0.2	5.1
V-1942	VC-50	(29-31)	74	25	1	0.78	0.4	1.9	0.0	3.4
V-1942	VC-50	(39-41)	85	15	1	0.97	0.0	1.7	0.4	4.9

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
V-1942	VC-50	(49-51)	83	17	1	0.92	0.1	1.8	0.3	4.2
V-1942	VC-50	(59-61)	19	80	1	0.30	1.8	1.9	-1.1	2.9
V-1942	VC-50	(69-71)	47	22	31	0.10	3.3	5.1	0.2	1.3
V-1942	VC-50	(79-81)	68	16	16	0.34	1.6	4.2	-1.0	2.7
V-1942	VC-50	(89-91)	88	7	5	0.91	0.1	2.6	2.1	9.1
V-1942	VC-50	(99-101)	81	17	3	0.90	0.2	2.3	1.9	9.8
V-1943	VC-51	(5-6)	5	77	19	0.05	4.3	3.4	0.1	2.1
V-1943	VC-51	(29-32)	14	19	67	0.01	7.1	4.7	-1.2	2.3
V-1943	VC-51	(34-36)	36	60	4	0.21	2.3	2.8	-0.3	3.0
V-1944	VC-52	(10-12)	2	98	1	0.12	3.0	1.5	-1.1	5.0
V-1944	VC-52	(15-17)	1	99	1	0.13	2.9	1.5	-1.1	4.8
V-1944	VC-52	(20-22)	4	96	1	0.17	2.6	1.6	-1.4	4.2
V-1944	VC-52	(25-27)	6	94	0	0.18	2.5	1.7	-1.4	4.0
V-1944	VC-52	(30-32)	7	93	0	0.22	2.2	1.7	-1.2	3.8
V-1851	VC-52	(35-37)	7	93	0	0.22	2.2	1.7	-1.3	3.5
V-1944	VC-52	(40-42)	12	88	1	0.21	2.2	1.8	-1.2	3.8
V-1944	VC-52	(45-47)	12	87	1	0.21	2.2	1.9	-1.1	4.1
V-1944	VC-52	(65-67)	2	98	1	0.12	3.1	1.6	-1.2	4.8
V-1944	VC-52	(70-72)	7	92	1	0.18	2.5	1.8	-1.2	4.0
V-1944	VC-52	(75-77)	8	92	0	0.24	2.1	1.7	-1.1	3.7
V-1944	VC-52	(90-92)	62	38	0	0.64	0.7	2.0	-0.5	1.8
V-1944	VC-52	(80-82)	7	93	1	0.21	2.2	1.7	-1.1	4.1
V-1944	VC-52	(95-97)	29	70	1	0.36	1.5	2.0	-0.5	3.5
V-1944	VC-52	(100-102)	26	74	1	0.34	1.6	2.0	-0.7	3.5
V-1944	VC-52	(105-107)	30	70	0	0.39	1.4	1.9	-1.0	2.7
V-1944	VC-52	(110-112)	65	35	0	0.71	0.5	1.8	-0.4	2.1
V-1944	VC-52	(115-117)	66	33	0	0.74	0.4	1.8	-0.3	2.6
V-1944	VC-52	(120-122)	37	61	2	0.43	1.2	2.2	0.3	4.6
V-1944	VC-52	(cc)	51	17	32	0.11	3.2	5.2	0.3	1.3
V-1947	VC-55	(5-7)	0	83	17	0.03	5.1	2.4	-0.4	2.0
V-1947	VC-55	(10-12)	0	90	10	0.05	4.2	2.2	0.1	3.1
V-1947	VC-55	(15-17)	0	100	0	0.12	3.1	1.3	-1.0	3.7
V-1947	VC-55	(20-22)	0	100	0	0.14	2.8	1.3	-1.3	3.3
V-1947	VC-55	(25-27)	0	100	0	0.15	2.7	1.3	-1.3	3.3
V-1947	VC-55	(30-32)	0	100	0	0.17	2.6	1.4	-1.5	3.1
V-1947	VC-55	(35-37)	1	99	0	0.17	2.6	1.4	-1.4	3.4
V-1947	VC-55	(40-42)	2	98	0	0.18	2.5	1.4	-1.5	3.6
V-1947	VC-55	(45-47)	3	97	0	0.18	2.5	1.5	-1.5	3.9
V-1947	VC-55	(50-52)	3	97	0	0.17	2.5	1.5	-1.6	3.9
V-1947	VC-55	(55-57)	7	93	0	0.20	2.3	1.6	-1.6	4.0
V-1947	VC-55	(60-62)	4	96	0	0.18	2.4	1.5	-1.5	4.2
V-1947	VC-55	(65-67)	5	95	0	0.18	2.5	1.5	-1.6	4.2
V-1947	VC-55	(70-72)	5	94	0	0.19	2.4	1.5	-1.6	4.0
V-1947	VC-55	(75-77)	4	96	0	0.19	2.4	1.5	-1.5	4.1
V-1947	VC-55	(80-82)	6	94	0	0.19	2.4	1.5	-1.6	4.1
V-1947	VC-55	(85-87)	9	91	0	0.20	2.3	1.6	-1.6	4.1
V-1947	VC-55	(90-92)	5	95	0	0.18	2.5	1.5	-1.6	4.2
V-1947	VC-55	(95-97)	5	95	0	0.18	2.5	1.5	-1.6	4.3

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
V-1947	VC-55	(100-102)	2	98	0	0.15	2.7	1.4	-1.5	4.2
V-1947	VC-55	(105-107)	1	99	0	0.15	2.7	1.4	-1.3	4.2
V-1947	VC-55	(110-112)	5	95	0	0.20	2.3	1.5	-1.7	3.7
V-1947	VC-55	(115-117)	5	95	0	0.20	2.4	1.5	-1.7	4.0
V-1947	VC-55	(120-122)	2	98	0	0.18	2.5	1.4	-1.5	3.5
V-1947	VC-55	(125-127)	4	96	0	0.23	2.1	1.4	-1.5	3.2
V-1947	VC-55	(130-132)	20	80	0	0.35	1.5	1.7	-1.4	2.9
V-1947	VC-55	(135-137)	27	73	0	0.40	1.3	1.7	-1.3	2.4
V-1947	VC-55	(140-142)	40	60	0	0.48	1.1	1.8	-1.0	2.4
V-1947	VC-55	(145-147)	47	53	0	0.54	0.9	1.8	-0.8	2.5
V-1947	VC-55	(150-152)	39	61	0	0.48	1.1	1.8	-1.2	1.9
V-1947	VC-55	(155-157)	26	74	0	0.37	1.5	1.8	-1.1	3.1
V-1947	VC-55	(160-162)	46	54	0	0.55	0.9	1.8	-0.9	2.0
V-1947	VC-55	(165-167)	68	32	0	0.78	0.4	1.8	-0.3	3.1
V-1947	VC-55	(170-172)	25	75	0	0.38	1.4	1.7	-1.3	2.6
V-1947	VC-55	(175-177)	17	83	0	0.33	1.6	1.7	-1.4	2.9
V-1947	VC-55	(180-182)	12	89	0	0.28	1.9	1.6	-1.5	3.4
V-1947	VC-55	(185-187)	11	89	0	0.28	1.9	1.6	-1.5	3.5
V-1947	VC-55	(190-192)	9	91	0	0.27	1.9	1.6	-1.4	3.6
V-1947	VC-55	(195-197)	29	71	0	0.39	1.4	1.8	-1.3	2.6
V-1947	VC-55	(200-202)	21	79	0	0.34	1.6	1.7	-1.2	3.3
V-1947	VC-55	(205-207)	39	61	0	0.49	1.0	1.8	-1.1	2.1
V-1975	VC-57	(9-11)	0	97	3	0.07	3.8	1.6	-0.3	4.4
V-1975	VC-57	(19-21)	0	95	5	0.07	3.9	1.7	-0.1	4.1
V-1975	VC-57	(29-31)	1	98	1	0.09	3.5	1.3	-0.9	5.5
V-1975	VC-57	(95-99)	60	22	18	0.26	2.0	4.3	-0.7	2.2
V-1977	VC-59	(8-10)	0	99	1	0.08	3.7	1.4	-0.9	3.7
V-1977	VC-59	(18-20)	85	15	0	1.04	-0.1	1.6	0.1	3.8
V-1977	VC-59	(38-40)	67	33	1	0.71	0.5	2.0	-0.1	2.9
V-1977	VC-59	(58-60)	76	23	1	0.83	0.3	1.9	0.4	4.7
V-1985	VC-65	(25-27)	29	69	3	0.20	2.3	2.5	-0.8	2.7
V-1985	VC-65	(48-50)	33	67	0	0.49	1.0	1.7	-0.9	2.8
V-1985	VC-65	(58-60)	35	65	1	0.51	1.0	1.8	-0.5	3.9
V-1985	VC-65	(68-70)	89	11	0	1.20	-0.3	1.3	-0.3	3.3
V-1985	VC-65	(78-80)	79	21	0	1.03	-0.1	1.4	-0.3	3.2
V-1985	VC-65	(88-90)	66	34	0	0.88	0.2	1.6	-0.2	4.1
V-1986	VC-66	(5-7)	0	99	1	0.08	3.6	1.4	-0.6	3.9
V-1986	VC-66	(15-17)	0	99	1	0.09	3.5	1.3	-0.7	3.8
V-1986	VC-66	(25-27)	0	99	1	0.10	3.4	1.3	-0.6	4.3
V-1986	VC-66	(35-37)	0	97	3	0.09	3.6	1.6	-0.1	4.7
V-1986	VC-66	(55-57)	0	99	1	0.07	3.8	1.3	-0.6	3.1
V-1986	VC-66	(65-67)	0	100	0	0.14	2.9	1.4	-1.3	3.5
V-1986	VC-66	(75-77)	0	99	0	0.13	3.0	1.4	-1.2	4.4
V-1986	VC-66	(85-87)	0	99	1	0.12	3.1	1.4	-1.2	4.0
V-1987	VC-67	(4-6)	0	97	3	0.07	3.8	1.5	-0.4	4.0
V-1987	VC-67	(14-16)	0	99	1	0.10	3.3	1.3	-0.9	3.6
V-1987	VC-67	(24-26)	53	47	0	0.46	1.1	2.1	-0.9	1.7
V-1987	VC-67	(34-36)	10	89	0	0.24	2.1	1.8	-1.2	3.4

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
V-1987	VC-67	(44-46)	24	76	1	0.27	1.9	2.0	-1.0	3.4
V-1988	VC-68	(6-8)	0	99	1	0.08	3.6	1.3	-1.0	3.6
V-1988	VC-68	(26-28)	73	26	0	0.81	0.3	1.8	-0.1	2.8
V-1988	VC-68	(43-45)	45	37	18	0.15	2.7	4.3	0.4	1.9
V-1989	VC-69	(6-8)	34	66	0	0.42	1.2	1.9	-0.9	2.4
V-1989	VC-69	(16-18)	5	95	0	0.24	2.1	1.6	-1.3	3.7
V-1989	VC-69	(26-28)	9	91	1	0.21	2.3	1.7	-1.1	4.8
V-1989	VC-69	(36-38)	55	44	1	0.52	1.0	2.1	-0.2	3.6
V-1989	VC-69	(46-48)	82	17	1	1.01	0.0	1.6	-0.7	7.5
V-1989	VC-69	(56-58)	83	16	1	0.99	0.0	1.7	0.6	6.2
V-2004	VC-71	(6-8)	0	96	4	0.09	3.5	1.8	0.6	5.4
V-2004	VC-71	(11-13)	0	99	1	0.12	3.1	1.5	-0.5	5.3
V-2004	VC-71	(16-18)	1	99	1	0.10	3.4	1.4	-0.6	5.4
V-2004	VC-71	(21-23)	0	98	2	0.12	3.1	1.6	0.0	5.6
V-2004	VC-71	(26-28)	1	97	2	0.10	3.4	1.5	-0.3	5.6
V-2004	VC-71	(31-33)	1	98	1	0.13	2.9	1.5	-0.4	5.8
V-2004	VC-71	(36-38)	1	98	1	0.15	2.7	1.5	-0.8	5.0
V-2004	VC-71	(41-43)	1	98	1	0.14	2.9	1.5	-0.9	4.7
V-2004	VC-71	(46-48)	0	99	1	0.12	3.0	1.4	-0.9	4.8
V-2004	VC-71	(51-53)	0	99	0	0.15	2.7	1.3	-1.0	4.4
V-2004	VC-71	(56-58)	2	98	0	0.20	2.3	1.5	-1.2	3.9
V-2004	VC-71	(61-63)	0	99	1	0.14	2.8	1.4	-0.5	5.6
V-2004	VC-71	(66-68)	21	77	2	0.29	1.8	2.1	-0.4	4.3
V-2004	VC-71	(71-73)	17	82	1	0.25	2.0	1.9	-0.7	4.4
V-2004	VC-71	(76-78)	47	53	0	0.60	0.8	1.8	-0.7	2.3
V-2004	VC-71	(81-83)	38	62	0	0.48	1.1	1.8	-0.9	2.4
V-2004	VC-71	(86-88)	65	35	0	0.77	0.4	1.7	-0.4	2.4
V-2004	VC-71	(91-93)	72	28	0	0.87	0.2	1.6	-0.4	2.4
V-2004	VC-71	(96-98)	64	36	0	0.78	0.4	1.7	-0.4	2.5
V-2004	VC-71	(101-103)	71	29	0	0.88	0.2	1.6	-0.3	3.0
V-2004	VC-71	(106-108)	36	64	0	0.48	1.1	1.9	-0.8	2.6
V-2004	VC-71	(111-113)	53	46	0	0.52	1.0	2.0	-0.7	1.9
V-2004	VC-71	(116-118)	33	67	0	0.35	1.5	2.0	-1.0	2.5
V-2004	VC-71	(121-123)	31	69	0	0.38	1.4	1.9	-0.9	2.8
V-2004	VC-71	(126-128)	72	28	0	0.84	0.3	1.7	-0.2	2.9
V-2120	VC-76	(25-27)	1	96	3	0.11	3.2	1.7	-0.5	4.9
V-2120	VC-76	(30-32)	1	97	2	0.12	3.1	1.6	-0.7	4.4
V-2120	VC-76	(35-37)	1	98	2	0.13	3.0	1.6	-0.8	4.4
V-2120	VC-76	(40-42)	1	97	2	0.13	2.9	1.6	-0.8	4.3
V-2120	VC-76	(45-47)	4	95	1	0.17	2.5	1.6	-1.2	4.2
V-2120	VC-76	(50-52)	5	95	1	0.18	2.5	1.7	-1.3	4.0
V-2120	VC-76	(55-57)	5	95	1	0.17	2.5	1.7	-1.3	4.1
V-2120	VC-76	(65-67)	4	96	1	0.19	2.4	1.5	-1.2	4.3
V-2120	VC-76	(70-72)	19	80	1	0.29	1.8	1.9	-1.1	3.5
V-2120	VC-76	(75-77)	16	84	0	0.21	2.2	1.8	-1.6	4.3
V-2120	VC-76	(80-82)	30	70	0	0.38	1.4	1.9	-1.0	2.9
V-2120	VC-76	(85-87)	29	71	0	0.39	1.4	1.8	-1.2	2.4
V-2120	VC-76	(90-92)	39	61	0	0.50	1.0	1.8	-0.8	2.8

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
V-2120	VC-76	(95-97)	58	42	0	0.66	0.6	1.8	-0.5	2.7
V-2121	VC-77	(0-2)	3	97	1	0.16	2.6	1.5	-1.2	4.5
V-2121	VC-77	(20-22)	53	47	1	0.60	0.7	1.9	-0.6	2.3
V-2121	VC-77	(40-42)	64	36	0	0.72	0.5	1.8	-0.4	2.3
V-2121	VC-77	(60-62)	75	25	0	0.86	0.2	1.7	-0.2	3.0
V-2121	VC-77	(80-82)	75	25	0	0.93	0.1	1.6	-0.3	3.1
V-2121	VC-77	(100-102)	87	13	0	1.15	-0.2	1.4	0.0	4.9
V-2122	VC-78	(20-22)	0	91	9	0.03	5.0	1.9	-0.8	2.0
V-2122	VC-78	(55-57)	0	56	44	0.01	7.0	3.3	-0.9	1.4
V-2122	VC-78	(105-107)	0	80	20	0.02	5.6	2.4	-0.7	1.6
V-2123	VC-79	(35-37)	2	96	2	0.24	2.1	2.0	-0.4	3.2
V-2123	VC-79	(40-42)	4	96	1	0.43	1.2	1.5	-0.2	5.4
V-2123	VC-79	(45-47)	2	97	1	0.42	1.3	1.5	-0.2	5.4
V-2123	VC-79	(50-52)	21	79	0	0.61	0.7	1.4	-0.7	3.9
V-2123	VC-79	(55-57)	44	56	0	0.79	0.4	1.5	0.0	6.0
V-2124	VC-80	(60-62)	25	74	1	0.60	0.7	1.6	0.1	6.4
V-2124	VC-80	(80-82)	42	57	0	0.72	0.5	1.6	-0.4	3.9
V-2124	VC-80	(100-102)	18	82	1	0.53	0.9	1.6	-0.4	4.0
V-2124	VC-80	(120-122)	13	87	0	0.52	0.9	1.4	-0.8	3.7
V-2124	VC-80	(140-142)	4	95	0	0.39	1.4	1.5	-0.6	4.1
V-2124	VC-80	(160-162)	48	51	1	0.62	0.7	1.8	-0.3	3.5
V-2126	VC-82	(16-18)	0	90	10	0.04	4.7	2.1	-0.7	2.8
V-2126	VC-82	(32-34)	78	17	5	0.71	0.5	2.7	1.4	6.0
V-2126	VC-82	(42-44)	78	11	12	0.49	1.0	3.8	1.3	3.7
V-2127	VC-83	(25-27)	0	98	2	0.06	4.1	1.6	-1.0	3.2
V-2127	VC-83	(35-37)	20	79	1	0.20	2.3	2.2	-1.1	2.9
V-2127	VC-83	(45-47)	13	84	3	0.12	3.0	2.2	-1.1	3.9
V-2127	VC-83	(62-64)	38	62	0	0.41	1.3	2.0	-0.9	2.4
V-2128	VC-84	(20-22)	1	98	1	0.17	2.6	1.5	-0.7	4.6
V-2128	VC-84	(40-42)	2	98	0	0.24	2.0	1.4	-1.3	3.4
V-2128	VC-84	(60-62)	4	95	1	0.25	2.0	1.5	-0.7	5.3
V-2128	VC-84	(80-82)	20	78	2	0.32	1.6	2.0	-0.5	3.4
V-2130	VC-86	(25-27)	0	99	1	0.10	3.4	1.4	-0.7	4.0
V-2130	VC-86	(50-52)	0	99	1	0.13	3.0	1.5	-0.9	4.4
V-2130	VC-86	(75-77)	43	57	1	0.47	1.1	2.0	-0.7	2.4
V-2130	VC-86	(100-102)	69	31	0	0.83	0.3	1.7	-0.2	3.0
V-2130	VC-86	(125-127)	73	27	0	0.85	0.2	1.7	-0.1	3.3
V-2130	VC-86	(150-152)	1	98	1	0.17	2.6	1.5	-0.8	5.2
V-2130	VC-86	(175-177)	7	92	1	0.24	2.0	1.7	-0.9	4.4
V-2174	VC-89	(4-6)	0	99	1	0.07	3.8	1.4	-0.9	3.1
V-2174	VC-89	(9-11)	2	98	1	0.10	3.3	1.4	-1.6	5.4
V-2174	VC-89	(14-16)	1	98	0	0.13	3.0	1.5	-1.6	4.5
V-2174	VC-89	(19-21)	6	94	1	0.15	2.7	1.7	-1.6	4.7
V-2174	VC-89	(24-26)	72	27	0	0.74	0.4	1.9	-0.3	2.2
V-2174	VC-89	(29-31)	76	24	1	0.80	0.3	2.0	0.4	4.7
V-2174	VC-89	(34-36)	77	23	0	0.83	0.3	1.8	-0.1	2.5
V-2174	VC-89	(39-41)	76	24	0	0.79	0.3	1.9	-0.4	1.5
V-2174	VC-89	(44-46)	80	20	0	0.89	0.2	1.8	-0.2	2.4

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
V-2174	VC-89	(49-51)	70	30	0	0.73	0.5	1.9	-0.3	2.1
V-2174	VC-89	(54-56)	72	28	0	0.76	0.4	1.9	-0.4	2.0
V-2174	VC-89	(59-61)	76	23	0	0.83	0.3	1.8	-0.2	2.6
V-2174	VC-89	(64-66)	72	28	0	0.76	0.4	1.9	-0.3	2.4
V-2174	VC-89	(69-71)	55	45	1	0.51	1.0	2.1	-0.5	2.3
V-2174	VC-89	(74-76)	57	43	1	0.63	0.7	1.9	-0.3	3.3
V-2174	VC-89	(79-81)	44	56	1	0.51	1.0	2.0	-0.4	3.5
V-2174	VC-89	(84-86)	17	77	7	0.20	2.3	2.6	0.2	3.7
V-2174	VC-89	(89-91)	27	72	1	0.38	1.4	2.0	-0.5	3.7
V-2174	VC-89	(94-96)	56	44	0	0.59	0.8	2.0	-0.4	2.9
V-2174	VC-89	(99-101)	78	21	0	0.88	0.2	1.8	-0.1	2.8
V-2177	VC-92	(4-6)	0	100	0	0.12	3.1	1.3	-1.3	3.2
V-2177	VC-92	(9-11)	0	100	0	0.12	3.1	1.3	-1.2	3.3
V-2177	VC-92	(14-16)	0	99	1	0.13	3.0	1.4	-1.1	3.9
V-2177	VC-92	(19-21)	39	60	0	0.32	1.7	2.1	-1.2	2.3
V-2177	VC-92	(24-26)	9	91	1	0.18	2.5	1.7	-1.5	4.2
V-2177	VC-92	(29-31)	68	31	0	0.72	0.5	1.9	-0.4	2.1
V-2177	VC-92	(34-36)	80	20	0	0.92	0.1	1.7	-0.1	2.8
V-2177	VC-92	(39-41)	44	56	0	0.42	1.3	2.1	-0.9	2.2
V-2177	VC-92	(44-46)	19	81	0	0.21	2.2	1.9	-1.6	3.8
V-2177	VC-92	(49-51)	1	97	2	0.14	2.9	1.6	-0.6	4.9
V-2177	VC-92	(54-56)	2	98	0	0.16	2.7	1.5	-1.5	4.1
V-2177	VC-92	(59-61)	15	84	1	0.23	2.2	1.9	-1.1	4.0
V-2177	VC-92	(64-66)	63	37	1	0.63	0.7	2.0	-0.4	2.4
V-2177	VC-92	(69-71)	47	53	0	0.56	0.8	2.0	-0.7	1.8
V-2177	VC-92	(74-76)	48	51	0	0.45	1.2	2.1	-0.8	2.1
V-2178	VC-93	(5-7)	0	95	5	0.07	3.8	1.8	0.2	4.3
V-2178	VC-93	(10-12)	0	99	1	0.10	3.3	1.4	-1.1	4.3
V-2178	VC-93	(15-17)	26	73	1	0.27	1.9	2.0	-1.2	2.9
V-2178	VC-93	(20-22)	56	44	0	0.55	0.9	2.0	-0.7	1.8
V-2178	VC-93	(25-27)	62	37	0	0.64	0.7	2.0	-0.5	1.8
V-2178	VC-93	(30-32)	77	23	0	0.85	0.2	1.8	-0.2	2.2
V-2178	VC-93	(35-37)	74	26	0	0.80	0.3	1.8	-0.3	2.3
V-2178	VC-93	(40-42)	71	28	0	0.76	0.4	1.9	-0.2	2.5
V-2178	VC-93	(45-47)	69	31	0	0.89	0.2	1.6	-0.1	3.5
V-2178	VC-93	(50-52)	65	35	1	0.75	0.4	1.9	-0.1	3.4
V-2178	VC-93	(55-57)	76	23	1	0.86	0.2	1.8	0.2	4.0
V-2178	VC-93	(60-62)	77	22	1	0.82	0.3	1.9	0.0	2.8
V-2178	VC-93	(65-67)	29	70	1	0.20	2.3	2.3	-1.3	3.1
V-2178	VC-93	(70-72)	5	94	1	0.12	3.1	1.6	-1.6	5.9
V-2178	VC-93	(75-77)	2	94	5	0.10	3.4	2.0	0.3	5.1
V-2178	VC-93	(80-82)	33	65	3	0.29	1.8	2.4	-0.3	3.5
T-373	VC-1	(10-12)	0	99	1	0.11	3.2	1.4	-0.6	5.4
T-373	VC-1	(20-22)	1	99	0	0.11	3.2	1.3	-1.2	4.4
T-373	VC-1	(30-32)	13	87	0	0.25	2.0	1.6	-1.6	3.9
T-373	VC-1	(40-42)	7	93	0	0.21	2.2	1.5	-1.6	4.2
T-373	VC-1	(50-52)	9	91	0	0.23	2.1	1.6	-1.6	4.3
T-373	VC-1	(60-62)	9	91	0	0.26	2.0	1.5	-1.6	3.8

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
T-372	VC-2	(28-30)	89	10	1	1.12	-0.2	1.6	1.0	9.0
T-372	VC-2	(35-37)	97	3	0	1.33	-0.4	1.2	0.6	11.0
T-372	VC-3	(10-12)	4	96	0	0.19	2.4	1.6	-1.4	3.4
T-372	VC-3	(15-17)	4	96	0	0.34	1.6	1.4	-1.2	3.2
T-372	VC-3	(20-22)	6	94	0	0.33	1.6	1.4	-1.3	3.5
T-372	VC-3	(25-27)	4	96	0	0.30	1.8	1.4	-0.9	4.5
T-372	VC-3	(30-32)	5	95	0	0.30	1.7	1.4	-1.1	4.1
T-372	VC-3	(35-37)	1	98	0	0.29	1.8	1.3	-1.0	3.8
T-372	VC-3	(40-42)	8	92	0	0.32	1.6	1.5	-1.2	3.9
T-372	VC-3	(45-47)	30	70	0	0.51	1.0	1.6	-1.0	3.0
T-372	VC-3	(55-57)	34	66	0	0.51	1.0	1.7	-0.9	3.3
T-372	VC-3	(60-62)	66	34	0	0.81	0.3	1.6	-0.6	2.4
T-372	VC-3	(65-67)	71	29	0	0.91	0.1	1.5	-0.6	2.4
T-372	VC-3	(70-72)	74	26	0	0.98	0.0	1.5	-0.4	3.2
T-388	VC-8	(6-8)	5	89	6	0.09	3.5	2.1	-0.6	4.2
T-388	VC-8	(11-13)	75	24	1	0.87	0.2	1.8	0.1	3.8
T-388	VC-8	(16-18)	94	6	0	1.25	-0.3	1.3	0.3	6.3
T-388	VC-8	(21-23)	70	29	0	0.84	0.3	1.8	0.1	3.9
T-388	VC-8	(26-28)	94	6	0	1.27	-0.3	1.3	0.1	5.7
T-388	VC-10	(7-9)	27	73	1	0.51	1.0	1.7	-0.3	4.2
T-388	VC-10	(43-45)	0	99	1	0.15	2.8	1.4	-0.6	4.4
T-388	VC-10	(48-50)	1	96	3	0.17	2.6	1.8	0.5	6.1
T-388	VC-10	(53-56)	1	97	2	0.23	2.2	1.8	0.8	7.3
T-388	VC-10	(74-76)	65	28	7	0.38	1.4	3.1	0.4	3.1
T-388	VC-11	(6-8)	66	33	1	0.92	0.1	1.7	1.5	12.0
T-388	VC-11	(11-13)	39	59	1	0.66	0.6	1.9	1.1	8.9
T-388	VC-11	(16-18)	18	81	1	0.55	0.9	1.6	0.4	8.5
T-388	VC-13	(59-61)	0	99	1	0.26	1.9	1.5	0.3	6.8
T-388	VC-14	(18-20)	0	98	2	0.10	3.4	1.6	0.2	5.6
T-388	VC-14	(30-32)	0	99	1	0.09	3.5	1.4	0.1	6.1
T-388	VC-15	(4-6)	0	97	3	0.08	3.8	1.8	0.6	5.1
T-388	VC-15	(18-20)	0	99	1	0.18	2.5	1.6	0.1	6.2
T-388	VC-15	(22-24)	0	98	2	0.10	3.3	1.6	0.6	6.6
T-388	VC-15	(27-29)	0	99	1	0.13	2.9	1.5	0.1	6.3
T-388	VC-15	(30-32)	0	98	2	0.12	3.1	1.7	0.9	7.0
T-388	VC-15	(39-41)	0	87	13	0.03	5.3	2.2	-0.7	1.9
T-388	VC-15	(48-50)	0	93	7	0.04	4.9	2.0	-0.3	2.5
T-388	VC-15	(53-55)	0	95	5	0.04	4.5	1.9	0.1	3.3
T-388	VC-16	(11-13)	0	99	1	0.09	3.5	1.4	-0.1	5.5
T-388	VC-16	(16-18)	0	92	8	0.06	4.0	2.3	1.0	3.9
T-388	VC-16	(21-23)	0	96	4	0.07	3.8	1.8	1.0	5.8
T-388	VC-16	(26-28)	0	99	1	0.08	3.7	1.4	-0.4	4.3
T-388	VC-16	(31-33)	0	97	3	0.06	4.0	1.7	0.3	4.5
T-388	VC-21	(9-11)	0	94	6	0.06	4.1	1.9	0.0	3.6
T-388	VC-21	(14-16)	0	99	1	0.08	3.7	1.4	-0.1	5.2
T-388	VC-21	(19-21)	0	99	1	0.11	3.2	1.4	-0.9	4.1
T-388	VC-21	(24-26)	0	98	2	0.08	3.7	1.6	0.2	5.7
T-388	VC-22	(10-12)	0	89	11	0.04	4.7	2.1	-0.2	2.5

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
T-388	VC-22	(15-17)	0	98	2	0.06	4.0	1.7	0.3	4.7
T-388	VC-22	(20-22)	0	98	2	0.06	4.1	1.6	-0.3	3.6
T-388	VC-22	(25-27)	0	98	2	0.06	4.1	1.6	-0.1	4.1
T-388	VC-22	(30-32)	0	99	2	0.06	4.0	1.5	-0.3	3.9
T-388	VC-22	(35-37)	0	99	1	0.07	3.8	1.4	-0.2	4.7
T-388	VC-22	(40-42)	0	98	2	0.09	3.5	1.6	0.2	5.6
T-388	VC-22	(45-47)	0	99	1	0.08	3.7	1.4	-0.7	3.8
T-389	VC-35	(31-33)	9	90	1	0.13	2.9	1.7	-1.4	5.7
T-389	VC-35	(36-38)	0	99	1	0.13	3.0	1.4	-1.0	4.3
T-389	VC-35	(41-43)	0	99	1	0.14	2.8	1.4	-0.8	4.6
T-389	VC-35	(46-48)	0	99	1	0.14	2.8	1.4	-0.8	4.6
T-389	VC-29	(35-37)	1	98	1	0.19	2.4	1.5	-0.8	4.7
T-389	VC-29	(40-42)	1	98	1	0.11	3.2	1.5	-0.8	4.9
T-389	VC-29	(45-47)	1	98	1	0.14	2.9	1.4	-1.0	4.8
T-389	VC-29	(50-52)	6	93	1	0.25	2.0	1.6	-0.9	4.4
T-389	VC-29	(55-57)	41	58	0	0.58	0.8	1.7	-0.7	3.4
T-389	VC-29	(60-62)	37	63	1	0.48	1.1	1.8	-0.6	3.4
T-389	VC-29	(65-67)	1	99	1	0.16	2.7	1.4	-0.7	5.1
T-400	VC-A20	(10-12)	0	99	1	0.17	2.6	1.3	-0.6	5.1
T-400	VC-A20	(12-14)	0	73	27	0.02	5.9	3.0	-0.4	1.5
T-400	VC-A20	(14-16)	0	80	20	0.03	5.3	2.7	-0.4	1.8
T-400	VC-A20	(16-18)	0	79	21	0.02	5.4	2.6	-0.6	1.8
T-400	VC-A20	(18-20)	0	68	32	0.02	6.0	3.0	-0.7	1.6
T-400	VC-A20	(20-22)	0	60	40	0.01	6.6	3.2	-0.8	1.3
T-400	VC-A20	(22-24)	0	88	12	0.04	4.6	2.2	-0.1	2.6
T-400	VC-A20	(24-26)	0	96	4	0.07	3.8	1.9	-0.7	5.0
T-400	VC-A20	(26-28)	0	97	4	0.07	3.8	1.8	-0.7	5.1
T-400	VC-A20	(28-30)	0	96	4	0.07	3.8	1.9	-0.7	4.9
T-400	VC-A20	(30-32)	0	96	4	0.07	3.9	1.9	-0.6	4.6
T-400	VC-A20	(32-34)	0	96	4	0.07	3.8	1.9	-0.6	4.7
T-400	VC-A20	(36-38)	0	96	4	0.07	3.8	1.9	-0.2	4.3
T-400	VC-A20	(38-40)	0	96	4	0.07	3.8	1.8	0.0	4.1
T-400	VC-A20	(40-42)	0	95	5	0.06	4.1	2.1	-0.6	4.1
T-400	VC-A20	(42-44)	0	94	6	0.06	4.2	2.1	-0.6	3.8
T-400	VC-A20	(44-46)	0	94	6	0.05	4.2	2.2	-0.6	3.7
T-400	VC-A20	(46-48)	0	89	11	0.04	4.5	2.6	-0.5	2.6
T-400	VC-A20	(48-50)	0	91	9	0.06	4.0	2.3	-0.4	3.4
T-400	VC-A20	(50-52)	0	90	10	0.06	4.1	2.3	-0.3	3.2
T-400	VC-A20	(52-54)	0	91	9	0.06	4.0	2.4	-0.5	3.3
T-400	VC-A20	(54-56)	0	91	9	0.06	4.0	2.2	-0.1	3.3
T-400	VC-A20	(56-58)	0	92	8	0.06	4.0	2.5	-0.6	3.5
T-400	VC-A20	(58-60)	0	89	11	0.06	4.1	2.6	-0.5	3.0
T-400	VC-A20	(60-62)	7	70	22	0.05	4.3	3.9	-0.1	1.8
T-400	VC-A20	(62-64)	0	77	23	0.02	5.6	3.2	0.0	1.5
T-400	VC-A8	(14-16)	0	71	29	0.02	6.1	3.1	-0.3	1.4
T-400	VC-A8	(16-18)	0	70	30	0.01	6.2	3.3	-0.2	1.2
T-400	VC-A8	(18-20)	0	78	22	0.02	5.7	3.1	-0.1	1.4
T-400	VC-A8	(20-22)	0	94	6	0.08	3.7	2.2	-0.5	4.2

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
T-400	VC-A8	(22-24)	0	96	4	0.09	3.5	2.0	-0.5	4.9
T-400	VC-A8	(24-26)	0	96	4	0.09	3.5	2.0	-0.6	4.9
T-400	VC-A8	(26-28)	0	97	4	0.09	3.5	2.0	-0.5	4.9
T-400	VC-A8	(28-30)	0	96	4	0.09	3.4	2.0	-0.4	4.8
T-400	VC-A8	(30-32)	0	96	4	0.10	3.4	2.1	-0.5	4.8
T-400	VC-A8	(32-34)	0	97	4	0.10	3.4	2.0	-0.4	4.8
T-400	VC-A8	(34-36)	0	96	4	0.10	3.4	2.1	-0.4	4.8
T-400	VC-A8	(36-38)	0	96	4	0.10	3.4	2.1	-0.4	4.8
T-400	VC-A8	(38-40)	0	96	4	0.09	3.4	2.1	-0.4	4.7
T-400	VC-A8	(40-42)	0	96	4	0.10	3.4	2.1	-0.1	4.5
T-400	VC-A8	(42-44)	0	96	4	0.09	3.5	2.1	-0.2	4.6
T-400	VC-A8	(44-46)	0	95	4	0.08	3.6	2.2	-0.3	4.5
T-400	VC-A8	(46-48)	0	95	5	0.08	3.7	2.1	-0.2	4.3
T-400	VC-A8	(48-50)	0	94	6	0.06	4.0	2.2	-0.4	3.9
T-400	VC-A8	(50-52)	0	97	3	0.09	3.5	1.8	-0.4	5.4
T-400	VC-A8	(52-54)	1	95	5	0.08	3.7	2.1	-0.4	4.4
T-400	VC-A8	(54-56)	0	94	5	0.07	3.9	2.2	-0.4	4.1
T-400	VC-A8	(56-58)	0	96	4	0.07	3.9	2.0	-0.5	4.5
T-400	VC-A8	(58-60)	0	98	2	0.08	3.7	1.7	-0.2	5.1
T-400	VC-A8	(60-62)	1	97	2	0.07	3.8	1.6	0.0	5.6
T-400	VC-A6	(30-31)	34	51	15	0.16	2.7	3.9	-0.4	2.2
T-400	VC-A17	(60-63)	54	36	10	0.27	1.9	3.6	0.6	2.8
T-400	VC-A17	(63-66)	70	27	4	0.54	0.9	2.7	0.7	4.3
T-400	VC-A17	(66-69)	53	41	6	0.32	1.7	3.1	0.5	3.4
T-400	VC-A17	(69-72)	49	45	6	0.29	1.8	3.1	0.3	3.3
T-401	VC-38	(22-24)	0	83	17	0.04	4.6	3.1	0.4	2.0
T-401	VC-38	(24-26)	1	88	11	0.06	4.1	2.7	0.5	2.9
T-401	VC-38	(26-28)	11	82	7	0.11	3.1	2.8	0.2	3.5
T-401	VC-38	(28-30)	20	76	4	0.21	2.3	2.6	0.2	4.0
T-401	VC-38	(30-32)	13	83	4	0.18	2.5	2.4	0.1	4.4
T-401	VC-38	(32-34)	40	59	2	0.38	1.4	2.3	0.0	4.0
T-401	VC-38	(34-36)	41	58	2	0.36	1.5	2.4	-0.1	3.8
T-401	VC-38	(36-38)	38	60	2	0.34	1.6	2.4	0.0	3.9
T-401	VC-38	(38-40)	41	57	1	0.39	1.4	2.3	-0.1	3.8
T-401	VC-38	(40-42)	31	68	2	0.32	1.7	2.3	-0.2	3.9
T-401	VC-39	(15-17)	0	94	6	0.07	3.9	2.1	-0.5	4.1
T-401	VC-39	(17-19)	0	90	10	0.04	4.6	2.5	-0.4	2.7
T-401	VC-39	(19-21)	0	94	6	0.07	3.8	2.1	-0.1	4.1
T-401	VC-39	(21-23)	1	95	5	0.09	3.5	2.0	-0.1	4.3
T-401	VC-39	(23-25)	0	93	7	0.06	4.0	2.2	-0.4	3.8
T-401	VC-39	(25-27)	0	94	6	0.08	3.7	2.3	-0.4	4.1
T-401	VC-39	(27-29)	1	95	4	0.12	3.1	2.2	-0.3	4.6
T-401	VC-39	(29-31)	1	97	2	0.11	3.1	1.8	-0.2	5.8
T-401	VC-39	(31-33)	0	98	2	0.12	3.1	1.7	-0.2	5.8
T-401	VC-39	(33-35)	0	98	2	0.12	3.1	1.6	-0.3	4.9
T-401	VC-39	(35-37)	0	98	2	0.13	3.0	1.7	-0.1	5.7
T-401	VC-39	(37-39)	1	98	2	0.12	3.0	1.8	-0.1	5.6
T-401	VC-39	(39-41)	0	98	1	0.13	3.0	1.6	-0.8	4.4

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
T-401	VC-39	(41-43)	1	97	2	0.11	3.2	1.6	-0.9	4.4
T-401	VC-39	(43-45)	0	97	3	0.08	3.6	1.6	-0.6	3.8
T-401	VC-39	(45-47)	0	98	2	0.11	3.2	1.6	-0.8	4.1
T-401	VC-39	(47-49)	3	95	2	0.16	2.6	1.8	-1.1	3.7
T-401	VC-39	(49-51)	2	97	1	0.17	2.6	1.7	-1.0	3.6
T-401	VC-39	(51-53)	1	98	1	0.16	2.6	1.7	-1.0	3.7
T-401	VC-39	(53-55)	2	96	1	0.16	2.6	1.7	-1.0	3.8
T-401	VC-34	(40-42)	0	94	6	0.09	3.5	2.0	0.1	4.0
T-401	VC-34	(42-44)	0	94	6	0.11	3.2	2.1	0.0	4.1
T-401	VC-34	(44-46)	2	93	5	0.14	2.9	2.1	-0.2	4.1
T-401	VC-34	(46-48)	2	95	4	0.15	2.7	2.1	-0.2	4.1
T-401	VC-34	(48-50)	4	92	4	0.15	2.7	2.2	-0.3	3.9
T-402	VC-50	(5-7)	0	82	18	0.03	5.1	2.4	-0.7	2.0
T-402	VC-50	(10-12)	0	80	21	0.02	5.5	2.4	-0.9	1.8
T-402	VC-50	(15-17)	0	88	12	0.03	4.9	2.1	-0.9	2.1
T-402	VC-50	(20-22)	0	74	26	0.02	5.8	2.6	-0.9	1.6
T-402	VC-50	(25-27)	0	83	18	0.03	5.0	2.4	-0.6	2.0
T-402	VC-50	(30-32)	0	80	20	0.02	5.4	2.4	-0.9	1.8
T-402	VC-50	(35-37)	0	82	18	0.03	5.2	2.3	-0.8	1.9
T-402	VC-50	(40-42)	0	83	17	0.03	5.0	2.4	-0.8	2.2
T-402	VC-50	(45-47)	0	85	15	0.03	5.0	2.3	-0.7	2.0
T-403	VC-35	(9-11)	0	99	1	0.08	3.6	1.4	-0.3	4.6
T-403	VC-35	(14-16)	0	98	2	0.09	3.4	1.5	0.0	5.5
T-403	VC-35	(19-21)	0	99	1	0.09	3.5	1.4	-0.3	4.6
T-403	VC-35	(24-26)	0	99	1	0.10	3.3	1.3	-0.6	4.2
T-403	VC-35	(cc)	0	99	1	0.09	3.5	1.3	-0.5	4.2
T-403	VC-36	(21-23)	4	96	0	0.25	2.0	1.5	-1.5	3.5
T-403	VC-36	(27-29)	0	100	0	0.17	2.6	1.3	-1.4	3.1
T-403	VC-36	(32-34)	61	39	0	0.66	0.6	1.8	-0.9	1.6
T-404	VC-3	(24-26)	3	97	1	0.15	2.8	1.6	-1.6	3.8
T-404	VC-3	(29-31)	3	96	1	0.14	2.8	1.7	-1.3	4.2
T-404	VC-3	(39-41)	9	91	0	0.33	1.6	1.6	-1.2	2.7
T-404	VC-3	(49-51)	2	98	1	0.11	3.2	1.5	-1.4	4.5
T-404	VC-3	(54-56)	2	98	0	0.20	2.3	1.5	-1.2	3.9
T-404	VC-3	(59-61)	22	78	0	0.42	1.3	1.7	-1.0	3.0
T-405	VC-37	(65-68)	34	66	0	0.46	1.1	1.8	-0.9	2.5
T-405	VC-37	(71-74)	49	50	1	0.60	0.7	1.9	-0.2	3.7
T-405	VC-41	(26-30)	98	2	1	1.29	-0.4	1.3	0.7	8.5
T-405	VC-53	(10-12)	0	100	1	0.09	3.5	1.2	-0.5	4.7
T-405	VC-53	(20-22)	0	100	0	0.09	3.4	1.2	-0.7	4.1
T-405	VC-53	(30-32)	0	99	1	0.08	3.6	1.3	-0.2	5.1
T-405	VC-53	(40-42)	0	99	1	0.09	3.6	1.3	-0.5	4.5
T-405	VC-53	(50-52)	0	98	2	0.08	3.7	1.7	-0.3	5.4
T-405	VC-53	(69-71)	17	82	1	0.19	2.4	2.0	-0.8	4.9
Martin	161 m	0	0	100	0	0.12	3.1	1.3	-1.1	3.5
Martin	279 m	0	0	100	0	0.12	3.1	1.3	-1.1	3.4

Appendix III: Grain Size Data (cont.)

Dive #	Core#	Interval cm	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
MLML	MLP-8-21	(0-6)	0	94	6	0.06	4.1	1.6	-0.7	2.6
MLML	MLP-8-21	(6-10)	0	98	2	0.08	3.7	1.4	-0.8	2.7
MLML	MLP-8-21	(10-13)	0	96	4	0.07	3.8	1.6	-0.4	3.6
MLML	MLP-8-21	(13-16)	0	98	2	0.08	3.6	1.4	-0.6	3.6
MLML	MLP-8-21	(13-16)	0	99	1	0.10	3.4	1.2	-1.0	2.8
MLML	MLP-8-21	(20-24)	0	99	1	0.10	3.4	1.2	-1.0	3.2
MLML	MLP-8-21	(24-28)	0	99	1	0.09	3.5	1.3	-1.1	3.0
MLML	MLP-8-21	(28-32)	0	100	1	0.11	3.2	1.3	-1.2	3.4
MLML	MLP-8-21	(32-34)	0	99	1	0.10	3.3	1.3	-1.1	3.5
MLML	MLP-8-21	(34-36)	0	100	0	0.10	3.3	1.2	-1.4	3.3
MLML	MLP-8-21	(36-38)	15	84	1	0.13	3.0	1.9	-2.1	5.6
MLML	MLP-8-21	(0-6 Fine)	0	93	7	0.05	4.3	1.7	-0.8	2.1
MLML	MLP-8-21	Mud	0	60	40	0.01	6.5	3.5	-0.4	1.2

Appendix III: Grain Size Data (cont.)

Location	Sand Type	% Gravel	% Sand	% < Silt	Mean (mm)	Mean(Phi)	St Dev	Skew	Kurt
Brighton	Beach	0	100	0	0.12	3.1	1.2	-1.1	2.7
ML Jetty	Beach	0	100	0	0.12	3.1	1.2	-1.1	3.4
MBARI	Beach	2	98	0	0.38	1.4	1.3	-1.2	3.1
Monterey Hotel	Beach	0	100	0	0.19	2.4	1.1	-1.1	2.6
Carmel Beach	Beach	0	100	0	0.30	1.7	1.3	-1.3	2.8
Salinas Riv SB	Beach	0	100	0	0.12	3.0	1.2	-1.0	2.7
Portrero Road	Beach	0	100	0	0.26	1.9	1.4	-1.4	2.4
M Landing Nth	Beach	0	100	0	0.16	2.7	1.2	-1.4	2.3
Zmudowski	Beach	0	100	0	0.14	2.8	1.1	-1.2	1.7
Pajaro Dunes	Beach	0	100	0	0.11	3.2	1.2	-1.3	2.1
Jetty North	Beach	0	100	0	0.13	3.0	1.2	-1.3	1.9
Seaside Beach	Beach	0	100	0	0.22	2.2	1.3	-1.4	3.6
Pfeiffer Beach	Beach	0	100	0	0.13	3.0	1.3	-1.6	2.9
Shorelab	Beach	0	100	0	0.13	2.9	1.3	-1.5	2.8
Monterey Hotel	Dune	0	100	0	0.20	2.3	1.1	-1.2	2.1
Costco Plaza	Dune	0	100	0	0.20	2.3	1.3	-1.3	2.1
Marina South	Dune	0	100	0	0.25	2.0	1.2	-1.3	1.9
Marina Beach	Dune	0	100	0	0.24	2.1	1.2	-1.2	2.4
Marina North	Dune	0	100	0	0.26	2.0	1.2	-1.1	2.6
Salinas Riv SB	Dune	0	100	0	0.19	2.4	1.3	-1.1	3.2
Portreo Road	Dune	0	100	0	0.16	2.6	1.2	-1.0	3.1
Shorelab	Dune	0	100	0	0.15	2.8	1.2	-1.1	2.5
Jetty North	Dune	0	100	0	0.21	2.3	1.2	-1.1	2.9
Slough North	Dune	0	100	0	0.19	2.4	1.2	-1.1	2.6
Zmudowski	Dune	0	100	0	0.14	2.9	1.2	-1.2	2.0
Pajaro Dunes	Dune	0	100	0	0.13	2.9	1.2	-1.2	2.2
Manresa	Dune	0	100	0	0.16	2.7	1.2	-1.2	2.3
Seaside Dunes	Dune	0	100	0	0.16	2.7	1.3	-1.3	2.7
Salinas River Bl	River	0	100	0	0.19	2.4	1.3	-0.9	4.3
Arroyo Seco	River	2	98	1	0.27	1.9	1.4	-0.5	5.4
San Antonio	River	2	98	0	0.41	1.3	1.3	-0.6	5.5
San Benito	River	17	82	2	0.38	1.4	1.9	-0.2	4.8
Pajaro	River	0	99	2	0.11	3.2	1.4	-0.5	4.1
Salinas Riv Gon	River	0	0	99	1.10	0.2	2.5	1.5	-0.6
Nacimiento Riv	River	0	0	100	0.20	0.3	1.6	1.4	-1.0
San Lorenzo Riv	River	0	0	99	1.10	0.3	1.9	1.6	-0.5
Tres Pinos Cr	River	0	0	94	5.70	0.2	2.3	2.3	0.6
Salinas Riv Grn	River	1	1	99	0.50	0.2	2.3	1.5	-1.0
Arroyo Seco Gr	River	11	11	89	0.30	0.4	1.4	1.5	-1.0
Carmel River	River	40	40	60	0.70	0.6	0.7	1.7	-0.2
Aptos Creek	River	12	12	87	0.80	0.3	2.0	1.8	-1.1
Soquel Creek	River	5	5	95	0.20	0.4	1.4	1.4	-0.9
MBARI 2.4 m	(?)	22	22	78	0.10	0.5	0.9	1.5	-0.8
MBARI 2.7 m	(?)	33	33	67	0.10	0.7	0.6	1.5	-0.7
MBARI 4 m	(?)	26	26	73	0.10	0.6	0.7	1.5	-0.7

APPENDIX IV: QFL DATA

Appendix IVa: Sub-Samples Selected for QFL Analysis

Core # or Location	Depth from Core Top (cm)	Phi	Water Depth	Latitude	Longitude
V-1947 VC-55	11	3	86	36.80521	121.79857
V-2004 VC-71	7	3	134	36.80210	121.80617
V-1986 VC-66	6	3	226	36.78957	121.82752
V-1869 VC-18	21	3	291	36.79397	121.84579
V-1730 VC-4	6	3	444	36.79552	121.89059
V-1872 VC-21	10	3	519	36.79083	121.90305
V-1851 VC-16	10	3	693	36.78263	121.93409
V-1851 VC-16	10	2	693	36.78263	121.93409
V-1851 VC-16	10	1	693	36.78263	121.93409
V-1851 VC-16	90	3	693	36.78263	121.93409
V-1851 VC-16	90	2	693	36.78263	121.93409
V-1851 VC-16	90	1	693	36.78263	121.93409
V-1851 VC-16	170	3	693	36.78263	121.93409
V-1851 VC-16	170	2	693	36.78263	121.93409
V-1851 VC-16	170	1	693	36.78263	121.93409
V-1987 VC-67	6	3	887	36.76423	121.98614
V-1975 VC-57	10	3	1,008	36.78063	122.01294
T-232 PC-57	15	3	1,097	36.58176	122.04872
V-1759 PC-34	5.5	3	1,158	36.76183	122.03877
V-2124 VC-80	61	3	1,297	36.73243	122.01720
V-2124 VC-80	61	4	1,297	36.73243	122.01720
V-2121VC-77	21	3	1,392	36.72516	122.01529
V-2122 VC-77	21	4	1,392	36.72516	122.01529
T-167 PC-56	20	3	1,951	36.68190	122.10401
T-389 VC-29	38	3	2,104	36.65667	122.11506
T-389 VC-29	38	4	2,104	36.65667	122.11506
T-212 PC-73	13	3	2,431	36.57097	122.18743
T-160 PC-41	9	3	2,742	36.61903	122.32898
T-217 PC-9	12	3	2,810	36.61817	122.38268
T-388 VC-22	11	3	3,172	36.49392	122.61596
T-388 VC-22	11	4	3,172	36.49392	122.61596
T-400 VC-A20	11	3	3,612	36.21903	123.15842
T-400 VC-A20	11	4	3,612	36.21903	123.15842
T-401 PC-39	16	3	3,884	35.54287	122.99842
T-401 PC-39	16	4	3,884	35.54287	122.99842
Pajaro Dunes State Beach	2.5	3	(N/A)	36.86517	121.81875
Zmudowski State Beach	2.5	3	(N/A)	36.83667	121.80250
Moss Landing North	2.5	3	(N/A)	36.81506	121.79163
South of Jetty	2.5	3	(N/A)	36.80579	121.78884
Portrero Road	2.5	3	(N/A)	36.79130	121.79308
Salinas River State Beach	2.5	3	(N/A)	36.77553	121.79783
Carmel River Beach	2.5	3	(N/A)	36.53806	121.92861
Salinas River	2.5	3	(N/A)	36.63139	121.67306
Pajaro River	2.5	3	(N/A)	36.89944	121.59501
Salinas River Gonzales	2.5	3	(N/A)	36.48710	121.46582
Arroyo Seco River	2.5	3	(N/A)	36.28222	121.32389
Nacimiento River	2.5	3	(N/A)	36.00390	121.39591
San Antonio River	2.5	3	(N/A)	36.06901	121.32251
Tres Pinos Creek	2.5	3	(N/A)	36.78281	121.31320
San Benito River	2.5	3	(N/A)	36.85222	121.43083
Scotts Valley	2.5	3	(N/A)	37.06182	122.01777
Pacific Grove	2.5	3	(N/A)	36.58929	121.92196

Appendix IVb: QFL Compositions

Cruise #	Core #	Water Depth	Core Depth (cm)	Phi	# Q	# F	# L	Total	% Q	% F	% L
V-1947	VC-55	86	11	3	135	66	114	315	43	21	36
V-2004	VC-71	134	7	3	138	64	108	310	45	21	35
V-1986	VC-66	226	6	3	142	55	125	322	44	17	39
V-1869	VC-18	291	21	3	134	66	117	317	42	21	37
V-1730	VC-4	444	6	3	133	56	114	303	44	19	38
V-1872	VC-21	519	10	3	128	62	111	301	43	21	37
V-1851	VC-16	693	10	3	132	59	112	303	44	20	37
V-1851	VC-16	693	10	2	115	57	148	320	36	18	46
V-1851	VC-16	693	10	1	121	65	136	322	38	20	42
V-1851	VC-16	693	90	3	135	62	117	314	43	20	37
V-1851	VC-16	693	90	2	143	64	109	316	45	20	35
V-1851	VC-16	693	90	1	132	62	115	309	43	20	37
V-1851	VC-16	693	170	3	126	66	114	306	41	22	37
V-1851	VC-16	693	170	2	135	62	125	322	42	19	39
V-1851	VC-16	693	170	1	125	64	120	309	41	21	39
V-1987	VC-67	887	6	3	125	66	112	303	41	22	37
V-1975	VC-57	1008	10	3	108	57	138	303	36	19	46
T-232	PC-57	1098	15	3	141	47	115	303	47	16	38
V-1759	PC-34	1158	5.5	3	124	48	132	304	41	16	43
V-2124	VC-80	1297	61	3	136	45	125	306	44	15	41
V-2124	VC-80	1297	61	4	150	42	125	317	47	13	39
V-2121	VC-77	1392	21	3	145	45	126	316	46	14	40
V-2122	VC-77	1392	21	4	150	42	128	320	47	13	40
T-167	PC-56	1951	20	3	165	36	123	324	51	11	38
T-389	VC-29	2104	38	3	144	33	149	326	44	10	46
T-389	VC-29	2104	38	4	135	32	142	309	44	10	46
T-212	PC-73	2431	13	3	122	39	150	311	39	13	48

Appendix IVb: QFL Compositions (Cont.)

Cruise #	Core #	Water Depth	Core Depth (cm)	Phi	# Q	# F	# L	Total	% Q	% F	% L
T-160	PC-41	2742	9	3	130	45	157	332	39	14	47
T-217	PC-9	2810	12	3	145	42	153	340	43	12	45
T-388	VC-22	3172	11	3	108	35	163	306	35	11	53
T-388	VC-22	3172	11	4	110	40	165	315	35	13	52
T-400	VC-A20	3612	11	3	92	38	194	324	28	12	60
T-400	VC-A20	3612	11	4	110	37	160	307	36	12	52
T-401	PC-39	3884	16	3	115	42	165	322	36	13	51
T-401	PC-39	3884	16	4	111	35	172	318	35	11	54
Location				Phi	# Q	# F	# L	Total	% Q	% F	% L
Pajaro Dunes State Beach				3	132	76	114	322	41	24	35
Zmudowski State Beach				3	125	63	122	310	40	20	39
Moss Landing North				3	147	55	115	46	17	36	17
South of Jetty				3	141	48	134	44	15	42	15
Portrero Road				3	132	55	117	43	18	39	16
Salinas River State Beach				3	156	61	108	325	48	19	33
Carmel River Beach				3	132	63	129	41	19	40	19
Salinas River				3	149	68	96	48	22	31	22
Pajaro River				3	111	44	156	36	14	50	14
Salinas River Gonzales				3	146	64	98	47	21	32	21
Arroyo Seco River				3	153	56	102	49	18	33	18
Nacimiento River				3	161	54	97	52	17	31	17
San Antonio River				3	148	63	98	48	20	32	20
Tres Pinos Creek				3	102	48	177	31	15	54	15
San Benito River				3	100	44	165	32	14	53	14
Scotts Valley Santa Margarita					205	66	32	68	22	11	22
Pacific Grove Tertiary Sand					198	65	38	66	22	13	22
Toro Road					195	75	36	64	25	12	25

APPENDIX V: ACCESSORY MINERAL DATA

Appendix Va: Accessory Mineral Samples

Core # or Location	Interval	Core Type	Depth (m)	Latitude	Longitude
MLP-8-21	(6-10 cm)	diver core	20	36.80333	121.79028
GS161	(0-5 cm)	grab sample	161	36.79903	121.81305
V-1868 VC-18	(2-4 cm)	vibracore	283	36.79397	121.84579
GS297	(0-5 cm)	grab sample	291	36.79370	121.84503
V-1873 VC-22	(11-13 cm)	vibracore	292	36.79291	121.84635
V-1878 VC-28	(10-12 cm)	vibracore	294	36.79345	121.84618
V-1741 VC-6	(10-12 cm)	vibracore	423	36.79540	121.88370
V-1744 VC-9	(15-17 cm)	vibracore	423	36.79589	121.88290
V-1740 VC-5	(7-9 cm)	vibracore	424	36.79575	121.88320
V-1730 VC-4	(5-7 cm)	vibracore	443	36.79543	121.89030
V-1748 VC-13	(10-14 cm)	vibracore	444	36.79575	121.89073
V-1872 VC-21	(9-11 cm)	vibracore	519	36.79082	121.90322
V-1870 VC-19	(6-8 cm)	vibracore	689	36.78436	121.93365
V-1877 VC-27	(12-14 cm)	vibracore	692	36.78260	121.93467
V-1861 VC-16	(9-11 cm)	vibracore	692	36.78360	121.93313
V-1871 VC-20	(8-10 cm)	vibracore	699	36.78223	121.93332
V-1776 PC-30	(6-7 cm)	push core	873	36.75940	121.98390
T-232 PC-57	(14-16 cm)	push core	1,097	36.58176	122.04872
V-1874 VC-23	cc	vibracore	1,159	36.76048	122.04230
T-167 PC-77	(18-20 cm)	push core	1,945	36.68318	122.10095
T-214 PC-79	(12-14 cm)	push core	2,431	36.57097	122.18743
T-212 PC-53	(7-10 cm)	push core	2,702	36.60325	122.30534
T-160 PC-50	(14-15 cm)	push core	2,743	36.61996	122.33017
T-217 PC-21	(11-12 cm)	push core	2,810	36.61850	122.38344
T-388 VC-22	(10-12 cm)	vibracore	3,172	36.49392	122.61597
T-400 VC-A20	(10-12 cm)	vibracore	3,612	36.21904	123.15842
Carmel Beach	0-5 cm	hand core	0	36.53806	121.92861
New Brighton Beach	0-5 cm	hand core	0	36.97842	121.93466
Pajaro Dunes Beach	0-5 cm	hand core	0	36.86517	121.81875
Zmudowski State Beach	0-5 cm	hand core	0	36.83667	121.80250
M. Landing Beach North	0-5 cm	hand core	0	36.81506	121.79163
Jetty North Beach	0-5 cm	hand core	0	36.80788	121.78971
Jetty South Beach	0-5 cm	hand core	0	36.80579	121.78884
Portrero Road Beach	0-5 cm	hand core	0	36.79130	121.79308
Salinas River Beach	0-5 cm	hand core	0	36.77553	121.79783

Appendix Vb: Observed Optical Properties of Accessory Minerals this Study

Mineral	Color	Relief	Pleochroism	Extinction Angles	Interference Color	Cleavage Angle
Hornblende	Green or Brown	Moderate to High +	Green/Brown	Inclined	2nd order Green to Yellow	56 & 124
Augite	Green Brown to Brown	Moderate +	Pale Green	Inclined	2nd order Green to Yellow	87
Hypersthene	Brown	High +	V. Pale green	Parallel	1st Black and Gray	88
Garnet	Clear to Pink	Very High +	none	N/A	Opaque	(-)
Sphene	Yellow Wedges	Extremely High +	Brownish Green	23-50 degrees	4th order Green	(-)
Zircon	Frosted Clear	Extremely High +	none	Parallel	3rd Green to 4th Pink	(-)
Serpentine	Mottled Green w inclusions	Moderate +	Pale Yellow Green	None	1st order Gray	(-)
Tremolite/Actinolite	Colorless to Pale Green	Moderate +	Slight Yellow Green	Inclined	1st order Red to 2nd Blue	56
Epidote	Light Yellow Green	High +	Slight Yellow Green	25-40	2nd order Yellow to Red	(-)
Apatite	Yellow Green	Moderate to High +	none	Parallel	1st order Gray	(-)
Glaucophane	Blue	High +	Blue/Violet	Inclined	2nd order Green to Yellow	(-)
Zoisite	Colorless	High +	Slight Green	Parallel	2nd order Green to Yellow	(-)
Lawsonite	Gray	Moderate +	Brownish Yellow	Symmetrical	1st order Yellow to Red	97
Blotite	Green or Brown	Moderate to High +	Green/Brown	Parallel	3rd order Green to Pink	~80 and 120
Opauques	Metallic Luster	Very High +	(-)	(-)	Opaque	(-)

Abbreviations used for Appendix Vc and Vd

HB/Bio = Hornblende/Biotite
Aug = Augite
Hyper = Hypersthene
Serp = Serpentine
Trem-Act = Tremolite/Actinolite
Epid = Epidote
Apat = Apatite
Glau = Glaucophane
Zoi = Zoisite
Law = Lawsonite

Table Vc: Accessory Mineral Point Counts

Sample	Depth	HB/Bio	Augite	Hyper	Garnet	Sphene	Zircon	Serp	Trem-Ac	Epidote	Apatite	Glau	Zoisite	Lawsonite	Others	Opaques	Total
Pajaro Dunes	0	75	52	70	3	3	0	10	6	3	4	9	0	5	10	87	337
Zmudowski Beach	0	33	29	26	2	2	0	7	7	9	2	4	0	4	9	183	317
Slough North	0	39	40	30	4	4	0	2	6	4	2	5	0	4	8	177	325
Jetty North	0	57	38	34	7	5	2	4	7	7	3	4	2	4	6	121	301
Jetty South	0	91	22	10	32	2	0	3	8	5	3	2	2	4	6	117	307
Potrero Road	0	57	25	8	32	1	1	2	4	7	3	2	11	1	8	152	314
Salinas River	0	68	32	15	35	6	0	3	2	11	0	0	2	0	8	121	303
Carmel River	0	126	20	12	35	6	3	0	8	12	8	0	0	0	6	91	327
MLP-8-21	20	134	36	48	10	4	2	2	10	10	4	6	2	4	7	52	331
MLML GS-161	161	121	28	42	12	4	1	10	16	10	6	10	3	6	10	53	332
V-1868 VC-18 (2-4 cm)	283	103	34	42	6	4	2	6	12	8	3	7	2	6	9	76	320
V-1873 VC-22 (11-13 cm)	292	117	32	56	4	2	0	5	4	10	3	7	0	5	8	64	317
V-1878 VC-28 (10-12 cm)	294	109	28	43	8	6	0	4	9	10	4	7	4	9	9	54	304
V-1744 VC-9 (16-17 cm)	424	121	22	51	4	2	2	4	6	6	4	8	2	4	8	61	305
V-1741 VC-6 (10-12 cm)	427	126	31	58	6	4	2	4	6	8	4	10	2	6	9	47	323
V-1740 VC-5 (7-9 cm)	425	116	23	44	4	8	2	5	6	8	2	6	2	5	10	67	308
V-1730 VC-4 (5-7 cm)	444	153	22	61	3	4	0	5	5	4	2	7	0	3	9	48	326
V-1748 VC-13 (10-14 cm)	444	99	20	42	8	3	1	4	6	10	3	8	3	6	9	81	303
V-1872 VC-21 (8-11 cm)	520	115	14	51	6	4	2	8	8	11	3	7	3	4	9	60	305
V-1870 VC-19 (6-8 cm)	690	141	28	56	3	6	0	5	4	5	3	7	2	3	11	44	318
V-1877 VC-27 (12-14 cm)	692	133	12	58	6	4	0	6	7	4	3	4	1	4	11	83	336
V-1861 VC-16 (9-11 cm)	693	130	24	49	8	6	1	5	8	6	3	3	0	4	9	72	328
V-1871 VC-20 (8-10 cm)	700	117	25	42	4	2	2	5	8	6	4	4	1	4	8	81	313
V-1776 PC-30 (6-7 cm)	874	122	23	42	6	5	1	3	9	4	4	6	0	2	10	71	308
T-232 PC-57 (14-16 cm)	1,098	144	22	46	28	4	0	0	6	12	2	0	0	0	8	65	337
V-1874 VC-23 (cc)	1,159	124	20	41	18	3	3	4	6	10	2	8	2	4	10	65	320
T-167 PC-77 (18-20 cm)	1,945	147	16	43	14	2	2	3	10	7	6	6	2	6	9	55	328
T-214 PC-79 (12-14 cm)	2,432	143	20	43	18	6	2	5	8	8	4	5	2	6	9	28	307
T-212 PC-53 (7-10 cm)	2,702	134	22	47	20	6	1	4	6	9	4	6	1	5	8	28	301
T-160 PC-50 (14-16 cm)	2,744	148	22	43	17	4	1	4	14	8	6	7	2	6	7	22	311
T-217 PC-21 (11-12 cm)	2,810	145	10	42	19	4	6	3	6	16	4	10	2	5	10	29	311
T-388 VC-22 (10-12 cm)	3,172	147	23	40	18	5	3	3	8	15	4	7	2	5	12	32	324
T-400 VC-A20 (10-12 cm)	3,612	138	18	38	25	3	3	6	7	11	5	5	1	5	12	28	305

Appendix Vd: Accessory Mineral Percentage Compositions

Sample	Depth	HB/ Bio	Aug	Hyper	Garnet	Sphene	Zircon	Serp	Tr- Act	Epid	Apat	Glau	Zoi	Law	Other	Opaq
Pajaro Dunes	0	22	15	21	1	1	0	3	2	1	1	3	0	2	3	26
Zmudowski Beach	0	10	9	8	1	1	0	2	2	3	1	1	0	1	3	58
Slough North	0	12	12	9	1	1	0	1	2	1	1	2	0	1	3	55
Jeffy North	0	19	13	11	2	2	1	1	2	2	1	1	1	1	2	40
Jeffy South	0	30	7	3	10	1	0	1	3	2	1	1	1	1	2	38
Potrero Road	0	18	8	3	10	0	0	1	1	2	1	1	4	0	3	48
Salinas River	0	22	11	5	12	2	0	1	1	4	0	0	1	0	3	40
Carmel River	0	39	6	4	11	2	1	0	2	4	2	0	0	0	2	28
MLP-8-21	20	41	11	15	3	1	1	1	3	3	1	2	1	1	2	16
MLML GS-161	161	36	8	13	4	1	0	3	5	3	2	3	1	2	3	16
V-1873 VC-22 (11-13 cm)	292	37	10	18	1	1	0	2	1	3	1	2	0	2	3	20
V-1868 VC-18 (2-4 cm)	283	32	11	13	2	1	1	2	4	3	1	2	1	2	3	24
V-1878 VC-28 (10-12 cm)	294	36	9	14	3	2	0	1	3	3	1	2	1	3	3	18
V-1741 VC-6 (10-12 cm)	424	39	10	18	2	1	1	1	2	3	1	3	1	2	3	15
V-1744 VC-9 (16-17 cm)	427	40	7	17	1	1	1	1	2	2	1	3	1	1	3	20
V-1730 VC-4 (5-7 cm)	425	38	8	14	1	3	1	2	2	3	1	2	1	2	3	22
V-1748 VC-13 (10-14 cm)	444	47	7	19	1	1	0	2	2	1	1	2	0	1	3	15
V-1748 VC-13 (10-14 cm)	444	33	7	14	3	1	0	1	2	3	1	3	1	2	3	27
V-1872 VC-21 (8-11 cm)	520	38	5	17	2	1	1	3	3	4	1	2	1	1	3	20
V-1870 VC-19 (6-8 cm)	690	44	9	18	1	2	0	2	1	2	1	2	1	1	4	14
V-1877 VC-27 (12-14 cm)	697	40	4	17	2	1	0	2	2	1	1	1	0	1	3	25
V-1861 VC-16 (9-11 cm)	693	40	7	15	2	2	0	2	2	2	1	1	0	1	3	22
V-1871 VC-20 (8-10 cm)	700	37	8	13	1	1	1	2	3	2	1	1	0	1	3	26
V-1775 PC-30 (6-7 cm)	874	40	8	14	2	2	0	1	3	1	1	1	0	1	3	23
T-232 PC-57 (14-16 cm)	1,098	43	7	14	8	1	0	0	2	4	1	0	0	0	2	19
V-1874 VC-23 (cc)	1,159	39	6	13	6	1	1	1	2	3	1	3	1	1	3	20
T-167 PC-77 (18-20 cm)	1,945	45	5	13	4	1	1	1	3	2	2	2	1	2	3	17
T-214 PC-79 (12-14 cm)	2,432	47	7	14	6	2	1	2	3	3	1	2	1	2	3	9
T-212 PC-53 (7-10 cm)	2,702	45	7	16	7	2	0	1	2	3	1	2	0	2	3	9
T-160 PC-50 (14-16 cm)	2,744	48	7	14	6	1	0	1	5	3	2	2	1	2	2	7
T-217 PC-21 (11-12 cm)	2,810	47	3	14	6	1	2	1	2	5	1	3	1	2	3	9
T-388 VC-22 (10-12 cm)	3,172	45	7	12	6	2	1	1	3	5	1	2	1	2	4	10
T-400 VC-A20 (10-12 cm)	3,612	45	6	13	8	1	1	2	2	4	2	2	0	2	4	9

APPENDIX VI: COBBLE/GRAVEL DATA

Appendix VIa: Gravel/Cobble Sample Locations

Core #	Latitude	Longitude	Water Depth
V-1730 VC-4	36.79552	121.89059	444
V-1851 VC-16	36.78263	121.93409	693
V-1870 VC-19	36.78436	121.93368	690
V-1873 VC-22	36.79316	121.84618	292
V-1874 VC-23	36.76075	122.03964	1,159
V-1875 VC-24	36.76145	122.03732	1,165
V-1878 VC-28	36.79358	121.84601	296
V-1900 VC-31	36.79615	121.89063	443
V-1929 VC-37	36.78926	121.90321	526
V-1936 VC-44	36.81007	121.94125	89
V-1942 VC-50	36.78040	121.90426	552
V-1943 VC-51	36.75532	121.92665	100
V-1944 VC-52	36.78531	121.90311	533
V-1947 VC-55	36.80521	121.79857	86
V-1975 VC-57	36.78063	122.01294	1,008
V-1977 VC-59	36.79529	121.86583	381
V-1985 VC-65	36.78210	121.83103	84
V-1987 VC-67	36.76423	121.98614	887
V-1988 VC-68	36.77221	121.96289	802
V-1989 VC-69	36.77917	121.91731	632
V-2004 VC-71	36.80210	121.80617	134
V-2120 VC-76	36.72836	122.01751	1,356
V-2121 VC-77	36.72516	122.01529	1,392
V-2123 VC-79	36.71038	122.01624	1,466
V-2126 VC-82	36.78117	122.02781	1,054
V-2127 VC-83	36.81363	121.80322	19
V-2128 VC-84	36.81993	121.81011	19
V-2130 VC-86	36.80134	121.81040	150
V-2174 VC-89	36.79278	121.84478	288
V-2177 VC-92	36.78450	121.90302	517
V-2178 VC-93	36.79014	121.90299	524
T-372 VC-2	36.70104	122.07771	1,784
T-372 VC-3	36.70104	122.07771	1,784
T-388 VC-8	36.49392	122.61197	3,167
T-388 VC-10	36.49390	122.61206	3,164
T-388 VC-11	36.49390	122.61206	3,163
T-389 VC-29	36.65667	122.11506	2,104
T-400 VC-A17	36.21925	123.15827	3,603
T-405 VC-41	36.22610	122.88271	3,448
Dive Number	Latitude	Longitude	Depth
V-1850 ROV	36.75633	122.02708	1,169
V-2150 ROV	36.78441	121.90353	537
Onshore Location	Latitude	Longitude	
Tres Pinos Creek	36.78281	121.31320	
San Benito River	36.85222	121.43083	
Pacheco Creek	36.98968	121.37812	
Pajaro River	36.89944	121.59500	
Salinas River	36.48710	121.46582	
Arroyo Seco River	36.28222	121.32389	
Nacimiento River	36.00390	121.39591	
San Antonio River	36.06901	121.32251	
Carmel River	36.48144	121.74225	
San Lorenzo River	36.97528	122.02342	
Soquel Creek	36.98525	121.95722	
Aptos Creek	37.00222	121.90450	

Appendix VIb: Canyon Cobble Point Count Data

Core	Depth	Granite	Sandstone	High Grade	Franciscan	Monterey	Volcanic	Chert	Total
V-1730 VC-4	70-72 cm		1	1					1
	80-82 cm								1
	8 cm					1			1
V-1851 VC-16		3	1		1				5
V-1870 VC-19									1
V-1873 VC-22	72-74 cm								1
V-1874 VC-23	10-15 cm	12	8	3	21			4	49
	17-19 cm		1	4	2	1	1		8
	25-30 cm	14	7	6	14	1	2	6	50
	32-34 cm	2		3	2			2	9
	35-40 cm	10	6	6	18	1			41
	47-49 cm	4			5				9
	53-58 cm	15	6	8	21		1		51
	62-64 cm	10	4	3	13	1			31
	68 cm	5		1	8		1		15
	cc	12		9	17		1		39
V-1875 VC-24	2-7 cm	12	7	9	16			4	48
	10-12 cm	1	2	3	3				9
	12-17 cm	12	2	5	27	1	1	1	49
	20-22 cm			3	4				7
	22-27	18	3	9	25	3	4		62
	30-32 cm			3	5				8
	32-37 cm	14	1	5	21	1		3	45
	cc	1		2	5				8
V-1878 VC-28	50-52 cm		1						1
V-1900 VC-31	55-57 cm				1				1
	110-112				1				1
V-1929 VC-37	21-23 cm	1		1	4				6
	32-34 cm	2		6	5	1		1	15
V-1936 VC-44	50-52 cm					1			1
V-1943 VC-51	34-36 cm		4						4
V-1975 VC-57	95-99 cm	2	2	3	3	3			13
Totals-12cores		150	56	93	242	16	11	21	589

Appendix VIIb: Canyon Cobble Point Count Data (cont.)

Core	Depth	Granite	Sandstone	High Grade	Franciscan	Monterey	Volcanic	Chert	Total
V-1942 VC-50	29-31 cm	4	4	1	5	1			15
	39-41 cm	2	1	1	4	1			9
	49-51 cm	2	1	1	5	1			10
	69-71 cm				5	1			6
	79-81 cm	6	3	3	1	1		1	15
	89-91 cm	8	2	2	4	1		1	16
	99-101 cm	7	3	2	1	2	1		16
V-1944 VC-52	90-92 cm		2						2
	95-97 cm	1							1
	105-107 cm				1				1
	110-112 cm	1	1		1				3
	115-117 cm		1		1				2
	120-122 cm		1						1
	cc	6	6	5	2		1	1	21
V-1947 VC-55	140-142 cm	2	1		2		1		6
	145-147 cm		4		2			1	7
	150-152 cm	3							3
	155-157 cm				1				1
	160-162 cm	2	1	1	1				5
	165-167 cm				1	1		1	3
	195-197 cm				1			1	2
	200-202 cm			1			1		2
	205-207 cm		1	1					2
V-1977 VC-59	18-20 cm			3	2	1	1	1	8
	38-40 cm	2	1	1	1		1		6
	58-60 cm	1		1	6		1	2	11
V-1985 VC-65	58-60 cm	2	1		2				5
	68-70 cm	2		2	1			1	6
	78-80 cm				1				1
	88-90 cm	2	1		2				5
V-1987 VC-67	26-28 cm	10	4	3	7	1	2	2	29
	44-46 cm				1				1
V-1988 VC-68	43-45 cm	1	4		4				9
Totals-7 Cores		64	43	26	65	11	9	12	230

Appendix VIb: Canyon Cobble Point Count Data (cont.)

Core	Depth	Granite	Sandstone	High Grade	Franciscan	Monterey	Volcanic	Chert	Total
V-1989 VC-69	6-8 cm	1		1					2
	36-38 cm		6					2	8
	46-48 cm	3	4	2	4	1		2	16
	56-58 cm	3	5	2	2		1		13
V-2004 VC-71	76-78 cm	2	3		1			1	7
	81-88 cm		1		1				2
	86-88 cm	5	5		4				14
	91-93 cm	3	3	1		2			9
	96-98 cm	1	2	1	2			2	8
	101-103 cm	4	3		1				8
	111-113 cm	2	1						3
V-2120 VC-76	95-97 cm					1			1
V-2121 VC-77	40-42 cm		1		1				2
	60-62 cm	1	3	1		1	1	1	8
	80-82 cm	1	1		1				3
	100-102 cm	2	2						4
	110-112			2					2
V-2123 VC-79	55-57 cm		1			1			2
V-2126 VC-82	32-34 cm	1	1		1	2			5
	42-44 cm	5	2				1		8
V-2130 VC-86	100-102 cm		1						1
	125-127 cm		1		1				4
V-2177 VC-92	19-21 cm	2		2					6
	29-31 cm	2		4					6
	34-36 cm	3		2	1				5
	39-41 cm	2		4	3	1		3	14
	44-46 cm			1	3				6
	64-66 cm	1	1	1			1		3
	74-76 cm	1		1	2	1			5
					1		1	1	5
Totals- 8 Cores		45	47	26	29	10	5	12	174

Appendix VIIb: Canyon Cobble Point Count Data (cont.)

Core	Depth	Granite	Sandstone	High Grade	Franciscan	Monterey	Volcanic	Chert	Total
V-2174-VC-89	24-26 cm		2	2					4
	29-31 cm		1	5	1				7
	34-36 cm	3	2	1		1		2	11
	39-41 cm	3		2					7
	44-46 cm	3	2		1				6
	49-51 cm	2		2	4				8
	54-56 cm		1	2	2				5
	59-61 cm	2	2	2	3			2	11
	64-66 cm	1	1	1	1			1	5
	69-71 cm	2		1	2				5
	74-76 cm	1	1	1	1		1		5
	79-81 cm	1	1	1	1		1		5
	89-91 cm					4			4
	94-96 cm	3		6	1				10
	99-101 cm	1	2	4	1			1	9
V-2178 VC-93	Large Clasts	5	1	2	2				10
	15-17 cm	3					1		4
	20-22 cm	1	1	1	1	1			5
	25-27 cm	3	1		1				5
	30-32 cm	8		4	1				13
	35-37 cm	5	1	2	2			1	11
	40-42 cm	2		4	4				10
	45-47 cm	2			1	1			4
	50-52 cm			4			1		5
	55-57 cm	4		2				1	7
	60-62 cm	5	2	3	2		1		13
	65-67 cm	2							2
	80-82 cm	1	1		1	1		1	5
Totals- 2 Cores		63	22	52	35	8	7	9	196

Appendix VIb: Canyon Cobble Point Count Data (cont.)

Core	Depth	Granite	Sandstone	High Grade	Franciscan	Monterey	Volcanic	Chert	Total
T-372 VC-2	28-30 cm	6	3	1	1				11
	(?)	1	3	2	1		1	1	9
T-372 VC-3	60-62 cm	1			2				3
	65-67 cm	1	1						2
	70-72 cm	1	1						2
T-388 VC-8	11-12 cm	1	1	3	1				6
	16-18 cm	3			1				4
	21-23 cm		1						1
	26-28 cm		1		1				2
T-388 VC-10	7-9 cm		1		1				2
	74-76 cm	6	1		1				8
T-388 VC-11	6-8 cm		2						2
T-389 VC-29	45-47 cm	1	1		1				3
	50-52 cm	1							1
T-400 VC-17A	60-63 cm		2						2
	63-66 cm		3						3
	66-69 cm		1		1				2
	69-72 cm		5		1				6
	Large Clast		1						1
T-405 VC-41	26-30 cm	35	31	3	9	1	0	2	81
T-405 VC-42			1						1
Totals- 9 cores		57	60	9	20	1	1	3	151

Appendix VIc: Canyon Cobble Point Count Totals and Percent Rock-Clast Composition

	Granite	Sandstone	High Grade	Franciscan	Monterey	Volcanic	Chert	Total
Totals: Page 166	150	56	93	242	16	11	21	589
Totals: Page 167	64	43	26	65	11	9	12	230
Totals: Page 168	45	47	26	29	10	5	12	174
Totals: Page 169	63	22	52	35	8	7	9	196
Totals: Page 170	57	60	11	20	1	1	3	153
Total Clasts	379	228	208	391	46	33	57	1342
% Totals	28	17	16	29	3	3	4	
V-1850	30	7	28	33	1	2	5	153
V-2150	39	9	34	25	11	4	10	153
Totals V-1850 V-2150	69	16	62	58	12	6	15	306
Total (Pages 166-170)	379	228	208	391	46	33	57	1342
Total Cobbles	448	244	270	449	58	39	72	1648
% Revised Total	27.2	14.8	16.4	27.2	3.5	2.4	4.4	

Appendix VIId: Onshore Cobble Point Count Totals

Location	#Granite	#Sandstone	#High Grade	#Franciscan	#Monterey	#Volcanic	#Chert	Total
Tres Pinos Creek	23	107	18	130	0	30	15	323
San Benito River	25	65	15	148	0	45	18	316
Pacheco Creek	20	65	0	165	0	55	12	317
Pajaro River	28	74	25	138	0	25	22	312
Salinas River	95	10	85	0	96	15	3	304
Arroyo Seco River	115	33	88	0	70	0	4	310
Nacimientos River	153	0	172	0	0	0	0	325
San Antonio River	180	36	90	0	0	0	0	306
Carmel River	250	0	15	0	45	0	0	310
San Lorenzo River	160	36	45	0	73	0	4	318
Soquel Creek	63	249	0	0	0	0	0	312
Aptos Creek	45	270	0	0	0	0	0	315

Appendix VIe: Onshore Cobble Point Count Percentages

Location	% Granite	% Sandstone	% High Grade	% Franciscan	% Monterey	% Volcanic	% Chert	% Total
Tres Pinos Creek	7	33	6	40	0	9	5	100
San Benito River	8	21	5	47	0	14	6	100
Pacheco Creek	6	21	0	52	0	17	4	100
Pajaro River	9	24	8	44	0	8	7	100
Salinas River	31	3	28	0	32	5	1	100
Arroyo Seco River	37	11	28	0	23	0	1	100
Nacimientos River	47	0	53	0	0	0	0	100
San Antonio River	59	12	29	0	0	0	0	100
Carmel River	81	0	5	0	15	0	0	100
San Lorenzo River	50	11	14	0	23	0	1	100
Soquel Creek	20	80	0	0	0	0	0	100
Aptos Creek	14	66	0	0	0	0	0	100