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COCCOLITH CORRELATION OF CALIFORNIA CENOZOIC GEOLOGIC FORMATIONS

BY

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ABSTRACT

Planktic transoceanic coccolith zones that have been identified and published for California Cenozoic geologic formations are summarized for reference in correlation work. The summary includes literature reports of 62 formational units that range from upper Paleocene (Zone CP4) to upper Pliocene (Zone CN12).

INTRODUCTION

Coccolith biostratigraphy was first applied to California marine geologic formations by Bramlette and Riedel (1954). For example, the guide fossil *Discoaster lodoensis* Bramlette and Riedel was reported from the lower Eocene Capay Shale of California and was correlated to Haiti, Trinidad, and France. Also, *Discoaster barbadiensis* Tan was shown to be limited to the Eocene, but to occur in almost every Eocene coccolith assemblage from widely scattered regions in California, France, New Zealand, and Tunisia. The major pioneering work on California assemblages appeared in Bramlette and Sullivan (1961) and Sullivan (1964, 1965). These studies featured detailed species lists of old and newly described taxa, from Paleocene and Eocene formations in California, and were used to identify new biostratigraphic zones that could be recognized in California and in transoceanic localities. Later detailed studies (Gibson, 1976; Warren and Newell, 1980; Poore and others, 1981; and Almgren and others, 1988) examined correlations of many formations and benthic foraminiferal provincial stages using coccolith zonations which had been gradually proven, through application during the Deep Sea Drilling Project, to be useful for worldwide correlation (Bukry, 1978, 1981a). Unlike the global correlation emphasized by Bramlette and co-authors, many California studies used coccoliths to help explain local or regional formation relationships, such as Almgren and McDougall (1975), Kheradyar (1988), and Kies and Abbott (1982).

This report presents a summary list of specific geologic formations in California from the main publications from 1954 to 1991 that provide coccolith zonal biostratigraphy. Because this is an initial compilation, it is expected that subsequent appendices can add new or missing references on a periodic basis as coccolith work continues at government, industry and university laboratories.

ZONATION HISTORY

There has been considerable continuity in the application of coccolith biostratigraphy in California. This occurred because the pioneering development phase (1954-1967) of M. N. Bramlette and F. R. Sullivan overlapped the transition phase to deep-sea studies in works such as Martini and Bramlette (1963) and Bramlette and Wilcoxon (1967) which related early JOIDES offshore biostratigraphy to the onshore framework. The period of regular Deep Sea Drilling Project (DSDP) and Ocean Drilling Program (ODP) coring (1968-1991) provided a central focus for applying new biostratigraphic and eco-stratigraphic relations to California formations (Bukry, in press). Cooperation between M. N. Bramlette at Scripps Institution of Oceanography and other La Jolla area nannopaleontologists (D. Bukry, E. D. Milow, P. H. Roth, A. D. Warren, and J. A. Wilcoxon) in the late 1960's and early 1970's provided a fairly consistent approach to California coccolith zonation. Consistency in coccolith taxonomy was supported by H. Tappan (UCLA) with A. R. Loeblich, Jr., at Chevron's La Habra Research Laboratory, through publication of a series of annotated indexes (for example, see Loeblich and Tappan, 1966, 1971).

Most coccolith biostratigraphy in the 1970's and 1980's for California applied the DSDP zonation (Bukry, 1971, 1973, 1975) which was codified by Okada and Bukry (1980). Because the most published California coccolith biostratigraphers, such as M. V. Filewicz, P. L. Miller, R. Z. Poore, and A. D. Warren, have used a common zonation, there is little conversion problem when correlating results throughout California. Use of the same zonation can also help to corroborate determinations, as for the Goler Formation where independent studies by M. V. Filewicz and D. Bukry produced the same late Paleocene (Zone CP8) correlation (Squires and others, 1988). The Okada and Bukry (1980) zonation with boundary ages from Haq (1983a) is shown (Figures 1a and 1b) as a reference for formation age estimates. The Haq reference was used because it completely dates the CN-, and CP-subzonal system used here. Other more updated time scales that may be referred to include Barron and others (1985), Berggren and others (1985), and Haq and others (1987), especially for the middle to late Miocene CN5 to CN9 (J. A. Barron, verbal communication, 1991).

Planktic coccolith biostratigraphy is a convenient method for correlating to a global standard and type sections (Bramlette and

Epoch/Subepoch		Zone/Subzone		Basal Age (Ma)	Unit Name
		CN12	d	2.2	*D. triradiatus*
	L		c	2.4	*D. pentaradiatus*
			b	2.5	*D. surculus*
			a	3.5	*D. tamalis*
Pliocene		CN11	b	3.6	*D. asymmetricus*
			a	3.7	*S. neoabies*
	E	CN10	d	4.2	*A. delicatus*
			c	4.6	*C. rugosus*
			b	5.0	*C. acutus*
			a	5.4	*T. rugosus*
		CN9	b	6.7	*A. primus*
	L		a	8.0	*D. berggrenii*
		CN8	b	8.6	*D. neorectus*
			a	9.2	*D. bellus*
		CN7	b	10.2	*C. calyculus*
Miocene			a	12.0	*C. carteri*
		CN6		12.5	*C. coalitus*
	M	CN5	b	13.5	*D. kugleri*
			a	14.2	*C. miopelagicus*
		CN4		15.5	*S. heteromorphus*
		CN3		17.2	*H. ampliaperta*
		CN2		19.0	*S. belemnos*
	E	CN1	c	22.2	*D. druggii*
			b	23.0	*D. deflandrei*
			a	24.8	*C. abisectus*

Figure 1a. Neogene coccolith biostratigraphic units (Okada and Bukry, 1980, Bukry, 1981b, 1985) with age estimates (Haq, 1983a).

Epoch/Subepoch		Zone/Subzone		Basal Age (Ma)	Unit Name
	L	CP19	b	27.8	*D. bisectus*
			a	30.0	*C. floridanus*
Oligocene		CP18		33.0	*S. distentus*
		CP17		33.8	*S. predistentus*
	E	CP16	c	34.4	*R. hillae*
			b	35.0	*C. formosus*
			a	35.8	*C. subdistichus*
	L	CP15	b	37.6	*I. recurvus*
			a	39.2	*C. oamaruensis*
		CP14	b	41.8	*D. saipanensis*
			a	44.3	*D. bifax*
	M	CP13	c	46.4	*C. staurion*
Eocene			b	47.5	*C. gigas*
			a	49.2	*D. strictus*
		CP12	b	50.6	*R. inflata*
			a	52.0	*D. kuepperi*
		CP11		53.4	*D. lodoensis*
	E	CP10		54.8	*T. orthostylus*
		CP9	b	55.8	*D. binodosus*
			a	57.0	*T. contortus*
		CP8	b	57.3	*C. eodela*
			a	57.8	*C. bidens*
	L	CP7		58.8	*D. nobilis*
Paleocene		CP6		59.6	*D. mohleri*
		CP5		61.0	*H. kleinpellii*
		CP4		62.0	*F. tympaniformis*
		CP3		63.4	*E. macellus*
	E	CP2		65.7	*C. danicus*
		CP1	b	66.3	*C. tenuis*
			a	66.6	*C. primus*

Figure 1b. Paleogene coccolith biostratigraphic units (Okada and Bukry, 1980) with age estimates (Haq, 1983a).

Sullivan, 1961; Bramlette and Wilcoxon, 1967; Hay and others, 1967). Also, combining this long-range capability with the short duration of many distinctive coccolith species allows more reproducible age resolution than localized benthic faunal changes, such as those of benthic foraminifers and mollusks, over the varied Cenozoic marine depositional conditions in the California area.

PUBLISHED FORMATION NAMES WITH IDENTIFIED COCCOLITH ZONATION AND COUNTY LOCATION

The formation names listed below are reproduced directly as shown in the published text references which are cited under the names. Quotation marks are in the source reference (for example, Gibson, 1976, p. 87; and Sullivan, 1965, p. 1). This list simply reports names from cited references. But the zone codes shown are either a direct reference or an interpretation of a zone name or a species list in the references cited. Formation names and references are listed in alphabetic order.

ALHAMBRA FM.

Zone: CP13.

Location: Contra Costa Co.

Reference: Bukry, unpublished data, 1991, for E. E. Brabb sample 90CB2925; Sullivan, 1965.

ANITA FM.

Zone: CP6, 7, 8, 9a?, 9b, 10, 11, 12a, 12b, and 14.

Location: Santa Barbara Co.

Reference: Gibson, 1976; Sullivan, 1964, 1965.

ARDATH SHALE

Zone: CP12b.

Location: San Diego Co.

Reference: Bukry and Kennedy, 1969; Bukry, 1980.

"BOLADO PARK FM."

Zone: CP6, 8, 9/10, and 11.

Location: San Benito Co.

Reference: Sullivan, 1965.

BUTANO SANDSTONE

Zone: CP10/11, 11, 12, 12b/15, 13, 14, and 14a.

Location: Santa Clara Co., Santa Cruz Co., and San Mateo Co.

Reference: Bukry, Brabb, and Vedder, 1977; Haq, 1983b; Kanter, 1988; Kheradyar, 1988; Poore and Bukry, 1983; Warren and Newell, 1980.

CAÑADA FM.

Zone: C9, 10, 11, and 12b.

Location: Santa Barbara Co. (Santa Cruz Island).

Reference: Kies and Abbott, 1982.

CANOAS MEMBER (OF KREYENHAGEN FM.)

Zone: CP12b, 13a, and 13b.

Location: Fresno Co.

Reference: Bramlette and Sullivan, 1961.

CAPAY SHALE

Zone: CP9, 10, and 11.

Location: Contra Costa Co. and Solano Co.

Reference: Almgren and Filewicz, 1984; and Almgren, Filewicz, Heitman, 1988.

CERROS SHALE (MEMBER OF LODO FM.)

Zone: CP10 and CP10/11.

Location: Fresno Co.

Reference: Squires, 1988.

CHURCH CREEK FM.

Zone: CP15.

Location: Monterey Co.

Reference: Brabb, Bukry, and Pierce, 1971.

COZY DELL FM.

Zone: CP12/13, 13, 13b, and 14a.

Location: Santa Barbara Co.

Reference: Almgren, Filewicz, and Heitman, 1988; Bukry, Brabb, and Vedder, 1977; Sullivan, 1965; Warren and Newell, 1980.

DOMENGINE SANDSTONE

Zone: CP11 and CP12a.

Location: Contra Costa Co., Fresno Co., and Kern Co.

Reference: Almgren, Filewicz, and Heitman, 1988; Bramlette and Sullivan, 1961; Warren, 1983.

GALLAWAY FM.

Zone: CN3

Location: Mendocino Co.

Reference: Miller, 1981.

GAVIOTA FM.

Zone: CP15b.

Location: Santa Barbara Co.

Reference: Lipps and Kalisky, 1972.

"GERMAN RANCHO FM."

Zone: CP12b and 14.

Location: Mendocino Co.

Reference: Miller, 1981.

GOLER FM.

Zone: CP8.

Location: Kern Co.

Reference: Squires, Cox, and Powell, II, 1988.

HAMILTON SAND

Zone: CP9.

Location: Contra Costa Co.

Reference: Almgren, Filewicz, and Heitman, 1988.

IMPERIAL FM.

Zone: CN9/11.

Location: Riverside Co.

Reference: Bukry, unpublished data, 1979, for R. Z. Poore samples RS-7 and -8 from type locality.

IVERSEN BASALT

Zone: CP18/19?

Location: Mendocino Co.

Reference: Miller, 1981.

JOLLA VIEJA FM.

Zone: CP12b and 14a.

Location: Santa Barbara Co. (Santa Cruz Island).

Reference: Kies and Abbott, 1982.

JUNCAL FM.

Zone: CP11, 12, 12a, 12b, and 13/14a.

Location: Santa Barbara Co.

Reference: Bukry, Brabb, and Vedder, 1977; Thompson, 1988.

KELLOGG SHALE

Zone: CP13, CP13c and CP14a.

Location: Contra Costa Co.

Reference: Almgren and McDougall, 1975; Barron, Bukry, and Poore, 1984.

KREYENHAGEN FM.

Zone: CP11, 12a, 12b, 13a, 13b, 13, 14a, and 14b.

Location: Kern Co.

Reference: Almgren, Filewicz, and Heitman, 1988; Warren, 1983.

LAS JUNTAS SHALE

Zone: CP10 and 14.

Location: Contra Costa Co.

Reference: Bukry, Brabb, and Vedder, 1977; Sullivan, 1964, 1965; Bukry, unpublished data, 1991, for E. E. Brabb sample 90CB2923.

LOCATELLI FM.

Zone: CP4.

Location: Santa Cruz Co.

Reference: Haq, 1983b.

LODO FM.

Zone: CP6, 7, 8, 9, 9b, 10, 11, and 12a.

Location: Fresno Co., Kern Co., San Benito Co.

Reference: Almgren, Filewicz, and Heitman, 1988; Bramlette and Sullivan, 1961; Sullivan, 1964, 1965; Warren, 1983.

LOS MUERTOS CREEK FM.

Zone: CP11 and 13.

Location: San Benito Co.

Reference: Sullivan, 1965.

LUCIA MUDSTONE (MEMBER OF RELIZ CANYON FM.)

Zone: CP10 and 11.

Location: Monterey Co. and San Benito Co.

Reference: Bukry, Brabb, and Vedder, 1977; Sullivan, 1965.

MANIOBRA FM.

Zone: CP9, 10, and 11.

Location: Riverside Co.

Reference: Advocate, Link, and Squires, 1988.

MARKLEY FM. (UPPER, WHITE SANDS)

Zone: CP14b.

Location: --

Reference: Almgren, Filewicz, and Heitman, 1988.

MARKLEY FM. (UPPER, SIDNEY FLAT SHALE MEMBER)

Zone: CP13 and 14a.

Location: Contra Costa Co.

Reference: Almgren, Filewicz, and Heitman, 1988; Almgren and McDougall, 1975.

"MARKLEY CANYON FILL"

Zone: CP16a and CP16b-c.

Location: Solano Co.

Reference: Almgren, Filewicz, and Heitman, 1988.

MARTINEZ FM.

Zone: CP4, 5, 6, 7, and 8.

Location: Contra Costa Co.

Reference: Almgren, Filewicz, and Heitman, 1988.

"MARTINEZ" FM.

Zone: CP5.

Location: Ventura, Co.

Reference: Sullivan, 1965.

MATILIJA FM.

Zone: CP12 and CP13.

Location: Santa Barbara Co.

Reference: Almgren, Filewicz, and Heitman, 1988; Sullivan, 1965.

"MATILIJA" FM.

Zone: CP9b.

Location: Santa Barbara Co.

Reference: Gibson, 1976.

MEGANOS SHALE

Zone: CP9.

Location: Contra Costa Co.

Reference: Almgren, Filewicz, and Heitman, 1988.

MISSION VALLEY FM.

Zone: CP13 and CP14 or higher.

Location: San Diego Co.

Reference: Kennedy, 1975; Bukry, unpublished data, 1991, from M. Roeder sample I8/395.

MONTEREY FM.

Zone: CN2, 3, 4, 5, 5/8, and 9?.

Location: Orange Co., San Luis Obispo., Santa Barbara Co., Santa Cruz Co., and Ventura Co.

Reference: Bukry, Brabb, and Vedder, 1977; DePaolo and Finger, 1991; Khan, Coe, and Barron, 1989; Warren, 1981; Wilcoxon, 1969.

MUIR FM.

Zone: CP14.

Location: Contra Costa Co.

Reference: Sullivan, 1965.

NORTONVILLE FM.

Zone: CP13.

Location: Contra Costa Co.

Reference: Almgren and McDougall, 1975.

POINT ARENA FM.

Zone: CN3, 4, and 5a.

Location: Mendocino Co.

Reference: Miller, 1981.

POZO FM.

Zone: CP7.

Location: Santa Barbara Co.

Reference: Kies and Abbott, 1982.

POZO FM. OR CAÑADA FM. (UNDIFFERENTIATED)

Zone: CP11.

Location: Santa Barbara Co. (San Miguel Island).

Reference: Kies and Abbott, 1982.

REPETTO FM.

Zone: CN11b/12a.

Location: Los Angeles Co.

Reference: Bukry, 1981b.

RICES MUDSTONE (MEMBER OF SAN LORENZO FM.)

Zone: CP17/19 and CP18.

Location: Santa Cruz Co.

Reference: Bukry, Brabb, and Vedder, 1977; Poore and Bukry, 1983.

RINCON FM.

Zone: CP19b, CN1c, and CN1c/CN2.

Location: San Luis Obispo Co., Santa Barbara Co., and Ventura Co.

Reference: Tennyson, Keller, Filewicz, and Cotton Thornton, 1991; Warren and Newell, 1980.

SACATE FM.

Zone: CP14a, 14b, and 15a.

Location: Santa Barbara Co.

Reference: Almgren, Filewicz, and Heitman, 1988; Warren and Newell, 1980.

SALTOS SHALE (MEMBER OF MONTEREY FM.)

Zone: CN3 and 4.

Location: San Luis Obispo Co.

Reference: Poore, McDougall, Barron, Brabb, and Kling, 1981.

SANDHOLDT MEMBER (OF MONTEREY FM.)

Zone: CN2, 3, and 4.

Location: Monterey Co.

Reference: Poore, McDougall, Barron, Brabb, and Kling, 1981.

SAN LORENZO FM.

Zone: CP13, 14a, 14b, 15a, 15b?, and 16?.

Location: Santa Cruz Co.

Reference: Bukry, Brabb, and Vedder, 1977; Haq, 1983b; Warren and Newell, 1980.

SANTA SUSANA FM.

Zone: CP5, 6, 8, 9, and 11.

Location: Ventura Co.

Reference: Filewicz and Hill, 1983; Squires, R. L., 1991; Sullivan, 1965.

SODA LAKE SHALE

Zone: CN1.

Location: Ventura Co.

Reference: Lagoe, 1988.

STADIUM CONGLOMERATE

Zone: CP14/15, CP14 or higher.

Location: San Diego Co.

Reference: Kennedy and Moore, 1971; Kennedy, 1975.

"TEJON" FM.

Zone: CP13.

Location: Kern Co.

Reference: Sullivan, 1965.

TERTIARY MUDSTONE AT PINE RIDGE

Zone: CP9.

Location: San Luis Obispo Co.

Reference: Vedder, McLean, Stanley, and Wiley, 1991.

TWO BAR SHALE

Zone: CP14b and CP15.

Location: Santa Cruz Co.

Reference: Bukry, Brabb, and Vedder, 1977; Poore and Bukry, 1983.

VACAVILLE SHALE

Zone: CP11, 12, and 13.

Location: Solano Co.

Reference: Almgren, Filewicz, and Heitman, 1988; Sullivan, 1965.

VAQUEROS(?) FM.

Zone: CP19, CN1, 3, and 4.

Location: Santa Cruz Co.

Reference: Poore and Bukry, 1983.

VAQUEROS FM.

Zone: CP17/19 and CP18/19.

Location: Santa Cruz Co.

Reference: Bukry, Brabb, and Vedder, 1977; Poore and Bukry, 1983.

VINE HILL SANDSTONE

Zone: CP7 and CP6/8.

Location: Contra Costa Co.

Reference: Sullivan, 1964; Bukry, unpublished data, 1991, for E. E. Brabb sample 90CB2915.

WAGONWHEEL FM.

Zone: CP10.

Location: Kern Co.

Reference: Warren, 1983.

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REFERENCES CITED

Advocate, D. M., Link, M. H., and Squires, R. L., 1988, Anatomy and history of an Eocene submarine canyon: The Maniobra Formation, southern California, in Filewicz, M. V., and Squires, R. L. (editors), Paleogene stratigraphy, west coast of North America, Pacific Section, Society of Economic Paleontologists and Mineralogists, v. 58, p. 45-58.

Almgren, A. A., and Filewicz, M. V., 1984, Benthic foraminiferal and calcareous nannofossil biostratigraphy of the Markley Canyon fill, in Almgren, A. A., and Hacker, P. D. (editors), Paleogene submarine canyons of the Sacramento Valley: Pacific Section, American Association of Petroleum Geologists Symposium Volume, p. 115-124.

Almgren, A. A., Filewicz, M. V., and Heitman, H. L., 1988, Lower Tertiary foraminiferal and calcareous nannofossil zonation of California: An overview and recommendation, in Paleogene stratigraphy, west coast of North America, Pacific Section, Society of Economic Paleontologists and Mineralogists, v. 58, p. 83-105.

Almgren, A. A., and McDougall, K., 1975, Stratigraphic relationship of the middle Eocene Kellogg and Sidney Flat Shales of northern California, in Weaver, D. W. (editor), Paleogene symposium and selected papers: Pacific Section, American Association of Petroleum Geologists, p. 1-13.

Barron, J. A., Bukry, D., and Poore, R. Z., 1984, Correlation of the middle Eocene Kellogg Shale of northern California:

Micropaleontology, v. 30, p. 138-170.

Barron, J. A., Keller, G., and Dunn, D. A., 1985, A multiple microfossil biochronology for the Miocene: Geological Society of America Memoir 163, p. 21-35.

Berggren, W. A., Kent, D. V., Flynn, J. J., and Van Couvering, J. A., 1985, Cenozoic geochronology: Geological Society of America Bulletin, v. 96, p. 1407-1418.

Brabb, E. E., Bukry, D., and Pierce, R. L., 1971, Eocene (Refugian) nannoplankton in the Church Creek Formation near Monterey, central California: U.S. Geological Survey Professional Paper 750-C, p. C44-C47.

Bramlette, M. N., and Riedel, W. R., 1954, Stratigraphic value of discoasters and some other microfossils related to Recent coccolithophores: Journal of Paleontology, v. 28, p. 385-403.

Bramlette, M. N., and Sullivan, F. R., 1961, Coccolithophorids and related nannoplankton of the early Tertiary in California: Micropaleontology, v. 7, p. 129-188.

Bramlette, M. N., and Wilcoxon, J. A., 1967, Middle Tertiary calcareous nannoplankton of the Cipero Section, Trinidad, W. I.: Tulane Studies in Geology, v. 5, p. 93-131.

Bukry, D., 1971, Cenozoic calcareous nannofossils from the Pacific Ocean: San Diego Society of Natural History Transactions, v. 16, p. 303-327.

Bukry, D., 1973, Low-latitude coccolith biostratigraphic zonation: Deep Sea Drilling Project Initial Reports, v. 15, p. 685-703.

Bukry, D., 1975, Coccolith and silicoflagellate stratigraphy, northwestern Pacific Ocean, Deep Sea Drilling Project Leg 32: Deep Sea Drilling Project Initial Reports, v. 32, p. 677-701.

Bukry, D., 1978, Biostratigraphy of Cenozoic marine sediment by calcareous nannofossils: Micropaleontology, v. 24, p. 44-60.

Bukry, D., 1980, Coccolith correlation for Ardath Shale, San Diego County, California: U.S. Geological Survey Professional Paper 1175, p. 230.

Bukry, D., 1981a, Cenozoic coccoliths from the Deep Sea Drilling Project: Society of Economic Paleontologists and Mineralogists Special Publication 32, p. 433-444.

Bukry, D., 1981b, Pacific Coast coccolith stratigraphy between Point Conception and Cabo Corrientes, Deep Sea Drilling Project Leg 63: Deep Sea Drilling Project Initial Reports, v. 63, p. 445-471.

Bukry, D., 1985, Mid-Atlantic Ridge coccolith and silicoflagellate biostratigraphy, Deep Sea Drilling Project Sites 558 and 563: Deep Sea Drilling Project Initial Reports, v. 82, p. 591-603.

Bukry, D., in press, Transoceanic correlation of middle Eocene coccolith Subzone CP14a at Batiquitos Lagoon, San Diego County, <u>in</u> Abbott, P. L., and May, J. A. (editors), Eocene geologic history of San Diego: Pacific Section, Society of Economic Paleontologists and Mineralogists, Field Guide and Symposium Volume (October, 1991).

Bukry, D., Brabb, E. E., and Vedder, J. G., 1977, Correlation of Tertiary nannoplankton assemblages from the Coast and Peninsular Ranges of California: Memoir Segundo Congreso

Latinoamericano de Geologia, v. 3, Venezuela Boletin de Geologia Publicacion Especial no. 7, p. 1461-1483.

Bukry, D., and Kennedy, M. P., 1969, Cretaceous and Eocene coccoliths at San Diego, California: California Division of Mines and Geology Special Report 100, p. 33-43.

DePaolo, D. J., and Finger, K. L., 1991, High-resolution strontium-isotope stratigraphy and biostratigraphy of the Miocene Monterey Formation, central California: Geological Society of America Bulletin, v. 103, p. 112-124.

Filewicz, M. V., and Hill, M. E., 1983, Calcareous nannofossil biostratigraphy of the Santa Susana and Llajas Formations, north side of Simi Valley, in Squires, R. L., and Filewicz, M. V. (editors), Cenozoic geology of the Simi Valley area, southern California: Pacific Section, Society of Economic Paleontologists and Mineralogists, Fall Field Trip Volume and Guidebook, p. 45-60.

Gibson, J. M., 1976, Distribution of planktonic foraminifera and calcareous nannoplankton, Late Cretaceous and early Paleogene: Journal of Foraminiferal Research, v. 6, p. 87-106.

Haq, B. U., 1983a, Jurassic to Recent nannofossil biochronology: An update: Benchmark Papers in Geology, v. 78, p. 358-378.

Haq, B. U., 1983b, Calcareous nannofossil biostratigraphy of Paleogene of the Santa Cruz Mountains, California: U.S. Geological Survey Professional Paper 1213, p. 38-39.

Haq, B. U., Hardenbol, J., and Vail, P. R., 1987, Chronology of fluctuating sea levels since the Triassic: Science, v. 235,

p. 1156-1167.

Hay, W. W., Mohler, H. P., Roth, P. H., Schmidt, R. R., and Boudreaux, J. E., 1967, Calcareous nannoplankton zonation of the Cenozoic of the Gulf Coast and Caribbean-Antillian area and transoceanic correlation: Gulf Coast Association of Geological Societies Transactions, v. 17, p. 428-459.

Kanter, L. R., 1988, Paleolatitude of the Butano Sandstone, California, and its implications for the kinematic histories of the Salinian Terrane and the San Andreas Fault: Journal of Geophysical Research, v. 93, no. B10, p. 11,699-11,710.

Kennedy, M. P., 1975, Geology of the San Diego Metropolitan area, California: California Division of Mines and Geology Bulletin 200, p. 1-56.

Kennedy, M. P., and Moore, G. W., 1971, Stratigraphic relations of Upper Cretaceous and Eocene formations, San Diego coastal area, California: American Association of Petroleum Geologists Bulletin, v. 55, p. 709-722.

Khan, S. M., Coe, R. S., and Barron, J. A., 1989, High-resolution magnetic polarity stratigraphy of Shell Beach section of the Monterey Formation in Pismo basin, California, in Garrison, R. E. (editor), Japan-US Seminar on Neogene siliceous sediments of the Pacific region: Syllabus and Fieldtrip Guidebook, p. 106-122.

Kheradyar, T., 1988, Calcareous nannofossil biostratigraphy of the Butano Sandstone, Santa Cruz Mountains, California, in Filewicz, M. V., and Squires, R. L. (editors), Paleogene stratigraphy, west coast of North America: Pacific Section, Society of Economic Paleontologists and Mineralogists, v. 58, p. 151-165.

Kies, R. P., and Abbott, P. L., 1982, Sedimentology and paleogeography of lower Paleogene conglomerates, Southern California Continental Borderland, in Fife, D. L., and Minch, J. A. (editors), Geology and Mineral Wealth of the California Transverse Ranges: South Coast Geological Society, Annual Symposium and Guidebook 10, p. 337-349.

Lagoe, M. B., 1988, An outline of foraminiferal biofacies in the Soda Lake Shale Member, Vaqueros Formation, Cuyama Basin, California, in Bazeley, W. J. M. (editor), Tertiary tectonics and sedimentation in the Cuyama Basin, San Luis Obispo, Santa Barbara, and Ventura Counties, California: Pacific Section, Society of Economic Paleontologists and Mineralogists, v. 58, p. 21-27.

Lipps, J. H., and Kalisky, M., 1972, California Oligo-Miocene calcareous nannoplankton biostratigraphy and paleoecology, in Stinemeyer, E. H. (editor), Proceedings of the Pacific Coast Miocene biostratigraphic symposium: Pacific Section, Society of Economic Paleontologists and Mineralogists, p. 239-254.

Loeblich, A. R., Jr., and Tappan, H., 1966, Annotated index and bibliography of the calcareous nannoplankton: Phycologia, v. 5, p. 81-216.

Loeblich, A. R., Jr., and Tappan, H., 1971, Annotated index and bibliography of the calcareous nannoplankton VI: Phycologia,

v. 10, p. 315-339.

Martini, E., and Bramlette, M. N., 1963, Calcareous nannoplankton from the experimental Mohole drilling: Journal of Paleontology, v. 37, p. 845-856.

Miller, P. L., 1981, Tertiary calcareous nannoplankton and benthic foraminifera biostratigraphy of the Point Arena area, California: Micropaleontology, v. 27, p. 419-443.

Okada, H., and Bukry, D., 1980, Supplementary modification and introduction of code numbers to the low-latitude coccolith biostratigraphic zonation (Bukry, 1973; 1975): Marine Micropaleontology, v. 5, p. 321-325.

Poore, R. Z., and Bukry, D., 1983, Eocene to Miocene calcareous plankton from the Santa Cruz Mountains and northern Santa Lucia Range, California and northern Santa Lucia Range, California: U.S. Geological Survey Professional Paper 1213, p. 49-61.

Poore, R. Z., McDougall, K., Barron, J. A., Brabb, E. E., and Kling, S. A., 1981, Microfossil biostratigraphy and biochronology of the type Relizian and Luisian Stages of California, in Garrison, R. E., and Douglas, R. G. (editors), The Monterey Formation and related siliceous rocks of California: Pacific Section, Society of Economic Paleontologists and Mineralogists, p. 15-41.

Squires, R. L., 1988, Rediscovery of the type locality of *Turritella andersoni* and its geologic age implications for West Coast Eocene strata, in Filewicz, M. V., and Squires, R. L.

(editors), Paleogene stratigraphy, west coast of North America: Pacific Section, Society of Economic Paleontologists and Mineralogists, v. 58, p. 203-207.

Squires, R. L., 1991, Paleontologic investigations of the uppermost Santa Susana Formation, south side of Simi Valley, southern California: American Association of Petroleum Geologists Bulletin, v. 75, p. 382.

Squires, R. L., Cox, B. F., and Powell, C. L., II, 1988, Late Paleocene or early Eocene mollusks from the uppermost part of the Goler Formation, California, in Filewicz, M. V., and Squires, R. L. (editors), Paleogene stratigraphy, west coast of North America: Pacific Section, Society of Economic Paleontologists and Mineralogists, v. 58, p. 183-187.

Sullivan, F. R., 1964, Lower Tertiary nannoplankton from the California Coast Ranges--Part I, Paleocene: California University Publications in Geological Sciences, v. 44, p. 163-228.

Sullivan, F. R., 1965, Lower Tertiary nannoplankton from the California Coast Ranges--Part II, Eocene: California University Publications in Geological Sciences, v. 53, p. 1-75.

Tennyson, M. E., Keller, M. A., Filewicz, M. V., and Cotton Thornton, M. L., 1991, Contrasts in early Miocene subsidence history across Oceanic-West Huasna Fault System, northern Santa Maria Province, California: American Association of Petroleum Geologists Bulletin, v. 75, p. 383.

Thompson, T. J., 1988, Outer-fan lobes of the lower to middle Eocene Juncal Formation, San Rafael Mountains, California, in Filewicz, M. V., and Squires, R. L. (editors), Paleogene stratigraphy, west coast of North America: Pacific Section, Society of Economic Paleontologists and Mineralogists, v. 58, p. 113-127.

Vedder, J. G., McLean, H., Stanley, R. G., and Wiley, T. J., 1991, Paleogeographic implications of an erosional remnant of Paleogene rocks southwest of the Sur-Nacimiento fault zone, southern Coast Ranges, California: Geological Society of America Bulletin, v. 103, p. 941-952.

Warren, A. D., 1981, Calcareous nannoplankton biostratigraphy of Cenozoic marine stages in California, in Kleinpell, R. M., The Miocene stratigraphy of California revisited, p. 60-69.

Warren, A. D., 1983, Lower Tertiary nannoplankton biostratigraphy in the central Coast Ranges, California: U.S. Geological Survey Professional Paper 1213, p. 22-38.

Warren, A. D., and Newell, J. H., 1980, Plankton biostratigraphy of the Refugian and adjoining stages of the Pacific Coast Tertiary: Cushman Foundation Special Publication 19, p. 233-251.

Wilcoxon, J. A., 1969, Tropical planktonic zones and calcareous nannoplankton correlations in part of the California Miocene: Nature, v. 221, p. 950-951.