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Title of article Reconnaissance Geology of the State of Baja California

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MEMOIR 140

Contents 20 p.

APPENDIX 3.

MINERALOGY AND PETROGRAPHY OF METAVOLCANIC ROCKS TIJUANA - TECATE AREA

Sample	Albite	Quartz	K-spar	Biotite	Actinolite	Epidote	Chlorite	White mica	Sphene	Carbonate	Lithic fragments	Texture
12a	X	X				0	X	0			X	Hornfelsed dacitic lithic - crystal tuff
13c	X	X	?	X		0		0				Hornfelsed dacitic crystal tuff or vitrophyre
13e	X	X		0	0		X	0	0		X	Hornfelsed andesitic breccia
13g	X	X	0	0			0	0	0		X	Hornfelsed dacitic lithic - crystal tuff
13i	X	X		0		0	X		X	0		Hornfelsed andesitic tuff - breccia
13j	X	X		0				0		0		Hornfelsed dacitic tuff - breccia
13k	X	0			X	0	0	0	0	0		Hornfelsed diabase
14a	X	0			X	0	0					Hornfelsed diabase
14c	X			X		0	0	0	0			Hornfelsed andesitic Crystal tuff or porphyritic andesite
14h	X	X	0	0				X		0		Hornfelsed dacitic crystal tuff

X - major component; more than 10%

0 - minor component; less than 10%

Locations

12a Tijuana - Tecate road near 1266 km marker

13c - k Tijuana - Tecate road near 1264 km marker

14a - h Tijuana - Tecate road near 1262 km marker

NOTE: from Hawkins, 1970 b

Appendix 4.

Location and Petrographic Description of Chemically Analyzed Plutonic Rocks (For location, refer to Plate 3)

B3J-60 Long. 115°56' W, Lat. 32°01' N; Tijuana drainage, Air Photo 1421; south side of road southwest of Laguna Hansen [Loc. 18].

Hypidiomorphic granular, 2-5 mm with porphyritic microcline up to 12 mm; minor myrmekite; plagioclase subhedral 2-5 mm, moderately zoned; quartz anhedral, up to 5 mm; microcline subhedral and interstitial, biotite subhedral 0.5-1 mm, tan to dark reddish brown.

B3M-21 Long. 116°19' W, Lat. 31°52' N; Tijuana drainage. Air Photo 1124; just west of Valle San Rafael. Equant 4 km diameter pluton with irregular boundary [Loc. 10].

Xenomorphic granular, micrographic, 1-2 mm; potassium feldspar subhedral, ~2 mm, perthitic; quartz up to 1 mm, largely graphic; plagioclase subhedral, 1-2 mm, moderate zoning; biotite 0.2 mm in 3 mm cumulo-porphyritic clusters, light to very dark brown.

B3M-35 Long. 116°27' W, Lat. 31°37' N; C.I.T. Air Photo 1302-241; roadside west of Ejido Uruapan 20 km SE of Maneadero; long irregular pluton [Loc. 11].

Hypidiomorphic granular, 1-4 mm; plagioclase 1-4 mm, euhedral to subhedral, moderate zoning, recrystallization to sericite and epidote minerals; quartz up to 2 mm, anhedral and interstitial; hornblende 0.5-3 mm, subhedral, commonly rims pale augite and is in turn rimmed by biotite; biotite, 1-4 mm, anhedral, very dark brown to pale yellow brown; augite 0.5-1 mm, subhedral, nearly colorless.

B3T-40 Long. 116°14' W, Lat. 31°09' N; very small body on north side of Valle Calentura [Loc. 21].

Hypidiomorphic granular to subophitic, 0.5-2 mm; plagioclase 0.5-2 mm subhedral, moderate zoning; hornblende 0.5-3 mm anhedral, pale to medium green; hypersthene 0.5-2 mm, subhedral, pink-pale green pleochroism, occurs as cores within hornblende.

B3K-41 Long. 116°13' W, Lat. 31°10' N; north side of Valle Calentura [Loc. 21].

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App. 4-2

Hypidiomorphic granular, 0.5-3 mm, planar alignment of hornblende and biotite; plagioclase, 1-3 mm, subhedral, moderate zoning, some myrmakitic crystallization; quartz to 2.5 mm, anhedral and interstitial, and semicomposite; biotite 0.5-2 mm subhedral, in aggregates with hornblende, tan to dark brown; hornblende 0.5-2 mm, subhedral, simple twins, color zoning, pale green to moderate olive green; microcline to 2 mm, anhedral and interstitial.

B5G-54 Long. 114°09' W, Lat. 28°39' N; N.O.R. Air Photo 120-100, south of Bahia Santa Rosalia where a small exposure of gabbro reaches the coast [Loc. III-36].

Hypidiomorphic granular, 0.5-1 mm; plagioclase 0.5-1 mm, subhedral, zoned, recrystallized; hornblende 0.5-3 mm, anhedral to subhedral; quartz up to 0.1 mm, anhedral and interstitial.

B5F-48C Long. 113°56' W, Lat. 29°31' N; north of La Asamblea, N.O.R. Air Photo 122-72 [Loc. III-34].

Hypidiomorphic granular, 0.5-1 mm; plagioclase 0.5-1 mm, subhedral, zoned, recrystallized; hornblende 0.5-3mm, anhedral to subhedral, actinolitic, mottled pale green, partially recrystallized; biotite 0.5-1 mm, subhedral, heavily altered to chlorite; quartz up to 0.5 mm anhedral and interstitial.

B5F-2D Long. 113°45' W, 28°45' N; hillside to the south of San Borja, part of a large axial body composed largely (?) of tonalite [Loc. III-35].

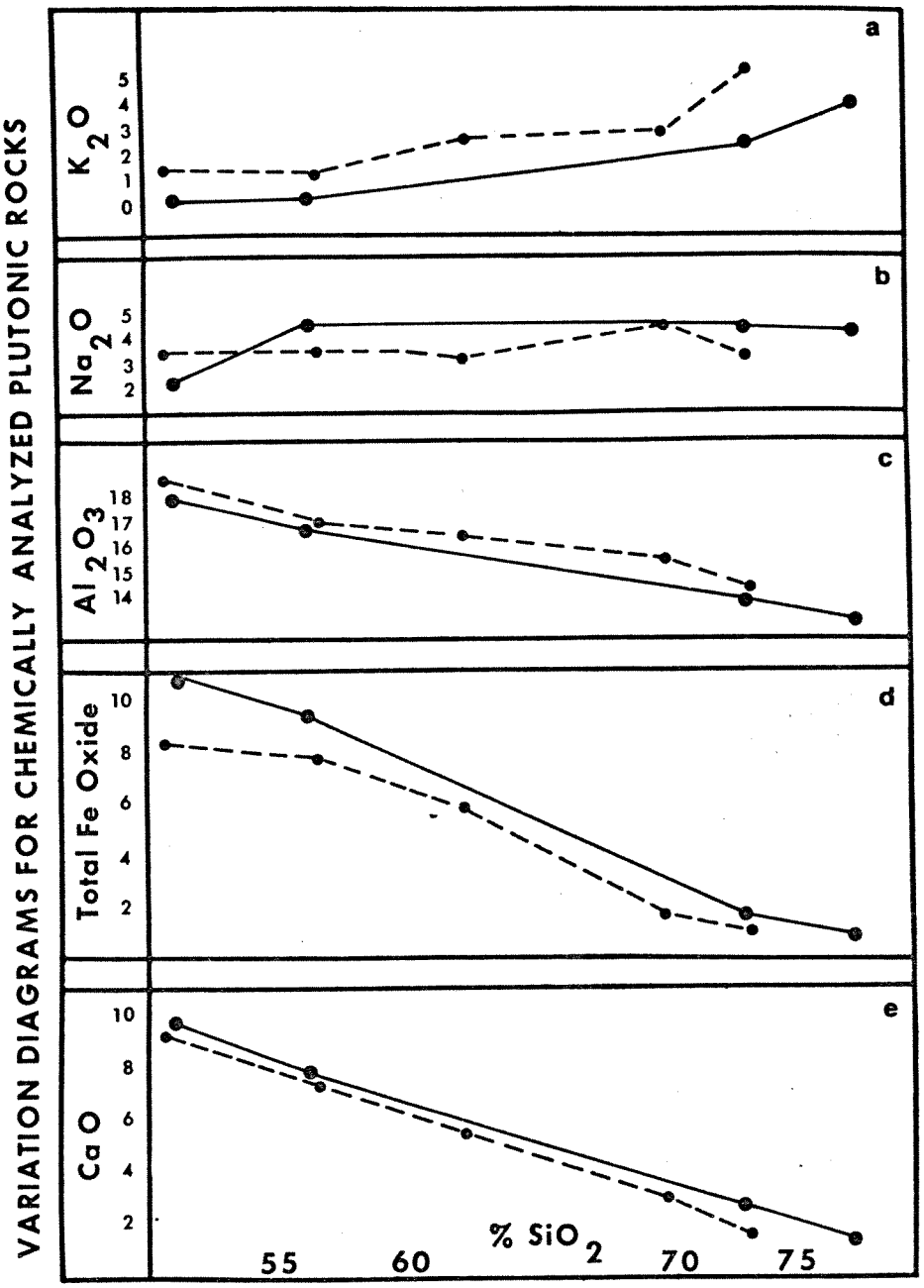
Hypidiomorphic granular, 1-4 mm with minor myrmekite; plagioclase 1-3 mm subhedral, moderate zoning; quartz 1-5 mm anhedral; microcline 0.5-3 mm, anhedral intergrowths; biotite 0.5-1 mm, anhedral to subhedral, tan to medium reddish brown.

B5E-53A Long. 112°54' W, Lat. 28°26' N; shore of Bahia San Francisquito, near contact of large axial body of adamellite [Loc. III-37].

Xenomorphic granular, 1-6 mm, minor myrmekite; quartz up to 4 mm, anhedral; microcline 1-6 mm subhedral, perthitic intergrowth; plagioclase, up to 2 mm; biotite 0.2-0.5 mm, subhedral, tan to reddish brown.

For modes and plagioclase composition see Tables 5 and 6.

APPENDIX 5


VARIATION DIAGRAMS FOR CHEMICALLY ANALYZED PLUTONIC ROCKS
a
K_2O
5
4
3
2
1
0
b
Na_2O
5
4
3
2
c
Al_2O_3
18
17
16
15
14
d
Total Fe Oxide
10
8
6
4
2
e
CaO
10
8
6
4
2
55
60
% SiO_2
70
75

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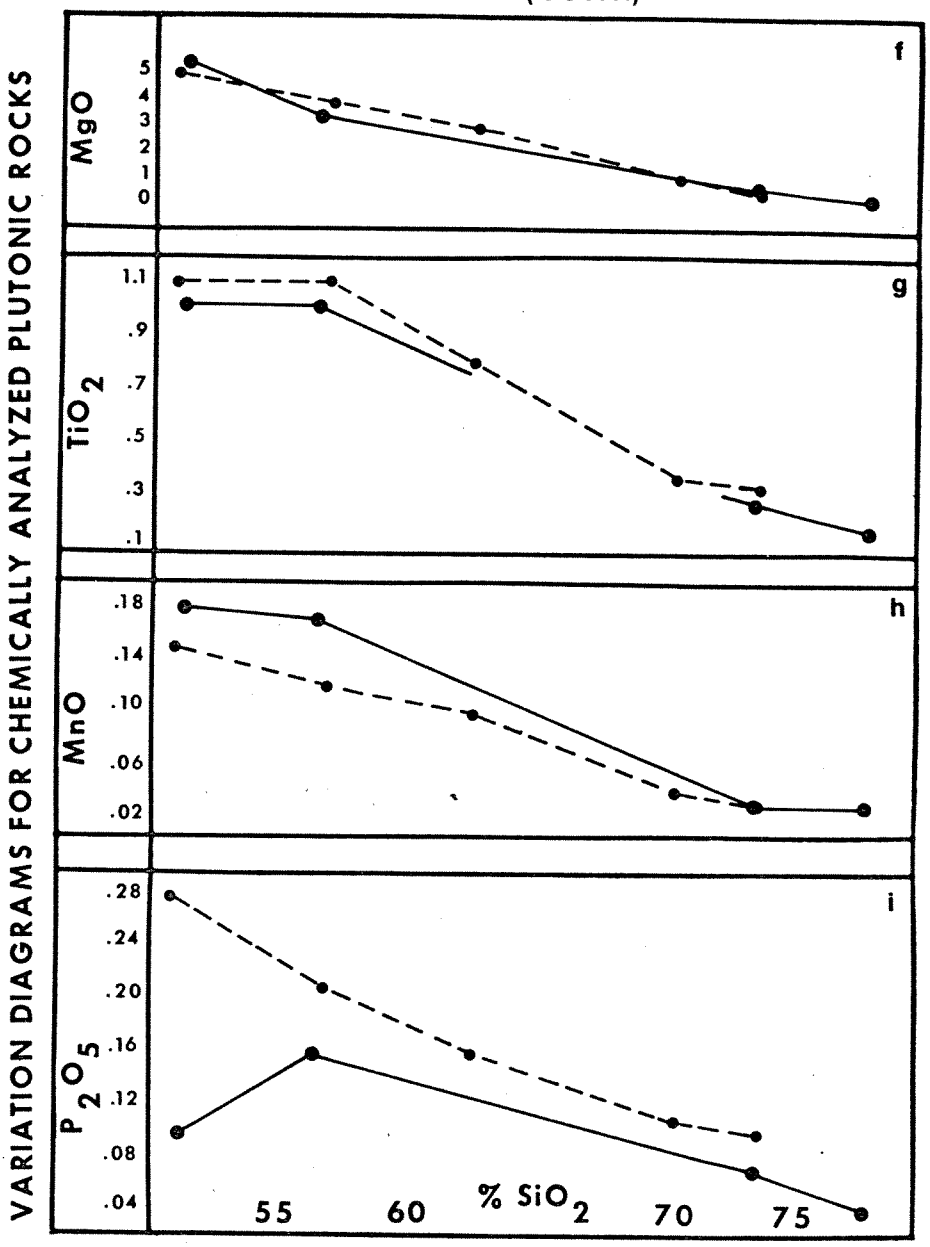
APPENDIX 5 (CONT.)



Appendix 6. Citations of Neogene marine strata near the center of the state of Baja California.

From Böse and Wittich, 1913, p. 352:

Desde los alrededores del Rosario vemos el Terciario y principalmente los conglomerados mencionados arriba extenderse hacia el interior de la Península. Los conglomerados contienen aquí en su base con frecuencia fosiles mal conservados de aspecto muy moderno; en la parte superior no hemos podido encontrar restos orgánicos. En la subida del Rosario para San Fernando, encontramos tales conglomerados cubriendo el pórfido. En los llanos de Buenos Aires (cerca de la ex-misión de San Fernando) hemos observado areniscas friables y arenas cubiertas por conglomerados y parece que estas rocas se extienden bastante hacia el Este.

From Flores and Gonzáles, 1913, p. 246:

Las únicas rocas sedimentarias que se encuentran en la región recorrida por nosotros, son las areniscas y conglomerados volcánicos que forman el subsuelo del rancho de San Juan de Dios y la parte inferior de las mesas de las cercanías de ese rancho; y algunas calizas que aparencen en fajas y gruesos bancos en los alrededores de San Fernando y en los criaderos de ónyx do la "New Padrara Co." En los alrededores de San Fernando los bancos tienen una dirección general de 70° D.E., con 12° de inclinación al N.E. y contienen restos fósiles mal conservados que parecen ser de ostreidos.

Appendix 7.

Locations and Petrographic Descriptions of Volcanic Rocks

A0W-1126C Northwest of Hill 771, San Quintín. Described by Woodford (1928) as a diabase flow with 66% labradorite, 15% olivine, 15% augite, iron oxides and apatite, with quartz and perthitic orthoclase in vesicles.

A0W-1123A Southwest Hill, San Quintín. Described by Woodford (1928) as a basalt flow consisting of An 67% plagioclase, olivine, augite, and iron ores in a glassy groundmass.

HQ-129 East of Bahía de los Angles. Described by Hirschi and de Quervain (1933) as a hyalophitic pyroxene-amphibole andesite; plagioclase An 55-85, hornblende, hypersthene, augite, olvine, apatite and glass, minor magnetite and zircon.

HQ-133 East of Bahía de las Animas. Described by Hirschi and de Quervain (1933) as a biotite-hornblende andesite vitrophyre: plagioclase An 40-50, biotite, hornblende and glass, minor constituents apatite, magnetite, zircon.

HQ-134 East of Bahía de las Animas. Described by Hirschi and de Quervain (1933) as a biotite-hornblende-hypersthene andesite vitrophyre: plagioclase An 30-45 60%, hornblende 12%, biotite 12%, quartz 10%, hypersthene 67%, with smaller percentages of augite and glass, minor amounts of magnetite, apatite, zircon.

C-1 Tres Marías volcanic field, northeastern Territory of Baja California. Described by K. von Chrustschoff (1885) as porphyritic leucitophyre: Leucite, augite, olivine, and glass spherulites (?) in a groundmass of anorthite plagioclase, magnetite, nepheline, biotite, melilite (?), sphene, apatite, orthoclase, and glass.

B3A-33 North side of Arroyo Rosarito just east of Rosarito Beach (117°02', 32°21'): Dark gray, porphyritic; phenocrysts of olivine, augite, and zoned andesine-labradorite, matrix of plagioclase laths, opaque minerals, deuteric and secondary minerals.

B3G-141 Immediately east of Rancho Santa Clara, between Tres Hermanos and Cerro Colorado, (116°06', 31°43'): light gray porphyritic, large phenocrysts of labradorite in a microcrystalline groundmass of olivine, clinopyroxene, and opaque minerals. Some phases of this rock are holocrystalline gabbroic anorthosite with labradorite phenocrysts up to seven centimeters (Burk, Senior report, San Diego State, 1969).

B4F-62 East-central Mesa San Carlos (115°27', 29°40'): medium gray, pilotaxitic, microcrystalline; phenocrysts of relict olivine; groundmass of labradorite, clinopyroxene, opaque minerals, possibly a little interstitial sanidine.

B5F-85 Isla Lobos (113°03', 28°54'): vesicular, brownish gray, trachytic, vitrophyric, with microlites of oligoclase (?) scattered prisms of high birefringence clinopyroxene, and opaque minerals in a glassy groundmass.

B4P-23 Cerro León, a volcanic crater on the coast south of Puertecitos, (114°40', 30°11'): vesicular, dark gray, glomeropophyritic, hyalophitic; phenocrysts of labradorite-bytownite in a groundmass of plagioclase microlites, hypersthene, opaque minerals and glass.

B5G-158 Between Arroyo San José and Punta Blanca, Pacific Coast, (114°45', 29°13'): vesicular, olive gray, microporphyritic, intergranular; phenocrysts of relict olivine in a groundmass of plagioclase, clinopyroxene, and opaque minerals; zeolites fill vesicles.

B5W-100b Recent flow south of Arroyo San José (114°48', 29°18'): finely vesicular, medium brownish gray, trachytic, hyalophitic; composed of plagioclase, clinopyroxene, opaque minerals, apatite, and a trace of secondary quartz; a matrix of glass.

B6G-11 Sierra San Felipe (115°10', 31°16'): olive gray, microporphyritic, trachytic, hyalophitic; containing intermediate plagioclase, hornblende, a trace of clinopyroxene, opaque minerals, and glass.

B6G-49 West-central San Quintín volcanic field (116°01', 30°28'): dark gray, vesicular, hypocrystalline, porphyritic, trachytic; consisting of high birefringent clinopyroxene and olivine in a groundmass of plagioclase, and abundant opaque minerals, possibly some interstitial sanidine.

B9B-15 Northern Sierra Santa Rosa (114°57', 31°02'): massive medium dark gray, intergranular; laths of clinopyroxene and small grains of olivine and opaque minerals in a groundmass of plagioclase and minor glass.

B8B-66 Northwest of Cerro Borrego (115°18', 31°28'): brownish black, glomeroporphyritic, intersertal; phenocrysts of relict olivine, small clinopyroxene, plagioclase, and abundant opaque minerals.

B8B-67 Northwest of Cerro Borrego (115°18', 31°29'): medium gray, subophitic, weakly trachytic; phenocrysts of relict olivine, augite and partially resorbed intermediate plagioclase, groundmass of more basic plagioclase, hypersthene, opaque minerals and glass.

B8B-15a North of road between El Paraíso and Valle San Felipe (115°11', 31°21'): medium gray, porphyritic, intersertal, subophitic: intermediate plagioclase, clinopyroxene, and minor amphibole with celadonite (?), and abundant zeolite filling cavities.

B9B-55 Northwest of San Felipe (115°00', 31°11'): olive gray, vesicular, trachytic, glomeroporphyritic, vitrophyric; phenocrysts of augite; olivine; intermediate plagioclase, opaque minerals, zeolite, and glass.

KA-517 Southern Sierra Pinta (115°11', 31°31'): medium gray, slightly vesicular; phenocrysts of oligoclase in an intersertal groundmass of plagioclase, opaque minerals and clinopyroxene.

KA-518 Misión Santa Gertrudis (113°05', 28°02'): pinkish gray vitric-crystal tuff with fine spherulitic crystallization, crystals of intermediate plagioclase, biotite, and opaque minerals.

KA-523 Southwest of Bahía de las Animas (113°24', 28°38'): pale red crystal vitric tuff; andesine with small percentages of lamprobolite, augite, biotite, and opaque minerals; divitrified glass fragments contain plagioclase microlites.

KA-524 Southwest of Bahía de las Animas (113°24', 28°38'): brownish gray, intergranular; principally clinopyroxene and sanidine, lesser biotite and relict olivine, small amounts of calcite and palagonite.

KA-531 Llano San Pedro, south of Bahía de las Animas (113°17', 28°36'): grayish red purple, porphyritic, hyalophitic; intermediate plagioclase with lesser augite and opaque minerals in a glassy groundmass.

KA-539 Top of old grade south of La Misión (116°50', 32°05'): olive gray, porphyritic, intersertal; large phenocrysts of labradorite with lesser augite and opaque minerals in a crystalline groundmass.

KA-540 Just north of La Ventana, Sierra Pinta (115°05', 31°45'): grayish purple, porphyritic, hyalotrachytic, intergranular; predominantly oligoclase-andesine with lesser clinopyroxene, opaque minerals and possibly some relict hornblende, quartz, and potassium feldspar.

KA-541 Just west of La Ventana, Sierra Pinta (115°06', 31°44'): light gray, glomeroporphyritic, trachytic, vitrophyric, probably a crystal tuff; sodic to intermediate plagioclase, some large plagioclases partially resorbed, lamprobolite, hypersthene, biotite, cristobalite, sanidine, glass.

KA-550 East of El Rodeo (115°39', 31°37'): pale red, porphyritic, hyalophitic, welded tuff; oligoclase-andesine, and potassium feldspar, with lesser quartz and relict biotite.

KA-552 Northeast of Rosarito (114°02', 28°38'): medium gray, glomeroporphyritic, subophitic to intergranular; augite rimmed with aegerine augite, relict olivine, secondary phlogopite after relict biotite (?), rutile, untwinned oligoclase in interstitial areas.

KA-553 Capping basalt above Misión San Borja (113°51', 28°44'): medium dark gray, pilotaxitic; intermediate to basic plagioclase, olivine, augite, ilmenite, apatite.

KA-559 Older volcanic series northwest of Puertecitos (114°45', 30°26'): light brownish gray, vitric, lithic, crystal tuff, welded shard structure; andesine is the most abundant crystal, with traces of pyroxene, zircon, and zeolite; rock fragments include diabase.

KA-561 Younger series northwest of Puertecitos (114°45', 30°26'): yellowish gray, spherulitic perlite; two-thirds glass, one-third zeolite, with a few crystals of sodic plagioclase.

Appendix 8. Original citation of evidence for deep recent submergence of the peninsula.
From Böse and Wittich (1913, p. 357-359):

Encima de las capas descritas aquí se encuentra particularmente en la región meridional de nuestra zona otro depósito, ciertamente no de una potencia muy grande, pero de suma importancia para la historia geológica de la Península. Es un depósito que se compone generalmente de arenas y médanos, en aislados casos también de conglomerados; todos estos depósitos contienen numerosos restos de conchas recientes, enteramente las mismas especies como hoy día se encuentran en la orilla del Océano Pacífico. Estos depósitos los hemos encontrado en todas partes del referido distrito; en algunos lugares estos restos de conchas marinas son escasas, pero siempre se encuentran por lo menos algunos fragmentos. Los hemos observado desde la orilla del mar continuamente hasta el punto mas alto 1050$^{m.}$ visitado por nosotros, y allí nos dijo nuestro guía que las mismas conchas se hallaron en perfecto estado y en grandes cantidades también en las sierras a nuestro lado, sierras que probablemente pasan la altura de 1800$^{m.}$ Hemos visto que estas conchas no se encuentran únicamente en el lado del Pacífico, sino hemos podido seguir a estos depósitos atravesando la sierra para el lado del Golfo de California y el punto más alto alcanzado por nosotros es precisamente el puerto de San Juan en el parteaguas de la sierra de San Borjas. No sabemos con exactitud hasta que altura llegan estos depósitos enteramente modernos en la región al Norte de San Quintín, pues para esto sería necesario un estudio de aquellas regiones en este sentido. Nosotros hemos visto allí estos depósitos hasta la altura de unos 200$^{m.}$; cerca de la ex-misión de San Miguel se encuentran estos depósitos de conchas recientes segun las observaciones del Sr. Francisco Crosswhaitte en una altura de 300$^{m.}$ El Sr. Crewe Read, viajero explorador inglés, nos comunicó que había observado grandes cantidades de conchas recientes en un rincón del valle de la Encantada en la cresta de la sierra de San Pedro Mártir, en una altura de más de 2000$^{m.}$ Los Sres. Alfredo y Andrés Johnson que son probablemente los mejores conocedores de la sierra de San Pedro Mártir y del desierto que queda al Este de ella, nos han dado algunas informaciones interesantes.

Entre otras cosas, nos dijeron que en el Cajón, un portezuelo en la región de Aguacaliente situado en la vertiente del golfo de la Sierra de San Pedro Mártir se encuentran en una altura de 3,000 a 3,500 pies (approximadamente 1,000$^{m.}$) numerosas conchas marinas recientes pertenecientes a las mismas especies que hoy día se encuentran en la playa del mar. Según las indicacione de los Sres. Johnson, las conchas más frecuentes en aquel localidad pertenecerán a los géneros Mytilus, Venus y Pecten. Los referidos señores no recuerdan haber visto conchas recientes a mayor altura en la sierra de San Pedro Mártir. La existencia de conchas recientes a gran altura en la vertiente oriental, hace probable que antes también existian en el lado del Pacífico de la sierra de San Pedro Mártir, pero debamos tomar en consideración que en esta región las lluvias ya son mucho más frecuentes y más abundantes, la vegetación es mucho más densa, de modo que la mayor parte de las conchas recientes ya debe ser destruída y es probable que sólo en algunos lugares muy favorables se habrán conservado algunos restos.

Este hallazgo de conchas recientes en todas partes y an alturas muy grandes, nos prueba que la Península debe haber sido cubierta por el mar en tiempos muy recientes, probablemente todavía en aquel período que en Europa se designa como el periodo prehistórico. En aquel tiempo estaba casi toda la Península sumergida y probablemente solo los picos mas altos de la sierra de San Pedro Martir salián fuera del agua. Que esta sumersión de la Península ha tenido lugar en tiempos geológicalmente no muy remotos, lo prueba también la forma de los valles y cañadas producidos por la erosión del mar, los que conservan todavía en muchas partes su forma primitiva casi sin alteración, de modo que la erosión no ha tenido tiempo para darles a las corrientes de agua una dirección determinada y que éstas no hayan formado valles de erosión de rios. No podemos entrar en la discusion detallada de este problema tan importante para la geología por no ser este informe el lugar propio para esto, sino lo haremos en nuestro informe geológico. Hay mucha probabilidad que esta sumersión de la Península no tocaba únicamente a la parte septentrional sino también a la meridional, lo que indican las observaciones hechas allí por el Dr. E. Wittich.

APPENDIX 9.

GRAVITY BASE STATIONS, ADJUSTED TO LOS ANGELES M AT 979,593.771 MGAL

Stn.	Location	Description	Latitude	Longitude	Elevation (meters)	Observed Gravity	Simple Bouguer Gravity
66-1	San Diego, Calif., USA	S.E. corner, seismic pier, San Diego State Univ.	32°46.588N	117°04.1W	124.85	979,525.41	-10.11
66-2	San Diego, Calif., USA	Loading dock, Geol. Bldg. San Diego State Univ.	32°46.631N	117°04.1W	124.15	979,525.99	- 9.72
66-3	Ensenada	Parking lot curb, old Universidad Autonoma	31° 51.45N	116°36.71W	20.45	979,453.25	-28.00
66-4	Ensenada	Statue of Miguel Hidalgo, Mexico B.M. #7	31°51.86N	116°37.58W	8.5	979,460.42	-23.73
66-10	San Diego, Calif., USA	East seismic pier, San Diego Nat. Hist. Museum	32°43.74N	117°08.89W	87.20	979,517.86	-21.17
66-13	Tijuana	Inside door, old airport terminal	32°32.3N	116°59.4W	151.8	979,485.90	-24.82
66-15	Ocotillo, Calif., USA	USC & GS "Ocotillo, 1935" (Chapman base #339)	32°44.02N	116°00.07W	144.63	979,460.31	-67.80
66-16	Calexico, Calif., USA	Rockwood Plaza, Historical Landmark 808	32°40.11N	115°29.54W	1.5	979,510.07	-40.87
66-17	Mexicali	Monument to Rudolfo Sánchez, on Mexican Highway #5	32°36.92N	115°26.31W	8.5	979,501.96	-43.25
66-18	North of San Felipe	Scripps Inst. of Oceanog. tide station	31°10.07N	114°53.40W	4.6	979,398.72	-30.28
66-19	San Felipe	Intersection, Mex. Hwy. #5 and dirt road to south	31°01.42N	114°50.34W	16.8	979,396.01	-19.10
66-21	Puertecitos	SW corner of solar still	30°21.0N	114°38.1W	5.2	979,332.69	-31.44
66-23	Coast SW of Isla Huerfanito	Rock outcrop near extreme high tide line	30°07.6N	114°37.9W	4.0	979,314.34	-32.52

APPENDIX 9. (continued)

GRAVITY BASE STATIONS, ADJUSTED TO LOS ANGELES M AT 979,593.771 MGAL

Stn.	Location	Description	Latitude	Longitude	Elevation (meters)	Observed Gravity	Simple Bouguer Gravity
66-24	San Luis Gonzaga	Road intersection to South Camp	29°47.9N	114°24.2W	16.8	979,277.97	-40.78
66-26	San Luis Gonzaga	Airport at South Camp	29°48.6N	114°23.65W	3.4	979,286.12	-36.19
66-28	Punta Prieta	Weather station	28°55.07N	114°09.15W	199.0	979,178.05	-37.06
66-29	El Rosarito	Weather station	28°38.22N	114°01.71W	124.7	979,189.41	-18.99
66-30	El Tomatal	Adobe house near beach (only foundation remains)	28°29.49N	114°03.99W	5.5	979,234.75	13.90
66-31	El Arco	Weather station	28°01.41N	113°24.39W	279.2	979,123.68	- 8.15
66-32	Bahía de los Angeles	Onyx pier, San Diego Nat. Hist. Mus. field station	28°56.91N	113°26.92W	6.1	979,216.96	-38.46
66-33	Laguna Chapala	House foundation	29°25.1N	114°23.9W	662.6	979,120.50	-41.73
66-34	San Agustín	Near DCM-IAGS B.M. DDA-177 *	29°55.9N	114°57.4W	576.1	979,185.49	-33.55
66-35	Rancho El Aguila	DCM-IAGS B.M. DDA-171 *	29°57.67N	115°03.4W	535.3	979,205.10	-24.29
66-36	La Turquesa	In road near DCM-IAGS B.M. DDA-145 *	30°03.0N	115°28.4W	422.2	979,253.46	- 5.11
66-37	El Rosario	Fish cannery west of town	30°03.2N	115°43.9W	28.3	979,312.43	-23.90
66-38	El Rosario	Gas pump, DCM-IAGS B.M. DDA-128 *	30°03.6N	115°43.5W	36.3	979,309.05	-26.24
66-41	San Vincente	Km 183 sign post on Mex. Highway #1	31°20.9N	116°15.8W	242.9	979,397.07	0.56

* Departmento Cartográfico Militar - Inter-American Geodetic Survey Bench Mark

APPENDIX 9. (continued)

GRAVITY BASE STATIONS, ADJUSTED TO LOS ANGELES M AT 979,593.771 MGAL

Stn.	Location	Description	Latitude	Longitude	Elevation (meters)	Observed Gravity	Simple Bouguer Gravity
66-42	Tecate	Railroad station U.S.G.S. B.M. 321164	32°34.05N	116°37.7W	514.0	979,412.43	-29.37
66-43	Las Palmas	North bridge abutment, Mex. Highway #3	32°22.8N	116°36.9W	272.5	979,441.46	-32.58
66-44	Ojos Negros	Entrance to Sangre de Cristo ranch	31°52.3N	116°08.8W	814.4	979,257.81	-68.31
66-45	Valle Trinidad	Road intersection near old airport	31°23.6N	115°43.3W	780.9	979,213.84	-80.39
66-46	San Matías Pass	Large boulder at foot of pass	31°18.05N	115°20.87W	655.9	979,225.59	-85.84
66-47	Valle San Felipe	Road intersection, NE side	31°18.50N	115°13.07W	461.2	979,292.44	-57.93
66-48	Valle San Felipe	Road intersection, south end	31°04.17N	115°15.18W	395.0	979,257.53	-86.78
66-49	San Felipe	Old gas pump, waterfront	31°01.35N	114°49.85W	6.4	979,395.97	-17.09
66-56	Guerrero Negro	Airport, SW corner hanger	27°58.0N	114°03.7W	4.9	979,131.09	-49.25
66-60	El Barril	Weather station	28°17.3N	112°53.4W	18.0	979,182.37	-20.72

APPENDIX 10.

ANALYSES OF IRON ORE FROM SAN VICENTE AREA

Mina Hercules (calculated as metal):		Mina Colussus (on the average):	
Fe	61.84%	Fe	58.85%
P	0.19%	SiO_2	8.57%
SiO_2	6.2%	P	2.00%
Mn	0.31%	Cu	0.51%
S	0.049%	S	0.74%
Water and volatiles	4.30%	Water	2.8%
Al	0.72%	also Mn, Ca and Al.	
Traces of Mg and Ca.			

(from Wittich, 1915)

APPENDIX 11.

ANALYSIS OF HOT SPRINGS IN ARROYO VOLCAN

Density	1.004
Residue	3.715 grams per liter
CO_2 (free)	2.224 grams per liter
CO_2 (combined)	0.746 grams per liter
SiO_2	0.136 grams per liter
B_2O_3	0.123 grams per liter
N_2O_5	trace
Cl	0.630 grams per liter
FeO	trace
CaO	0.622 grams per liter
MgO	0.208 grams per liter
K_2O	0.155 grams per liter
Na_2O	0.974 grams per liter
Li_2O	0.009 grams per liter
	3.603

from Flores and Gonzales, 1913

APPENDIX 12.

ANALYSES OF BRINES FROM CERRO PRIETO GEOTHERMAL WELL M-3.

	(mg/l)
Li	13.6
Na	5610.0
K	1040.0
Ca	320.4
Sr	27.4
Ba	57.0
Cu	0.09
Ag	0.05
Au	tr.
H_2S	6.8
SO_4	13.5
CO_3	90.2
F	0.88
Cl	9694.0
H_3BO_3	73.2

from Alonso and Mooser, 1964

APPENDIX 13.

CHEMICAL ANALYSES (in parts per million) OF BRINE FROM WELL I.I.D. No. 1, BRINE FROM WELL I.I.D. No. 3, AND WATER FROM WISTER MUDPOTS, SOUTH END OF SALTON SEA.

	I.I.D. No. 1	I.I.D. No. 3	Wister Mudpots
Estimated depth of occurrence	3500-5000 feet	1575 feet	surface
Temperature of occurrence	300 C°	105 C°	21 C°
Density	1.21	1.023	1.014
pH (25 C)	5.2	7.5	7.1
SiO_2	400	120	59
Al	4.2	2	6 (?)
Fe	2290	0.7	0.8
Mn	1400	6.4	0.9
Ca	28000	1130	79
Mg	54	74	325
Sr	400	85	4
Ba	235	3	0.2
Na	50400	10600	6470
K	17500	1250	466
Li	215	40	9.6
Rb	135	. .	. .
Cs	14	. .	. .
NH_4	409	321	34
B	390	100	54
HCO_3	150	1880	4340
SO_4	5	621	900
Cl	155000	19700	8480
F	15	1	14
Br	120	15	. .
I	18	4.5	. .
NO_3	. .	9	. .
As	12	0.16	. .
Cu	8	. .	0.05
Zn	540	. .	. .
Pb	102	. .	0.3
Ag	1	. .	. .
Total sulfide as H_2S	16	. .	. .
TOTAL	258000	35600	21240

NOTE: from Muffler and White, 1969

APPENDIX 14.

COMPARISON OF RELATIVE ABUNDANCES OF ELEMENTS IN BOLEO COPPER ORE WITH RELATIVE ABUNDANCES IN IGNEOUS ROCKS, IN PERCENT

Symbol	Average abundance of Elements in Boleo Copper Ore	Average abundance of Elements in Ingneous Rocks (Rankama and Sahama, 1950)
Si	13.67	27.72
Mn	6.54	0.10
Fe	6.43	5.00
Cu	4.86	0.007
Al	4.06	8.13
H	2.60	present
Ca	2.55	3.63
S	2.13	0.052
Mg	1.77	2.09
Cl	1.35	0.031
Na	0.93	2.83
K	0.88	2.59
Zn	0.81	0.013
C	0.72	0.032
Ti	0.28	0.44
Co	0.12	0.0023
Pb	0.06	0.0016
Ni	0.04	0.008
P	0.03	0.118
As	0.03	0.0005
Sb	0.02	0.0001
Sr	0.0X	0.03
Ba	0.0X	0.025
V	0.0X	0.015
Mo	0.01	0.001
Zr	0.00X	0.022
Y	0.00X	0.0028
Ag	0.0009	0.00001
Cr	0.000X	0.02
Be	0.000X	0.0006
Au	2×10^{-5}	5×10^{-7}