

Consejo Superior de Investigaciones Científicas (CSIC)

Institut de Ciències de la Terra *Jaume Almera*

Departament de Geofísica

Programa de Doctorado de *Tectònica y Geofísica*, bienio 96-98

**EVOLUCIÓN TECTÓNICA DEL MARGEN CONTINENTAL OESTE
DE MÉXICO: FOSA MESOAMERICANA Y GOLFO DE CALIFORNIA
(CORTES-P96)**

Tesis

Presentada por **Rafael Bartolomé de la Peña** ante el *Departament de Geodinàmica i Geofísica* de la *Universitat de Barcelona* para optar al grado de Doctor en Ciencias Físicas.

Director:

Dr. Juan José Dañobeitia

Tutor: **Dr. Josep Anton Muñoz**

Barcelona, Marzo de 2002

Referencias

*Solo dos hombres en el mundo merecen fama:
el que inventó el vino y el que inventó la cama.*

Chuy Yady

*No me importa que piense usted despacio:
me preocupa que publique más deprisa de lo que reflexiona.*

Wolfgang Pauli, físico austriaco (1900 - 1958)

REFERENCIAS

- Allan J.F.**, Geology of the Colima and Zacoalco grabens, SW Mexico : Late Cenozoic rifting in the Mexican Volcanic Belt. *Geol. Soc. Am. Bull.*, 97, 473-485, 1986.
- Allan, J.F., S.Nelson, Luhr, J.F., I.S.E.Charmichael, M. Woopat, and P.J. Wallace**, Pliocene-Holocene rifting and associated volcanism in southwest Mexico, In: The Gulf and Peninsular provinces of the Californias, *J. Dauphin y B. Simoneit (editors), Am. Assoc. Pet. Geol. Bull., Memoir 47*, 1991.
- Alva-Valdivia, L.M., Goguitchaichvili A., Ferrari, L., Rosas-Elguera J., Urrutia-Fucugauchi, J., Zamorano-Orozco, J.**, Paleomagnetic data from the Trans-Mexican Volcanic Belt: implications for tectonics and volcanic stratigraphy, *Earth Planets Space*, 52, 467-478, 2000.
- Attewell, P.B., Ramana, Y.V.**, Wave attenuation and internal friction as functions of frequency in rocks, *Geophysics*, 31, 1049-1056, 1966.
- Atwater, T.** Implications of plate tectonics for the Cenozoic tectonic evolution of western North America, *Geol. Soc. Am. Bull.*, 81, 3513-3536, 1970.
- Atwater, T.**, Plate Tectonic history of the Northeast Pacific and Western North America. In: Winterer, E.L., Hussong, D.M., Decker, R.W. (Eds.), *The Eastern Pacific Ocean and Hawaii- The Geology of North America N. Geological Society of America, Boulder*, pp. 21-72, 1989.
- Bandy, W.L., T.W.C.Hilde, J. Bourgois**, Redefinition of the plate boundaries between the Pacific, Rivera, Cocos and North American plates at the north end of the Middle America trench, *EOS Trans. AGU*, 69, 1415-1416, 1988.
- Bandy, W.L., C-Y., Yan**, Present-day Rivera-Pacific and Rivera-Cocos relative plate motions, *EOS, Trans. AGU*, 70, 1342, 1989.
- Bandy, W.L.**, Geological and Geophysical investigation of the Rivera-Cocos plate boundary: implications of plate fragmentation, *Ph. D. Thesis*, Texas A&M University, Austin., 1992.
- Bandy, W.L., Pardo, M.**, Statistical examination of the existence and relative motions of the Jalisco and southern Mexico blocks, *Tectonics*, 13, 755-768, 1994.
- Bandy W., Mortera-Gutierrez J., Urrutia-Fucugauchi J., Hilde TWC**, The subducted Rivera-Cocos plate boundary : where is it, what is it, and what is its relationship to the Colima rift ?, *Geophys. Res. Lett.*, 22, 3075-3078, 1995.
- Barrier E., Bourgois J., and Michaud F.**, Le systeme de rift actifs du point triple de Jalisco: vers un proto-golfe de Jalisco. *C.R. Acad. Sci., Paris*, 310, 1513-1520, 1990.

- Bartolomé, R., Dañobeitia, J.J., Córdoba, D., Canales, J.P., Romero, M., Núñez-Cornú, F.J., Sallares, V., Delgado-Argote, L.A., Michaud, F.** Arquitectura y Evolución Cortical desde la Zona Meridional de la Península de baja California hasta Puerto Vallarta. y el grupo de trabajo CORTES-P96. UGM, *GEOS*, Vol. 17, 4, 285, 1997.
- Bartolome, R., J. J. Dañobeitia, D. Cordoba, D. Graindorge, J.P. Canales, R. Carbonell, L.A. Delgado-Argote, M. Romero, and Ph. Charvis.** Architecture and Crustal Evolution Across the EPR at 22°N from The Southern tip of Baja California to Puerto Vallarta. *Annales Geophysicae*, Supl. I, Vol. 16, C283, EGS XXIII, Nice, Abril 1998.
- Bartolomé, R., Graindorge, D., Dañobeitia, J.J., Córdoba, D., Canales, J.P., Diaz, J., Gallart, J., Delgado-Argote, L., Ph Charvis** Crustal evolution from the southern margin of Baja California Peninsula to the Jalisco block (West Mexico). 8th Intern. Sympo., Seismic Reflection Profiling of the Continents, 1998.
- Bönhel H., Moran-Zenteno D., Schaaf P. and Urrutia-Fucugauchi J.** Paleomagnetism and isotope data from southern Mexico and the controversy over the pre-neogene position of Baja California, *Geofis. Int.*, 31, 253-261, 1992.
- Bourgeois, J., Michaud F.** Active fragmentation of the North American plate at the Mexican triple-junction area off Manzanillo, *Geo-Marine Lett.*, 11, 59-65, 1991.
- Bracewell, R.N.**, The Fourier transform and its applications: *McGraw-Hill Book Co.*, 1965.
- Bryan, G.M.**, *In situ* indications of gas hydrates, in I. R. Kaplan, ed., *Natural gases in marine sediments: New York*, Plenum, pp. 298-308, 1974.
- Burbach, G., Frolich, C., Pennington, W., and Matumoto, T.** Seismicity and tectonics of the subducted Cocos plate, *J. Geophys. Res.*, 89, 7719-7735, 1984.
- Canales, J. P., Dañobeitia, J. J., Detrick, R. S., Hooft, E.E.E., Bartolomé, R.** Variations in axial morphology along the Galápagos spreading center and the influence of the Galápagos hotspot, *J. Geophys. Res.*, 102, B12, 27341-27354, 1997.
- Carlson, R.L. & Raskin, G.S.** Density of the oceanic crust, *Nature*, 311, 555-558, 1984.
- Christensen, N. I., and Shaw, G.H.** Elasticity of mafic rocks from the Mid-Atlantic Ridge, *Geophys. J. R. Astr. Soc.*, 20, 271-284, 1970.
- Claypool, G. W., Presley B.J. and Kaplan, I. R.** Gas analysis of sediment samples from legs 10, 11, 13, 14, 15, 18 and 19, in J.S. Creager et al, Initial reports of the deep sea drilling project, v. 19: Washington, D.C., US Government Printing Office, pp. 879-884, 1973.

- Claypool, G. W., and Kaplan, I. R.** The origin and distribution of methane in marine sediments. In *Natural gases in marine sediments* I. R. Kaplan, Ed., Plenum Press, pp. 99-139, New York, 1974.
- Corrigan, J., Mann, P., Ingle, J.C.,** Forearc response to subduction of the Cocos Ridge, Panamá-Costa Rica, *Geol. Soc. Am. Bull.*, 102:628-52, 1990.
- Couch, R. and S Woodcock,** Gravity and structure of the continental margins of southwestern Mexico and northwestern Guatemala, *J. Geophys. Res.*, 86, 1829-1840, 1981.
- Crosson, R.S.,** Cascadia subduction zone: Large scale structure from receiver function analysis, seismicity, and teleseismic arrival time tomography, [abs.], Wadatti Conference on Great Subduction Earthquakes, Alaska, Sep 16-19, pp.35, 1992.
- Dañobeitia, J.J., Delgado-Argote, L., Michaud, F., Carbonell, R., Canales, J.P., Bartolomé, R., Ayarza, P. & CORTES-96 WORKING GROUP.** Informe Campaña: " Evolución tectónica del margen continental oeste de México: Fosa Mesoamericana y Golfo de California ", 123 pp, 1996
- Dañobeitia, D. Córdoba, L.A. Delgado-Argote, F. Michaud, R. Bartolomé, M. Farrán, and CORTES-P96 Working Group*.** Expedition gathers new data on crust beneath Mexican West Coast, *EOS, Trans. Am. Geophys. Union*, 78, 49, 565-572, 1997.
- Dañobeitia J.J, Córdoba D, Bartolomé R., Michaud F., Carbonell R. Graindorge D., Delgado-Argote, L., Nuñez Cornu, F.** Crustal Structure at the contact between the Rivera Plate and Jalisco block (West Coast of Mexico). 8th Intern. Sympo., Seismic Reflection Profiling of the Continents, 1998.
- DeMets, C. and Stein, S.,** Present-Day kinematics of the Rivera Plate and Implications for Tectonics in Southwestern Mexico, *J. Geophys. Res.*, 95, B13, 21931-21948, 1990.
- DeMets, C., Gordon, R.G., Argus, D.F., and Stein, S.,** Current plate motions, *Geophys. Res. J. Int.*, 101, 425-478, 1990.
- DeMets, C. and Wilson, D.,** Relative motions of the Pacific, Rivera, North American and Cocos plates since 0.78 Ma, *J. Geophys. Res.*, 102, 2789-2806, 1997.
- DeMets, C. and Traylen, S.,** Motion of the Rivera plate since 10 Ma relative to the Pacific and North American plates and the mantle. In: Ferrari, L., Stock J., Urrutia-Fucugauchi, J. (Eds) , The Influence of plate interaction on post-Laramide magmatism and tectonics in Mexico, *Tectonophysics*, 318, 1-4, 119-159, 2000.
- Dillon, W.P., Grow J.A., Paull, C.K.,** Unconventional gas hydrates seals may trap gas off southeast US: *Oil and Gas Journal*,. 78, n-1, 124-130, 1980.

- Dillon, W.P., Lee, M.W., Fehlhaber, K., and Coleman, D.F.,** Gas hydrates on the Atlantic Continental Margin of the United States – Controls on concentration, in *The Future of Energy Gases*, edited by D.G. Howell, pp. 313-330, U.S. Geol. Surv., Reston, Va., 1993.
- Einsele, G., and Kelts, K.,** Pliocene and quaternary mud turbidites in the Gulf of California; Sedimentology, mass physical properties and significance, in Curray, J.R., and Moore, D. G., Initial reports of the Deep Sea Drilling Project, Volume 64: Washington, D.C., US Government Printing Office, pp. 1169-1178, 1982.
- Eissler, H. and K.C. McNally,** Seismicity and tectonics of the Rivera plate and implications for the 1932 Jalisco, Mexico, earthquake, *J. Geophys. Res.*, 89, 4520-4530, 1984.
- Ewing, J.I. and Hollister, C.H.,** Regional aspects of deep sea drilling in the western North Atlantic, in C.H. Hollister et al, *Initial reports of the deep sea drilling project*, v. 11: Washington, D.C., U.S. Government Printing Office, pp. 951-973, 1972.
- Fabriol, H., Delgado-Argote, L., Dañobeitia, J., Córdoba D., González A., García-Abdeslem J., Bartolomé, R., Martín-Atienza, B., Frias-Camacho, V.,** Backscattering and geophysical features of volcanic ridges offshore Santa Rosalía, Baja California, Gulf of California, México, *J. Vol. Geother. Res.*, 93, 75-92, 1999.
- Ferrari L. and Rosas-Elguera J.,** Late Miocene to Quaternary extensional the northern boundary of the Jalisco Block, western México: The Tepic-Zacoalco rift revised., *Geol. Soc. Am. Bull.*, Sp. Pap., 1997. **FALTA PAGINAS**
- Ferrari L., López-Martínez M., Aguirre-Díaz, G., and Carrasco-Núñez G.,** Space-time patterns of Cenozoic arc volcanism in central México: from the Sierra Madre Occidental to the Mexican Volcanic Belt, *Geology*, 27, 303-306, 1999.
- Ferrari L., Conticelli S., Vaggelli G., Petrone C.M. and Manetti P.,** Late Miocene volcanism and intra-arc tectonics during the early development of the Trans-Mexican Volcanic Belt, In: Ferrari, L., Stock J., Urrutia-Fucugauchi, J. (Eds) , The Influence of plate interaction on post-Laramide magmatism and tectonics in Mexico, *Tectonophysics*, 318, 161-185, 2000.
- Gastil G., Krummenacher D. and Jensky A.W.,** Reconnaissance geologic map of the west-central part of the state of Nayarit, Mexico. *Geol. Soc. Am. Maps*, Series MC-24, scale 1:200000, 1978.
- Grant, F.S. and West, G.F.,** Interpretation theory in applied geophysics: *McGraw-Hill Book Co.*, 1965.
- Handschumacher, D.W.,** Post-Eocene plate tectonics of the eastern Pacific, in *The Geophysics of the Pacific Ocean Basins and Its Margin*, *Geophys. Monogr. Serv.*, vol. 19, edited by G.H. Sutton, M.H. Manghnani, and R. Moberly, pp. 177-202, AGU, Washington, D.C., 1976.

- Hatton L., Worthington M., Makin J.,** Seismic Data Processing, *Blackwell Scientific Publications*, 1988.
- Hedberg, H.D.,** Methane generation and petroleum migration, in W.H. Roberts III, and R.J. Cordell, *Problems of petroleum migration: AM. ASSOC. PET. GEOL. BULL. Studies in geology*, n.10, pp. 179-206, 1980.
- Heirtzler, J.R., Dickson, G.O., Herron, E.M., Pitman, W.C., III, and Le Pichon, X.,** Marine Magnetism anomalies, geomagnetic field reversals, and motions of the ocean floor and continents: *J. Geophys. Res.*, 73, 2119-2136, 1968.
- Hey, R.,** Tectonic evolution of the Cocos-Nazca spreading center, *Geol. Soc. Am. Bull.*, 88, 1404-1420, 1977.
- Hyndman, R.D. and Davis, E.E.,** A mechanism for the formation of methane hydrate and seafloor bottom-simulating reflectors by vertical fluid expulsion, *J. Geophys. Res.*, 97, 7025-7041, 1992.
- Hyndman, R.D., Spence G.D., Chapman, R., Riedel, M., Edwards, R.N.,** Geophysical studies of marine gas hydrate in northern Cascadia, in: *Natural Gas Hydrates: Occurrence, and Detection Geophysical Monograph 124*, American Geophysical Union, 2001.
- Hollister, C.D., et al.,** Initial Reports of the Deep Sea Drilling Project, v. 11: Washington, D.C., US Govt. Printing Office, 1077 pp., 1972.
- Johnson, C.A., C.G.A. Harrison,** Tectonics and volcanism in central Mexico: A Landsat Thematic Mapper perspective, *Remote Sens. Envir.*, 28, 273-286, 1989.
- Kjartansson, E. and Rocca, F.,** The exploding reflector model and laterally variable media, *Stanford Exploration Project Report No.16*, Stanford University, 1979.
- Kiltgord, K., Mammerrickx, J.,** Northern East Pacific Rise: Magnetic anomaly and bathymetric framework, *J. Geophys. Res.*, 87, 6725-6750, 1982.
- Korenaga, J., Holbrook W. S., Singh S.C., and Minshull T.A.,** Natural gas hydrates on the southeast U.S. margin: Constraints from full waveform and travel time inversions of wide-angle seismic data, *J. Geophys. Res.*, 102, 15.345-15.365, 1997.
- Kvenvolden, K. A and Barnard L.,** Hydrates of natural gas in continental margins, in *Studies in continental margin geology*, ed. Watkins, J.S. and Drake C.L., *Am. Assoc. Pet. Geol. Bull.*, Memoir 34, 1983.
- Kvenvolden, K. A.** Gas hydrates: geologic perspective and global change. *Rev. Geophys.*, 31, 173-187, 1993.

- Kvenvolden, K. A and Lorenson, T.D.**, The Global occurrence of natural gas hydrate, *in: Natural Gas Hydrates: Occurrence, and Detection Geophysical Monograph* 124, American Geophysical Union, 2001.
- Lancelot, Y., and Ewing, J.I.**, Correlation of natural gas zonation and carbonate diagenesis in Tertiary sediments from the north-west Atlantic, in C.C. Hollister et al, *Initial reports of the deep sea drilling project*, v. 11: Washington, D.C., US Government Printing Office, pp. 791-799, 1972.
- Larson, R.L., Pitman, W.C., III**, World-wide correlation of Mesozoic Bulletin, v. 83, pp. 3645-3662, 1972.
- Lavergne, M.**, Seismic Methods, *Institut Français du pétrole publications, Graham & Trotman Limited*, Éditions Technip, 1989.
- Lonsdale, P.**, Geology and tectonic history of the Gulf of California *in: E.L. Winterer, D.M. Hussong, and R.W. Decker*, editors, *The Eastern Pacific Ocean and Hawaii*, Geological Society of America, *The Geology of North America*, v. N, p. 499-521, 1989.
- Lucchita, I.**, Late Cenozoic uplift of the southwestern Colorado Plateau and adjacent lower Colorado River region, *Tectonophysics*, 61, 63-95, 1979.
- Luhr, J., S. Nelson, J. Allan, I.S.E. Carmichael**, Active rifting in southwestern Mexico: Manifestations of an incipient east-ward spreading-ridge jump, *Geology*, 13, 54-57, 1985.
- Luhr, J.F., and Carmichael, I.S.E.**, Petrological monitoring of cyclical eruptive activity at Volcán Colima, México, *J. Vol. Geother. Res.*, 42, 235-260, 1990.
- Luhr, J.F. and Simkin, T.**, Paricutin: The volcano born in a Mexican Cornfield. *Geoscience Press*, Phoenix, 427pp., 1993.
- Mammerickx, J., Kiltgord, K.**, Northern East Pacific Rise: evolution from 25 m.y.B.P. to the Present, *J. Geophys. Res.*, 87, 6751-6759, 1982.
- Mammerickx, J.**, The Morphology of propagating spreading centers: New and old, *J. Geophys. Res.*, 89, 1817-1828, 1984.
- Markl, R.G., G.M. Bryan and J.I. Ewing**, Structure of the Blake-Bahama Outer Ridge, *J. Geophys. Res.*, 75, 4539-4555, 1970.
- Martiny B., Martínez-Serrano R.G., Morán-Zenteno D.J., Macías-Romo C. and Ayuso R.A.**, Stratigraphy, geochemistry and tectonic significance of the Oligocene magmatic rocks of western Oaxaca, southern Mexico. In: Ferrari, L., Stock J., Urrutia-Fucugauchi, J. (Eds) , *The Influence of plate interaction on post-Laramide magmatism and tectonics in Mexico*, *Tectonophysics*, 318, 1-4, 71-98, 2000.

- MacKay, M.E., Jarrard, R.D., Westbrook, G.K., Hyndman, R.D.**, Origin of bottom simulating reflectors: Geophysical evidence from the Cascadia accretionary prism. *Geology*, 22, 459-462, 1994.
- Max, M.D. and Pellenberg, R.E.**, Clathrate-Based fuel storage and transport media: Potential impact, Fuel Chemistry Symposium on gas hydrates, American Chemical Society, abril 1997.
- McIver, R.D.**, Hydrocarbon gas (methane) in canned deep sea drilling project core samples, in I.R.Kaplan, ed., Natural gases in marine sediments: New York, Plenum, pp. 65-69, 1974.
- Menard, H.W.**, Fragmentation of the Farallon Plate by pivoting subduction, *J. Geol.*, 86, 99-110, 1978.
- Michaud F., Dañobeitia J.J., Carbonell R., Bartolomé R., Córdoba D., Delgado L., Núñez-Cornu F. and Monfret T.**, New Insights into the subducting oceanic crust in the Middle American Trench off western Mexico (17-19°N). In: Ferrari, L., Stock J., Urrutia-Fucugauchi, J. (Eds) , The Influence of plate interaction on post-Laramide magmatism and tectonics in Mexico, *Tectonophysics*, 318, 1-4, 187-200, 2000.
- Molnar, P. and Sykes, L.R.**, Tectonics of the Caribbean and Middle American region from local mechanisms and seismicity, *Geol. Soc. Am., Bull.*, 80, 1639-1684, 1969.
- Moore G., Marone C., Carmichael I.S.E. and Renne P.**, Basaltic volcanism and extension near the intersection of the Sierra Madre volcanic province and the Mexican Volcanic Belt., *Geol. Soc. Am. Bull.*, 106, 383-394, 1994.
- Mooser, F.**, The Mexican volcanic belt: Structure and tectonics, *Geofis. Int.*, 12,55-70, 1972.
- Nafe, S.E. and Drake, C.L.**, Physical properties of marine sediments, in: The Sea, 3, 794-819, edited by M.N. Hill, Interscience, New York N.Y., 1961
- Nava, A.**, La inquieta superficie terrestre, *Fondo de Cultura Económica, S.A. de C.V.*, ISBN 968-16-3467-5, 1993.
- Newman, P.**, Divergence effects in a layered earth, *Geophysics*, 38, 481-488.
- Nixon, G.T.**, The relationship between Quaternary volcanism in central Mexico and the seismicity and structure of subducted oceanic lithosphere, *Geol. Soc. Am. Bull.*, 93, 514-523, 1982.
- Palmer A.R. and Geissman J.**, 1999 Geologic Time Scale, The Geological Society of America, Product Code CTS004, 1999.
- Pardo and Suárez**, Steep subduction geometry of the Rivera plate beneath the Jalisco Block in western Mexico, *Geophys. Res. Lett.*, 20, 2391-2394, 1993.

- Pardo and Suárez**, Shape of the subducted Rivera and Cocos plates in southern Mexico: Seismic and tectonic implications. *J. Geophys. Res.*, 100, B7, 12357-12373, 1995.
- Paull, C. K., Ussler, W., and Dillon, W. P.** Is the extent of glaciation limited by marine gas-hydrates ? *Geophys. Res. Lett.*, 18, 432-434, 1991.
- Paull, C. K., Ussler, W., III, and Borowski, W.S.,** Sources of biogenic methane to form marine gas hydrates – in situ production or upward migration?, *Annals of the New York Academy of Sciences*, 715, 392-409, 1994.
- Pecher, I.A., Ranero, C.R., von Huene, R., Minshull, T.A. and Singh, S.C.,** The nature and distribution of bottom simulating reflectors at the Costa Rican convergent margin, *Earth Planet. Sci. Lett.*, 139, 459-469, 1998.
- Ponce, L., Gaulon, Suárez, G., and Lomas, E.,** Geometry and state of stress of the downgoing Cocos plate in the Isthmus of Tehuantepec, Mexico, *Geophys. Res. Lett.*, 19, 773-776, 1992.
- Richter K., Carmichael I.S.E. and Becker T.,** Pliocene-Quaternary faulting and volcanism at the intersection of the Gulf of California and the Mexican Volcanic Belt, *Geol. Soc. Am. Bull.*, 107, 612-627, 1995.
- Richter K.,** A comparison of basaltic volcanism in the Cascades and western Mexico: compositional diversity in continental arcs, *Tectonophysics*, 318, 1-4, 99-117, 2000.
- Robin, C., Cambus, G., and Gourguad, A.,** Eruptive and magmatic cycles at Fuego de Colima volcano (Mexico), *J. Vol. Geother. Res.*, 45, 209-225, 1991.
- Rosas-Elguera J., Ferrari L., Garduño V.H. and Urrutia-Fucugauchi J.,** The continental boundaries of the Jalisco block and their influence on the Plio-Quaternary kinematics of western México, *Geology*, 24, 921-924, 1996.
- Rubio, E.,** Estructura y evolución del margen sur chileno, Tesis Doctoral, U.Barcelona, 2000.
- Ruiz-Martínez V.C., Osete M.L., Vegas R., Núñez-Aguilar J.I., Urrutia-Fucugauchi J. and Tarling D.H.,** Palaeomagnetism of Late Miocene to Quaternary volcanics from the eastern segment of the Trans-Mexican Volcanic Belt. In: Ferrari, L., Stock J., Urrutia-Fucugauchi, J. (Eds) , The Influence of plate interaction on post-Laramide magmatism and tectonics in Mexico, *Tectonophysics*, 318, 1-4, 217-233, 2000.
- Sallares, V., J. J. Dañobeitia, E. Flueh and G. Leandro.,** Wide-angle Seismic Velocity Structure Across The Middle American Trench In Northern Costa Rica, *Jour. of Geodyn*, 27,327-344, 1999.

- Sallares, V., Dañobeitia, J.J., Flueh, E.** Lithospheric Structure of the Costa Rican Isthmus: Effects of Subduction Zone Magmatism on an Oceanic Plateau *J. Geophys. Res.*, 106 (B1), 621-643, 2001
- Sandwell, D.T. and Smith W.H.F.**, Global Marine Gravity, *EOS Trans, AGU*, 73, 43, 133, 1992.
- Sandwell, D.T. and Smith W.H.F.**, Marine gravity anomaly from Geosat and ERS-1 altimetry, *J. Geophys. Res.*, 102, 10039-10054, 1997.
- Sassen Roger**, *Presentation to the Annual Meeting of the Natural Gas Supplí Association*, 1998.
- Schaaf, P., Moran-Zenteno D., Hernández-Bernal M., Solis-Pichardo G., Tolson G., and Köhler H.**, Paleogene continental margin truncation in southwestern Mexico: geochronological evidence, *Tectonics*, 14, 1339-1350, 1995.
- Schaaf, P., Böhnel H., Pérez-Venzor, J.A.**, Pre-Miocene palaeogeography of the Los Cabos Block, Baja California Sur: geochronological and palaeomagnetic constraints, In: Ferrari, L., Stock J., Urrutia-Fucugauchi, J. (Eds) , *The Influence of plate interaction on post-Laramide magmatism and tectonics in Mexico*, *Tectonophysics*, 318, 1-4, 53-69, 2000.
- Sheriff, R.E, and Geldart, L.P.**, *Exploración sísmológica, vol. I*, ed: Sistemas Editoriales técnicos, S.A., de C.V., 1991.
- Shipley, T.H., Houston, M.H., Buffer, R.T. et al.**, Seismic evidence for widespread possible gas hydrate horizons on continental slopes and rises: *Am. Assoc. Pet. Geol. Bull.*, v. 63, p. 2204-2213, 1979.
- Shipley, T. H., Didyk, B.M.**, Occurrence of methane hydrates offshore southern Mexico, Initial Reports of the Deep Sea Drilling Project, vol. 66, 1982.
- Singh, S.K., Ponce L., and Nishenko S.P.**, The great Jalisco, Mexico, earthquake of 1932: subduction of the Rivera Plate, *Bull. Seismol. Soc. Am.*, 75, 1301-1313, 1985.
- Sloan, E. D.** Clathrate hydrates of natural gases, *Marcel Bekker Inc.*, New York, pp. 1-641, 1990.
- Spencer, J.E., Normark W.R.**, Tosco-Abreojos fault zone: A Neogene transform plate boundary within the Pacific margin of southern Baja California, Mexico, *Geology*, 7, 554-557, 1979.
- Stoiber, R.E., and Carr, M.J.**, Quaternary volcanic and tectonic segmentation of Central America, *Bull. Volcanol.*, 37, 304-325, 1973.
- Stolt, R.H. and A.K. Benson**, Seismic migration theory and practice, in: Handbook of geophysical exploration, sect. I (Seismic Exploration), vol. 5, edited by K. Helbig and S. Treitel, *Geophysical Press*, London, 1986.

- Suárez, G., S.K. Singh,** Tectonic interpretation of the Trans-Mexican Volcanic Belt-discussion, *Tectonophysics*, 127, 155-160, 1986.
- Suárez, G., Monfret, T., Wittlinger, G., and David, C.,** Geometry of subduction and depth of the seismogenic zone in the Guerrero gap, Mexico, *Nature*, 345, 336-338, 1990.
- Taber, J. and S. Smith,** Seismicity and focal mechanisms associated with the subduction of the Juan de Fuca plate beneath the Olympic peninsula, Washington, *Bull. Seismol. Soc. Am.*, 75, 237-249, 1985.
- Taylor, F. W.** The greenhouse effect and climate change. *Rep. Prog. Phys.*, 54, 881-981, 1991.
- Taner, M.T. and Koehler, F.,** Velocity spectral-digital computer derivation and applications of velocity functions: *Geophysics*, 39, 859-881, 1969.
- Trofimuk, A. A., Cherskiy, N. V., and Tsarev, V. P.,** Accumulation of natural gases in zones of hydrate-formation in the hydrosphere: Doklady-Earth Science Section 212, pp. 87-90, 1974.
- Tucholke, B.E., Bryan G.M. and Ewing, J.I.,** Gas-hydrate horizons detected in seismic-profiler data from the western North Atlantic: *Am. Assoc. Pet. Geol. Bull.*, 61, 698-707, 1977.
- Turcotte, D.L. and Schubert, G.,** Geodynamics, John Willey, New York, 1982.
- Urrutia, F.J.H., Böhnel, H.,** Tectonic interpretation of the Trans-Mexican Volcanic Belt- discussion, *Tectonophysics* 138, 219-323, 1987.
- von Huene, R., and Pecher, I.,** Vertical tectonics and the origins of BSRs along the Peru margin, *Earth Planet. Sci. Lett.*, 166, 47-55, 1999.
- Wallace P. and Carmichael I.S.E.,** Alkaline and calk-alkaline lavas near Los Volcanes, Jalisco, Mexico: geochemical diversity and its significance in volcanic arcs. *Contrib. Miner. Petrol.*, 111, 423-439, 1992.
- Wallace P., Carmichael I.S.E., Richter K. and Becker T.,** Volcanism and tectonism in western Mexico: a contrast of style and substance, *Geology*, 20, 625-628, 1992.
- Watkins, J.S., McMillen, K.J., and others,** Tectonic synthesis, Leg 66; Transect and vicinity, Initial reports of the Deep Sea Drilling Project: Washington D.C., US Government Printing Office, v.66, pp. 837-849, 1982.
- Watkins, J.S.,** The Middle America Trench off southern Mexico, *in:* E.L. Winterer, D.M. Hussong, and R.W. Decker, editors, The Eastern Pacific Ocean and Hawaii, Geological Society of America, The Geology of North America, v. N, p. 523-535, 1989.

- Wessel,P & Smith,W.**, The Generic Mapping Tools-GMT, 1995.
- White, R.S.**: Seismic bright spots in the Gulf of Oman. *Earth Planet. Sci. Lett.*, 37, 29-37, 1977.
- Wilson, M.**, Igneous Petrogenesis, *Chapman & Hall*, ISBN 041253310 3 (PB), 1989.
- Wood, W.T., and Gettrust, J.F.**, Deep-tow seismic investigations of methane hydrates, *in: Natural Gas Hydrates: Occurrence, and Detection Geophysical Monograph 124*, American Geophysical Union, 2001.
- Yeats,R.S., Haq B.U.**, Deep-sea drilling off the California: Implications of leg 63, *Initial Rep. Deep Sea Drill. Proj.*, 63, 949-961,1981.
- Yilmaz Ö.**, Seismic Data Processing, *Society of Exploration Geophysicists*, 1988.
- Zuehlsdorff, L., Spiess, V., Huebscher, C., Villinger, H., and A. Rosenberger**, Implications for focused fluid transport at the northern Cascadia accretionary prism from a correlation between BSR occurrence and near seafloor reflectivity anomalies imaged in a multi-frequency data set, *Geologische Rundschau*, 88, in press, 2001.