Historia del Departamento de Sismología

SISMOLOGÍA
CICESE

José Antonio Vidal Villegas
Julia del Carmen Sánchez-Rodríguez

6 de diciembre 2019

Departamento de Sismología del CICESE

“Trabajando para saber que la Tierra está viva . . . en el noroeste de México también tiembla”

¿Por qué debemos conocer la historia del Departamento?

Para conocer los sucesos que han dado forma actual al Departamento y reconocer el trabajo de su personal.

Fuente de datos para realizar investigación en sismología

Columna Vertebral de Sismología

Sismos que ...

Temblor de Victoria (Mag 6.1)

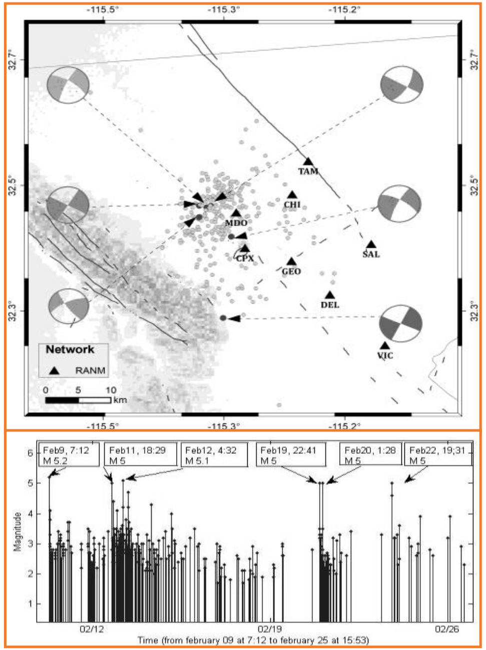
9 de junio de 1980

- Inicio de la captura y procesamiento de las señales digitales.
- *Se registran las réplicas.*
- Se obtiene apoyo por parte de CONACyT y se da origen a la red Telemétrica RESNOR

Enjambre de Cerro Prieto de 2008

(5 sismos, 5.1 Mag 5.5)

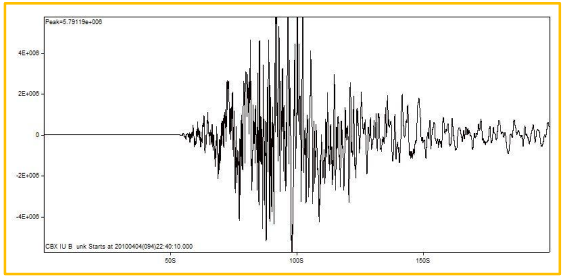
- Con el apoyo obtenido de la iniciativa privada se da origen a la Red Acelerométrica de Mexicali (RAUBC)



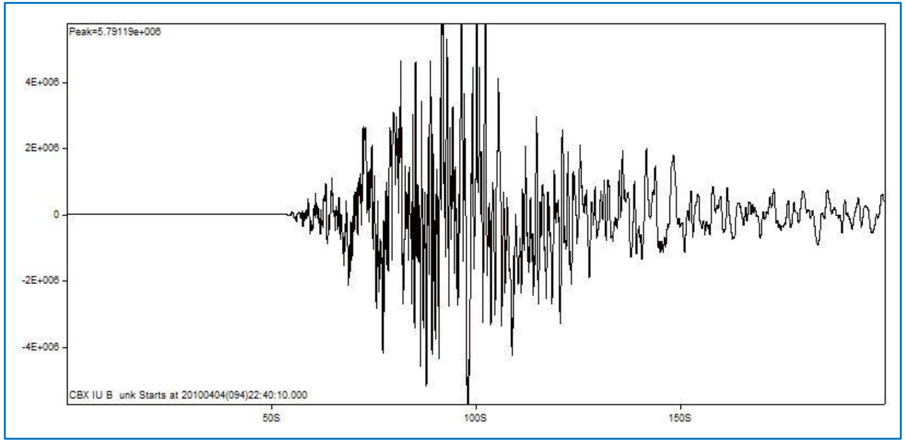
Sismo del Mayor-Cucapah (Mag 7.2)

4 de abril de 2010

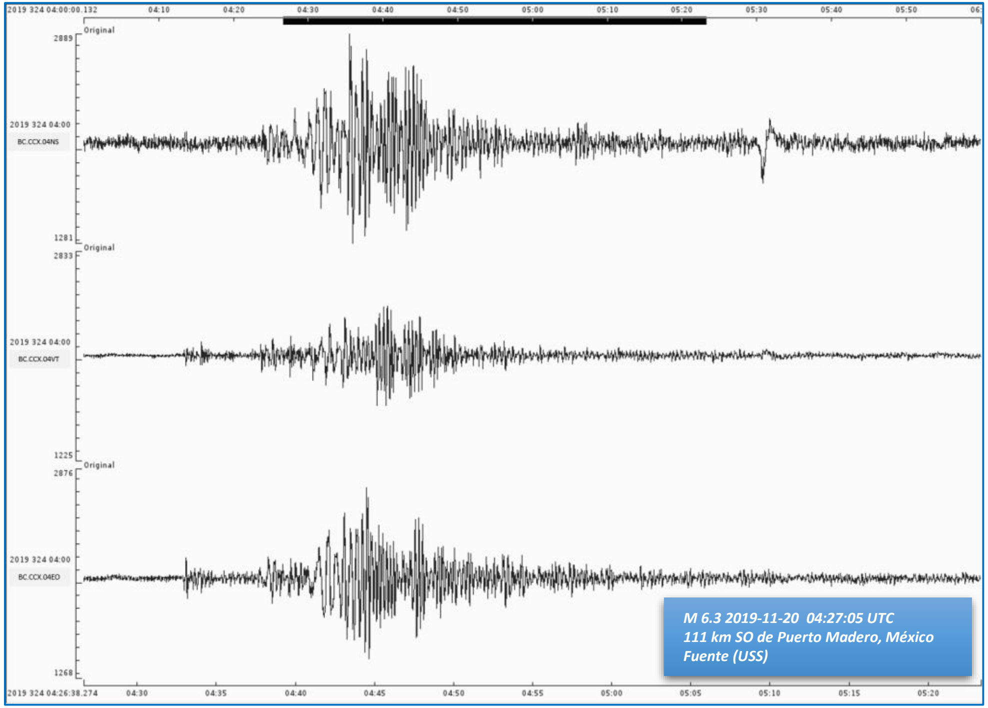
- Marca un parteaguas entre el RESNOM de esas fechas y lo que ha crecido hasta el momento.
- *Se obtiene apoyo de CONACyT vía el Gobierno de BC y, la USGS dona instrumentos de Banda Ancha para 10 estaciones.*
- Se mejora RESNOM y se busca la integración de las redes para formar la RSC



http://158.97.29.201



Registro del sismo Mayor – Cucapah de magnitud 7.2, estación Cerro Bola, componente Este-Oeste.



Estación de Periodo Largo CCX

Jefaturas

Geofísica

0 **Juan A. Madrid González †** – **C. Alfonso Reyes Zamora**

(1973 – 1975) (1975 – 1983)

Sismología

1 **Luis Munguía Orozco**
(1983 – 1991)

2 **Juan A. Madrid González †**
(1991 – 1994)

3 **Cecilio J. Rebollar Bustamante †**
(1994 – 2000)

4 **Raúl R. Castro Escamilla**
(2000 – 2003)

5 **Carlos Huerta López**
(2003 – 2006)

6 **Alejandro F. Nava Pichardo**
(2006 – 2010)

7 **Víctor M. Wong Ortega**
(2010 – 2015)

8 **José Antonio Vidal Villegas**
(2015 – al presente)

RESNOR/RESNOM

- Francisco Farfán
- Mauro Medina
- Luis Orozco
- Alejandro Hinojosa
- Rosa Álvarez Tinajero
- Miguel Navarro
- Vicente Navarro
- Manuel Chong †
- Óscar Gálvez
- Ignacio Méndez
- Luis Inzunza
- Julia del Carmen Sánchez
- Manuel Luna Munguía
- Guillermo Díaz de Cossío
- Sergio Arregui
- Alejandro López Lara †
- Alejandra Núñez
- Armando Valdez Terriquez
- Manuel Moller
- Andrés Navarro Rodríguez

Falta foto de Andrés









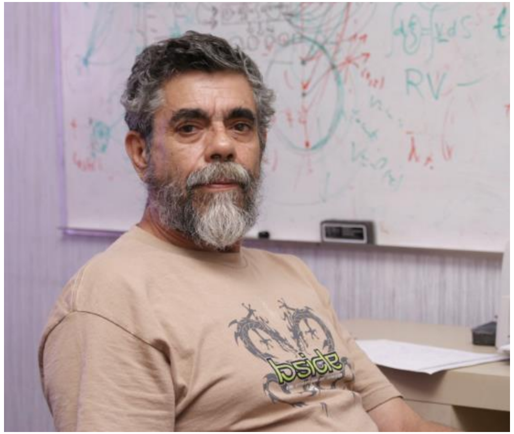




Departamento de Geofísica

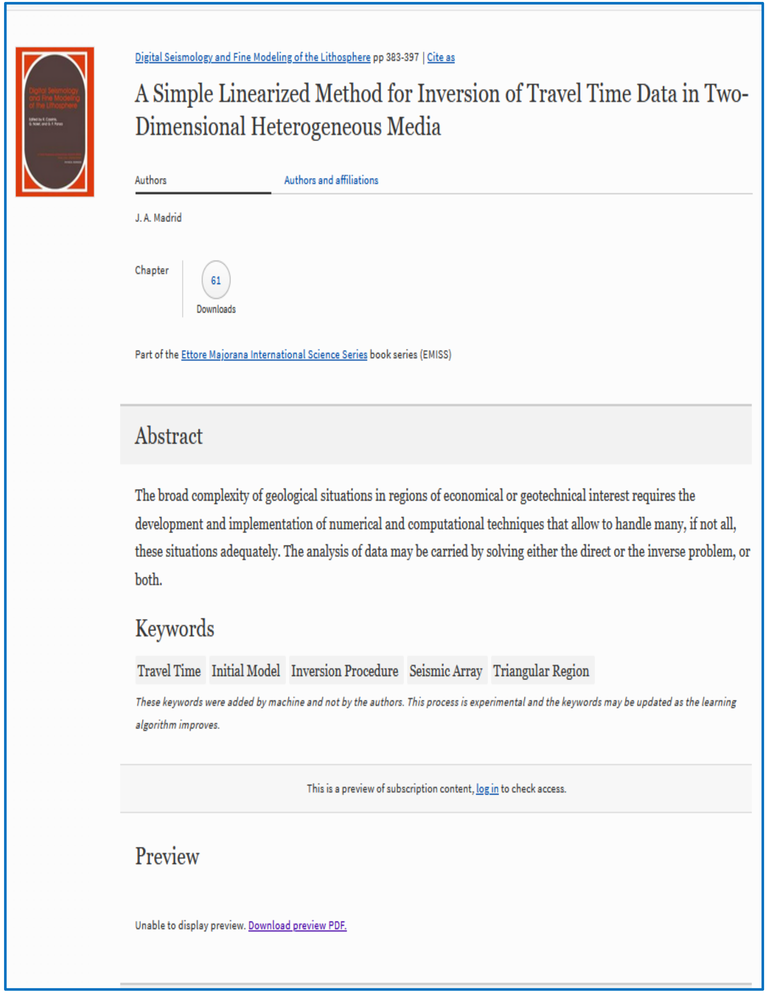
Juan Madrid †

- Primer jefe Departamento de Geofísica (1973 a 1975)
- Investigador, profesor
- Línea de Investigación – *Teoría de Rayos*
- Jefe Departamento Sismología (1991-1994)



1974
Wiggings R. A. and J. A Madrid (1974). ***Body Wave Amplitude Calculations***. Geophys. J. R. Astr. Soc. 37, 423-433

1976
Johnson, T. L., Madrid González, J. A., & Méndez Olague, R. (1976). ***A study of microseismicity in northern Baja California***. Mexico. Bulletin of the Seismological Society of America, 66(6), 1921-1929. (ID: 1853)



Digital Seismology and Fine Modeling of the Lithosphere pp 383-397 | Cite as

A Simple Linearized Method for Inversion of Travel Time Data in Two-Dimensional Heterogeneous Media

Authors | Authors and affiliations

J. A. Madrid

Chapter | 61 Downloads

Part of the Ettore Majorana International Science Series book series (EMISS)

Abstract

The broad complexity of geological situations in regions of economical or geotechnical interest requires the development and implementation of numerical and computational techniques that allow to handle many, if not all, these situations adequately. The analysis of data may be carried by solving either the direct or the inverse problem, or both.

Keywords

Travel Time | Initial Model | Inversion Procedure | Seismic Array | Triangular Region

These keywords were added by machine and not by the authors. This process is experimental and the keywords may be updated as the learning algorithm improves.

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Preview

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Departamento de Geofísica

César Alfonso Reyes Zamora

- **Profesor** *(1973 – 2013).*
- **Investigador** *(1975 - 2016)*
- **Línea de Investigación –** *Ingeniería aplicada a la sismología*
- **Jefe de Departamento de Geofísica** *(1975 -1978)*
- **Jefe de RESNOR**
- **Líder del grupo Estudios Especiales**
- **Líder del grupo de Ingeniería Sísmica**

1975
Reyes Zamora, C. A., Brune, J. N., Madrid González, J. A., Rebollar Bustamante, C. J., Munguía Orozco, L., Barker, T., & Canales, L. (1975). A microearthquake survey of the San Miguel fault zone, Baja California, Mexico. Geophysical Research Letters, 2(2), 173-176. (ID: 6075)


Jim Brune, sismología, Scripps, y Alfonso Reyes, CICESE, sismología, jefe de geofísica

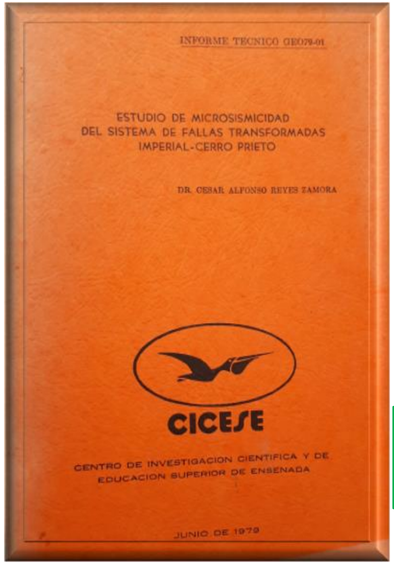
2011
Reyes Zamora, C. A., Sánchez Rodríguez, J. C. y Nuñez Leal, M. A. (2011). Sistema de información en tiempo real de la respuesta sísmica del edificio PCC-I, del STC-Metro. Reporte técnico no. 1. d p. (ID: 15404)

1978
Reyes Zamora, C. A., González García, J. J., Munguía Orozco, L., Nava Pichardo, F. A., Vernon, F. L. y Brune, J. N. (1978). Locations of aftershocks of the Oaxaca earthquake using smoked paper recorders and digital event recorders. Geofísica Internacional. 17(3): 341-349 p. (ID: 4664)

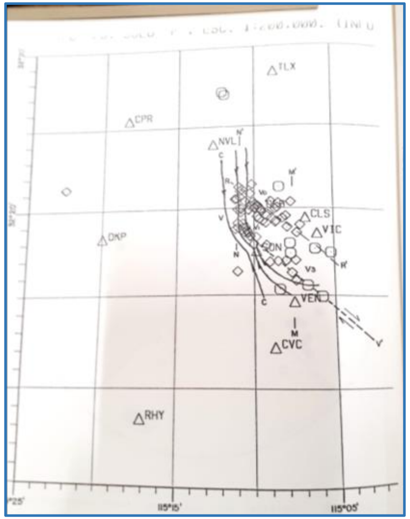
Departamento de Geofísica

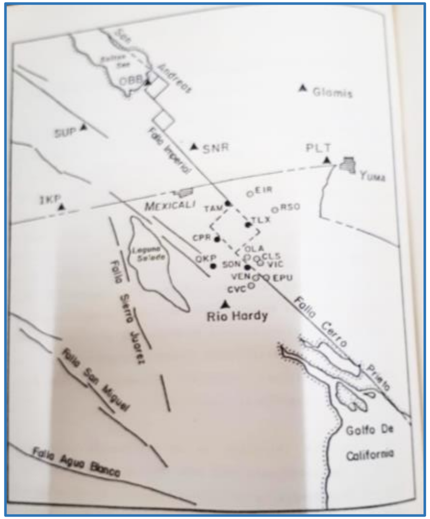
César Alfonso Reyes Zamora

- Se presenta a CFE el proyecto **“Desarrollo de metodologías para la exploración del campo geotérmico de Cerro Prieto usando métodos pasivos de microsismicidad”.**
- Con lo cual se crea la Red de Cerro Prieto (**RESCEP**) «**1977-1983**»



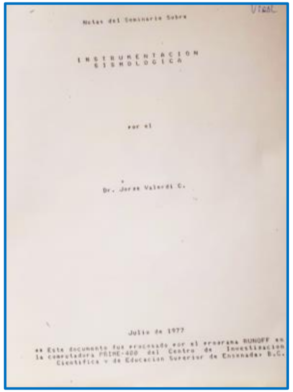
1980
Albores León, A., Reyes Zamora, C. A., Brune, J. N., González García, J. J., Mendoza Garcilazo, L. H., & Suárez Vidal, F. (1980). Seismicity studies in the region of the Cerro Prieto Geothermal Field. Geothermics, 9, 65-77. (ID: 6569





Departamento de Geofísica

Desarrollo de la Telemetría y estación sísmica digital


Notas del Seminario Sobre

INSTRUMENTACION SISMOLOGICA

por el

Dr. Jorge Valerdi C.

Julio de 1977

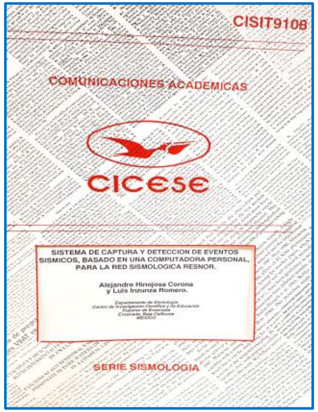
** Este documento fue procesado por el programa RUNOFF en la computadora PRIME-400 del Centro de Investigacion Cientifica y de Educacion Superior de Ensenada, B.C.

Jorge Valerdi C.

Carlos Duarte M.

Mauro Medina H.

Desarrollo del Software para recepción de datos sísmicos


CISIT9108

COMUNICACIONES ACADEMICAS

CICESE

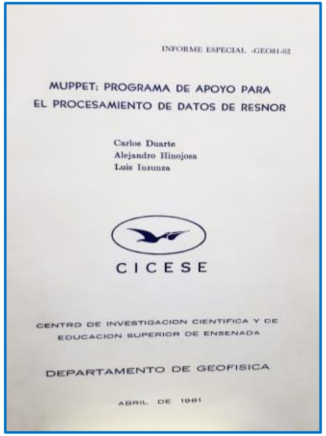
SISTEMA DE CAPTURA Y DETECCION DE EVENTOS SISMICOS, BASADO EN UNA COMPUTADORA PERSONAL, PARA LA RED SISMOLOGICA RESNOR.

Alejandro Hinojosa Corona y Luis Inzunza Romero.

SERIE SISMOLOGIA

Alejandro Hinojosa Corona

Luis Inzunza Romero


INFORME ESPECIAL -GEO81-02

MUPPET: PROGRAMA DE APOYO PARA EL PROCESAMIENTO DE DATOS DE RESNOR

Carlos Duarte
Alejandro Hinojosa
Luis Inzunza

CICESE

CENTRO DE INVESTIGACION CIENTIFICA Y DE EDUCACION SUPERIOR DE ENSENADA

DEPARTAMENTO DE GEOFISICA

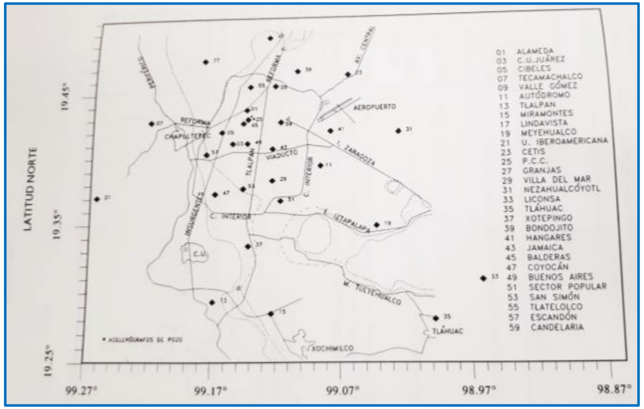
ABRIL DE 1981

Departamento de Sismología

César Alfonso Reyes Zamora

Fundación ICA

- Líder de Grupo de Estudios Especiales- Se consolida el proyecto en Cd. de México con Fundación ICA, se instalan 30 acelerógrafos.



Luis H. Mendoza Garcilazo
José G. Acosta Chang
Carlos I. Huerta López
Fernando Favela Vara

Proyecto instrumentación de edificio PCC

- Líder de Grupo de Ingeniería Sísmica – Instrumentación del edificio del Puesto Central de Control del Metro "Edificio Bernardo Quintana", en la Cd. De México.

César Alfonso Reyes Zamora

Personal técnico que le apoyó

- ❑ Josefina Rodríguez Jacobo
- ❑ Guillermo Díaz de Cossío B.
- ❑ Ernesto Rocha Guerrero †
- ❑ Humberto Delgadillo Hernández
- ❑ César Ballesteros Borbolla
- ❑ Guillermo Reyes del Ángel
- ❑ Bárbara Uribe Martínez
- ❑ Edith Fernández Sinohue
- ❑ Julia Sánchez-Rodríguez
- ❑ Diana Leticia Fong Mata
- ❑ Hiroshi Natsu Cárdenas
- ❑ Alejandra Núñez Leal

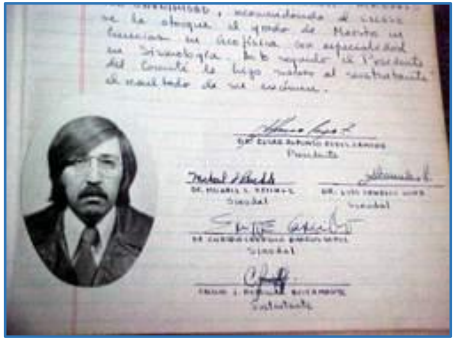
Proyecto

“Instrumentación de Puesto Central de Control del Metro (PCC)”

Departamento de Sismología

Cecilio Rebollar Bustamante †

- **Primer Maestro en Ciencia *(4 de mayo de 1977)***
- **Investigador, Profesor**
- **Jefe de RESNOR**
- **Fundador de RESBAN**



1990

Rebollar Bustamante, C. J. (1990). Estimates of shallow attenuation of the San Miguel Fault, Baja California. Bulletin of the Seismological Society of America, 80(3), 743-746. (ID: 2369

Personal técnico que le apoyó

- Antonio Mendoza Camberos
- Arturo Pérez Vertti Ramírez

2001

Rebollar Bustamante, C. J., Quintanar Robles, L., Castro Escamilla, R. R., Day, S. M., Madrid González, J. A., Brune, J. N., Astiz, L., & Vernon, F. L. (2001). Source characteristics of a 5.5 magnitude earthquake that occurred in the transform fault system of the Delfin Basin in the Gulf of California. Bulletin of the Seismological Society of America, 91(4), 781-791. (ID: 3004)

Article | Full-text available

Depth of the Moho in northern Baja California using (Pg-Pn) travel times

December 1999 · Geofísica Internacional 40(1)

Source · DOAJ

Luis M. Reyes · Cecilio J. Rebollar · Raúl R. Castro

Overview | Stats | Comments | Citations (7) | References (8) | Related research (10+)

Abstract and figures

Mean Moho depths along the axis of the Peninsular Ranges in northern Baja California are obtained from refracted waves of events in northern Baja California recorded on an array of 9 broadband seismic stations across the northern Baja California Peninsula at about latitude 31°N. We used 35 events located with RESNOM (Red Sísmica del Noroeste de México) and RANM (Red de Acelerógrafos del Noroeste de México) local data. Focal depths range from 3 to 15 km and magnitudes from 2.1 to 3.9. A 1-D velocity model (Nava and Brune, 1982) was used to calculate theoretical travel times of Pg and Pn for different Moho depths. The differences between observed and theoretical (Pg-Pn) travel times was minimized in an iterative process in order to find the most likely Moho depth along the axis of the Peninsular Ranges between latitudes 31.3° and 31.7°N. It was found that the average Moho depth is approximately 42±3 km in the western Peninsular Ranges, diminishing to 31±3 toward the west along the Pacific Ocean and to 20±3 km toward the Gulf of California.

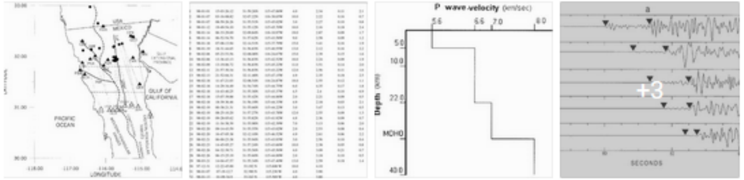
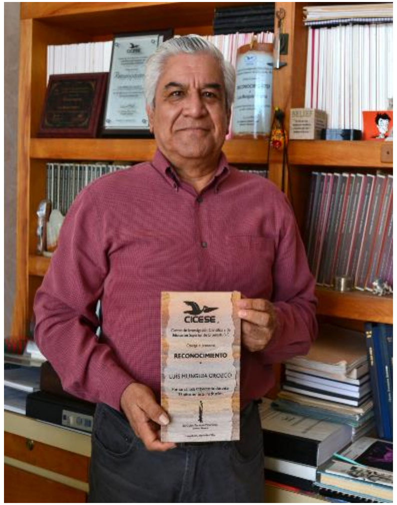


Figure content uploaded by Raúl R. Castro | Author content

Departamento de Sismología

Luis Munguía Orozco

- Investigador, Profesor *(1979 – a la fecha).*
- Línea de Investigación – *Riesgo Sísmico: atenuación, respuesta de sitio y zonificación*
- Jefe de Departamento de Sismología *(1983-1991).*
- Director de la División Ciencia de la Tierra *(19*
- *Jefe de RESNOR*
- *Líder de RANM*



1991
Vidal Villegas, J. A., & Munguía Orozco, L. (1991). Local magnitude and source parameters for earthquakes in the peninsular ranges of Baja California, Mexico. Bulletin of the Seismological Society of America, 81(6), 2254-2267. (ID: 2366)

1986
Munguía Orozco, L., Simila, G. W., Mcnally, K. C., & Thompson, H. (1986). The september 19, 19885 Michoacan earthquake: aftershock acceleration data recorder by a temporary installation of strong motion instruments. Geophysical Research Letters, 13(6), 581-584. (ID: 4668

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Geophysical Research Letters

Aftershocks of the 8 July, 1975 Canal de las Ballenas, Gulf of California, Earthquake

Luis Munguia, Michael Reichle, Alfonso Reyes, Richard Simons, James Brune

First published: November 1977 | https://doi.org/10.1029/GL004i011p00507 | Citations: 17

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Abstract

A M_s = 6.5 earthquake occurred on 8 July, 1975 in the northern part of the Gulf of California. The calculated seismic moment is 2 × 10^{25} dyne-cm. This event occurred in a region of particular interest since the position of the transform fault in this region was not well known and had been locked for at least 20 years. Over 180 aftershocks were located along a zone 54 Km long, 10 Km wide and 10-15 Km deep running between Baja California and Isla Angel de la Guarda. The depth of the aftershock zone is somewhat greater than that found in previous studies in the Gulf. The aftershock trend and that of the fault plane solution is consistent with an event occurring along a vertical strike-slip fault with motion in the direction of known regional plate movement.

Geophys. J. R. astr. Soc. (1984) 79, 747–771

Simulations of strong ground motion for earthquakes in the Mexicali—Imperial Valley region

Luis Munguia* and James N. Brune *Institute of Geophysics and Planetary Physics (A025), Scripps Institution of Oceanography, University of California at San Diego, La Jolla, California 92093, USA*

Received 1984 March 10; in original form 1983 July 15

Summary. In this paper computer modelling is used to test simple approximations for simulating strong ground motions for moderate and large earthquakes in the Mexicali—Imperial Valley region. Initially, we represent an earthquake rupture process as a series of many independent small earthquakes distributed in a somewhat random manner in both space and time along the rupture surface. By summing real seismograms for small earthquakes (used as empirical Green's functions), strong ground motions at specific sites near a fault are calculated. Alternatively, theoretical Green's functions that include frequencies up to 20 Hz are used in essentially similar simulations. The model uses random numbers to emulate some of the non-deterministic irregularities associated with real earthquakes, due either to complexities in the rupture process itself and/or strong variations in the material properties of the medium. Simulations of the 1980 June 9 Victoria, Baja California earthquake (M_L = 6.1) approximately agree with the duration of shaking, the maximum ground acceleration, and the frequency content of strong ground motion records obtained at distances of up to 35 km for this moderate earthquake. In the initial stages of modelling we do not introduce any scaling of spectral shape with magnitude, in order to see at what stage the data require it. Surprisingly, such scaling is not critical in going from M = 4–5 events to the M = 6.1 Victoria earthquake. However, it is clearly required by the El Centro accelerogram for the Imperial Valley 1940 earthquake, which had a much higher moment (M_S ~ 7). We derive the spectral modification function for this event. The resulting model for this magnitude ~ 7 earthquake is then used to predict the ground motions at short distances from the fault. Predicted peak horizontal accelerations for the M ~ 7 event are about 25–50 per cent higher than those observed for the M = 6.1 Victoria event.

*Present address: Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), Av. Espinoza No. 843, Ensenada, Baja California, México.

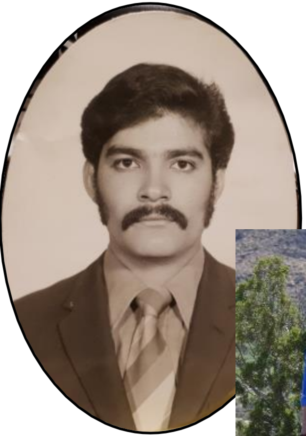
Personal técnico que le apoyó

- ❑ Tito Valdez
- ❑ Miguel Navarro
- ❑ Manuel Luna

Departamento de Sismología

José Javier González García

- **Investigador, Profesor**
- **Línea de Investigación – Sismicidad, sismotectónica y sismología computacional**
- **Jefe de RESNOM**



1977
González García, J. J., & Flores Luna, C. F. (1977). Evidencia sísmica de refracción de una zona de esparcimiento en la boca del Golfo de California. Anales del Instituto de Geofísica, 22-23, 117-129. (ID: 5135)

1990
González García, J. J. (1990). La falla imperial en el Valle de Mexicali. Revista de Ingeniería Sísmica, (40), 35-46. (ID: 6571)

2019
Robles Avalos, J. C., González Ortega, J. A.(***), **González García, J. J**.(*) y Vidal Villegas, J. A.(***) (2019). Coseismic displacements and Mw estimation of the El Mayor-Cucapah earthquake, Mexico, from GPS source spectra. Geofísica Internacional. 58(2): 169-178 p. doi:DOI: http://dx.doi.org/10.22201/igeof.00167169p.2018.58.2.1968 (ID: 23828)

Geophysical Research Letters

Solid Earth | Free Access

Guadalupe Island, Mexico as a new constraint for Pacific plate motion

J. J. Gonzalez-Garcia, L. Prawirodirdjo, Y. Bock, D. Agnew

First published: 30 August 2003 | https://doi.org/10.1029/2003GL017732 | Citations: 13

SECTIONS PDF TOOLS SHARE

Abstract

[1] We use GPS data collected on Isla de Guadalupe and in northern Baja California, Mexico, to estimate site velocities relative to Pacific plate motion. The velocities of all three geodetic monuments on Guadalupe fit a rigid Pacific plate model with residuals of 1 mm/yr. Using the Guadalupe data and data from five IGS stations on the Pacific plate (CHAT, KOKB, KWJ1, MKEA, and THTI) we estimate an angular velocity for this plate that is consistent with other recently-published estimates. Our results indicate that Isla de Guadalupe lies on the Pacific plate, and that GPS data collection on the island usefully constrains Pacific plate motion and rigidity.

1. Introduction

[2] Determining the motion and rigidity of the Pacific plate by geodetic means is difficult because most of the plate lies under water. The most recent study of Pacific plate motion [Beavan et al., 2002] used data from 11 stations, most of them located in the central and western Pacific. Unfortunately, stations on the California coast and on the offshore islands are problematic because of possible tectonic activity in the continental crust. However, Isla de Guadalupe, being on oceanic crust, can potentially provide an important additional constraint on Pacific plate motion. As Morgan [1968] pointed out in the first paper on global plate motions: "If the distances between Guadalupe Island, Wake Island, and Tahiti, all within the Pacific block, were measured to the nearest centimeter and then measured again several years later, we suppose these distances would not change." With the Global Positioning System (GPS) we can now perform these measurements with even greater precision than in Morgan's thought experiment.

Departamento de Sismología

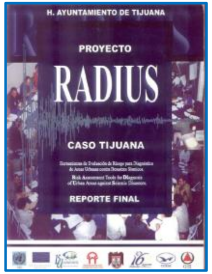
Luis Humberto Mendoza Garcilazo

- **Investigador, Profesor**
- **Línea de Investigación –** ***Sismología aplicada a la ingeniería***
- **Líder de RAUBC**
- **Jefe de RESNOM (2018 – a la fecha)**

1991
- Luis Mendoza da inicio a su contribución con acciones de prevención de sismos (83 proyectos con financiamiento externo).
- Apoyo a proyectos de forma colaborativa.
- Dentro del Departamento de Sismología se abre la línea de investigación de ***"Respuesta Sísmica en edificios"***.

2015

Mendoza Garcilazo, L. H. (2015). Atlas de Riesgos Naturales del Municipio de Tijuana. Centro de Investigación Científica y de Educación Superior de Ensenada. ISBN: N/A. 1-117 p. (ID: 20308)



1991

Mendoza Garcilazo, L. H., Acosta Chang, J. G., Huerta López, C. I., Reyes Zamora, C. A., & Otero P., J. A. (1991). Mapa de períodos dominantes de la vibración ambiental de los suelos blandos del Valle de México. Revista de Ingeniería Sísmica, (43), 19-58. (ID: 5788)

2018

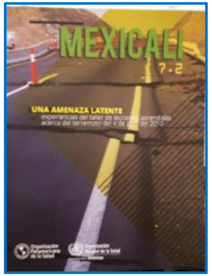
Vidal Villegas, J. A., Munguía Orozco, L., González Ortega, J. A., Nuñez Leal, M. A., Ramírez Ramos, E. E**., Mendoza Garcilazo, L. H.**, Castro Escamilla, R. R. y Wong Ortega, V. M. (2018). The Northwest Mexico Seismic Network: real time seismic monitoring in northern Baja California and northwestern Sonora, Mexico. Seismological Research Letters. 89(2A): 324-337 p. doi:10.1785/0220170183 (ID: 23131)

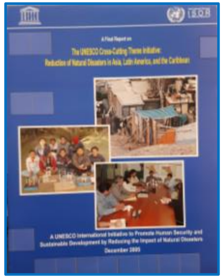
Departamento de Sismología

Luis Humberto Mendoza Garcilazo

Personal técnico y apoyo

- Ana María Frías León
- Rogelio Reyes Serrano
- Sergio Vázquez Hernández
- Orlando Granados Hernández
- Ignacio Méndez Figueroa
- Ena Gámez Balmaceda
- Jessica Jazmín Salas
- Laura Gabriela Ortiz





PROTECCIÓN CIVIL
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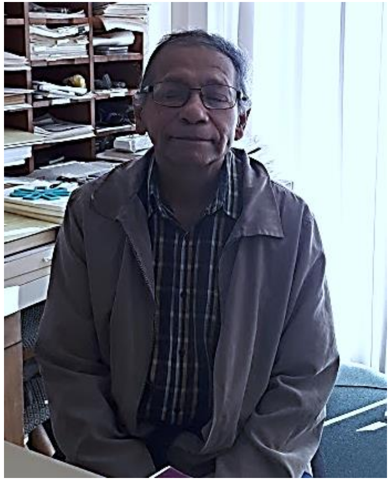

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Personal técnico

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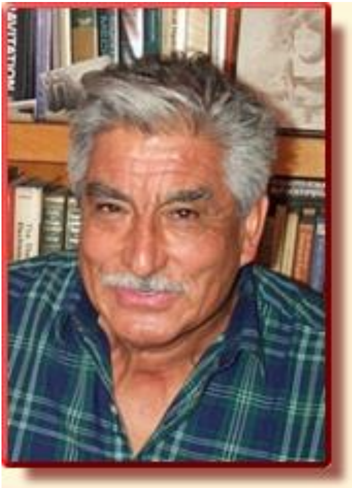

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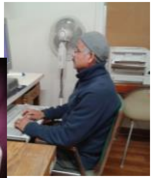

Personal técnico

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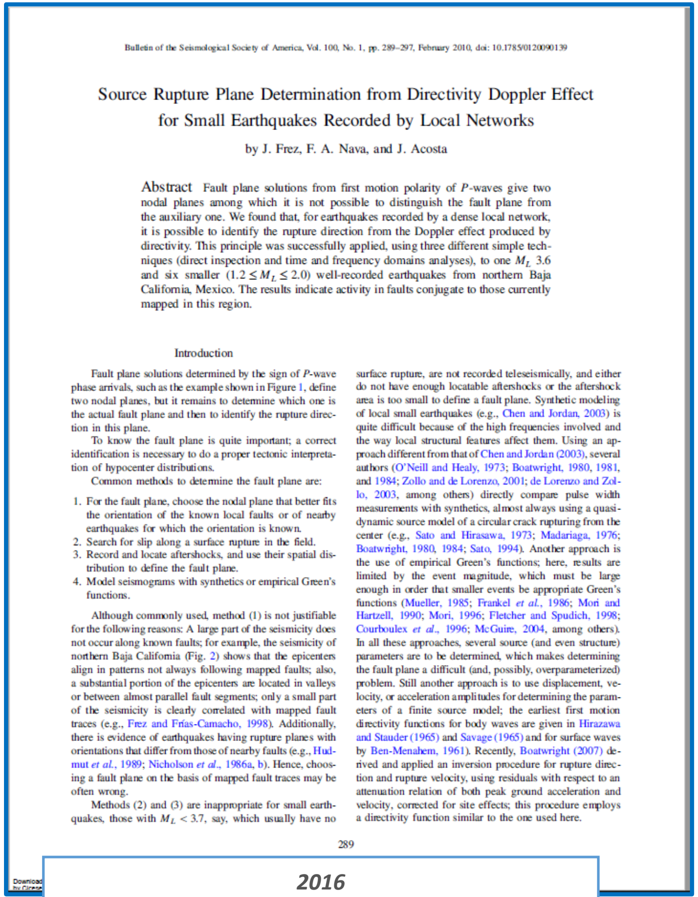

Bulletin of the Seismological Society of America, Vol. 100, No. 1, pp. 289–297, February 2010, doi: 10.1785/0120090139

Source Rupture Plane Determination from Directivity Doppler Effect for Small Earthquakes Recorded by Local Networks

by J. Frez, F. A. Nava, and J. Acosta

Abstract Fault plane solutions from first motion polarity of *P*-waves give two nodal planes among which it is not possible to distinguish the fault plane from the auxiliary one. We found that, for earthquakes recorded by a dense local network, it is possible to identify the rupture direction from the Doppler effect produced by directivity. This principle was successfully applied, using three different simple techniques (direct inspection and time and frequency domains analyses), to one M_L 3.6 and six smaller ($1.2 \le M_L \le 2.0$) well-recorded earthquakes from northern Baja California, Mexico. The results indicate activity in faults conjugate to those currently mapped in this region.

Introduction

Fault plane solutions determined by the sign of *P*-wave phase arrivals, such as the example shown in Figure 1, define two nodal planes, but it remains to determine which one is the actual fault plane and then to identify the rupture direction in this plane.

To know the fault plane is quite important; a correct identification is necessary to do a proper tectonic interpretation of hypocenter distributions.

Common methods to determine the fault plane are:

1. For the fault plane, choose the nodal plane that better fits the orientation of the known local faults or of nearby earthquakes for which the orientation is known.
2. Search for slip along a surface rupture in the field.
3. Record and locate aftershocks, and use their spatial distribution to define the fault plane.
4. Model seismograms with synthetics or empirical Green's functions.

Although commonly used, method (1) is not justifiable for the following reasons: A large part of the seismicity does not occur along known faults; for example, the seismicity of northern Baja California (Fig. 2) shows that the epicenters align in patterns not always following mapped faults; also, a substantial portion of the epicenters are located in valleys or between almost parallel fault segments; only a small part of the seismicity is clearly correlated with mapped fault traces (e.g., Frez and Frías-Camacho, 1998). Additionally, there is evidence of earthquakes having rupture planes with orientations that differ from those of nearby faults (e.g., Hudmut *et al.*, 1989; Nicholson *et al.*, 1986a, b). Hence, choosing a fault plane on the basis of mapped fault traces may be often wrong.

Methods (2) and (3) are inappropriate for small earthquakes, those with $M_L < 3.7$, say, which usually have no surface rupture, are not recorded teleseismically, and either do not have enough locatable aftershocks or the aftershock area is too small to define a fault plane. Synthetic modeling of local small earthquakes (e.g., Chen and Jordan, 2003) is quite difficult because of the high frequencies involved and the way local structural features affect them. Using an approach different from that of Chen and Jordan (2003), several authors (O'Neill and Healy, 1973; Boatwright, 1980, 1981, and 1984; Zollo and de Lorenzo, 2001; de Lorenzo and Zollo, 2003, among others) directly compare pulse width measurements with synthetics, almost always using a quasi-dynamic source model of a circular crack rupturing from the center (e.g., Sato and Hirasawa, 1973; Madariaga, 1976; Boatwright, 1980, 1984; Sato, 1994). Another approach is the use of empirical Green's functions; here, results are limited by the event magnitude, which must be large enough in order that smaller events be appropriate Green's functions (Mueller, 1985; Frankel *et al.*, 1986; Mori and Hartzell, 1990; Mori, 1996; Fletcher and Spudich, 1998; Courboulex *et al.*, 1996; McGuire, 2004, among others). In all these approaches, several source (and even structure) parameters are to be determined, which makes determining the fault plane a difficult (and, possibly, overparameterized) problem. Still another approach is to use displacement, velocity, or acceleration amplitudes for determining the parameters of a finite source model; the earliest first motion directivity functions for body waves are given in Hirazawa and Stauder (1965) and Savage (1965) and for surface waves by Ben-Menahem, 1961). Recently, Boatwright (2007) derived and applied an inversion procedure for rupture direction and rupture velocity, using residuals with respect to an attenuation relation of both peak ground acceleration and velocity, corrected for site effects; this procedure employs a directivity function similar to the one used here.

289

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Stolte, C., Mcnally, K. C., Gonzalez Ruiz, J. R., Simila, G. W., Reyes Zamora, C. A., Rebollar Bustamante, C. J., Munguía Orozco, L., Mendoza Garcilazo, L. H. y Richter, C. F. (1986). Fine structure of a postfailure Wadati-Benioff zone. Geophysical Research Letters. 13(6): 577-580 p. (ID: 4785)

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- **Jefe Departamento de Sismología (2000 – 2003)**
- **Líder de RESBAN**

COMUNICACIONES ACADEMICAS

SERIE SISMOLOGIA

DETERMINACION DE CURVAS DE AMPLITUD ESPECTRAL DE RESPUESTA INSTRUMENTAL DE LA RED SISMICA DEL NOROESTE DE MEXICO (RESNOM)

Raúl R. Castro Escamilla, Oscar Gálvez Valdés, Luis Orozco León, Francisco Farfán Sánchez, Ignacio Méndez Figueroa, Luis Inzunza Romero y Julia Sánchez Rodríguez

CICESE

CENTRO DE INVESTIGACION CIENTIFICA Y DE EDUCACION SUPERIOR DE ENSENADA

Castro Escamilla, Raúl R., Oscar Gálvez Valdés, Luis Orozco León, Francisco Farfán Sánchez, Ignacio Méndez Figueroa, Luis Inzunza Romero y Julia Sánchez Rodríguez. 1995. Determinación de Curvas de Amplitud Espectral de Respuesta Instrumental de la Red Sísmica del Noroeste de México (RESNOM). Informe Técnico. Comunicaciones Académicas, Serie Sismología, CICESE 44 pp. CTSIT9506.

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Personal técnico

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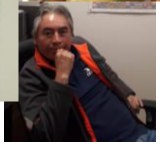
- ❖ Arturo Pérez Vertti Ramírez
- ❖ Luis Inzunza Romero



The Broadband Seismological Network (RESBAN) of the Gulf of California, Mexico

by Raúl R. Castro, Antonio Mendoza-Camberos, and Arturo Pérez-Vertti

ABSTRACT

The Red Sismológica de Banda Ancha del Golfo de California (RESBAN) is a regional broadband network that monitors the seismic activity that occurs in the Gulf of California (GoC), Mexico. This network is operated by Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California (CICESE) and at the present time consists of 17 stations. The first stations were installed in 1995 and between 2002 and 2008 additional stations, from Network of Autonomously Recording Seismographs (NARS), were installed as part of a collaboration project (NARS-Baja array) among Utrecht University, the California Institute of Technology, and CICESE. The Mexican National Seismological Service (SSN), operated by the Universidad Nacional Autónoma de México (UNAM), also installed new stations near the main cities in the Baja California peninsula and Sonora. The database generated by these networks has permitted study of the seismotectonics of the GoC in more detailed and to investigate the velocity structure of this region. We present in this article a description of the seismic network and a review of the main results that have been reported using the data set generated with this regional permanent network.

INTRODUCTION

The Red Sismológica de Banda Ancha del Golfo de California (RESBAN) is a broadband seismological network located in the Gulf of California (GoC) region. This regional array started operating autonomous stations in 1995 and complemented the larger Network of Autonomously Recording Seismographs (NARS)-Baja array (Trampert *et al.*, 2003; Clayton *et al.*, 2004) that operated in the GoC region between 2002 and 2008. Figure 1 shows the distribution of the stations of these arrays. The typical instrumentation of the RESBAN stations consists of Güralp CMG-40T sensors, digital three-channel recorders with Global Positioning System (GPS) for time control, and 24-bit Güralp digitizers housed in concrete shelters that provide protection from weather conditions (Fig. 2). The NARS-Baja network consisted of 19 broadband seismic stations equipped with STS2 sensors, a passive data logger, a GPS receiver, and a laptop with the data acquisition and timing systems (Trampert *et al.*, 2003). This network consisted of autonomously recording seismographs. Thus, the data had to be retrieved on site at least twice a year. Data from this array were stored by the Incorporated Research Institutions for Seismology Data Management Center and the Southern California Earthquake Center at Caltech. The distribution of the stations of these networks that surround the GoC (Fig. 1) permits to constrain earthquake locations and the faulting processes of this region.

The data from these broadband networks also made it possible for us to study the crust and upper-mantle structure of the GoC region (López-Pineda *et al.*, 2007; Persaud *et al.*, 2007; Zhang *et al.*, 2007; Zhang, 2009) to constraint the seismicity (Castro, Pérez-Vertti, *et al.*, 2011; Sumy *et al.*, 2013) and to learn about the dynamic processes of the mantle through anisotropy studies (Obrebski *et al.*, 2006, Obrebsky and Castro, 2008; van Benthem *et al.*, 2008).

The NARS-Baja array was removed in November 2008, leaving important instrumental gaps in the GoC region. However, new stations from RESBAN were installed on the NARS-Baja sites and the National Seismological Service (SSN), operated by the Universidad Nacional Autónoma de México (UNAM), also installed other new stations near the cities of La Paz, Tijuana, and Mexicali, in the Baja California peninsula and in Hermosillo, Sonora (Fig. 1). Two more stations were also installed by the SSN in San Pedro Martir (SPIG) and in Santa Rosalia (SRIG). At the present time, the data from the RESBAN stations BAHB, GUYB, and NE80 are sent to the SSN in real time and retransmitted to Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California (CICESE) with the Earthworm Monitoring System (Instrumental Software Technologies Inc.). Since 2009, the signals of these stations are received simultaneously in the SSN and in CICESE. The signals of the rest of the stations enter into the local Earthworm program via satellite or Internet link.

We describe in this article results obtained using these data sets, reported on the seismotectonics of the GoC region, on the crust and upper-mantle structure and on the regional seismic attenuation and anisotropy.

TECTONIC CONTEXT

When the Farallon subduction ceased beneath Baja California at ~12 Ma, the GoC region underwent extension in the east-northeast direction. This basin-and-range type of extension, together with dextral transform faulting, accommodated the

338 Seismological Research Letters Volume 89, Number 2A March/April 2018

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Ⓔ

Delayed Dynamic Triggered Seismicity in Northern Baja California, México Caused by Large and Remote Earthquakes

by Raúl R. Castro, Héctor González-Huízar, F. Ramón Zúñiga, Víctor M. Wong, and Aaron A. Velasco

Abstract We analyze the seismicity in northern Baja California, Mexico, that occurred one month before and one month after the 11 March 2011 (M_w 9.1) Tohoku-Oki, Japan, earthquake and for two other large and remote earthquakes, the 27 February 2010 central Chile (M_w 8.8) earthquake and the 11 April 2012 northern Sumatra earthquake (M_w 8.6). The northern region of Baja California exhibits high microseismic activity and moderate-size earthquakes. The seismicity in this region is monitored by the seismic network Red Sísmica del Noroeste de México (RESNOM) operated by the Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE). We use the RESNOM seismic catalog to search for changes in local seismic rates that occurred after the passing of surface waves generated by the three large earthquakes studied. When we compare one month of seismicity before and after the M_w 9.1 Japan earthquake, in the biggest of the three events analyzed, we observe the absence of triggered seismicity in the northern Peninsular Ranges and an increase of seismicity south of the Mexicali Valley, where the Imperial fault jumps southwest and the Cerro Prieto fault continues south. We also observe an increase of seismicity rate in the Cucapah fault and in the San Pedro Martir fault regions. The Cucapah fault region, the most active of the three regions during the studied period, shows an increase of seismicity several days after the 2010 Chile (M_w 8.8) and the 2011 Japan (M_w 9.1) earthquakes. This observation can be interpreted as evidence of delayed seismicity and confirms the observation of Rubinstein *et al.* (2009) that earthquakes tend to be triggered in regions with high ambient seismicity rates. We observed delayed triggering of earthquakes generated by two of the three remote earthquakes analyzed. These observations can be explained by dynamic triggering of prolonged fault creep as proposed by Shelly *et al.* (2011).

Online Material: Maps of seismicity and M_c.

Introduction

Observations of large earthquakes remotely triggering smaller earthquakes have been reported since the 1992 M_w 7.3 Landers, California, earthquake (Hill *et al.*, 1993; Anderson *et al.*, 1994; Bodin and Gomberg, 1994). More recently, other studies have documented that surface waves generated by large earthquakes can trigger seismicity at large distances (Hill and Prejean, 2007; Velasco *et al.*, 2008; González-Huízar *et al.*, 2012; Van Der Elst and Brodsky, 2013; Gomberg and Sherrod, 2014). The triggered seismicity can occur instantaneously during the passing of the seismic waves (Hill and Prejean, 2007), but a significant increase of seismicity can also occur several days or even weeks after the passing of the waves (e.g., Pankow *et al.*, 2004; Pollitz *et al.*, 2012). Mega-earthquakes such as the 11 March 2011 Tohoku-Oki (M_w 9.1) earthquake generate large surface waves that travel around the globe for several hours and may disturb the state of stress near active faults located far from the hypocentral region. González-Huízar *et al.* (2012) found evidence of dynamic triggered seismicity associated to the 2011 Tohoku-Oki earthquake. In particular, they detected small earthquakes that occurred in the Gulf of California, Mexico, during the passing of the surface waves generated by that megaquake. They also reported a seismic swarm, which included an M_w 5.2 earthquake that continued for two days after the passing of the surface waves.

In this article, we analyze the earthquake catalog from the seismic network Red Sísmica del Noroeste de México (RESNOM) in northern Baja California, Mexico, for

1825

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Bulletin of the Seismological Society of America, Vol. 101, No. 6, pp. 3072–3080, December 2011, doi: 10.1785/0120110112

Ⓔ

Short Note

Location of Aftershocks of the 4 April 2010 M_w 7.2 El Mayor–Cucapah Earthquake of Baja California, Mexico

by Raúl R. Castro, José G. Acosta, Víctor M. Wong, Arturo Pérez-Vertti, Antonio Mendoza, and Luis Inzunza

Abstract A magnitude M_w 7.2 earthquake occurred on 4 April 2010 at approximately 50 km southwest of the city of Mexicali, Baja California, Mexico. The regional networks Red Sísmica del Noroeste de México (RESNOM) that the Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE) operates and the Southern California Seismic Network (SCSN) located the main event between the sierras El Mayor and Cucapah at the southeastern end of the Pescadores fault. Twenty-four hours after the origin time of the main event, a temporal seismic network was installed around the faults that ruptured during this event. We used body-wave arrival times recorded by the first 14 stations installed to obtain precise hypocentral locations of this important sequence of earthquakes. Most of the aftershocks located on 6 and 7 April are distributed near the traces of the Pescadores and Cucapah faults, particularly at the southern end of these faults. The spatial distribution of the epicenters indicates that these faults and possibly others may extend southeast of Sierra Cucapah where the faults were buried by sediments and were activated during the seismic sequence. In this area, north of the Sierra El Mayor, where no faults were previously mapped, the epicenters align in the northwest–southeast direction. Most hypocenters have depths less than 15 km, suggesting that an important portion of the seismic slip was shallow. Based on the distribution of focal depths of the aftershocks, we infer that the seismogenic zone must be between 5 and 10 km.

Online Material: Tables of station and aftershock locations.

Introduction

El Mayor–Cucapah earthquake of Baja California (M_w 7.2) occurred near the Laguna Salada rift basin, in a region where shearing between the North American and the Pacific plates takes place (Fletcher and Seplz, 2009). Most of the extension in that region is accommodated by the Cañada David detachment and the Laguna Salada fault, which is an oblique high-angle normal-dextral fault that strikes northwest (Fletcher and Seplz, 2009). Historical earthquakes occurred in this fault system in 1892 (M_w 7.1) and 1934 (M 6.5; Hough and Elliott, 2004). However, field work (Fletcher *et al.*, 2010) indicates that the rupture occurred on another two fault segments, one located to the north of Laguna Salada, the Borrego fault, and another to the east, the Pescadores fault. The seismic sequence triggered by the 4 April 2010 (M_w 7.2) earthquake occurred on faults that do not seem to be part of the North America–Pacific plate boundary. Hauksson *et al.* (2010) proposed that El Mayor–Cucapah earthquake may have been controlled by the bends in the plate boundary, similar to when the 1992 Landers and the 1999 Hector Mine earthquakes occurred.

Twenty-four hours after the main event occurred, a temporal seismic network was installed by the Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE) around the faults that ruptured during the main event. On 6 April, the local network consisted of 14 recorders Reftek RT130 with 3-component L-28 short period sensors provided by the consortium Incorporated Research Institutions for Seismology Program for Array Seismic Studies of the Continental Lithosphere (IRIS-PASSCAL). Listing of these sites is available as an electronic supplement to this paper (Ⓔ Table S1). The number of stations installed increased after 7 April and operated until 14 May 2010. The distribution of the stations provided a very good azimuthal coverage of the rupture area at short epicentral distances. Thus, P- and S-wave arrival times from these local stations

3072

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1987
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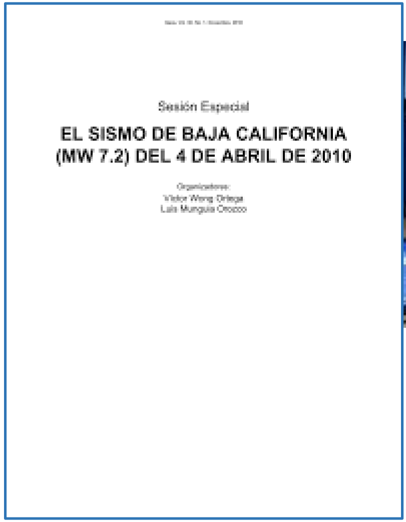

Sesión Especial

EL SISMO DE BAJA CALIFORNIA (MW 7.2) DEL 4 DE ABRIL DE 2010

Organizadores:
Víctor Wong Ortega
Luis Munguía Orozco

1995
Munguía Orozco, L., & Wong Ortega, V. M. (1995). Estudio de sismicidad en la zona geotérmica las Tres Vírgenes, Baja California Sur. In F. Medina Martínez, L.A. Delgado Argote y G. Suárez Reynoso. (Eds.), La Sismología en México: 10 años después del temblor de Michoacán del 19 de septiembre de 1995 (M=8.1) Monografía No. 2. UGM (pp. 212-228). (ID: 2309)

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VARIACIONES DE TIEMPO DE RECORRIDO EN UN MEDIO UNIDIMENSIONAL CON VELOCIDAD ESTOCÁSTICAMENTE HETEROGÉNEA: UN EFECTO CONTRAINTUITIVO

RESUMEN


Source mechanism and surface wave excitation for two earthquakes in northern Baja California, Mexico

F. Alejandro Nava

James N. Brune

2003

Nava Pichardo, F. A., García Arthur, R. E., Frez Cárdenas, J. D., Acosta Chang, J. G., Carlos Villegas, J. y González García, J. J. (2003). Fast estimation of local magnitudes from non-standard wood-Anderson, short period, seismograms. Geofísica Internacional. 42(1): 61-68 p. (ID: 6846)

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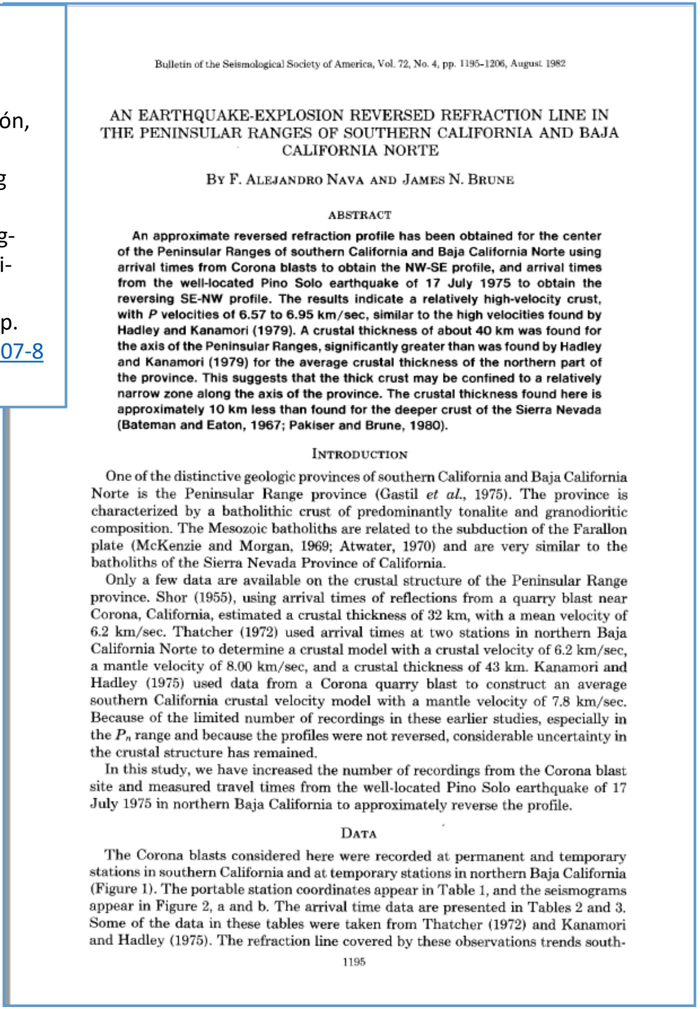
- **Rosalía García Arthur**


Bulletin of the Seismological Society of America, Vol. 72, No. 4, pp. 1195-1206, August 1982

AN EARTHQUAKE-EXPLOSION REVERSED REFRACTION LINE IN THE PENINSULAR RANGES OF SOUTHERN CALIFORNIA AND BAJA CALIFORNIA NORTE

BY F. ALEJANDRO NAVA AND JAMES N. BRUNE

ABSTRACT

An approximate reversed refraction profile has been obtained for the center of the Peninsular Ranges of southern California and Baja California Norte using arrival times from Corona blasts to obtain the NW-SE profile, and arrival times from the well-located Pino Solo earthquake of 17 July 1975 to obtain the reversing SE-NW profile. The results indicate a relatively high-velocity crust, with *P* velocities of 6.57 to 6.95 km/sec, similar to the high velocities found by Hadley and Kanamori (1979). A crustal thickness of about 40 km was found for the axis of the Peninsular Ranges, significantly greater than was found by Hadley and Kanamori (1979) for the average crustal thickness of the northern part of the province. This suggests that the thick crust may be confined to a relatively narrow zone along the axis of the province. The crustal thickness found here is approximately 10 km less than found for the deeper crust of the Sierra Nevada (Bateman and Eaton, 1967; Pakiser and Brune, 1980).

INTRODUCTION

One of the distinctive geologic provinces of southern California and Baja California Norte is the Peninsular Range province (Gastil *et al.*, 1975). The province is characterized by a batholithic crust of predominantly tonalite and granodioritic composition. The Mesozoic batholiths are related to the subduction of the Farallon plate (McKenzie and Morgan, 1969; Atwater, 1970) and are very similar to the batholiths of the Sierra Nevada Province of California.

Only a few data are available on the crustal structure of the Peninsular Range province. Shor (1955), using arrival times of reflections from a quarry blast near Corona, California, estimated a crustal thickness of 32 km, with a mean velocity of 6.2 km/sec. Thatcher (1972) used arrival times at two stations in northern Baja California Norte to determine a crustal model with a crustal velocity of 6.2 km/sec, a mantle velocity of 8.00 km/sec, and a crustal thickness of 43 km. Kanamori and Hadley (1975) used data from a Corona quarry blast to construct an average southern California crustal velocity model with a mantle velocity of 7.8 km/sec. Because of the limited number of recordings in these earlier studies, especially in the P_n range and because the profiles were not reversed, considerable uncertainty in the crustal structure has remained.

In this study, we have increased the number of recordings from the Corona blast site and measured travel times from the well-located Pino Solo earthquake of 17 July 1975 in northern Baja California to approximately reverse the profile.

DATA

The Corona blasts considered here were recorded at permanent and temporary stations in southern California and at temporary stations in northern Baja California (Figure 1). The portable station coordinates appear in Table 1, and the seismograms appear in Figure 2, a and b. The arrival time data are presented in Tables 2 and 3. Some of the data in these tables were taken from Thatcher (1972) and Kanamori and Hadley (1975). The refraction line covered by these observations trends south-

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Departamento de Sismología

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- **Investigador, Profesor**
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1991

Mendoza Garcilazo, L. H., Acosta Chang, J. G., **Huerta López**, C. I., Reyes Zamora, C. A. y Otero P., J. A. (1991). Mapa de períodos dominantes de la vibración ambiental de los suelos blandos del Valle de México. Revista de Ingeniería Sísmica. (43): 19-58 p. (ID: 5788)

2003

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Departamento de Sismología

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- **Investigador, Profesor**
- **Línea de investigación – *Física de medios porosos y sus aplicaciones***

2011
Müller, T. M. y Sahay Sahay, P. N. (2011). Stochastic theory of dynamic permeability in poroelastic media. Physical Review E. 84(2): 026329-1-6 p. doi:10.1103/PhysRevE.84.026329 (ID: 16266)

Wave Motion
Volume 11, Issue 5, September 1989, Pages 407-417

ELSEVIER

Eigenmodes for an elastic halfspace surrounding a semi-rigid cylinder

Pratap N. Sahay, Anton Z. Capri

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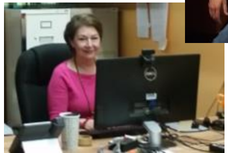
Abstract

The elastodynamics of a halfspace with a cylindrical hole belongs to a class of problems which involve solving the elastic wave equation in a geometry that is bounded by nonparallel surfaces. Integral transform techniques are not very suitable for the solution of such problems because the transform approach yields solutions in terms of wavefronts (or rays). For a nonparallel geometry one may need a large collection of such terms and this may be an inconvenient description. So, we have taken an approach to construct the eigenmodes (normal modes) for this geometry for a given set of boundary conditions. A set of linearly independent solutions, without any reference to sources or receivers, is developed and completeness of this set is verified explicitly. Using this complete set of eigenmodes the displacement field for any source problem in this geometry can be expressed following standard mathematical procedures.

2001
Sahay Sahay, P. N., Spanos, T. J. T., & De La Cruz, V. (2001). Seismic wave propagation in inhomogeneous and anisotropic porous media. Geophysical Journal International, (145), 209-222. (ID: 4489)



Personal técnico

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- **Líder de la Red de "Deformación de la corteza del Valle de Mexicali"**

1996

Glowacka, E., & Nava Pichardo, F. A. (1996). Major earthquakes in Mexicali Valley, Mexico, and fluid extraction at Cerro Prieto geothermal field. Bulletin of the Seismological Society of America, 86(1A), 93-105. (ID: 1451)

2009

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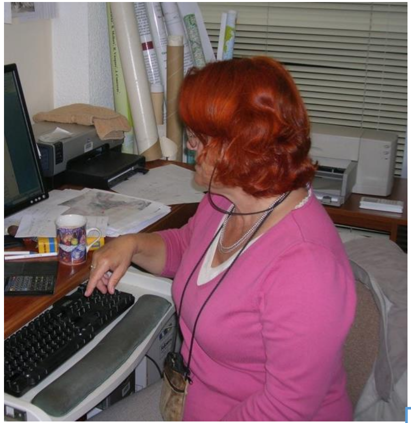

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- **Guillermo Díaz de Cossío**
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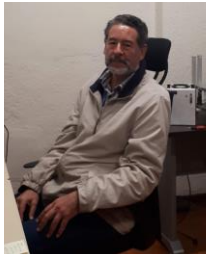

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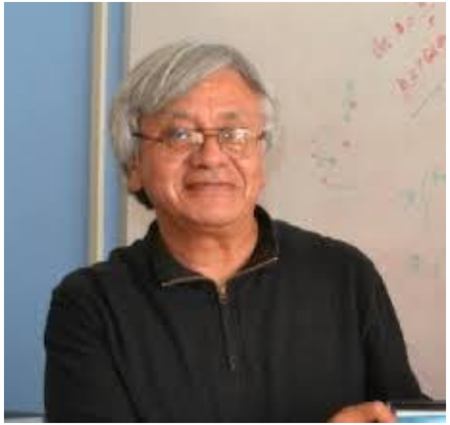
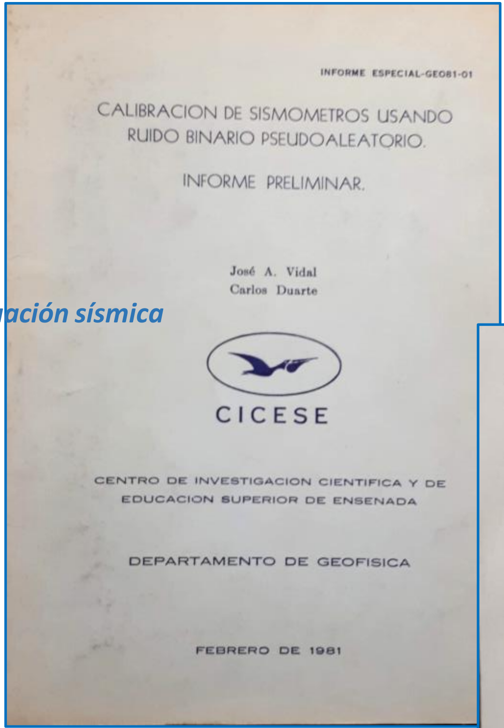
- **Líder de RSC (2015 – a la fecha)**
- **Jefe del Departamento de Sismología (2015 – a la fecha)**





INFORME ESPECIAL-GEO81-01

CALIBRACION DE SISMOMETROS USANDO RUIDO BINARIO PSEUDOALEATORIO.

INFORME PRELIMINAR.

José A. Vidal
Carlos Duarte

CICESE

CENTRO DE INVESTIGACION CIENTIFICA Y DE EDUCACION SUPERIOR DE ENSENADA

DEPARTAMENTO DE GEOFISICA

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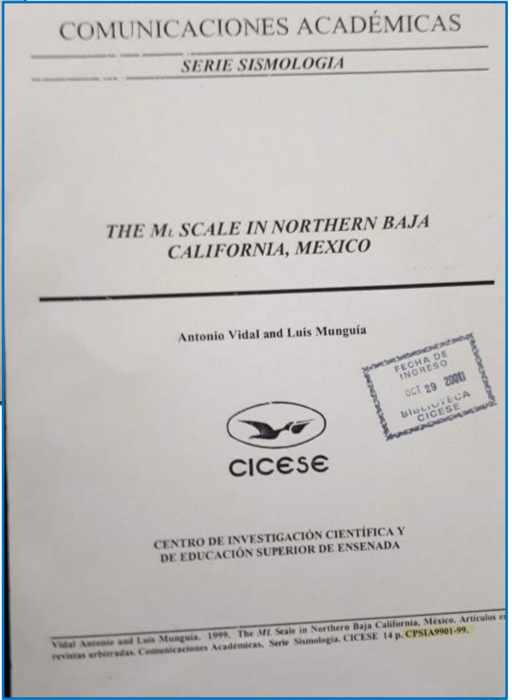
1991

Vidal Villegas, J. A., & Munguía Orozco, L. (1991). Local magnitude and source parameters for earthquakes in the peninsular ranges of Baja California, Mexico. Bulletin of the Seismological Society of America, 81(6), 2254-2267. (ID: 2366)



COMUNICACIONES ACADÉMICAS

SERIE SISMOLOGIA

THE M_L SCALE IN NORTHERN BAJA CALIFORNIA, MEXICO

Antonio Vidal and Luis Munguía

FECHA DE INGRESO OCT 29 2000 BIBLIOTECA CICESE

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CENTRO DE INVESTIGACIÓN CIENTÍFICA Y DE EDUCACIÓN SUPERIOR DE ENSENADA

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2019

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Las nuevas generaciones

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- **Línea de investigación –** ***Propagación de ondas sísmicas en medios complejos***
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2004

York, D., Evensen, N. M., López Martínez, M. y De Basabe Delgado, J. D. D. (2004). Unified equations for the slope, intercept, and standard errors of the best straight line. American Journal of Physics. 72(3): 367-375 p. (ID: 7101)

2015

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2019

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2014
González Ortega, J. A., Fialko, Y., Sandwell, D., Nava Pichardo, F. A., Fletcher Mackrain, J., González García, J. J., Lipovski, B., Floyd, M. y Funning, G. (2014). El Mayor-Cucapah (Mw 7.2) earthquake: Early near-field postseismic deformation from InSAR and GPS observations. Journal of Geophysical Research: Solid Earth. 119(2): 1482-1497 p. doi:10.1002/2013JB010193 (ID: 17127)

2017
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2019
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- Investigador *(Cátedra CONACyT), profesor*
- Línea de investigación – Sismología de volcanes

2011
Ávila Barrientos, L., Valdés González, C. y Novelo Casanova, D. (2011). Generation of isoseismal maps for Mexico using velocity and acceleration data. Natural Hazards. 59(2): 655-664 p. doi:10.1007/s11069-011-9786-8 (ID: 20633)

2016
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FA Nava, L Ávila-Barrientos, VH Márquez-Ramírez... - Journal of Seismology, 2018

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2012

González Huizar, H., Velasco, A., Peng, Z. y Castro Escamilla, R. R. (2012). Remote triggered seismicity caused by the 2011, M9.0 Tohoku-Oki, Japan earthquake. Geophysical Research Letters. 39(L10302): 1-5 p. (ID: 15021)

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Beccar Valera, M., González Huizar, H., Mariani, M. y Tweneboah, O. (2016). Use of wavelets techniques to discriminate between explosions and natural earthquakes. PHYSICA A-STATISTICAL MECHANICS AND ITS APPLICATIONS. 457: 42-51 p. doi:10.1016/j.physa.2016.03.077 (ID: 23852)

2019

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Carlos Eduardo Reinoza Gómez

- **Investigador, profesor**
- **Línea de investigación - *Geodesia y sismicidad de Baja California***

2014

Reinoza Gómez, C. E., Audemard Mennessier, F. A., Jouanne, F. y Beck, C. (2014). An overview of the GNSS Geodetic Measurements Applied to Geodynamic Studies in Venezuela. En: Michael Schmitz, Franck A. Audemard, Franco Urbani, Editores. El Límite Noreste de la Placa Suramericana ¿ Estructuras Litosféricas de la Superficie al Manto. Universidad Central de Venezuela. ISBN: 978-980-00-2800-1. 323-335 p. (ID: 23844)

2016

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2018

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Departamento de Sismología

Nuevo integrante: Por definirse en enero de 2020

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- ❑ Argelia Elena Enríquez Silva
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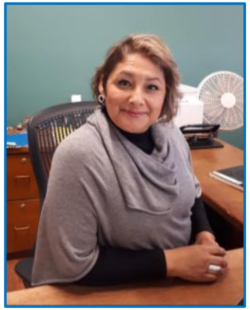








Próximamente

Abril de 2020

“Simposio a 10 años de la ocurrencia del sismo del Mayor-Cucapah”

Gracias