

The Earthquakes of August 3, 2009 in the Canal de Ballenas Region, in the Gulf of California, Mexico.

Castro, Raúl¹, Valdés, Carlos³, Shearer, Peter², Wong, Victor¹, Astiz, Luciana², Vernon, Frank², Pérez-Vertti, Arturo¹, Mendoza, Antonio¹

¹ Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), División Ciencias de la Tierra, Departamento de Sismología, km. 107 Carretera Tijuana-Ensenada, 22860 Ensenada, Baja California, México.

² Institute of Geophysics and Planetary Physics, Scripps Institute of Oceanography, University of California, San Diego, La Jolla, CA 92093-0225

³ Servicio Sismológico Nacional, Instituto de Geofísica, UNAM, Ciudad Universitaria, México.

ABSTRACT

On 3 August 2009 the National Seismological Service of Mexico (SSN) reported an earthquake of magnitude Mw 6.9 that occurred near Canal de Ballenas (28.48N, 112.24W), in the central region of the Gulf of California. The initial location reported by the SSN and IRIS suggested that the epicenter was on the North American plate near a fault that is considered inactive. This earthquake was preceded by a magnitude 5.8 event that occurred about 5 minutes before. In the next 40 minutes after the main event two aftershocks with magnitudes 4.9 and 5.9 occurred, and on 5 August a third aftershock of M 5.5 was located in the Canal de Ballenas region. The transform fault of Canal de Ballenas has been the site of other important events in the past. For instance on July 8, 1975 an earthquake with Ms 6.5 occurred west of Angel de la Guarda island. Other earthquakes of moderate magnitude have occurred in this region, more recently to the north, in the lower Delfin basin, on November 26, 1997 (M 5.5) and south of Angel de la Guarda island on November 12, 2003 (Mw 5.4) and September 24, 2004 (Mw 5.8). The events of August 2009 were recorded by the regional stations of the broadband network RESBAN that CICESE operates and by stations of the SSN also located in the region of the Gulf of California (in La Paz, Hermosillo, Santa Rosalia, San Pedro Martir and Mexicali). The focal mechanism of the main event, reported in the CMT Harvard catalog, is right lateral strike-slip with a strike of 216 deg and a dip of 78 deg. The regional records of the broadband stations permit the determination of precise locations and estimates of the rupture area of this important sequence of earthquakes. The resulting hypocentral coordinates indicate that the main events of this sequence occurred along the Canal de Ballenas transform fault.

Global CMT Catalog 1976 – 2009

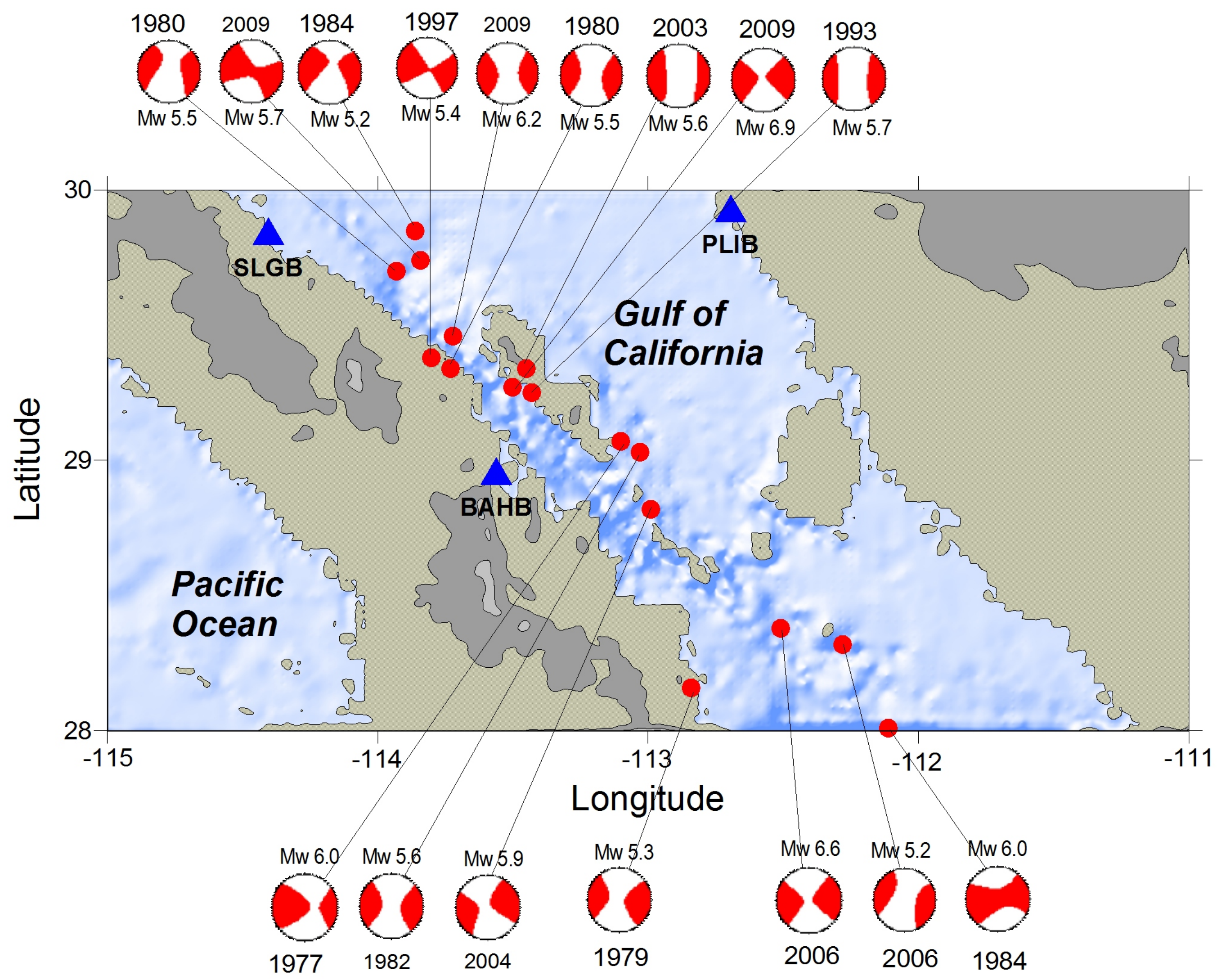


Figure 2) Centroid locations and focal mechanisms reported by the global CMT Harvard catalog for the period 1976 – 2009. The triangles are broadband stations of the RESBAN array.

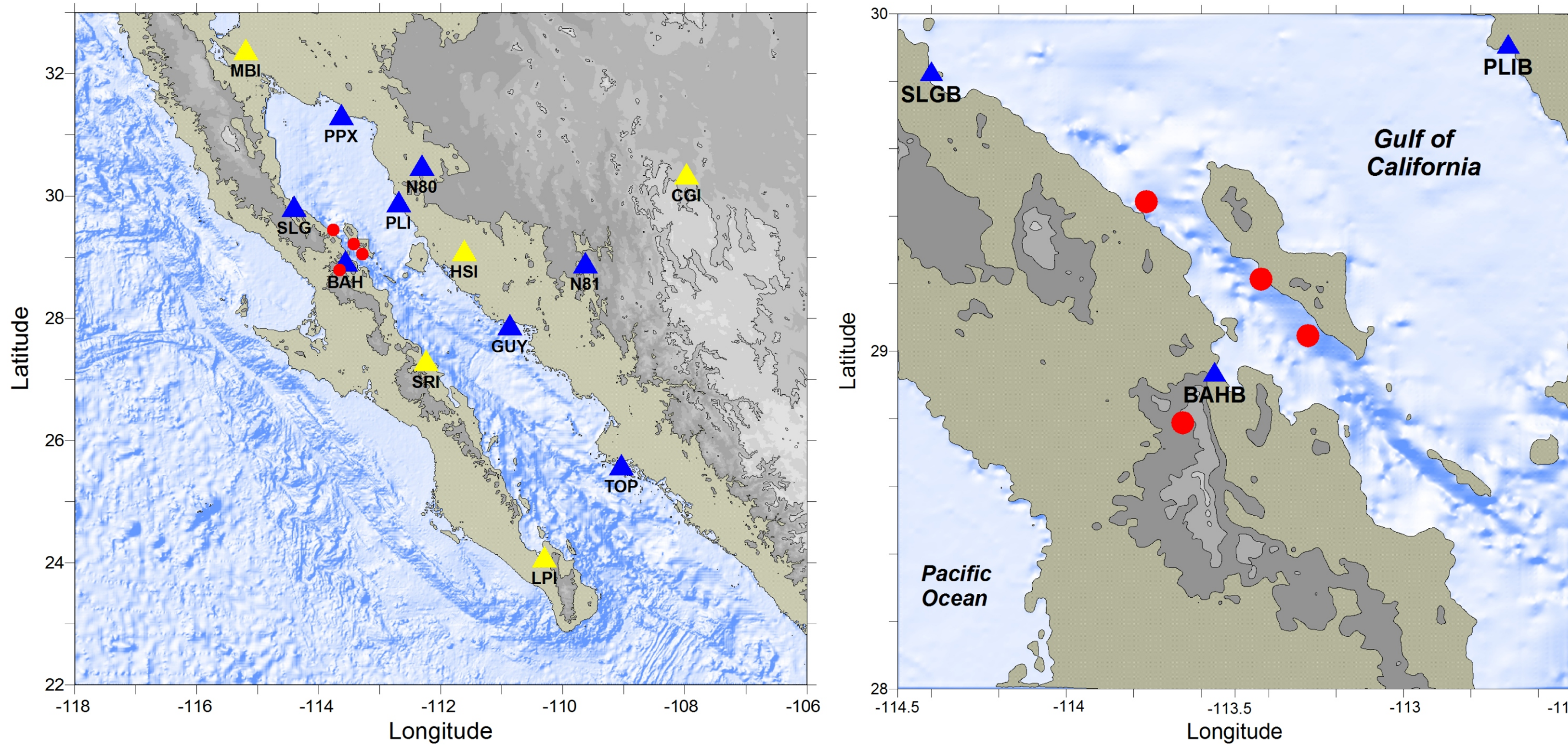


Figure 4) Distribution of the broadband stations that recorded the 2009 seismic sequence (map on left). Blue triangles are stations of the RESBAN array, operated by CICESE and the yellow triangles the stations of the National Seismological Service, operated by UNAM. The map on the right shows the preliminary epicentral locations of the main events that occurred on 3 August 2009.

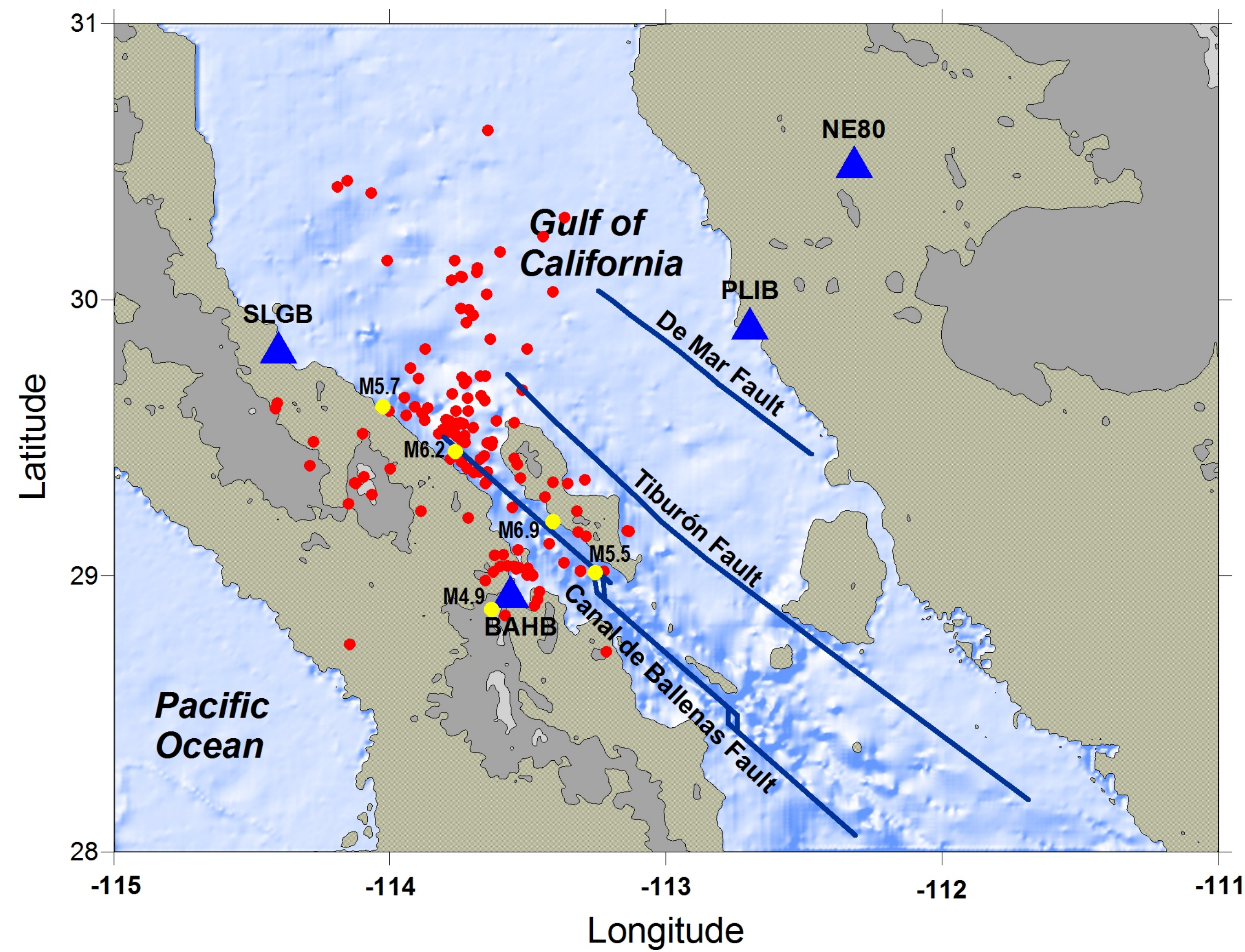


Figure 6) Distribution of epicenters relocated using the shrinking box Source-Specific Station Term (SSST) method of Lin and Shearer (2005). Yellow dots are the main events, red dots the aftershocks and blue triangles the recording stations.

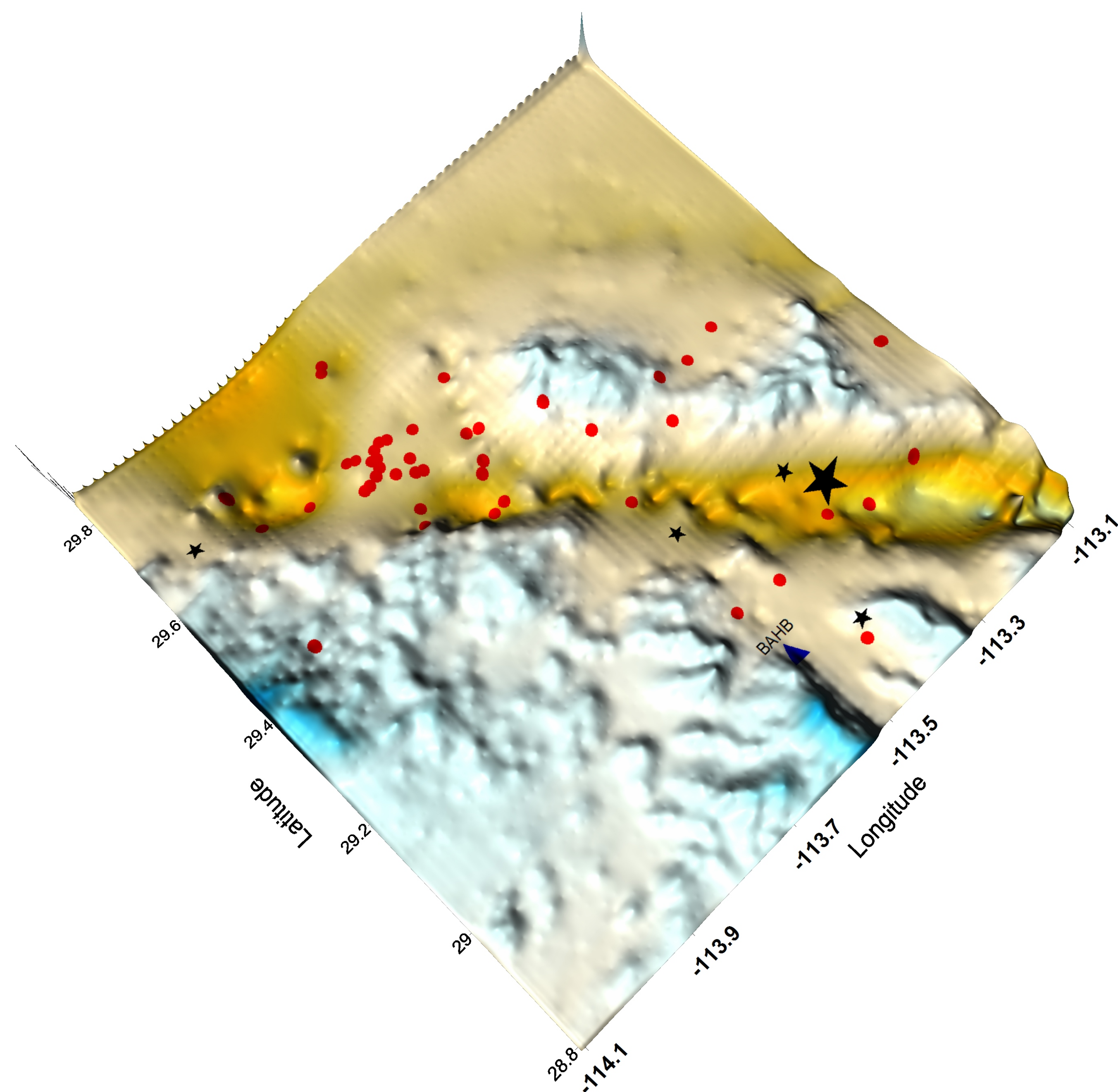
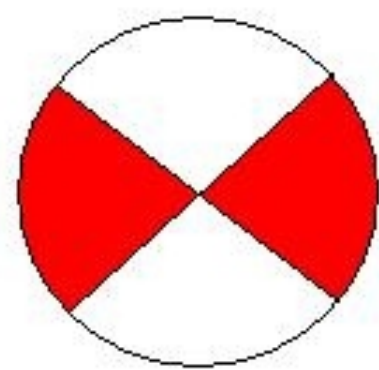


Figure 8) Topography (blue), bathymetry and the distribution of the aftershocks (red dots).

CMT 2009 / 08 / 03 18:00

Mw=6.9, Ms=7.0, Mo=2.49e+26

Strike=312, dip=87, slip= -174 (Right - lateral)



Ms =6.5
A=500 km²
L=50km, W=10 km
Stress drop= 4 bars

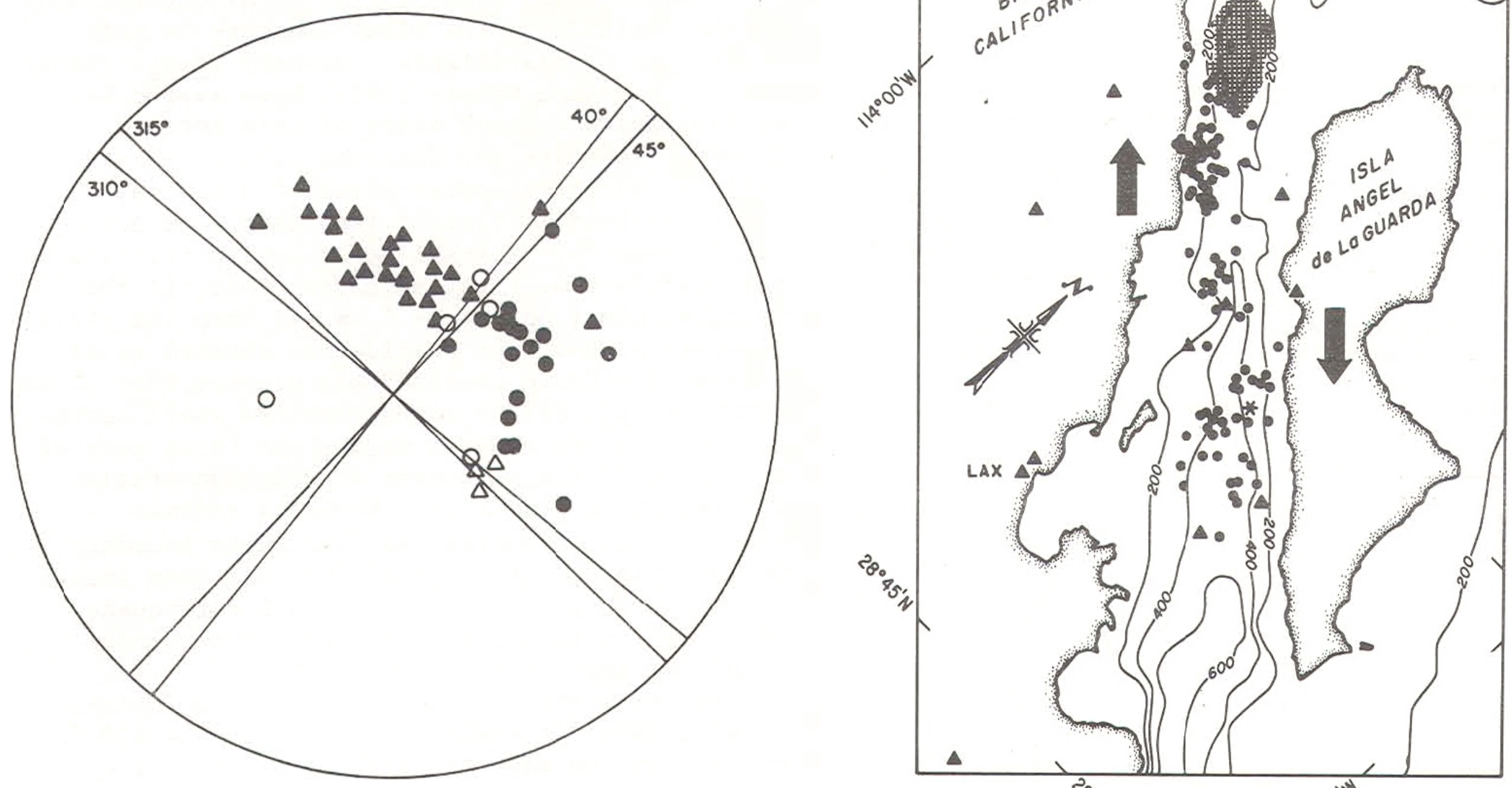


Figure 3) Location of the 1975 Canal de Ballenas (Ms 6.5) earthquake. The asterisk is the epicenter of the main event and the triangles are the portable recording stations used by Munguia et al. (1977) to locate the aftershocks. The map and the focal mechanism were taken from Munguia, L., M. Reichle, A. Reyes, R. Simons and J. Brune (1977), Aftershocks of the 8 of July, 1975 Canal de Ballenas, Gulf of California, earthquake, Geoph. Res. Lett., 4, 507-509.

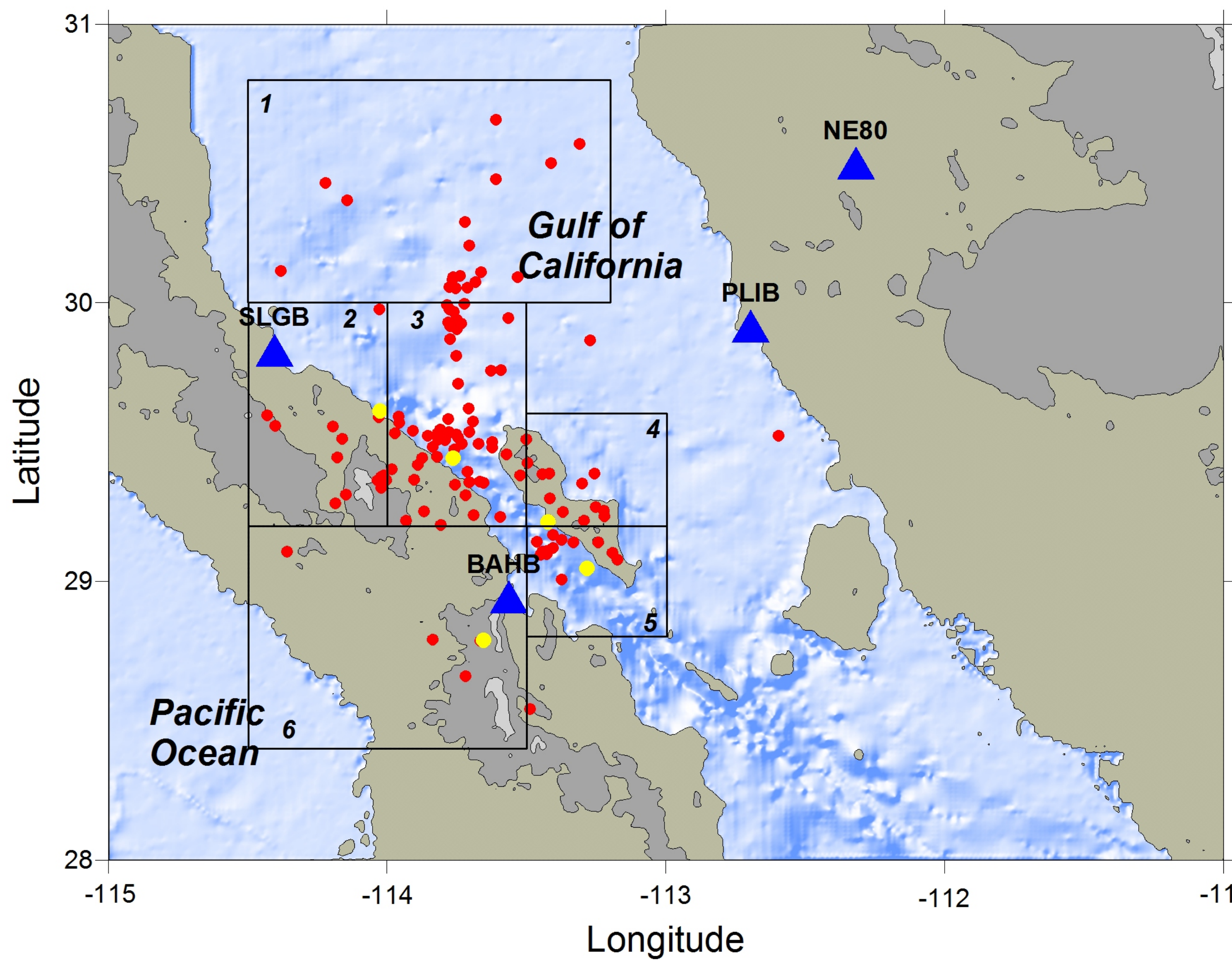


Figure 5) Preliminary locations obtained using the regional body-wave arrivals and Hypoinverse. For relocation purposes we divided the region in 6 boxes. Yellow dots are the main events that occurred on 3 August 2009.

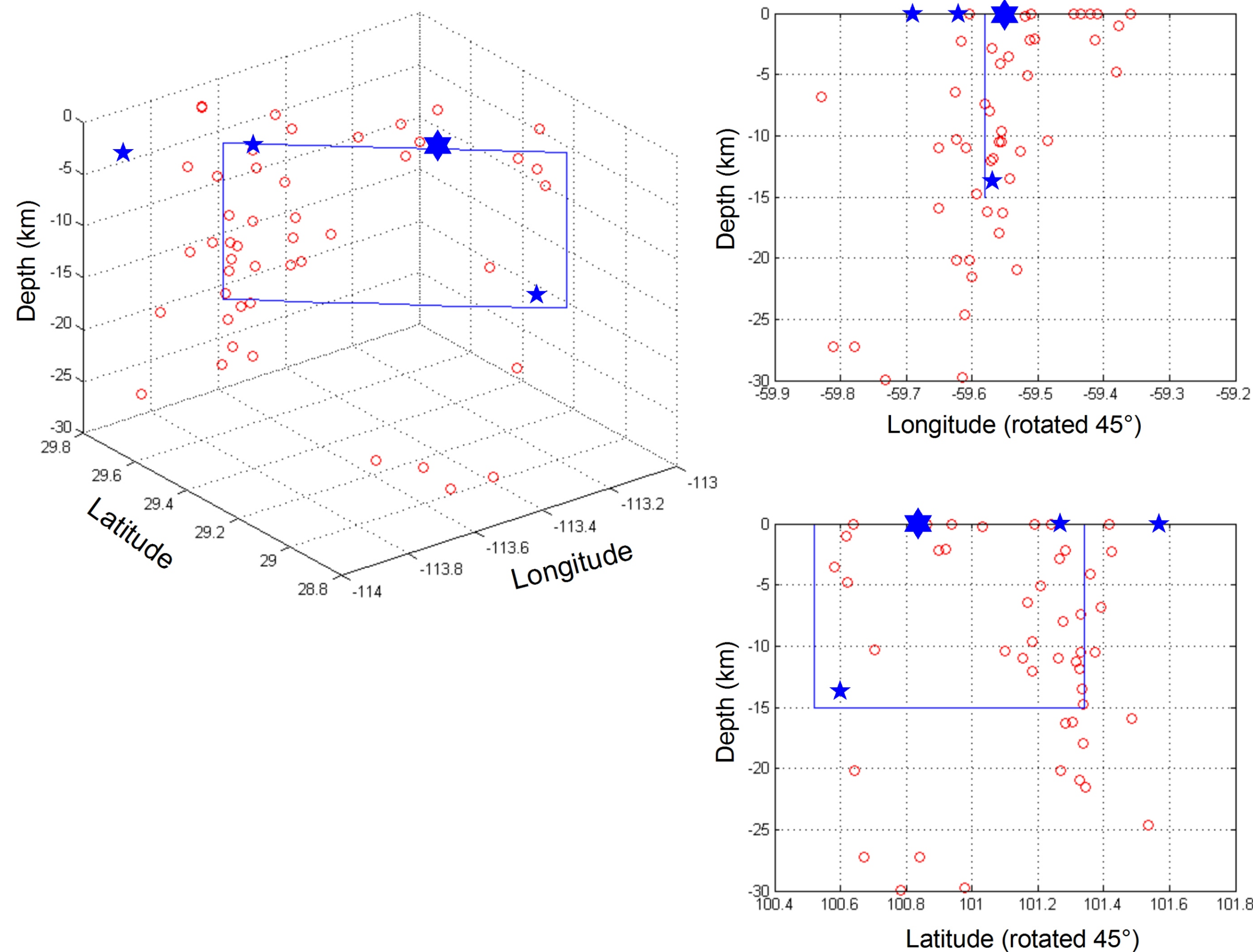


Figure 7) Distribution of the best located focal depths of the aftershocks inside boxes 3, 4 and 5 (see Figure 5). The blue lines represent the Canal de Ballenas fault plane in a 3D plot (left) and cross sections (plots on the right side). On top is a cross-section perpendicular to the fault plane and on the bottom a cross section in the direction of the fault plane. The blue stars are the main events of the sequence.

SUMMARY

The main event of 3 August 2009 (Mw 6.9) occurred in the Canal de Ballenas, along the boundary between the Pacific and the North America plates.

The rupture started south of the Canal de Ballenas fault with an mb 5.5 foreshock and finished in the northwestern end of the fault with an Mw 5.7 aftershock.

The spatial distribution of the aftershocks indicates a rupture length of 100 km. We assumed a fault width of 14 km, based on the focal depth of the foreshock. Then, we estimated an average slip of 52 cm and a stress drop of 8 bars.

ACKNOWLEDMENTS

The operation of the RESBAN array (Red Sismológica de Banda Ancha) has been possible thanks to the financial support of the Mexican National Council for Science and Technology (CONACYT) by means of the project 48852. Part of the analysis of this paper was made while one of the authors (RRC) was a UC MEXUS-CONACYT Visiting Scholar at the University of California, San Diego, IGPP-SIO. We also thank Luis Inzunza for the technical support provided.