Seismic Imaging of the southern Rivera Plate and Jalisco Block Subduction Zone

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Poster no.: T31F-2922

Session: Subduction Top to Bottom (ST2B-2) II Posters

Date: 14 December 2016

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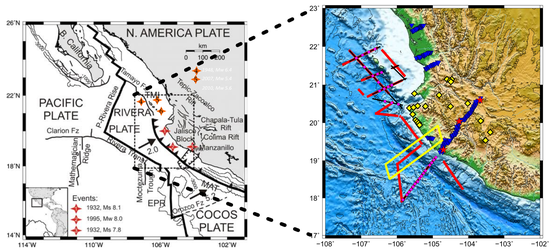
Abstract

The importance of structural aspects and high seismic activity risk of the Jalisco Block makes the Pacific Coast of Mexico in one of the most attractive region for geophysical investigations. Furthermore, tectonic studies in this interesting geological region of the Rivera-North American contact zone, carried out during last two years by TSUJAL Project, are currently providing numerous geophysical results.

In this study, we present the most relevant results in the southeastern part of the Rivera Plate-Jalisco Block area crossing the Mesoamerican Trench from to the east of Rivera Fracture Zone to La Huerta region (Jalisco state). Along this profile, we have combined wide-angle, multichannel seismic, multibeam bathymetry and seismicity data. The marine seismic sources used in this profile aboard RRS James Cook consisted of 12 guns divided in 4 subarrays of 3 guns each, with a total capacity of 5800 in^3, shooting every 50 m and providing 1773 shots in a line of 89 km long. These sources were initially designed to recover multichannel seismic data, but 7 seismic portable stations were deployed perpendicular to the coast to register those sources providing a wide-angle offshore-onshore seismic transect of 130 km length with NE-SW orientation.

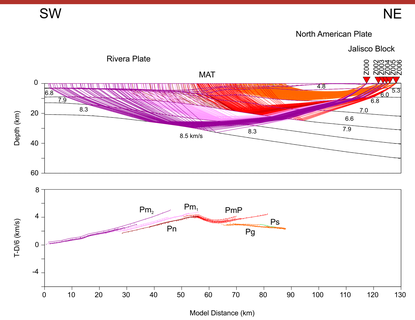
The MCS data were also acquired aboard the RRS James Cook using a 5.85 km long digital streamer deployed at 10 m depth with 468 active channels. The WAS and MCS data processing and interpretation joined bathymetry afford new information about the geometry of southern Rivera Plate subducting under Jalisco Block with a dip angle of 14°, seismic images of the continental accretionary wedge and, also, the deep and shallow crustal structure along this profile up to maximum depth of 35 km.

Tectonic Frame

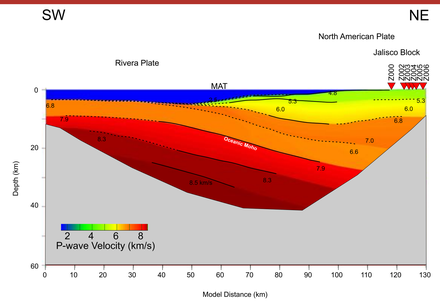


In the western Mexico, the Jalisco, Nayarit and Colima coasts are ones of the most active regions of North America. Our study is located in southern Rivera Plate, where two of the most important earthquakes have occurred. Figure 1 a represents the map with the major tectonic features: Rivera and Cocos plates subducting beneath the North American plate and transform faults zones associated with spreading. Figure 1 b is the active stage map of TsuJal Project (2014) with yellow rectangle that depicts our study area.

Wide-angle Seismic Modeling

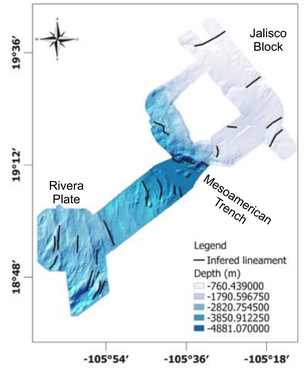


During this study, we have used forward and inverse modeling (Zelt and Smith, 1992) to obtain a 2D P-wave velocity model. In this figure, we represent the ray tracing for all seismic stations used (Z000, Z002, Z003, Z004, Z005, Z006) where we have interpreted refracted and reflected seismic phases in the crust and upper mantle. This model reproduces a normalized chi-square of 1.6 with an RMS of 68 ms.



P-wave velocity model of the TsuJal seismic profile Ts04 across southern Rivera Plate and Jalisco Block subduction zone. This velocity model is defined in term of seismic layers separated by discontinuities at specific depths. The values of velocities and depths have been manually adjusted in forward modeling and by root mean square inversion.

Bathymetry

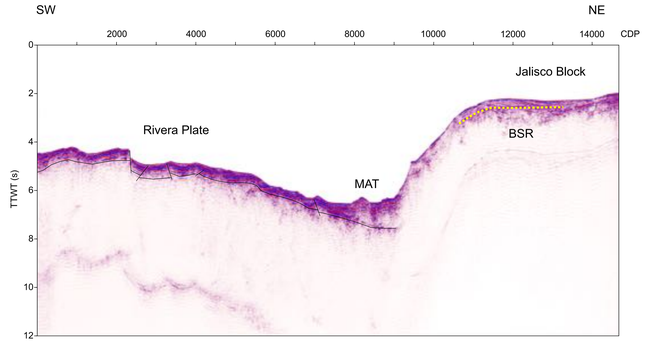


Bathymetry map in the surrounding area of TS04 profile.

In this figure, we can observe the structures of the oceanic crust with no sediments up to the Mesoamerican Trench, where depth is deeper than 4500 m.

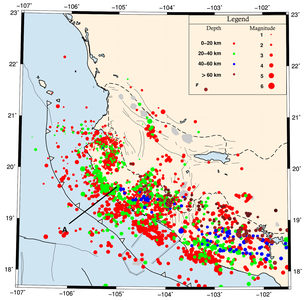
Moreover, two landslide areas characterized by circular shape, and also two sliding remains over Mesoamerican Trench are found in this area.

Multichannel Seismic Reflection

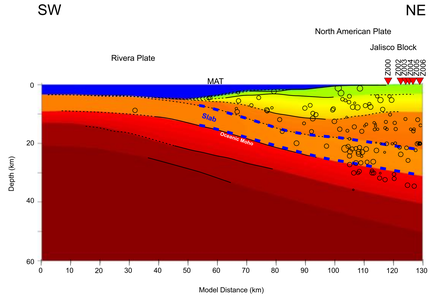


Time migration section of Ts04 Multichannel Seismic profile with most important structures interpreted. In the SW, the normal and inverse faults are due to the bending of the Rivera Plate during the subduction process. The sedimentary filling of the trench is about 1.2 s TTWT. The NE part is characterized by the presence of BSR and basin.

Seismicity



2002-2013 seismicity map registered by RESAJ and between 2006-2008 by MARS networks. The seismicity has been manually relocated with HYPO 71. To compare with the WAS results, we have traced a line of 130 km and same tendency that our WAS velocity model with 20 km width.



The comparison between seismicity and WAS data shows consistency with the structures proposed. Moreover, we can observe that seismicity data adjusts to those structures of the WAS model where we do not have data indicating the slab is subducting with a dip angle between 12-14° according Núñez-Cornú et al. (2002).

Conclusions

- This study characterizes the crustal structure in the southern region of Rivera Plate along an offshore-onshore seismic profile of 130 km perpendicular to the Mesoamerican Trench combining seismic and bathymetric data.
- The oceanic crust of Rivera Plate is 7 to 22 km thick with a dip angle of 12°-14°.
- The seismicity along Ts04 seismic profile shows correlation with the structures determined by WAS modeling.
- The preliminar study of MCS profile shows an inverse and normal fault sequence in the SW, the slope in the subduction zone and a sedimentary basin and BSR to the NE.

ACKNOWLEDGEMENTS: This Research is funded by : CONACYT – FOMIXJAL 2008 –96567 (2009); CONACYT – FOMIXJAL 2008 –96539 (2009); CONACYT – FOMIXJAL 2010 –149245 (2011); CONACyT-FOMIXJal (2012-08-189963) [MEXICO]; CGL (2011-29474-C02-01) DGI Plan Nacional I+D+i [España]. NOC Cruise Jc098, RRS James Cook UK; COIP/COPO/UNAM J-GAP2013 Cruise (BO El Puma); Secretaria de Marina (Mexico) ARM Holzinger; Secretaria de Defensa Nacional (Mexico); Unidad de Tecnologia Marina (Spain); Unidad Municipal de Proteccion Civil y Bomberos (Puerto Vallarta, Mexico); Unidad Estatal de Proteccion Civil y Bomberos (Nayarit State, Mexico); Unidad Municipal de Proteccion Civil y Bomberos (Jalisco State, Mexico); Reserva de la Biosfera (Islas Marias) CONANP-SEMARNAT; Organo Desconcentrado de Prevencion y Readaptacion Social de la SEGOP; Secretaria de Relaciones Exteriores (Mexico).