

Sesión Especial

**Geodynamics of the Mexican  
Subduction Zone: constraints  
from seismology, geochemistry  
and plate reconstructions**

Organizadores:  
Vlad Manea  
Marina Manea

SE05-1

### SEISMIC IMAGING OF THE RIVERA SLAB AND THE JALISCO BLOCK

Grand Stephen<sup>1</sup>, Yang Ting<sup>2</sup>, Sudharja Sandy<sup>1</sup>,  
Guzmán Marco<sup>3</sup>, Gómez González Juan Martín<sup>3</sup>,  
Domínguez Reyes Tonatiuh<sup>4</sup> y Ni James<sup>5</sup>

<sup>1</sup>*Jackson School of Geosciences, The University of Texas at Austin, USA*

<sup>2</sup>*State key Lab. of Marine Geology, School of Ocean & Earth Sciences, Tongji University, China*

<sup>3</sup>*Centro de Geociencias, UNAM*

<sup>4</sup>*Observatorio Vulcanológico, Universidad de Colima*

<sup>5</sup>*Physics Department, New Mexico State University, USA*

steveg@maestro.geo.utexas.edu

The subduction zone of western Mexico is a unique region on Earth where microplate capture and overriding plate disruption are occurring today. The young, small Rivera plate and the adjacent Cocos plate are subducting beneath the Jalisco block of Mexico. Here we present results obtained from the MARS (MApping the Rivera Subduction zone) seismic array that consisted of 50 broadband seismometers deployed in Jalisco, Colima, and Michoacan states from January, 2006 through June, 2007. Teleseismic tomography results show that below a depth of 150 km there exists a clear gap between the Rivera and Cocos slabs that increases in width with depth. The gap between the plates lies beneath the northern part of the Colima Graben and may be responsible for the location of Colima volcano. The images indicate that the deep Rivera plate is subducting more steeply than the adjacent Cocos plate and also has a more northerly trajectory. At a depth of about 100 km both the Rivera and Cocos slabs have increased dips such that the slabs are deeper than 200 km beneath the Trans-Mexican Volcanic Belt (TMVB). It is also found that the Rivera plate is at roughly 140 km depth beneath the young central Jalisco Volcanic lineament. Our images suggest that the Rivera plate and western most Cocos plate have recently rolled back towards the trench and that the Jalisco Volcanic lineament is arc related. This scenario may explain the unusual magmatic activity seen in the TMVB.

SE05-2

### 3D GEODYNAMIC MODELING AND GEOLOGIC EVIDENCES OF CENOZOIC SLAB DETACHMENT BENEATH WESTERN NORTH AMERICA

Ferrari Luca, Manea Vlad Constantin y Manea Marina

*Centro de Geociencias, UNAM*

luca@geociencias.unam.mx

Geologic history and plate reconstructions indicate that subduction of an oceanic plate may cease when a spreading ridges arrives close to the trench because of the positive buoyancy of oceanic crust younger than 5 Ma. In some cases seismic tomography show gaps in high velocity bodies suggesting that the slab broke off before subduction ended. This is because the deeper part of the slab continues to sink in the mantle while the upper part sticks with the upper plate. To date this process has been investigated only by two dimensional models. These models are not able to reproduce the lateral propagations of the detachment, thought to have occurred at several places worldwide and recently confirmed in central Mexico by the MASE and MARS

experiments. Here we present results of 3D numerical simulations of the evolution of the western North America subduction system since 40 Ma, tailored to the evolution of the Farallon slab after the interaction of the East Pacific Rise (EPR) with North America. Subduction of the Farallon plate mostly ceased when the EPR arrived close to the trench, leaving a series of small microplates with ~1 to 3 Ma old oceanic crust off the west coast of Baja California. A gap in the slab must have formed to allow the formation of the Gulf of California rift. Our model show the evolution of this process time and space, which can be related to geologic events in the upper plate.

The model show that the slab broke off some m.y. after the initial interaction between the EPR and the trench (~20 Ma) at the latitude of California and that the tear propagated laterally toward the SSE into Mexico. Propagation to the north was prevented by the E-W trending Mendocino fracture zone (MFZ). The slab to the north of the MFZ, which is over 25 m.y. older, is much stronger than to the south, so the rupture rather propagates almost orthogonal to the MFZ paralleling the active trench. Lateral propagation of detachment appears to be a self-sustained process which may be accompanied by second order phenomena like localized delamination of continental lithosphere. The detachment produces a large, trench-parallel, slab window through which the asthenosphere is welling up to the base of the upper plate. Several magmatic and tectonic episodes of southwestern North America may be related to the propagation of the leading edge of the slab free area shown by our model. In the southwestern United States and Sonora it may be associated to the large magnitude extension responsible for the formation of the metamorphic core complexes in Early Miocene. Toward the south, where subduction was still active, it likely produced the ~24-19 Ma ignimbrite flare up of the southern Sierra Madre Occidental (Ferrari et al., 2002). In central Mexico the propagation of the detachment has been linked to a short (2-3 m.y.), eastward-migrating pulse of mafic volcanism that took place from ca. 11.5 to ca. 5 Ma to the North of the present Trans-Mexican Volcanic Belt (Ferrari, 2004).

SE05-3

### GEOCHEMISTRY OF THERMAL SPRINGS ALONG THE MEXICAN PACIFIC COAST AND THE VOLATILE TRANSPORT FROM THE SUBDUCTING SLAB AT THE FOREARC ZONE

Taran Yuri<sup>1</sup>, Inguaggiato Salvo<sup>2</sup>, Ramírez Guzmán Alejandro<sup>3</sup>,  
Bernard Romero Rubén<sup>1</sup>, Mazot Agnes<sup>1</sup> y Peiffer Loic<sup>1</sup>

<sup>1</sup>*Instituto de Geofísica, UNAM*

<sup>2</sup>*Istituto Nazionale di Geofisica e Vulcanologia, Palermo, Italia*

<sup>3</sup>*Universidad Autónoma de Guerrero*

taran@geofisica.unam.mx

We report here the chemical and isotopic compositions of gases and waters for 22 groups of hot and warm springs in a 30 km-wide zone along the Mexican Pacific coast from 16°N (~ Salina Cruz) to 21°N (~ Punta Mita). Most of the springs discharge diluted waters with temperatures of 38-45°C, with a N<sub>2</sub>-rich bubbling gas and 3He/4He ratios of 0.16 to 4.5Ra, where Ra is the atmospheric ratio of 1.4x10<sup>-6</sup>. Several springs are characterized by a high CH<sub>4</sub> content (10 vol % to 75 vol%) with a thermogenic CH<sub>4</sub> (-25‰ < #13C < -45‰). Same springs have also positive #15N (up to +5‰ in the Rio Purificacion and El Salitre hot springs). The highest 3He/4He were measured in hot springs within Colima Graben (El Salitre, 2.4Ra) and close to the Puerto Vallarta fault zone (El Tuito, 2.9Ra, Desembocada, 4.5Ra). Elevated 3He/4He ratios

were measured in the springs of the Michoacan coast (1.9-2.3Ra). The lowest  $3\text{He}/4\text{He}$  ratios are characteristic for the Guerrero and Oaxaca coastal springs (0.16-0.3Ra). It follows from our data that the southern part of the studied zone does not demonstrate either a connection with the deep slab-crust interface or a presence of a degassing accretion material. To the north of Guerrero along the coast, the elevated  $3\text{He}/4\text{He}$  may indicate some contribution of He from the mantle wedge through deep faults. The indubitable presence and degassing of the accretion material show three groups of springs north of the border between Michoacan and Colima (between Rivera and Cocos plates) along the coast: El Salitre, Purificacion and Punta Mita. These springs discharge high salinity waters (14 g/l of Cl in El Salitre springs) with  $\delta^{15}\text{N} \sim +5\text{‰}$  and variable amount of  $\text{CH}_4$  and hydrocarbons. Their  $\delta\text{D}$  and  $\delta^{18}\text{O}$  are shifted from meteoric water to seawater values.

This work was supported by a grant from PAPIIT # IN101706.

SE05-4

**SEISMIC REFLECTION IMAGING OF SLOPE INSTABILITIES AND STRIKE-SLIP TECTONISM IN THE OFFSHORE PORTION OF THE SOUTHERN JALISCO SUBDUCTION ZONE: EVIDENCE FOR SEAMOUNT COLLISION, SUBDUCTION EROSION AND FOREARC SLIVERING**

Bandy William L.<sup>1</sup>, Mortera Gutiérrez Carlos A.<sup>1</sup> y Ortega Ramírez José<sup>2</sup>

<sup>1</sup>*Instituto de Geofísica, UNAM*

<sup>2</sup>*Instituto Nacional de Antropología e Historia*

bandy@geofisica.unam.mx

The oblique convergence of the Rivera plate with respect to the North American plate along the Jalisco subduction zone should, in the absence of a buttress, produce a forearc sliver; the sliver moving NW relative to the North American Plate. Recent seismic reflection investigations [e.g., Bandy et al. *Tectonophysics*, v. 398, 2005] have yielded evidence, in the southernmost part of the Jalisco subduction Zone off Manzanillo, for a broad zone (the Bourgeois fault zone) of recent strike slip tectonism within the upper continental slope region. These studies have also evidenced the occurrence of tectonic erosion and associated subsidence. To investigate the NW extent of this strike-slip tectonism and subsidence, 50 high-resolution, seismic reflection, profiles were collected during the MORTIC07 Campaign of the B/O EL PUMA (January-February, 2008), between Manzanillo and the area just north of Chamela. The SIMRAD TOPAS system was employed. Funds for this campaign were graciously provided by CONACyT and UNAM (IGF, DGAPA and CABO) (100% Mexicano). A preliminary analysis of these newly collected data indicates that the strike-slip tectonism noted previously off Manzanillo extends northwestward along the offshore part of the Jalisco Subduction zone to at least the NW limit of the newly surveyed area. Thus, this tectonism is a regional process, consistent with it being the result of the oblique convergence between the Rivera and North American plate as previously proposed. The analysis also suggests that the extensive deformation off Manzanillo may be related to the collision and subduction of seamounts/bathymetric highs and the resulting subduction erosion.

SE05-5

**LIGHT ELEMENT ABUNDANCE AND ISOTOPIC CONSTRAINTS ON SLAB/MANTLE AND CRUSTAL INFLUENCES IN LAVAS OF THE TRANS-MEXICAN VOLCANIC BELT**

Ryan Jeffrey<sup>1</sup>, Savov Ivan<sup>2</sup>, Shirey Steven<sup>3</sup> y Grose Christopher<sup>1</sup>

<sup>1</sup>*Department of Geology, University of South Florida*

<sup>2</sup>*School of Earth and Environment, Leeds University*

<sup>3</sup>*Department of Terrestrial Magnetism, CIW*

ryan@shell.cas.usf.edu

While boron and lithium are enriched in the sediments and altered ocean crustal rocks reaching trenches, their abundance and isotopic signatures in continental arcs can reflect diverse source and process effects. In the Trans-Mexican volcanic belt (TMVB), regular variation in the age and subduction velocity of the downgoing plate allow us to address changes in Li and B signatures related to slab-mantle exchanges. As well relatively hot slab conditions in the western TMVB may serve to minimize H<sub>2</sub>O-mediated slab inputs, permitting the study of mantle and crustal contributions to the Li and B signatures of erupted lavas.

B contents and B/Be ratios are low (<10 ppm; B/Be < 10) in mafic TMVB lavas, while evolved lavas reach values # 50 ppm, indicating B-rich crustal inputs (i.e., Hochstaedter et al, 1996). Mean B/Be appears to increase from west to east across the arc, reaching values of 20 or higher in lavas from Pico de Orizaba. Elevated Be contents and Be/Zr ratios are observed in some western TMVB centers (Mascota, Volcan San Juan) and may indicate the presence of enriched horizons in the western TMVB mantle.

#11B in western TMVB lavas are surprisingly high, with values up to +10.6 ‰ in some Colima Graben minettes, but much lower values in calc-alkaline Colima lavas. This heavy #11B signature may reflect relict slab B remobilized during extension in the western arc. Evolved lavas have markedly lower #11B (-1.6 to -9.9‰), indicating that high B crustal rocks can have very low #11B signatures, so crustal assimilation can result in lowered #11B. All TMVB lavas thus far examined seem to reflect mixing between high #11B alkaline lava (old slab?) and low #11B crustal end-members.

In contrast, Li and #7Li appear insensitive to present or past slab influences in the TMVB. Li contents are similar in mafic lavas from across the arc, and while Li/Yb ratios are elevated in western TMVB centers, this appears to reflect Yb depletions due to residual amphibole ± garnet during melting. #7Li in the western TMVB, at +3 to +5‰, is similar to arcs globally (i.e., Tomascak et al 2002) as well as to MORBs and OIBs. As western TMVB lavas show global #7Li values, it is likely that active convection and replenishment of mantle wedge sources continues, despite slowing convergence. Evolved TMVB lavas move to somewhat lower #7Li, reaching values similar to those measured in entrained crustal xenoliths, and approaching average crustal #7Li at 0‰ (Teng et al 2005).

SE05-6

**2D NUMERICAL MODELS OF RIDGE-TRENCH COLLISION: IMPLICATIONS FOR SLAB DETACHMENT BENEATH BAJA CALIFORNIA**

Burkett Erin y Billen Magali  
*University of California, Davis*  
 burkett@geology.ucdavis.edu

The approach of a buoyant spreading ridge to a subduction zone is a scenario that may lead to detachment of a subducted slab. Previous work has called upon the detachment process as a possible explanation for observed ridge abandonment and slab-window related magmatism in Baja CA/western Mexico, but such a scenario has not previously been tested using fully-dynamic numerical models. We use two-dimensional fully-dynamic models of ridge approach to a subduction zone to explore the dependence of detachment and resultant surface effects on subducted slab length, ridge-trench distance, spreading rate, and lithospheric yield strength. We find that our models, which include non-Newtonian rheology, demonstrate the following dynamics of ridge approach: (a) a decrease in subduction velocity as the ridge approaches the trench, (b) a shrinking surface plate that maintains a uniform subduction velocity, (c) rapid slab detachment at depths ranging from 55-95 km depth depending on the slab age (7-12 My) and (d) ridge abandonment distances of 125-225 km from the trench, and slab gap distances of 200-270 km from the trench. Slab gap distance is used as a proxy for the distance to a possible slab-window related magmatism. These results are consistent with observations in Baja CA, where detachment of the Cocos slab may explain abandonment of observed segments of the East Pacific Rise 50-200 km outboard of the trench and the presence of a non-arc magmatic pulse 100-250 km inboard of the trench, with geochemical signatures separate from that associated with the normal subduction history for the Farallon plate.

SE05-7

**SUBDUCTING SLAB TIME-SPACE VARIATION AND ITS RELATIONSHIP WITH VOLCANISM IN SOUTHERN MEXICO**

Manea Vlad Constantin y Manea Marina  
*Centro de Geociencias, UNAM*  
 vlad@geociencias.unam.mx

One of the key parameters for understanding the position through time of a subducting slab is the spatial variation through time of volcanic arcs. Using the distribution of dated rocks for Central and Southern México (Chiapas), we propose the evolution of the subducting slab as following: between 25 and 17 Ma ago, the volcanic arc formed an approximately continuous belt in Central México, Chiapas and Guatemala. Then, between 17 and 12 Ma ago, the Central Mexican Volcanic Belt (CMVB) moved inland, suggesting that the subducting slab become subhorizontal. To the south, the rest of the volcanic arc remained parallel with MAT, probable due to a steep slab. Later, between 12 and 7 Ma, the flattening process of the Cocos slab continued further SE, while the Central America Volcanic Arc (CAVA) retreated SE. Between 7 and 3 Ma ago, the CAVA continued to retreat SE and the volcanic activity close to the Chiapas coast ceased completely. The Tuxtla Volcanic Front (TVF) was born during this time period. The last episode of this scenario took place between 3 and 0

Ma, and is represented by the onset of the Modern Chiapanecan Volcanic Arc (MCVA).

Since the slab dip, age, and convergence rate of the Cocos slab beneath the CAVA in Guatemala are similar to those beneath Chiapas, why are the two active volcanic arcs so different? To answer this question we perform a 4D geodynamic model using the UNAM supercomputer KanBalam. Modeling results show that the onset of the flat-slab northwest of the TR, in Central México, would have produced a strong mantle-wedge inflow in the neighboring region to the SE. This intake would have migrated over time, creating the non-trench parallel MCVA. The isotopic ages of the MCVA decrease from NW to SE, suggesting that the arc was propagating through time from NW to SE.

SE05-8 CARTEL

**PETROLOGIC EVOLUTION THE EASTERN TRANS-MEXICAN VOLCANIC BELT: EVIDENCE FOR A ROLLBACK-INDUCED DELAMINATION OF MANTLE LITHOSPHERE?**

Orozco Esquivel Teresa y Ferrari Luca  
*Centro de Geociencias, UNAM*  
 torozco@geociencias.unam.mx

The Late Miocene to Quaternary petrologic evolution of a wide region located to the north of the active front of the eastern Trans-Mexican Volcanic Belt (TMVB) has been reconstructed using a large collection of samples. These samples are well located into a geochronologically controlled stratigraphy based on about 60 high precision ages obtained in the past few years. The region run from the Pachuca-Tulancingo area (Hidalgo state) in the south to the Huejutla- Sierra de Tantima area (northern Veracruz state), and is centered along the trace of the Middle America Subduction Experiment (MASE). In this region volcanic activity shows a progressive trenchward migration at an apparent rate of ~20 km/m.y., which is interpreted to reflect the rollback of the subducting plate after the detachment of the lower part of the slab at ~7.5 Ma. The first and northernmost volcanic episode consists of alkaline, OIB-like basalts with ages between ~7.5 and ~4 Ma. The oldest lavas, emplaced at greater distance from trench, show geochemical evidence that indicates an origin in the lithospheric mantle; this signature weakens with time while crustal contribution is increasingly identifiable. Toward the end of this episode, at ~4.4 Ma, a massive regional rhyolitic ignimbrite and large peraluminous rhyolite dome erupted. These rocks represent the product of fractional crystallization of magmas similar to those emplaced in the previous episode with some degree of crustal assimilation. This episode is followed by a mid Pliocene (~3.8-2.4 Ma) succession of mafic to intermediate, mainly shoshonitic, lavas intercalated in a fluvio-lacustrine succession (Atotonilco Fm.). Lavas appear slightly modified by subduction components and are locally covered by late Pliocene (2.14 Ma), riebeckite-bearing peralkaline rhyolite lavas and Quaternary intraplate basalts (1.6-1.3 Ma). The isotopic and elemental composition of the mid Pliocene to Quaternary lavas indicate that crustal assimilation/melting played an important role in their genesis, whereas contribution of subducted components was negligible.

The late Miocene mafic volcanism is related to the detachment of the lower part of the subducting slab, now confirmed by seismic tomography along the MASE transect. Trenchward migration of volcanism and geodynamic modeling indicate that, after detachment, the subducting plate started to increase its dip because of the loss of slab pull. This caused convection of asthenosphere into the mantle wedge that thermally weakened

the mantle lithosphere and eventually delaminate it, as presently observed in the MASE results. We speculate that by the end of Pliocene the mantle lithosphere was already almost completely removed and the convective mantle arrived in contact to the base of the crust, being able to produce crustal melting and/or high assimilation.

SE05-9 CARTEL

### **LA ZONA DE WADATI-BENIOFF EN JALISCO, COLIMA Y MICHOACÁN. RESULTADOS DEL PROYECTO MARS**

Guzmán Marco

*Centro de Geociencias, UNAM*

marco@dragon.geociencias.unam.mx

Para el proyecto MARS (MApping the Rivera Subduction), llevado a cabo de enero de 2006 a junio de 2007, se instalaron 47 sismógrafos de banda ancha en Jalisco, Colima y Michoacán. Resultados previos de tomografía sísmica muestran una placa Rivera en subducción hasta los 400 km de profundidad.

La localización de 3906 sismos nos ha permitido definir la zona de Wadati-Benioff, tanto para la placa Rivera como para la porción de la placa de Cocos subducida bajo Michoacán. En las secciones sísmicas correspondientes a la placa Rivera, se delinea claramente un segmento subducido que aumenta gradualmente de profundidad al alejarse de la trinchera mesoamericana. La placa de Rivera subducida toma entonces una forma contorsionada.

La sismicidad delinea bien la separación entre las placas de Cocos y Rivera en subducción. Es clara la existencia de una discontinuidad a profundidades entre 30 y 90 km.

SE05-10 CARTEL

### **ANOMALIAS MAGNETICAS EN LA PLACA DE RIVERA, AL NORTE DE LA INTERSECCION ENTRE LA TRINCHERA MAT Y LA DORSAL EPR, FRENTE A COLIMA**

Peláez Gaviria Juan Ramón<sup>1</sup>, Mortera Gutiérrez Carlos A.<sup>2</sup>, Bandy William L.<sup>2</sup> y Michaud François<sup>3</sup>

<sup>1</sup>*Posgrado en Ciencias de la Tierra, UNAM*

<sup>2</sup>*Instituto de Geofísica, UNAM*

<sup>3</sup>*UMR Géosciences Azur, UPMC*

jpelaezg@geofisica.unam.mx

El límite entre las placas de Rivera, Cocos, Pacífico y Norte América, ha estado influenciado por la evolución del segmento Pacífico-Cocos (PCS), de la dorsal "East Pacific Rise" (EPR). Varios estudios difieren en la evolución reciente de este segmento en relación al límite sur de la Placa Rivera. Esta discusión se ha mantenido vigente debido a la poca resolución espacial de las anomalías magnéticas y de la batimetría multihaz en la región, sumado a la alta complejidad del relieve oceánico y sus anomalías magnéticas. Para entender la compleja tectónica del área, se llevo a cabo un minucioso mapeo de las anomalías magnéticas en dos campañas oceanográficas (MARTIC-04 y MARTIC-05) con el B/O EL PUMA en 2004 y 2006; en las cuales se obtuvieron datos magnéticos de alta resolución espacial complementados con la batimetría multihaz del relieve del piso oceánico. Los datos magnéticos son corregidos por los efectos de las variaciones diurnas del campo geomagnético y por el rumbo del buque, y

reducidos a valores de la anomalía magnética de la corteza oceánica. La revisión del nuevo mapa de anomalías magnéticas en relación con la nueva compilación de batimetría multihaz aporta una nueva explicación para la evolución del segmento EPR-PCS desde los 3 Ma, como un propagador que avanzó y retrocedió en interacción con la Transformada de Rivera, afectando el límite entre las placas Rivera y Cocos frente a la zona de subducción de Jalisco y Colima.

