Sesión Especial

GEODYNAMICS OF THE TRANS-MEXICAN VOLCANIC BELT AND THE MEXICO SUBDUCTION ZONE: INSIGHTS FROM GEOLOGY, GEOCHEMISTRY, GEOPHYSICS AND MODELING/GEODINÁMICA DE LA FAJA VOLCÁNICA TRANS-MEXICANA Y DE LA ZONA DE SUBDUCCIÓN MESOAMERICANA: INTEGRANDO GEOLOGÍA, GEOQUÍMICA, GEOFÍSICA Y MODELADO

Organizador:
Luca Ferrari

SE17-1

A GEODYNAMICAL PERSPECTIVE ON THE SUBDUCTION OF COCOS AND RIVERA PLATES BENEATH MEXICO AND CENTRAL AMERICA

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The Middle America subduction zone (MASZ) involves the subduction of the Rivera and Cocos young oceanic plates beneath the North American and Caribbean plates and is bounded by the Gulf of California rift and the Panama slab window. This unique subduction system has been often studied separately in its northern (Mexican) and southern (Central America) parts. Here we illustrate the main geodynamic processes controlling the whole subduction system based on integration of regional geology, volcanism, tectonics, and recent seismic experiments to show the connection between deep geodynamic processes and their manifestation on the surface.

The MASZ is characterized by a contorted slab surface with both trench-parallel and trench-orthogonal tears, irregularly distributed seismicity and volcanism, exceptionally large slow slip events (SSE) and non-volcanic tremors (NVT). The most striking feature of the MASZ is perhaps the shallow flat slab subduction in central Mexico, which is flanked by steep subduction of the Rivera plate and of the Cocos plate beneath Central America. The explanation for this geometry is likely related to a combination of subduction parameters such as convergence rates, trench dynamics and plate age. The onset of flat slab in central Mexico dates back to the middle Miocene and was caused primarily by the superposition of two causes: the acceleration of EPR spreading at rates above 15 cm/yr and the trench rollback plus the advancing of a thicker overriding plate. At present, the trench perpendicular migration velocity along the northern MASZ varies from ~1 cm/yr offshore western Mexico to ~0.4 cm/yr in southern Mexico, while in the southern MASZ the trench rolls forward at nearly ~-2 cm/yr. This contrasting behavior resulted in the formation of a diffuse NOAM-CAR-COCOS triple junction that is producing extension in the Caribbean plate and shortening in the North American plate. Since the end of Miocene this triple junction has propagated to the northwest into the strike slip faults and fold belt of the Sierra de Chiapas, with small blocks of the North American margin dragged into the trail of the eastward escaping Chortis block. A late Miocene to early Pliocene episode of slab detachment decoupled the upper part of the subducting plate form the older slab and allowed the partition of the subducting plates into segments with different dip. This has been forming trench orthogonal tears between the Rivera and Cocos plate and, perhaps, in the western Cocos plate. Toroidal mantle flow is expected, and partly observed, around these tears as well as at the northwestern termination of the Rivera slab and at the southwestern end of the Cocos plate in the Panama slab window. This trench parallel asthenospheric flow combines with the poloidal flow associated to the changing slab dip and with the basal topography of the overriding plate, creating a complex 3D flow. Changes in 3D asthenosphere flow with variation in viscosity, temperature and thickness coupled with the heterogeneities of the crust in the overriding plate may explain the unusual distribution and contrasting chemical variation of volcanism observed along the MASZ.

SE17-2

PLATE KINEMATICS OF THE CENTRAL MEXICAN PACIFIC MARGIN: UPDATE AND REVIEW

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The last several years have seen a significant increase in the amount and types of studies whose results have a direct bearing on the kinematics of the Rivera plate and the crustal blocks comprising western Mexico. These include marine geophysical surveys along the margins of the Rivera plate, onshore GPS studies and earthquake studies of the mantle and subducting Rivera plate beneath the Jalisco block of western Mexico. These results indicate that the kinematics of this area have been quite dynamic.

In this talk we will summarize these new studies and their bearing on the kinematics and dynamics of the central Mexican Pacific margin and will reiterate the old idea that ridge-trench collisions are the principle dynamic process producing the plate motion changes and structural deformation along the Pacific margin of central Mexico. Specifically, will review how such collisions can explain the plate motion changes, plate fragmentation and plate boundary conversions observed in this area. Lastly, we thank the moderator of this special session of the UGM, Luca Ferrari, for inviting us give a presentation summarizing these varied data sets and their implications to the plate kinematics of this region.

SE17-3

AN ANALOG MODEL OF THE MIDDLE AMERICAN SUBDUCTION ZONE AND THE MANTLE FLOW BENEATH THE JALISCO AND MICHOACAN BLOCKS

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We built a laboratory model of the present-day Northern Middle American subduction zone to understand the mantle flow patterns beneath the Jalisco and Michoacan blocks. The scaled model consists of two polyethylene strips with different angles and velocities, which are forced into a glucose syrup tank. One of the strips dips 60$^\\circ$ and moves at a velocity of 20 mm/min simulating the Rivera plate. The other one dips 45$^\\circ$, moves at 60 mm/min and represents the Cocos plate. One cm in the model represents 15 km in the natural scale whereas one minute represents one million years. The syrup contains spherical beads of pasta to track the different flow paths within the simulated mantle. The modelling sheds light on how the plate motions and their slab geometries control the mantle flow patterns in the Northern Middle American subduction zone. The model shows the following: (1) Pasta beads at shallow depths in the modelled mantle wedge move toward the fast moving strip representing the Cocos plate. (2) The pasta beads situated close to the strips are carried down to the lower part of the tank. (3) Pasta beads situated in the simulated astenospheric mantle, near the gap between the strips, first show a downgoing movement as they move through the gap, then they change direction and ascend into the modelled mantle wedge. These results reveal complex patterns of toroidal and corner flows. Model results are in agreement with seismic anisotropy studies conducted in the Jalisco and Michoacan blocks.

SE17-4

FORMACIÓN DE ESTRATOVOLCANES ANDESÍTICOS POR FUSIÓN DE DIAPIROS DESPRENDIDOS DE LA PLACA SUBDUCIDA

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La porción occidental de la Faja Volcánica Transmexicana (FVTM) está gobernada por la subducción pronunciada de la placa Rivera, y por la existencia de un rift continental a 230 km de la trinchera bajo el cual la placa subducida descansa a más de 300 km de profundidad. Las rocas ígneas máficas del frente volcánico son lamprófidos ricos en potasio que han sido influenciados por fundidos profundos y calientes (>950 °C) provenientes de la placa subducida. En cambio el vulcanismo máfico de la parte trasera del arco está constituido por rocas basálticas ricas en titanio que se derivan de bajos grados de fusión parcial de un manto prácticamente anhidro. Las rocas máficas de la región parecen mostrar entonces que los efectos de la subducción se concentran en el frente volcánico y se diluyen hacia el tras-arco. Este esquema tan simple, sin embargo, se complica, porque al menos cinco estratovolcanoes andesíticos con características típicas de arco se han emplazado en la zona del tras-arco durante los últimos 200 mil años (San Juan, Sangangüey, Tepetiltic, Ceboruco y Tequila). Todos estos volcanes producen secuencias monótonas de rocas andesíticas calci-alcalinas ricas en agua (>6 wt%), altos Mg# (~60) y patrones de elementos traza que sugieren la influencia de fundidos de baja temperatura (<800 °C), en donde el anfíbol juega un papel muy importante. Sin embargo resulta difícil modelar la composición de estas andesitas a través de cristalización de basaltos, o por fusión directa de anfibolitas corticales, debido a que contienen Mg# muy elevados y grandes cantidades de agua disuelta. Invocar la fusión de la placa subducida en facies de anfibolita parece también complicado, pues la placa Rivera debajo del tras-arco descansa a una profundidad que excede por mucho el campo de estabilidad del anfíbol. Nuestros datos sugieren en cambio que los estratovolcanoes andesíticos se forman mediante la fusión de diapiros constituidos por una mezcla mecánica de manto serpentinizado, sedimentos y fragmentos de corteza continental erosionada, que logran desprenderse de la placa subducida por efectos de flotación diferencial. Una vez dentro del manto, estos diapiros se funden por conducción térmica y ascienden rápidamente al verse atrapados dentro del régimen descompresivo y extensional que gobierna el occidente de México.

SE17-5

PETROGENESIS AND GEODYNAMIC SIGNIFICANCE OF SILICIC VOLCANISM IN THE WESTERN TRANS-MEXICAN VOLCANIC BELT: THE ROLE OF GABBROIC CUMULATES

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The abundant silicic volcanism of the western Trans-Mexican Volcanic Belt has been suggested to be the manifestation of the rifting of the Jalisco block from mainland Mexico since the Pliocene. We revise this interpretation and propose a new petrogenetic model integrating new and published geochronologic, geochemical, and isotope data. We recognise three episodes of silicic volcanism. The oldest one (silicic domes and minor pyroclastic flows) has a volume of ~370 km3 and Ar-Ar and obsidian FT ages of ~7.5 to 5 Ma, and was emplaced north of Guadalajara above a thick succession of ~11 to 8.7 Ma basaltic lavas. This was followed between 4.9 and 2.9 Ma by large amount of rhyolitic lavas and ash flow tuffs (~500 km3) emplaced between Guadalajara and Compostela. The third episode is made of rhyolitic domes and flows (~430 km3) of Pleistocene age emplaced between Tequila and Guadalajara, with La Primavera caldera (~35 km3) as the sole explosive volcanic episode.

Rhyolites have high LILE/HFSE values and negative spikes at Nb, P and Ti. They also show the same Ba/Nb and K/Rb values and slightly higher Rb/Sr ratios as the 11-9 Ma basalts. Rhyolite Sr isotope values (87Sr/86Sri = 0.70371 – 070598) are only slightly more radiogenic than the 11-8 basalts (87Sr/86Sri = 0.70349-0.70410), whereas Nd isotope ratios are indistinguishable. Sr and Nd isotope ratios of the rhyolites are also similar to those of lower crust nearby, indicating that they can be compatible either with assimilation and fractional crystallization (AFC) of basalts or with partial melting of the lower crust.

The similarity in #Nd isotope compositions between basalt and rhyolites strongly argues for a “mantle-origin” of the rhyolites. Nevertheless, a problem posed by any basalt-origin model lies in the large (2:1) volume of intermediate cumulates that should be associated to the final silicic magmas. We propose an alternative model in which the production of the ~7.5-3 Ma silicic magmatism is the result of partial melting of crustal gabbroic complexes underplated at the base of the crust during the Late Miocene pulse of volcanism, that became part of the crust because of the density contrast. Subsequent basalt intrusion in the lower crust heated and melted these gabbroic complexes forming silicic magmas, which subsequently underwent AFC differentiation processes. Geochemical and isotope data of rhyolites can be successfully modelled by low degree of melting of the Late Miocene gabbroic complexes leaving a residue dominated by plagioclase and clinopyroxene. This melt is subsequently modified via AFC processes en-route to the surface. Late Miocene slab detachment and subsequent slab rollback produced pulses of mafic magma that decrease in volume with time, forming gabbroic cumulates. Melting of this newly formed gabbroic crust originate the first episode of silicic magma during a period of low tectonic activity. Extensional faulting since the Pliocene favours the eruption of both silicic magma and lesser amount of mafic lavas. Rifting at the boundaries of the Jalisco block is seen as a rollback induced reactivation of crustal structures but is unlike to evolve into a Jalisco microplate.

SE17-6

THREE-DIMENSIONAL STRUCTURE OF THE SUBDUCTION SYSTEM IN CENTRAL AND SOUTHERN MEXICO

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The subduction system in central and southern Mexico exhibits a wide range of along-strike behaviors that are not easily explained by known variations in the Cocos Plate or the overriding continent. Tomography and converted-phase studies show the central part of the region is characterized by flat subduction with a very weak and thin decoupling zone between the continent and slab. There is a large portion of the forearc that is missing and the (very) active arc itself is some 300 km from the trench. This contrasts with southern Mexico where the slab dips at 30-degrees dip and the arc is absent. There is seismic evidence of an opposing-dip slab that may have recently truncated the Cocos slab. Hydration levels estimated from Vs/Vp and Vs measurements indicate an increase in hydration towards the central (flat slab) portion of the subduction zone.

SE17-7

ISOTOPIC SIGNATURES OF TRANS MEXICAN VOLCANIC BELT STRATOCONES: EVIDENCE FOR HETEROGENEOUS BASEMENT COMPONENTS

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The Trans Mexican Volcanic Belt (TMVB) is formed by more than 1000 monogenetic cindercones and 15, partially active stratovolcanoes. In this contribution, we focus on Sr-Nd-Pb isotopic data of Volcán de Colima, Nevado de Toluca, Popocatépetl, La Malinche and Pico de Orizaba. Magma compositions are generally calc-alkaline andesitic with minor dacitic and basaltic-andesitic compositions. Except to some Pico de Orizaba samples, all five stratocones display elevated La/SmN ratios, significant for low degrees of partial melting. Crystal fractionation (Colima and La Malinche) and AFC processes (Orizaba and some Popocatépetl samples) are the more important magmatic processes, accompanied by magma mingling in the case of Popocatépetl.

Sr-Nd-Pb isotopic signatures for the five volcanoes are heterogeneous. From W to E increasing radiogenic ratios were observed. 87Sr/86Sr and epsilon Nd values are 0.7035-0.7036 and +6.9 to +4.7, 0.7037-0.7042 and +6.7 to +3.8, 0.7040-0.7045 and +6.2 to +2.5, 0.7046-0.7048 and +2.0 to + 0.8, 0.7037-0.7048 and +1.4 to -1.8 for Colima, Toluca, Popocatépetl, La Malinche and Pico de Orizaba volcanoes, respectively.

Colima volcano to the east is magmatically by far the most primitive TMVB volcano whereas Pico de Orizaba to the west shows the most evolved isotopic signatures. In the case of Colima, a plagiogranitic basement was identified although the Sr-Nd isotopic ratios between both magmas are very similar. However, clear differences are displayed when looking at their O isotopic ratios. In the case of Pico de Orizaba, Pb isotopes discard a Grenvillian Oaxaquia crustal component but favor, instead, a Paleozoic Acatlán-type basement. La Malinche, Popocatépetl, and Nevado de Toluca volcanoes show interactions with shallow crustal materials such as Cretaceous limestones, but its lower crustal basement is more heterogeneous with a mixture of Oaxaquia, Acatlán, and other unknown components.

SE17-8

SEISMIC STRUCTURE IN CENTRAL MEXICO: IMPLICATIONS FOR FRAGMENTATION OF THE SUBDUCTED COCOS PLATE

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The fine-scale seismic structure of the central Mexico subduction zone is studied using moderate-sized (M4-6) intraslab earthquakes. Regional waveforms from the Mapping the Rivera Subduction Zone (MARS), Meso America Subduction Experiment (MASE), Veracruz-Oaxaca (VEOX), and Servicio Sismológico Nacional (SSN) seismic arrays are complicated and contain detailed information about the subduction zone structure, including evidence of lateral heterogeneity. This waveform information is used to model the structure of the subducted plates, particularly along the transitions from flat to normal subduction located to the west and east of the MASE array. In the west, recent tectonic studies have shown evidence for possible slab tearing along the eastern projection of the Orozco Fracture Zone (OFZ), while in the east, observations of a sudden change in slab dip coupled with the abrupt end of the Trans Mexican Volcanic Belt suggest a second possible slab tear. The lateral extent of a thin ultra-slow velocity layer (USL) imaged atop the Cocos slab in recent studies along the MASE array is examined here using MARS waveforms to the west and MASE, VEOX, and SSN waveforms to the east. In the west, we find an edge to this USL which is coincident with the western boundary of the projected OFZ region. Forward modeling of the 2D structure of the subducted Rivera and Cocos plates using a finite-difference algorithm provides constraints on the velocity and geometry of each slab\'s seismic structure in this region and confirms the location of the USL edge. Coupled with the results of recent plate motion studies showing that the Cocos plate moves differently on either side of the OFZ, we propose that the Cocos slab is currently fragmenting into a North Cocos plate and a South Cocos plate along the projection of the OFZ. This tearing event may be a young analogy to the 10 Ma Rivera-Cocos plate boundary, and may be related to the slab rollback process in central Mexico. In the east, we observe changes in waveform complexity across the sharp transition in slab dip, which may indicate a possible tear in the South Cocos plate. We perform 1D and 2D waveform modeling in order to image the structure of the slab and overriding plate in this region.

SE17-9

SILICIC VOLCANISM IN THE CENTRAL-EASTERN TRANS-MEXICAN VOLCANIC BELT: ROLE OF SLAB ROLLBACK AND CRUSTAL MELTING

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In the central-eastern Trans-Mexican Volcanic Belt (TMVB), volumetrically significant silicic volcanism (SiO2>65 wt. %) was emplaced since ~7.3 Ma in a wide region located behind the present volcanic front. Silicic volcanism is mainly associated to calderas that show a trenchward migration with time. Bimodal basaltic–silicic suites are also recognized in the whole region and have been previously interpreted as a result of rifting processes, however, the absence of important extensional faulting casts doubt on this interpretation.

On the basis of geochronological and geochemical data, we reconstructed the Late Miocene to Quaternary evolution of a wide region in the northeastern part of the TMVB between Pachuca (Hidalgo State) in the south and the Sierra de Tantima (Veracruz State) in the north. Mafic volcanism first appeared at ~7.6 in the northernmost part of the region with OIB-like basalts showing geochemical evidence for an origin in the lithospheric mantle. This signature weakens with time while crustal assimilation and magma mixing processes become significant in the early Pliocene and diminish afterwards.

First evidence of silicic volcanism are remnants of peraluminous rhyolitic tuffs, dated at 6.61 Ma, which have the most isotopically enriched composition (87Sr/86Sr= 0.71167, Epsilon Nd= -2.89). The next silicic event is marked by the emplacement of extensive peraluminous ignimbrites and rhyolitic domes associated to the Carboneros caldera. These rocks were dated at ~4.4 Ma and have 87Sr/86Sr = 0.70626-0.70723 and Epsilon Nd= -0.78 to -1.72. The last event corresponds to the emplacement of early Pleistocene (2.14 Ma) peralkaline rhyolite lavas with 87Sr/86Sr = 0.70437 and Epsilon Nd= 1.26. The trend to less radiogenic compositions with time indicates a change in magma source from the late Miocene to the Quaternary, with a decreasing role of crustal sources and an increasing contribution of mantle sources.

The concurrent inception of silicic volcanism with the beginning of the trenchward migration of the arc points to a causal link between the two phenomena. Trenchward migration of the volcanic front is interpreted to reflect the rollback of the subducting plate after the detachment of the lower part of the slab at ~7.5 Ma, which occurred after a prolonged episode of flat subduction. In this scenario, silicic volcanism may have originated by partial melting of the lower crust, hydrated by infiltration of slab-derived fluids during flat subduction, which was progressive exposed to asthenospheric mantle as the slab retreated. Lower crustal heating and melting would be a transient process in a given area, and it propagated toward the present volcanic front as rollback advanced.

SE17-10

GUERRERO, MEXICO ASEISMIC SLOW SLIP EVENTS AND DECOUPLED FOREARC SLIVER MOTION ALONG THE CHACALAPA FAULT

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Large, equivalent magnitude Mw~7.5, aseismic slow slip events (SSE) occur every 3-4 years in the Guerrero segment of the subduction zone of Mexico. Each trenchward transient slip of 10-20 cm on the plate interface produce more than 6 cm total surface displacement during 10-12 months of slip duration. As a result the SSEs significantly perturb the long-term interseismic deformation tendency. Continuous GPS position time series measured during the last 15 years in Guerrero provide a sufficiently long observation period to reliably estimate secular components of the interseismic displacement velocities, Vis, in the forearc area. Oblique convergence of the Cocos plate across the Middle America trench (MAT) in Guerrero should produce a consistent, inland decreasing trench-parallel component (Vtp) of Vis in the a case that the North America plate were rigid. Nonetheless, GPS data show that trench-parallel component, Vtp, abruptly drops by 4-5 mm across the Chacalapa fault (CF), which separates the Xolapa allochthonous terrane from the main forearc inland. If the Xolapa terrane is a forearc sliver (XS) then according to McCaffrey's [1992] model, the trench-parallel sinistral motion of the XS should be approximately 4-5 mm/yr along the CF, and the slip vectors of subduction thrust earthquakes orient at 4-5 deg clockwise to the trench-normal vector (Tn). Analysis of slip directions obtained from the catalog of focal mechanisms [Pacheco and Singh, 2010] for such seismic events shows that the mean weighted slip direction with respect to Tn is about of 3 deg, which is smaller but close to the modeled estimate. Apparently the trench-parallel transition of the XS along the strike-slip Chacalapa fault accommodates oblique component of the convergence between the Cocos-NA plates. Seismologic records of strike-slip crustal earthquakes on the CF should provide additional evidence for the XS existence. Surprisingly the seismic activity at the fault area is extremely low, and there are no significant seismic events close to the fault with M > 4 in the catalog of the Servicio Sismologico Nacional (SSN). Large historical earthquakes on the CF are also unknown. GPS stations distribution across the CF is not sufficiently dense to determine a degree of coupling of the fault. Based only on the current data and observations, the Xolapa sliver is probably seismically decoupled from the main forearc area and accommodates most of the oblique component of the convergence velocity.

SE17-11

SLAB GEOMETRY UNDER OAXACA AND ITS RELATIONSHIP WITH THE EASTERN TRANS-MEXICAN VOLCANIC BELT

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Subduction of the Cocos Plate beneath North America has a variable and complex behavior that is imprinted on the Trans-Mexican Volcanic Belt (TMVB) geometry and geochemistry. The eastern edge of the TMVB is characterized by the interruption of arc volcanism and a NS alignment of stratovolcanoes. It has been assumed that the slab goes from a flat subduction under central Mexico to a constant ~26° subduction under the Isthmus of Tehuantepec in a smooth transition. A first glimpse of the slab geometry under Oaxaca, from a sparse station distribution, shows the slab continues to be flat at least until Tehuacán, Puebla, where the slab suddenly changes to a ~55° dip to the northeast. This occurs at a distance of ~75 km from the Pico de Orizaba volcano, which is a similar distance as the active Popocatepetl volcano from the place where the slab dives into the mantle along the Meso-American Subduction Experiment line. East of this region, receiver function images show an abrupt change in the geometry of the slab, suggesting of the presence of a possible tear. We further identify the interaction of the slab with the 410 discontinuity, which verifies the shallower geometry.

SE17-12

HE ISOTOPES AND GEODYNAMICS OF THE MEXICAN PACIFIC MARGIN

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Two oceanic plates are subducting beneath the continental North America Plate along the Mexican Pacific coast: Cocos Plate south of Colima graben (~19°N) and a young Rivera Plate to the north of Colima graben. The trench is situated ~ 60 km from the shore line which is close compared to other continental margins. Chemical and isotopic composition of helium, carbon and nitrogen in deep geothermal wells, bubbling and dissolved gases were determined for volcanic fumaroles, high-temperature drilled and non-drilled geothermal fields of the Trans-Mexican Volcanic Belt (TMVB), and more than 40 groups of thermal springs between 16°N and 21°N, in a ~30 km-wide zone along the Pacific coast and in a large forearc zone between the coast and TMVB. Several cross-sections of the 3He/4He values from the coastal line to TMVB mark the main tectonic and geological features of the Mexican subduction zone. Highest 3He/4He were measured in hot fluids from Los Humeros and Los Azufres fields and in cold springs of Acoculco caldera. The observed 3He/4He ratios in the coastal springs were 0.16Ra to 4.5Ra (where Ra=1.4x10-6, the air ratio) indicating that some springs discharge gas with a high contribution of mantle helium while the others contain helium of the crustal origin. High 3He/4He ratios were measured in springs located close to Colima graben, the apparent surface border between Rivera and Cocos plates and also within the Puerto-Vallarta (Rio Ameca) graben at the northernmost part of the coastal forearc zone. The permeability of these areas to the mantle He is interpreted as a margin effect at the northern part of the subduction zone and as a "slab window" in the vicinity and to the south of Colima graben; a discontinuity between subducting plates.

The geographic distribution of 3He/4He ratios were used for the first-order estimation of distribution of the heat flow within the coastal area. We suggest that for the thermal modeling of the forearc heat flow, the heterogeneity of the heat sources (slab margins and slab discontinuities) should be taken into account. The 3He/4He distribution can help to constrain the geometry of zones permeable for the mantle heat and volatiles.

SE17-13 CARTEL

PORCIONES DE MANTO HIDRATADO POR TRANSFERENCIA DE FLUIDOS O FUNDIDOS DERIVADOS DE DIAPIROS PROVENIENTES DE LA PLACA: RIFT TEPIC-ZACOALCO, OCCIDENTE DE LA FAJA VOLCÁNICA TRANSMEXICANA

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Las evidencias geoquímicas de la variedad magmática del occidente de la Faja Volcánica Transmexicana (FVTM) muestran composiciones contrastantes gobernadas por las condiciones térmicas, contenidos de agua y elementos reciclados asociados a la naturaleza de los fluidos o fundidos derivados de la subducción. Con la finalidad de comprender la influencia de estos parámetros en la génesis de las series magmáticas del occidente de la FVTM, hemos empleado el uso del termómetro de H2O/Ce a datos de contenidos de agua estimadas por el higrometro de plagioclasa-líquido utilizando las composiciones de plagioclasas publicadas. Los rangos obtenidos en temperatura varían de 806 a 1208 ºC y los rangos en contenido de agua de 7.5 a 0.5% en peso. Los resultados indican que las temperturas estimadas en los estratovolcanes San Juan, Ceboruco y Tequila ubicados en el rift Tepic-Zacoalco, cuya localización por encima de la placa en subducción es aproximadamente de 300 km, se encuentran por debajo de los 870 ºC. Estas temperaturas son inconsistentes con la estructura térmica en el trasarco (950 ºC e.j. modelos númericos; ~1300 ºC H2O/Ce corregido por presión). Sin embargo, en conjunto con la evidencia petrológica y geoquímica esto parece ser consistente con un ascenso de materiales corticales hidratados desprendidos de la placa en subducción en forma de diapiros, los cuales, son incorporados en la cuña del manto caliente donde gradualmente incrementan su temperatura por difusión hasta inducirse su fusión parcial debido a la baja temperatura de solidus de algunos de sus componentes. Por otra parte, en las estimaciones de los contenidos de agua (1.3-3.5% en peso) y temperaturas (1079-1304 ºC) obtenidas con el higrometro de plagioclasa-líquido y el termómetro de olivino-líquido respectivamente, a partir de las composiciones medidas en cristales de plagioclasas y olivinos realizadas en este estudio por el método de Ablación Láser aclopado a un cuadrúpolo (LA-ICPMS); se observa que los basaltos alcalinos con señales débiles de la subducción reflejan en sus características químicas una influencia de fluidos o fundidos derivados de las porciones hidratadas inyectadas por los diapiros en la cuña del manto. Así mismo, los basaltos alcalinos sin señal de la subducción, con bajos contenidos de agua (1.3% en peso) y altas temperaturas (1304 ºC), soportan la idea de la formación de porciones de manto hidratado por mecanismos de diapiros focalizados que permean la cuña del manto selectivamente y en función probablemente a su cercanía con las placas tectónicas límitantes.

SE17-14 CARTEL

CARACTERIZACIÓN PETROGRÁFICA Y GEOQUÍMICA DEL MAGMATISMO SILÍCICO DE LA CUENCA DE SERDÁN-ORIENTAL

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La actividad ígnea cuaternaria en la Cuenca de Serdán-Oriental (CSO), en el extremo oriental del arco mexicano, ha producido algunas estructuras volcánicas de composición silícica, emplazadas en asociación bimodal con el magmatismo máfico-intermedio dominante. Dichas estructuras están distribuidas en el sector centro-septentrional de la CSO con burdo alineamiento N-S, y están representadas de norte a sur por los domos volcánicos del Cerro Las Águilas, Cerro Pizarro, Cerro Pinto, Las Derrumbadas; y por el Volcán Jalapasquillo, un pequeño cráter de explosión ubicado inmediatamente al sur de Las Derrumbadas.

Los productos de los aparatos silícicos son vitrófidos o micropórfidos riolíticos con características petrográficas similares: todos presentan una matriz afanítica, a menudo con foliación magmática, conformada por microlitos de sanidino y plagioclasa probablemente intercrecidos con cuarzo, y titanomagnetita; en los vitrófidos, el vidrio predomina sobre las otras fases de la matriz. Las rocas presentan índices de porfiricidad #7%, con fenocristales de sanidino, cuarzo, escasa plagioclasa, y dos generaciones de biotita, una de color rojo oscuro y una verde olivo, en placas extremadamente finas; en ocasiones, los fenocristales de sanidino, cuarzo y biotita forman agregados glomeroporfídicos, definidos por grupos de hasta 10 cristales. Las relaciones texturales indican el siguiente orden de cristalización: biotita rojo oscuro; cuarzo-sanidino-biotita verde olivo; matriz.

Las rocas silícicas de la CSO se clasifican como riolitas calcialcalinas de alto K; todas son peraluminosas, como indican los valores de ASI=1.1-1.2, y la presencia de corindón normativo (1.2-2%). Por otra parte, los datos de elementos traza revelan contrastes interesantes entre los diferentes edificios volcánicos. Las rocas del Cerro Pinto exhiben un marcado empobrecimiento en Ba, Sr (6-13 ppm) y Ti, y patrones de REE extremadamente planos (La/Yb=2), con anomalías negativas prominentes de Eu (Eu/Eu*=0.1). Dichas anomalías están prácticamente ausentes, o muy débiles (Sr=89-266 ppm; Eu/Eu*=0.7-0.9), en las riolitas de Las Derrumbadas y del Volcán Jalapasquillo, cuya característica más sobresaliente es el fraccionamiento extremo de REE (La/Yb=72-280; La/Sm=7; Gd/Yb=8-26), acompañado por un empobrecimiento notable de Y (5-7 ppm) y HREE. Los productos del Cerro Las Águilas y Pizarro muestran características geoquímicas similares a los de Las Derrumbadas, como concentraciones relativamente altas de Sr (74-127 ppm), débiles anomalías negativas de Eu (Eu/Eu*=0.8), y patrones fraccionados de LREE (La/Sm=5); sin embargo, en analogía con el Cerro Pinto, presentan patrones planos de HREE (Gd/Yb=2), con concentraciones absolutas de Y y HREE no tan empobrecidas (Y=16-19 ppm).

Si los magmas silícicos derivaran de un proceso de fusión cortical, las variaciones composicionales documentadas entre los domos de la CSO indicarían que la anatexis afectó litologías diferentes, ubicadas en distintos niveles del basamento. Por un lado, las características geoquímicas de Las Derrumbadas y del Volcán Jalapasquillo parecen consistentes con la fusión de una corteza inferior metasedimentaria granulitizada, con abundante granate y menor plagioclasa como fases residuales. Por otra parte, los patrones planos de REE observados en los domos Cerro Pinto, Pizarro, y Las Águilas sugieren una derivación a partir de una fuente relativamente somera, con proporciones variables de feldespato en la paragenesis residual.

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SE17-15 CARTEL

EL MAGMATISMO MÁFICO-INTERMEDIO DE LA CUENCA DE SERDÁN-ORIENTAL

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Se presenta un estudio petrográfico y geoquímico del magmatismo máfico-intermedio de edad cuaternaria emplazado en la Cuenca de Serdán-Oriental (CSO), en el sector oriental del arco mexicano. En esta región, numerosos conos volcánicos, maares y mesetas lávicas están ubicados a >360 km de distancia desde la trinchera, sobre un basamento continental muy grueso bajo el cual la placa oceánica yace a >120 km de profundidad.

Los conos volcánicos y flujos de lava emplazados a lo largo de la CSO presentan texturas porfídicas con fenocristales de olivino ±clinopiroxeno ±plagioclasa. Las rocas colectadas en los cráteres de explosión del sector central de la CSO, así como los flujos de lava y malpaís emplazados hacia el sector meridional (i.e. hacia el frente volcánico), incluyen también asociaciones de fenocristales de olivino, ortopiroxeno y plagioclasa; olivino, dos piroxenos y plagioclasa; dos piroxenos, plagioclasa ±anfíbol; plagioclasa y anfíbol. A pesar de las diferencias en la paragénesis de fenocristales, los productos de la CSO presentan características petrográficas comunes: los fenocristales máficos tienden a formar agregados glomeroporfídicos con o sin plagioclasa; los fenocristales de plagioclasa muestran evidencias de desequilibrio o deformación mecánica; la matriz contiene a menudo agregados de clinopiroxeno; olivino y clinopiroxeno; o plagioclasa, con evidencias de deformación mecánica.

Los datos geoquímicos revelan la existencia de diferentes variedades máficas en el área de estudio, y permiten observar una relación entre la diversidad geoquímica del magmatismo y su distribución geográfica. Los productos emplazados hacia el frente varían en composición desde basalto a andesita calcialcalina, y muestran patrones típicos de magmas de arco (Ba/Nb=61-133, promedio=90; La/Yb=6-14; Gd/Yb=2-3). En la porción meridional de la cuenca se ha emplazado también una suite de alto K, que presenta un mayor enriquecimiento de LILE a contenidos similares de HFSE, y relaciones de REE más altas (Ba/Nb=152-169; La/Yb=24-43; Gd/Yb=4-6). Los productos emplazados hacia los sectores central y septentrional de la CSO presentan una variación composicional análoga desde basalto hasta andesita, aunque por lo general presentan concentraciones mayores de TiO2 y Na2O, y contenidos más altos de HFSE a valores similares de LILE (Ba/Nb=20-125, promedio=53), respecto a las rocas del sector sur.

El patrón de distribución magmática reconocido en la CSO es consistente con diferentes grados de fusión parcial del manto, en relación con contribuciones variables de la placa oceánica. En particular, la disminución de las relaciones Ba/Nb y Zr/Nb en los productos emplazados desde el frente hacia el tras-arco refleja una disminución gradual en el aporte de fluidos al manto, y por lo tanto menores grados de fusión parcial de las peridotitas, conforme la placa de Cocos subduce a mayor profundidad. Por otra parte, la coexistencia de rocas calcialcalinas y de alto K en el frente sugiere el involucramiento de componentes de la subducción distintos: fluidos acuosos enriquecidos en LILE pudieron haber contribuido a la generación de los típicos magmas calcialcalinos; mientras que fundidos parciales de los materiales subducidos podrían explicar el mayor enriquecimiento en elementos incompatibles y el mayor fraccionamiento de REE de las rocas potásicas.

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SE17-16 CARTEL

ESTUDIO DE INTERFEROMETRÍA SÍSMICA EN EL VOLCÁN POPOCATÉPETL. VARIACIONES EN LA VELOCIDAD DEL MEDIO DEBIDO A PROCESO ERUPTIVOS DEL AÑO 2012.

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Presentamos resultados preliminares del análisis de las correlaciones cruzadas de registro continuo (marzo-julio) del movimiento en cuatro estaciones triaxiales de banda ancha (la apertura máxima es de 12 km). El objetivo es explorar si el método de interferometría sísmica provee información sobre el estado de esfuerzos previos a etapas eruptivas. Obtuvimos crosscorrelogramas para cada componente del movimiento (Z,R,T) para cada día por apilar ventanas de tiempo de 40 s. Observamos que existen días consecutivos que no es posible obtener correlación entre pares de estaciones; probablemente causados por problemas instrumentales o variaciones en el tiempo absoluto. Entre las estaciones más cercanas, 4 km en promedio, obtenemos correlaciones consistentes y cuyos correlogramas no aparecen para días de mayor intensidad volcánica. La similitud entre los correlogramas Z y R indican una adecuada extracción de ondas de Rayleigh, mientras que en la componente T tenemos la onda de Love. En distancias más largas el periodo de registro aún no permite extraer las propiedades de dispersión, sin embargo, la pérdida de correlación prevalece para aquellos días de mayor actividad.

SE17-17 CARTEL

DEFORMACIÓN DE LA CORTEZA TERRESTRE OBSERVADA CON ESTACIONES GPS PERMANENTES EN LA DELEGACIÓN IZTACALCO Y PARTE NORTE DE LA DELEGACIÓN IZTAPALAPA

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Durante los últimos 6 años hemos ampliado la red de sitios de observación con GPS de alta precisión, que hemos utilizado para monitorear el hundimiento en la Ciudad de México. Estos nuevos sitios se empezaron a instalar a partir de 2006, dos en la parte norte de la Delegación Iztapalapa y tres en la Delegación Iztacalco. Los nuevos sitios son permanentes y con monitoreo continuo.

Los resultados que hemos obtenido, indican que las velocidades de hundimiento son prácticamente constantes durante los períodos observados, con valores que van de 12 a 15 cm por año en la zona que nos ocupa.

Los desplazamientos horizontales en cambio muestran variaciones locales, así como variaciones con el tiempo, que en general son de unos cuantos milímetros.

Mostramos los probables sitios en donde se instalarán 4 sitios más para seguir ampliando la red de monitoreo en el Valle de México.