THE ROLE OF SUBDUCTION PROCESSES IN THE MORPHOGENESIS OF THE CONTINENTAL SHELF TO SLOPE SYSTEM IN THE PACIFIC MARGIN OF NICARAGUA

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The Pacific convergent margin of Nicaragua is an atypical margin affected by strike-slip displacement in the onshore forearc, producing high variability of tectonic and stratigraphic features. With the aim to reconstruct the deep geodynamic setting and the structural and stratigraphic features of the subduction system, we analysed a network of low-resolution, deep-penetration multichannel seismic-reflection profiles acquired offshore western Nicaragua and oriented perpendicularly to the MAT. We compared the geoseismic sections with geophysical and geological data obtaining quantitative parameters that describe the subduction processes.

We identified three sectors with different tectonic features: a) Cocos oceanic plate, dominated by extensional tectonics, with a high number of "bending-related faults"; b) Caribbean forearc, dominated by a compressional regime, generating thrusts, backthrusts and high-angle reverse faults; c) Nicaragua Depression, subject to NW-SE strike-slip regime, parallel to the MAT.

The main phases of the Nicaragua accretionary complex evolution were interpreted in the frame of the Coulomb Wedge Model (CWM). During the lower-middle Oligocene NE-dipping thrusts and high-angle reverse faults activated in response to the shortening affecting the accretionary complex. In the middle–upper Oligocene underthrusting affected the region from the trench to the Sandino forearc basin, with backstop structures behind the accretionary front, while the backthrusting generated a structural high. The activation of underthrust and backthrust suggests that the system was in disequilibrium condition, that we ascribe to underplating. During the upper Oligocene–Pleistocene the Sandino basin succession underwent an extreme along-strike, trench-parallel variability of stratal pattern and thickness, due to the strong variability of accommodation space. From Pleistocene to Present landslides submarine activated. According to the CWM, we assume that these events triggered as a consequence of over-critical condition.

Our observation were inserted in a 3D model, which evidenced that the WBZ is characterized by an abrupt change of dip and that dip angle increases southward, in agreement with the age variations of the Cocos plate.

One of the most important outcomes, particularly for geological hazards, deals with the genesis of large-scale submarine landslides that we ascribe to the equilibrium condition of CWM. Slab angle is subject to high variability that has occurred both at large scale, with long-dip and along-strike variations, and at small scale, due to processes such as underthrusting, underplating, and the local release of gases.

CHANGING GEOMETRIES AND DIFFERENT EVOLUTION ALONG THE COSTARICA CONVERGENT MARGIN: THE ROLE OF AGE AND STRUCTURES OF THE SUBDUCTING OCEANIC CRUST

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The Middle American Trench (MAT) is one of the most complex subduction margin in the world, due to the interaction between five major lithospheric plates: North America, Caribbean, Cocos, Nazca and South America. The minor Panama microplate lies among them.

We focused on the study of the Costa Rica subduction margin, located in the southernmost part of the MAT, where the Cocos Plate subducts NE-wards under the Caribbean Plate and the Panama microplate, at a rate ranging from 87 mm/y to the North, in front of the Nicoya Peninsula, to 92-95 mm/y to the South, in front of the Osa Peninsula.

Main aim is to provide a reliable model of the Costarican margin, focusing on the role of the geodynamic processes on the geometries and evolution of the margin.

A 3D model of the Wadati-Benioff Plan, realized by using a database of hypocentres in Costa Rica, consisting of 2674 events of M> 4.0 between 1922 and 2017, allowed us to highlight the variation of seismicity in relation to the different domains of the EPR (East Pacific Rise), CNS (Cocos-Nazca Spreading Centre) and Cocos Ridge and to reconstruct the variable geometries of the slab along the Costarican margin. The slab dip variations, as well as the variation in the seismicity depth, correlate with the variations, from NW to SE, of the age of the oceanic crust, and to the characteristics of the EPR, CNS and Cocos Ridge domains. Subduction angle varies from ~60° in front of Nicoya Peninsula, with the subduction of the EPR domain, until ~10° in front of Osa Peninsula, where the Cocos Ridge is subducting.

Also seismicity depths show a sharp variation: under the Nicoya Peninsula seismicity reaches 250 km; in central Costa Rica, where the subduction of the CNS develops, seismicity depth does not exceed 100/120 km; under the Osa Peninsula seismicity is confined within the first 60 km.

This evidence is due to a more buoyant lower plate because to the minor density, due to its higher temperature, of the relatively young Cocos Ridge. The subduction of the Cocos Ridge gives rise to the formation of a slab window under Osa Peninsula, due to a gap of volcanism and seismicity.

ASSESSING EARTHQUAKE HAZARD IN THE CARIBBEAN AND CENTRAL AMERICA (CCARA): PRELIMINARY RESULTS

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Central America and the Caribbean lays within an area of high seismicity associated with a complex tectonic setting, producing large destructive earthquakes, tsunamis, and explosive volcanoes. Seismicity is mainly concentrated along the main active plate boundaries. Several destructive earthquakes (M>7.0) are reported in historical earthquake catalogues and dedicated studies, which caused extensive damage and destruction on settlements, often associated to large numbers of casualties. Recent earthquakes (e.g. Haiti 2010 M=7.0, Costa Rica 1991 M=7.8, Guatemala 1976 M=7.5) demonstrated the actual and urgent need to reduce the impact of large events on nations within this region.

Nowadays, the knowledge on earthquake occurrence and earthquake hazard more in general is quite variable across the region. However, several seismic hazard models exist at both regional and national scale, developed within independent or collaborative projects.

We can outline that most of the currently available hazard models have been derived using dissimilar modelling approaches, contrasting base assumptions and variegated sets of input information.

The primary goal of the hazard component of the CCARA project will be therefore to collect and homogenize the current knowledge into a set of databases and to build a new hazard model, which will constitute a synthesis of the current best scientific knowledge across the region.

In this communication, we intend to describe the process followed for the creation and harmonization of critical earthquake datasets needed in the construction of the hazard model (e.g. earthquake catalogue, seismically active faults, local and national databases of strong motion recordings) and for the creation of the earthquake hazard model itself.

2001 EL SALVADOR EARTHQUAKES, IMPLICATIONS FOR SEISMIC HAZARD ASSESSMENT

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The earthquake sequence occurred in El Salvador between January and February 2001 has been considered one of the most destructive event occurred in El Salvador in the last fifty years. It began with the devastating earthquake of January 13 (Mw7.7), located 40 km from the coast, in the subduction zone of Cocos-Caribbean plates, with a focal depth of 60 km. Exactly after a month, on February 13, another destructive earthquake (Mw 6.6) was located 30 km inland.

From San Salvador, inside the Caribbean plate at a shallower focal depth of about 10 km. The 13 February earthquake was associated to the local fault system aligned with the Central America Volcanic Arc.

The January and February 2001, El Salvador, earthquakes were related the former to subduction along a submarine seismic structure, and the latter to an onshore seismic structure. Both quakes caused severe damage especially due to wide and abrupt landslides phenomena. Thousands of landslides of different type and size were triggered, particularly in the coastal mountain ranges and along the volcanoes in the Great Interior Valley. Liquefaction phenomena and lateral spreading were widely observed along coastal area; fractures were observed alone and/or in conjunction with other geological effects. The landslides were the most extensive and destructive among the secondary effects and caused most of the human deaths, especially after. the 13 January earthquake (Las Colinas landslides killed about 600 persons). The slides severely damaged the main lifelines (roads, aqueducts, power lines, etc.), engineered structures, as well as coffee plantations. The most affected area by the earthquake effects was prevalently located in a sparsely inhabited volcanic environment. Thus, the possibility of applying the common macroseismic intensity scales, based on damages to buildings, as well as the effects on humans and objects, was limited to a few settlements and villages.

The ongoing study presented here describes the geological-geomorphological environments affected by both earthquakes and defines the earthquake intensity by taking into consideration the occurrence, size and areal distribution of earthquake environmental effects. Indeed, this study can significantly improve the evaluation of seismic intensity, which still remains a critical parameter for a realistic seismic hazard assessment, allowing to compare historical and modern earthquakes.

CORRELATIONS BETWEEN LARGE SCALE LANDSLIDES AND SEISMOGENIC FAULT AFTER THE FEBRUARY 13, 2001 EL SALVADOR EARTHQUAKE

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The February 13, 2001, strike-slip earthquake (Mw 6.6) struck the central region of El Salvador (Central America), inside the Caribbean plate overriding the subducting Cocos plate, at a hypocentral depth of 10 km. The earthquake sequence took place inside the Great Interior Valley, crossed along its whole length by the El Salvator dextral-slip fault system. The valley hosts also a chain of Quaternary and active volcanoes that extend across the country from east to west. According to Canora *et al*. (2010), the 13 February earthquake was associated to a 21 km long rupture of the San Vicente fault segment of the El Salvador fault zone. The right-lateral strike-slip surface rupture had a maximum surface displacement of 0.60 m, without any significant vertical component. An earlier destructive earthquake had occurred one month before the February event, on January 13 (Mw 7.7), within the subducting Cocos plate 40 km off the Salvadorian coast. The latter was the largest seismic event occurred in El Salvador in more than 50 years. It caused 900 fatalities and severe damage, mainly due to earthquake-induced landslides. Although the February 13 event was smaller in magnitude than the January earthquake, it caused substantial damage and more than 300 deaths. The most devastating impact of the 2001 earthquakes was the triggering of hundreds of landslides, some of which damaged and destroyed towns, roads and other lifelines, also causing serious damages to the local economy based on coffee plantations and other agricultural productions. Among the landslides generated by the February event, there were some with estimated volume ranging between 800,000 to 12,000,000 m3. These large landslides were markedly distributed in the region of maximum seismic intensity, in a narrow belt along the surface rupture zone. Comprehensive analysis reveals that these large catastrophic landslides could be specifically tied to the main seismotectonic structure of the El Salvador fault zone, i.e., be directly caused by the fault slip. This observation can be quite relevant for future hazard assessment.

APLICACIÓN DE LA TÉCNICA GPS PARA EL ANÁLISIS DE GEODINÁMICA. APLICACIÓN A LA VULCANOLOGÍA: “CASO VOLCÁN DE SAN MIGUEL”

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Los estudios de deformación tectónica en El Salvador, a través de la técnica GPS, dieron inicio formalmente en el año 2004. El apoyo recibido por parte de la Universidad de Wisconsin-Madison, la Universidad Complutense de Madrid y la Universidad Politécnica de Madrid han permitido mejor el conocimiento de la geodinámica del país, a través de los campos de velocidades calculados. En el caso de El Salvador, el uso de esta técnica no sólo se ha restringido al estudio de la deformación tectónica, sino que ha sido también aplicada al monitoreo volcánico, y en particular al caso del volcán de San Miguel. Después del evento eruptivo del 29 de diciembre de 2013, y durante los cuatro primeros meses de 2014, el Ministerio de Medio Ambiente y Recursos Naturales de El Salvador (MARN) y el Instituto Nacional de Geofísica y Vulcanología de Italia (INGV), reforzaron el monitoreo en la zona. Un legado de esta iniciativa fue el establecimiento de una red para la medición de la deformación del terreno, usando la técnica GPS. Sin embargo, el tiempo de observación fue muy corto para establecer la línea base de deformación del volcán, por lo cual se planteó esta investigación para alcanzar este objetivo. La línea de tiempo fue extendida por medio de mediciones adicionales en el área proximal del volcán. Seis de los diez bancos de marca instalados por el MARN-INGV fueron observados de nuevo, utilizando receptores de GPS de doble frecuencia, marca Trimble, colectando datos en forma continua y por campaña durante el 2015. Con el propósito de obtener las coordenadas geocéntricas precisas, en una etapa de post-proceso, se utilizó el Servicio Automático Posicionamiento Preciso (APPS), del Sistema Diferencial Global GPS (GDGPS) del Laboratorio de Propulsión Jet de la NASA (JPL). Finalmente fueron calculados los campos de velocidades y los desplazamientos reducidos para el volcán. Los resultados muestran que el flanco Norte del volcán es la más inestable y propensa a una erupción lateral. Hasta la fecha de elaboración de esta investigación, una deformación permanente de 15 mm es observada después de dos períodos intensos de actividad volcánica, probablemente asociados con procesos de inyección magmática.

SERIE SÍSMICA OCURRIDA DURANTE ABRIL DE 2017, EN SECTOR SUROESTE DEL ÁREA METROPOLITANA DE SAN SALVADOR

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El origen de los sismos en El Salvador obedece a una tectónica de placas compleja. Las fuentes sísmicas que principalmente afectan al país son el proceso de subducción entre la placa de Cocos y la placa del Caribe, con eventos tipificados como interfase e intraplaca; así como el sistema de fallas geológicas locales dentro del territorio que origina eventos corticales de moderada magnitud y foco superficial. Históricamente los sismos de origen cortical en El Salvador han sido los responsables de la mayor cantidad de pérdidas humanas y económicas en el país. San Salvador es la ciudad del continente americano con más afectaciones por este tipo de fenómenos. En los últimos 31 años, el Área Metropolitana de San Salvador (AMSS) ha experimentado, al menos 18 series sísmicas de origen cortical. Los eventos más relevantes en este periodo corresponden a los terremotos del 10 de octubre de 1986, 17 de febrero de 2001 y 11 de abril de 2017, con magnitudes de 5.7, 5.1 y 5.1, respectivamente. Este trabajo se enfoca a caracterizar la última serie sísmica ocurrida en abril de 2017, y que se focalizó sobre el sector suroeste del AMSS. En total se registraron alrededor de 610 sismos, desde el 9 de abril al 2 de mayo, de los cuales 68 fueron reportados como sentidos. La intensidad instrumental del terremoto de magnitud 5.1 fue de V-VI en Antiguo Cuscatlán, el cual fue asociado con un nivel de percepción fuerte y un daño potencial leve. Se estima que aproximadamente el 70% de la energía total de toda la serie fue liberada por este evento. Se presentan los aspectos más relevantes de esta serie sísmica, que comprende desde el análisis espacio temporal de los sismos, hasta el análisis de mecanismo de disparo por incremento en los esfuerzos estáticos de otros planos de fallas aledaños. La causa de esta sismicidad se atribuye al movimiento de fallas geológicas locales, y no con la actividad del volcán de San Salvador, a pesar de su cercanía con el área epicentral. Los análisis preliminares indican que el proceso de ruptura fue múltiple sobre un mismo segmento de falla del sistema circundante.

PELIGROSIDAD VOLCÁNICA ASOCIADA A ERUPCIONES PROVENIENTES DEL CRÁTER CENTRAL DEL VOLCÁN DE SAN SALVADOR, EL SALVADOR

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En El Salvador, el desarrollo tectónico del graben central que contiene la cordillera volcánica activa es complejo y está estrechamente vinculado a la actividad volcánica que tiene su origen en la fusión parcial de la cuña del manto bajo la Placa del Caribe. Evidencias geológicas, estructurales y geomorfológicas analizadas en los últimos años muestran que este sistema de fallas constituye una gran estructura tectónica, la Zona de Fallas de El Salvador (ESFZ), con orientación N94ºE y buzamiento 70ºS, que incluye diversos segmentos estructurales (Martínez *et al*., 2004; Corti *et al*., 2005; Agostini *et al.,* 2006). El sistema de fallas NW-SE, producto de los esfuerzos tensionales, se considera localmente predominante y determina la posición de muchos edificios volcánicos de la cordillera volcánica salvadoreña (Bosse *et al*., 1976; Carr 1984), como es el caso del Complejo volcánico San Salvador (CVSS) entre otros, delimita la configuración de las cuencas pull-apart entre los segmentos del ESFZ. El conjunto de edificios volcánicos del CVSS se extiende en un área de ~1180 km2 , entre las coordenadas geográficas 13.66° a 13.88° N y 89.47° a 89.09° W, donde se interestratifican los depósitos de este complejo volcánico con los de las calderas volcánicas aledañas, de Coatepeque al NW y de Ilopango al Este. La revisión de la historia eruptiva del CVSS, con énfasis en la reconstrucción estratigráfica del cráter activo Boquerón y la identificación de erupciones explosivas, ha sido el objeto de investigaciones que han culminado con la evaluación de la peligrosidad de este volcán, logrando definir escenarios de peligro para diferentes procesos volcánicos y construir mapas de peligros que señalen las áreas que podrían resultar afectadas por una futura erupción. Los diversos trabajos desarrollados han permitido llegar a conclusiones sobre la extensión y la forma como diversas áreas alrededor del CVSS podrían resultar afectadas, pero también abrir nuevas interrogantes sobre diversos aspectos de la historia y evolución del complejo volcánico, incluyendo progresivamente el estudio de la relación sísmica con la actividad volcánica, especialmente tomado el hecho que la última erupción del CVSS en 1917 fue precedida por dos eventos sísmicos de magnitud superior a 6 .

THE CENTRAL AMERICA SEISMICITY IN THE FRAMEWORK OF THE CARIBBEAN PLATE EVOLUTION: AN INTRODUCTION

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The Caribbean Plate is an independent lithospheric element of more than 4 million square km, characterized today by the un-deformed or less deformed Cretaceous oceanic plateau of Colombia and Venezuela Basins (almost 1 million square km), and the Palaeozoic-Mesozoic Chortis continental block (about 700,000 square km), both bounded by deformed marginal belts (about 2,3 million square km), resulting from the Mesozoic to Present interactions with the adjacent Nazca, Cocos, and Americas Plates. The crustal thickness of the Caribbean Plate varies from, 6-8 km, west of the Beata Ridge, to 20 km between the Central Venezuelan and the western part of the Beata Ridge until, 3-5 km in the southeast of the Venezuela Basin (Diebold and Driscoll, 1999). The crust varies also in thickness from Yucatán Basin (8-9 km, Hall 1995) to Colombian and Grenada Basins. The thickness of the marginal belts ranges from 10 - 22 km to 18 km (Case *et al.*, 1990). The Caribbean lithosphere has been deformed and tectonically emplaced over the Pacific and Atlantic oceanic crusts producing the western and eastern arc systems of the Central American Isthmus and Lesser Antilles. It has also been squeezed against the North and South American continental crusts, thereby originating suture zones in the Cordilleras of Guatemala-Greater Antilles and Venezuela. The active northern (Guatemala-Greater Antilles) and southern (northern Venezuela) plate margins are mainly made by deformed terranes in shear zones bounded by east-west trending sinistral and dextral strike-slip faults (ej. Motagua, El Pilar) respectively, while the western (Central America Isthmus) and eastern (Lesser Antilles) ones are represented by convergent systems and related active magmatic arcs. In particular, the settlement of the western margin of the Caribbean (Central America) and North America (Mexico) Plates is close related with the oblique subduction of the Cocos oceanic Plate, inducing, since the Late Cretaceous, important compressional, strike-slip and tensional tectonic phases, leading different rotation rates in the original Central America blocks (Maya, Chortis, Chorotega, Choco), finally building the present-day Central American Isthmus as a mosaic of these different blocks reciprocally juxtaposed and facing the Middle American Trench. As the consequence, the widespread Central America seismicity (intraplate, interface, suprasubduction and crustal) is mainly constrained by the oblique subducion of the Cocos Plate with different slab dipping angle from south (Costa Rica) to north (Mexico), maybe producing some free-boundaries in the slab itself, a dextral strike-slip tectonic along the Volcanic Arc, and a severe strike-slip tectonic in obducing plate.

RECENT INTRAPLATE EARTHQUAKES IN CENTRAL AMERICA (MEXICO, EL SALVADOR AND NICARAGUA), IN THE FRAME OF THE SUBDUCTION GEOMETRY VARIABILITY

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Central America and Mexico are highly seismically active territories, associated with subduction of the Cocos oceanic plate under the Caribbean/North America plates along the Middle America Trench, at an estimated rates of 7-9 cm/year. The Benioff zone extends to a depth of ~220 km beneath the volcanic cordillera in El Salvador, Nicaragua and Costa Rica, with variable dip from Costa Rica (32°–40°) to central Nicaragua (75°–80°) and northern Nicaragua-Gulf of Fonseca (40°–60°). The oblique convergence generates a trench-orthogonal compression and a strike-slip deformation parallel to the volcanic arc. North of the Caribbean plate, the Cocos slab moves beneath the Mexican-North America plate with both different direction (N-NE) and dip (few degree before plunging in the mantle at high angle), allowing the emplacement of the transverse Mexican volcanic arc. The related tectonic features define the main seismogenic zones: 1) the subduction intraplate zone, including the largest earthquakes (Mmax 7.3-7.5), with focal depths >50 Km, characterized by reverse faulting connected to plate convergence and normal-slip events related to the flexure of the slab; 2) the subduction Interface, at 26-70 km depth, with Mmax 7.7-8.2; 3) the upper crustal zone, strike-slip dominated, characterized by moderate magnitude events (5.5 < Mw < 6.8, Mmax 6.4-7.0) and focal depth < 20 km. The seismic activity registered in the metropolitan areas of San Salvador (El Salvador), April 2017, with M 5.1, and Managua (Nicaragua), March-April 2014, with M 5.1-6.6, lies along two main NW-SE structural elements, affecting the Central America Volcanic Arc: the El Salvador Fault Zone, a segmented strike-slip fault zone with a dominant E–W-trend, and the Nicaraguan Depression, a system of NE-SW-trending strike-slip and oblique-normal faults. The San Salvador activity indicates a NNW-trending near-surface, left-lateral focal mechanism located in the Crustal seismogenic zone, associated to a conjugate fault of the El Salvador Fault Zone or alternatively to the E-W right-lateral master faults. The Managua activity was interpreted as due to a first deep event (65-135 km depth), located in the Subduction Interface to Subduction In-Slab seismogenic zones, which reactivated a subsequent shallow sequence (10-15 km depth), located in the Crustal seismogenic zone, according to the NW-SE right-lateral system, or alternatively to the conjugate NE-SW left-lateral asymmetric system. The recent seismic activity registered on 2017, September 7 (M 8.1) and 19 (M 7.1) offshore South-Western Mexico and in Central Mexico, was located along the Middle America Trench and in the Mexican volcanic arc respectively. Focal mechanisms indicate NW-SE-trending normal faulting consistent with extension in the subduction hinge of the Cocos plate, at intermediate depths (50-60 km). The recent and historical seismicity demonstrates that, independently form their magnitude, they are capable of producing severe damages because of their shallow depth.

POST-EARTHQUAKE SAFETY EVALUATIONS IN MEXICO CITY FOLLOWING THE M7.1 EARTHQUAKE ON 19 SEPTEMBER 2017

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Following the M7.1 earthquake that hit Puebla State on September 19th 2017, three structural engineers deployed through the EU Civil Protection (EUCP) Mechanism to join the United Nations Disaster Assessment and Coordination (UNDAC) Team with the aim of providing technical and scientific assistance to the the Government of Mexico on stability and damage assessment of buildings. The UNDAC Team facilitated contact of the EU experts with Centro Nacional de Prevencion de Desastres (CENAPRED), the technical-scientific branch of the National Civil Protection. CENAPRED expressed interest in a comparative study and evaluation of the ongoing post-earthquake rapid assessments. The team liaised with the main actors involved in post-earthquake rapid evaluations: CENAPRED, UNAM Faculty of Architecture, Colegio de Ingenieros. Informations were collected on similar activities performed by the Government of Mexico City, being Mexico a Federal State with authomomy at State level. CENAPRED manages the Atlas of Risks ("Atlas de Riesgos") that is intended to be a database for the results of evaluations by all teams conducting evaluations and includes the results of the evaluations, the name of the inspector and other details. The team also inspected a sample of buildings that had already been inspected by national experts. In order to provide a valuable set of results for comparison for CENAPRED, the results of the EU team's evaluations were summarized in a Geographical Information System tool. These results provide a map with the geographical distribution of the buildings evaluated, the results of the evaluation, photos and general observations. At the time of writing, the information available through the Atlas of Risk databases only contains evaluation results carried out by UNAM Faculty of Archiecture and only two of the buildings coincide with the list provided to the EU team. For the other buildings, the comparison has been carried out against the results that were posted in some of the buildings by the Director Responsable the Obra (DRO). The assessment between the EU team and those posted by DROs coincide, which suggests that even without a detailed briefing, international teams, if experienced enough, can produce results which are consistent with those of local experts. These activities performed by the EU experts helped to identify gaps and compare data collection methods. They also provided a baseline for comparison to support CENAPRED's interpretation of the ongoing assessment efforts. The presentation will follow the final report of the mission, organised in three sections: description of the situation, main findings and recommendations.

RECENT SEISMICITY IN CENTRAL AMERICA: TAKE A LOOK FROM EUROPE

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Since 1889, when Ernst von Rebeur-Paschwitz recorded the first teleseismic seismogram in Potsdam, worldwide major earthquakes are identified, located and analysed by seismologists and institutions located at great distance from the hypocenter. The modern broad-band instruments allow sensitivities and signal processing unthinkable only few decades ago, when the previous M8 Mexican earthquake occurred.

We briefly present some information about earthquake characteristics and the space-time evolution of the most recent seismicity in Central Americas, as recorded by the main European seismological agencies (GFZ, EMSC, OGS).

Early warning systems for earthquake and tsunami are now widespread; citizenship's testimonies of damage surf on internet and cross the oceans faster than seismic waves; land movements are detected by satellites put in space by several international agencies. All these facts help diminuishing the time needed for the immediate response to catastrophes whilst the times of recovery, mitigation and preparedness remain substantially unchanged.

Witnesses' testimonies and photos to assess an earthquake's impact (effects on buildings and landscapes) are gathered by EMSC by just clicking on a simple illustration.

LastQuake's users will be able to describe how they felt their earthquake and make valued contributions to the EMSC seismologists but also with their friends on Facebook and their followers on Twitter. The earthquakes occurred in Mexico in September 2017 are the first events well documented by LASTQUAKE app. By involving citizens and using them as a primary source of information, scientists can study the population reaction to seismic events (sociology of risk and risk management), and obtain valuable testimonies on the seismic events themselves. Follow the Citizen Seismology EMSC project.

ANÁLISIS MORFOTECTÓNICO Y CONFIGURACIÓN DE LAS PLACAS DEL SUR DE MÉXICO Y NORTE DE MESOAMERICA

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Las características morfotectónicas y la configuración de las placas del Sur de México y norte de Mesoamérica muestran los rasgos de las serranías y cuencas formadas por la interacción de la placa de Cocos, la Placa Norteamericana y la placa Caribe. Analizando la información existente se pretende entender mejor la tectónica del Sur de México y el Norte de Mesoamérica, compilando la información dispersa en diferentes informes locales, y haciendo una interpretación regional. Se han considerado trabajos de morfotectónica y sismología que analizan los estilos estructurales y los movimientos de las placas. Tectónica del Norte de Mesoamérica: El sistema de fallas Polochic-Motagua, de aproximadamente 400 km de extensión, se extiende a través de Honduras, Guatemala y Chiapas, en el sur de México, y está compuesto por tres fallas de deslizamiento lateral izquierda (las fallas Polochic, Motagua y Jocotán). Tanto las fallas Polochic como Motagua muestran evidencia de actividad reciente en su sismicidad y morfología histórica. La falla de Jocotán generalmente se considera inactiva. Una serie de graben norte-sur se observan al sur de la falla de Motagua y al norte de la cadena volcánica asociada con la subducción Cocos - Caribe. La cadena volcánica finaliza en el sur de Chiapas en la vecindad de la huella de fallas de Polochic. El mayor terremoto ocurrió en febrero 1976, en Guatemala (Mw = 7.5) rompió 230 km de la falla Motagua y la parte noroeste de la ciudad del graben de Guatemala. La tectónica de la región es altamente compleja y aun cuando se han realizado estudios para conocer el movimiento entre las placas Cocos-Caribe-Norteamérica con apoyo de GPS geodésicos, no se ha logrado definir lo que ocurre en el límite occidental del sistema de fallas Motagua-Polochic. Los recientes sismos de subducción ocurridos en México tienen especial relevancia, por los daños ocasionados a la infraestructura de la Ciudad de México y en el caso de Guatemala surge preocupación porque el último gran sismo ocurrió hace tiene 41 años (febrero de 1976). Para el caso de México el sismo de subducción y de gran magnitud del 7 de septiembre de 2017 ocasiona daños menores en los Ciudad de México, en Oaxaca ocurren daños en una refinería, y fallecieron 45 personas, en Tabasco algunos edificios sufrieron daños, mientras que en Veracruz se afectaron 250 viviendas, y 17 de las casas fueron dañadas de gravedad. En el caso de Guatemala el sismo se sintió en todo el país, afectó 94 personas identificadas por Conred como damnificados, identificado 61 viviendas con daños severos. Con la información existente analizaremos la tectónica y la sismicidad regional a la luz de los últimos estudios realizados.

TECTÓNICA Y SISMICIDAD DE NICARAGUA

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Nicaragua es un país sísmicamente muy activo, principalmente en la región del Pacífico en el oeste, donde también se concentra la actividad volcánica. Las fuentes de la sismicidad se originan por la dinámica entre las placas tectónicas Cocos y Caribe, la actividad volcánica del arco cuaternario y el fallamiento superficial asociado. El monitoreo sísmico muestra que los sismos generados por la subducción de la placa oceánica Cocos bajo la placa continental Caribe suelen ser más frecuentes que los generados por la actividad volcánica, a excepción de ciertos períodos en los cuales la sismicidad volcánica incrementa considerablemente, como sucedió durante el año 2014. Sin embargo, los eventos sísmicos que han tenido mayor impacto, cuyas magnitudes varían entre 4.8 y 6.3, han sido asociados principalmente al fallamiento superficial de la ciudad de Managua y sus alrededores, en donde se ha propuesto la formación de una cuenca pull-apart que al mismo tiempo está segmentando al arco volcánico cuaternario. Tanto la geometría de esta segmentación como los mecanismos focales soportan que a lo largo del arco volcánico se está dando un fallamiento regional de movimiento lateral derecho. Estudios basados en mediciones GPS del movimiento de las placas en Centroamérica y el Caribe, junto con otras investigaciones con aplicación de modelos análogos, sugieren que la rotación de microbloques dentro de la Placa Caribe podría estar ocasionando este fallamiento lateral derecho y también las estructuras transtensionales o pull-aparts. La contribución de las estructuras tectónicas al nivel de sismicidad de Nicaragua ha servido de base para identificar las fuentes sismo generadoras de relevancia en los estudios de amenaza sísmica. En la actualidad el estudio de referencia que se tiene para la evaluación de la amenaza sísmica es el estudio regional realizado dentro del proyecto RESIS II, financiado por el gobierno de Noruega bajo la coordinación del CEPREDENAC. El estudio se basó en la determinación de escenarios sísmicos en términos de PGA (Peak ground acceleration) y PSA (Pseudo Spectral Acceleration) considerando periodos de retorno de 500, 1000, y 2500 años para toda la región Centroamérica, además de la determinación de espectros de amenaza uniforme para las capitales de cada país en estudio. Todos los análisis realizados con este proyecto se basaron en el catálogo sísmico para la región centroamericana actualizado hasta el año 2007.

THE MEXICAN EARTHQUAKE OF SEPTEMBER 19, 2017. STRONG MOTION ASPECTS, WITH EMPHASIS ON SITE EFFECTS AND DAMAGE PATTERNS IN MEXICO CITY

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We present a brief overview of the characteristics of the strong ground motions recorded during the event of September 19, 2017. We start by trying to answer the question of whether this was an unexpected event or not. After showing the earthquake hazard models currently used in Mexico, as well as the information available on frequency of occurrence of this type of events, we conclude that the event was not unexpected but, rather, had been considered as one of the earthquake design constrains for building code purposes. We then show the general size of the ground motions obtained near the epicentral region of the earthquake. It seems that, at some locations, the recorded motions correspond to a return period of about 1000 years. In the next section, we present response spectra recorded at a station located at firm ground, in the University City (CU), which is regarded as representative of the input motions to the soft soils of Mexico City. These spectra show a frequency content that is very different from that of the September 19, 1985 event. In fact, spectral amplitudes in 2017 are larger than those recorded in 1985 for periods below 1.5 sec, and are much smaller for longer periods. This frequency content determines the nature of the ground motions recorded at the lake bed zone, which are presented in the following section, in comparison with those recorded in 1985. It is shown that the damage patterns are also related to the peculiar frequency content of the incoming motion.

FIRST EVALUATION AND MAPPING OF THE ENVIRONMENTAL SEISMIC EFFECTS GENERATED BY THE 2017 MW 8.2 CHIAPAS EARTHQUAKE IN MEXICO

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A Mw 8.2 intraslab earthquake hit the whole Chiapas region and the southern part of the Oaxaca state in Mexico, on September 7, 2017 at 23h49 PM local time (nucleation depth 58 km). The rupture length of this mainshock was of 200-220 km, corresponding to the coastal sector from Salina Cruz to the Pijijiapan village. The focal mechanism obtained by the Mexico National Seismological Service (MNSS) indicates a normal fault striking N311° dipping 84.4° with rake of -94.7°.

We surveyed and categorized the earthquake environmental effects in the epicentral area, applying the ESI-07 scale (Environmental Seismic Intensity Scale; Michetti *et al.*, 2007); in the following we present our preliminary results. From our observations, the total area affected by secondary effects is in the order of 18.000 km2; however, ground cracks and landslides have been reported as far as in the Vera Cruz State and Guatemala (total area in the order of 54.000 km2).

Intensity of VII to IXESI-07 has been assigned in the Gulf of Tehuantepec region. In the epicentral area, displacements up to – 0.5 m by coseismic coastal subsidence (primary effects) have been documented at Salina Cruz and Playa Vicente in Juchitán Oaxaca. Oceanic tsunami propagation reached Puerto Chiapas (run-up of 3.4 m above tide level), Salina Cruz (run-up of 1.89 m), and Huatulco (run-up of 1.37 m), thirty-six minutes after the mainschock (MNSS). A maximum intensity of IXESI-07 has been assigned to this coastal area.

VIIIESI-07 is assigned to Cañón del Sumidero and Tuxtla Gutiérrez city, where ground effects included landslides and rockfalls, widespread in areas of unstable slopes; in some sectors, their sizes reached up to 104 m3. In beachfront areas, cracks on alluvial soils reached 40 cm of width and 1.40 m of depth (i.e., Salina Cruz). A value VIIESI-07 is assigned to Tuxtla Gutiérrez and Juchitán, the most notable ground effects were lateral spreading with up to 10 cm wide longitudinal fractures in paved roads and 20 cm wide in riverbanks. South of Tuxtla Gutiérrez city, small rock falls and landslides up to 102 m3 occurred. Lateral spreading and longitudinal and transversal fractures up to 10 cm wide are observed along paved roads at Xadaní and Juchitán Oaxaca.

These observations provide data for the generation of a macroseismic map of ESI-07 intensity, according to the distribution and size of the effects in the natural environment. This will be compared with traditional earthquake intensity evaluations (MMI, EMS-98), for integrating earthquake effects on man-made structures with environmental ones into a single and consistent earthquake intensity field.