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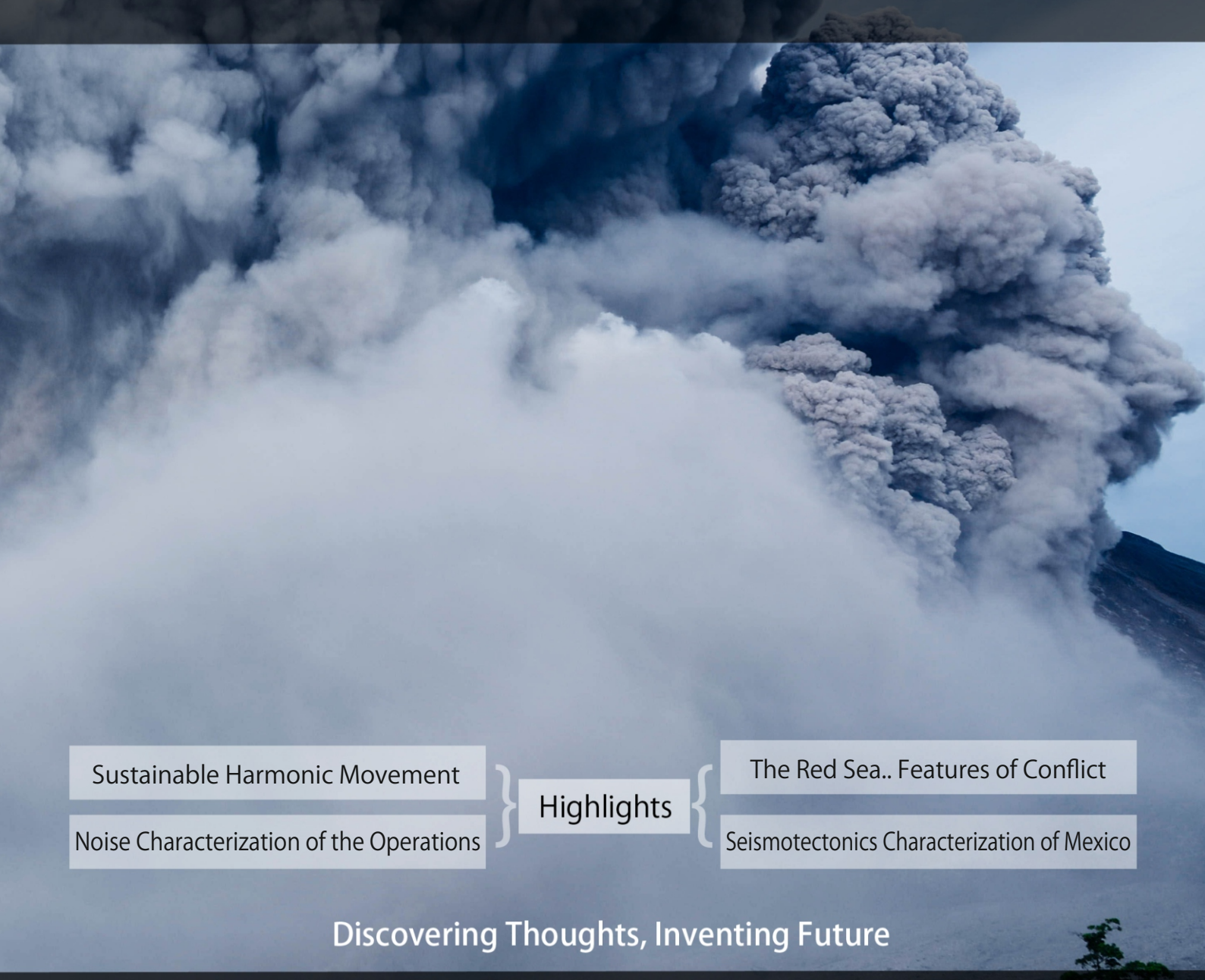

Highlights

- Sustainable Harmonic Movement
- Noise Characterization of the Operations
- The Red Sea.. Features of Conflict
- Seismotectonics Characterization of Mexico

Discovering Thoughts, Inventing Future

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An Assessment of Fire Hazard in the Historic Town of Ouro Preto based on Four Established Analysis Methodologies

By Kruger, Paulo Gustavo Von, Silva, Fernando José, Lasmar, Erika Esteves, Felippe, Anna Rita Tomich Magalhães, Castanheira, Ana Carolina, Oliveira, Crisley Nayanne & Gonçalves, Luana Oliveira
Federal University of Minas Gerais

Abstract- This work aims to present a comparison of 4 (four) analysis methodologies of the fire risks in historical sites. These analysis methodologies are the following: Ebrafire, Chichorro, Gretener and Multi-criteria. The Town area under study is bordered by Tiradentes Square, Senador Rocha Lagoa Street, Conêgo Camilo Veloso by street and Cônego de Bobadela Street in the historic center of Ouro Preto.

The comparative analysis among the four methodologies presented discrepancies in the degrees of fire hazards. However the block assessed presents a high risk of fire, since the great majority of buildings in the area received insufficient fire safety results.

Therefore, although the results here are not conclusive, since this research is in the initial phase, it is already possible to verify the urgency of mitigation actions to reduce the risk of fire in most buildings in the evaluated block.

Keywords: risk assessment methodology – fire risk management – historical sites –vulnerability – resilience – mitigation actions.

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Keywords: risk assessment methodology – fire risk management – historical sites –vulnerability – resilience – mitigation actions.

I. Introduction

According to the normative instruction number 01 dated August 24, 2012 of the Ministry of National Integration (Brazil), "disaster is a result of an adverse event, natural or man-made, under a vulnerable ecosystem, using human material of environmental damage in addition to economic and social damage" (Brazil 2012), and they can be classified, as to primary cause in:

- *Natural:* Arising from natural process or natural phenomena that may result in human losses or other impacts on health, damage to the environment, property, interruption of services and economic disturbances.
- *Technological:* Arising from accidents, dangerous procedures, infrastructure failures or specific human actions.

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According to the above paragraph, fires in buildings and historic sites are part of technological disasters, and their management can be a way of protecting cultural assets. In this sense, it is important to understand the concepts of vulnerability and resilience:

- *Vulnerability:* is the fragility of the place to withstand impacts, which is susceptible to the adverse effects of a hazard:
- *Resilience:* is the "capacity of a system and its components to anticipate, absorb, adapt to or recover from the effects of a hazardous event in a quick and efficient manner, including ensuring prevention, restoration or improvement of basic essential structures and functions" (IPCC, 2012).

Fire risk management helps to increase the resilience of a given social group, where possible vulnerabilities can be detected before a disaster occurs, and mitigation measures can be adopted.

Risk and Disaster Management (DRM) works with five phases: preparation, mitigation, prevention, response and recovery. The Sendai Framework (ALVES, 2016) recommends risk management based on four action priorities:

Priority 1: Understanding disaster risk;

Priority 2: Strengthening governance to manage disaster risk;

Priority 3: Investing in disaster risk reduction for resilience;

Priority 4: Improve preparedness to respond effectively and rebuild better recovery, rehabilitation and reconstrucion.

At the time of a disaster, communication networks and the technologies associated with them are crucial elements to plan emergencies and provide essential assistance to victims (COYLE AND MEIER, 2009). New technologies and their uses allow to improve prevention, planning and response capacities in times of crisis (ROCHE, PROPECK-ZIMMERMANN and MERICSKAY, 2013)

As confirmed by KLEIN, LUTZ and KUHN (2006), the processes related to crisis management are

based on geographical information and technology associated. The development of new technologies and information and communication, such as cell phones, internet, social networks or online mapping, has opened the way for new information manipulation practices. (ROCHE, PROPECK-ZIMMERMANN and MERICSKAY, 2013).

Geographical data and its tools are essential in all aspects of emergency management: preparation, response, recovery and mitigation. During emergencies, time is essencial (GOODCHILD and GLENNON, 2010).

According to Serpa (2009), some aspects can increase the risks of a fire, make difficult or prevent its combat and extinction, or cause the structural collapse of the building. Ouro Preto, the city chosen for the application of these methodologies, has favorable characteristics both from a heritage point of view - one of the first cities listed by IPHAN (1930) and the first Brazilian city declared by UNESCO as a World Heritage Site (1980) - and for the probability of fire propagation. These aspects are the following:

- Constructive characteristics of the building - constructive elements such as floors, ceilings, stairs made of wood;
- Construction of buildings in urban centers - without gaps between buildings and expansions or irregular occupations in the core of the blocks - enabling the rapid spread of flames;
- Lack of proper maintenance of buildings and their facilities;
- Change in the type of occupation without the proper adaptations for its new use;
- Adaptations for electrical installations and liquefied gas - LPG to adapt the building to the new use.

Due to the isolated location of the territory and difficult access, the materials available in the region and the workforce with their own techniques predominated, associated with the influences of the Baroque in force in the metropolis in the 17th century (VASCONELOS, 1951). It can be said, therefore, that vernacular architecture, the one built with local techniques and materials, has become characteristic, even for the simplicity of its form (BAETA, 2002).

The unstable situation experienced by the explorers, as their permanence in the place varied according to the results of gold extraction, meant that the buildings were erected in a temporary and simplified manner. Wattle and daub, wood or stone walls – the latter more like a foundation – and straw, palm trees or thatch roofs were the most used in colonial buildings in Minas Gerais. Wood was, still is, widely used from those hardwood to props and purlins for constructions of relative weight.

At a time when a Master Plan was a distant reality, and little was said about urban planning in the then Portuguese Colony, the territory was occupied according to the potential of the discovered gold mines, generally obeying the dominant direction parallel to the contour lines.

The dwellings were built side by side, without separation, in basic types of construction, with streams in the background. The central strategic position of religious buildings contributed as a reference point to encourage urbanization for the layout of the camp, carrying out the settlement of its inhabitants around open spaces, in the case of chapels (VASCONCELLOS, 1951).

The steep and curvy streets, with a short visual field, - which delay and/or prevent the passage of Fire Department vehicles, in addition to the extreme proximity of the buildings and the materials used in them, makes Ouro Preto an authentic “flammable city”, as explained by CLARET de GOUVEIA (2017).

II. Methods and Processes

For the execution of this research, the georeferenced data was obtained, from—previous research developed by the Geoprocessing Laboratory of the School of Architecture of the Federal University of Minas Gerais (UFMG) These data were used to simulate scenarios for predictive studies related to fire risk assessment through four methodologies: Chichorro Method (CHICHORRO, FERREIRA and CORREIA, 2016), EBRAFire Method (SILVA et al, 2020), Gretener Method, and the Multicriteria Method (LASMAR, 2020).

It is important to point out that the first two methodologies mentioned are being used through a partnership between the Universities of Porto and Beira Interior (both from Portugal), respectively, and the School of Architecture of the Federal University of Minas Gerais (EA-UFMG), Brazil.

a) Chichorro Method

The Chichorro Method (Holistic Calculation of the Construction Fire Risk and Enabled Optimization of its Reduction with Works) is a Fire Risk assessment model developed at the University of Porto (UP), Portugal, and which was born out of the concern from the analysis of buildings built in historic sites due to the increasing occurrence of urban fires, some of them of high severity, and the quantification of the impact that a fire started in a building may have.

This method is based on four global fire risk factors:

- Probability of fire occurrence;
- Total consequences of the fire;
- Development and spread of fire; and
- Effectiveness of fire relief and firefighting.

Through these four global factors, the methodology covers all aspects that relate to the calculation of fire risk, resulting in the translation of risks for users of a given building, in addition to the goods

contained therein (CHICHORRO, FERREIRA and CORREIA, 2016).

b) EBRAFire

EBRAFire, developed at the University of Beira Interior (UBI), Portugal, assigns a classification to the buildings analyzed, based on fundamental parameters, observed in empirical events, technical and regulatory standards. It has an intuitive layout in order to facilitate the entry of data, a field form in checklist format and a form with a summary of the results obtained in the procedure. EBRAFire also allows for a detailed analysis of the parameters to understand its contribution to the building's fire safety (SILVA et al, 2020).

The final result of the fire safety classification is the analytical comparison organized into four subchapters:

- Subchapter A, analyzes fire safety from the building's physical characteristics, location, materials and content;
- Subchapter B, studies the factors that contribute to the safety of users, such as behavior, activities and availability of means of combat;
- Subchapter C, examines the function of the space around the building and its contribution to fire and ignition safety, such as vegetation and adjacent buildings, as well as entrances;
- Subchapter D, observes safety measures applied to activities that occur adjacent to or within structures (fairs and cultural festivals, for example) (MOREIRA, 2018).

c) Gretener's Method

Created by engineer Max Gretener in 1960 at the time he was director of the Fire Protection Association in Switzerland, it was initially used to serve insurance companies. In 1968, it was adopted as a means of fire risk assessment by the Swiss Fire Department.

The method consists of determining a safety factor for each compartment of the building. It is a mathematical relationship where the numerator represents fire safety factors and the denominator represents fire risk factors. Fire safety will be verified if all safety factors are greater than or equal to one (SILVA and COELHO FILHO, 2007).

In this work, the version of the methodology contained in Technical Instruction 35 of the Minas Gerais Military Fire Department (CBMMG) was adopted, an adaptation proposed by Professor Antônio Maria Claret de Gouveia of the Federal University of Ouro Preto (UFOP), (CBMMG, 2018).

In this adaptation, fire safety is measured by assigning weights to nineteen factors represented by fire signaling measures, fire extinguishing (permanent fire brigade, for example), infrastructure (existence of fire hydrants inside the building), measures to protect building structures and safety measures, such as signage for emergency exits and escape routes (CBMMG, 2018).

Fire risk is defined by the product of a determined quantity that expresses the exposure to fire risk (or fire hazard) by a probable quantity that expresses the risk of fire activation (CBMMG, 2018).

d) Multicriteria Method

Finally, the Multicriteria Method (MCA), which is "a set of tools and mathematical methods that allow the comparison of different alternatives according to many criteria, often contradictory, in order to guide the decision maker to a judicious choice" (CHAKHAR and MOUSSEAU, 2008).

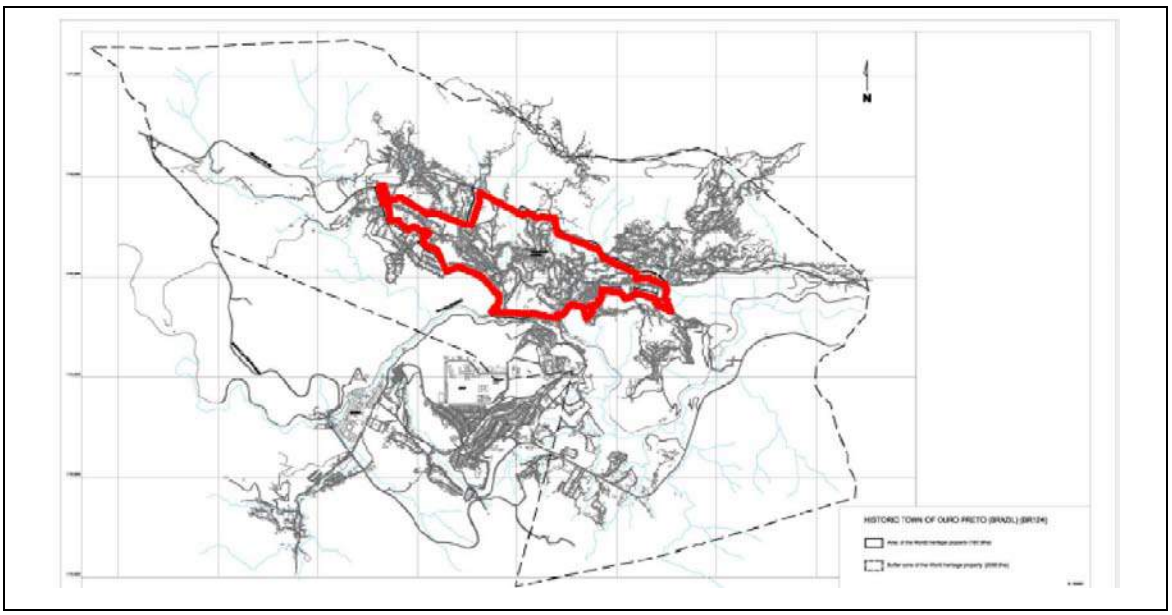
To carry out the MCA, it was necessary to define the objectives to be achieved, the variables of this process and their weights of importance. The distance between buildings, the ease of access for Fire Department vehicles, the concentration of fire load, the distance from the nearest fire hydrant, the existence (or not) of the Fire Department Inspection Report (AVCB), the state conservation of the building and the adequacy of electrical standards are some of the criteria adopted in this methodology (LASMAR, 2020).

III. Space Cutting

The city chosen for the risk assessment was Ouro Preto. Located in the central region of Minas Gerais, the city of Ouro Preto has the largest and most important collection of architecture and art from the colonial period in all of Brazil. Due to its size and conservation, Ouro Preto was one of the first cities chosen by the United Nations Educational, Scientific and Cultural Organization (Unesco) to be a World Heritage Site in 1980 (MINAS GERAIS, 2019).

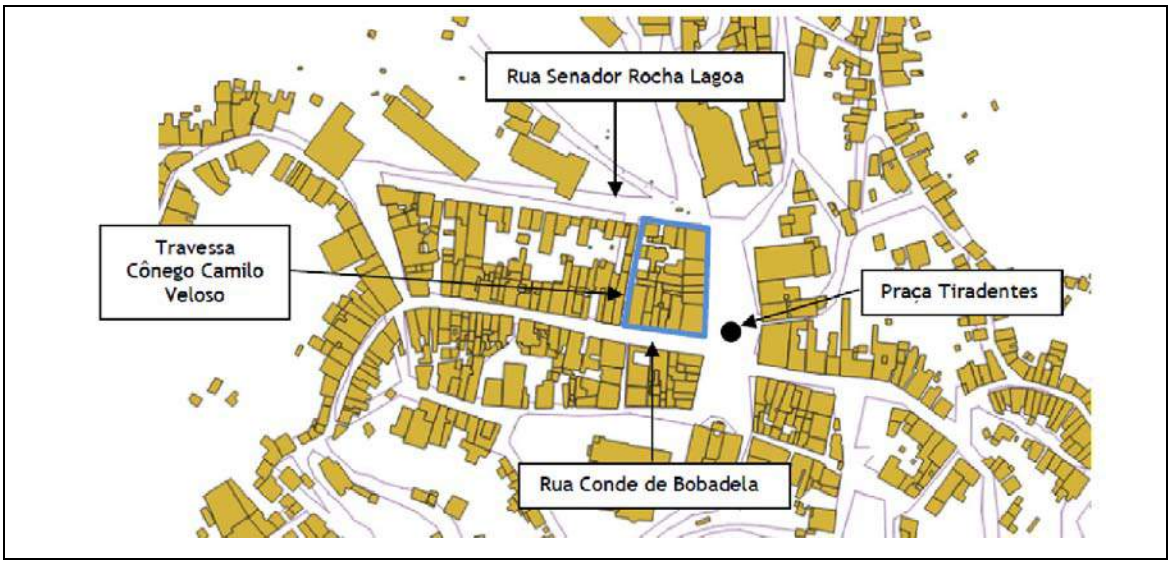
According to Claret de Gouveia (2017), Ouro Preto can be considered a flammable city due to its characteristics of urban implantation (buildings without lateral spacing and narrow streets), geographic (great hills and valleys) and construction characteristics (use of wood in floors, stairs, balconies etc). According to the author, the term flammable city "intended to designate formerly existing cities, which, given their great vulnerability and reduced security, had large areas destroyed under the action of widespread fires." (CLARET de GOUVEIA, 2017, p.15).

For the first phase of this research (still in progress), the block bordered by Tiradentes Square, Senador Rocha Lagoa street, Cônego Camilo Veloso by street and Conde de Bobadela street (Figure 2) was chosen.



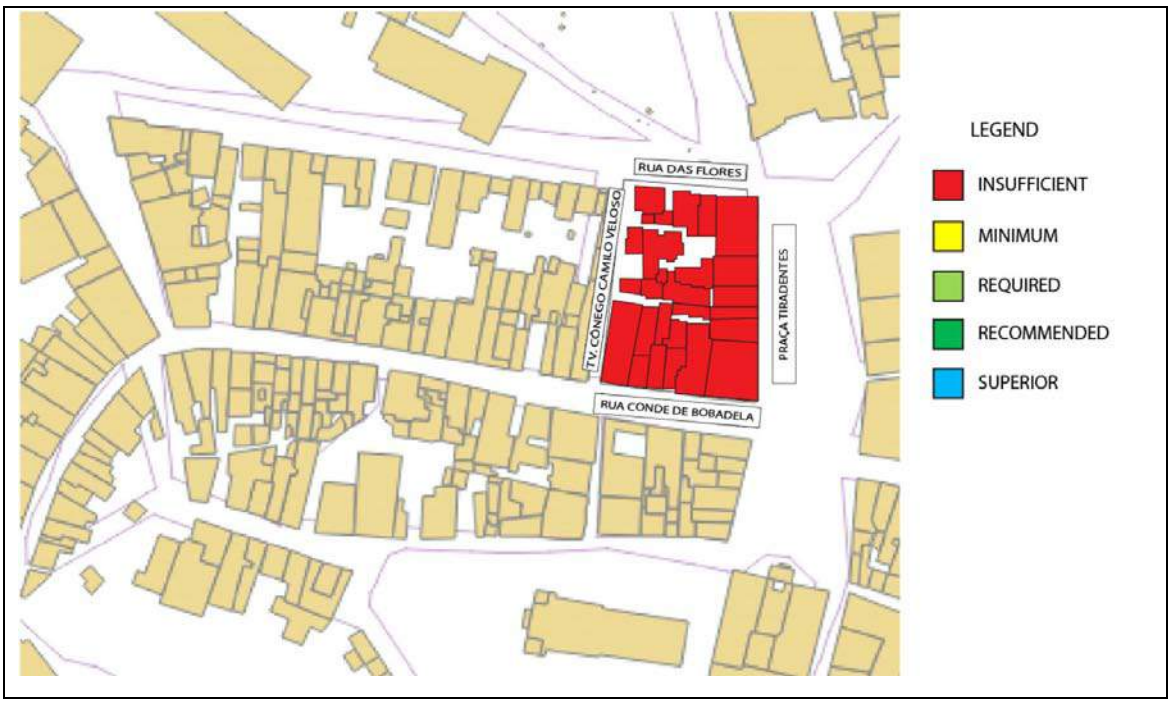
Source: MINAS GERAIS (2019)

Figure 1: Ouro Preto Historical Center (highlighted in red).



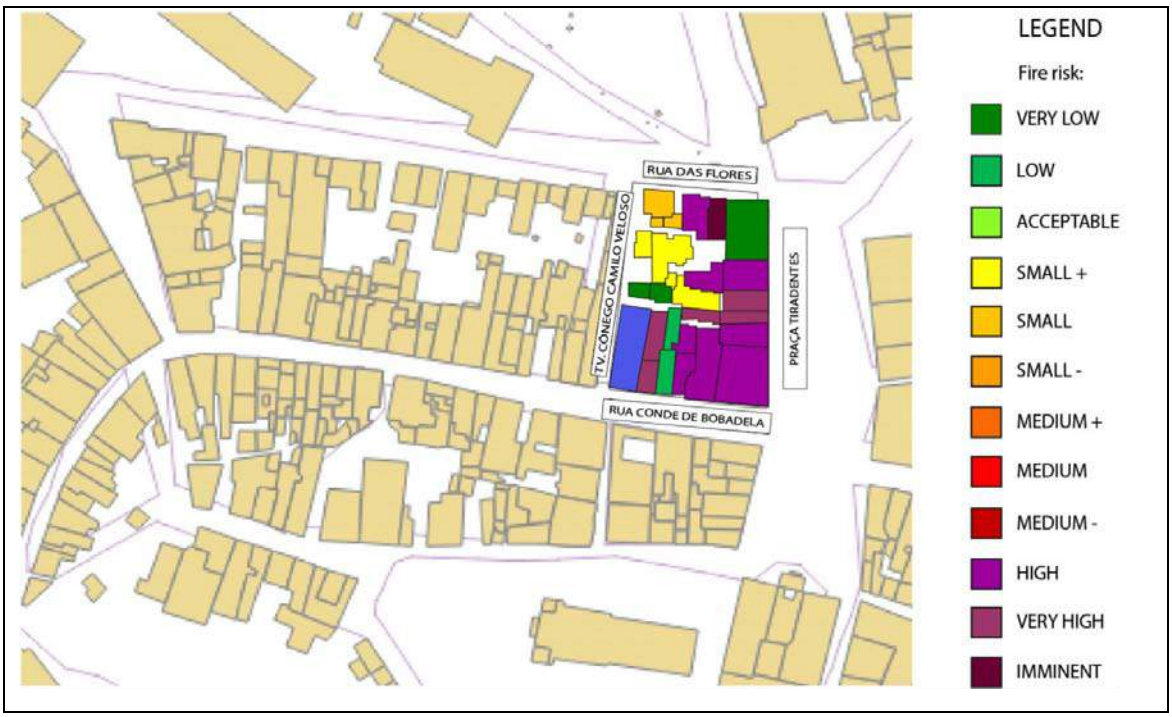
Source: Image prepared by the Geoprocessing Laboratory of the School of Architecture of the Federal University of Minas Gerais.

Figure 2: Area chosen for the study (highlighted in blue), within the Historic Center of Ouro Preto.



Source: Image prepared by the Fire Science and Technology Research Group – IGNIS

Figure 3: Fire risk assessment using EBRAFire.



Source: Image prepared by the Fire Science and Technology Research Group – IGNIS

Figure 4: Fire risk assessment using Chichorro.

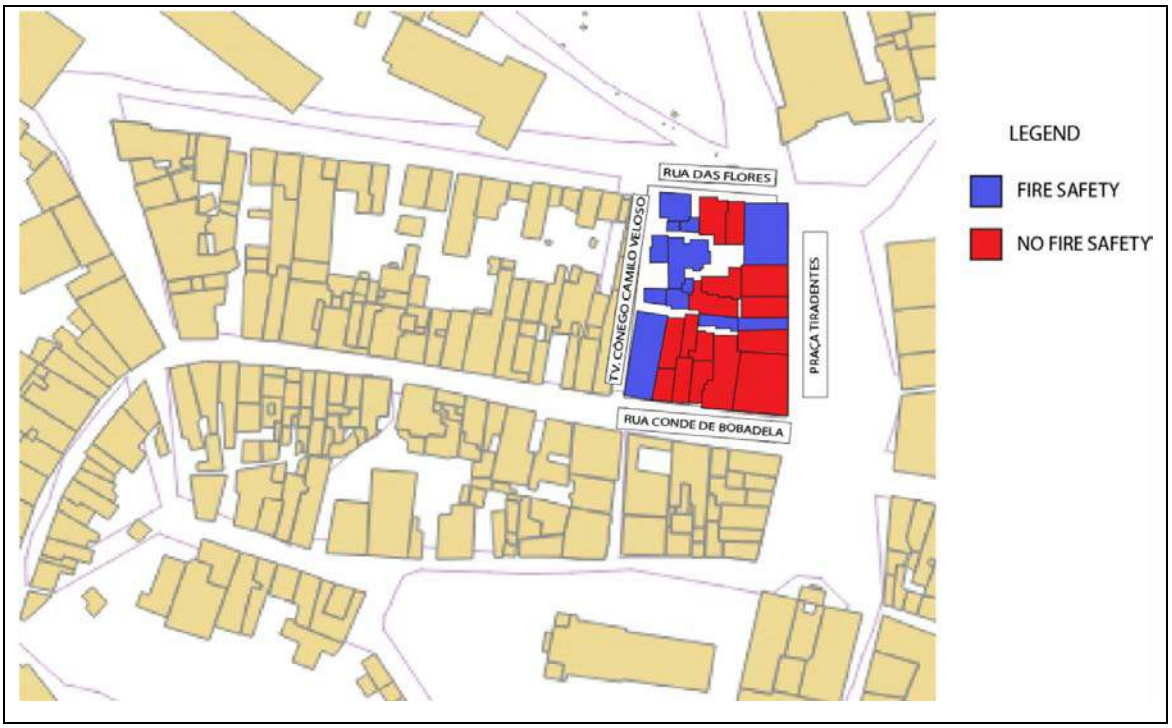


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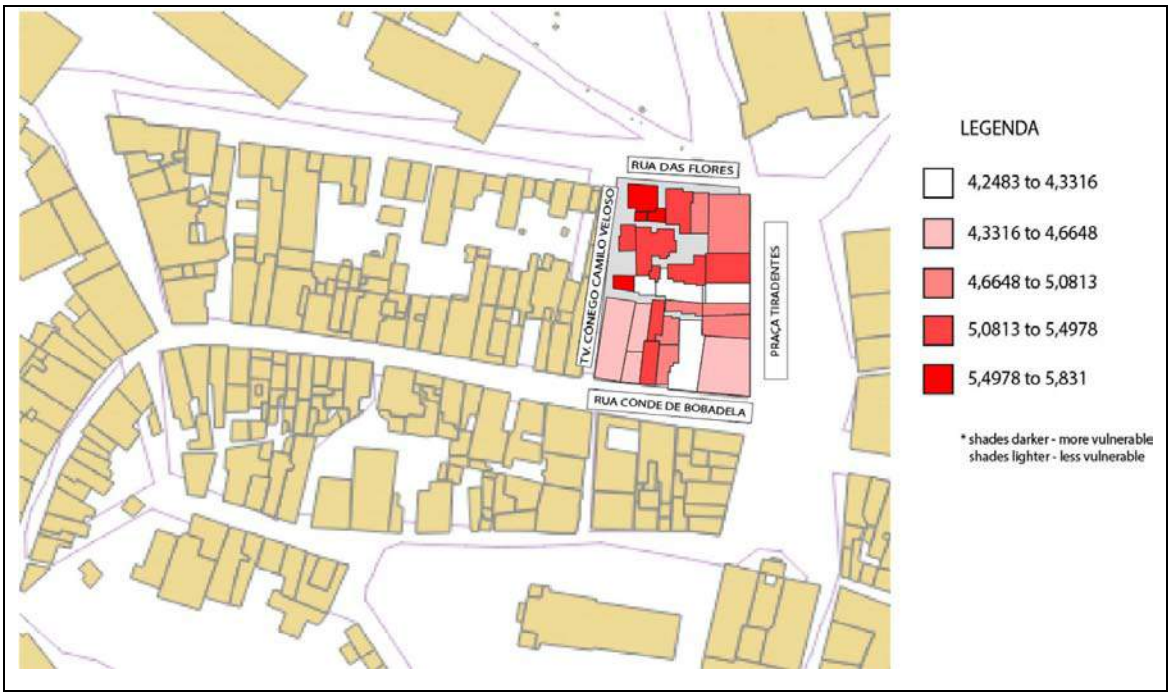
Figure 5: Fire risk assessment using Gretener.



Source: Image prepared by the Fire Science and Technology Research Group – IGNIS

Figure 6: Fire risk assessment using MCA.

Figure 6 shows the MCA result in color grading, according to the degree of vulnerability, ranging from darker tones, greater vulnerability, to lighter tones, with less vulnerability.

In Figure 3, all fourteen buildings analyzed had an insufficient fire safety level, according to EBRAFire. In Figure 4, two of these buildings were classified as A++ and one, A+, through the Chichorro Method. However,

the other buildings have similar degrees of fire risk, with C- (medium fire risk) D (high fire risk), E (very high fire risk) and F (imminent fire risk), the classes of risk obtained by Chichorro.

Figure 5 presents the results of the evaluation using the Gretener Method. Only thirteen of the seventeen buildings were evaluated, as some data were not obtained due to the social isolation imposed by the Covid 19 virus pandemic. Even so, it is clear that only two buildings, of all analyzed, "have fire safety".

Finally, when analyzing the results obtained with the MCA (Figure 6), it appears that there is a greater number of buildings with a greater degree of vulnerability.

As they are different evaluation methodologies, it was expected that different results could occur, a fact confirmed through the analysis presented here. EBRAFire analyzes the degree of safety based on the characteristics of the building and its surroundings and the safety of its users, Chichorro evaluates the building's performance, the probability of occurrence, the development and severity of a fire, Gretener, the ratio between fire safety factors and fire risk factors, and the MCA, sometimes conflicting pre-established criteria.

However, regardless of the methodology, it is notable to observe that most buildings (if not all, as in the case of EBRAFire) have a high degree of fire risk. Added to this are characteristics such as the implementation of buildings (no removal), changes in use and occupation and adaptations without monitoring or knowledge of the competent authorities (City Hall, IPHAN and Fire Department), greatly increasing the probability of a fire on a large scale.

It was found, for example, that some buildings that have a high degree of risk in two of the four methodologies (EBRAFire and Chichorro), have a Fire Prevention and Fire Fighting Policy. However, other items evaluated, such as state of conservation and nonexistence of escape routes, increased the degree of risk of some buildings; others do not even have a Fire Prevention and Fighting Policy. This means that such buildings lack fire-fighting equipment, alarm systems, heat and smoke detection, among other items.

It is noteworthy that the research is in its initial phase and evaluations of other areas within the historic center of Ouro Preto will tend to be similar, since the entities involved (residents, tenants and users) and the physical attributes (implementation, materials and construction techniques) have similar characteristics.

There is still the incompleteness of collected data. The collection of data is still incomplete as of this writing. This is due to the fact that several buildings still have not adopted the Fire Prevention and Fighting Policy, making it difficult to collect data from the Minas Gerais Military Fire Department for the city of Ouro Preto. Added to this was the beginning of social isolation imposed by the Covid 19 virus pandemic, which made it impossible to continue the research from March 2020 onward.

IV. Final Considerations

This work presented the first data of a still incipient research, started in the first half of 2019. This means that conclusive information will be reached over the next few years of its development, including the deepening of the evaluation by obtaining more data related to buildings and the expansion of this assessment to the entire Historic Center of Ouro Preto.

However, some issues can already be observed with the data obtained so far: the evaluated block presents a high risk of fire, since most of the buildings that are located there obtained insufficient results for fire safety.

This degree of risk can be increased if we consider the characteristics mentioned above, such as: constructive materials for the buildings there (wooden floors, ceilings and stairs); the implantation of buildings without gaps between buildings; expansions or irregular occupations in the core of the courts (providing the rapid spread of the flames), the lack of adequate maintenance of the buildings and their installations; and the type of occupation changed without adequate adaptations for its adaptation (electrical installations, for example) (SERPA, 2009).

Therefore, it is noteworthy that, although the results presented here are not yet conclusive, it is already possible to verify the urgency of the need for mitigating actions to reduce the risk of fire in most buildings in the assessed block, which corroborates a need for an imminent fire risk management policy.

In time, this approach will provide subsidies to increase resilience in this type of location, since the most vulnerable areas will be identified and mitigating actions can be established before a fire occurs.

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Seismotectonics Characterization of Mexico

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Abstract- Mexico is an active Seismotectonic Region in the most part of North American continental plate and has 2 types of seismicity (interplate and intraplate). There are in the hierarchical structure 3 Seismotectonic Provinces (North Western, Western and Eastern Centre). Inside they exist 11 Seismotectonic Units where the Seismogenic Zones are defined. The last mentioned are segmented. Western Province has the highest level and where the contact of the converging plates take place.

Keywords: *active zones, mexico, seismic hazard, seismotectonic.*

GJHSS-B Classification: *FOR Code: 040699*

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Seismotectonics Characterization of Mexico

Caracterización Sismotectónica de México

Mario Octavio Cotilla Rodríguez [α], Diego Córdoba Barba [σ] & Francisco Javier Núnez Cornú [ρ]

Resumen- **México es una Región Sismotectónica activa, mayoritariamente en la placa continental de Norteamérica y tiene los 2 tipos de sismicidad (entreplacas y de interior de placa). La estructura jerárquica contiene 3 Provincias Sismotectónicas (Norte-Occidental, Occidental y Centro-Oriental), en ellas hay 11 Unidades Sismotectónicas y en éstas se localizan las zonas sismogenéticas. Estas últimas están segmentadas. La Provincia Occidental es la de más nivel y donde se encuentra el contacto de las placas convergentes.**

Palabras clave: méxico, peligrosidad sísmica, sismotectónica, zonas activas.

Abstract- **Mexico is an active Seismotectonic Region in the most part of North American continental plate and has 2 types of seismicity (interplate and intraplate). There are in the hierarchical structure 3 Seismotectonic Provinces (North Western, Western and Eastern Centre). Inside they exist 11 Seismotectonic Units where the Seismogenic Zones are defined. The last mentioned are segmented. Western Province has the highest level and where the contact of the converging plates take place.**

Keywords: active zones, mexico, seismic hazard, seismotectonic.

I. Introducción

México [MX] es un País (~1.964.400 km^2) situado, mayoritariamente, en la placa continental de Norteamérica (Figura 1). Como estructura neotectónica tiene relación directa con el Océano Pacífico, el Golfo de México [GM], y el Mar Caribe. La longitud de sus costas es ~11.600 km (2,7 veces mayor la Occidental que la Oriental), y su población es ~122.10^6 habitantes. El territorio tiene 31 Estados (Figura 2). En la costa del Pacífico se localizan un conjunto de poblaciones e instalaciones turísticas muy importantes que están en los Estados de Chiapas, Colima, Guerrero, Jalisco, Michoacán, Nayarit, Oaxaca, y la parte S de Sinaloa. En ese entorno muy bien conectado con sistemas de carreteras, aeropuertos y puertos hay un formidable conjunto de playas (Figura 3). Estos sitios, con un fondo de población permanente superior a 10.10^6 habitantes, atraen al año ~30.10^6 turistas. Esta amplia región costera está sujeta, desde siempre, a los efectos directos de fuertes terremotos (ejemplos: 28.03.1787 (M 8,4-8,7) y 03.06.1932 (M 8,2)), y tsunamis. Es decir, tiene un alto peligro sísmico; y consecuentemente puede estar sujeta a importantes pérdidas.

MX tiene también otras áreas de costa en el oriente y de interior continental, que centran el interés turístico y cultural de extranjeros y nacionales. Entre ellas hay: 1) playas en Cancún, Tuxpan, Esmeralda, Boca del Río, y Rivera Maya; 2) parques temáticos y reservas de la biosfera (El Pinacote y Gran Desierto de Altar, El Vizcaíno, y Sian Ka'an); y 3) volcanes (Ceboruco, Chichonal, Cofre de Perote, Paricutín, y Popocatépetl). Todas están localizadas en zonas de peligro sísmico diverso, y con una cantidad de habitantes y turistas muy superior a la zona anteriormente comentada.

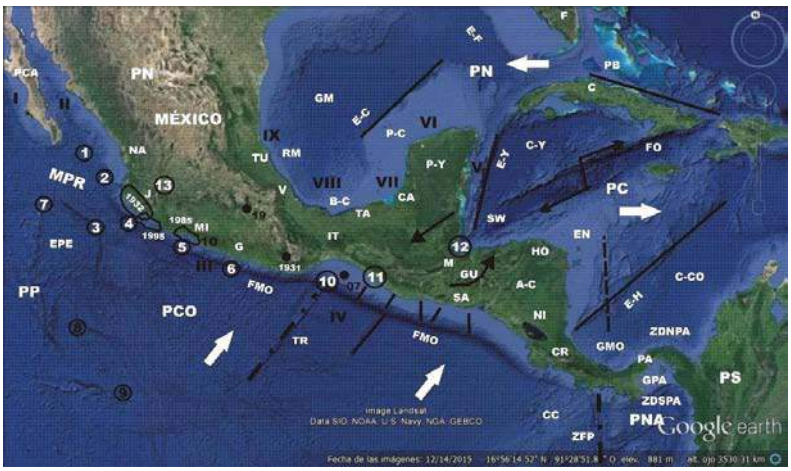

Figura 1: Esquema tectónico

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Aparecen: **1)** Lugares (A-C= América Central, B-C= Bahía de Campeche, C= Cuba, CA= Campeche, CC= Cresta de Cocos, C-CO= Cuenca de Colombia, CR= Costa Rica, CY= Cuenca de Yucatán, E-C= Escarpe de Campeche, E-H= Escarpe de Hess, E-F= Escarpe Farallón, E-Y= Escarpe de Yucatán, EN= Elevado de Nicaragua, EPE= Elevado del Pacífico Este, F= Florida, FO= Fosa Oriente, FMO= Fosa Mesoamericana, G= Guerrero, GM= Golfo de México, GMO= Golfo de Mosquitos, GPA= Golfo de Panamá, GU= Guatemala, HO= Honduras, IT= Istmo de Tehuantepec, J= Jalisco, M= Motagua, MI= Michoacán, NA= Nayarit, NI= Nicaragua, PA= Panamá, PB= Plataforma de Bahamas, P-C= Plataforma de Campeche, PCA= Península de California, P-Y= Península de Yucatán, RM= Ridge de México, SA= El Salvador, SW= Falla de Swan, TA= Tabasco, TU= Tuxpan, V= Veracruz, Zonas de Deformación de Panamá (Norte= ZDNPA, Sur= ZDSPA), y (líneas cortas y puntos negros: (TR= Tehuantepec Ridge y ZFP= Zona de Fracturas de Panamá)); **2)** círculos negros (epicentros de terremotos: A) 07= 07.09.2017 (M 8,2), 19= 19.09.2017 (M 7,1); B) 1931= 15.01.1931 (M 8,0) (ver Tablas 2, 8 y 11); **3)** circulo (negro) con número (blanco)= intersección principal de fallas (ver Tabla 5); **4)** Elipses (áreas de rupturas estimadas de los terremotos: 03.06.1932 (M 8,2), 19.09.1985 (M 8,1), 09.10.1995 (M 8,0)); **5)** Microplacas (MPR= Rivera); **6)** Segmentos de costa (I-IX); **7)** Placas (PC= Caribe, PCO= Cocos, PN= Norteamérica, PNA= Nazca, PP= Pacífico, y PS= Suramérica); y **8)** Sentido de movimiento (Placas= flechas gruesas blancas, y Bloques= flechas negras finas).

Al respecto de este último aspecto, sobre la base de los datos del Servicio Sismológico Nacional de México (2017), señalamos los 2 últimos terremotos fuertes (Figura 1): 1) 07.09.2017 (M 8,2/ h 58 km/ 14,85º N 94,11º O/ epicentro en el Golfo de Tehuantepec/ 102 muertos, 900 heridos, 2.500.000 afectados/ tsunami en Oaxaca (1,1 m)); 2) 19.09.2017 (M 7,1/ h 57 km/ 18,4º N 98,72º O/ epicentro en Axochiapa, Morelos/ 370 muertos/ 7.289 heridos). Estos 2 eventos ocasionaron de conjunto las siguientes cifras de muertos (472) y heridos (8.189). El primero de ellos se localizó en el Océano Pacífico y el segundo en la parte interior continental mejicana.

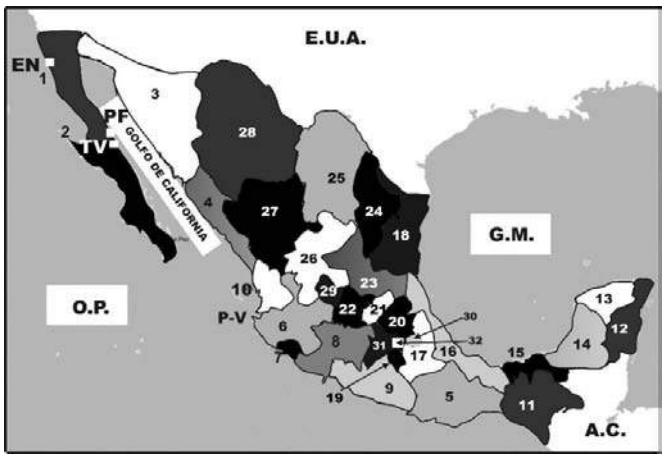

Figura 2: Estados de México

Aparecen: **1)** Lugares (A.C.= América Central, E.U.A.= Estados Unidos de Norteamérica, G.M.= Golfo de México, O.P.= Océano Pacífico, P-V= Puerto Vallarta; cuadrados blancos (EN= Ensenada, PF= Punta Francisquito, TV= Tres Vírgenes)); y **2)** Estados (1= Baja California, 2= Baja California Sur, 3= Sonora, 4= Sinaloa, 5= Oaxaca, 6= Jalisco, 7= Colima, 8= Michoacán, 9= Guerrero, 10= Nayarit, 11= Chiapas, 12= Quintana Roo, 13= Yucatán, 14= Campeche, 15= Tabasco, 16= Veracruz, 17= Puebla, 18= Tamaulipas, 19= Morelos, 20= Hidalgo, 21= Quetetaro de Arteaga, 22= Guanajuato, 23= San Luis Potosí, 24= Nuevo León, 25= Coahuila de Zaragoza, 26= Zacatecas, 27= Durango, 28= Chihuahua, 29= Aguas Calientes, 30= Tiaxcala, y 31= México, D.F.).

Figura 3: Vistas de cuatro playas mejicanas del Pacífico

En las 5 fotos se observan, en la primera línea de la costa, algunas instalaciones turísticas y el inmediato relieve de montaña. Esas fantásticas playas están abiertas al Océano Pacífico en el segmento de tsunamis locales (ver Figura 9) y dentro de la zona sísmica D (ver Figura 10).

Este trabajo se desarrolló en el marco del Proyecto TSUJAL ("Caracterización del peligro sísmico y tsunamigénico asociado con la estructura cortical del contacto placa de Rivera-bloque de Jalisco"), y su objetivo es presentar las bases principales, suficientemente sólidas, para la delimitación y realización de una zonación (o regionalización) sismotectónica y la confección, en una segunda etapa, de un mapa sismotectónico [MS] en MX.

II. Sismotectónica

a) Antecedentes para las investigaciones sismotectónicas

Un MS es un tipo de material sismológico especial, dinámico, no probabilístico, y tampoco ecléctico (Cotilla y Álvarez, 1991), que tiene que ser claro, conciso y objetivo. Él representa la relación entre la neotectónica y los terremotos, y es un documento fundamental para estudios de peligrosidad sísmica. El MS es válido para un periodo determinado no concreto ni específico.

En general, los criterios para la preparación de un MS aparecen en Gorshkov (1984), Pavoni (1985), Cruz (1990), Cotilla y Álvarez (1991), y Rogozhin (2012). Ellos destacan la necesidad de incluir datos sobre: 1) neotectónica; 2) sismicidad histórica e instrumental; 3) mecanismos focales; 4) fallas activas y zonas de alineamientos; y 5) estructura de la corteza. Todos esos elementos se localizan, diferentemente, en diversos estudios de MX, por lo que puede asegurarse hay una buena base. Algunos países y regiones tienen estos mapas: 1) *África* (Meghraoui *et al.,* 2016), 2) *Argentina* (Perucca y Bastras, 2006), 3) *Cuba* (Cotilla *et al.,* 1991), 4) *China* (Jun *et al.,* 2013), 5) *Ecuador* (Instituto Geográfico Militar de Ecuador, 1992; Ortiz Panchi, 2013), 6) *España* (Rey Pastor, 1956; Almela y Puyal, 1960; IGME, 1983; IGN, 1992; Bernardeu *et al.,* 1993; López Fernández *et al.,* 2008), 7) *Francia* (*Bureau e Reserches Geologiques et Minéres*, 1981; Vogt, 1981), 8) *Honduras* (Cruz, 1990, 1999), 9) *India* (Kayal, 2001), 10) *Italia* (Meletti *et al.* 2000; Romero y Pugliese, 2000), 11) *Japón* (Kakimi *et al.,* 2003), 12) *Noruega* (Byrkjeland *et al.,* 2000), 13) *Portugal* (Moreira, 1985), 14) *Rumania* (Polonic, 1986), 15) *Rusia* (Buné *et al*., 1970; Gorshkov, 1984; Gubin, 1990; Imaev *et al.,* 2000; Imaeva *et al.,* 2011, 2015; Rogozhin, 2012), y 16) *Venezuela* (Fiedler, 1969).

Especialistas norteamericanos sostienen que la Sismotectónica es el estudio de la relación entre los terremotos, la tectónica activa y las fallas individuales de una región. De otra parte, los especialistas rusos configuran un marco de investigación sismotectónico en 3 etapas principales sobre la base de una selección de indicadores geológicos y geofísicos que conducen a la: 1) preparación de un MS; 2) distinción y caracterización de las zonas sísmicas potencialmente activas; y 3) elaboración de los materiales de peligrosidad sísmica. Entre ellos están los mapas de zonas sismogeneradoras y origen de terremotos, que equivalen en la literatura de Occidente a "corredores sismotectónicos".

Tomando en consideración, cronológicamente, los trabajos de Medviedev (1968), Riznichenko y Gorbunova (1968), Buné *et al.* (1970), Fiedler y Rivero (1977), Buné y Gorshkov (1980), Yang y Aggarwal (1981), Belousov *et al.* (1983), Krestnikov *et al.* (1983), Grünthal *et al.* (1985), Meghraoui *et al.* (1986), Xu y Liu (1986), Ebel *et al.* (1998), CEF (1990), Imaev *et al.* (1990), Dlala (1992), NUREG-1451 (1992), Regulatory Guide 1.165 (1997), Muir Wood (1999), Orozco y Osorio (2004), Cardona *et al.* (2005), Grases y Lirio (2006), Omerbashich y Sijaric (2006), Fujita *et al.* (2009), Imaeva *et al.* (2009). Schurr *et al.* (2014), Feld *et al.* (2015), Kuchai y Kozina (2015), y Lu *et al.* (2018) se puede asegurar que en las investigaciones sismotectónicas hay que: 1) incluir 2 elementos (zonas y fallas); y 2) realizar una regionalización. Esta última consiste, fundamentalmente, en identificar, cartografiar y clasificar las fallas y áreas activas y con ello delimitar las zonas lineales con características sísmicas similares. Además, se representan superficies territoriales atendiendo a las características neotectónicas y la sismicidad. Las superficies tienen homogeneidad sismotectónica, y pueden subdividirse en estructuras de menor categoría y dimensiones distintas (provincias y unidades). Esta metodología se ha aplicado en este trabajo.

El estudio de las fallas activas, conocidas también como zonas sismotectónicas o sismogenéticas, es, como se dijo, una etapa inicial del trabajo. Esas fallas son estructuras, relativamente, lineales que han demostrado actividad sísmica en la actualidad. A esas estructuras se les considera fuentes de sismos (o sismogeneradoras) y ellas tienen una serie de características distintas como: magnitud máxima y periodo de recurrencia de los terremotos que no siempre es posible de establecer con precisión. En este punto es deseable la confección de un catálogo de fallas activas, que incluya documentación gráfica. Esos elementos están sujetos al régimen tectónico regional y se localizan en las Provincias Sismotectónicas [PS] y las Unidades Sismotectónicas [US].

Uno de los primeros trabajos, bien fundamentados, sobre la catalogación de las fallas activas es el resultado de Trifonov y Machette (1993). Posteriormente, Assinovskaya y Soloviev (1994) realizan un estudio de las características de las fallas activas y su relación con los terremotos en el Mar de Barents. Paris y Romero (1994) lo implementaron en Colombia. Para Cuba hay 2 resultados Cotilla *et al.* (2007A) y Cotilla (2014), pero, como dicen esos autores, que no cierran el tema. En MX hay varios catálogos de fallas, entre ellos seleccionamos dos: 1) Cruz Castillo (2002); y 2) Cid Villegas (2015). El primero de esos trabajos se

dedica a la Península de California y su entorno inmediato, donde destacan 20 estructuras. El otro cubre todo MX, y describe 151 fallas, clasificándolas en 3 niveles (A= 28, B= 7, y C= 116). Este último autor asegura que han quedado muchas cuestiones pendientes.

b) Trabajos Sismotectónicos

Diferentes especialistas han investigado la sismotectónica de MX, pero consideramos que es una base de partida lo expuesto por Zúñiga *et al.* (1997) sobre la Regionalización Sismotectónica. Ellos sostienen que: *"…Basándose en los datos de los catálogos instrumental e histórico, el territorio de México se subdividió, de manera global, en Unidades Sismotectónicas con el propósito de posteriormente definir dentro de éstas Zonas Sismogenéticas para ser utilizadas en las estimaciones del Riesgo…"*. Así consideraron 6 aspectos: 1) la localización de terremotos; 2) las características tectónicas de las zonas; 3) los mecanismos focales y los patrones de fallas; 4) las características principales de la liberación de energía de los sismos dentro de cada región; 5) la historia sísmica de cada región; y 6) reducir a un mínimo el número de regiones primarias, de las cuales se puede partir para subdivisiones más refinadas.

Seleccionamos 13 publicaciones (Tabla 1) que representan, desde nuestro punto de vista, el espíritu y el contenido fundamental de las investigaciones sismotectónicas en MX. Es significativo que todos esos trabajos siguen la tendencia de los especialistas norteamericanos. Ellos cubren el periodo final de 1980 al 2016. Todos estudian aspectos locales sobre la sismogenésis, salvo tres, los indicados con los números 4-6 y 13. En particular los trabajos de Zuñiga *et al.* (1997, 2017) se circunscriben por completo al territorio mexicano; y a pesar de que sus mapas regionales difieren (19 y 18 regiones, respectivamente) comprobamos que tienen una gran semejanza. Además, lo expresado acerca de la regionalización por el grupo: 1) primero de autores (*"…es de ningún modo única…"*); 2) segundo de autores (*"…pueden realizarse particiones más finas y precisas…"*) permite proponer una nueva investigación sismotectónica.

c) Estructura sismotectónica

La confección de un MS implica, como se dijo, no sólo el conocimiento de la neotectónica y la sismicidad de un territorio, sino también utilizar la experiencia de especialistas de otros países en tareas de este tipo. Así, la principal utilidad del MS está dirigida al peligro sísmico (Cotilla y Álvarez, 1991; Imaeva *et al.,* 2015, 2016, 2016A). Además, hay que considerar que las estructuras sismotectónicas: 1) están sujetas a complejos procesos de acumulación y liberación de energía, que no siempre se ajustan a ciclos perfectos; y 2) que tales procesos son independientes. Éste es el caso que nos ocupa, MX; ya que está demostrado por: 1) Guzmán Speziale y Gómez (2006) la diferenciación entre la actividad sísmica en las áreas del Occidente de los pares de placas Pacífico-Norteamérica, Cocos-Norteamérica y Cocos-Caribe; y 2) Lyon Caen *et al.* (2006) con medidas de GPS, en el trazo del sistema cuasi paralelo de fallas Polochic-Motagua, la diferencial cinemática de las placas Cocos-Norteamérica-Caribe.

Tabla 1: Selección de trabajos con contenido sismotectónico

Nº	(Año) Autor (es) / Medio	Título
1	(1988) González Ruiz J.R. y McNally K.C./ J.Geophys.Res., 96, 6.297-6.317.	Stress accumulation and release since 1882 in Ometepec, Guerrero, Mexico: Implications for failure and risk assessment of a seismic gap.
2	(1992) Suarez G. y Comte D./ En: Wadati Conference on Great Subduction Earthquakes, Sep-tember 16-17. Editores: D. Christensen *et al.,* 65-66 pp. Geophys.Inst. Univ. of Alaska, Fairbanks.	Comparative analysis of seismogenic coupling in Chile and Mexico: The role of the upper lithospheric thickness.
3	(1995) Kostoglodov V. y Bandy W./ J.Geophys.Res., 100, 17.977-17.989.	Seismotectonic constraints on the convergence rate between the Rivera and North American plates.
4	(1994) Zúñiga R. y Guzmán W./ Informe técnico, Seismic Hazard Project, del IPGH.	Main seismogenic sources in México.
5	(1997) Zúñiga R., Suárez G., Ordaz M. y García Acosta V. / Reporte Final. Capítulo 2: México. Centro Internacional e Investigaciones para el desarrollo. Otawa, Canada. Proyecto 89-0190. IPGH, 84 p.	Proyecto peligro sísmico en Norteamérica y el Caribe.
6	(1997) Montero P.W., Penaldo H.G. y Rojas Q.W./ Universidad de Costa Rica, Instituto Panamericano de Geografía e Historia, Centro Internacional de Investigaciones para el Desarrollo, y Centro de Coordinación para la Prevención de Desastres Naturales de América Central. 43 p.	Informe final del Proyecto de Amenaza Sísmica de América Central.
7	(1998) Ortiz M., Singh S.K., Pacheco J. y Kostoglodov V./ Geophys.Res.Lett., 25, 2.857-2.860.	Rupture length of the October 9, 1995 Colima-Jalisco earthquake (Mw 8) estimated from tsunami data.

8	(2005) Aguirre G.J., Nieto Obregón J. y Zúñiga F.R./ Geol.Jour., 40, 215-243.	Seismogenic basin and range and intra-arc normal faulting in the Central Mexican Volcanic Belt, Querétaro, México.
9	(2006) Kostoglodov V., Larson K.M. y Franco I./ AGU Fall Meeting Abstracts	Seismotectonics of Central Mexico subduction zone from cristal deformation studies.
10	(2008) Riquer Trujillo G., Williams Linere F., Lermo Samaniego J., Leyva Soneranes R., Neri Flores I. y Santamaría López J./ Soc. Mexicana de Ingeniería Estructural. XVI Congreso Nacional de Ingeniería Estructural, Veracruz, 14 p.	Ampliación de la red de registro sísmico basada en una regionalización sismotectónica preliminar del Estado de Veracruz.
11	(2016) Martínez López M.R. y Mendoza C./ Bol.Soc.Geol. Mexicana, 68(2), 199-214.	Acoplamiento sismogénico en la zona de subducción Michoacán- Colima-Jalisco, México.
12	(2016) Espinosa Rodríguez L.M., Hernández Santana J.R. y Méndez Linares A.P./ Minería y Geología, 32 (4), 91-109.	Evidencia geodésica de movimientos verti-cales recientes en la zona sismogeneradora de Acambay, México.
13	(2017) Zúñiga F.R., Suárez G., Figueroa Soto A., y Mendoza A. / J. of Seismology, 21(6), 1.295-1.322.	A first-order seismotectonic regionalization of Mexico for seismic hazard and risk estimation.

Eck y Stoyanov (1996) comprobaron que los límites político-administrativos en Bulgaria redujeron el alcance de las investigaciones sismotectónicas. Posteriomente, Radulian *et al.* (2000) estudiaron las zonas sismogenéticas en Rumanía e incluyeron datos de países vecinos. Guendel y Protti (1998) analizaron la Sismotectónica de toda América Central. DeShon *et al.* (2003) determinaron la sismogenésis de la zona del Pacífico entre Honduras y Costa Rica. Cotilla y Córdoba (2004) presentaron una interpretación sismotectónica para la Península Ibérica (España y Portugal). Molina *et al.* (2008) realizaron una amplia investigación de peligro y amenaza sísmica, con la correspondiente zonificación sismotectónica, de América Central (Costa Rica, El Salvador, Guatemala, Honduras, y Panamá). Meghraoui *et al.* (2016) presentan una colosal obra sismotectónica de África, que evidentemente sobrepasa los límites de territorios individuales. Éste es el caso de MX, ya que las regiones tienen, en sus áreas terrestres y marinas, una manifiesta heterogeneidad tectónica en cuanto a microplacas, bloques y zonas de deformación que se corresponde con 2 tipos de sismicidad. Este patrón se aviene con lo expuesto por England y Jackson (1989) y Gordon (1998).

Para MX algunos especialistas han realizado interesantes trabajos de tectónica (Alaniz Álvarez *et al.,* 2002) y morfotectónica, a diferentes escalas y para áreas y regiones diversas (Carranza Edwards *et al.,* 1975; Aguayo y Marín, 1987; Ortiz Pérez y Boceo, 1989; Ortiz *et al.,* 1993; Hernández Santana *et al.,* 1995, 2007, 2009; Ramírez Herrera y Urrutia Fucugauchi, 1999; Reyes Bache, 2004; Cotilla *et al.,* 2017). De ellos es factible comprobar que las estructuras están segmentadas y tienen algunas intersecciones importantes. También en el campo geofísico se ha determinado la segmentación de las estructuras (Bourgois y Michaud, 1991; Bandy, 1992; Londsale, 1995; Pushcharovsky, 2006). Esto significa que las líneas sismogenéticas no son muy extensas, ni regulares, tampoco homogéneas, ni completamente nacionales.

La segmentación de fallas activas tiene su principal antecedente en el trabajo de Wheeler y Krystinik (1827). Otros estudios como los de Krestnikov *et al.* (1983), Ikeda *et al.* (2009), y Stockmeyer *et al.* (2014) demuestran a partir de estudios geológicos y geofísicos, ambos en el sentido amplio de los términos, la limitación en la capacidad de generar eventos sísmicos máximos. Esto es aplicable al caso de MX.

d) Apuntes Sobre Geología-Tectónica

La preparación de un MS es un material que requiere un profundo estudio de muchos resultados en geología, geomorfología, y tectónica de otros especialistas; lo cual se puede constatar con las referencias indicadas. Esto, evidentemente, ha requerido mucho tiempo y esfuerzo, y la utilización de resultados publicados, correctamente referenciados, evitando duplicidades. Así aseguramos que las investigaciones geológicas y tectónicas, en el sentido amplio de los términos, permiten configurar una buena base para enfrentar la Sismotectónica de MX. Seguidamente relacionamos esos trabajos: Adamek *et al.* (1987), Álvarez (2002, 2007), Álvarez Gómez *et al.* (2008), Anderson *et al.* (1989), Antoine y Pyle (1970), Antonelis (1999), Arnaiz Rodríguez y Garzón (2012), Aubouin *et al.* (1982, 1984), Axen (1995), Bandy *et al.* (2005, 2011), Barckhausen *et al.* (2001), Bartolomé *et al.* (2016), Batllori Sampedro *et al.* (2006), Beck y Ruff (1989), Bergantino (1971), Blackell y Richards (2004), Bryant *et al.* (1968), Buffler *et al.* (1979), Burbach *et al.* (1984), Burkart (1978, 1983), Burkart y Deaton (1987), Burkart y Self (1985), Campa (1978), Campa Uranda (1984), Campa y Coney (1983), Campos Enriquez y Sánchez Zamora (2000), Chen y Clayton (2012), Coney (1983), Correa *et al.* (2009), Couch y Woodcock (1981),

Cserna (1984), Coyan *et al.* (2013), Cruz Carrillo (2002), Dañobeitia *et al.* (1997, 2016), Delgado *et al.* (1997), Demant (1978, 1984), DeMets (2001), DeMets y Stein (1990), DeMets y Traylen (2000), DeMets y Wilson (1997), DeMets *et al.* (2007), Dengo (1985), Díaz y Mooser (1972), ERN-CAPRA (2007), Fernández (2002), Ferrari (1995), Ferrari y Rosas Elguera (2000), Ferrari *et al.* (1992), Fisher (1964), Fletcher y Munguia (2000), Frez y González (1991), Garrison y Martín (1973), Gordon y Muehlberger (1994), González Torres (2005), Gusiakov (2002), Gutiérrez *et al.* (2015), Guzmán *et al.* (1989), Guzman Speziale (2001, 2010), Guzmán Speziale y Meneses Rocha (2000), Guzmán Speziale y Gómez (2006), Guzman Speziale *et al.* (1989, 2006), Hamilton (1961), Heil y Silver (1985), Iida *et al.* (1967), Johnston y Thorkelson (197), Khutorskoy *et al.* (1994), Klitgord y Mammerickx (1982), Molina (1997), Kostoglodov y Ponce (1994), Leon Soto *et al.* (2009), Llata Romera (2011), López Ramos (1983), Luhr *et al.* (1985), Lyon Caen *et al.* (2006), Manea y Manea (2011), Manea *et al.* (2005), Mann y Burke (1984), Mann y Corrigan (1990), Mann *et al.* (1981), McNally y Minster (1981), Menard y Fisher (1958), Mercier de Lepinar *et al.* (1997), Meschede y Barckhausen (2000), Michaud *et al.* (1996, 2000, 2001, 2005), Minsihull *et al.* (2005), Morán (1984), Morán *et al.* (2005), Moore y Buffngton (1968), Moore y Castillo (1974), Moore *et al.* (1982, 1985), Mueller y Rockwell (1995), Nieto Samaniego *et al.* (2005), Norini *et al.* (2006), Normark y Curray (1968), Nunn (1985), Núñez Cornú *et al.* (2016), Ortega Gutiérrez *et al.* (1992), Padilla Sánchez (2007, 2013), Pardo y Suárez (1993, 1995), Peláez Gaviria *et al.* (2013), Pérez Campos *et al.* (2008), Petersen (1976), Pindell J., y Kennan (2001), Plafker (1976), Plattner *et al.* (2009), Ponce *et al.* (1992), Protti *et al.* (1994), Ramos Zúñiga *et al.* (2012), Quintero y Guendell (2000), RESIS II (2008), Rojas *et al.* (2012), Rosencratz (1990), Rosenblueth *et al.* (1989), Ross y Scotese (1988), Sandoval (1985), Sedlock *et al.* (1993), Selvans *et al.* (2011), Serpa *et al.* (1989), Serrano Díaz *et al.* (2004), Servicio Oceanográfico Nacional (2009), Shubert y Cebull (1984), Silver *et al.* (1990), Soloviev y Go (1975), Stefan *et al.* (1988), Stock *et al.* (1993), Suarez (2013), Suárez y López (2011), Suter (1987), Suter *et al.* (1992, 2001), Tolson (2005), Urbina y Camacho (1913), Urrutia Fucugauchi y Castillo (1977), Watkins *et al.* (1982), Wdowinski (1998), *World Stress Map* (2016), Zoback (2012), y Zúñiga y Guzmán (1994).

Los países en el margen del Pacífico americano, tienen relación directa con los límites tectónicos del sistema de placas Caribe-Norteamérica-Cocos-Nazca y de la microplaca Rivera (Figura 1). Ellos son parte del "Cinturón de Fuego del Pacífico". En ese margen hay significativas diferencias en la morfología e hipsometría del relieve, las velocidades relativas de movimiento, los niveles de actividad sísmica y volcánica, y los tipos de fuentes sismogenéticas (de interior de placas y de entre placas). En la figura 3 de Demant (1978) se aprecian la geometría, la configuración y los elementos principales del entorno tectónico contemporáneo de MX. Destacamos de ella la posición, el contacto geo-dinámico de las placas Cocos y Caribe y la configuración arqueada de América Central (al S de Chiapas y hasta Panamá).

La fosa Mesoamericana [FM] es una estructura deprimida, relativamente estrecha, y sísmicamente activa que se extiende a lo largo de la costa del Océano Pacífico desde Nayarit-Puerto Vallarta (en MX) hasta el S de Chile. Aquí hay diferentes velocidades de convergencia entre los sistemas de placas Rivera-Norteamérica, Cocos-Norteamérica, Cocos-Caribe, y Cocos-Nazca-Suramérica (Figuras 4 y 5). En ese entorno, cuasi-lineal se distinguen cadenas de montañas en las partes emergidas, fosas y depresiones submarinas y volcanes. Así, se aprecia la diversidad de las zonas de subducción con sus perfiles de Wadati-Benioff [W-B], que están asociadas con la actividad y el peligro. Esa actividad se refiere a los terremotos (Tabla 2), tsunamis y volcanes. La frecuencia de ocurrencia en ese periodo de eventos con $M \geq 6{,}4$ es de 1,4.

La zona de subducción de MX es una franja inmediata a la costa del Pacífico y parte de la FM. Ella está definida no sólo por la geometría batimétrica, la localización de las cadenas volcánicas sino también por la actividad sísmica. En general, la zona de W-B destaca por su diferente buzamiento (ángulos de 50^{o}-70^{o}), y profundidades de los hipocentros de hasta >200 km, en el continente. Entre Nayarit y Chiapas (de N a S), se diferencia por la: 1) edad estimada (en 10^{6} de años) de 8 a 15; y 2) forma de su eje central que cambia de cóncavo a lineal a cóncavo (Figuras 1 y 5).

Tabla 2: Terremotos en México de 2000-2017 (M≥ 6,4)

Nº	Fecha	M / h (km)	Coordenadas (N / O)	Nº	Fecha	M / h (km)	Coordenadas (N / O)
1	2000.08.09	7,0/ 9	17,94 / 102,71	13	2012.03.20	7,4/ 16	16,25 / 98,52
2	2001.05.19	6,5/ 20	18,27 / 105,72	14	.04.11	6,4/ 16	17,90 / 103,06
3	2003.01.21	7,6/ 10	18,22 / 104,60	15	.12	6,8/ 10	28,78 / 113,43
4	2006.01.04	6,7/ 10	28,10 / 112,07	16	.11.07	7,3/ 16	14,08 / 93,32
5	2008.02.12	6,6/ 90	16,19 / 94,54	17	2014.04.18	7,2/ 10	17,18 / 101,19
6	.09.23	6,4/ 42	17,16 / 105,16	18	.05.08	6,4/ 17	17,11 / 100,87
7	.10.26	6,6/ 23	13,87 / 92,50	19	.07.07	6,9/ 60	14,75 / 92,63
8	2009.08.03	6,9/ 10	28,48 / 112,24	20	.29	6,4/ 117	17,70 / 95,63
9	2010.04.04	7,2/ 10	32,54 / 115,36	21	2015.09.15	6,7/ 10	24,96 / 109,49
10	.10.21	6,5/ 8	24,62 / 109,43	22	.12.17	6,6/ 90	15,76 / 93,70
11	2011.04.07	6,7/ 167	17,20 / 94,34	23	2017.09.07	8,2/ 58	14,85 / 94,11
12	.12.10	6,5/ 58	17,84 / 99.98	24	.19	7,1/ 57	18,40 / 98,72

Totales: 6,4-6.9= 16; 7,0-7,9= 7; 8,0-8,2= 1

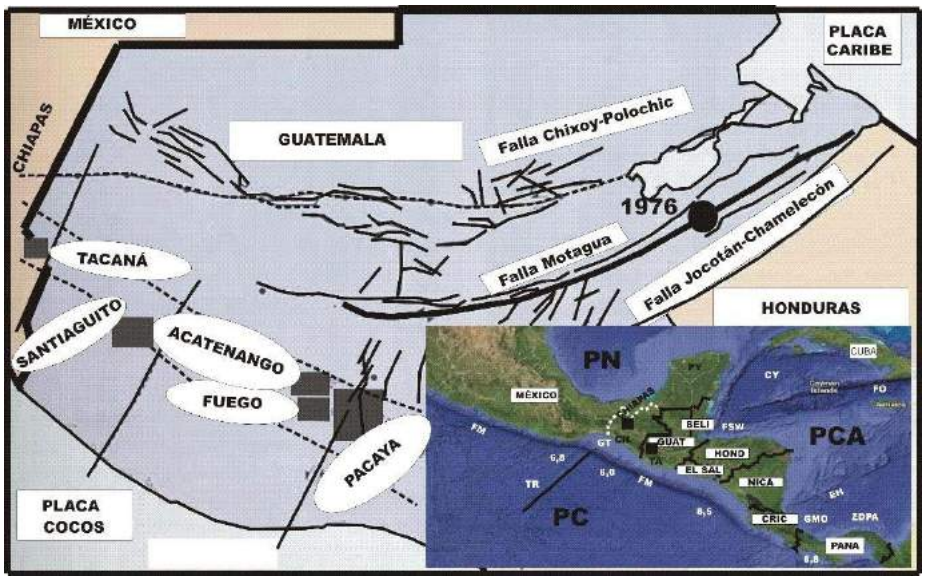

Figura 4: Región de Chiapas-Guatemala

Aparecen: **1)** Principales fallas y fracturas de Guatemala (líneas negras); **2)** Volcanes activos de Guatemala (rectángulos grises); **3)** Epicentro del terremoto del 04.02.1976 (M 7,6) (ver Tabla 3); y **4)** Recuadro: A) con los países, al S y E, de México (BELI= Belize, CRIC= Costa Rica, EL SAL= El Salvador, GUAT= Guatemala, HOND= Honduras, NICA= Nicaragua, y PANA= Panamá); B) Placas (PC= Cocos, PCA= Caribe, y PN= Norteamérica); C) Volcanes (CH= Chichón (Chiapas-México) y TA= Tacaná (Guatemala), indicados con cuadrados negros); D) velocidad relativa (cm/año); y E) Lugares (CY= Cuenca de Yucatán, EH= Escarpe de Hess, FM= Fosa Mesoamericana, FO= Fosa Oriente, SW= Falla Swan, GMO= Golfo de los Mosquitos, GT= Golfo de Tehuantepec, PY= Península de Yucatán, TR= Tehuantepec Ridge, y ZDPA= Zona de deformación de Panamá).

La placa Pacífico abarca la mayor parte del Océano homónimo (Figura 1). En la parte E limita con las placas de Norteamérica (donde está MX) y de Suramérica. En algunos de sus segmentos se definen microplacas (ejemplos: Juan de Fuca, Gorda y Explorador y que están asociadas con la falla de San Andrés). También se configura la cadena volcánica Cascadia, y más al S, de la Península de California, aparecen la microplaca Rivera, la placa Cocos (3.10^6 km^2), y la placa Nazca. Estas 3 últimas son restos de la placa Farallón (23.10^6 años). Las 2 primeras subducen bajo la placa norteamericana y se vinculan con la Cadena Volcánica Trans-mejicana (o Eje Neovolcánico [ENV]) (Figura 6). La microplaca Rivera, ubicada al N de la placa Cocos, se separó de ésta hace $5\text{-}10.10^6$ años y se desplaza con una velocidad relativa de unos 2,5 cm/año, y la placa Cocos con 5 y 8 cm/año cerca de Manzanillo y en Tehuantepec, respectivamente. Además existe una importante disminución de la velocidad relativa de convergencia, entorno a la Cuenca de Manzanillo, de 2-6 cm/año. La zona marina, al S del Golfo y la Península de California y el NO de Puerto Vallarta, tiene un importante cambio estructural, donde hay 3 sistemas de fallas del tipo: 1) transcurrente; 2) inverso (subducción asociada a la FM); y 3) normal (transversal a los anteriores y que se corresponde con el graben de Vallarta). Esta zona es un elemento excepcional y único para la comprensión geodinámica

de la región. También en el entorno de MX hay otras 3 importantes zonas tectónicas relacionadas con la intersección de grandes estructuras, los Puntos Triples de las placas: 1) Pacífico-Norteamérica (Cerro Prieto-Laguna Salada-Golfo de California); 2) Norteamérica-Cocos-Rivera (Baja California-Puerto Vallarta); y 3) Caribe-Cocos-Norteamérica (en Chiapas-Guatemala) (Figuras 1, 4 y 6). La primera intersección (Punta Borrascosa) corresponde a la bifurcación de la falla sismogenética de San Andrés en un sistema cuasi paralelo de 3 fallas activas (Cerro Prieto, Amado y Wagner). A este sistema le denominamos Fracturas del Golfo. A menor escala existe una intersección de estructuras en Colima-Laguna de Chapala-Tepic-Zacoalco (Figura 6). Estas últimas son de menor categoría y actividad. Aquí el punto triple se configura con 3 estructuras tipo graben, y direcciones NO-SE (Tepic-Zacoalco), E-O (Chapala), y N-S (Colima). El primer y tercer graben tienen volcanes activos (Sanganguey, Ceboruco y Colima). Todas estas estructuras se vinculan con fallas de tipo normal, la mayoría inactivas en la etapa actual de acuerdo con nuestros datos. No obstante, se considera que atendiendo a la estructura y la disposición espacial de los graben, en las inmediaciones de la laguna de Chapala (Figura 7), hay un tensor resultante del proceso de interacción con dirección ENE. Esa dirección se corresponde con la convergencia de las placas.

El límite del S de MX (entre las placas de Norteamérica y del Caribe, está acompañado por la placa Cocos) (Figura 4), mencionado anteriormente, está dado por 3 sistemas de fallas cuasi paralelas (Chixoy-Polochic, Motagua, y Jocotán-Chamelecón) localizadas, principalmente, en la parte continental de Guatemala. Ellas aunque tienen una misma dirección aproximada E-O y ser de tipo transcurrente, demuestran actividad sísmica muy distinta. En particular la falla Motagua se asocia al terremoto del 04.02.1976 (M 7,9/ h 5 km/ Intensidad de 9 grados/ 22.870 muertos, 76.504 heridos, y $>1.10^6$ damnificados), y considera tiene relación al E con la falla activa Swan. La falla del Polochic no tiene relación aparente con la falla Motagua. Su trazo en el relieve es continuo hasta alcanzar Chiapas donde se divide en 2 segmentos; aunque Authemayou *et al.* (2012) sostiene que es activa. Mientras que la falla Jocotán no tiene actividad sísmica reconocida, pero se describe muy bien por segmentos como tipo falla normal. También se ha determinado, con medidas de GPS, un movimiento relativo (de 1,7 cm/año) entre las mencionadas placas y que la velocidad disminuye hacia el Pacífico. Sin embargo, Authemayou *et al.* (2011) sostienen que en la intersección de 3 las placas se configura un gran punto triple activo (su figura 1), con un modelo de tipo "*pull-up and zipper",* para el sistema de fallas Polochic-Motagua. Con anterioridad, Cotilla y Udías (1999) propusieron para la región un modelo geo-dinámico que contenía un sistema de bloques y zonas sismoactivas. En él se indicaba el importante campo tensional del área de interacción geodinámica de las placas Caribe-Norteamérica-Cocos; y consideraron sólo la sismoactividad de la falla Motagua y su relación lateral con la falla Swan. Esta falla Swan ha tenido una actividad reciente (09.01.2018) con un sismo de M 7,6 / h 10 km / 17,469 N 83,52 O (USGS). El evento ha sido el mayor registrado hasta la fecha en ella; sin embargo, sólo fue percibido en la zona de Quintana Roo, sin daños materiales.

e) Volcanes

Desde el punto de vista tectónico y geo-dinámico resulta muy útil la evaluación de los mapas de: 1) Anomalías de Bouguer Total, escala 1:5.000.000 (la figura 4 de Arnaiz Rodríguez y Garzón, 2012), donde están bien delimitadas las grandes estructuras tectónicas en el entorno 100º/ 50º O y 5º/ 30º N. Aparece la zona continental de América del Norte-México-América del Sur con los valores mínimos que se relacionan con la subducción; mientras que la placa Cocos alcanza un máximo de ~279-340 mGal y se asegura que es joven; y 2) Flujo de Calor de la Corteza, en el sector de MX, que muestra una significativa diferenciación entre la zona Norte-Central, hasta las inmediaciones de Manzanillo y el ENV, con respecto al S de la mencionada Cadena hasta Oaxaca-Chiapas-Yucatán. También en el mapa del espesor continental de Norteamérica se distingue una distribución transversal con incremento al E.

Además, se valoraron otros estudios sobre los sistemas volcánicos: Meyer Abich (1956), Mina (1972), Mooser (1972), Carr y Stoiber (1973), Stoiber (1973), Stoiber y Rose (1974), Cruz y Wyss (1983), Hauback (1984), Lugo *et al.* (1985), Verma (1985), Allan (1986), Johnson y Harrison (1989), Delgado Granados (1993), Fidel Smoll *et al.* (1997), Garduño Monroy *et al.* (1998), Ego y Ansan (2002), CENAPRED (2001), Fisher *et al.* (2003), Husen *et al.* (2003), Macías *et al.* (2003), García Palomo *et al.* (2004), Cox *et al.* (2008), Ferrari *et al.* (2012), y Clemente *et al.* (2013). De ellos se identifica y confirma que en la zona costera continental americana la presencia de una extensa cadena volcánica, que está asociada directamente con la subducción en la FM. Ahí la placa que subduce lo hace con distinto ángulo, profundidad, actividad en diferentes segmentos de la línea de costa y edad. Existe también otro conjunto volcánico activo, pero con dirección transversal (el ENV), y que no es paralelo a la trinchera, aunque su morfología y disposición espacial puede vincularse a la subducción de la microplaca Rivera (Figura 5). Este ENV (L= 900 km, A= 120-130 km, Hmed= 2.500 m) tiene entre sus volcanes a 4 estructuras relacionadas con la neotectónica (altitud (m)/ año última actividad): Ceboruco (2.280/1875), Colima (3.880/2016), Nevado de Colima (4.250), y Popocatépetl (5.550/2016). La

figura 40 de CENAPRED (2001) expone que son 7 los volcanes con mayor peligrosidad en MX (Ceboruco, Colima, El Chichón (1.315/1982), Popocatépetl, Pico de Orizaba (3.690/1858), San Martín de Tuxla (1.650/1796), y Tacaná (en el S de Chiapas: 4.067/1986)).

Seguidamente relacionamos otros volcanes de MX atendiendo a 2 características (altitud (m)/ año de última erupción): (Barcena (332/1953), Citlaltépeti (5.767/1846), El Jorullo (1.330/1967), Jocotitlan (3.900/1.270), Michoacán-Guanajuato (3.860/1952), Paricutin (2.800/1952), Pinacate (2.800/1952), San Andrés Tuxla (en las inmediaciones del GM: 3.690/1858), Socorro (1.050/1993-94) y Tres Vírgenes (1.940/2011): en la Península de California (superficie de 143.600 km^2 (L= 1.400 km, A= 70 km)), en la Sierra homónima (Figura 8)). En la figura 1 de Pardo y Suárez (1995) aparece la relativa interrupción de las cadenas volcánicas en la parte continental del S de MX y Guatemala.

Dean y Drake (1978) aseguran que: 1) la fractura de Tehuantepec afecta a la FM, divide a la placa Cocos, y se extiende en la zona continental hacia Chiapas; y 2) la zona de subducción está dividida, sucesiva y lateralmente, en segmentos de 100-300 km. Sandoval (1985) determina que los principales rasgos morfotectónicos del talud interior de la FM se continúan al interior continental, como la falla Tecpan (en Guerrero), por más de 300 km. También que en la zona costera, y en las inmediaciones de la localidad de Manzanillo, está el graben El Gordo (dirección SSO-NNE), que se asocia espacialmente con el comentado graben de Colima (dirección S-N), donde hay volcanes. Además, hay una importante actividad sísmica (09.10.1995) incluidos tsunamis en Manzanillo. Todos esos elementos lineales estarían en la zona límite de placas Pacífico-MX).

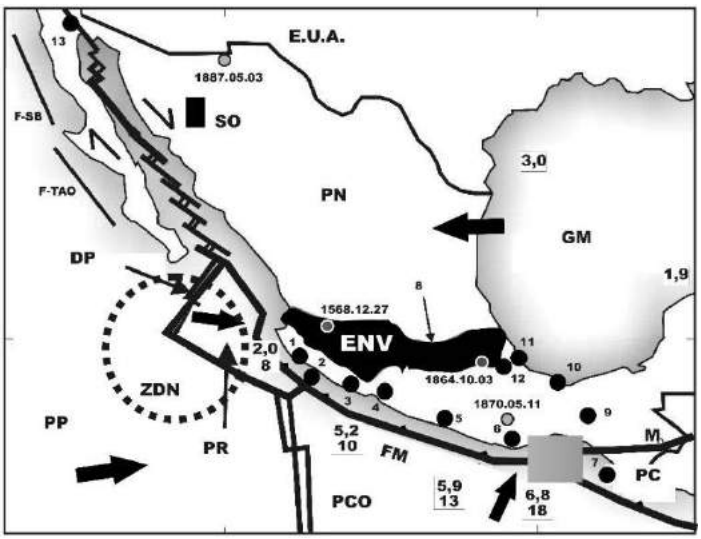

Figura 5: Principales placas

Aparecen: **1)** Placas (PC= Caribe, PCO= Cocos, PN= Norteamérica, PP= Pacífico, y PR= Rivera); **2)** Elementos (DP= Dorsal del Pacífico, ENV= Eje Neovolcánico, E.U.A.= Estados Unidos de Norteamérica, FM= Fosa Mesoamericana, F-SB= Falla de San Benito, F-TAO= Falla Tosco-Abreojos, GM= Golfo de México, M= Motagua, SO= Sonora (rectángulo negro) y ZDN= Zona de deformación neotectónica (círculo de puntos negros); **3)** Sentido de movimiento de las: (A) placas (flechas negras gruesas), B) fallas (flechas negras finas)); **4)** Fallas y fracturas (líneas negras); **5)** velocidad relativa de movimiento (cm/año) y edad (10^6 años) aparecen en un cuadrado; **6)** Epicentros de terremotos: A) (circulo negro y número asociado [1= 1995.10.09 (M 8/ tsunami/ 49 muertos-200 heridos), 2= 2003.01.21 (M 7,6/ 20 muertos-290 heridos), 3= 1985.09.19 (M 8,1/ 9.500 muertos), 4= 1985.09.21 (7,6), 5= 2012.03.20 (M 7,4/ 2 muertos-14 heridos), 6= 1999.09.30 (M 7,4), 7= 2017.09.07 (M 8,2), 8= 2017.09.19 (M 7,1), 9= 1902.09.23 (M 7,8), 10= 1959.08.26 (M 6,4), 11= 1973.08.28 (M 7,3/ 1.200 muertos), 12= 1920.01.03 (M 8,0/ >650 muertos), 13= 2010.04.04 (M 7,2/ 4 muertos)]); B) 4 históricos con I= X grados (circulo gris y fecha asociada) ver Tablas 6 y 7); y **7)** Zona de intersección tectónica Chiapas-Guatemala (rectángulo gris), que incluye al volcán Tacaná. En este entorno está el sismo del SO de Tapachuela, Chiapas (frontera Guatemala-México) del 07.07.2014 (M 6,9/ h 56 km/ 14,65 N 92,56 O/ >250 réplicas).

Al S de MX, en el segmento Chiapas-Guatemala-Caribe, hay una relativa interrupción en el relieve del sistema montañoso continental (en cuanto a los niveles hipsométricos). Aquí el acoplamiento de las placas Caribe y Cocos es relativamente suave, y esta última se hunde con un ángulo menor, por lo que la zona de W-B es más superficial. Mientras que para el segmento de América Central, donde el arco volcánico, hay un mayor buzamiento de la zona W-B de 60°-80° con dirección NE, e hipocentros de hasta 200 km. A lo largo, de la costa, para esa subducción se identifican varios segmentos de hasta 300 km y se aprecian importantes diferencias en el rumbo y el buzamiento en esos planos. Esto se corresponde con los mecanismos focales determinados a distintos rangos de profundidad. Así, en los primeros 10 km hay fallas de tipo normal, que pasan al tipo inverso a 15-50 km. Evidentemente, esto es un marco tectónico activo complejo.

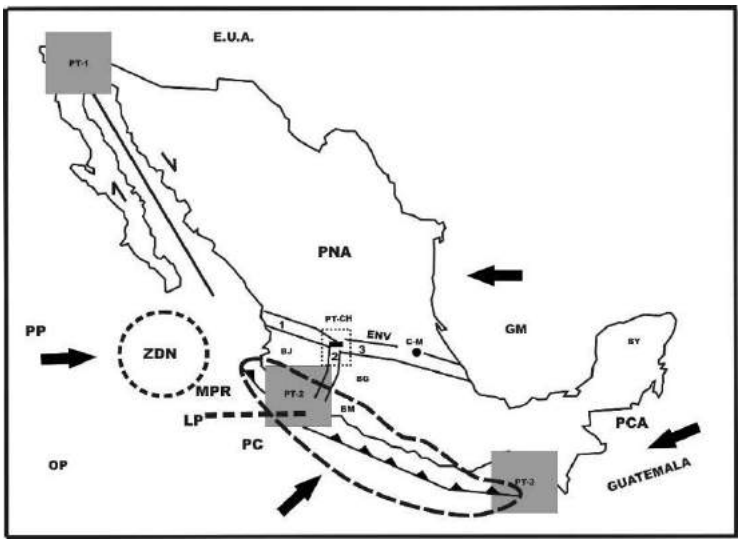

Figura 6: Esquema de las zonas tectónicas significativas

Aparecen: **1)** Lugares (C-M= Ciudad de México, ENV= Eje Neovolcánico, E.U.A.= Estados Unidos de América, GM= Golfo de México, LP= Límite de placas, y OP= Océano Pacífico); Placas (PCO= Cocos, PC= Caribe, PN= Norteamérica, PP= Pacífico, y MPR= Microplaca Rivera); **2)** Sentido de movimiento de las placas (flechas gruesas negras); **3)** Zona de deformación neotectónica (ZDN: circulo con puntos); **4)** Punto Triple (A) cuadrado gris (PT-1= Cerro Prieto-Laguna Salada (Punta Borrascosa), PT-2= California-Vallarta y PT-3= Chiapas-Guatemala), y B) rectángulo de puntos con rectángulo negro en el centro (PT-CH= Chapala. Ver Figura 7); **5)** Graben (1= Tepic-Zacoalco, 2= Colima, y 3= Chapala); **6)** Zona epicentral significativa (elipse con línea discontinua); y **7)** Zona de subducción (línea negra con triángulos), y 10) Fracturas y fallas del Golfo de California (con sentido de movimiento relativo).

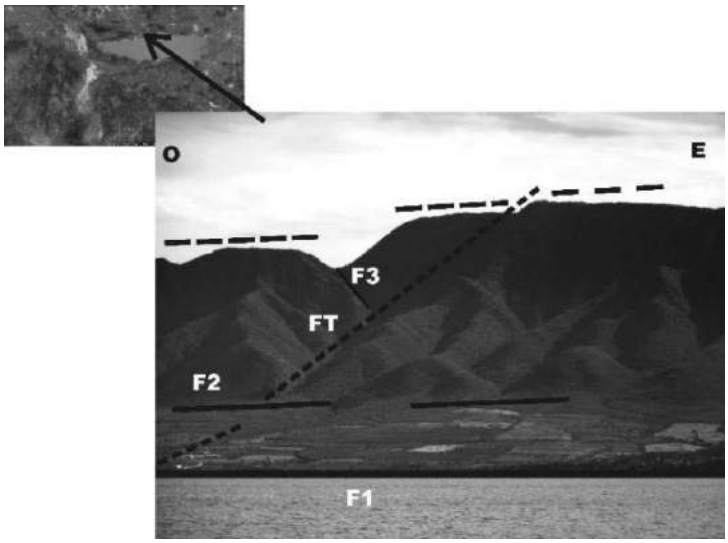

Figura 7: Laguna de Chapala

En la combinación fotográfica de la Laguna de Chapala, dentro del Eje Neovolcánico, aparecen indicados: **1)** parte de los niveles hipsométricos máximos escalonados (líneas largas discontinuas negras); y **2)** sistema de fallas y fracturas (líneas continuas y discontinuas cortas negras, con letras en blanco) determinado y cartografiado por Cotilla *et al.* (2017), ver Figura 6. La Laguna y su entorno montañoso aledaño forman parte del mesobloque activo Guadalajara. Esta región pertenece a la zona sísmica B (ver Figura 10).

Como se comentó, para el caso de MX, el territorio de América Central también se divide en segmentos tectónicos sobre la base de la distribución y posición de las alineaciones volcánicas activas. Esa zonación de 7 partes se corresponde con la morfología y disposición de los volcanes, el patrón de las fallas recientes, la existencia de alineaciones transversales y la ocurrencia de terremotos someros. En ellos se aprecian rupturas diversas de las placas de subducción. La situación tectónica resulta mucho más compleja al E de la Cresta de Panamá, donde aparece la zona de Fracturas de Panamá (Figura 1). Esta zona limita las placas oceánicas Cocos y Nazca y tiene mecanismos focales de tipo transcurrente. En ese marco, la segunda placa penetra con ángulo de buzamiento suave y oblicuamente en la fosa de Panamá, y hacia la placa de Suramérica. Esto se visualiza con la morfología, la hipsometría y la distribución del relieve en la región continental.

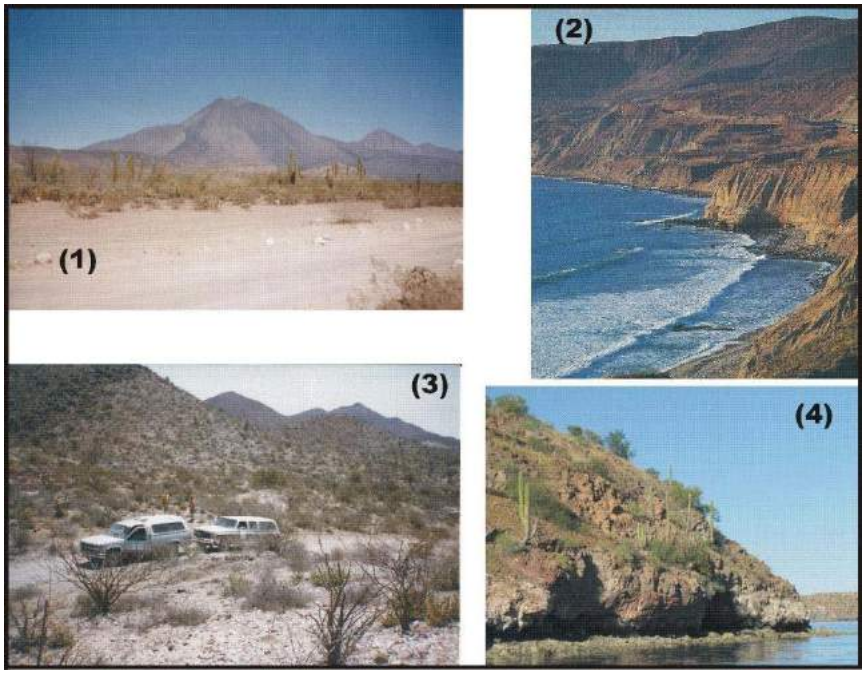

Figura 8: Vistas de la Península de California

Las fotografías muestran 4 áreas diferentes en la Península de California (**(1)**= volcán Tres Vírgenes (1.940 m / año de la última actividad 2011); **(2)**= costa abrupta del Pacífico en Ensenada; **(3)**= alineación montañosa N-S del desierto, con depósitos aluviales, en las inmediaciones de Punta Francisquito; y **(4)**= pendiente rocosa >40^{o} orientada al SE, y en contacto directo con el Golfo de California (ver Figuras 2, 5, y 6). Las zonas sísmicas B, C y D incluyen a estas áreas (ver Figura 10)).

Respecto de la complejidad tectónica mencionada se conoce que en esa parte marina se distinguen algunos otros elementos morfológicos diversos como: sierras y elevaciones montañosas oceánicas (ejemplos: la Cresta de Cocos y los Montes de Fisher). A partir de ellos, se asegura que son los responsables de las modificaciones de los planos de subducción; ya que constituyen "asperezas". También se sostiene que la profundidad de los terremotos entre Costa Rica y Panamá es inferior a 70 km, y que el plano subducción es de ~60^{o}. No obstante, los terremotos de interior de placa se localizan en profundidades superiores a 50 km y tienen fallas normales.

Una somera comparación entre MX y otros países americanos del Pacífico aparece en la tabla 3. En ella hay datos de superficie, población, actividad sísmica, volcanes, y tsunamis. Seguidamente, relacionamos algunos volcanes del arco volcánico del Pacífico (al S de MX). Ese segmento tectónico es mucho más activo y con mayor cantidad de volcanes (altitud (m)/ año de la última erupción). Así por países están 49 estructuras volcánicas activas: 1) *Chile (11)* (Caibuco (2.015/2015), Chaitén (962/2008-09), Chiliques (5.778/2003), Copahue (2.997/2012-14), Cordón Caulle (2.240/2011), Hudson (1.950/2011), Llaima (3.125/2008-09), Nevado de Chillán (3.122/2016), Planchín (3.977/2010), Puyehue (2.240/2011-12), y Villarrica (2.847/2015)); 2) *Costa Rica (5)* (Arenal (1.670/2010), Irazú (3.432/1994), Poás (2.708/2017), Rincón de la Vieja (1.916/2018), y Turrialba (3.340/2018)); 3) *Ecuador (8)* (Chiles (4.756/1936), Cotopaxi (5.897/2015), Pichincha (4.784/1999), Reventador (3.562/2007), Sangay (5.280/2007), Sumaco (3.990/1933), Tungurahua (5.023/2014), y Wolf- Islas Galápagos (1.707/2015)); 4) *El Salvador (5)* (Izalco (1.965/1966), San Miguel (2.130/2013), San Salvador (1.850/1917), San Vicente (2.173/2009), y Santa Ana (2.382/2005)); 5) *Guatemala (5)* (Acatenango (3.976/1972), Fuego (3.763/2015), Pacaya (2.552/2010), Santiaguito (2.500/2016), y Tacaná (4.092/1986)); 6) *Nicaragua (7)* (Cerro Negro (728/1999), Concepción (1.610/2007), Masaya (635/2003), Momotombo (1.297/2015), Momotombito (390/1998), San Cristóbal (1.745/2012), y Telica (1.061/2011)); 7) *Panamá (2)* (Barú (3.474/1550), y La Yeguada (1.297/1620)); y 8) *Perú (6)* (Huaynaputina (4.850/1600), Misti (5.822/1985), Sabancaya (5.967/2016), Tutupaca (5.815/1902), Ubinas (5.672/2016), y Yucamane (5.550/1802)).

Tabla 3: Datos de Países del Pacífico Americano al Sur de México

Nº	País	Superficie (km^2)/ Población (aproximadas)	Mmáx / h (km) / fallecidos	Volcanes/ Tsunamis
1	El Salvador	21.10^3/ 733.10^4	8,1/ 25/ 400	22/ 3
2	Chile	756.10^3/ $17,6.10^6$	9,6/ 35/ 1.655-2.000	~500/ 35
3	Costa Rica	51.10^3/ $4,9.10^6$	7,6/ 10/ 125	17/ 15
4	Guatemala	109.10^3/ $17,4.10^6$	7,9/ 60/ 22.870	37/ 5
5	Honduras	$112,5.10^3$/ $911,5.10^4$	7,3/ 10/ 7	4/ 7
6	Nicaragua	62.10^5/ $130,4.10^3$	7,9/ 45/ 22.870	21/ 8
7	Panamá	$75,5.10^3$/ $4,1.10^6$	7,9/ -/ 5	3/ 4
8	Perú	$1,3.10^6$/ 32.10^6	8,4/ 33/ 240	~400/ 123

f) Relieve y Neotectónica

En la revisión bibliográfica realizada también se ha valorado un amplio conjunto de resultados sobre el relieve y la neotectónica de MX de los que destacamos 32 (período 1920-2013) (Tabla 4) y que, evidentemente, sirven de base a nuestros estudios. Así, puede asegurarse que: 1) existe una importante variación del relieve donde se reconoce un conjunto de 15 provincias fisiográficas (Figura 9). En ellas hay 73 sub-provincias; 2) el sistema orográfico puede resumirse en: un conjunto de 3 llanuras (Costera del Pacífico, Costera del Golfo, y de la Península de Yucatán), una altiplanicie (mejicana), una depresión (Balsas), y un grupo de 6 cadenas-sierras montañosas (Baja California, Madre Occidental, Madre Oriental, Madre del Sur, Chiapas, y Volcánica Transversal). Además, se considera que la diferenciación longitudinal y transversal de los sistemas montañosos se relaciona con la transmisión de esfuerzos desde las zonas de placas; 3) las líneas de costa occidental (I-IV) y oriental son heterogéneas y con áreas basculadas (V-IX) (Figura 1); 4) hay una cronología diferencial de terrazas marinas en las costas del occidente y del oriente; y 5) el sistema fluvial de superficie tiene una diferente organización y dimensión con 3 cuencas o vertientes principales (Occidental, Oriental e Interior (situada entre las 2 anteriores, pero de mucha menor dimensión)). En este sentido se ha generalizado y representado una divisoria principal de primer orden de aguas de superficie que divide a MX en sentido longitudinal, y con manifiesta asimetría al Océano Pacífico (Figura 9).

Comparando las figuras de las Provincias Geológicas con las Regiones Fisiográficas se constata una relación unívoca en cuanto a la disposición de sus zonas y sectores. Esto es importante, porque se aprecia en ellas la influencia del sistema de placas sobre el territorio mexicano. De hecho esto último también se reconoce implícitamente en: 1) el patrón de la sismicidad instrumental (Figura 7); y 2) el mapa de Regiones Sísmicas (Figura 10). Otra característica del relieve de MX es la brusca interrupción del sistema de zonas y regiones en las inmediaciones del ENV (Figura 9). Ese sistema tiene dirección N-S y está formado por 7 zonas (Llanura Costera del Pacífico, Sierra Madre Occidental, Sierras y Llanuras del Norte-Mesa del Centro, y Grandes Llanuras de Norteamérica-Llanura Costera del Golfo Norte).

En particular la actividad neotectónica vertical se evidencia en la costa de Pacífico mexicano (Woods, 1980), donde hay diversos y variados conjuntos de terrazas marinas emergidas (ejemplo: el Golfo de California). En él, Ortlieb (1978) determinó allí un sistema con altitudes de 3-130 m. En la zona de Puerto Vallarta distinguimos Punta Mita, Farallón, Tecuán, y Manzanillo; y en Oaxaca están Punta Maldonado, Brisa Zicatela, Santa Elena, y Coyote. Ese tipo de estructuras también ha sido identificado y estudiado por Ramírez Herrera y Urrutia Fucugauchi (1999), y Ramírez Herrera (2011).

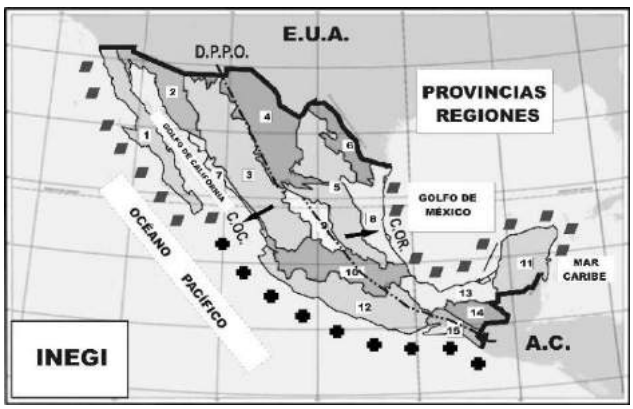

Figura 9: Esquema de las regiones de México

Aparecen: **1)** Lugares (A.C.= América Central, y E.U.A.= Estados Unidos de Norteamérica); **2)** Divisoria Principal de Primer Orden [D.P.P.O.] (líneas cortas negras y puntos); **3)** Sentido del escurrimiento superficial (flechas negras) [C.OCC.= Cuenca Occidental, C.OR.= Cuenca Oriental]; **4)** zonas de impacto de tsunamis de Fuentes (Lejanas (diamante de color gris), y Locales (cruz gruesa negra)); y **5)** Provincias fisiográficas del I.N.E.G.I. (1= Península de la Baja California. 2= Llanura Sonorense, 3= Sierra Madre Occidental, 4= Sierras y Llanuras del Norte, 5= Sierra Madre Oriental, 6= Grandes Llanuras de Norteamérica, 7= Llanura Costera del Pacífico, 8=Llanura Costera del Golfo Norte, 9= Mesa del Centro, 10= Sierra Volcánica Transversal (Eje Neovolcánico), 11= Península de Yucatán, 12= Sierra Madre del Sur, 13= Llanura Costera del Golfo Sur, 14= Sierra de Chiapas y Guatemala, y 15= Cordillera Centroamericana). Se aprecia que las zonas tienen un arreglo lateral sucesivo con relación al Océano Pacífico, salvo la Nº 10.

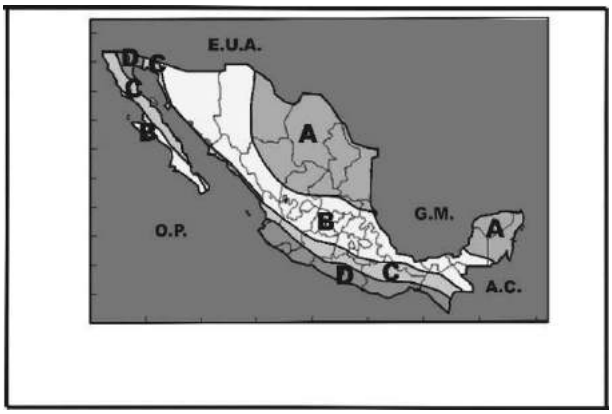

Figura 10: Regiones sísmicas de México

Aparecen: **1)** Lugares (A.C.= América Central, E.U.A.= Estados Unidos de América, G.M.= Golfo de México, y O.P.= Océano Pacífico); y **2)** Regiones de SGM (2017) (nivel-categoría: A= Bajo, B= Medio, C= Alto, y D= Muy alto). La observación realizada en la figura 9 se comprueba también en ésta, el arreglo lateral y sucesivo de las zonas con respecto al Océano Pacífico.

Como se dijo en la Introducción, MX tiene una extensa línea de costa, y ha sido dividida en regiones por Lanza Espino *et al.* (2003) en un conjunto de segmentos (5 en el GM-Mar Caribe, y 9 en la parte del Pacífico). La macro-región del Pacífico además de ser más extensa resulta mucho más compleja que la Oriental. En esa línea se distingue el principal cambio de estilo tectónico regional de MX, en las inmediaciones de Nayarit-Puerto Vallarta, donde el ENV, que pasa de transcurrente (Península de California) a subducción (al S de Nayarit). En ese segmento se ha determinado una zona de deformación neotectónica (Cotilla *et al.,* 2017) (Figuras 1, 5, y 6).

Tabla 4: Estudios sobre el relieve y la neotectónica

Nº	(Año) Autor (es) / Medio	Título
1	(1920) Wittich E./ Bol.Soc.Mex. de Geografía y Estadística, 8, 128-140.	Morfología y origen de la Mesa Central de México.
2	(1941) Ordoñez E./ Revista Geográfica, IPGH, 1(2-3), 1-49.	Las provincias fisiográficas de México.
3	(1961) Álvarez M./ Bol.Soc.Geol. Mexicana, XXIV (2).	Provincias fisiográficas de la República Mexi-cana.
4	(1964) Ordoñez E./ Guía del Explorador Minero, Cap. VI, 103-142.	Principales provincias geográficas y geológi-cas de la República Mexicana.
5	(1964) Raiby E./ Cambridge Mass, 2nd Edition.	Landforms of Mexico.
6	(1964) Rusnak G.A. y Fisher R.L./ Memoirs of the American Association of Petroleum Geologists (3), 144-156.	Structural history and evolution of Gulf of California.
7	(1964) Rushnak G.A., Fisher R.L. y Shepard F.P./ Memoirs of the American Association of Petroleum Geologists (3), 59-75.	Bathymetry and faults of Gulf of California.
8	(1969) Bataillon C./ Editores: Siglo XXI, México.	Las regiones geográficas en México.
9	(1975) Carranza E.A., Gutiérrez E.M. y Rodríguez T.R./ Anales del Centro de Ciencias del Mar y Limnología, 1(2), 81-88.	Unidades morfotectónicas continentales de las costas mexicanas.
10	(1978) Ortlieb L./ Revista Inst.Geol., 2(2), 200-211.	Reconocimiento de las terrazas marinas cuaternarias en la parte central de Baja Cali-fornia.
11	(1978) Lugo H.L./ Bol.Soc.Geol. Mexicana, 39(2), 91-100.	Perfil geomorfológico transversal de la Península de Baja California (entre los paralelos 31° y 31°15')
12	(1980) Woods J.A./ Quaternary Research, 13, 346-364.	Geomorphology, deformation and chronology of marine terraces along the Pacific coast of central Baja California.

13	(1980) Lugo H.L. y Ortiz M.A./ Bol.Soc.Geol. Mexicana, 48(1-2), 1-14.	Análisis geomorfológico-estructural del con-junto montañoso de la región de Cabo Co-rrientes, Jalisco.
14	(1981) Carfantan J.Ch./ Bol.Inst.Geol., 5(2), 207-216.	Evolución estructural del sureste de México: Paleogeografía e historia tectónica de las zonas internas mesozoicas.
15	(1981) INEGI/ Secretaría de Programación y Presupuesto, México.	Carta fisiográfica de la República Mexicana (8 hojas en escala 1:1.000.000).
16	(1982) Nixon G.T./ Geol.Soc.Am.Bull., 93(6), 514-523.	The relationship between Quaternary volcanism in Central Mexico and the seismicity and the structure of subducted ocean lithosphere.
17	(1986) Lugo H.L./ Bol.Inst. Geog., 15, 9-39.	Morfoestructuras del oceánico mexicano.
18	(1990) Lugo H.L./ Revista Inst.Geol., 9(1), 82-111.	El relieve de la República Mexicana.
19	(1990) Delgado Argote L.A. y Carballido Sánchez E.A./ Bol.Inst.Geol., 9(1), 21-32.	Análisis tectónico del sistema transpresivo neogénico entre Macuspana, Tabasco y Puerto Ángel, Oaxaca.
20	(1990) Instituto Nacional de Estadísticas, Geografía e Informática/ Atlas Nacional de México, Tomo 1, Sección I, 1.1.	Hipsometría y batimetría, escala 1:4.000.000.
21	(1990) Johnson C.A. y Harrison C.G.A./ Phys. Earth Plan.Int., 64, 87-210.	Neotectonics in Central Mexico.
22	(1991) Allan J.F., Nelson S.A., Luhr J.F., Charmichael I.S.E. Wopat M. y Wallace P.J./ En: The Gulf and Peninsular provinces of the California. Editores: J. Dauphin y B. Simoneit. Am.Assoc.Pet.Geol.Bull., Memoir., 47, 425-445.	Pliocene-Holocene rifting and associated volcanism Mexico: An exotic terrane in the making.
23	(1995) Nieto Samaniego A.F., Alainz Álvarez S.A. y Ortega Gutiérrez F./ Revista Mexicana de Ciencias Geológicas, 12(1), 1-8.	Estructura interna de la falla de Oaxaca (México) e influencia de las anisotropías litológicas durante su actividad Cenozoica.
24	(1998) Barrier E., Velasquillo L., Chávez M. y Gaulon R./ Tectonophysics, 287, 77-96.	Neotectonic evolution of Isthmus of Tehuantepec (Southern Mexico).
25	(2001) Suter M., López Martínez M. y Quintero Legorreta O./ Geol.Soc.Am.Bull., 113, 693-703.	Quaternary intra-arc extension in the Central Trans-Mexican Volcanic Belt.
26	(2003) Priego Santander A., Isunza E., Luna G.N. y Pérez J.L./ Dirección del Manejo Inst. de Cuencas Hidrográficas. Dirección General de Investigaciones en Ordenamiento Ecológico y Conservación de Ecosistemas Inst. Nacional de Ecología.	Cuencas hidrográficas escala 1:250.000 (metadato).
27	(2004) Márquez Azua, Cabral Cano E., Correa Mora F. y DeMets Ch./ Geofísica Internacional, 43(3), 319-330.	A model for Mexican neotectonics based on nationwide GPS measurements, 1993-2001.
28	(2005) Instituto Nacional de Estadísticas, Geografía e Informática/ Dirección General de Geografía.	Provincias fisiográficas de México.
29	(2009) Márquez B. y DeMets C./ Geochemestry, Geophys., Geosystems, 10(2), 1-16.	Deformation of Mexico from continuous GPS from 1993 to 2008.
30	(2010) PEMEX /	Provincias geológicas de México.
31	(2011) Ramírez Herrera Mª T., Kostoglodov V. y Urrutia Fucugauchi J./ Pure appl.geophys., 168, 1.415-1.433.	Overview of recent coastal tectonic deformation in the Mexican subduction zone.
32	(2013) Lanza Espino G de la, Ortiz Pérez M.A. y Carbajal Pérez J.L./ Investigaciones Geográficas, 81, 33-50.	Diferenciación hidrogeomorfológica de los ambientes costeros del Pacífico, del Golfo de México y del Mar Caribe.

Coincidimos con Aguayo y Marín (1987) en que: 1) las provincias morfotectónicas de MX resultan de la interacción de 3 placas (Norteamérica, Pacífico y Caribe) que han actuado simultáneamente durante el Cr Superior Tardío-Q; y 2) los rasgos morfotectónicos observados en el continente y el margen Pacífico se asocian con fallas y fracturas (SO-NE). Pero, añadimos que ellas continúan activas. Además, como indicaron Cotilla *et al.* (2017), en su figura 1, hay 14 intersecciones principales de fallas activas en la zona del Océano Pacífico y en el interior de MX (Tabla 5). Entre ellas destaca la zona de deformación neotectónica indicada en las figuras 1, 5, y 6, y que se ajusta a lo expuesto en el párrafo anterior. Así, sobre la base del análisis de esas intersecciones (conocidas también como nudos) entorno a MX entendemos: 1) existe una zona de deformación activa; 2) las fallas activas están segmentadas; y 3) hay más de 7 intersecciones en las inmediaciones de Puerto Vallarta, y 3 en Oaxaca. Al comparar esos 2 territorios, vemos que para la primera región hay mayor: 1) cantidad de fracturas; 2) número de zonas de articulación;

3) diversidad de direcciones; y 4) actividad neotectónica (Figura 12). Además, existe una relación inversa en cuanto a las intersecciones y alineamientos entre las partes marina y continental respectiva (Puerto Vallarta= 7/4, y Oaxaca= 3/14). Destaca también que la densidad de epicentros es muy superior en Oaxaca, con respecto a Puerto Vallarta, por lo que consideramos esto es debido, principalmente, a la diferente dimensión de las placas y al muy diferente ángulo de convergencia de esas placas.

La figura 8 de Cotilla *et al.* (2017) muestra las deformaciones neotectónicas y los sistemas de fracturas y fallas para el entorno de Nayarit-Puerto Vallarta-Bahía de Banderas-Colima-Laguna de Chapala. También se ha comprobado la influencia de la transmisión de esfuerzos tectónicos en lugares alejados de la línea de costa del Pacífico como en el entorno del volcán Nevado-Toluca, y el NE de MX. El análisis realizado prueba la presencia de un conjunto de fallas activas (E-O) y de extensión (N-S), así como otras de tipo transcurrente. Además, suponemos que entorno a Puerto Vallarta hay una ligera tendencia de desplazamientos antihorario (al N) y horario (al S), por ser el área de encuentro del sistema de fallas del Golfo de California y la FM, con la intercalación en ángulo de la microplaca Rivera, y con actividad sísmica.

Tabla 5: Intersecciones principales de México

Nº	Fallas – Estructuras	Coordenadas (N / O)
1	Tamayo / Elevado Pacífico-Rivera	22 / 109
2	Tamayo / Fosa Mesoamericana	21 / 107
3	Rivera / Elevado del Pacífico E / Clarion	18 / 106
4	El Gordo / Fosa Mesoamericana	18 / 105
5	Orozco / Balsas	17 / 103
6	O`Gorman / Fosa Mesoamericana	16 / 99
7	Rivera / Elevado del Pacífico E	21 / 110
8	Orozco / Elevado del Pacífico E	15 / 106
9	O`Gorman / Elevado del Pacífico E	12 / 104
10	Tehuantepec / Fosa Mesoamericana	15 / 95
11	Chiapas / Caribe	17 / 87
12	Motagua / Fosa Mesoamericana-Caribe	18 / 92
13	Chapala / 3 graben (Colima-Tepic-Chapala)	20 / 105
14	Punta Borrascosa / Fallas San Andrés-Cerro Prieto-Laguna Salada	31 / 115

Comprobamos que en la Península de California la tectónica determina al relieve, mientras que la litología y el clima tienen mucha menos influencia (Figura 5). Su sistema de elevaciones montañosas tiene un conjunto irregular de escalones (pulsos) y asimetría transversal. Se ha comprobado el desplazamiento lateral al NO con relación a la parte continental adyacente, a través del sistema de fallas del Golfo, que tiene sismicidad asociada. En la figura 6 aparece la representación de un contacto de placas (PT-1= Cerro Prieto-Laguna Salada (Punta Borrascosa)). Así, se identifica a la provincia tectónica de *Salton Through* que conecta al sistema de fallas del Golfo de California con la falla San Andrés (Figura 5). Estos datos sugieren que se puede producir una cuenca oceánica y la ruptura continental. En ella hay cuencas activas con fallas transformes y movimiento lateral derecho que están organizadas "*en-echelon* y *pull-apart*". La cuenca de Salton se subdivide en 2 partes: 1) Cerro Prieto (Mexicali, Baja California); y 2) Brawley (Valle Imperial, California). Ellas son centros de dispersión con deriva continuada desde el final del Mioceno Medio (~12 Ma). En la parte emergida (Figura 9) reconocemos en la región 3 zonas, todas de montaña: 1) Norte, de dirección NNO; 2) Centro, de igual dirección, pero menos enérgico; y 3) Sur, en contacto con el sistema de fallas del Golfo. En este sentido, se puede asegurar que la Península y el Golfo de California pueden ser considerados un polígono geo-dinámico para el estudio de la neotectónica americana (Figura 5).

g) Datos de sismicidad

La información sobre la sismicidad se obtuvo, principalmente, de los siguientes trabajos: Ambraseys (1995), Ambraseys y Adams (1996), Astiz y Kanamori (1984), Bandy *et al.* (1997), Barrientos *et al.* (2006), Bayona Vivieros *et al.* (2017), Benz *et al.* (2010), Bravo *et al.* (2004), Camacho *et al.* (1997), Cheal y Steward (1982), Castro (2015), Cisternas y Vera (2008), Courboulex *et al.* (1997), Dean y Drake (1978), Doser (1987), Doser y Rodriguez (1993), DuBois y Smith (1980), Eissler y McNally (1984), Ellsworth (1990), Esteva (1970), Figueroa (1968, 1970), Flores y Camacho (1922), Franco *et al.* (2013), Frolich (1982), Frohlich y Davis (2002), Galván Ramírez y Montalvo Arrieta (2008), Gangopadhyay y Sen (2008), García Acosta y Suárez (1996), Glowacka y Nava (1996), Glowacka *et al.* (2002), Guendel y Bungum (1995), Hauksson *et al.* (2011), Instituto de Geofísica (2010), Jimenez y Ponce (1978), Kanamori y Stewart (1976), Kostoglodov *et al.* (1996), Lozos (2016), Madariaga (1998), Mazzotti (2007), Medina (1997), Medina *et al.* (1987), Natali y Sbar (1982), Nava (1987), Nettles (2006, 2007), Nieto Samaniego *et al.* (2012), Nishenko y Singh

(1987), Norabuena *et al.* (2004), Núñez Cornú y Sánchez Mora (1999), Núñez Cornú *et al.* (1998, 2002, 2004), Pacheco *et al.* (1997, 2006), Pacheco y Sykes (1992), Peraldo y Montero (1999), Quintanar Robles *et al.* (2011), Reyes *et al.* (1979), Rojas *et al.* (1993), Rutz López y Núñez Cornú (2004), Rutz López *et al.* (2013), Sallarés *et al.* (1999), SSN (2016, 2015, 2014, 2014A, 2013, 2011), Shor y Roberts (1958), Singh y Mortera (1991), Singh *et al.* (1981, 1984, 1985, 1985A, 1999, 2007), Suarez *et al.* (1990), Suter *et al.* (1996), SSM (2017), SSN (2000), Torres Vera (2010), Trejo Gómez *et al.* (2015), UNAM- Seismological Group (2010), Shedlock *et al.* (2000), Valdés *et al.* (1986), Warren *et al.* (2008), Wesnousky y Scholz (1980), White *et al.* (2004), Wolters (1986), Yagi *et al.* (2004), Yamamoto *et al.* (1984), Yang *et al.* (2009), y Zúñiga *et al.* (1997).

En las tablas 2 y 6-17 aparecen los datos sobre la sismicidad histórica y la instrumental. Por lo general, se incluyen los terremotos más fuertes. El CENAPRED (2001) asegura que, en 1900-1990, MX ha tenido ~6.10^3 muertos y pérdidas de valor ~$4.500.10^6$ U.S.D. La figura 11, obtenida del SSN de la UNAM, aparece la sismicidad del año 2011. En ella se distingue la distribución espacial de 4.168 epicentros atendiendo a la magnitud. Los terremotos se localizan mayoritariamente (3.135 eventos (~75 %)) en la zona del Océano Pacífico, y ajustados a la línea costera; aunque su alineación, densidad y espaciamiento lateral es diferente por segmentos. La configuración responde a un mismo patrón sismotectónico que también se aprecia en los mapas de los años 2012-2018 (SSN), en cuanto a densidad, magnitud y profundidad. También destacamos los valores porcentuales para tres intervalos de magnitudes (3-4/ 78 %; 4-5/12 %; y 5-7/0,3 %).

Tabla 6: Sismicidad histórica de México en 1805-1900 (M≥7,5)

M	Fecha	Coordenadas (N / O)	M	Fecha	Coordenadas (N / O)
7,5	1805.03.25	18,90 / 103,89	7,7	1818.05.31	19,10 / 103,60
	1845.03.09	16,60 / 97,00		1837.11.22	20,00 / 105,00
	1858.06.19	19,60 / 101,60		1854.05.05	16,30 / 97,30
	1875.02.11	21,00 / 103,80	7,9	1845.04.07	16,60 / 99,20
	1882.07.19	17,70 / 98,20		1870.05.11	15,80 / 96,70
7,6	1806.03.25	20,22 / 103,41		1899.06.24	17,10 / 100,50
	1820.05.04	17,20 / 99,60		1900.01.20	20,00 / 105,00
				Total	*14*

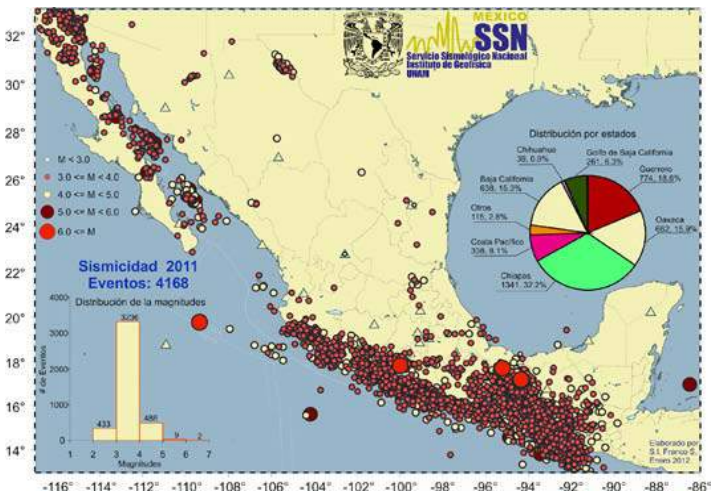

Figura 11: Sismicidad registrada durante 2011 (Servicio Sismológico Nacional, Instituto de Geofísica, UNAM)

El mapa de sismicidad y cuerpos volcánicos de MX y un segmento de América Central de Benz *et al.* (2010) muestra para el periodo 1900-2010 la diferenciación espacial y temporal de la actividad sísmica. Destaca, en él, una estrecha banda de epicentros en color rojo desde el Golfo de California a la América Central. Ella es relativamente estrecha y lineal, ajustada principalmente a la línea de costa. Los eventos tienen ~80 km de profundidad. Los terremotos fuertes están agrupados en 2 segmentos principales: A) Puerto Vallarta-Guerrero (años: 1907, 1909, 1911, 1932, 1941, 1973, 1979, 1985, 1995, y 2003); y B) Oaxaca (años: 1917, 1928, 1931, 1978, y 1999). En esa banda, lógicamente, predominan los terremotos con menores magnitudes. En ese sentido destaca la muy baja densidad epicentral de la Península de California y en el Istmo de Tehuantepec. La mayor densidad está hacia América Central. La disposición de terremotos más profundos (representados en color verde (h> 70 km)) se observa a continuación de la banda anterior y hacia

el interior del territorio emergido. En ella también se distingue la muy grande distorsión en cuanto a densidad de epicentros y la geometría en la distribución de conjunto de los eventos. Así, desde las inmediaciones de Veracruz (costa del GM) y hacia América Central la banda de sismicidad es prácticamente homogénea y muy densa. Los terremotos asociados con el ENV son muy escasos, pero en él destaca el terremoto del 23.03.1908 (M 7,5). En ese mapa también aparecen 2 isolíneas de la profundidad de subducción (60 km y 100 km). Ellas son aproximadamente paralelas y ajustadas a la disposición de la línea de costa del Océano Pacífico. Sin embargo, la isolínea de 100 km sólo aparece desde las inmediaciones de Veracruz y hacia América Central.

Tabla 7: Sismicidad histórica más relevante por regiones (1568-1870)

Nº	Fecha	Intensidad	Región	Nº	Fecha	Intensidad	Región
1	1568.12.27	X	Jalisco	11	1787.03.28	IX	Guerrero-Oaxaca
2	1604.03.03	X	Oaxaca	12	1697.02.07	IX	Guerrero
3	1682.03.19	VIII-IX		13	1754.09.01	XI	
4	1696.08.23	IX		14	1820.05.04	IX	
5	1727.03.10	IX		15	1845.04.07	X	
6	1787.04.03	IX		16	1711.08.15	IX	Puebla-Tlaxcala
7	1795.03.23	VIII-IX		17	1864.10.03	X	
8	1801.10.05	IX		18	1776.04.21	IX	Acapulco
9	1870.05.11	X		19	1858.06.19	X	Michoacán
10	1882.07.19	IX		20	1806.03.25	VII	Colima
				21	1818.05.31	X	Jalisco-Colima

Totales: XI= 1, X= 7, IX= 10, VIII-IX= 2, VII= 1

Se mencionó que hay otros 2 mapas que muestran una zonación sismotectónica de MX por profundidad de ocurrencia de terremotos (Zúñiga y Guzmán, 1994; Zúñiga *et al.,* 1997). En ellos aparecen 19 zonas, siendo las de mayor nivel las localizadas en el contacto de las placas. De forma general y esquemática, los autores coinciden con otros especialistas en que MX tiene los 2 tipos de sismicidad: 1) entreplacas (donde se produce el contacto directo); y 2) intraplaca (o del interior de la placa continental). Esas zonas tienen diferencias en cuanto a magnitud y frecuencia de ocurrencia. Los terremotos más fuertes (M> 7,0) en MX están a lo largo de la costa del Pacífico, y son causados por la subducción de las placas oceánicas mencionadas bajo la placa continental de Norteamérica y del Caribe. Para ellas se han estimado profundidades de subducción mayores de 100 km.

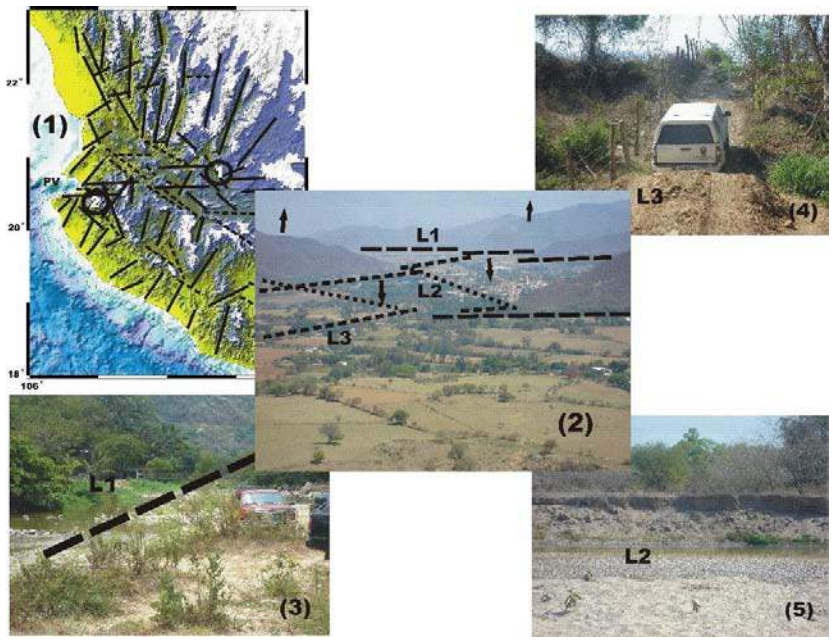

Figura 12: Estructuras lineales y deformaciones del relieve en el entorno de Puerto Vallarta

En la combinación de 5 imágenes aparecen: **(1)** lugar (PV= Puerto Vallarta), red de alineaciones (líneas continuas y discontinuas negras) y 2 zonas morfoestructurales anómalas (1 y 2, en color blanco, y circulo negro) dentro de los bloques Yagariza (B4) y Santo Domingo (B3), respectivamente (Cotilla *et al.,* 2017). Esos 2 bloques, están en las zonas sísmicas D y C, respectivamente (ver Figura 10); **(2)** algunas líneas de debilidad tectónica (en color negro y discontinuas) (L1= E-O, L2= NO, L3= N-S) y las tendencias predominantes de movimientos verticales

(flechas negras). Estos elementos se entrecruzan con un total de 11 microbloques (Cotilla *et al.,* 2017), y tienen sismicidad asociada utilizando los datos de Rutz *et al.* (2013); **(3)** alineación transversal E-O a un valle fluvial encajado (tipo V); **(4)** conjunto de ondulaciones (h= -3 a -5 m) N-S del relieve limitadas por alineación E-O; y **(5)** asimetría vertical de un valle fluvial relacionado con la dirección NO. A 3 km al norte de esta zona hay afloramiento de aguas termales.

Como consecuencia de los terremotos, en la FM se producen tsunamis que han afectado al litoral. En ese contacto existe, como hemos visto antes, una zona límite de placas (Pacífico-Norteamérica-Caribe) y es donde se libera, a diferentes profundidades, la mayor cantidad de energía. La zona límite de placas resulta ser una banda, relativamente homogénea y de 100-200 km de ancho, donde están además de la falla principal otras de menores dimensiones (transversales y paralelas) asociadas con ella. También ocurren terremotos fuertes en el continente (interior de placa), pero no son tan frecuentes como los de tipo entreplacas: 1) con M> 7,0/ h> 60 km y frecuente mecanismo de falla normal (Chapala: 27.12.1568 (M 7,5)), aunque hay de falla inversa (Ometepec: 20.03.2012 (M 7,4)); y 2) de M< 7,0 (Acambay: 19.11.1912 (M 6,9); Jalapa: 03.01.1920 (M 6,4)). Estos eventos pueden ocasionar daños considerables. También hay sismos con M< 5,5 que se consideran como sismicidad de fondo, muy difíciles de asociar con una estructura determinada. Los terremotos más importantes de la zona del Pacífico Mexicano, que permiten comprender la diferente interacción de las placas aparecen en las tablas 2 y 6-8. Destaca que en 110 años (1907-2017) han ocurrido 8 terremotos con M≥ 8,0; y considerando la intensidad de XI grados (1754-2017) el periodo sería de 263 años, y la cantidad 9. Las cifras indican recurrencias de 14 y 29 años, respectivamente. Sin embargo, la tabla 11 muestra que en el periodo de 1995-2017 han ocurrido 2 terremotos con M≥ 8,0, lo que da un periodo de recurrencia de 61 años. Esta cifra difiere de las precedentes en ~30 años.

Tabla 8: Sismicidad de 1900-1995 (M≥ 7,5)

M	Fecha	Coordenadas (N / O)	M	Fecha	Coordenadas (N / O)
7,5	1902.04.19	14,90 / 91,50	7,7	1902.09.23	18,00 / 106,50
	1908.03.27	17,00 / 101,00		1911.06.07	19,70 / 103,70
	1911.12.16	16,90 / 100,70		1917.12.29	15,00 / 97,00
	1928.03.22	16,23 / 95,45		1941.04.15	18,85 / 102,94
	.10.09	16,30 / 97,30		1973.01.30	18,38 / 103,00
	1937.12.23	17,10 / 98,07	7,8	1928.06.17	16,33 / 96,70
	1943.02.22	17,62 / 101,15		1932.06.18	19,50 / 103,50
	1957.07.28	17,11 / 99,10		1957.07.28	17,11 / 99,10
	1973.01.30	18,39 / 103,21		1978.11.29	15,77 / 96,80
	1976.02.04	15,26 / 89,20	7,9	1942.08.06	14,80 / 91,30
	1985.09.21	17,62 / 101,82		1985.10.09	18,79 / 104,47
7,6	1903.01.04	15,00 / 93,00	8,0	1907.04.15	16,70 / 99,20
	1911.06.07	17,50 / 102,50		1931.01.15	16,10 / 96,64
	1928.06.17	16,33 / 96,70		1995.10.09	18,99 / 104,25
	.10.09	16,34 / 97,29	8,1	1903.01.14	15,00 / 98,00
	1932.06.18	19,50 / 103,50		1908.03.26	16,70 / 99,20
	1941.04.15	18,85 / 102,94		1985.09.19	18,14 / 102,71
	1965.08.23	16,30 / 95,80	8,2	1932.06.03	19,57 / 104,82
	1973.01.30	18,41 / 103,02		*Totales:*	*7,5-7,9= 33*
	1978.11.29	16,01 / 96,59			*8,0-8,2= 7*
	1979.03.14	17,31 / 101,35			*1900-1960= 28*
	1985.09.21	17,83 / 101,68			*1960-1995= 13*

Hay varios terremotos importantes que permiten comprender la tectónica activa de MX, entre ellos: 1) el del 15.01.1931 (Mw 8,0/ h 40 km) con mecanismo focal de tipo falla normal (E-O), aproximadamente en las coordenadas de la ciudad de Oaxaca. Es decir, el foco estuvo, justamente, en la placa que subduce y bajo el continente. Esto define muy bien la amplitud de la capa sismoactiva; 2) los de 1932 (Figura 1) en Jalisco (03.06: Mw 8,2 y 18.06: Mw 7,8), que tienen una extensa zona de ruptura; 3) el del 11.12.1995 (Mw 6,4) con un plano de falla tipo deslizamiento lateral derecho (N87°E), en la zona de interacción difusa entre la microplaca Rivera y la placa Cocos. Éste es una réplica del terremoto acontecido días antes (09.10.1995: Mw 8,0). Estos últimos estarían en la zona límite de placas; y 4) el ocurrido el 07.09.2017 (Mw 8,2 en el Golfo de Tehuantepec, presentado en la Introducción). Otros sismos que confirman la sismoactividad, diversa y distribuida, del territorio de MX son: 1) los 4 terremotos de Veracruz (1-1) 03.01.1920 (M 8,0), 1-2) 28.08.1973 (M 7,7), 1-3) 07.04.2011 (M 6,7), y 1-4) 29.07.2014 (M 6,4)); 2) un sismo en Mexicali (Baja California) 04.04.2016 (M 4,1); 3) tres enjambres sísmicos en el Golfo de

California (3-1) año 1981 con 50 sismos, 3-2) 2007 con 91 terremotos, y 3-3) 25-28.03.2016 con 47 sismos); 4) Guadalajara, Jalisco 11.05.2016 (4,8); 5) dos terremotos en Quintana Roo (5-1) 10.06.2001 (M 4,7), y 5-2) 11.01.2015 (M 4,2)); 6) Chihuahua 27.08-09.2013 con 57 sismos de ellos 30 con M> 4,0; 7) Saltillo, Coahuila 31.05.2015 (M 4,0); y 8) dos enjambres sísmicos en Nuevo León (8-1) 07.10.2013-18.03.2014 con más de 100 terremotos, 8-2) 2012 con 89 sismos). Además, como muestras estadísticas está la sismicidad, registrada, en los años 2017-2015, 2012 y 2011 por cantidad de ocurrencias en los Estados de MX (Tabla 9). De las tablas 2 y 6-12, se extraen las conclusiones: 1) de la mejora constante y sucesiva en la detección de sismos. Concretamente, identificamos 3 periodos: 1-1) 1990-1999= 8.315 eventos (92 evento/año); 1-2) 2000-2011= 82.857 eventos (7.532 evento/año); y 1-3) 2012-2017= 70.650 eventos (14.139 evento/año); 2) que los mayores valores de actividad están en 3 Estados del Pacífico (Oaxaca, Chiapas y Guerrero). Ellos representan, de conjunto, por año las siguientes cifras: 2017= 85 %, 2016= 75 %, 2015= 77 %, 2012= 78 %, y 2011= 65 %; 3) cuando se incluyen los Estados de Colima, Jalisco y Michoacán las cifras por años se incrementan sustancialmente (2017= 93 %, 2016= 89 % y 2015= 88 %); 4) que el terremoto más fuerte, de ese periodo, ocurrió en Oaxaca (8,2); 5) que predomina por cantidad el rango de M 6,0-6,9 (96 eventos) sobre el de 7,0-7,6 (16 eventos); 6) que la cantidad de terremotos en el intervalo de profundidad 8-60 km supera al de >60-167 km (18 / 4); 7) sólo 2 eventos tienen h> 100 km; y 8) las cantidades de terremotos con rango de M 7,5-7,9 / 8,0-8,2, en la tabla 2 (2000-2017) y la tabla 8 (1990-1995), son 1 / 1 y 40 / 7, respectivamente. Esto indica un pulso de mucha actividad en el periodo 1990-1995 respecto al otro periodo. También de los datos del SSN-UNAM es posible conocer la cantidad de terremotos por rangos de magnitud para el entorno del GM en el intervalo 01.01.1999-31.01.2018 (Tablas 13 y 14). La estadística muestra que en 1990-2017 los terremotos con M≥ 6,0 representaron menos del 1 % y que el promedio (por año) de esos terremotos es ~4 (Tabla 11). Esto difiere de los datos de la tabla 2.

Tabla 9: Sismicidad de México en 5 años (SSN-UNAM)

Año (Total)	2017	2016	2015	2012	2011
Estado (Nº Figura 2)	(26.413)	(15.460)	(10.946)	(5.081)	(4.168)
Oaxaca (5)	49,7 %	36,4 %	29,3 %	27,3%	15,9 %
Chiapas (11)	22,9 %	18,9 %	29,3 %	26,4%	32,2 %
Guerrero (9)	12,6 %	20,1 %	18,8 %	24,5%	16,6 %
G. California (1-2)	3,3 %	5,7 %	7,3 %	6,1 %	6,3 %
Michoacán (8)	3,4 %	5,6 %	5,8 %		
Jalisco (6)	2,5 %	4,3 %	2,0 %		
Colima (7)	2,3 %	3,9 %	3,1 %		
Veracruz (16)	1,7 %	2,8 %	2,2 %		

Tabla 10: Sismicidad de México (01.01.1999-31.01.2018) (SSN-UNAM)

M	Terremotos	
>0	97.049	
>4	19.753	
>5	699	
>6	79 (0,09 %)	
>7	11	M (Lugar y (h (km)): 7,0 (Chiapas 113- Puebla 63- Michoacán 16)= 3; 7,2 (Guerrero 18- Baja California 10)= 2; y 7,1 (Morelos 57) / 7,3 (Chiapas 17) / 7,4 (Oaxaca 39) / 7,5 (Guerrero 18) / 7,6 (Colima 9) / = 1 cada uno)
>8	1	M (Lugar y (h (km)): 8,2 (Chiapas 58)

Tabla 11: Magnitudes (≥ 6,0) de México (1990-2017) (SSN-UNAM)

Año	Total	M (6,0-6,9)	M (7,0-7,9)	M (≥ 8,0)	Total (M≥ 6,0)
1990	796	2	-	-	2
91	728	1	-	-	1
92	614	-	-	-	-
93	916	5	1	-	6
94	622	3	-	-	3
95	678	6	2	1	9
96	789	2	1	-	3
97	1.019	6	1	-	7
98	1.024	5	-	-	5
99	1.099	4	2	-	6
2000	1.052	2	1	-	3

01	1.344	6	-	-	6
02	1.688	3	1	-	4
03	1.323	3	1	-	4
04	1.346	3	-	-	3
05	1.210	-	-	-	-
06	1.355	-	-	-	-
07	1.528	2	-	-	2
08	1.955	2	-	-	2
09	2.302	1	-	-	1
10	3.462	3	1	-	4
11	4.292	5	-	-	5
12	5.244	10	2	-	12
13	5.360	4	-	-	4
14	7.607	7	1	-	8
15	10.945	3	-	-	3
16	15.281	6	-	-	6
17	26.213	2	2	1	5
Totales:	*161.822*	*96*	*16*	*2*	*114 (0,7 %)*

Las figuras 6 y 7 de Pardo y Suárez (1995) representan las soluciones de los mecanismos focales, y los ejes T, respectivamente. Ellas dan una imagen de la situación tectónica actual en el segmento Puerto Vallarta-ENV-Chiapas, así se aprecia la modificación de los planos de subducción. También la figura 2 de Ego y Ansan (2002) recoge, para la parte central del ENV, 4 soluciones de mecanismos focales donde los ejes de esfuerzos principales indican direcciones NO-SE (σ_1) y NE-SO (σ_2). Esto se corresponde con los resultados sobre la extensión del Cuaternario determinada por Suter *et al.* (2001). Estos últimos autores en su figura 5 representan 31 soluciones de mecanismos focales (tipo compresivo) para el tramo de costa Manzanillo-Chiapas.

En la figura 13 se tiene una representación, suficientemente ilustrativa, del *World Stress Map* del 2000, para el territorio de MX-América Central-Caribe. El mismo aunque es más simple que el utilizado anteriormente del año 2016, permite comprobar lo comentado sobre los tensores y las direcciones de subducción, convergencia y contactos de placas. Consideramos que en la zona de interior de placa en MX los mecanismos principales de la generación de terremotos son de 2 tipos: 1) debilidad-fragilidad cortical (por el proceso de subducción); y 2) concentración de esfuerzos (por transmisión desde las placas).

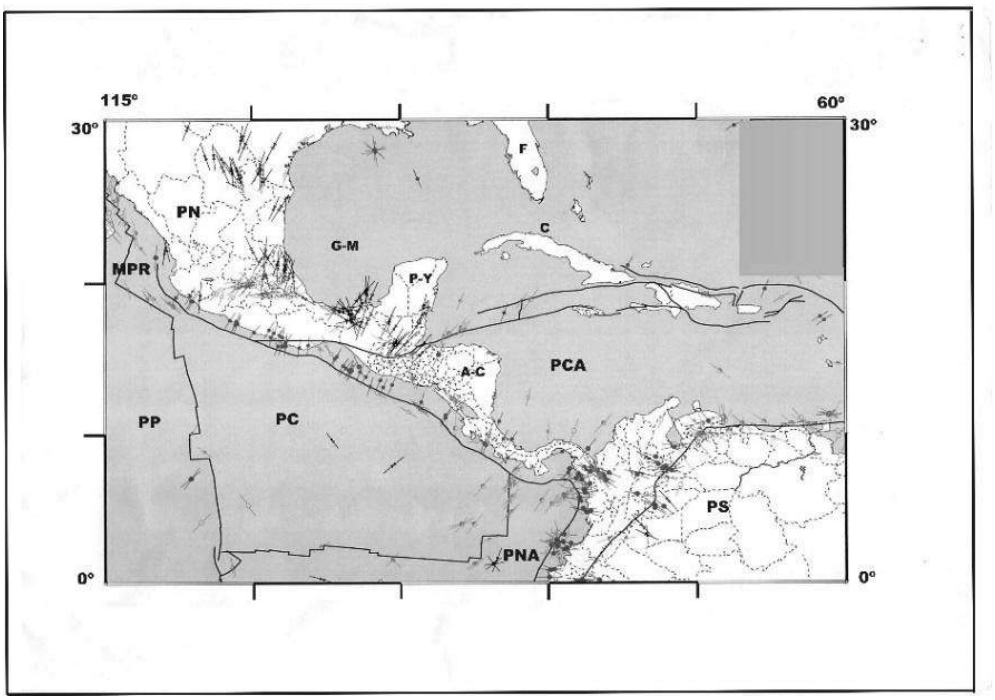

Figura 13: World Stress Map- 2000

La sismicidad en la placa Caribe, para el segmento de América Central, tiene una importante densidad de terremotos con profundidades 5-25 km. Algunos de ellos alcanzan magnitudes máximas superiores a 6,0; aunque en las inmediaciones de Guatemala-El Salvador-Nicaragua se han dado los mayores valores. También, muchos terremotos fuertes (cerca del centenar) han sido documentados en la región de Honduras, Costa Rica y Panamá; y de la que hemos comentado el proceso de subducción en la FM. Los eventos fuertes están en el segmento de El Salvador (M 8,1), mientras que en Costa Rica la sismicidad es de menor nivel (Tabla 3). Estas diferencias se corresponden con las variaciones en ángulo de los planos de subducción.

El GM es un mar de tipo intra-continental (~1,5.10^6 km^2) con una profundidad máxima de ~4 km. Él es una cuenca de tipo carbonatada con grandes espesores de sedimentos, que acumula un volumen muy grande de fluidos. En esa área se han determinado deformaciones tectónicas activas en su parte SO, con registros sísmicos. Además de los terremotos de la tabla 13 están los siguientes, también de tipo interior de placa: 26.08.1959: 18,26 N / 94,43 E (M 6,4/ h(km) 21; 1967: 19,23 N / 95,74 O (M 5,7/ h(km) 26; 29.08.1973: (M 8,3); 10.09.2006: 26,32 N / 86,84 E (M 5,9/ h(km) 30; 23.05.2007: 21,98 N / 96,14 E (M 5,5/ h(km) 44; y 29.10.2009: 19,14 N / 95,58 E (M 5,7/ h(km) 17)), y el segmento costero Tabasco-S de Veracruz, inmediato al Istmo de Tehuantepec, destaca por su actividad sísmica (h> 100 km) (Tabla 14). Aquí los terremotos están relacionados con la subducción de la placa Cocos. Esto le diferencia del N del ENV, que tiene eventos sísmicos someros.

Tabla 12: Algunos terremotos en 4 Estados del oriente y centro de México

Nº	Estado (Nº en Figura 2)	Fecha	M / h (km) / Fallecidos	Nº	Estado (Nº en Figura 2)	Fecha	M / h (km)
1	Veracruz (16)	1864.10.03	7,3 / -	3	Tumaulipas (18)	2016.05.16	3,6 / 5
		1879.05.09	7,0 / -			.06.17	3,7 / 10
		1916.06.02	7,0 / 150			.01.03	3,4 / 5
		1920.01.03	8,0 / - / >650			.08.15	3,6 / 10
		1937.07.25	7,7 / 85 / 34			.15	4,0 / 10
		1959.08.26	6,4 / 21 / 20			.09.14	3,7 / 16
2	Campeche (14)	1973.08.28	7,3 / 84 / 1.200			.10.21	3,5 / 10
		2007.02.09	4,8 / 10		Quintana Roo (12)	2017.01.17	3,7 / 10
		2011.01.23	4,4 / 10	4		.11.13	3,9 / 10
		.02.10	4,0 / 10			2002.06.10	4,1 / 10
		2015.05.10	4,7 / 33			2015.01.12	4,0 / 15
		2016.03.08	3,6 / 5		*Totales:*	*8,0= 1*	*6,0-7,0=1*
		2017.09.25	4,0 / 15			*7,0-7,9= 5*	*3,0,6,0=17*

Desde el punto de vista tectónico el GM es considerado, incorrectamente, un margen continental a-sísmico (Figuras 5 y 8). Pero, su sismicidad se diferencia en 3 sectores: 1) Costa Norte (Luisiana-Misisipi, U.S.A. con eventos débiles (ejemplo: 24.07.1978: 26,49 N/ 88,79 E (M 5,0/ h (km) 5))); 2) Central, también con eventos débiles (Mmáx 5,8); y 3) SO, entre las ciudades de Veracruz y Ciudad del Carmen (con sismicidad superficial y terremotos de magnitudes bajas y medias (M 6,4)). Aquí la cantidad de terremotos registrados en los últimos 50 años es mucho mayor que en los sectores del N y Central. La actividad del sector septentrional está asociada con la acumulación de sedimentos por el río Misisipi. También la concentración de terremotos entorno a Ciudad del Carmen es debido a cambios tensionales por la extracción de fluidos. En áreas alejadas de la costa han ocurrido algunos terremotos, pero sentidos en algunas localidades continentales como Jaltiplan-Veracruz (Tablas 12-14).

Tabla 13: Terremotos del Golfo de México 01.01.1999-31.01.2018 (SSN-UNAM)

Fecha	M/h(km)/ Coordenadas (N/O)	Estado (Nº en Figura 2)	Fecha	M/h(km)/ Coordenadas (N/O)	Estado (Nº en Figura 2)
2006.09.10	5,7/10/26,25/87,26	Q.Roo-12	1993.08.23	4,8/10/22,38/99,23	Tamaulipas-18
2003.04.10	5,4/10/15,87/87,95		1992.11.30	4,8/30/23,26/98,03	
2011.12.10	4,8/34/16,87/86,18		2008.09.23	4,3/12/ 22,45/97,57	
2013.08.24	4,7/10/15,57/86,04		1994.04.09	4,3/12/23,12/99,65	
2012.05.03	4,7/20/17,27/85,55		2015.08.04	4,1/5/24,31/99,04	
2002.06.10	4,6/12/19,04/88,08		2012.06.24	4,1/16/ 22,64/97,99	
2008.06.21	4,5/20/17,96/87,87		2008.10.30	4,1/25/22,54/97,83	
2012.05.11	4,4/10/15,83/86,87		2016.08.14	4,0/10/24,24/98,54	
2014.01.13	4,3/82/16,23/88,67		2015.08.07	4,0/3/ 24,27/99,29	

2015.01.11	4,2/20/20,32/87,51		2011.02.12	4,0/35/23,18/99,15	
2008.02.09	4,8/20/19,60/92,25	Tabasco-15	1999.06.15	7,0/63/18,13/97,54	Veracruz-16
2016.03.08	4,7/33/19,54/92.17		2011.04.07	6,7/171/17,22/94,32	
2015.05.10	4,5/13/19,60/92,25		2014.07.29	6,4/117/17,70/95,67	
2005.04.01	4,5/18/18,74/92,04		2011.02.25	6,0/135/17,69/95,21	
1998.06.03	4,4/34/19,04/90,84		2004.06.29	4,2/10/27,91/90,18	
2013.10.20	4,3/5/19,51/92,29		.06.22	4,1/114/19,42/88,82	Yucatán-13
2011.01.22	4,3/10/19,50/92,12		2015.04.07	2,9/10/21,22/89,40	
2000.01.14	4,3/10/19,46/92,01	*Totales:*	*6,0-7,0= 1*	*5,0-6,0= 5 (16 %)*	*2,9-5,0= 31*
2001.07.20	4,2/156/19,04/92,05				
1998.06.03	4,0/34/19,04/90,84				

Tabla 14: Cantidad de terremotos en el entorno del Golfo de México (1990-2017)

Nº	Estado (Nº en Figura 2))	M	Terremotos
1	Veracruz (16)	> 0	1.941 (86 %)
		> 4,0	754
2	Tabasco (15)	> 0	142
3	Yucatán (13)	> 0	82
4	Tamaulipas (18)	> 0	78
5	Quintana Roo (12)	> 0	11
		Total	*2.254*

La figura 1 de Franco *et al.* (2013) muestra un significativo agrupamiento de terremotos en la intersección del ENV y el GM. En él, la sismicidad predominante es de baja energía y poca profundidad (< 70 km), y coincide, aproximadamente, con la ubicación del volcán San Andrés Tuxla. Otros epicentros de características similares, pero más escasos y dispersos, están a ambos lados, hacia Xalapa-Tampico y Veracruz-Campeche. En este último segmento hay una importante cantidad de eventos con profundidades superiores a 70 km. También los especialistas Ramos Zúñiga *et al.* (2012) presentan en su figura 1 un conjunto de 7 terremotos, con los mecanismos focales, incluidos en un fondo de sismicidad (1847-2012) para las partes norte y oriental de MX y del S de Estados Unidos (Texas). Interpretamos de esa interesante representación que la sismicidad, de mayor energía, tiene un marcado desplazamiento temporal del O al E: 1) en la zona de Texas, y con una misma solución de mecanismo focal (tipo normal), hay 3 terremotos: 16.08.1931 (6,4/ 10 km/ Valentine), 14.04.1995 (5,7/ 17 km/ Alpine), y 20.10.2011 (4,8/ 3 km/ San Antonio); 2) en la zona de MX están 4 eventos: 01.11.1928 (6,5/ 10 km/ Parral, Durango), 17.04.2006 (3,3/ 20 km Santiago, Nuevo León), 14.06.2009 (5,0/ 20 km/ General Terán, Nuevo León), y 14.06.2009 (5,1/ 10 km/ China, Nuevo León). Los 2 primeros tienen mecanismos de tipo normal, mientras que los del año 2009, muy cercanos entre sí, son de tipo transcurrente; 3) el tiempo de ocurrencia en esas 2 bandas de actividad sísmica es similar: Texas= 80 años, y MX= 81 años; 4) la distancia entre los primeros eventos, en las bandas respectivas, y los últimos es aproximadamente la misma. Los datos permiten asumir que los terremotos son de una misma familia sismotectónica. También, los valores de magnitud y profundidad de los eventos determinados en 2006-2007, por una red local temporal, en las inmediaciones del graben de Santiaguillo (Estado de Durango) tienen valores <2,5 y <10 km, respectivamente (Gómez González *et al.,* 2007). Esto se corresponde con lo expuesto sobre la tectónica contemporánea y la sismicidad de interior de placa.

En la figura 2 de Franco *et al.* (2013) se presentan, para el GM, 10 soluciones de mecanismos focales, que ilustran la actual dinámica de la región. Esas soluciones corresponden a fallas inversas de dirección NO-SE y buzamiento de 45º y se asocian con los procesos de sedimentación, antes mencionados. Otras soluciones de mecanismos focales de terremotos superficiales (ejemplo: 23.05.2007 del margen occidental del GM) que están relacionados con la falla Oriental Mejicana y un régimen transformante. Un trabajo similar en el GM es el de Singh *et al.* (2015). En él presentan 7 soluciones de mecanismos focales (terremotos de: 26.08.1959 (M 6,4/ 21 km), 11.03.1967 (M 5,7/ h 26 km), 24.07.1978 (M 5,0/ h 15 km), 06.09.1997 (M 4,5/ h 30 km), 10.09.2006 (M 4,9/ h 30 km), 23.03.2007 (M 5,6/ h 24 km), y 29.10.2009 (M 5,4/ h 17 km)) y llegan a conclusiones equivalentes.

La tabla 15 tiene los datos de la sismicidad principal en la Península de California-Golfo de California, para el periodo 1812-1984. Ellos fueron compilados a partir de las referencias antes indicadas. En la tabla 16 hay 44 terremotos determinados por el SSN de MX en el periodo 1999-2018, así vemos que: 1) la magnitud máxima no supera el valor de 7,2; y 2) las profundidades determinadas son predominantemente inferiores a 15 km.

La figura 1B de Márquez Azua *et al.* (2004) contiene los epicentros determinados en la: A) margen occidental mejicana desde Baja California a Chiapas.

En ella se aprecia muy bien: 1) la alineación costera de los epicentros; y 2) la muy diferente densidad de epicentros (mucho menor en Baja California); B) zona del GM. En esta última la sismicidad está muy dispersa y su densidad es mucho menor que en el margen Pacífico. También con las tablas 14 y 17 se puede estimar que en el GM y la Península de California ocurren 132 y 325 terremotos / año, respectivamente. Sin embargo, en el Reporte Especial del SSN de MX, para el terremoto del 19.01.2018 (M 6,3 / h 16 km / 10:17:45 / 26,66 N 111,10 O / 11 réplicas) de Loreto, Baja California Sur, se dice que en la región se producen 18 eventos con M 2,9-7,0 / año. También en el informe incluyen otros 2 terremotos con magnitud similar: 1) 18.06.1973 (M 7,0); y 2) 04.01.2006 (M 6,7 / h 10 km). Esto reafirma la mayor sismogenésis de la Península y el Golfo de California. Pero al analizar la sismicidad histórica y los datos de la tabla 17, la región de Baja California es más activa que la de Baja California Sur.

Tabla 15: Terremotos en la Península de California (1812-1984)

Nº	Zona	Fecha	M/h(km)	Observaciones
1	N de Tecate	1812.12.08	7,5/ -	Evento de San Juan Capistrano-40 muertos
2	N Sonora	1887.05.03	7,4/ -	Evento de Bavispe-51 fallecidos
3	B. California	1901.12.08	7,0/ -	
4	California	1902.12.12	7,1/ -	
5	G. California	1907.10.16	7,1/ 10	
6	G. California	1915.11.21	7,0/ 10	
7	B. California	1932.12.31	7,1/ -	
8	-	1934.12.12	7,1/ -	
9	B. California	1940.05.19	7,1/ -	
10	G. California	1954.04.20	7,0/ -	
11	-	1956.02.09	6,7/ -	
12	-	1979.11.21	7,0/ -	
13	-	1980.06.09	6,1/ -	Evento del Valle Imperial
14	-	1987.11.24	6,5/ -	
	Totales:	*6,0-7,0= 7*	*7-7,5= 7*	

Está comprobado que las 3 gráficas de la sismicidad de MX realizadas por Zúñiga *et al.* (1997): Nº 3.1 (Sismicidad en base al catálogo 1900-1994), Nº 4.1a (Temblores de subducción), y Nº 4.1b (Temblores de profundidad intermedia) se corresponden con las actuales determinaciones del Servicio Sismológico Nacional de la UNAM. También analizamos las informaciones sobre zonas sísmicas y peligrosidad sísmica, como sostienen Ulomov *et al.* (1993), Ulomov (1995), y Ulomov y Shemilina (1998). Así que presentamos 6 publicaciones sobre MX que cumplen este objetivo: Esteva (1970), Núñez Cornú (2011), Núñez Cornú y Ponce (1989), Instituto Nacional de Estadísticas, Geografía e Informática (2005A), Pacheco y Singh (2010), y Okal y Borrero (2011).

Otros datos sobre los 2 terremotos fuertes del año 2017, incluidos en la Introducción, de Chiapas (M 8,2) y Morelos (M 7,1) son: 1) Chiapas (14.06.2017 (M 7,0/ h 113 km/ 14,77º N 92,08º O), Oaxaca (08.09.2017 (M 6,1/ h 32 km/ 15,62º N 94,85º O)); 2) mecanismos focales de los terremotos de tipo falla normal; y 3) en Oaxaca ocurrió un tsunamis de 1,1 m). Ellos confirman que: 1) MX es un País con un importante peligro sísmico; 2) que los periodos de recurrencia, de los terremotos fuertes y sus premonitores y réplicas, aunque diferentes por regiones, deben ser tenidos en consideración al momento de realizar los planes constructivos; y 3) que algunas de las estructuras sismogenéticas tienen relación de continuidad en los países vecinos (Guatemala, El Salvador, y Honduras).

Las figuras 2.2 y 2.3 de RESIS II (2008) contienen las soluciones de los mecanismos focales del Global CMT-2008, para América Central con Mw >6,0 (11º-19º N/ 82º-95º O) y Mw >5,5 (06º-13º N/ 76º-88º O), para el periodo 1976-2007. En la primera de ellas los mecanismos son de tipo normal en la Depresión de Honduras (parte N) y transcurrentes de izquierda en las fallas de Swan y Motagua (Figura 4). Para la segunda figura destaca la alineación N-S de los mecanismos tipo transcurrente asociados con la Zona de Fracturas de Panamá.

Sabemos por el Informe Especial del SSN (2012) sobre el terremoto del 20.03.2012 (Figura 14) que: 1) el sismo principal tuvo los siguientes datos: M 7,4 / h 15 km / 12:02 horas / 16,42 N y 98,36 O (localizado en las cercanías de Ometepec-Guerrero-Pinotepa Nacional, Oaxaca) / sentido en gran parte de la zona centro de la República Mejicana; 2) en el intervalo temporal 23-26.03 hubo 193 réplicas con M 3,3-5,3 y h (km) 1-24; 3) algunos de los terremotos más importantes en el Estado de Oaxaca están relacionados con: 3-1) la placa de Norteamérica (15.01.1931 (M 8,0), 02.08.1968 (M 7,3), y 30.09.1999 (M 7,6)); y 3-2) el proceso de subducción de la placa Cocos (23.08.1965 (M 7,5), y 29.11.1978 (M 7,6); y 4) las localidades que históricamente han sido más afectadas por sismos son

Puerto Escondido, Pochutla, Puerto Ángel, Huatulco, Loxitla, Cacahua, Jamiltepec, Pinotepa Nacional, Ometepec y Miahuatlan. Este terremoto del año 2012 coincide espacialmente con el del 16.02.2017 (M 7,2) ya indicado en la Introducción (Figura 1). Pero, en el actual catálogo del SSN al fuerte evento de 2012, le han modificado algunos datos, pero sin cambiar la esencia de las informaciones: M 7,5 / h 18 km / 16,26 N 98,46 O / en el límite de Guerrero-Oaxaca.

Además, destacamos que en el intervalo 2015-2017 el SSN de MX ha indicado 13 terremotos importantes (3 del 2015, 6 del 2016, y 4 del 2017) (Tabla 18). De ellos sólo uno (13.09.2015 / M 6,7) está localizado en el Golfo de California (Baja California Sur), y el resto está al S de Jalisco, y el de mayor magnitud en Oaxaca. Esto confirma la importante sismoactividad de la costa Occidental mejicana.

Tabla 16: Terremotos de Baja California y Baja California Sur (01.01.1999-31.01.2018) (SSN-UNAM)

Nº	Fecha	M / h(km)	Coordenadas (N/ O)	Estado (Nº en Figura 2)	Fallecidos
1	2010.04.04	7,2/ 10	32,47 / 115,37	Baja California (1)	4
2	2012.12.14	6,4/ 15	31,19 / 119,42		
3	2014.03.21	5,6/ 17	30,39 / 114,08		
4	2013.08.26	5,6/ 17	33,09 / 115,47		
5	2012.08.22	5,5/ 16	23,27 / 115,50		
6	2002.02.22	5,5/ 5	32,20 / 115,44		
7	2016.03.27	5,4/ 15	30,00 / 114,50		
8	2010.04.08	5,4/ 10	32,33 / 115,10		
9	2014.03.21	5,3/ 20	30,25 / 114,13		
10	2008.02.11	5,3/ 16	32,14 / 115,00		
11	2014.09.15	5,2/ 5	30,214 / 114,32		
12	2011.12.23	5,2/ 20	30,52 / 114,27		
13	2014.03.21	5,1/ 5	30,42 / 114,02		
14	.04	5,1/ 15	31,19 / 119,42		
15	2011.02.18	5,1/ 20	32,14 / 115,01		
16	2010.09.50	5,1/ 10	29,90 / 114,18		
17	2004.08.30	5,1/ 10	29,52 / 116,55		
18	2011.02.20	5,0/ 15	32,23 / 115,14		
19	2010.09.14	5,0/ 10	32,17 / 115,08		
20	2005.04.26	5,0/ 10	30,25 / 114,13		
21	2003.02.07	5,0/ 8	31,63 / 115,14		
22	1999.06.03	5,0/ 5	32,37 / 115,22		
23	2012.04.12	6,8/ 5	28,83 / 113,16	Baja California Sur (2)	
24	2015.09.13	6,7/ 8	25,04 / 109,53		
25	2007.09.01	6,5/ 2	24,91 / 109,97		
26	2010.10.21	6,5/ 67	24,34 / 106,69		
27	2018.01.19	6,3/ 16	26,22 / 111,10		
28	2013.10.19	6,3/ 14	26,09 / 110,46		
29	2007.09.01	6,3/ 2	24,91 / 109,97		
30	2012.09.25	6,3/ 15	24,61 / 110,57		
31	2002.10.03	6,2/ 35	23,22 / 108,73		
32	2014.10.07	6,1/ 10	23,70 / 108,76		
33	2012.04.12	6,0/ 15	28,80 / 113,41		
34	2011.11.01	6,0/ 16	19,73 / 109,30		
35	.01	6,0/ 15	19,74 /109,31		
36	2012.10.08	5,8/ 14	20,12 / 109,94		
37	2013.01.13	5,7/ 10	25,92 / 110,34		
38	2012.10.05	5,5/ 10	23,58 / 108,51		
39	2011.04.26	5,4/ 18	27,85 / 111,39		
40	2012.04.15	5,4/ 15	28,94 / 113,22		
41	.09.13	5,3/ 28	24,90 / 109,42		
42	.04.12	5,2/ 16	24,12 / 108,97		
43	2015.09.13	6,7/ 100	25,04 / 109,53		
44	.26	5,0/ 20	24,13 / 108,93		
	Totales:	*>7,0= 1*	*6-7,0= 12 (27 %)*	*5-6,0= 31*	

Tabla 17: Cantidad de terremotos en el entorno de P. de California (1990-2017)

Nº	Estado (Nº en Figura 2)	M	Terremotos
1	Baja California (1)	> 0	3.713 (67 %)
		> 4,0	514
		> 5,0	26
2	Baja California Sur (2)	> 0	1.818 (33 %)
		> 4,0	517
		> 5,0	63
		> 6,0	12
		Total	*5.531*

Figura 14: Oaxaca y su entorno

Aparecen: Lugares (FM= Fosa Mesoamericana, 1= Pinotepa Nacional, 2= Puerto Ángel, 3= Ometepec, y 4= Jamiltepec); rectángulo gris indicando el año 2012 (área del evento principal (20.03.2012 M 7,4) y de sus principales réplicas; y localización del epicentro del terremoto de 16.02.2017 (M 7,2)).

Tabla 18: Selección de terremotos del periodo 2015-2017

Nº	Fecha	Tiempo	M / h(km)	Coordenadas (N / O)
1	2015.02.22	08:23:16	6,2/ 16	18,64 / 106,96
2	.09.13	03:14:09	6,7/ 8	25,04 / 109, 53
3	.12.17	13:49:54	6,6/ 91	15,76 / 93,70
4	2016.01.21	12:06:58	6,5/ 10	18,79 / 107,15
5	.04.15	09:11:25	6,1/ 12	13,56 / 92,28
6	.25	02:07:09	6,0/ 16	14,35 / 93,26
7	.27	07:51:19	6,0/ 20	14,35 / 93,26
8	.05.08	02:33:59	6,0/ 35	16,25 / 97,98
9	.06.07	05:51:36	6,1/ 16	18,23 / 105,38
10	2017.06.14	02:29:05	7,0/ 107	17,73 / 92,32
11	.07.09	23:49:17	8,2/ 46	14,76 / 94,10
12	.19	13:14:41	7,1/ 39	18,34 / 98,68
13	.23	07:53:04	6,1/ 11	16,50 / 95,15

Se presentan datos sobre algunos terremotos de América con más de 1.000 fallecidos (Tabla 19). Esta información permite valorar, de una forma muy simple y cuantitativa, el peligro sísmico en MX y de otros países americanos. También destaca la fiabilidad de la información porque los eventos son del periodo con registro instrumental. En la relación se han situado 2 terremotos de MX que corresponden a zonas distintas (México D.F. y Veracruz). Mientras que en la tabla 20 hay información de los 3 eventos más fuertes que han afectado a 2 zonas de América y a Japón. La energía liberada en forma de terremoto y tsunami fue muy elevada. Esos valores nunca se han producido en MX.

Tabla 19: Selección de terremotos de América con más de mil fallecidos

Nº	Fecha	M	Fallecidos	País
1	2010.01.12	7,0	300.000	Haití
2	1970.05.31	7,9	50.000	Perú
3	1939.01.24	7,8	30.000	Chile
4	1976.02.04	7,9	22.870	Guatemala
5	1972.12.23	6,2	20.000	Nicaragua
6	1985.09.19	8,1	3.150	México
7	1906.04.17	7,9-8,6	478-3.000	E.U.A.
8	1986.10.10	7,5	2.000	El Salvador
9	1999.01.25	6,2	1.230	Colombia
10	1973.08.28	7,3	1.200	México

Tabla 20: Selección de terremotos y tsunamis devastadores

Nº	Fecha	M (terremoto) / Hmáx olas (m)	País
1	1964.03.27	9,2/ 70	E.U.A. (Alaska)
2	2010.02.27	8,8-9,0/ 10	Chile
3	2011.03.11	9,1/ 40,5	Japón

h) Tsunamis

Los datos utilizados sobre tsunamis y sus peligros para MX aparecen, además de los citados en los epígrafes de Geología-Tectónica y Datos de Sismicidad, en: Soloviev (1970), Lockridge y Smith (1984), Kuroieva (1985, 2004), Sánchez y Farreras (1993), Farreras (1997), Arce *et al.* (1998), CENAPRED (1996, 2001), Ortiz *et al.* (2000), NOAA (2004, 2018), Servicio Geológico Mexicano (2007, 2007A), Brink *et al.* (2009), Suárez y Albini (2009), Cotilla y Córdoba (2011), Ramírez Herrera (2011), SEMAR (2012), y Geophysics Data Center (2017). Así los especialistas consideran que hay 2 tipos de fuentes tsunamigénicas que afectan al territorio mexicano: 1) cercanas (o locales); y 2) lejanas (Figura 9). Los datos analizados (1754-2018) indican que son ~50 los tsunamis que han impactado, diferentemente, la costa del Pacífico Mexicano. De ellos hay ~30 eventos de fuentes locales, con alturas de olas 0,1-10 m. En la tabla 21 se dan los más importantes. Sus efectos se han localizado principalmente (entre N de Puerto Vallarta y América Central). También es conocido, y significativo, que existe una muy importante diferencia entre la altura máxima de las olas por registro instrumental (3 m) y datos históricos (mucho mayores). Esto es similar a lo visto en la sismicidad histórica. En la tabla 22 aparece una selección tsunamis de 10 fuentes lejanas que han afectado las costas mejicanas. El rango de altura de las olas es de 0,2-2,5 m, pero su frecuencia es mayor que la de los tsunamis locales.

Tabla 21: Mayores tsunamis locales de México (1754-2017)

Nº	Fecha	M / I (Mercalli)	Altura (m)	Región	Fallecidos
1	1754.09.01	-/ XI	4	Guerrero	-
2	1787.03.28	8,3/ IX	4	Guerrero-Oaxaca	11
3	1928.06.17	7,8/ -	-	Oaxaca	-
4	1932.06.03	8,2/ -	10	Jalisco	4
5	.22	7,0/ -	10	Jalisco	75
6	1962.05.11	7,1/ -	5	Guerrero	-
7	1985.09.19	8.0/ -	2	Michoacán	-
8	1995.10.19	8,0/ -	5	Michoacán	1

Tabla 22: Tsunamis de fuentes lejanas

Nº	Fuente	Fecha	M	Altura (m)	Región afectada
1	Alaska	1964.03.20	9,2	2,4	Baja California
2	Chile	1960.05.22	8,8-9,0	2,5	Baja California
3	Colombia	1979.12.12	7,9	0,3	Guerrero
4	Hawai	1975.11.29	7,2	0,5	Baja California
5	Islas Aleutinas	1967.03.09	8,3	1,0	Baja California
		1965.02.04	8,2	0,5	Oaxaca
6	Islas Kuriles	1963.10.13	8,1	0,5	Guerrero
7	Japón	1968.05.16	8,0	0,3	Baja California
8	Kamchatka	1952.11.04	8,3	1,2	Oaxaca
9	Kermadec	1976.01.14	7,3	0,2	Guerrero
10	Perú	.11.20	6,8	0,1	Guerrero
		1966.10.17	7,5	0,2	Oaxaca

Consideramos que en las costas de MX hay 3 zonas bien diferenciadas con relación a los tsunamis. La costa del Pacífico tiene 2 zonas, una como receptora (Baja California) y otra generadora de tsunamis (Nayarit-Chiapas); y la costa del GM es receptora. Ésta es indicada por primera vez aquí (Figura 9). En la figura 15 se muestran 4 segmentos costeros del Pacífico mexicano que tienen importantes áreas de peligro por desprendimientos rocosos, por gravedad, e impacto de tsunamis. Ellos están en asociados a las zonas físico-geográficas 1 (Península Baja California), 10 (Sierra Volcánica Transversal), y 12 (Sierra Madre del Sur) de la figura 9 y a las zonas sísmicas B, C, y D de la figura 10.

De acuerdo con las fuentes consultadas, y antes indicadas, se puede asegurar, con bastante certidumbre, que: 1) en América Central se han producido ~49 tsunamis (periodo 1539-2000). De ellos 37 son del Océano Pacífico y el resto del Caribe. Esta cifra es equivalente a la de MX; y 2) en MX no han ocurrido eventos como los indicados en la tabla 20.

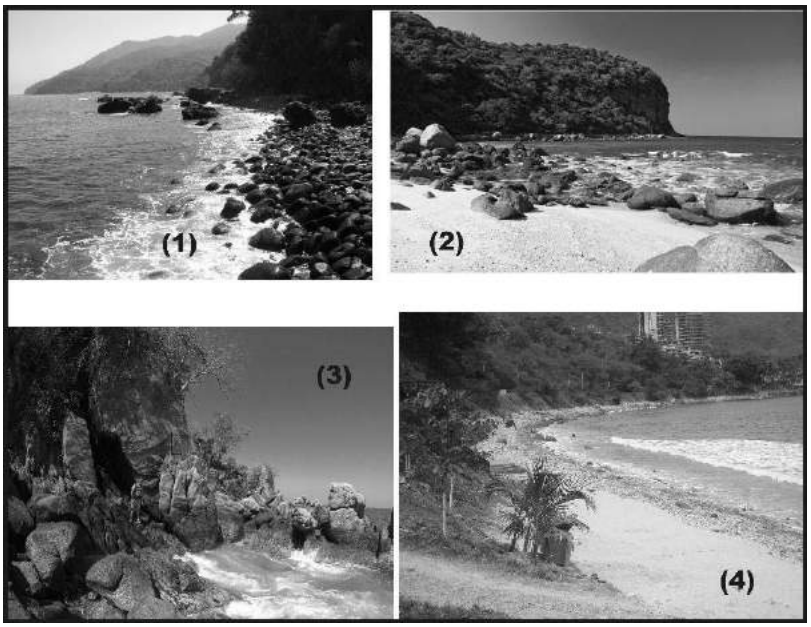

Figura 15: Vistas de costas rocosas del Pacífico mexicano

Las 4 fotos de la costa mejicana tienen características similares en cuanto a configuración, niveles altimétricos, desprendimientos gravitacionales de bloques, contacto directo con el Océano Pacífico, clasificación de zonas sísmicas (ver Figura 10), regiones físico-geográficas (ver Figura 9) y zona tsunamigénica local. Los sectores pertenecen a: **(1)**= Manzanillo; **(2)**= Nayarit; **(3)**=Guerrero; y **(4)**=Puerto Vallarta. Todos ellos son utilizados como áreas de ocio, y evidentemente tienen peligro.

III. Discusión y Conclusiones

Los datos de Azuz Adeath y Rivera Arriaga (2009) muestran para MX que en 2000-2005: 1) son 17 Estados los que tienen relación directa con la mar; 2) que la cantidad de habitantes pasó de 10.848.221 a 11.951.969, en la zona del Pacífico-Mar de Cortés; y 3) de los 265 municipios costeros en esa región, 92 tienen apertura al mar, 31 influencia marina, 32 influencia marina alta-media, y 89 influencia marina alta. Esto significa que hay una importante tendencia al crecimiento, económico y poblacional, en la región, y que evidentemente esas localidades están en peligro por la acción de los terremotos y tsunamis.

Otras informaciones económicas las tenemos del Servicio Portuario Nacional de México (2017). De éstas se confirma que hay 19 puertos deportivos, de ellos 15 están en la zona del Pacífico y 4 en el GM. En la primera zona hay 4 grandes instalaciones que reciben, sistemática y frecuentemente, grandes embarcaciones de Cruceros en: Cabo San Lucas, Ensenada, Mazatlán, y Puerto Vallarta. También existen 117 Puertos y Terminales Portuarias, completa y convenientemente equipados. Todas esas instalaciones conllevan importantes movimientos de personas, puestos de trabajo, y tienen peligro por los mismos fenómenos naturales ya mencionados.

MX es un territorio que tiene 3 tipos de peligros, en ocasiones interrelacionados, como terremotos, volcanes y tsunamis. Todos ellos han sido valorados en los epígrafes precedentes; pero lo principal del asunto es que históricamente esos fenómenos han afectado, considerable y reiteradamente, a la población y sus infraestructuras económicas y sociales. En este sentido, la práctica sismotectónica demuestra que, inclusive, en regiones de alta actividad sísmica no siempre es factible relacionar focos o epicentros con las fallas tectónicas conocidas. Así indicamos que en la página 17 del Informe del Servicio Geológico Mexicano (2007) aparece una figura con 15 Corredores Sismotectónicos (zonas sismogeneradoras) para los Estados de Oaxaca-Chiapas-Tabasco. Ellas son bandas irregulares,

en general alargadas y con direcciones muy diferentes, que no tienen relación aparente con la estructura neotectónica. El uso alternativo de estos elementos (alineamientos y zonas sismotectónicas) se encuentra en: *Armenia* (Zhidkov *et al.,* 1975); *California* (Guelfand, 1976); *Cuba* (Belousov *et al.,* 1983; Krestnikov *et al.,* 1983; Cotilla *et al.,* 1991; Cotilla y Córdoba, 2011); *España* (Gvshiani *et al.,* 1987; Cotilla y Córdoba, 2013); *La Española* (Cotilla *et al.,* 2007); *Mar de Barents* (Assinovskaya y Soloviev, 1994); *Rumanía* (Radulian *et al.,* 2000); y *Rusia* (Imaev *et al.,* 1990). Además, se considera que las zonas de debilidad tectónica pre-existentes, en las zonas de interior de placa, determinan en ella la ocurrencia de los terremotos. Esto está demostrado, para los casos de: 1) U.S.A. por Wesnousky y Scholz (1980), y Zoback (2012); 2) MX por Nieto Samaniego *et al.* (2012); y 3) Cuba, por Cotilla Rodríguez (2017). Tal hipótesis relaciona la heterogeneidad de la corteza con la distribución espacial de los eventos sísmicos en un marco tensorial por transmisión de los esfuerzos desde fuentes alejadas (Wdowinski, 1998).

Otra vía diferente, a las del párrafo anterior, es la utilizada en el ejemplo de Oaxaca, para un intervalo temporal de 8 años, por 3 grupos diferentes de autores: (1) Singh *et al.* (1981); (2) Astiz y Kanamori (1984); y (3) Núñez Cornú y Ponce (1989). Estos trabajos se fundamentan en la sismicidad. Seguidamente resumimos así los resultados: El grupo (1) divide la costa de Oaxaca en 3 zonas; el grupo (2) realiza 5 divisiones; y el grupo (3) presenta en la figura 8 (página 609) 8 zonas sísmicas. Todas estas zonas sísmicas cubren por completo la superficie territorial emergida de Oaxaca, y colindan entre sí. Ellas tienen configuraciones diferentes, aunque mantienen un paralelismo aproximado con la línea de costa. Posteriormente Suarez y Comte (1992) realizaron, para MX, por primera vez un análisis sismogénico a partir de la comparación de 2 territorios sísmicamente activos del Pacífico, MX y Chile. En este caso evaluaron las características de la subducción.

Atendiendo a lo expuesto en los epígrafes de Tectónica y Sismicidad se puede asegurar que hay 5 tipos de terremotos en MX. Ellos se localizan en las placas que interaccionan y sus zonas de contacto; y se corresponden con los 2 tipos de sismicidad comentados anteriormente. Así, en un perfil O-E (Pacífico-GM) consideramos que los terremotos son de tipo: 1) ante-fosa (la FM), asociados a la zona inmediata a la deformación o curvatura de la placa Cocos bajo la placa de Norteamérica. Estos eventos corticales son del interior de la placa oceánica, y con magnitudes bajas. No producen tsunamis; 2) entreplacas, que corresponden con la directa interacción de las placas Cocos y Norteamérica, y de la microplaca Rivera y la placa de Norteamérica. Estos eventos ocurren en la zona de contacto-acoplamiento (h <20-30 km), y tienen magnitudes importantes (6,0-8,2). Pueden producir tsunamis; 3) falla transcurrente (o desplazamiento lateral), en el contacto entre: 3-1) la placa Cocos y la microplaca Rivera; 3-2) las placas Pacífico y Norteamérica; y 3-3) las placas Norteamérica, Cocos y Caribe. Los terremotos no generan tsunamis, y sus magnitudes están entre 5 y 7,9; 4) de interior de la placa Cocos, cuando ésta subduce bajo la placa Norteamérica, los hipocentros alcanzan el rango de profundidad 50-200 km, y las magnitudes pueden ser de 8,0. Aquí los efectos y daños son muy importantes en la zona continental mejicana; y 5) de interior de la placa de Norteamérica, donde las profundidades son inferiores a 20 km. Las magnitudes son mayoritariamente bajas, y los terremotos pocos fuertes causan graves pérdidas.

Tomando en consideración lo expresado en los párrafos precedentes, se definen los principales elementos sismotectónicos de MX sobre la base de: 1) las características del entorno tectónico; 2) los principales elementos tectónicos; 3) las características neotectónicas; 4) la extensión geográfica; 5) la composición y configuración del relieve; 6) la sismicidad (histórica e instrumental); 7) los mecanismos focales predominantes; y 8) la estructura de la litósfera. Así hemos establecido la estructuración jerárquica de la sismotectónica del territorio.

Los autores consideran que MX es una Región Sismotectónica activa dentro de las placas de Norteamérica y del Pacífico, perfectamente diferenciada de otros territorios vecinos, incluso dentro de la primera placa. Ella está afectada directamente por las placas de Caribe, Cocos y Pacífico, y la microplaca Rivera. Éstas participan en los procesos de interacción dinámica, que generan la actividad sísmica, volcánica y de tsunamis locales. En la Región Sismotectónica delimitamos 3 PS (Figura 16), sobre la base de lo indicado en el párrafo anterior. En Cotilla y Álvarez (1991) y Cotilla *et al.* (1991) están los conceptos. Las tres PS delimitadas son: 1) PS Norte-Occidental (Península y Golfo de California); 2) PS Occidental (Puerto Vallarta-Tehuantepec); y 3) PS Centro-Oriental (Zonas del N y Centro-GM-Yucatán) (Figura 16). La de mayor nivel es la PS Occidental, donde están las regiones de Colima, Puerto Vallarta y Oaxaca. Cada una de las PS tiene US, y en éstas están las zonas sismogenéticas. Muchas de estas últimas tienen continuidad en regiones vecinas. Las 11 US aparecen en la figura 17 y sus principales características están en la tabla 23.

Figura 16: Provincias sismotectónicas

Se presenta la Región Sismotectónica Mejicana. En ella aparecen: **1)** Placas (PC= Caribe, PCO= Cocos, PN= Norteamérica, PNA= Nazca, PP= Pacífico, y PS= Suramérica); **2)** Microplaca (Rivera); **3)** Provincias (áreas indicadas por líneas blancas (1= Norte-Occidental, 2= Occidental, y 3= Centro-Oriental)); y **4)** Lugares (AC= América Central, C= Cuba, y F= Florida).

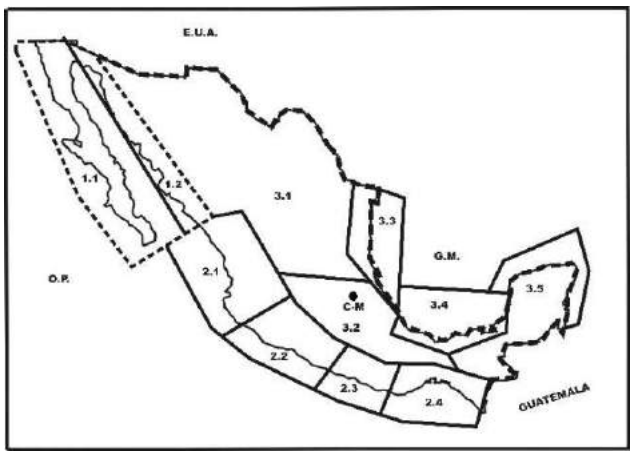

Figura 17: Unidades sismotectónicas

Aparecen: 1) Lugares (C-M= Ciudad de México, E.U.A.= Estados Unidos de América, G.M.= Golfo de México, y O.P.= Océano Pacífico); 2) Unidades Sismotectónicas (1= Provincia Sismotectónica Norte Occidental (1.1= Península, y 1.2= Golfo-Llanura Costera); 2= Provincia Sismotectónica Occidental (2.1= Nayarit-Puerto Vallarta, 2.2= Colima-Michoacán, 2.3= Guerrero, y 2.4= Oaxaca-Chiapas); y 3= Provincia Sismotectónica Centro-Oriental (3.1=Interior, 3.2= México, 3.3= Norte de Veracruz, 3.4= Veracruz, y 3.5= Yucatán)).

Tabla 23: Principales características de las Provincias Sismotectónicas

Nº	Características	Norte-Occidental	Occidental	Centro-Oriental
1	Identificación	1	2	3
2	Unidades	2	4	5
3	Mmáx	7,2	8,2	8,0
4	hmáx (km)	20	60	10-200
5	Terremotos / año	~1.000	~20.000	~600
6	Terremotos (M≥7,5/≥ 8,2)	3 / -	+ 50 / + 6	4 / -
7	Tipo de sismicidad	Entre placas	Entre placas	Interior de placas
8	Zona Sísmica	B-C-D	C-D	A-B
9	Estructura asociada	Fallas San Andrés-Cerro Prieto-Amado-Wagner	Fosa Mesoamericana	Golfo de México-Oriente de México
10	Fuente de tsunamis	Lejana	Local y lejana	Lejana
11	Hmáx (m) de las olas	2,5	10	-
12	(cantidad) Placas	(2) Norteamérica y Pacífico	(4) Caribe, Cocos, Norteamérica y Rivera	(1) Norteamérica
13	Peligro	II	I	II-III

Con relación a la prolongación de las zonas activas a otras regiones, se puede indicar que PEMEX (1982) ya representó en la figura 1 las 48 Provincias Geológicas que definieron para MX. En ella aparecen, por primera vez, 23 Provincias terrestres, 8 Provincias marinas y 17 Provincias mixtas, bajo el siguiente concepto: *"…Provincia Geológica es aquella superficie cartografiable de la superficie sólida del Planeta, de centenares de kilómetros cuadrados de extensión, caracterizada por sus rocas, su estructura y una secuencia de eventos tal que integre una historia evolutiva singular diferente a la de sus áreas adyacentes, de las cuales están separadas por límites estratigráficos, tectónicos, o ambos…"*.

Las US delimitadas en la PS Norte-Occidental, donde se produce el contacto transcurrente, son 2: 1) Península (Bahía Tortugas-San Lucas-La Paz-Angostura); y 2) Golfo-Llanura Costera (San Luis-Puerto Peñasco-La Yuta-Los Mochis-Mazatlán). La PS Centro-Oriental tiene su exclusiva relación, y directa, con la Placa de Norteamérica. En ella, la de menor categoría, pero con mayor área, hay 5 US: 1) Interior; 2) México; 3) Norte de Veracruz; 4) Veracruz (Veracruz-Tabasco-Campeche); y 5) Yucatán. De estas 5 unidades, la más activa es la cuarta. La sismicidad en todas es de interior de placa y con predominio de terremotos someros (h= 20-25 km).

Como se dijo anteriormente, la PS Occidental es la más activa de las 3, y tiene el mayor peligro de tsunamis. Aquí los terremotos tienen profundidades <50 km, mecanismos focales principalmente de subducción, y hay 4 US: 1) Nayarit-Puerto Vallarta; 2) Colima-Michoacán; 3) Guerrero; y 4) Oaxaca-Chiapas. En general, todas tienen características comunes por su relación espacio-temporal con la FM y los sistemas de placas del Pacífico, en una región convergente. Las convergencias de las placas para las Provincias Occidentales es: 1) Norte Occidental (Placas de Norteamérica-Pacífico); y 2) Occidental (Placas de Cocos-Norteamérica-Rivera, Cocos-Norteamérica, y Cocos-Norteamérica-Caribe). Cabe apuntar que Oaxaca-Chiapas tiene, en relación con Nayarit-Puerto Vallarta, un mayor nivel de actividad sísmica.

Los estudios de Kuroieva (1985, 1995, 2004), CEF (1993), Sánchez y Farreras (1993), CENAPRED (1996, 2001), NOAA (2004, 2018), SEMAR (2012) y Servicio Geológico Mexicano (2007, 2007A) recogen datos y recomendaciones sobre los peligros naturales, de nuestro interés aquí. A partir de ellos, principalmente, y con la base cierta de la afectación por terremotos fuertes (M> 7,0), tsunamis, y volcanes, y la cantidad de pérdidas humanas y económicas, se asume una gradación en 3 niveles de Peligro (I-III). Esos niveles por PS son: (I) Occidental, (II) Norte-Occidental y Centro-Oriental, y (III) Centro-Oriental.

Las figuras 18 y 19 son 4 fotografías realizadas en los recorridos por la US 2.1. La figura 18 (1) muestra uno de los resultados de la energía liberada y la virulencia del volcán Ceboruco, en el Estado de Nayarit, ~30 km de distancia de la localidad Ixtlán del Río. Esa localidad se encuentra desde el punto de vista morfotectónico en el bloque B4 (figura 13 de Cotilla *et al.,* 2017). Esta estructura está muy articulada y tiene una importante cantidad de fallas. La figura 18 (2) recoge parte de las ruinas del entonces señorial Hotel Casa Grande, en Melaque, Estado de Jalisco, que se incluye en el bloque morfotectónico B5 (figura 13 de Cotilla *et al.,* 2007). Esta instalación fue destruida por el terremoto del 19.10.1995 (M 8,0). Las aguas del tsunami llegaron a sus bases.

En el entorno de la Presa Santa Rosa (US 2.1), del Río Grande de Santiago en Amatitán, Estado de Jalisco realizamos una campaña de mediciones de grietas, juntas, fracturas y fallas (Figura 19). Este sistema de elementos se corresponde con el determinado en otros puntos del ENV. El bloque morfotectónico B2 (figura 13 de Cotilla *et al.,* 2007) con tendencia a levantamientos incluye a la Presa y al poblado vecino a ella. Comprobamos en la zona la significativa cantidad de grandes bloques desprendidos y desplazados, y que están asociados con esa red de estructuras. Evidentemente, esto es una seria amenaza en caso de un terremoto fuerte.

Las informaciones del INSIVUMEH, para el territorio de Guatemala, en el trienio 2012-2014 muestran un mismo patrón sísmico. Los terremotos registrados se incluyen en la tabla 24. Se observa que: 1) las cantidades de terremotos locales por año son similares (1.215 (2012), 1.734 (2013), y 1.283 (2014)); 2) hay un arreglo lateral sucesivo y cuasi-paralelo de epicentros desde el Océano Pacífico al interior continental; 3) la densidad epicentral disminuye significativamente en ese sentido. Este patrón se visualiza en los 3 pares de figuras 5 y 8 de sus boletines sismológicos. En particular, sus tres figuras 8 tienen las 6 zonas sismogenéticas en que regionalizan al territorio guatemalteco. De nuestro interés son 5 las zonas. Todas ellas tienen una figura geométrica prácticamente rectangular, y las identificadas como G1, G2, G3, y G4 son paralelas a la costa del Pacífico; mientras que la G6 se distingue por su transversalidad y relación con los sistemas de fallas Motagua-Polochic (Figura 4). Esta zona G6 es la que tiene menor cantidad de eventos sísmicos. Las zonas G1-G4 se avienen, de forma aproximada a la dirección y las características de la PS Occidental. Las proporciones de eventos por grupo de 4 zonas (G1-G4) y año son: 82 % (2014), 68 % (2013), y 70 % (2012). Esas cifras porcentuales son equivalentes a las determinadas para el conjunto de 3 Estados mexicanos del Pacífico (Guerrero-Oaxaca-Chiapas) por año: 85 % (2017), 75 % (2016), 77 % (2015), 78 % (2012), y 65 % (2011). Sin embargo, por cantidad de eventos las cifras son muy superiores en MX con respecto a los de Guatemala: 22.503 (2017), 11.656

(2016), y 8.472 (2015). Esas estructuras de Guatemala y MX están relacionadas con las zonas de convergencia e interacción geodinámica Cocos-Norteamérica y Cocos-Caribe.

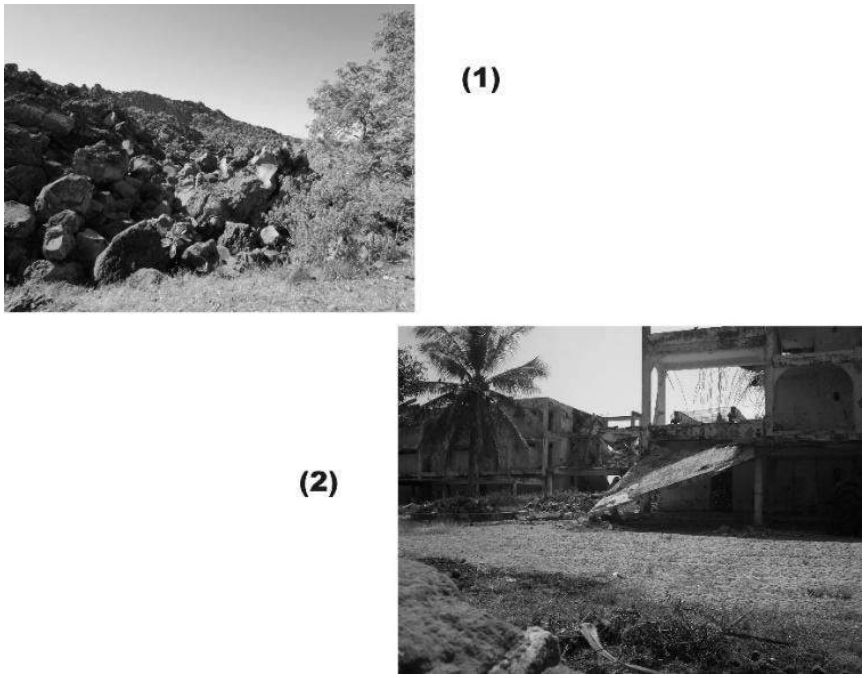

Figura 18: Áreas del volcán Ceboruco y Hotel de Melaque

En la combinación fotográfica se muestran los efectos de 2 importantes fenómenos naturales que han dañado, seriamente, a México: **(1)** Cantos del volcán Ceboruco en Nayarit (por la erupción de 1870); y **(2)** Daños irreparables al Hotel Casa Grande, de Melaque, por el terremoto de 19.10.1995 (M 8,0). El volcán está en el bloque Yaganiza (B4) y la zona sísmica B (ver Figura 10). El hotel pertenece al bloque San Andrés (B5) y la zona sísmica D (ver Figura 10).

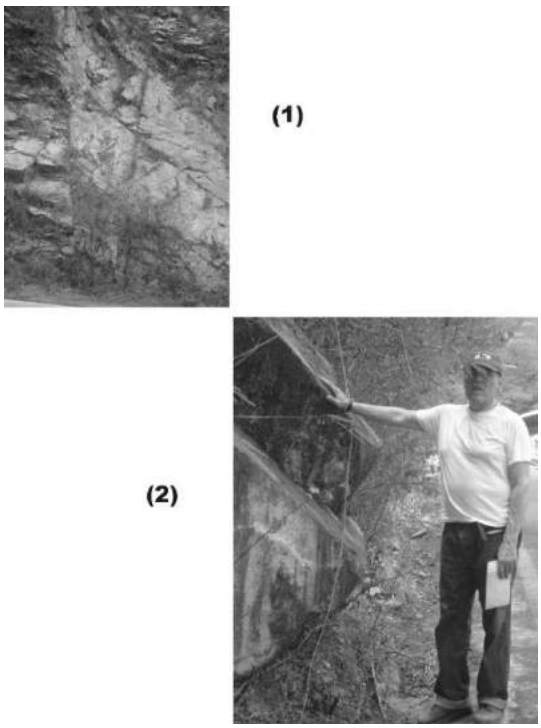

Figura 19: Inmediaciones de la Presa Santa Rosa

Las fotos muestran: **(1)** El sistema predominante de fracturas, cartografiado y analizado, en las inmediaciones de la Presa Santa Rosa en Jalisco; y **(2)** Evidencia del desprendimiento de grandes bloques en dirección al vecino asentamiento urbano, <20 m de distancia a la izquierda del primer autor. Estos sitios están en los límites de los bloques Galera (B2) y San Sebastián (B1) (Cotilla *et al.,* 2017).

Tabla 24: Datos de la sismicidad de Guatemala (INSIVUMEH)

Nº	Zona sismogenética	Siglas	Eventos 2012	Eventos 2013	Eventos 2014	Total
1	Guatemala Polochic Motagua Oeste	G6	14	180	152	346
2	Guatemala Pacífico Central	G1	429	395	404	1.229
3	Guatemala Antearco	G2	324	493	462	1.279
4	Guatemala Arco Volcánico Oeste - Guatemala Arco Volcánico Este	G3-G4	98	284	185	567
		Σ G1-G4	*851*	*1.172*	*1.051*	*3.074*

Como una comprobación final, de nuestro análisis y de la propuesta sismotectónica, se presentan datos de la sismicidad registrada (9.918), por el SSN de MX, en los meses de enero-marzo de 2018, considerada muestra de control (Tabla 25). Los Estados donde se concentró esta actividad fueron: Oaxaca, Guerrero, Chiapas, Michoacán, Colima, y Baja California (en el Pacífico). En ellos hay, para ese periodo, 15 terremotos con M≥ 5 (Oaxaca= 10, Chiapas= 2, y en Guerrero, Jalisco y Baja California Sur, uno cada uno). Estos eventos están en la PS Occidental y la PS Norte-Occidental. También se puede observar para 2 grupos de Estados la diferente cantidad de terremotos registrada con M≥ 4,0: 1) 727 en Guerrero-Chiapas-Oaxaca; y 2) 31 para Baja California-Baja California Sur. Destaca que para ese periodo en: 1) Campeche, Quintana Roo, y Yucatán no se registró sismicidad; y 2) Oaxaca el promedio de sismos es del 64 %. Esto significa, sin margen de duda alguna, que el patrón de sismicidad (Figura 20) es el mismo que hemos visto en epígrafes anteriores (Figura 11).

Tabla 25: Datos de la sismicidad principal de México del año 2018 (enero-marzo)

Mes	Total de terremotos / Estado con mayor (%)	M	Mmáx / h(km) / Fecha / Coordenadas / Lugar / mecanismo / réplicas
Enero	2.575/ Oaxaca (62)	2,2-6,3	6,3/ 16 / 19.01 / 26,66 N 111,11 O/ Loreto, Baja California Sur / transcurrente derecho / 22
Febrero	4.165/ Oaxaca (60)	1,5-7,2	7,2/ 12 / 16.02 / 16,25 N 98,03 O/ Pinotepa Nacional, Oaxaca / inverso / 4.894
Marzo	3.178/ Oaxaca (71)	1,6-5,3	5,3 / 13 / 20.03 / 15,87 N 98,72 O / Pinotepa Nacional, Oaxaca / - / ~60
Total	*9.918*		

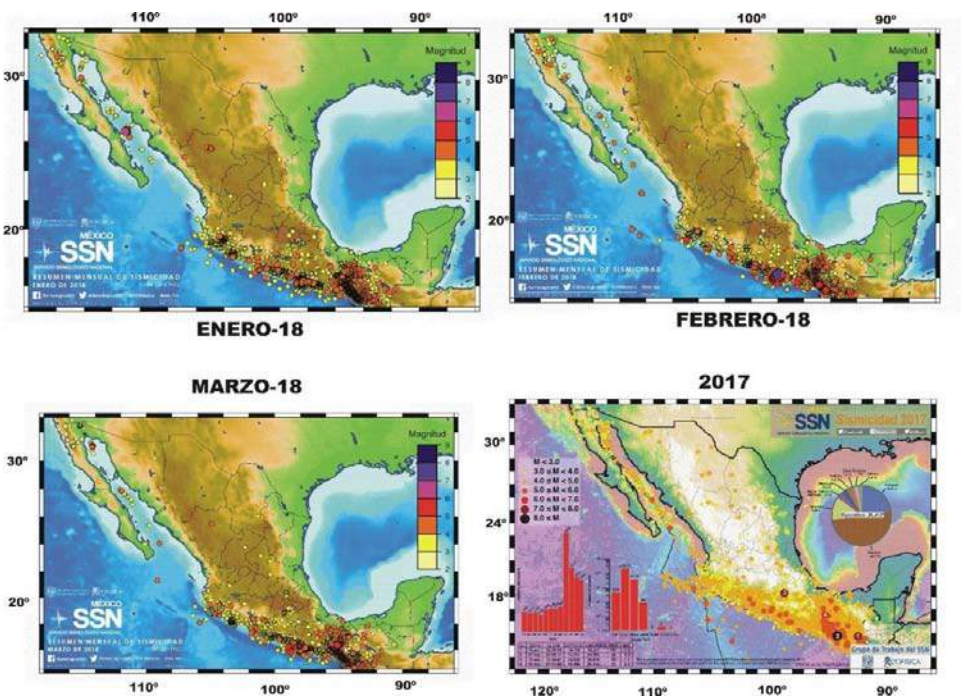

Figura 20: Mapas de sismicidad registrada por el SSN de México

Los 4 mapas del Servicio Sismológico Nacional de México representan la sismicidad registrada en los meses de enero-marzo de 2018 y el año 2017.

Concluimos que los datos expuestos en el trabajo demuestran que México puede sufrir terremotos fuertes y tsunamis, con importantes pérdidas humanas y económicas. Por esto, está justificada la nueva regionalización, aquí presentada; y que servirá de base al proyecto de un mapa sismotectónico. Sostenemos que México es una extensa y compleja Región Sismotectónica localizada, mayoritariamente, en la placa continental de Norteamérica y tiene 2 tipos de sismicidad (entreplacas y de interior de placa). Desde este punto de vista, hay en ella una estructura jerárquica activa e interrelacionada con Provincias, Unidades, y Zonas Sismogenéticas. Ha quedado de manifiesto que sus principales elementos sismotectónicos tienen relación de continuidad en otros países vecinos, como Estados Unidos de Norteamérica y Guatemala.

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Changes in Earth Cover and Relations with the Equation Universal Soil Losses in Basin of the Western Plateau of Sao Paulo, Brazil

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Abstract- The expansion of sugarcane crop in watersheds, located in the regions of Marilia and Presidente Prudente, in the interior of São Paulo, by replacing degraded pastures, is altering soil cover and influencing erosive processes. This article aims to analyze the land cover changes in the basin of Confusion's stream and relate to the parameters of the factors of the Universal Soil Loss Equation. The land cover charts were generated with images of CBERS's satellite dated 2009 and 2018 by supervised classification. The areas of the land cover classes were related to factor C of the USLE and data estimates of secondary sources of erosivity factor (R), erodibility factor (K) and topographic factor with the data of slope (LS). From these parameters, an estimate of soil loss was presented for the basin of Confusion's stream. The soil loss in the basin of Confusion's stream was estimated by 2018 data at 2,484 t/ha/y.

Keywords: hydrographic basin; erosion; cartography; GIS.

GJHSS-B Classification: FOR Code: 049999

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Strictly as per the compliance and regulations of:

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Abstract- **The expansion of sugarcane crop in watersheds, located in the regions of Marilia and Presidente Prudente, in the interior of São Paulo, by replacing degraded pastures, is altering soil cover and influencing erosive processes. This article aims to analyze the land cover changes in the basin of Confusion's stream and relate to the parameters of the factors of the Universal Soil Loss Equation. The land cover charts were generated with images of CBERS's satellite dated 2009 and 2018 by supervised classification. The areas of the land cover classes were related to factor C of the USLE and data estimates of secondary sources of erosivity factor (R), erodibility factor (K) and topographic factor with the data of slope (LS). From these parameters, an estimate of soil loss was presented for the basin of Confusion's stream. The soil loss in the basin of Confusion's stream was estimated by 2018 data at 2,484 t/ha/y.**

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I. Introduction

The first estimates of soil losses in Brazil were analyzed in the 1940s using experimental plots at the Agronomic Institute of Campinas (BERTONI; LOMBARDI NETO, 1999).

The Universal Equation of Soil Losses was developed from the studies of Wischmeier and Smith (1961 apud LAFLEN; MOLDENHAUER, 2003) from 10,000 data on soil loss rates in experimental plots in the United States of America.

Soil losses in Brazil are estimated at approximately 848 million tons per year (MERTEN; MINELLA, 2013). Fast-paced soil losses in the degraded areas of the Western Plateau of São Paulo represent environmental and economic damage.

The scale of watersheds has repercussions in recent years due to the details of the guaranteed by advances in geographic technologies. On the local scale, the particularities of each rural producer are found and mitigating measures are applied in the face of land degradation conditions. The dialogue with rural producers takes place through the technical knowledge of public agencies and researchers guide these agencies through extension projects. The definition of the concepts and principles of water management is essential to consolidate the necessary measures in river basins. Ideals based on rational water use are important to guide political decisions and favor of soil conservation measures and recovery of degraded areas.

The geoprocessing techniques used met the research needs, confirming that its use improves the processes and phases of spatial analysis. In addition, the created database can be replicated, corrected and updated at any time, which makes it dynamic and applicable to the most diverse spatial representation demands of the information contained therein (PIROLI, 2013).

The watershed is a territorial and physical unit present in nature bounded by drainage. Nature presents its diversity and researchers need to avoid generalizing small scales and seek to understand natural phenomena in field research.

In this sense, fieldwork is necessary, as the main methodology of the geographer, to investigate the nature of each hydrographic basin and present the diagnoses (inventories), to carry out environmental planning from the perspective of water resources management with adequate prognoses to ensure the future availability of drinking potable water (GUIMARÃES, 1999).

From the development of Geographic Information Systems, spatial data from watersheds served as parameters applying the Universal Equation of Soil Losses, mainly by the formation of numerical elevation models. The development of erosive processes in the large hydrographic basins of tropical environments made it propitious to apply this empirical model in river basins to generate databases in Geographic Information Systems (PARVEEN; KUMAR, 2012).

In recent years, research on river basins and geoprocessing techniques has become more present in geographical studies. The spatiality of erosive processes involves the understanding of the aspects of hydrographic basins and the transformations that occur in rural landscapes of changes in agricultural activities. The use of conservation practices for the recovery of areas with degraded soils can contribute to the mappings performed by geographers with support in geographic information systems.

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The Confusion Stream's basin has an area of 46,760 ha, located in the northwest part of the municipality of Rancharia. It is considered a sub-basin belonging to the River of Peixe basin. The channel of river of the main course is 35 km long, being the tributary Saltinho stream with an extension of 16 km. The basin has an average width of 22 km and a maximum length of 34 km. Figure 1 shows the location of the Confusion Stream's basin.

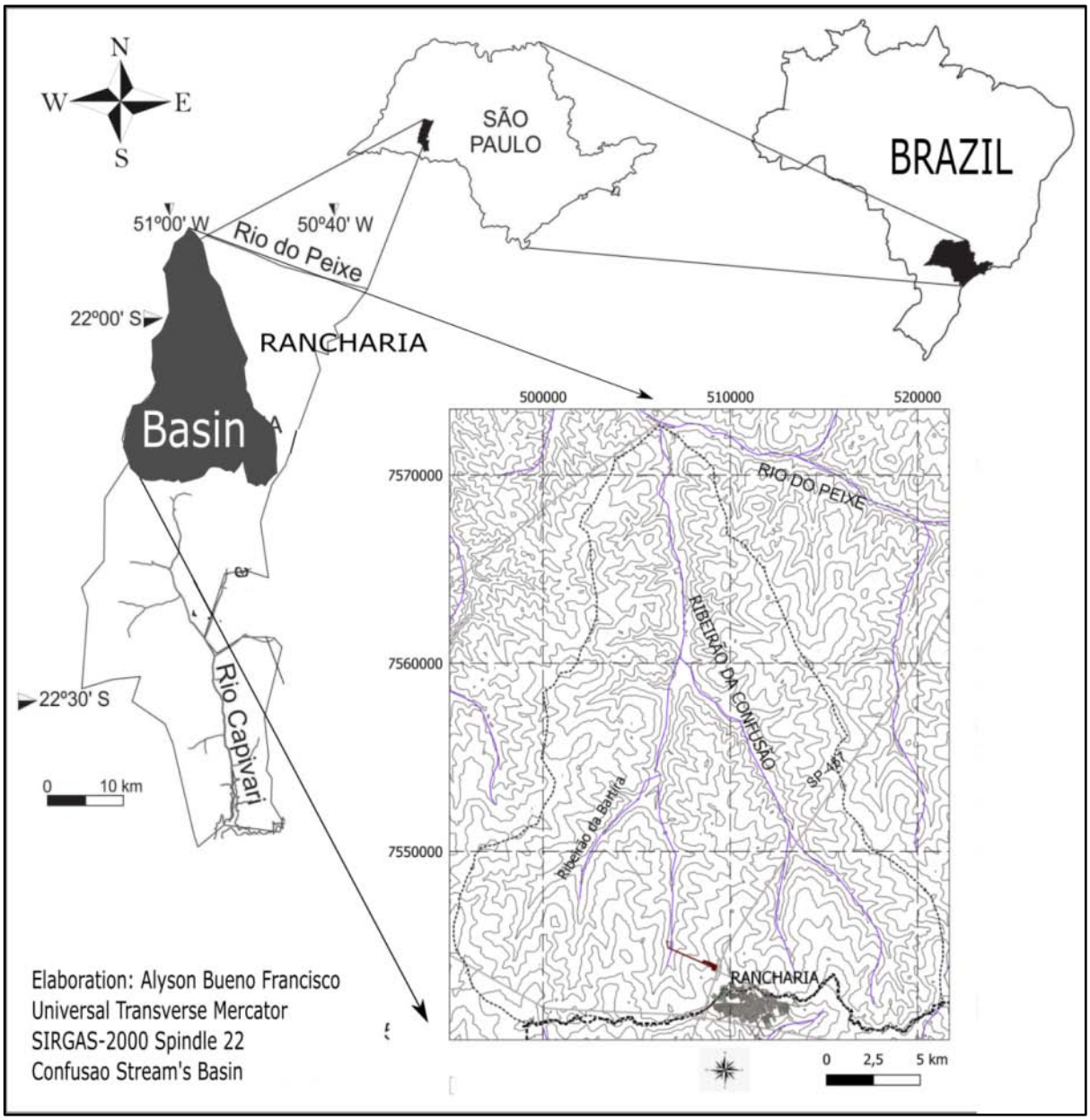

Figure 1: Map of Confusion Stream's Basin

The quotas relief of the Confusion Stream's basin has between 380 and 540 meters. The relief consists of wide hills and wavy tops belonging to the Western Plateau of São Paulo. The slope is generally low between 5° and 15° in more than 80% of the area, as shown in the chart in figure 2.

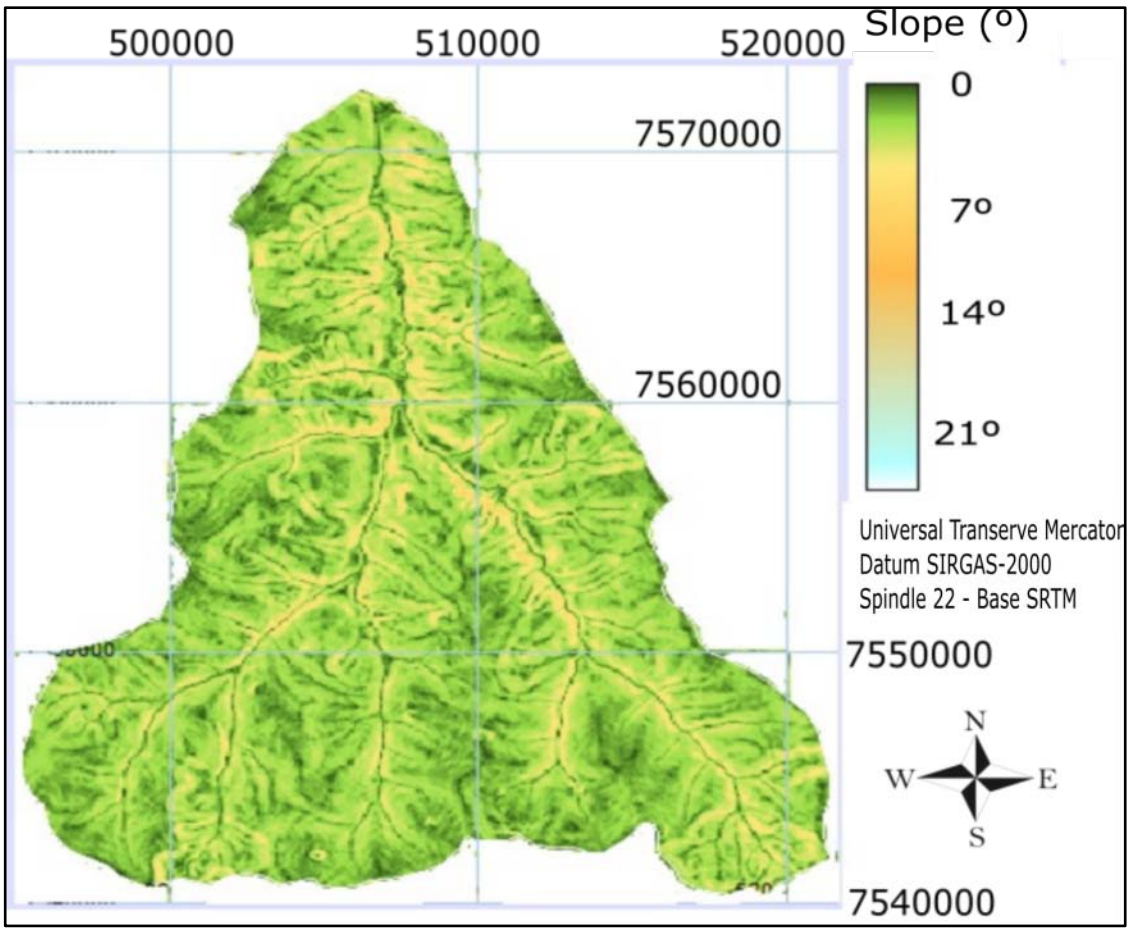

Figure 2: Map of Slope terrain in Confusion Stream's basin

According to the Map of Soils in the State of São Paulo (OLIVEIRA et al., 1999), the predominant soils in the Confusion Stream's basin are the Red Latosols and the Red-Yellow Argisols. The erodibility values of the surface horizon of the Red Argisols of the Presidente Prudente region are estimated at 0.051 Mg/ha/year. For the Red Latosols of the sandy phase, the estimated values were 0.016 Mg/ha/year (FREIRE; GODOY; CARVALHO, 1992).

On the climatic conditions in the region affected by water erosion, Francisco (2017) presents the erosivity of rain for the municipality of Rancharia, considering precipitation data between 1945 and 2003, being in rainy years the R factor of 9,088 MJ.mm/ha.h.ano; 7,129 MJ.mm/ha.h.year for regular years and 5,665 MJ.mm/ha.h.year for dry years.

Despite deforestation for cotton planting until the 1970s and later the domain of pasture planting for cattle herd farming, the Confusion Stream's basin has preserved fragments of native forest (approximately 8% of the area), including a fragment of approximately 3,000 hectares.

In the last 15 years, installing a sugar-alcohol plant in the southwestern part of the basin favored the increase of sugarcane planting areas (23% to 34% of the area) with the existence of terraced plantations, replacing the degraded pasture areas.

II. Methodology

The clinographic letter of slope was elaborated based on data from the digital elevation model from the SRTM mission, in the Slope routine of the TerrSet GIS. The slope data served as the basis for the elaboration of the estimation of the LS factor, ramp length (slopes) and unevenness (slopes).

The preparation of the land cover charts were carried out in the TerrSet Geographic Information System with orbital images of the CBERS satellite dated October 2009 and February 2018, through the supervised classification routine. The geographic referencing of the images was performed at GIS Idrisi. After geographic referencing, the false-color composition was applied with bands 2, 3 and 4.

Using the Digitize routine, reliable samples were selected with the vectorization of polygons, whose each class to be represented had a value. With the use of the Make-sig routine, signatures are created and then the classifier is defined with maximum likelihood with the use of the Max-like routine. Then, mode filtering was applied using a size 7x7. To cut out the area of the

Confusion Stream's basin, the limits of the Shuttle Radar Topography Mission (SRTM) data were delimited using SRTM data in the Global Mapper software. The vector that delimits the watershed was exported in Shapefile format, having as reference system the horizontal datum SIRGAS-2000.

Regarding the factors attributed to the Universal Equation of Soil Losses, the erodibility indexes presented by Freire et al. (1992). The rainfall erosivity (R) was estimated based on the reference of Francisco (2017) when presenting the values for an adjacent basin 15 km away from the Confusion Stream's basin. The types of soils identified in the hydrographic basin were adopted by the map presented by Oliveira et al. (1999). The C factor of soil management forms, by the land cover classes, followed the reference adopted by Pinto (1991). The factor conservation practices (P) was estimated based on the indices of calculations expressed by Bertoni and Lombardi Neto (1999).

III. Results and Discussion

Table 1 presents the land cover classes in 2009 and 2018 in the Confusion Stream's basin.

Table 1: Areas and plots of land cover classes in Confusion Stream's basin

Land covers classes	Area in 2009 (ha)	%	Area in 2018 (ha)	%
Urban areas and roads	0.58	0.01	1.55	0.003
Native forest	3,610.00	7.72	3,913.28	8.37
Water channel	1.42	0.01	1.58	0.003
Agricultural crop	10,679.00	22.84	15,768.36	33.72
Pasture	23,085.00	49.75	22,571.32	48.27
Land wood	326.00	0.70	-	-
Bare soil	8,698.00	18.75	3,504.06	09.61

Figure 3 presents the land cover map of the Confusion Stream's basin by 2009 data.

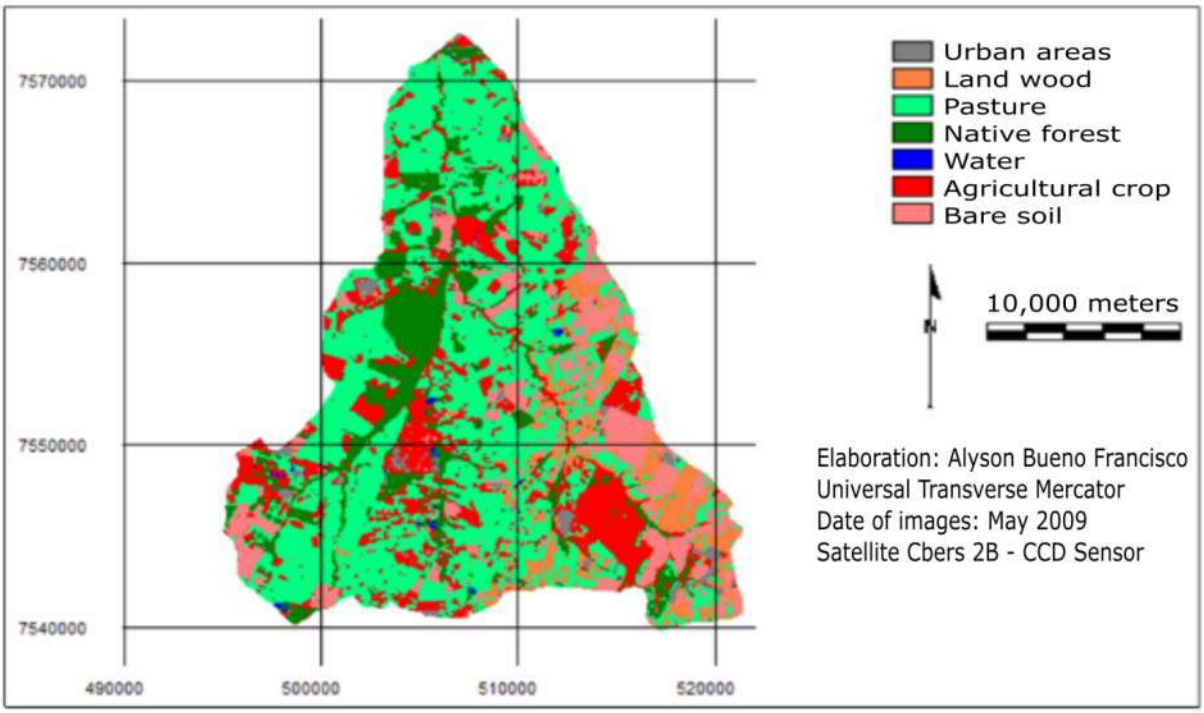

Figure 3: Map of Land Cover of the Confusion Stream's Basin (2009)

Figure 4 presents the land cover map of the Confusion Stream's basin by 2018 data.

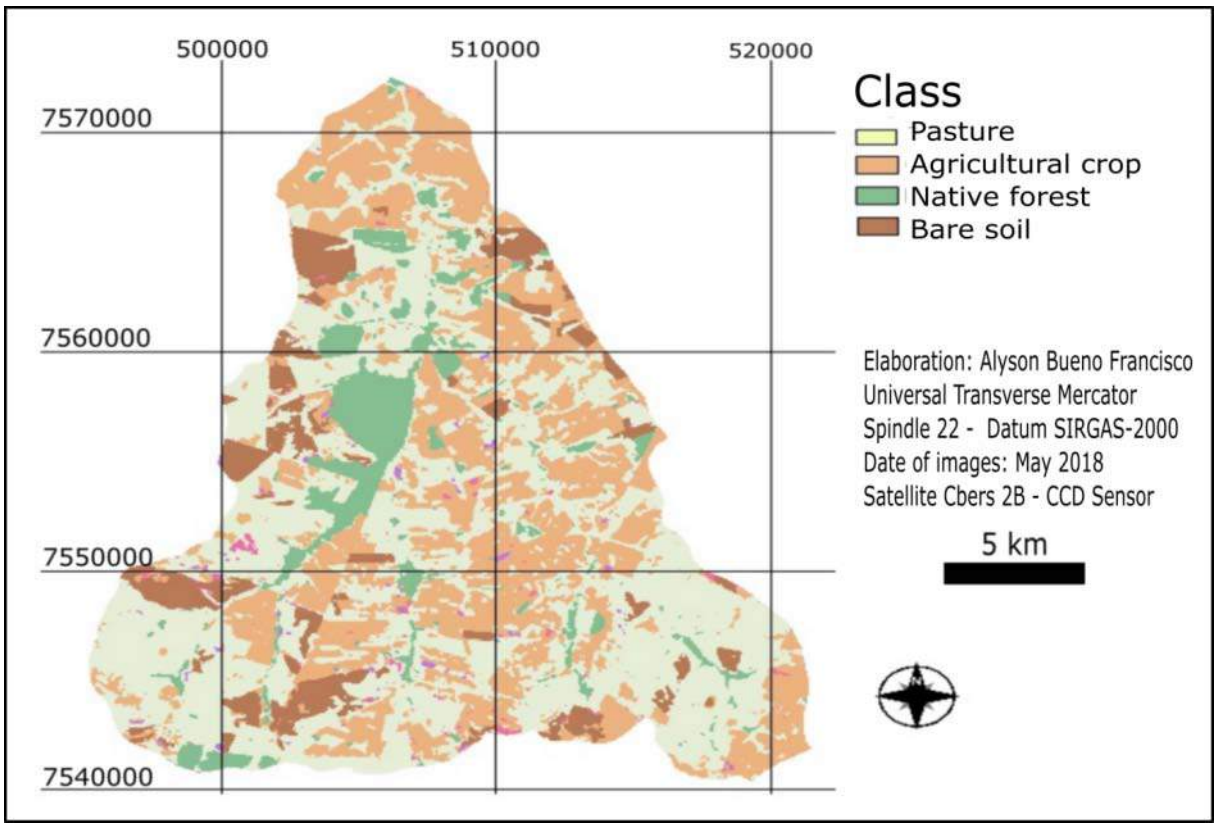

Figure 4: Map of Land Cover of the Confusion Stream's Basin (2018)

Table 2 shows the relationship between the areas of the land cover classes and the C factor of land use applied in the Universal Equation of Soil Losses.

Table 2: Relation land cover classes with factor C of USLE

Land covers classes	Factor C	Area in 2009 (ha)	C (2009)	Area in 2018 (ha)	C (2018)
Native forest	0.0004	3,610	0.00003	3,913.28	0.00003
Agricultural crop	0.0500	10,679	0.11420	15,768.36	0.16860
Pasture	0.0075	23,085	0.37000	22,571.32	0.36200
Land wood	0.0450	326	0.00700	-	-
Bare soil	0.1000	8,698	0.18601	3,504.06	0.00370

The data show factor C from 810.17 to 994.31, an increase of 18.5% in erosive potential according to land cover changes in 9 years.

The table 3 presents the relation of the areas of the land cover classes with the predominant types of soils by the K factor of erobility.

Table 3: Factor of erobility (K) in relation areas of land covers

Classe de cobertura da terra	Soil kind	Factor K	Área in 2009 (ha)	K (2009)	Área in 2018 (ha)	K (2018)
Native forest	Hydric soil	0.003	3,610	0.00023	3,913.28	0.00025
Agricultural crop	Clay soil	0.051	10,679	0.01165	15,768.36	0.01719
Pasture	Oxissoil	0.016	23,085	0.00799	22,571.32	0.00772
Land wood	Oxissoil	0.016	326	0.00011	-	-
Bare soil	Clay soil	0.051	8,698	0.00949	3,504.06	0.00382

The erodibility factor remained practically stable in 9 years, being present the addition of native forest areas present in hydromorphic soils of primary forests and a decrease in exposed soil areas, very conducive to the development of laminar erosion.

Based on the data of the factors of application of the Universal Equation of Soil Losses by erosivity presented to the municipality of Rancharia (PERUSI et al., 2004) in 7,300 MJ.mm/ha.h.year, we have the estimated indices for the land cover classes in table 4.

Table 4: Factor of erosivity rain (R) in relation areas land covers

Classe de cobertura da terra	Área in 2009 (ha)	R (2009)	Área in 2018 (ha)	R (2018)
Native forest	3,610	564.66	3,913.28	610.92
Agricultural crop	10,679	1,667.16	15,768.36	2,461.64
Pasture	23,085	3,603.94	22,571.32	3,523.7
Land wood	326	50.89	-	-
Bare soil	8,698	1,357.9	3,504.06	547.03
∑		7,244.55		7,143.29

When considering the average length of 100 m of ramp in the basin and the mean slope of 5.67% or 10°, the topographic factor was estimated at 0.006.

The factor of conservation practices was calculated based on the mean slope of 10°, being obtained in 0.19342.

When considering the estimated factors of the USLE for the basin, the rates of soil losses were estimated in 2009 by the land cover classes in table 5.

Table 5: Estimated factors of the USLE for the basin in 2009

Land covers	Factor R	Factor K	Factor LS	Factor C	Factor P	Ei	A (t/ha/year)
Native forest	564.66	0.00023	0.006	0.00003	0.19342	2.10^{-9}	0.0002
Agricultural crop	1,667.16	0.01165	0.006	0.11420	0.19342	0.0257	1,201.73
Pasture	3,603.94	0.00799	0.006	0.37000	0.19342	0.0123	577.51
Bare soil	1,357.9	0.00949	0.006	0.18601	0.19342	0.0027	130

The Confusion Stream's basin, with 46,760 ha, presents an estimate of soil losses at 1,909.24 t/ha/year in 2009.

When considering the estimated factors of the USLE for the basin, the rates of soil losses were estimated in 2018 by the land cover classes in table 6.

Table 6: Estimated factors of the USLE for the basin in 2018

Land covers	Factor R	Factor K	Factor LS	Factor C	Factor P	Ei	A (t/ha/year)
Native forest	610.92	0.00023	0.006	0.00003	0.19342	2.10^{-9}	0.0002
Agricultural crop	2,461.64	0.01165	0.006	0.11420	0.19342	0.038	1,777.23
Pasture	3,523.7	0.00799	0.006	0.37000	0.19342	0.012	566
Bare soil	547.03	0.00949	0.006	0.18601	0.19342	0.003	140.85

The Confusion Stream's basin, with 46,760 hectares, presents an estimate of soil losses at 2,484.08 t/ha/year in 2018.

IV. Conclusions

The estimates of soil losses are important for the management of watersheds with the application of mapping in the identification of the most degraded areas susceptible to erosion. The mapping of the current conditions of the hydrographic basin (inventory) favors the diagnosis of degradation conditions and proposals for environmental recovery.

Brazil is a country with large territorial extensions and watersheds that are distributed in several municipalities and states and it is important to implement policies for the management of water resources through partners with the various territorial units. Brazilian municipalities need to draw up an inventory with maps and databases of watersheds to favor water management.

Soil conservation is an interdisciplinary theme and can integrate several professionals from the technical and research fields to support public agencies in the proposals to recover areas degraded by rigorous erosive processes.

Soil degradation conditions require the improvement of more empirical scientific techniques and with the support of geographic information systems to contribute to the monitoring of erosive processes.

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The Red Sea..Features of Conflict & Cooperation Opportunities

By Dr. Abou Bakr Fathi Al Desouki

Abstract- *Purpose:* The study aims at showing the geostrategic importance of the Red Sea that makes it a venue of competition and conflict among many local, regional and international powers, showing the aspects of the conflict through determining its elements, introducing existing and future cooperation opportunities and determining the type of relationship between the aspects of the conflict and the opportunities of cooperation in the Red Sea.

Design / Methodology / Approach: The study is based on using "The New Functionalism Approach", this approach is an automatic and transitional approach in the same time so that integration among States shall necessarily start in the economic field that automatically leads – if necessary conditions are met – to move to other fields until the integration process reaches its peak. According to the new functionalism approach, the spillover factor is considered the major drive for the process of integration and merging.

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The New Functionalism Approach emerged following the criticisms that were addressed to the original functionalism approach that focused on the impossibility of combining and unifying the interests of peoples and the impossibility of segregating between political issues and their remarkability over other issues and eventually, the impossibility of convincing the States to waive part of its sovereignty in favor of the new functional institutions. The New Functionalism Approach came to place a different approach for integration and merging and developing new standards and indicators for this phenomenon. The New Functionalism Approach cares for the existence of the integration phenomenon among sovereign sector in States under the pressure of economic temptation.

The New Functionalism Approach includes a number of hypotheses of which the importance of placing some integrated sectors of independent States under monitoring, supervision and co-management as the integration section must enjoy vital and strategic importance for the economies of those States. This sector shall also enjoy the competitive feature that does not lead to the conflict of the interests of States and their feeling with threat.

The theory is also based on the concept of area integration instead of the integration approach within its international frame. The new functionalists believe that attempting to combine between a large group of States that differ in the economic, social and political sides is a kind of Utopia or idealism. Therefore, it is a must to focus on the area integration that starts from certain geographic regions that meet some preliminary conditions for the process of integration and merging.

Findings: Though the aspects of conflict in the Red Sea still continue, the opportunities of cooperation plays a positive role in neutralizing or delaying the conflict on the short run through maximizing the joint interests, deepening cooperation cases and mutual dependence through joint and institutional work that varies from bilateral to multiple in a way that might, by time, eliminate the sources of conflict, and realize security and stability in the Red Sea.

Keywords: *conflict – cooperation – security – red sea – horn of africa – suez canal –bab al-mandab – piracy – gulf security.*

I. Introduction

The Red Sea is a strategic water artery that links the east and the west. Therefore, it becomes one of the most important international trade routes. It is also the basic bridge for the transport of Gulf oil to world markets. Recently, the Red Sea and the Horn of Africa territory have become one of the most important regions in the world for attracting investment. The inauguration of the Suez Canal on 17th November 1869 was the basic turning point in the importance of this sea as it became a world strategic waterway. In the seventies of the twentieth century, the Arabs said that the Red Sea is an "Arabic Lake" considering its importance. Considering the development of this importance, the United States placed the sea region under Africa related American military command AFRICOM, since 2008 after it had been under the Central Command (Salem, 2021). Meanwhile, States became interested in developing external polices under the name "Red Sea" and sometimes under the name "The Horn of Africa and the Red Sea" (Rajab, 2021).

a) Main research question

This study investigates the following main research question: Would cooperation opportunities succeed in neutralizing, postponing or terminating the features of conflict in the Red Sea?

b) Research Assumptions

The basic assumption of this study is "Cooperation opportunities play a role in determining the future of the conflict in the Red Sea".

II. The Geostrategic Importance

Geographically, the Red Sea lies between the two continents; Asia and Africa. Its entrance is from the north of the Suez Canal and from the south Bab Al Mandab. It is the connecting ring between the Indian Ocean and the Mediterranean Sea and therefore, it becomes on the most important international waterways (Khan, 2018).

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New geostrategic landscape started to be formed in the Red Sea region for many reasons of which the military operation headed by the Arab coalition in Yemen since March 2015, the increasing influence of the international and regional powers in the Red Sea, the appearance of international-regional coalitions in addition to the increasing international competition over the development of ports in the Horn of Africa that becomes a major route for communications and Internet cables that link the world. The region has also become a target of competition between China, India and the United States to control the Indian Ocean. Meanwhile, the Ethiopian influence in the Red Sea and the Horn of Africa has escalated during the last two decades (Rajab, 2021) in parallel with the escalation of the influence of Gulf States whether in the form of military presence or economic interests. Consequently, one of the American reports described competition among Gulf States as the greatest threat for the security of the Horn of Africa (United States Institute of Peace, 2020).

This is in addition to the internal challenges that encounter the States of South Red Sea such as the appearance of the failed States, the emergence of border and internal conflicts and the increasing role of actors of non-States in piracy and terrorism crimes (Rajab, 2021). The Horn of Africa has also become an incubating environment for illegal trade of arms, human trafficking and drug trading as around (30-35) ton Afghan heroin is smuggled into the East Africa annually (Africa Union, 2010).

III. Features of Conflict

The more the strategic importance of the Red Sea, the more the sources of threat the Red Sea encounters. Challenges that reflect incompatibility among international and regional powers over the rules of competition. There is a state of interconnection and complication that govern many of the frames of political, economic and security competition and cooperation that the region witnesses. These all changes indicate that the frames of traditional regional interaction are no more guaranteed or effective. Therefore, some experts believes that the region is about to step into a new time era that is characterized by more interaction, rush, conflict and competition with the presence of a degree of turbulences and tensions so that it would not affect the strategic interests of great States (Abdel Wahab, 2021).

The elements of conflict and threat in the Red Sea region is determined through the following:

a) The increasing presence of international powers

The presence of these powers on the coasts of the Red Sea has been increased in light of the dissemination of the phenomena of leasing seaports. This often comes in parallel with the establishment of military bases close to these ports and consequently military bases of the United States, France, Russia, China, Turkey, Israel, Iran, Saudi Arabia and Emirates have been disseminated in Djibouti, Somalia, Eretria and the Sudan with the aim of realizing their related interests, contributing in securing the free international navigation, and combating piracy operations at Bab Al Mandab and Aden Gulf (`Emirates Center for Policies, 2021).

Competitive policies among international powers are multiple through relying on the dissemination of troops, establishing military bases, executing big projects in the field of developing the infrastructure and developing ports overlooking the Red Sea.

We refer to these powers as follow:

i. *The United States and Western Powers*

They seek enhancing their military presence in the Red Sea and expanding their influence in a way that serves their interests related to military domination in the Indian Ocean. The concept of "free navigation" represents a strategic target that governs these powers and therefore becomes one of their first task for their military dissemination. Then, came the phenomena of piracy in the Gulf of Aden that pushed the western powers to promptly form a Combined Maritime Forces to encounter this threat (Sallem, 2021).

The United States hired Camp Lemonnier in 2003 against 63 Million Dollars a year. The camp include the Combined Joint Task Force – Horn of Africa (CTF-HOA) in addition to the permission to use Djibouti seaport and airport by the American Air Force within its operation in the Gulf region and the Horn of Africa. The base includes around 4 thousand persons in addition to around 180 Japanese persons since 2011 under the name "Deployment Air Force for Counter-Piracy Enforcement (DAPE) (Salem, 2021).

The United States also established a base in Socatra on Yemeni coasts since 2010 to fight Al-Qaeda organization and piracy opposite Somali Coasts (Rajab, 2021). The United States also pursued to renew its partnership and enhance its security cooperation with the Sudan through the "US Africa Command (AFRICOM)" forces after deleting the Sudan from the list of States sponsoring terrorism (El Shark El Awsat, 2021).

As for the European Union, it has a special representative in the Horn of Africa region who is concerned with the improvement the European Union involvement in the region. The European Union physically military exists through EU NAVFOR Operation Atlanta to counter piracy. The European Union also allocated over (3) Billion Euros for the Horn of Africa during the period 2014/2020 through an investment fund related to Africa (Council of the European Union, 2018).

As for other Western powers, they exist in the French base "Heron" that include forces from France, Germany and Spain in accordance with a treaty concluded in 1977. The size of the French force is around 1,700, the German force is around 330 and

Spain has around 50 individuals that conduct air reconnaissance flights in the Horn of Africa region. Italy also maintains its own base "Base Militare Nazionale di Supporto" that could host around 300 individual and drones. Britain has bases in Kenya and Oman and its activating in Somalia (Salem, 2021).

ii. *China*

China follows a long run developmental perspective and is keen not to be involved in any competition with the great powers and the non-involvement in the internal affairs of the region countries. It is also pursue the execution of "the Belt and Road Initiative" that includes "the Maritime Silk Road" through the Red Sea to East Mediterranean ports then south of Europe (Rajab, 2021).

China also leased a base in Djibouti against 20 Million Dollars per year. It is its first base abroad and was inaugurated in 2017 and host around two thousand individuals in addition to a capacity to host 10 thousand soldiers (Salem, 2021).

China is considered the prime source of weapons in the region. It has distinguished relations with a number of African countries. It executes projects to expand Djibouti port in a way that grants Ethiopia an access on the Red Sea beach. Presently, China invests in the development of the port of "Doraleh". It owns (23.5%) of Djibouti related Free Zones and Ports Authority. China also controls the industry of developing the infrastructure in Ethiopia to connect it with the ports of Djibouti (Rajab, 2021). It is observed that the Chinese strategy in South Red Sea concentrates on Ethiopia, Eretria and Djibouti through basic infrastructure projects. It is a partner in Djibouti 2035 strategy (Vision 2035) to develop the ports that target turning Djibouti into "Africa Singapore") (United States Institute of Peace, 2020). Moreover, China participates in the UN Peace Keeping Force in South of Sudan with around one thousand soldiers as well as other UN tasks of peace keeping in Africa (Salem, 2021).

China also seeks to support developmental projects in the region by providing attractive loans (Zach, 2020). Western sources accuse China of adopting "Debt-Trap Diplomacy" where big projects are financed in poor countries that fail to repay. The debt of some countries of the Horn of Africa to China escalated (34% of the debt of Ethiopia as an example) (United States Institute of Peace, 2020).

Although China is keen not to play a direct role in keeping the security of the Gulf and Red Sea regions, it is clear in confirming the importance of securing "Strategic Sea Lines of Communications (SLOCs)" that are related to power supply lines. Therefore, Chinese Navy joined in the international counter piracy operations in 2008. It also contributed in evacuating Chinese workers from Yemen. Chinese – American cooperation mechanisms are also observed such as the "US-China Strategic & Economic Dialogue" though the stand of the consecutive American Administrations fluctuated in terms of welcoming understanding with China in this file (United States Institute of Peace, 2020).

iii. *Russia*

Russia seeks to equalize the American influence in the Red Sea by its attempt to establish a military base in Berbera in Somalia and the port of Zeila in Somaliland close to the borders with Djibouti (Stratfor, 2018). It also maintains good relations with Egypt in the North of the Red Sea that guarantee many economic and military privileges including the sale of weapons, joint maneuvers, and establishing nuclear reactors. In the South, Russia sought to establish a base in Djibouti, but the United States refused. In December 2020, Russia announced that it reached an agreement with the Sudan for the establishment of a navy military base in the port of Port Sudan for a period of 25 years liable for renewal for another ten years (Business Insider, 2020) with the aim of "enhancing peace and stability in the region" against providing arms to the Sudan (United States Institutes of Peace, 2020).

iv. *India*

India attempts to compete the Chinese presence in the Red Sea in order to control the western part of the Indian Ocean. It adopts the strategy of developing navy forces in the "blue waters" in order to equalize the Chinese strategy "Pearl Chain" (Institut De Relations Internationals Et Strategique, 2017).

Militarily, India has a reliable navy force that expands in the Indian Ocean. It concluded treaties with the United States and France to benefit by their bases in the Indian Ocean. It also joined counter piracy operations in the Horn of Africa and UN operations in south of the Sudan (Salem, 2021).

b) The Increasing Influence of Regional Powers

Regional powers also compete in order to find a leap in the Red Sea and the Horn of Africa, of which:

i. *Turkey*

Turkey seeks investment in countries of the Horn of Africa. It works on equalizing its economic presence with a military presence and has an access to the Red Sea. Turkey signed an agreement with Al Bashir government in the Sudan in 2017 in order to develop Suakin Port to be used by navy forces and commercial ships. They also signed other agreements related to agriculture, industrial, military and financial cooperation that worth (650) Million Dollars (Lofaso, 2018).

Turkey inaugurated a base in Somalia in 2017 at a cost of 50 Million Dollars hosting 200 soldiers. This presence is linked with the military presence of Turkey in Qatar and the joint maneuvers that are conducted between them. Meanwhile, Turkey provides Somalia military learning and training in the field of combating

terrorism. It inaugurated its biggest embassy in the world in Mogadishu in 2016. Turkey airlines are the only international airlines that regularly fly to Mogadishu. Turkey handles the management of Mogadishu port through a company called "Albairak" (Salem, 2021).

ii. *Iran*

Iran believes that the permanent presence in the entrance of the Red Sea is an important strategy in order to increase its capability "to deal with the cautious action in face of the Gulf States and in particular Saudi Arabia in addition to providing a base to support its regional allies such the Houthis, Hezbollah, Hamas and the Syrian regime (Fahmy, 2021).

At first, Iran sought to infiltrate into the Red Sea region through the soft power until it established a multi task military base in the Eritrean port "Massawa" as Eritrea remained an ally to Iran for a long period. Iran also seek to establish a permanent influence amid the Islamic communities in east and west Africa. It also seeks to push the Shiite movement in the Horn of Africa region particularly in Ethiopia and exploit the religious factor through the role of embassies and cultural centers (Fahmy, 2021).

iii. *Israel*

Israel seeks to create an influence in the Red Sea region. It seeks to invest the Sudanese – Israeli peace process in a way that achieves its interests and work on containing the Sudan that was a station for Israel enemies such as Al Qaeda organization and Iran. Israel also seeks to complete its expansion in the Horn of Africa and enhance its relations with Ethiopia, Kenia, Somali and Eritrea. It established its military bases in "Assab", "Massawa" and "Dahlak", "Haleb" and Fatima) ilands and eavesdropping center in the mountains of "EmbaSoira". The Israeli presence in Eritrea aims at gathering intelligence information to detect any movements of hostile parties in the Red Sea (Fahmy, 2021).

Israel also seeks to make port of Eilat on the Red Sea an access to African countries that is establishing a wide scope continental commercial movement between Africa and its Western and American counterparts the center of which shall be the port of Eilat (Abdel Rahman, 2018).

iv. *Ethiopia*

Ethiopia seeks to become a basic part in the regional equation of the region and to overcome the geopolitical that made it a landlocked country. This enhanced its attempts to own shares in ports of "Doraleh" in Djibouti, "Port Sudan" in the Sudan, "Lamu" in Kenia and "Berbera" in Somaliland. It is fully engaged in some integrated regional projects (Emirates Policy Center, 2021).

The Ethiopian Prime Minister, "Abiy Ahmed" declared in June 2018, two months before assuming office – declared the rebuilt of the naval capabilities of the Ethiopian army. Therefore, Addis Ababa signed in March 2019 a defense cooperation treaty with France to develop the Ethiopian navy force, enhance air cooperation and joint operations. This was followed by the appointment of Admiral KinduGezu to lead the establishment process of navy forces provided that the headquarter of the forces shall in the city of "Bahir Dar" the capital of "Amhara" region in the north of Ethiopia that overlook lake "Tana" (El Am, 2018).

In December 2019. An Ethiopian Djiboutian agreement was unveiled that provides the establishment of an Ethiopian naval base in Djibouti where 95% of Ethiopian import and export pass through Djibouti. Then Addis Ababa launched negotiations with Djibouti to participate in the development of port of "Doraleh". The Ethiopian ambition aspires to establish other bases in ports of Eritrea, Kenia, Somaliland, and the Sudan (Fahmy, 2021).

No doubt, the Ethiopian announcement of establishing Ethiopian military bases on the Red Sea is almost connected to the failure of negotiation among Egypt, the Sudan and Ethiopia over the Grand Ethiopian Renaissance Dam (BBC, 2021) that forms a threat to the shares of Egypt and the Sudan in Nile water in violation to the international treaties in addition to Ethiopia continuity to build the Grand Renaissance Dam without reaching a satisfactory agreement with Egypt, a matter that makes Egypt exposed to the limit of water poverty (Al Dessouky, 2019). Ethiopia and Russia also signed a military cooperation agreement on 12th July 2021 that would concentrate on turning the capabilities of the Ethiopian National Defense Forces into the fields of knowledge, skill and technology. It is well known that Russia is the main source for arming Ethiopia since long time ago (African Military Blog, 2021).

v. *Gulf States*

The influence of the Gulf Cooperation Council States has increased in the Red Sea and Horn of Africa region with the conflict around Yemen and within the frame of linking the security of the gulf with the security of the Red Sea and the Suez Canal in addition to the economic motives related to investment opportunities and the pursuit to enhance food security through military presence and providing aids. The influence of the United Arab Emirates, Qatar and Kingdom of Saudi Arabia appeared and Djibouti, in 2017, welcomed the presence of a Saudi base on its land. Some tension occurred between the United Arab Emirates and Djibouti regarding the activity of DP World Company that was nationalized. Meanwhile, the Emirates preferred to rely military in the two ports; the Eritrean "Assab" (that it lately withdrew from) and the Somalian "Berbera" in addition to its control over the Yemeni ports and islands. A tension also occurred between Somalia and

the Emirates due to the agreement concluded between the Emirates and "Somaliland" to establish a base on its land (Salem, 2021).

vi. *Egypt*

Egypt interest in the security of the Red Sea for being a natural extension of the Suez Canal in addition to the future hopes placed on the promising economic zone in Suez Canal region (Al Dessouky, 2018). Egypt's commitment with the security of the Red Sea is an extension to its commitment with the security of the Arabian Gulf that Egypt considers part and parcel of its national security. Egypt always emphasize that the security of the Gult is a "Red Line" (Salama, 2017). Egypt seeks to diversify its military forces in the Red Sea as it inaugurated the Command of the South Fleet in the port of Safaga (Arabic CNN, 2017). Egypt also inaugurated the biggest military base in the Red Sea region on 15th January 2020, that is "Barnis" base (Keshk, 2020).

The Egyptian Navy Forces also participate in securing the entrances to the Red Sea within the Arab coalition to counter the Hothi aggression in Yemen. It also conduct military maneuvers with the Red Sea countries and the international powers of which maneuvers with the United States, France, Spain, Saudi Arabia, Emirates, Jordan and Djibouti (Rajab, 2016).

c) *Maximization of Internal Challenges*

Some countries overlooking the Red Sea are witnessing many internal challenges of which:

i. *The Continuous State of the Failed Country*

Somalia is still suffering from the absence of the role of the State and the incapability of the federal government to perform its functions, exercise sovereignty over its national soil, and inability to achieve peace and stability for its people (Hashem, 2018). Still Mujahedin Youth Movement is capable to exercise violence, dictate its control over some parts of the Somali capital, parts of South of Somalia and some areas located on the borders with Kenia and Ethiopia (Abdel Wahab, 2021).

ii. *Continuity of Border Disputes*

The colonization policy lead to drawing borders among countries in an artificial way that serves its interest and contradicts the fact and privacy of the African peoples (Badawy, 2018). These disputes are still going on between the Sudan and Ethiopia and Ethiopian and Eretria – currently postponed due to the agreement of the two countries over other priorities in the Horn of Africa. There is a dispute between South of Sudan and the Sudan over the future of Abyei Area. Kenia and Somalia are also disputing over their maritime borders in the Indian Ocean (Oponeo, 2021) in addition to the dispute between Djibouti and Eretria due to the later occupation of "Dimayrah" area in 2008 (Badawy, 2018).

iii. *Domination of Internal Conflicts*

These are multi conflict in the region the most prominent of which is in the Tigray Region in Ethiopia between the federal government and the government of the region due to the attempts of Abiy Ahmed, Ethiopia Prime Minister, to consolidate his internal ambition by changing he equation of the federal ruling and present himself as being the strong man in the Horn of Africa Region (Oponio, 2021).

In November 2020, Abiy Ahmed launched an attack against Tigray People's Liberation Front (TPLF) promising to end the fight within few weeks (Walsh, Dahir, 2021). However, the conflict continued until Tigray troops recovered the capital of "Mekele" region and major cities in Tigray on 28th June 2021 after the retreat of the Ethiopian troops (The African Report, 2021).

The civil war in Ethiopia raises a number of fears of which the possibility of dividing Ethiopia, a matter that would lead to shaken the stability of the Horn of Africa as a whole, in particular that the crisis lead to the death of thousands and 1.7 million persons are homeless. This is in addition to ethnic cleansing crimes and sexual abuse by Ethiopian government troops and it Eritrean allies (Walsh, Dahir, 2021).

iv. *The Dissemination of Terrorist Organization*

The Horn of Africa region is witnessing the dissemination of extremist organizations that could threaten the security of the region. Of the most dangerous organizations; Harakat al-Shabaab al-Mujahideen in Somalia, Daesh Cells in North Somalia, Lord's Resistance Army in Uganda, Hothi Group in Yemen and the terrorist cells in South Yemen. These organizations are very dangerous and of very high capabilities to perform tough terrorist acts whether in the Horn of Africa or in the neighboring countries (Tawfik, 2018).

v. *The Continuity of War in Yemen*

The continuity of this war form a real threat to free navigation. Hothi rebels supported by Iran planted mines along the coasts of Yemen and used explosive boats and anti-ship projectiles to attack maritime vessels. This was clearly manifested in attaching the Saudi oil tanker in April 2018 (Abdel Rahman, 2020).

Along with the Yemeni crisis, a highly environmental threats appear of which the docking of the oil tanker "Safer" since for years in Ras Eissa port in El Hudaydah Governorate. This tanker carries around 1,148 million barrels of oil. The Hothis refuse to allow a UN inspection team from reaching it to verify its status and maintenance. Therefore, it became a time bomb that threatens with an environmental catastrophe in the Red Sea since the vessel is out of age and its body is liable for erosion. The Hothis used the tanker as a bargaining paper and extortion to obtain privileges without considering the risks oil leakages or the explosion of the tanker (Al Ain, 2020).

The United Nations declared that the negotiations of the tanker maintenance reached a dead end. Then the Security Council later demanded the Hothis to facilitate a safe unconditional access of UN experts to conduct a comprehensive evaluation and preliminary maintenance without delay. The United Nation declared that the inspector mission is still ready to go to Yemen to execute its task (D.W, b, 2021).

The continuity of the conflict in Yemen caused the great humanitarian crisis in the world. According to UN reports in 2018, 80% of the population in Yemen (30 million) needs one or another form of assistance. Almost 20% Yemeni suffer food shortage (Harden – Knights, 2019) and 11.3 million children need humanitarian assistance (UNICEF, 2018).

Estimates show that (230) out of 333 Yemeni district is expose to the risk of famine (Sharp, 2019) in a country that depends on importing 90% of food on which 22 million citizens live (The Soufan Center, 2018).

IV. Cooperation Opportunities

Cooperation opportunities in the Red Sea are multiple the most important of which are; the agreement of great powers to guarantee free navigation, the increase of regional or bilateral cooperation projects, the establishment of new regional conglomerations and turning the region into a major destination for investments and international trade.

a) Agreement of Great Powers to Guarantee Free Navigation

The free navigation in the Red Sea is a strategic priority of the great powers and there is an agreement over removing any threat that might impede the free navigation (Abdel Rahman, 2020). The Red Sea has always been a vital crossing point for international trade as being a low cost passage compared with other alternative routes for European goods heading to Asian markets and vice versa. What is worth USD (700) billion of total trade between Europe and Asia pass through Bab El Mandabstraight annually in addition to (4.8) million barrel of crude oil and petroleum products equivalent to 4% of total oil trade in the world pass daily (US Energy Information Administration, 2017).

What confirm the importance of guaranteeing world trade movement in the Red Sea, the world losses caused by the stranding of the gigantic cargo ship "Ever Given" in the Suez Canal during the period from 23-29 March 2021. Egypt lost around USD 84 to 98 million without computing the charges that would have been received from the ships that turned its course towards the Cape of Good Hope (Al-Ain, 2021).

At the level of world trade, the cost of closing the canal for a week amounted to USD 6 to 10 Billion. Meanwhile, the prices of transport, insurance production cost and fuel have been doubled several times. Oil prices increased by 6% after less than 48 hours of the cargo ship running ground (DW, a, 2021). Meanwhile, the cost of shipping goods from Asia to the American Eastern coast increased to more than Five Thousand Dollar compared to USD 2,775 in March 2020 (Arabic.Sputniknews, 2021).

Losses also affected China, Europe, North African countries, Gulf States and Turkey as China became the one of the most important suppliers to the markets of these countries. We could say that two third of the goods exchanged between Germany and China passes through Suez Canal. Meanwhile, Gulf States export between one million to one million and half barrels of oil daily through Suez Canal to European and Turkish markets as well as markets of other countries (DW, a, 2021).

The closure of the canal pushed some ships to move towards the Cape of Good Hope bearing the cost of extending the voyage period for around two weeks including the cost of additional fuel. Experts argue that 45% of the volume of goods in the ports of Newyork, Newjersey in the United States passes through the Suez Canal and that around 9 billion 600 million Dollars of goods stuffed in containers passes daily through the Suez Canal (Al-Ain, 2021).

b) The Increase of Regional & Bilateral Cooperation Projects

The rhythm of bilateral cooperation among the countries of the region increased as Ethiopia depends on the ports of Djibouti. The relevant annual income Djibouti realize is arount (2) billion Dollars. Ethiopia started to operate a railway line between Ethiopia and Djibouti since 2018 to transport goods and people. Meanwhile, Ethiopia contribute in the development of the port of "Berbera" in Djibouti. There are also projects to develop a land transport road from Ethiopia and South of the Sudan to the port of "Lamo" and another road that ling the Ethiopian capital with Khartoum (Farid, 2021).

The countries of the Horn of Africa are heading to become oil and gas exporting countries as China is investing in the development of the Oil & Gas Sector in Ethiopia by developing the pipes that would transport the oil and gas to the refinery station that would be established in Damerjog in Djibouti instead of transporting it to the container terminal existing in Doraleh (Styan, 2018).

There are also new projects that increase the opportunities of cooperation in the Red Sea region of which:

i. *Suez Canal Axis*

Suez Canal is considered one of the most five sustainable sources of the Egyptian national income from hard currencies with annual revenues that reach more than (5.6) billion Dollars during the year 2020 (DW, a, 2021). Egypt bets to maximize its gains through promising investment opportunities in the Suez Canal

region and in particular in the industry field. Global companies have already started investment there. The first stages of more than an industrial zone have already been completed the most prominent of which is the Chinese Zone (Suez Canal Authority Information Center, 2019).

ii. *Suakin Island*

Turkey and the Sudan concluded an agreement in December 2017 that allow Turkey to redevelop "Suakin Island" and invest this Archaeological area that goes back to the Ottoman dynasty to become a touristic area that could be a transit station to receive Turkish Muslim pilgrims on their to the Sacred Lands in the Kingdom of Saudi Arabia, though this agreement had been impeded by ousting President El Bashir and the internal Sudanese changes (Salah, 2017).

iii. *"NeomProject"*

The great investment project was announced in October 2017 with the participation of the Kingdom of Saudi Arabia, Jordan and Egypt with total investment estimated (500) billion Dollars. The project includes the establishment of a bridge that crosses the Red Sea to link the new city "Neom", Egypt and other African continent. It is expected to be inaugurated in 2025. The project aims to enhance the trade movement and the movement of individuals and investments among Africa, Asia and Europe (Shay, 2016).

The Kingdom of Saudi Arabia also seeks based on it ambitious vision 2030 to develop around 200 km along the costs of the Red Sea including fifty small islands to enhance touristic initiatives that target attracting foreign investments. The city of "Neom" shall be inside the coastal strip (Abdel Rahman, 2021).

c) Establishing New Regional Conglomerations

On 6th January 2020, a charter for the establishment of "the Council of the Arab and African States Overlooking the Red Sea and the Gulf of Aden" to coordinate among eight countries; Saudi Arabia, Egypt, the Sudan, Djibouti, Yemen, Somalia, Jordon and Eritrea in order to protect the international navigation and achieve integration and development in all fields (Independent Arabia, 2020). The GDP of the countries participating in this entity exceeds One Trillion One Hundred Billion Dollar while the number of population is more than 233 Million people (Abdel Wahab, 2021).

The newly born council is considered as a joint working system that targets increasing the level of cooperation and understating among the member countries, coordinating political stands among them, establishing close security cooperation, developing economic and commercial relations, enhancing investments among the member countries, enhancing maritime transport, enhancing cooperation among sea ports along the cost of the Red Sea, opening communications channels with the countries that do not overlook the Red Sea and the Gulf of Aden with the aim of cooperation to protect the Red Sea from the risks threatening its security and stability and encountering the infiltration of some regional powers in the Horn of Africa that target crippling the Arab and African security of the countries of the Red Sea (Aaskar, 2020).

The Red Sea also represents with all that it contains wasted wealth potentials that has not been optimally exploited by the countries of the region. Therefore, this council could enhance the opportunities of economic cooperation among them to exploit the resources and wealth of the sea. It could also be a nucleus for the establishment of a greater and more comprehensive entity that target enhancing African Arab integration and cooperation. It could also enhance the opportunities for agreement between the member countries and the international and regional powers present in the Red Sea as being an arena for negotiation in the future (Aaskar, 2020).

d) Joint Security Cooperation in Encountering Piracy

The continuous threat from maritime piracy during the last two decades pushed the international powers to form Combined Maritime Forces (CMF). These forces are composed of three working teams; the First is Combined Task Force 150 (CTF 150) that conducts Maritime Security Operations (MSO) beyond the Arabian Gulf to guarantee the free navigation crossing the region and seeks to resist criminal and terrorist organization as well as illegal activities. The activity of this force overs the Red Sea, Gulf of Aden, Indian Ocean and Gulf of Oman in addition to the routes leading to the three water passages; Straight of Hormuz, Bab Al Mandab and Suez Canal. A large number of regional and international power participate in this force (Combined Maritime Forces).

As for Combine Task Force 151 (CTF 151), it is concerned with deterring and preventing piracy and armed robbery in the Sea, participating with regional partners in enhancing the capabilities of securing free navigation. This force was formed in January 2009 to combat piracy and was approved by virtue of the International Security Council decision no. 2500 (2019). The scope of its activity was expanded to include wider maritime security to support Combined Maritime Forces.

As for Combined Task Force 152 (CTF 152), it enhance maritime security cooperation in the Arabia Gulf. It also contribute in protecting the maritime infrastructure including oil platform from any terrorist threat (Combine Maritime Forces).

The European Union also participates in the operation of securing the Horn of Africa through "Atlanta" operation that performs deterrence, protection and oppression against piracy and armed robbery works before the Horn of Africa up to the west of the Indian ocean. It also protect the ships of food program and other shipment vessels that are exposed to threat.

The operation started in December 2008. The European Union renewed its mission for the year 2020 (Arabic Sputniknews, 2018).

e) The Red Sea a Major Destination for Investment & International Trade

The Red Sea region has become a major destination for investment and international trade where China is pursuing the execution of "The Belt & Road Initiative" and consequently executing the strategy of "String of Pearls" that targets the development of sea port at the entrance of the Red Sea and the investment in the basic infrastructure projects in the Red Sea countries (Rajab, 2021) as it seeks to invest around (120) Billion Dollars in its new projects with expectations of investments that amount to (700) Billion Dollars as per the preliminary estimates (Putten, Meijnders, 2015).

China also aims at increasing the volume of its trade exchange with the Red Sea countries where it amounted to around USD 93 Billion in 2018 and reached USD 187 Billion in 2020 by adding the Gulf States with the Horn of Africa countries – that is double the trade exchange between the United States and these countries (Zach, 2020). The volume of China trade with the continent of Africa amounted to around USD 215 Billion annually (United States Institute of Peace, 2020). China's investment in the African continent amounted to USD (200) Billion (Arman, 2015).

Japan also targets enhancing investment in the Horn of Africa in a way that maximizes its strategic interests there particularly in the field of exporting infrastructure. This comes within the frame of its commitment with investments amounting to USD 10 Billion within a batch of investment that amounts to USD 30 Billion the ex-Japanese Prime Minister, Shinzo Abe, undertook during TICAD conference that was held in Kenya in August 2016 (Anadolu Agency Website, 2019).

Japan enhances cooperation with India in order to establish the Asian African Development Trajectory that basically focus on the fields of importance for economic and social development in Africa. It is a Japanese Indian alliance that aims at investing around USD 200 Billion – though has not yet been activated. It combines the Indian expertise and understanding of the African market with the Japanese technological advancement and financing capabilities. This trajectory aims at enhancing the joint efforts to improve development aids in Africa based on the principle "gains for all" and consolidating peace and stability through economic growth and development (Aaskar, Japan).

The volume of the Indian trade exchange with Africa amounted to around USD 62 Billion in 2018. The volume of exchange with the Horn of Africa jumped from USD 550 Million in 2001 to USD 5.4 Billion in 2017 (Associated Press, 2020). India also succeeded to be the first trade partner for the countries of the Red Sea region during 2018 surpassing China (Institut De Relations Internationals et Strategiques, 2017).

V. Conclusion

Challenges in the Red Sea region are multiple and are potential sources to trigger conflicts whether between competing major and regional States or among or inside the Red Sea States themselves. Meanwhile, the presence of extremely dangerous non-state organizations whether the Houthi in Yemen or Harakat al-Shabaab al-Mujahideen in Somalia could conduct terrorist acts that threaten the security and stability of the region or the disruption of maritime navigation in the Red Sea. The conflict has multiple feature and the potential of its occurrence is possible at any time, but in the meantime, cooperation opportunities are many and multiple and could have potential positive impacts on the future of the conflict.

We notice that there is an agreement among the various power to guarantee free navigation in the Red Sea. They all agree to protect and secure it. We could imagine the world anxiety when the navigation movement was disrupted in the Suez Canal because of the "Ever Given" vessel ran aground and the volume of world losses to which we referred to some of them. This means that the suspension of navigation causes huge losses for all while free navigation is always a gain for all. Meanwhile, major powers do not have a desire to be involved in regional and international conflicts in order to preserve their interests.

Meanwhile, participating in interests through bilateral or group cooperation projects prevents conflict because mutual interest postpones the conflict and might end it. Conflict is always very expensive and causes huge losses. Border dispute between Eritrea and Ethiopia has been temporary neutralized due to the presence of other mutual interests between the two parties in the Horn of Africa whereas existing or undergoing bilateral projects would cost enormous sums. Total expected investment of Saudi "Neom" project amounts to USD 500 Billion as mentioned in the research. However, such projects would yield great gains to their parties and definitely all seek gain not loss.

Sources of threat are not uniform in the Red Sea. If the presence of some international powers in seaports or in military bases represents a threat to the security of the Red Sea from the view point of some, this presence is considered an economic interest for some other. Djibouti is an example because it considers leasing bases and seaports is an important source of income.

Meanwhile, working through institutional conglomerations prevents conflict due to the existence of a framework that gathers countries within which long discussions are held about the posed problems. All parties whether the parties participating in the conflict or

others, consult each other. In addition, these institutions have mechanisms to resolve disputes in accordance with definite procedures set out in the charter establishing such conglomerations that all parties accepts in the event of participating in such institutions. There is no doubt that such mechanisms often exert the best efforts to totally resolve or neutralize the dispute. These institutions consolidate the state of cooperation and increase its opportunities based on its numerous targets.

Countries that accept joint work through regional organizations often depend on each other when interests overlap, a matter that makes the notion of disagreement between them irrelevant and if it exists, it would be in lowest level possible in a way that do not negatively impact the other field of cooperation.

The presence of international successful experiences in joint work as in the case of the participation of international and regional powers to encounter piracy within the Combine Maritime Forces becomes a motive to continue the success, repeat the experience of cooperation in other fields and consolidate mutual reliance and understanding among all parties.

Turning the region into a destination for investments and international trade makes various parties keen to protect their interests and avoid damaging them whether by themselves or by others. The presence of this quantity of huge investment and exchanged trade creates thousands of work opportunities that youth need and consequently improves the level of economic and social life and in turn prevent and limit crimes that make people be involved under poverty and need.

Consequently, in the event of the proper and effective employment of cooperation opportunities, it could neutralize or postpone the conflict in the near future. They might eliminate the conflict on the long run in light of the entanglement of interest and deepening cooperation cases that is if we assume that the aspects of conflict remain silent and do not escalate. The conflict is existing and extended in light of the nature of international relations, the contradictions of strategies of States and the nature of relationship that control it whether with friendship or enmity indicators. However, the joint interest might compel States to change their enmity strategy towards some, neutralize conflicting beliefs, belongings and ideology.

VI. Recommendations

- The importance of working on intensifying cooperation frameworks and maximizing the joint interests between regional and international powers from one hand and the countries of the Red Sea the other hand in a way that helps enhancing and activating cooperation opportunities and ultimately ends any areas of disagreement and in turn escalation and conflict.
- Encouraging regional conglomerations at the top of which the Arab and African States overlooking the Red Sea and the Gulf of Aden to continue and provide their opportunities of success. Such conglomerations are a great opportunity for the States considering them as an arena for discussion and interaction that may lead to joint vision around all the issues of the region. They may also lead agreements to launch regional cooperation projects among the States of the Red Sea to benefit by their huge wealth.
- Establishing relations for geostrategic interaction and dialogue between the Arab and African States overlooking the Red Sea and the regional and international powers existing in the Red Sea as well as the Red Sea neighboring States in various forms whether permanent as in granting those States the observer membership adopted with some or in non-permanent form through establishing forums or round table discussion about certain issues that join those States of mutual interests in the Red Sea Region.
- Ensure the continuous harmonization among the powers existing in the Red Sea region about guaranteeing the free international navigation across the Red Sea course through its two inlets; the Southern at Bab el Mandeb and the Northern at the Suez Canal and enhancing the security of the region or combating certain crimes such as piracy, weapon smuggling or human trafficking. Agreement over the minimum limit of security and enhancing security cooperation in a certain qualitative issue results in the gradual agreement over more comprehensive security systems and generalizing cooperation in various issues.

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Necropower, Necropolitics and the "Precariat": An Approximation to the Current Brazilian Geographic/Historical Context

By Alcindo José de Sá

Introduction- This essay deals with a discussion and analysis of a theme that, in the current historical period, has been emerging with considerable prominence. Therefore, we start with a small rescue of what power is, in the context of the modern Nation-State, that is, power as an entity with the capacity for "control and domination over men and things" (RAFFESTIN, 1993), that is, on a sovereign territory, with laws and norms capable of guiding both the natural *zoes* (the naked bodies) of the natural man, and the political *bio* (the man, democratically participatory and subjugated to established powers).

However, this order is gradually falling apart, considering, in particular, the processes of the globalist economy, bringing in its wake the exponential rise of the science workforce, the machinic world of instrumental reason, taking many *zoes,* naked *bodies* and biopolitics (AGAMBEN, 2005), to fall or be relegated to the culture of garbage, of professional non-recyclability, under an increasingly fragmented productive world; lives wasted and subject not to a culture of life, but to a policy of death in its various facets, directly or indirectly (BAUMAN, 2005).

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I. Introduction

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Hence Mbembe (2018, p.09), in his short and dense essay, *Necropolitics,* warns that politics (of the Modern State, or Post, as you wish):

> [...] privileged the normative theories of democracy and made the concept of reason one of the most important elements both in the project of modernity and in the territory of sovereignty... Politics, therefore, is defined twice: a project of autonomy and the realization of an agreement in a collectivity through communication and recognition. This, we are told, is what differentiates it from war (MBEMBE, 2018, p.09).

In this crucible, the aforementioned author claims that in this territorial context, he became the "place in which the most absolute *in human condition* that ever occurred on earth" (referring to the Jewish holocaust) took place. takes his concern not for the formatting of a sovereignty that privileges a *status* (State) of a project for man's autonomy, but the "generalized instrumentalization of human existence and *the material destruction of human bodies and populations".* Instead of considering reason the truth of the subject, we can look to other less abstract and more palpable founding categories, "such as *life and death"* (*idem*, pp. 10-11), since both, directly and indirectly, are involved in productive and normative processes, whether as entities of diseconomies or economies, that is, entropies or not in the sphere of power.

That is why Bataille (apud MBEMBE, 2018, p.14) emphasizes that "life beyond utility... is the domain of sovereignty", a fact to denote that the "sovereign", or sovereigns, in addition to "watching and punishing" , as Foucault (2014) reminds us, the productive social body also controls the *"naked" bodies,* the wasted lives, human remains of a capitalism that started to discard a substantial part of what was its own essence: work as informed energy, the basis of relative and absolute surplus value and the foundation of its expanded accumulation, as Marx pioneered in his book O Capital (2011). After all, he points out that the capitalist production system will always lack a reserve army, no matter if it is precarious, proletarianized, *uberized*, or simply its *naked body*; *a homo sacer* (AGAMBEN, 2004).

Finally, in the eyes of the present, the title was too premonitory, since, in terms of scale/cartography, we continue at the same level, our *"used territory"* (SANTOS, 1996) experiences an overlapping of powers; from the State/nation of "one-dimensional" power subservient to the global economy, the power of necropolitics penetrates into its variant facets: that of the vile slaughter of structurally discarded social strata; *homo sacer* who were born on the margins of the territory, lived wanderers in the territory and died by assassins, "officials" or militiamen, without territory. In the meantime, the sovereign power also breaks down in the inertia or inability to re-signify the territory through citizen educational inclusion, as well as creating non-genocidal health policies, such as the one Brazil is currently experiencing with Covid-19.

II. From the One-Dimensional Power of the "Traditional" Nation-State to its Multidimensional Face

We begin this essay by seeking, first, a concise definition of how we can define *power* in a geographic

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perspective. For that, we refer to Claude Raffestin (1993, p. 52), when he asserts that an explanation for this political/territorial entity is complex, multifaceted, and difficult to define. For the aforementioned author, this is due to his dubious face: a power that does not want to show itself, concomitant, but, paradoxically, in many cases, forced to become palpable and visible. "The first is easier to surround because it manifests itself through the complex apparatuses that enclose the territory, control the population and dominate the resources. It is the visible, massive, identifiable power" (the Power of the Nation State with a capital P). It inspires danger, distrust, as it suggests threat. (RAFFESTIN, 1993, p. 52).

However, the aforementioned author also highlights that, even more perilous, is the invisible power, as it emanates from all relationships, that is, from the multidimensionality and immanence of any organization or relational system (for example, unions, companies, financial corporations , powers parallel to the State, in short, powers with a tiny p that involve dissymmetries of income, information and social class).

In this perspective, and based on Deleuze and Foucault, Raffestin (1993, p.56) emphasizes that where there is exercise of power there is a corresponding exercise of knowledge. Thus, "energy (human, spent on work) can be transformed into information, therefore, into knowledge; the information can allow the release of energy, therefore of force. Under these conditions, power is also a place of transmutation", that is, of metamorphosis, change, including entropy.

That is why Balandier (*apud* RAFFESTIN, p.54) points out: for "this society, power will be defined as the result of the entropy [unpredictability, uncertainty] that threatens it with disorder". Ending this epistemological/ conceptual base paragraph, we mention Etzioni (*apud* RAFFESTIN, p.54-55), noting that the power of coercion is based on the application of "physical sanctions", the remunerative power *"rémunérative"* it is based on the "control of material resources, on the allocation of salaries or bonuses, while the normative power is based on the manipulation of symbolic resources...

And, in other words, it can be said that power, in terms of mobilized powers, is defined by a variable of energy and information". In these terms, we can say that power is based on work. This would be the basic vein and source of two seminal elements that dynamize the command: energy and information. "Work is informed energy" and hence, "it is admissible to speak of resistance where there is power: resistance of matter or *resistance of the social body to transformation"* (RAFFESTIN, 1993, p. 56).

In this perspective, power has as its objective "the control and domination over men and things" and, thus, we can rescue the Power of traditional "tripartite" Political Geography: the socially organized population, dominating a territory and its resources.

In this "classical" view of Power, or micropowers, it stands out that we are referring to the view of the Modern State, significant of a legal and political superstructure that supports the economic infrastructure of numerous productive, marketing and financial units *giving them* legislative/normative support, as well as, if necessary, the *repressive legality,* in case entropy, disorder come to lash them, that is, when there is resistance from the social body, or the breakdown of energy in information and this, in knowledge manipulated by the dominant capital.

Therefore, the coercive power of that State often results in physical sanctions, as mentioned above. However, when we talk about the "social body", it is evident that we are dealing with human beings, in social interaction, under the toil of a capitalist system that has changed its productive processes, as well as social relations of production and action of the Rule of Law and, consequently, of powers, since its dawning.

Santos (1996) has been highlighting the rise of global capitalism, particularly in the last three decades, under the aegis of the "technical-scientific-informational environment", providing the creation of a single engine, a single currency [although with new or past names, referenced in the dollar], unique symbologies with ballast on the ship; in the global networked information system.

Harvey (1993), in the book Post-Modern Condition, dissects the models of liberal production in the 19th century, the Fordist and Fordist/Keynesian production model, especially after World War II, in many countries in Europe and the world and neoliberalism in the context of the current capitalist mode of production. The same question is asked: is it a mere temporary repair or, as Fukuyama (1992) pointed out, "the end of history", in its full success. Bauman in Liquid Modernity (2001), Wasted Lives (2005), and in countless other works has a deeply critical view, seeing an ever more fragmented, fleeting capitalism, both in production and consumption, more and more creating a "garbage culture", "lives for consumption" and an increasingly precarious job, as it has become under-work, non-work, creating homeless people, putting people on streets, drug addicts, that is, forced nihilists, or "useless people" no longer recyclable.

III. From the "Modern" UNI and Multidimensional State of "Law" to the State of Necropower

It is in the aforementioned "new context" that we can locate the "social body" with deprived bodies, or increasingly marginalized from the social scope, since their energies are not transformed into information and education mediated by work. They are "naked" men, as

Agamben (2004) says, and thus merely biological beings, but intentionally under the gaze of power.

But this agreement fell apart, as already stated, because "Instead of considering reason the truth of the subject, we can look to other less abstract and more palpable founding categories, such as life and death" (*idem*, p 10-11), since both, directly and indirectly, are involved in productive and normative processes, whether as entities of diseconomies or economies, that is, entropies or not in the sphere of power.

That is why Bataille (*apud* Mbembe, 2018, p. 14) emphasizes that "life beyond utility... is the domain of sovereignty", a fact to denote that the "sovereign", or sovereigns, in addition to "watch over and punishing", as Foucault (2014) reminds us, the productive social body also controls the "naked" bodies, the wasted lives, the human remains of a capitalism that started to discard a substantial part of what was its own essence: work as energy informed (BAUMAN, 2005), the basis of relative and absolute surplus value and the backing of its expanded accumulation, as pioneered by Karl Marx (2011) in his book The Capital. After all, as the aforementioned author warned, the capitalist production system will always lack a reserve army, no matter if precarious, proletarianized, discarded, or simply *naked* or *uberized* (emphasis added). If, redundantly, the sovereign world of capital is perhaps pointing out new directions.

Thus, in this globalized world (for many, in process of deglobalization, at least politically), for Mbembe (2018, p. 15), based on Bataille:

> Sovereignty has many configurations. But, in the final analysis, it is the refusal to accept the limits to which the fear of death would have subjected the subject. The world of sovereignty, Bataille argues, "is the world in which the limit of death has been abandoned. Death is present in it, its presence defines this world of violence, but while death is present, it is always there only to be denied, never for something else. (MBEMBE, 2018, p. 15)

The sovereign, he concludes, "it is he who he is, as if death were not. It does not respect the limits of identity any more than it respects those of death, or, moreover, those limits are the same; he is the transgression of all these limits". Since the natural domain of prohibition includes death, among others (eg sexuality, dirt, excrement), sovereignty requires that 'the force to violate the prohibition of killing, however true, will be under conditions that consumption defines'". Hard and profound assertions, considering that the sovereign State, by suppressing one of its foundations which was "the refusal to accept the limits to which the fear of death would have subjected it", it is assumed that death, in a barbaric and animalistic way, becomes something banal. A fact, as emphasized by Agamben (2004), comparable to the death of a *Homo Sacer*, a being, in the legal context of the Roman Empire, in which his death had no value, either as a sacrifice to the Gods or as a human meaning to "secular" society.

In Pernambuco parlance, and especially in Recife, a "nasty soul", who should not even have been born; a useless piece of garbage that must and should be decimated, either through the repressive forces of the Sovereign State, or through assassins, cold killers and militia, since they are "naked" bodies, devoid of pious souls and not "good citizens", or that is, people with minimal training in civility and moral values; thieves and cold killers of good citizens. In short, beings that, for the most part, were born outside the law, deprived of social and territorial insertion (SÁ, 2013).

Those beings, as highlighted by Agamben (2004), on which the State applies itself by disapplying itself. In the Brazilian case, beings with constitutional rights firmly marked (Education, Health, Housing, Work), but who, in the practice of the human functionality of the territory in its use, are nothing more than dead writings.

IV. Meanderings of Necropolitics and Necropower in Brazil

We should not forget that a large part of this "social body", as it belongs, in the current historical context, to "human waste", no longer recyclable, outside the consumption network, implies, recalling Mbembe (2018, p. 13):

> [...] since the natural domain of prohibition includes death, among others... sovereignty demands that 'the force to violate the prohibition of killing, although true, will be under conditions that consumption defines'. (MBEMBE, 2018, p. 13)

And that is why the present history is pregnant with facts that corroborate this assertion, as much, as already emphasized, in micro territories, dominated by parallel micropowers (of "bad guys"[1]), as in macro

[1] Agamben (2004, pp.115-116) emphasizes that it is therefore necessary to reread, from the beginning, "the myth of the foundation of the modern city, from Hobbes to Rousseau. The State of Nature is, in fact, a state of exception, in which the city presents itself for a moment (which is, at the same time, a chronological interval and a timeless last) *tamquam dissoluta.* The foundation is not, therefore, an event that is fulfilled once and for all *in illo tempore,* but it is continuously operating in the civil state in the form of a sovereign decision. This, on the other hand, immediately refers to the life (and not the free will) of the citizens, which thus appears as an original political element, the Urphänopmenon of politics: but this life is not simply the reproductive natural life, the zoe from the Greeks, nor the bios, a qualified way of life; it is, above all, the bare life of homo sacer and wargus, a zone of indifference and transit between man and beast, nature and culture". The aforementioned author also adds: "the exception ratio is a ratio of *bunch*. The one who has been banned is not, in fact, simply outlawed and indifferent to it, but is *abandoned* by it, that is, exposed and put at risk on the threshold where life and law, external and internal, entwine. About him, it's literally not possible to say that it is outside or within the planning (thus, in its origin, *in bando, a bandono,* and *bandito* means both excluded, set aside 'as open to all, free', as in *mensa bandita* and *redina bandita)*. It is in this sense

territories of Nation States, under the aegis of global capital manipulated by large corporations and by finance capital, managed by bodies such as the IMF, World Bank, etc.

In the latter case, the brute force, the "force to violate the power to kill" of the Ecuadorian State over its citizens in a recent period is quite evident, as they were deprived of consumption power, especially of increased fuels prices, imposed by the "sovereign" State under the dictates of the IMF and now in Brazil, by the new fuel policy at the mercy of the free variation of the dollar. When it comes to micropowers, it is well illustraded that in many countries, especially in Brazil, the Philippines, Turkey, etc., the growing power of the militias, manipulating the daily basic consumption habits of people in certain territories, reaching the extreme of dictating the "State of Exception" (suspension of classes, closing of businesses, if certain extortions are not paid) in the National State itself, with the power to dictate the *Exceptio;* powers, which even execute representatives of the power of the Federated Nation State (not to forget the murder of Councilor Marielle Franco and her driver Anderson Gomes).

The aforementioned councilor, a great combatant for human rights, has also long been researching the militarization of slums, as well as the "militianization" of these territories. In the meantime, we cannot fail to highlight the legislature, to a large extent, financed, during the electoral campaign period, by the economic power of agricultural, industrial and financial corporations, legislating under the pressure of *lobbes* of each segment in their own benefits, to the detriment of formatting and planning of a minimum welfare state. It is a State, as stated by Agamben (2004), which applies itself by unapplying itself, in other words, it is based on constitutional precepts of minimum assistance to the citizen, but in praxis, it relegates them.

Therefore, in the name of a lean and balanced state, the *State of National* Exception claims not to have financial conditions to provide for the underprivileged, and the market advocates that only competition and competitiveness can absorb surplus labor. On the other hand, the Judiciary Branch, to a certain extent, only executes the normative dictates of the executive and legislative.

In this sense, it is clear that due to the lack of support from the political/legal State and the market, particularly in Brazil, many intentional and pseudo invisible deaths due to poverty, that is, due to the lack of sanitation (the proliferation of dengue, zika, chicungunya, yellow fever and now covid, etc.), due to the poor service and medical/hospital incapacity and the total lack of education, are part of the "use of strength to violate the prohibition of killing" by the Sovereign State.

In this context, it is worth adding something we wrote in a recent past, when we used to say that with the advent of globalist instrumental rationality, the world of language, in the words of BIFO (2005), dominated by the lifeless, mathematical, semiocapital, without the erotic body that one thinks in us far beyond the *bare life,* of a social life immersed in civilized parameters, of tolerance between strangers, came to triumph (SÁ, 2013). Hence,

> politics, when carrying out the metaphysical task that led it to assume more and more the form of a bioliths, failed to build the articulation between *zoe* (nature) and *bios* (politics), between voice and language, which should restore the fracture . The naked life continues attached to it, under the form of exception, in other words, of something that can only be included through exclusion. How is it possible to 'politicize' the 'natural sweetness' of zoe? And, first of all, does it have a real necessity of being politicized or is the poitician already contained in it as its most precious nucleous? The biopolitics of modern totalitarianism on one hand, the consumer society and mass hedonism on the other certainly constitute, each in its own way, an answer to these questions. Until, however, an entirely new policy – that is, no longer founded on the *exceptio* of the bare life – does not present itself, all theory and all practice will remain imprisoned in a dead end, and the 'beautiful day' of life it will only obtain political citizenship through blood and death or in the perfect folly to which the society of the spectacle condemns it (AGAMBEN, 2014, p. 18-19).

And continuing, we used to write: as Castoriades (2002) warns us, if society (in particular the Western one) managed to "civilize" itself two or three space/temporal scales throughout its historical process, why, in this present time, it has not been able to "politicize zoe's natural sweetness?"; and to create a space with more citizenship content? We believe that Agamben (2014) provides us with a path: as already illustrated, zoe is born, intentionally, through the dominant visible and invisible powers, as exceptio makers of bare lives, or. why not say, null [our emphasis], considering today, as Bauman (2005) assures us, both the insensitivity of the National State of Exception and the indifference of the market and, in this dead end, or rather, in this alley with only one exit (the market), the fine day of life will only obtain political "citizenship" through blood and death, in the context of the perfect nonsense of globalist ideology, of the semiocapital society of the discarding spectacle of bodies with naked lives endowed only with natural zoe.

Therefore, this same society of spectacle commercially speculates the wildest violence (especially

that the paradox of sovereignty can take the form: 'there is no outlaw'. The original relationship of the law to life is not application but abandonment. The unsurpassed power of the *nómos,* its original 'force of the law', it's what maintains life in its group by abandoning it". Finally, in our liquid and more and more fluid world (BAUMAN, 2014), of increasingly "flexible" laws, there is no being outside the law, but the original relationship of the law with ihis life, it is not the formal application of that life, but abandonment. Hence the existence of so many "bandits", organizing their own "laws".

in countries where parallel states of exception dominate lives and territories, with their bloodthirsty and ruthless criminal organizations, such as the traditional CV (Comando Vermelho), PCC (First Command of the Capital), etc., in Brazil, with ramifications, already in almost the entire national territory, in front of the constituted official powers), as barbarism, but actually camouflaging, transmitting as a simulacrum a reality that is in fact part of the biopolitics of State/market totalitarianism in the so-called post-modern world.

It's not about defending the barbarism in which Brazilian society and others find themselves, as a new dialectic of class struggle (even because to define social classes in this society of media alienation and communicational networks, of an extreme work of precariousness, or of a cognition raised to "small bourgeois", in addition to traditional capitalists of all kinds, is something complex even for sociologists) as a form of conformism and surrender to this society of consumption, nihilism, mass hedonism, exclusionary and cruel . But it is also an undeniable fact that rational actions, or even messed up in the bare lives of the parallel political exception, of homo sacer, however cruel or inhuman they may seem, or appear in the semiocapital spectacle, that bathe in blood and death with more intensity , have mobilized the counterpowers, including the Powers with capital letters, with a view to creating political citizenship and minimal territorial insertion, through their blood and deaths in the current historical period (SÁ, 2013, p. 108).

As proof of the struggle, according to data from CIMI (Indigenous Missionary Council), 135 indigenous people were killed in 2018 in the Brazilian territory in the struggle for their living spaces. The IPEA (Institute for Applied Economic Research) points out that, with 65,000 deaths, homicides set a record in the country in 2017 [according to more recent surveys, in the last two years there has been a small decrease] and young black people have been its biggest victims. [2]

> "Within the racial issue, a study reveals that for every non-black (white, indigenous, yellow, according to self-attribution criteria used by the IBGE) killed in Brazil, almost 3 blacks (blacks and browns) were murdered. This scenario is getting worse over the last decade; while the non-black homicide rate increased 3.3% from 2007 to 2017, that of blacks increased 33.1%".[3]

Taking the small empirical framework mentioned above as a parameter, let us pay attention to the speeches of Mbembe (2018, p. 16-19), when he relates Foucault's notion of biopower to two other concepts: "the state of exception and the state of siege". He examines:

> These trajectories through which the state of exception and the relationship of enmity became the normative basis for the right to kill. In such instances, power (and not necessarily state power) continually refers to and appeals to exception, emergence and the fictional notion of the enemy... biopower seems to work through the division between the people who should live and those who should to die... That 'race' (or indeed 'racism' has a prominent place in the proper nationality of biopower is entirely justifiable... Arendt finds its roots in the demolishing experience of otherness and suggests that the politics of race is ultimately related to the politics of death. Indeed, in Foucaultian terms, racism is above all a technology designed to allow the exercise of biopower, 'this old sovereign right to kill'. (MBEMBE, 2018, p. 16-19)

Of course, all this is associated with the action of capital in all its instances and its Western political practices (now spread across the world), involving more and more natives and migrants and their race and gender variants. It is in this context that we can fit the zoes, the naked bodies (mostly black) increasingly marginalized in Brazilian territory and being decimated, since in our biopower, they are situated to die, in the context of sovereign law (Official or not) to kill. Not by chance, the Governor of Rio de Janeiro Wilson Witzel (currently impeached) advocated that arms dealers could be blown up by missiles and that a prison should be built along the lines of Guatánamo; also rifles could be distributed to the population to help exterminate the undesirables.

What is certain is that the aforementioned governor has used, even if in a camouflaged way, a true state of "siege" in certain "peripheral" territories in Rio de Janeiro, since the police state has been entering them, under the argument of fighting criminal organizations (which also exist in fact), yet without any protection for the civilian population, and even killing children, mostly black, in the crossfire of "stray" bullets and, thus, we have to agree with Arendt (2012), as she emphasizes that policy of race (in the case of the city of Rio de Janeiro with its slums and hills dominated by the population, mostly black and poor), is related to the politics of death.

At the Federal level, we have the project to combat crime, in which one of its regulations is to give powers to kill to any police officer who finds himself vulnerable to a "criminal" suspicion (the "bourgeois" newspapers themselves have shown many workers, helpless victims of these suspicions).

Thus, we repeat, in this clash, power (and not necessarily state power) "continuously refers and appeals to exception, emergence and the fictional notion of the enemy... biopower seems to work through the division between people who should live and those

[2] Available at: https://g1.globo.com/natureza/noticia/2019/09/24/numero-de-assassinatos-de-indigenas-cresce-20percent-no-brasil-em-2018-aponta-relatorio.ghtmlhttps ://g1.globo.com/natureza/noticia/2019/09/09/24/numero-de-assassinatos-de-indigenas-cresce-20percent-no-brasil-em-2018-aponta-relatorio.ghtml

[3] Available at: http://www.ipea.gov.br/atlasviolencia/arquivos/downloads/6537-atlas2019.pdfhttp://www.ipea.gov.br/atlasviolencia/arquivos/downloads/6537-atlas2019.pdf

who must die" (MBEMBE, 2018). The real world of "Every man for himself'."

And it is in this context that terror becomes evident "as a way of marking aberration in the political body, and politics is read both as a mobile force of reason and as an erratic attempt to create a space in which 'error' would be minimized, the truth strengthened, and the enemy eliminated" (MBEMBE, 2018, p. 23). Reinforcing: in an interview with journalist Roberta Pennafort, from the newspaper O Estado de São Paulo, on 11/01/2018, the then Governor-elect of Rio Wilson Witzel said: "the police will aim for the little head and... fire". At a certain point of the interview, the professional asks if he defended the "unlawfulness exclusion" for police officers on duty, having the same answer: "if it is a confrontational act, in which the policeman is covered by an illegality exclusion, it is not homicide, is death in combat. It is resisting arrest and police record. The act is lawful", since it is in the penal code.

Continuing with the interview, she also asks him,in case he granted authorization to execute (as happened recently, when a bus was hijacked on the Rio/Niterói bridge by an outlaw") and the policeman was prosecuted, she questions whether the responsibility couldn't be laid into the hands of the former Governor? He immediately answers: "nothing will be laid into my hands. It will be laid in the state's lap. The State has to understand what kind of public security it wants". In the meantime, the journalist provokes: then "from the police, the citizen expects the correct conduct; but not from the bandit, ...". And the former Governor still answers: "the correct thing is to kill a bandit with a rifle. The police will do the right thing: they will aim for the little head and... fire! So there's no mistake", even though Globo's G1 portal on 10/20/2019 alleges that naver have so many police officers been killed as in this year.[4][5]

Therefore, it is more than notorious that the assertions of Mbembe (2018) have full empirical territorial realization, as this frame of reference in Rio de Janeiro [and practically throughout Brazil, as former Governor Wilson Witzel has only expressed what most governors in Brazil think, regardless of political lineages] proves that the killing powers of both the "bandits" of criminal organizations and the powers of the State are insatiable, events that denote, let us say, a psychopathic biopolitics, always on the lookout for prey, even if it is a fictional enemy, in this world dominated by a technological/informational and communicational productive process based on the reason of indifference (our emphasis).

We can envise what was mentioned above, also in the proposal of the Anti-Corruption and Anti-violence Project of, now, Former Minister Sérgio Moro, when he predicted that, "in the judgment of crimes in self-defense, "the judge may reduce the sentence by half or stop applying it if the excess is due to excusable fear, surprise or violent emotion". The case will only be tried if there is an excess – for example, a very high number of shots. In the case of police officers on duty, the proposal makes it clearer which situations can be considered defense actions. The text allows for the release of penalties for the police officer or public security officer who kills someone on duty in a situation of "armed conflict or imminent risk of armed conflict" and to prevent "unfair and imminent aggression against his or others' rights", assault or risk of assault on hostages. Or the agent who "prevents aggression or risk of aggression to the victim held hostage during the commission of crimes". It should be noted that in the aforementioned Former Minister's Project, the "unlawful exclusion" was not approved by Congress, even though the killing of zoes remains intense, regardless of this clause [it is only necessary to glimpse the constant massacres in prisons, such as in São Luiz, Manaus, etc., in addition to those listed in the "peripheries" of the metropolitan regions of Recife, Rio de Janeiro, Belém, etc.). The current law:

> [...] defines self-defense as the situation in which the police officer, 'with moderate use of the necessary means, repels unjust aggression, current or imminent, to his own rights or to others'. In practice, on-duty police officers would not respond to criminal prosecution in case they kill someone as a result of confrontation or ordinary people, who present evidence that the death occurred in self-defense. [6]

That is, it is evident that the strength of the biopower of the state of exception may, in case of "excusable fear, surprise or violent emotion" not penalize the "defensive" aggressor agent, that is, not penalize the police agent or the security agent public, especially if they kill a zoe with a "stray" bullet, a bandit who is in the middle of an armed conflict or at risk of conflict with the "law enforcement officers". Thus, "politics [or biopolitics] is read both as a moving force of reason and as an erratic attempt to create a space in which 'error' would be minimized, truth reinforced, and the enemy eliminated" (MBEMBE, 2018, p.24), as stated above. In other words, the law is now mobile, "liquid" and minimizing error [in this case, an erratic "rational" killing], because what matters is the increasingly palpable and reinforced truth of the existence of an enemy that needs to be eliminated.

[4] Available at: https://politica.estadao.com.br/noticias/eleicoes,a-policia-vai-mirar-na-cabecinha-e-fogo-diz-novo-governador-do-rio,70002578109 https://politica .estadao.com.br/noticias/eleicoes,the-police-will-mirar-na-cabecinha-e-fogo-diz-novo-governor-do-rio,70002578109

[5] Available at: https://g1.globo.com/jornal-nacional/noticia/2019/09/20/no-rio-numero-de-mortes-por-policiais-em-2019-e-recorde.ghtml

[6] Available at: https://g1.globo.com/politica/noticia/2019/02/04/moro-apresenta-a-governadores-projeto-anticrime-com-14-alteracoes-em-leis.ghtml

V. Some Statistical References of Necropolitics

But what is certain is that, despite crime rates having shown a small drop in 2019, we are still one of the countries where most people are killed in the world. Therefore, considering, in particular, data surveys from the IPEA (Institute for Applied Economic Research) and the Brazilian Forum on Public Security, the number of deaths, annually in Brazil, is 30 times greater than in the whole of Europe; more than half a million people were murdered in the last decade (553 thousand – between 2010-2020), that is, 153 deaths a day, and for the first time in the country's history, in 2016 the number of homicides in Brazil surpassed the number of 60 thousand, more precisely 62,517 thousand crimes of lethal and intentional death (CVLI), an amount corresponding to the sum of the numbers from 154 countries, according to the aforementioned IPEA and the Igarapé Institute.Samira Bueno, executive director of the Brazilian Public Security Forum, the organization responsible for preparing the yearbook, says that: [7]

> [...] Brazil has had such high rates for so many years that one can speak of endemic violence and, now, also epidemic. It is a serious and chronic problem. We concentrate 2.8% of the world's population and 11% of homicides. We are an extremely violent country. (BUENO, 2018)

Corroborating this catastrophe, the periodic Brasil de Fato reports that, between 2004 and 2007, in Iraq, a country officially at war, 76,266 died in Sudan, 12,719 in Sudan, 12,417 in Afghanistan and 11,833 in Colombia. In Brazil, on the same time scale, the number of deaths reached the level of 147,333, that is, a number 34,098 higher than in the four countries in conflict.[8]

The Old/New Strategies of the Nation-State to the Action of the "Colonizing" Necropower in Brazil and in the World.

And still in a very perceptively way, about the various forms of suppression of zoes, naked bodies, devoid of civilizing belonging, of civitas, of city, of citizenship, Bauman (2001) further deepens the discretionary spaces that they live to submit to, given the different scales of power, in particular the power of "liquid", "fluid" capital, which flows over various legal and illegal networks, concrete and abstract, under the facilitation of its exercise, whether under the tutelage of the nation-state or not .

Therefore, Mbembe (2018, p. 32-35) makes a lucid review of the role of the formation of the modern European State and its legal order Jus publicum europeaum, in which it "postulated the legal equality of all States. This equality applied especially to the 'right to make war' (to take life)".

Thus, this right meant, at the same time, that the power to kill or negotiate was a right of the State, in the context of its borders without affronting others. "On the other hand, the State would commit to 'civilize' the ways of killing and assign rational objectives to the very act of killing." To that end:

> In modern philosophical thought, as well as in European political practice and imagination, the colony represents the place where sovereignty fundamentally consists in the exercise of a power outside the law (ab legibus solutus) and in which 'peace' tends to assume the face of an 'endless war'... As such, the colonies are the place par excellence where controls and guarantees of judicial order can be suspended – the zone where the violence of the State of exception supposedly operates in the service of 'civilization'. (MBEMBE, 2018, p. 32-35)

And seeking an explanation that is, incidentally, brilliantly geographical, Mbembe (2018, p. 38-39), asserts:

> The 'colonial occupation' itself was a matter of apprehension, demarcation and assertion of physical and geographical control – inscribing a new set of social and spatial relations on a terrain. This inscription of new relationships ('territorialization') was, finally, equivalent to the production of borders and hierarchies, zones and enclaves; the subversion of existing property regimes; the classification of people according to different categories; resource extraction; and, finally, the production of a wide reserve of cultural imaginaries. (MBEMBE, 2018, p. 38-39)

And in the context of this modernity, South Africa as a nation-state under the inspiration of the Jus publicum europeaum and the apartheid regime, considered the "district" its basic structure and the bantustans (homelands) rural territories in which labour regulated migrant work was fixed and urbanization, finally, under control. Quoting Belenda Bozzoli, Mbembe (2018, p. 39) expresses that "the district was particularly a place where 'severe oppression and poverty were experienced based on race and social class". For the aforementioned author (idem, p.41), modern sovereignty is "the ability to define who matters and who does not matter, who is 'disposable' and who is not", and in this context, the most recent occupations, unlike the Modern (from Jus publicum europeaum), with its disciplinary and biopolitical framework, more avidly touches on the necropolitics of the postmodern state and, therefore, deregulated in its capacity to kill.

Now, considering the colonial and post-colonial period, with the Modern State, both in Africa and in other continents, the discipline and biopolitics, the naked bodies monitored by disciplinary laws and norms, have always been also characterized, under the European political imagination.

[7] Available at: https://oglobo.globo.com/brasil/atlas-da-violencia-2018-brasil-tem-taxa-de-homicidio-30-vezes-maior-do-que-europa-22747176.

[8] Available at: http://www.brasildefato.com.br/node/12564

Therefore, the colony and the State have always represented the place where sovereignty consists fundamentally in the exercise of a power outside the law (ab legibus solutus) and in which "peace" tends to assume the face of an 'endless war, as shown, statistically, in a previous paragraph about Brazil.

And it is in this context that the repression of race and class that fell with all brutality and massacres is found, especially in South Africa, as a colony and through apartheid under the aegis of the "Modern" Nation-State, politically guided by white minorities.

In the meantime, we see these events as a harbinger of what Mbembe himself (2018) today defines as necropolitics. However, the aforementioned author fits it better, considering the "contemporary occupation of Palestine", but we believe that militia Brazil is also a fertile field. In the Palestinian territory, Israel deprives the Palestinian nation not only of its identity, but also of its authorities' legitimacy, in the name of its partly divine right to exist (we must also not forget that Israel is strategic in US Geopolitics). Thus,

> [...] violence and sovereignty, in this case, claim a divine foundation: the quality of the people is forged by the worship of a mythical deity, and national identity is imagined as identity against the other, against other deities [Allah and the God of Abraham, Isaac and Jacob]... As a result, [postmodern] colonial violence and occupation rest on the sacred terror of truth and exclusivity (mass expulsion, resettlement of 'stateless' people in refugee camps, establishment of new colonies). Behind the sacred Semitic terror, the constant exhumation of missing bones; the permanent memory of a body torn into a thousand pieces and unrecognizable; the limits, or rather the impossibility of representing an 'absolute' crime, an unspeakable death: the terror of the holocaust... In these circumstances, colonial occupation is not only equivalent to control, surveillance and separation, but also to seclusion (MBEMBE, 2018, p. 42-43).

Considering this new/old contemporaneity, we see, in the face of a growing literature on decolonialism, as devoid of great empirical foundations; we see much more of a world in a deep process of recolonization under the ab legibus solutus, based on the European political imagination, of the jus publicum europeaum. Decolonial visions are very important as utopias, such as the much-refuted discourse of the new Latin American constitutionalism, rehearsed in Bolivia and elsewhere, especially Brazil, countries today subjected to the fiercest legal, military and regulatory, globalist technical/scientific/informational and financial pressure gestated in the "labs" of American Universities and the FBI, like the famous Lawfares to forge and condemn leaders with popular appeal, as well as suppress territories with tendencies of social and productive relations not totally subjugated to the market.

Therefore, still anchoring ourselves in Mbembe (2018, p. 52-53) and, in part, the basis to the inspiration for this essay, it is worth accepting his lucid writings, under the inspiration of Bauman, when he mentions that:

> This new era is that of global mobility. One of its characteristics is that military operations and the exercise of the right to kill are no longer the exclusive monopoly of the state, and the 'regular army' is no longer the only means of carrying out these functions. The assertion of a supreme authority in a given political space is not easy. Instead, a mosaic of incomplete and overlapping, disguised and tangled rights to govern emerges, in which actual different geographically intertwined legal instances surplus, and in which plural allegiances, asymmetric suzerainty abound. In this heteronomous organization of territorial rights and claims, it makes little sense to insist on the distinction between 'internal' and 'external' political fields, separated by clearly demarcated boundaries. (MBEMBE, 2018, p. 32-35)

These are assertions that, in our view, corroborate our thesis of a postmodern neocolonial process, in which the globalist power monitors a new geopolitics based on national States weakened by ethnic, religious, class issues, having their "neo-imperial" economic centers. such as USA (United States of America), China, Russia, EU (European Union), to dominate and:

> [...] manipulate urban militias, private armies, armies of regional lords, private security and state armies that proclaim the right to exercise killing violence... increasingly, most armies are made up of citizen soldiers, child soldiers, mercenaries and privateers... diffuse and polymorphous organizations, war machines are characterized by their capacity for metamorphosis. Its relationship with space is mobile. (MBEMBE, 2018, p. 38-39)

Therefore, as Raffestin (1993) emphasizes in the "classic" one-dimensional State and its centralizing power, it could scrutinize the territory, according to its strategic objectives of spatial usufruct. In the multidimensional State, in addition to its centralized monitoring power, there is, taking into account the various dissymmetries in relational systems of power, whether of large corporations/private organizations, or even large corporate organizations of the State, overlapping conflicts, considering the breakdown, in the logic of capitalist accumulation, essential to the work/information/knowledge and power unit. It is in this crucible that resurfaces, today, especially in Brazil, the "renaissance of the medieval militias", mercenaries, corsairs, child soldiers, etc.

A Brief Overview of External and Internal Geocropolitics in Brazil: Final Notes for a Reflection.

In this context, how can we situate and characterize the war in Syria? Corroborating the assertions mentioned in the previous paragraph, the civil conflict in Syria, initially as a protest within the framework of the Arab Spring against the government of the Nation-State of Bashar Al-Assad, in the early 2000s, the movement later descends into a fierce civil war, having as the first group opposed to Assad the Free Syrian

Army (ELS), a dissidence of the national army. Later, due to global geopolitical interests, Russia, Iran and Shiite militiamen started to support the aforementioned president, since Russia has always coveted commercial access, via the Mediterranean, and Iran and Shiite militiamen struggle with Saudi Arabia, a country that maintains close ties with the United States militarily and commercially, as it is the largest producer and exporter of oil and its ally, in addition to having the largest reserve of this ore. In addition, the US aims to create a transport channel through the conflict area, which would minimize costs and risks, in particular, avoiding the Strait of Hormuz.

In this whirlwind of conflicts, we cannot forget the Kurds, with the Yankee support and enemies of Turkey, nor the emergence of the IS (Islamic State), a Jihadist group that emerged after the Iraq war. Finally, Jaysh al Islam, ELS and Ahrar al Sham stand out as the most important militia rebels, financed by the USA, Saudi Arabia, etc. What is certain is that the conflict continues forcing 65 million people to leave their homes, besides hundreds of thousands of deaths, 6 million forced to leave their homes and another 5.5 million to beg refuge, a veritable diaspora around the world (GALILEO MAGAZINE, 30/09/2019).

Why do we talk about postmodern neocolonized states? Having seen the account above, we could also add States destroyed by the US and EU such as Libya ruled, until then, by Muammar al-Khaddafi, Iraq by Saddam Hussein, events that have made these countries, today, spaces "governed" by diffuse organizations and polymorphous, territorially mobile, with armies made up of "citizen soldiers, child soldiers (so present in the recruitment of the Islamic State), mercenaries and corsairs, slaves, many of them recruited from within themselves, also, from European states or not. Finally, under the baton of old and emerging global empires, we repeat, it is forged:

> A mosaic of incomplete and overlapping, disguised and tangled rights to govern emerges, in which different actuall geographically intertwined legal instances de facto surplus, and in which plural allegiances, asymmetric suzerainty abound. In this heteronomous organization of territorial rights and claims, it makes little sense to insist on the distinction between 'internal' and 'external' political fields, separated by clearly demarcated boundaries. (MBEMBE, 2018, p. 38-39)

In short, in this context of globalization organized on the basis of increasingly heteronymous rights, the growing flexibility of the power to kill comes to the fore. Liquid, fluid deaths of naked bodies, of zoes in a world increasingly riddled with "wasted lives", human waste no longer recyclable by an increasingly rational, mathematical and technicist economy (BAUMAN, 2005), in which the reserve army now is subjected to a plot based on necropower and necropolitics.

This is because its economic/territorial constitutional base obeys a relational system of dissymmetrical power; from the colony to the mimetic configuration of the national state of European ballast, the order of extraction of surplus labor has prevailed and still prevails, in many cases, in a form, today, almost enslaved. Inhuman works that feed a capitalism in which the market is indifferent to contexts of overexploitation and the State is exempt from its social responsibility, to a large extent, alleging lack of resources to alleviate the suffering of these underprivileged people.

With regard to indigenous territory in the Brazilian space, we have a vast literature on the extermination of nations under the weight oof capital's greed over defenseless nations, as they are obliged to submit to a mosaic of incomplete and overlapping rights to govern, disguised and entangled, in which different legal instances that are de facto geographically intertwined surplus, and in which plural allegiances, asymmetric suzerainty abound.

In this case, we can ask: what management and governance powers does the National Indian Foundation (FUNAI) have in relation to loggers, miners, land grabbers, with their "plural loyalties" and their active and passive militias, amid fragile and fragile indigenous suzerainty asymmetric? To Mbembe (2018, p. 57):

> The concentration of activities related to the extraction of valuable resources around these enclaves has, in turn, converted these enclaves into privileged spaces of war and death. The war itself is fueled by the growth in sales of extracted products. (MBEMBE, 2018, p. 38-39)

Miserably in Brazil, often with the approval of the Rule of Law. The aforementioned incomplete and overlapping rights to govern are even more incited when dealing with organized crime, today constituted by organizations with their well-structured syntagmatic codes such as "parallel" necropower, with their "norms" of territorial creation of networks, nodes, and spaces contiguous psychotropic consumption or also smuggling and money laundering. As Bauman emphasizes (2005, p. 96):

> The power to exclude would not be a mark of sovereignty if the sovereign's power had not joined the territory... At any given time, frontier lands were known at the same time as a factor of displacement and a unit of recycling of the displaced. Nothing more can be expected of its new global variety, except, of course, the new planetary scale of production and recycling problems. (BAUMAN, 2005, p. 96)

And, whether we like it or not, the "sovereign power of drug trafficking/smuggling" or organized crime, almost always aligned, has joined the territories, as a source, in part, of recycling problems and seeking solutions, such as the modus operandis of narcotic products or not, a strategy of setting up networks for distribution through them, international and national, money laundering, "administration" of conflicts between

factions, considering the "plural loyalties", PCC, CV and other infinities that proliferate and they spread throughout Brazilian territory, with their "nodes" in São Paulo, Rio de Janeiro and, now, their "sub nodes", such as those in Manaus, Belém, Fortaleza, Natal, just to mention a few, in addition to strategic cities in these embedded networks on the borders between Brazil, Peru, Bolivia and Paraguay as scales for the distribution of weapons, narcotics, money, in short, recycling problems. Thus, as Mbembe asserts (2018, p. 57-58),

> In most places, the collapse of formal political institutions under the pressure of violence tends to lead to the formation of militia economies. War machines (in this case, militias or rebel movements) quickly become extremely organized predatory mechanisms, taxing territories and the populations that occupy them and relying on a variety of transnational networks and diasporas that provide them with material and financial support. (MBEMBE, 2018, p. 57-58)

This agenda is on the agenda of our "rotten" and poor powers, in which their capacities to govern are denoted incomplete and overlapping, disguised and tangled, in which different legal instances de facto are geographically intertwined, and in which plural allegiances abound , asymmetric suzerainty (the famous militias and their suzerains and entrenched loyalties, including in the "Sovereign State".

Hence riots and wild killings in prisons, with dismembering and beheading, water distribution taxes, transport, "private security", illegal constructions, domains of public areas territories for the preservation of water sources, for later real estate speculation, became commonplace, in special in Rio de Janeiro, São Paulo, Brasília, and other large cities; "extremely organized predatory mechanisms", war machines that already find echoes, including in the battered "formal institutions" of power of the "Sovereign State".

We still find it pertinent to highlight, never failing to value Mbembe's current work (2018), that geographer Milton Santos (2009), in his vast work on the study of the urban, in a pioneering approach (at least in the Brazilian context), he refers to, or creates the neologism necropolis, to highlight the deep socio-spatial fragmentation in Brazilian metropolises. That is, considering the profound dissymmetries in the making of the great metropolises in our country, the aforementioned author found that the metropolis, in the Greek sense, as the sum of metropolis (mother, womb) and polis (city), polarizer of countless cities and its municipalities in the political, economic and cultural fields, never had a maternal spirit of belonging, of civitas, of citizenship. On the contrary, as today, they have become necropolises, fields of war between anti-civil, segregationist, socially and territorially peoples; places where strangers cannot meet, as Bauman (2005) points out.

In this context, in 2019, according to data from Depen (National Penitentiary Department), linked to the Ministry of Justice, Brazil held more than 773,000 prisoners in Prison Units and in police stations (agenciabrasil.ebc.com.br). Making this scenario even more intense, the number of people living in extreme poverty has been growing exponentially. Data from the IBGE Social Indicators Synthesis, 6.5% of the Brazilian population in 2018, that is, more than 13 million inhabitants were in that stage (agenciadenotícias.ibge.gov.br). As for the income gap, in 2017, the rich in Brazil earned 36.1 times more than half of the poorest, an average of R$27,213, while the underprivileged earned R$754 (agenciabrasil.ebc.com.br). As for access to health, more than 100 million people (www1.folha.uol.com.br), mostly with low incomes, are assisted by the SUS (Unified Health System), an inclusive and universal structure, however , lacking financial assistance, a fact that leads its claimants to real situations of calamity, due to the deficit of a reasonable medical structure. Overcrowding, lack of equipment and technicians are the watchwords.

And now with the covid-19 pandemic, a real sense of terror has spread. As for people in need of work and income, it is also worth noting that some of them live in 6329 slums spread across the country, unhealthy places subject to various risks, such as sliding barriers, which kill so much, especially in rainy periods. As Wacquant (2007, p. 7) says, they are spaces located at the base of the hierarchical system of regions that make up a metropolis, in which urban pariahs reside and where social problems congregate and become infected, attracting the unequal and excessively negative attention of the media, politicians and state leaders.

It is in this context that the desperation of the marginalized grows, or as Morin (2002) says, people tend to change from their sapiens stage to the demens and from this, in many cases, to the Killer, as shown by the number of crimes and deaths lethal and intentional in Brazil, previously reported. Also, and in this line, Mbembe (2018, p. 61-64), highlights the necropower and the necropolitics of the State of Israel, vis-à-vis the Palestinians, and the two mechanisms of retaliation of this nation and its necropolises: "the 'logic of survival and the 'logic of martyrdom'". Based on Elias Canetti, he emphasizes that:

> The survivor is the one who, having walked the path of death, knowing the exterminations and remaining among those who fell, is still alive. Or more precisely, the survivor is the one who, after fighting many enemies, managed not only to escape with his life, but also to kill his aggressors. Therefore, the lowest degree of survival is killing. (Idem, p.62).

These strong assertions, perhaps explain, to a large extent, the hit men, extermination groups, militias that spread throughout our metropolises and their great clashes between themselves and the rule of law. The consequences: the population without citizenship and belonging, under the umbrella of the repressive apparatus of the official State, is under the gun of "stray bullets" and, as a consequence, in many cases, death, that is, remaining among those who have fallen, which denotes a true necropower. As for the question of martyrdom, "the body does not hide just one weapon. He is transformed into a weapon, not in a metaphorical sense, but in a truly ballistic sense: the suicide bombers" (Idem, p. 64).

In the Brazilian case, despair has certainly not reached this level, but martyrdom for a significant portion of the poor and marginalized population, translates into great suffering, affliction, scourge, ordeal, torment, for everything that has been exposed, under the insensitive aegis of necropolitics and necropower, monitored by internal and external organizations. Corroborating our assertion, Mendietta (apud Bauman 2008, p. 92-93) emphasizes: "the cities that historically and conceptually used to be the metonymy of protection and security have become sources of threat and violence". David Garland (apud Bauman 2005, p. 86-87) adds:

> There was a marked shift in emphasis from welfare to penal... The penal mode, while becoming more prominent, also became more punitive, more emphatic, more safety-oriented... The well-being mode, at the same time that it became more silent, became more conditional, more focused on the crime, more aware of the risks... Offenders are now less likely to be represented in official discourse as destitute citizens seeking support. They are shown instead as reprehensible, worthless, and somewhat dangerous and killable individuals. (GARLAND apud BAUMAN 2005, p. 86-87)

This is the sad panorama of the necro-geography to which we were submerged in Brazil.

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Local Sustainability Model based on Sustainable Harmonic Movement Analysis

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Abstract- The proposed Local Sustainability Model (LSM) is framed in the Sustainable Development Goals (SDGs) and focused on Sustainable Cities and Communities. The research is based on the initial praxis developed in the construction of an LSM (Gonzales, 2019) for the Artisanal Gold Mining Activities in southern Peru (AGMA), and is based on the application of the Sustainable Harmonic Movement (SHM) analysis and its integration to methods and techniques such as Canvas, Dolphy, Dynamic Programming, Statistical Validation to determine the sustainability indicators and achieve the measure of Sustainable Development. Finding the LSM implies taking advantage of the natural resource in an efficient and effective way, for which it should be considered to determine the scope limited by the systematized environment (environment), considering in its evaluation the indicators of Environmental, Economic, Social and Governance Sustainability.

Keywords: sustainability, local sustainability model, sustainable development, sustainability harmonic movement.

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Local Sustainability Model based on Sustainable Harmonic Movement Analysis

Mario A. Gonzales Torres

Abstract- The proposed Local Sustainability Model (LSM) is framed in the Sustainable Development Goals (SDGs) and focused on Sustainable Cities and Communities. The research is based on the initial praxis developed in the construction of an LSM (Gonzales, 2019) for the Artisanal Gold Mining Activities in southern Peru (AGMA), and is based on the application of the Sustainable Harmonic Movement (SHM) analysis and its integration to methods and techniques such as Canvas, Dolphy, Dynamic Programming, Statistical Validation to determine the sustainability indicators and achieve the measure of Sustainable Development. Finding the LSM implies taking advantage of the natural resource in an efficient and effective way, for which it should be considered to determine the scope limited by the systematized environment (environment), considering in its evaluation the indicators of Environmental, Economic, Social and Governance Sustainability. To establish the LSM, it is necessary to determine the indicators and indices and their dimensionality in order to develop the activity and complement the evaluation with the Sustainable Harmonic Movement analysis in order to find the optimal Local Sustainability Model. The conceptualized LSM can be used in different activities that involve the use of natural resources within a systematized environment.

Keywords: sustainability, local sustainability model, sustainable development, sustainability harmonic movement.

I. Introduction

In the vision of directing the development of man (UN, 1987) established the scope of Sustainable Development[1] alternative to economic development, its foundation being the sustainability that has as a premise ¨satisfying the needs of the present without compromising the capacity of future generations¨, guaranteeing the balance between economic growth, the environment and social well-being. Likewise, the Sustainable Development Goals (UN, 2015) have been established, which prioritize and lead to the consideration of new actions to confront poverty, protect the planet and improve the lives and prospects of people in the world. Currently as an alternative to develop economic activities oriented to the SDGs.

Local Sustainable Development is based on the concept of endogenous local development that grants a predominant role to companies, organizations, local institutions and civil society itself, identifying the economic dimension that allows local entrepreneurs to improve competitiveness, the social dimension and the institutional dimension and the basic values of the development process. (Stöhr, 1985). The vision of local economic development in addition to economic development in general, are added the fields of analysis of natural capital, social capital, importance of institutional strengthening, promotion of the participation of local communities, human capital, by improving access to education, nutrition and health, the role of women, the innovation needs of each territorial productive system in context, competitiveness, economic globalization and the assessment of environmental sustainability (ECLAC, 2011).

II. Sustainability Model

The Local Sustainability Model (LSM) is conceptualized within strategic planning (Ander, 1995) with the purpose of highlighting the importance of current policies and interaction of social actors. This is how the LSM is characterized by being dynamic, highlighting in the methodology the contribution of the opinion of experts, who have a scale of values of what is convenient and not convenient in the objective of finding Economic, Environmental, Social and Governance Sustainability[2] necessary for develop the model. The beginning of the evaluation of the problem is established with the baseline which includes the regulations and specifies the normative planning. The Sustainability Model is articulated at the strategic level with what it can be and at the operational level with the desire to make a flexible scheme. Thus, in a first stage, the selection of indicators is determined from a cause/ effect model or an analytical approach (Glave et al., 1995) and then they are subjected to the logic in the construction of the model, evaluating the indicators. In a second stage, the indices for each proposed model are dimensioned and interact.

The conceptualization of the LSM is established through the relationship of variables between the definition of Local Sustainable Development (LSD) and

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[1] The definition of Sustainable Development is established according to the Rio Declaration 1992.

[2] According to the Earth Summit, Johannesburg 2002 the 4th component of Sustainability was established as Governance. In this scope, its correspondence with Institutional Sustainability is considered.

Sustainable Local Development for activities (SLD^{Ai}) referring to the following relationship.

$$LSD = SLD^{A1} + SLD^{A2} + SLD^{A3} + \ldots\ldots + SLD^{An}$$

$$LSD \approx SLD^{AX}$$

$$SL = \mathbf{B}(S^{AX})$$

Involving the advance of other economic activities in the local geographical area, with which in this context Local Sustainability is measured in function to Activity Sustainnability by the following recursive equation:
Where:

B: Between 0 and 1
B = 1 greater predominance of activity X

Having,
$S^{L} = f(S^{L}_{E}, S^{L}_{S}, S^{L}_{A}, S^{L}_{I})$
$S^{AX} = f(S^{AX}_{E}, S^{AX}_{S}, S^{AX}_{A}, S^{AX}_{I})$
In unambiguous correspondence there is:
$S^{AX} = f(S^{AX}_{E}, S^{AX}_{S}, S^{AX}_{A}, S^{AX}_{I})$
The following relationship is established in a matrix:

$[S_i^L] = \mu\,[S_{ij}^{AX}].\,[S_i^L]$ (i)
For i=j i=1,2,3,4
Where:
$[S_{ij}^{AX}]$: Sustainability Matrix

III. Sustainability Indicators

The Indicators of the Local Sustainability Model are represented in the Sustainability Matrix, which represents the relationships between the Economic, Social, Environmental and Institutional Sustainability indicators of the proposed activity X. These are:

Economic Sustainability Activity X = S^{AX}_{E};
Social Sustainability Activity X = S^{AX}_{S}
Environmental Sustainability Activity X = $S^{AX}_{A;}$
Institutional Sustainability Activity X = S^{AX}_{I}
Local Economic Sustainability = S^{L}_{E};
Local Social Sustainability = S^{L}_{S}
Local Environmental Sustainability = $S^{L}_{A;}$
Local Institutional Sustainability = S^{L}_{I}

From the relationship established in (i) for Local Sustainability and the Sustainability of the proposed local activity, we have:

$[S_i^L] = \mu\,[S_{ij}^{AX}].\,[S_i^L]$ (i)
$[S_i^L] = \mu'\,[I_{ij}^{AX}].\,[S_i^L]$
$[S_i^L] = \mu''\,[I_{ij}^{AX}] / \|I_{ij}\|.\,[S_i^L]$

Being: $\|I_{ij}\|$ the largest scalar value for Iij, with i = j
and

$[I_{ij}^{AX}]$: Matriz de Sostenibilidad de Indicadores
$[I_{ij}^{AX}]/\|I_{ij}\|$: Matriz de Sostenibilidad de Indicadores Normalizada

The Normalized Sustainability Matrix is constructed from the division of the largest scalar value for $\|I_{ij}\|$ where Iij, with i = j, thus characterizing that the trace will take the Optimal value of 4 which represents the ideal Indicator Sustainability for LSM.

IV. Materials and Methods

The research was based on the praxis developed of the construction of an LSM for artisanal gold mining activities in southern Peru (Gonzales, 2019), and is based on the use of the Canvas and Dolphi Methods, for the determination of objectives and goals, expert opinion and Dynamic Programming techniques for logical sequence and statistical analysis withthe Friedman statistician with p value that allows to identify the sustainability indicators and indices and their dimension to the activity and availability of the resource to later build the Description Sheets of Sustainability Indicators associated with their dimensionality and then submit them to the analysis of the Sustainable Harmonic Movement (SHM) in order to evaluate the optimal MSL of Indicators.

Table N°1: Models and Index

Sustainability Index	$I^{E}MA$	$I^{A}MA$	$I^{S}MA$	$I^{I}MA$
Model	340	340	340	340
Model 1	85	85	85	60
Model 2	85	85	85	70
Model 3	85	85	85	80
Model 4	85	85	85	90

Table N° 2: Description Sheet of Sustainability Indices

Sustainability Index	Index	Model 1	Model 2	Model 3	Model 4
Economic	$I^{E}MA$	0.27	0.26	0.25	0.25
Social	$I^{A}MA$	0.27	0.26	0.25	0.25
Environmental	$I^{S}MA$	0.27	0.26	0.25	0.25
Institutional	$I^{I}MA$	0.27	0.22	0.24	0.26

V. Analysis and Discussion of Results

Based on the results of the AGMA research supported by the operational dimensionality of the activity of 340 participants, the SHM analysis was carried out based on the AHM[3] iteration relationship, finding the following data shown in the Description Sheet of Sustainability Indicators. The established indices are: Economic Indicator I^{E}_{MA}, Social Indicator I^{S}_{MA}, Environmental Indicator I^{A}_{MA} associated with Training and the Indicator Institutional I^{I}_{MA} Institutional Indicator, associated with Business Risk. See Tables N°1 and N°2.

Using the Adapted Holzer Method (AHM)[4] the natural frequencies of sustainability were determined under the condition initial unit S value, and iterated through the following relationship:

$$S_i = S_{i-1} - (w^2/k_j) \sum_{1}^{i-1} I_j.S_j$$

Where:

Sustainability Displacement (S)
Sustainability Frequency (W)
Frequency of Natural Sustainability (Wn)
Sustainability Constant (K) y Sustainability Indicator (I)

Iterating the AHM equation for each model built based on the dimensioned indices for 340 participants in the LSM we have the tabulation of w and the obtaining of w_n for 04 dimensioned models. See Figures N°1, N°2, N°3 and N°4.

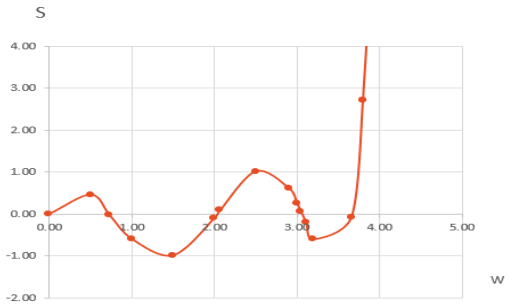

Figure N°1: Tabulation and Graph Model 1

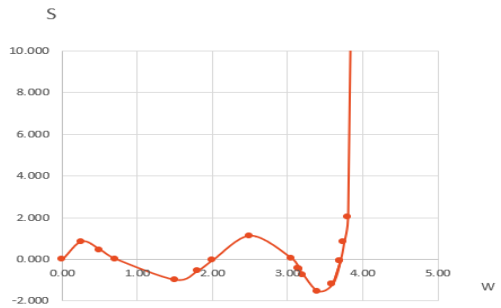

Figure N°2: Tabulation and Graph Model 2

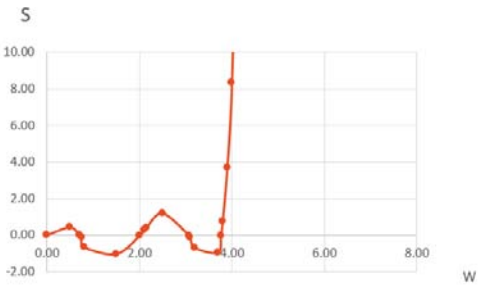

Figure N°3: Tabulation and Graph Model 3

[3] The Sustainable Harmonic Movement (MAS) is defined in reference to a physical system of masses subjected to the Oscillatory Harmonic Movement for the sustainability components.
[4] The Adapted Holzer Method (MHA) is based on the adaptation of the solution of the mass motion equation by the Holzer Method submitting the 4 Sustainability components.

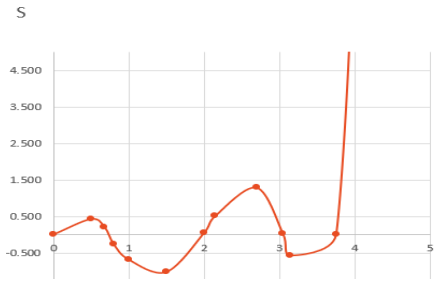

Figure N°4: Tabulation and Graph Model 4

From the graphs, the natural frequencies of sustainability are determined and are presented in Table N°3. Likewise, the tabulation of Sustainability Frequencies complies with the Variation and Trend Tests of Natural Sustainability Frequencies. See Table N°4 and Figure N°5.

Table N°3: Natural Frequencies of Sustainability

Natural Frequencies by Sustainability Model		Model 1 Wn	Model 2 Wn	Model 3 Wn	Model 4 Wn
Economic	$I^{E}MA$	0.73	0.70	0.70	0.70
Social	$I^{A}MA$	2.07	2.00	2.00	2.00
Environmental	$I^{S}MA$	3.05	3.05	3.08	3.05
Institutional	$I^{I}MA$	3.66	3.70	3.76	3.76
Sustainability Condition		Acceptable	Acceptable	Acceptable	Acceptable

Table N°4: Variation of Natural Frequencies of Sustainability

Relative Variation of Wn	Model 1 Wn	Model 2 Wn	Model 3 Wn	Model 4 Wn
Wn2- Wn1	1.34	1.30	1.30	1.30
Wn3- Wn2	0.98	1.05	1.08	1.05
Wn4- Wn3	0.61	0.65	0.68	0.71
Sustainability Condition	Acceptable	Acceptable	Acceptable	Acceptable

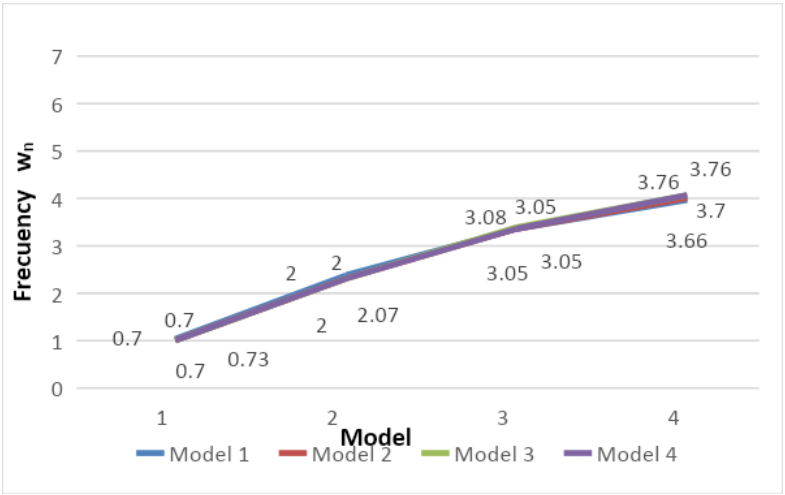

Figure N°5: Sustainability Natural Frequencies Trend

The Sustainability Matrices H_i and their normalization are as follows:

$$\mathscr{H}_{1=}\begin{pmatrix}85 & 0 & 0 & 0\\ 0 & 85 & 0 & 0\\ 0 & 0 & 85 & 0\\ 0 & 0 & 0 & 60\end{pmatrix} \Rightarrow \begin{pmatrix}1 & 0 & 0 & 0\\ 0 & 1 & 0 & 0\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & 0.71\end{pmatrix}$$

$$\mathcal{H}_2=\begin{pmatrix}85&0&0&0\\0&85&0&0\\0&0&85&0\\0&0&0&70\end{pmatrix}\Rightarrow\begin{pmatrix}1&0&0&0\\0&1&0&0\\0&0&1&0\\0&0&0&0.82\end{pmatrix}$$

$$\mathcal{H}_3=\begin{pmatrix}85&0&0&0\\0&85&0&0\\0&0&85&0\\0&0&0&80\end{pmatrix}\Rightarrow\begin{pmatrix}1&0&0&0\\0&1&0&0\\0&0&1&0\\0&0&0&0.94\end{pmatrix}$$

$$\mathcal{H}_4=\begin{pmatrix}85&0&0&0\\0&85&0&0\\0&0&85&0\\0&0&0&90\end{pmatrix}\Rightarrow\begin{pmatrix}0.94&0&0&0\\0&0.94&0&0\\0&0&0.94&0\\0&0&0&1\end{pmatrix}$$

The Local Sustainability Model (LSM) for AGMA represented by the Sustainability Matrix H_3 presents a Trace equal to 3.94, which represents the optimal model.

VI. Conclusions

- The Sustainable Harmonic Movement (SHM) analysis of dimensioned sustainability indicators based on the Adapted Holzer Model (AHM) allows establishing the optimal Local Sustainability Model based on the Environmental, Social, Economic and Institutional Sustainability components of the proposed activity.
- The Local Sustainability Model based on the AGMA enables the construction of other Local Sustainability Models for other activities based on the SHM analysis, for which the value of **B** must be determined in the recursive equation.
- Given the applicability in the construction of the Sustainability Model, the MAS analysis can be established as an evaluation and measure of sustainability in its components, serving as an instrument in decision-making.

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Noise Characterization of the Operations of a Manufacturing and Marketing Company of Type 1 Hydrolytic Glass Containers

By H. Jilmer Cano Arratea
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Abstract- The present investigation carried out a study on exposure to noise doses to workers in a company that manufactures, and markets hydrolytic glass containers type 1. The objective is to characterize the exposure profiles of the GES by comparing the results with the LMP. The study population is made up of all workers exposed to noise and the population of 103 and a sample of 45, the methodology used is that of the worst condition and according to the AIHA guidelines. The results were analyzed according to two indicators, maximum value for samples smaller than 6 and in case of higher evaluations it was analyzed under the UCL, obtaining as results 9 groups of GES, of which 89% present a level of exposure without hearing protection greater than the LMP.

Keywords: exposure assessment, hearing, hearing conservation, monitoring, noise.

GJHSS-B Classification: FOR Code: 040699

Strictly as per the compliance and regulations of:

Noise Characterization of the Operations of a Manufacturing and Marketing Company of Type 1 Hydrolytic Glass Containers

Caracterización del ruido de las operaciones de una empresa de fabricación y comercialización de envases de vidrio hidrolítico tipo 1

H. Jilmer Cano Arratea

Resumen- La presente investigación realizó un estudio sobre exposición a dosis de ruido a trabajadores en una empresa de fabricación y comercialización de envases de vidrio hidrolítico tipo 1. El objetivo fue caracterizar los perfiles de exposición de los GES por comparación de los resultados con el LMP. La población del estudio está conformada por todos los trabajadores expuestos a ruido, población es 103 y la muestra de 45, la metodología usada es la peor condición (BOHS, 2011) y según las directivas de la AIHA. Los resultados se analizaron de acuerdo con dos indicadores, valor máximo para muestras menores a 6 y en caso evaluaciones mayores se analizaron bajo el UCL, obteniendo como resultados 9 Grupos de GES, de las cuales el 89% presenta un nivel de exposición sin protección auditiva mayor al LMP.

Palabras clave: evaluación de la exposición, audición, conservación de la audición, monitoreo, ruido.

Abstract- The present investigation carried out a study on exposure to noise doses to workers in a company that manufactures, and markets hydrolytic glass containers type 1. The objective is to characterize the exposure profiles of the GES by comparing the results with the LMP. The study population is made up of all workers exposed to noise and the population of 103 and a sample of 45, the methodology used is that of the worst condition and according to the AIHA guidelines. The results were analyzed according to two indicators, maximum value for samples smaller than 6 and in case of higher evaluations it was analyzed under the UCL, obtaining as results 9 groups of GES, of which 89% present a level of exposure without hearing protection greater than the LMP.

Keywords: exposure assessment, hearing, hearing conservation, monitoring, noise.

I. Introducción

Amfa Vitrum es una empresa líder en el Perú en la fabricación y comercialización de envases de vidrio hidrolítico tipo 1, como ampollas, frascos viales y con presencia internacional (AMFA VITRUM, 2020).

Dado que sus operaciones se realizan en su sede en Lima, las principales fuentes de ruido ocupacional son los motores de sistemas de inyección y extracción de aire. Los trabajadores realizan trabajos directamente en las máquinas ampolleteras y con los productos recepcionados del mismo.

a) El Perfil De Exposición Al Sonido

El perfil de exposición se puede definir como la estimación de la intensidad de la exposición y como puede variar en el tiempo para cada Grupo de Exposición Similar GES. (American Industriak Hygiene Association, 2010).

El perfil de exposición al sonido es una aplicación estructurada organizacionalmente del procedimiento basado en tareas y puede ser una metodología confiable y verificable para estimar la exposición al sonido del trabajador que permite el uso óptimo de los datos recopilados en el campo. (Hager, 2010).

Los Grupos de Exposición Similares (GES), son grupos de trabajadores que poseen un perfil general similar de exposición al (los) agente(s) bajo estudio, debido a la similitud y frecuencia con que ejecutan la actividad, los materiales y procesos con los cuales trabajan, y la manera similar como llevan a cabo la actividad. (American Industriak Hygiene Association, 2010).

"Muchas veces se usa la palabra ruido para describir el sonido no deseado", asimismo desde un punto de vista mecánico "El sonido generalmente se define como las fluctuaciones en la presión por encima y por debajo de la presión ambiental de un medio que tiene elasticidad y viscosidad. El medio puede ser un sólido, un líquido o un gas. (Associates in Acoustics, 2019).

El rango de audición humana aceptado se extiende desde 20 Hz hasta 20.000 Hz.

El nivel de sonido continuo equivalente, expresado como Leq,T, se usa para cuantificar el nivel de presión sonora promedio para un cierto período de medición. En la ecuación N° 1 se muestra de manera matemática. (Associates in Acoustics, 2019)

$$LAeqT = 10\log\left(\frac{1^{t1}}{Tt1}\int P\left[\frac{A(t)}{Po}\right]^2\right)dt \qquad \text{.....Ec.1}$$

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P_A =Presión Acústica

P_0=Presión de Referencia

El Resolución Ministerial N°375-2008-TR establece los estándares nacionales para ruido ocupacional en relación con el valor del nivel diario de exposición al ruido ponderado A, LEX,8h, el cual se calcula a partir de la ecuación N°2.

$$\mathrm{LEx,8h} = \mathrm{LP,A,eqte} + 10log\int\left(\frac{Te}{To}\right)\,dt \qquad \text{Ec.2}$$

$L_{p,AeqTe}$ es el nivel de presión sonora equivalente ponderado A para la duración efectiva de la jornada laboral

T_e es la duración efectiva de la jornada laboral (ver Tabla 1).

T_o es la duración de referencia T_0=8h

Tabla 1: Límites máximos permisibles de exposición a ruido

Nivel de ruido en escala "A", dB(A)	Tiempo de exposición
100	¼ hora/ día
97	½ hora/ día
94	1 hora/ día
91	1 ½ horas/ día
88	4 horas/ día
85	8 horas/ día
84.5	9 horas/ día
83	12 horas/ día
82	16 horas/ día

Fuente: RM-375-2008-TR.

Para fines del estudio se ha elaborado una escala en función del Límites máximos permisibles (LMP), tal como se muestra en la Figura 1.

NIVEL DE RIESGO	NIVEL DE EXPOSICIÓN
Bajo	Exposición a ruido < Nivel de Acción*
Medio	Nivel de Acción ≤ Exposición a ruido < LMP
Alto	LMP ≤ Exposición a ruido

Nota: Nivel de Acción es el 50% del LMP considerando una tasa de cambio de 3dB. Para un LMP de 85dB, el Nivel de Acción será 82dB.

Figura 1: Semaforización de niveles de exposición. Fuente: Elaboración propia

II. Métodos

a) Población de estudio

La evaluación se realizó con dosímetros de ruido, los cuales fueron aportados por cada trabajador durante el 70% de su jornada laboral, que es igual a 8 horas diarias.

La muestra del estudio objetivo estuvo constituida por 45 trabajadores que fueron agrupados en nueve (09) GES, en la tabla 2, se muestra los puestos que conformaron el estudio.

El Programa de Monitoreo Ocupacional del año 2019, contempló la evaluación de nueve (09) GES, los cuales se muestra sus respectivos códigos y cantidad de muestras evaluadas.

Tabla 2: Puestos que conforman los GES con sus respectivas poblaciones

Código GES	Nombre del GES	Puestos que conforman el GES	N° de personas (N)
CGES-001	Almaceneros	Almacenero	6
CGES-002	Analistas de control de calidad	Analista	11
CGES-003	Artes gráficas	Artes gráficas	2
CGES-004	Operador de servicios generales	Carpintero	2
CGES-006	Mecánicos-Eléctricos	Mecánicos-Eléctricos	7

CGES-011	Operadores de Producción	Operador	20
CGES-012	Reguladores de Producción	Regulador	9
CGES-014	Verificadores	Revisora	38
CGES-015	Jefes de planta	Supervisor	8

Fuente: Elaboración propia

Para elección de muestra, el estudio consideró dos criterios 1) método de la peor condición, el cual consiste en realizar mediciones menores a seis (06) y escoger el valor más alto obtenido como representativo, considerando el criterio de mayor protección para el trabajador, 2) Recomendación de la Asociación Americana de Higiene Industrial (AIHA), que considera que "La línea base mínima debe constar de un mínimo de seis muestras.

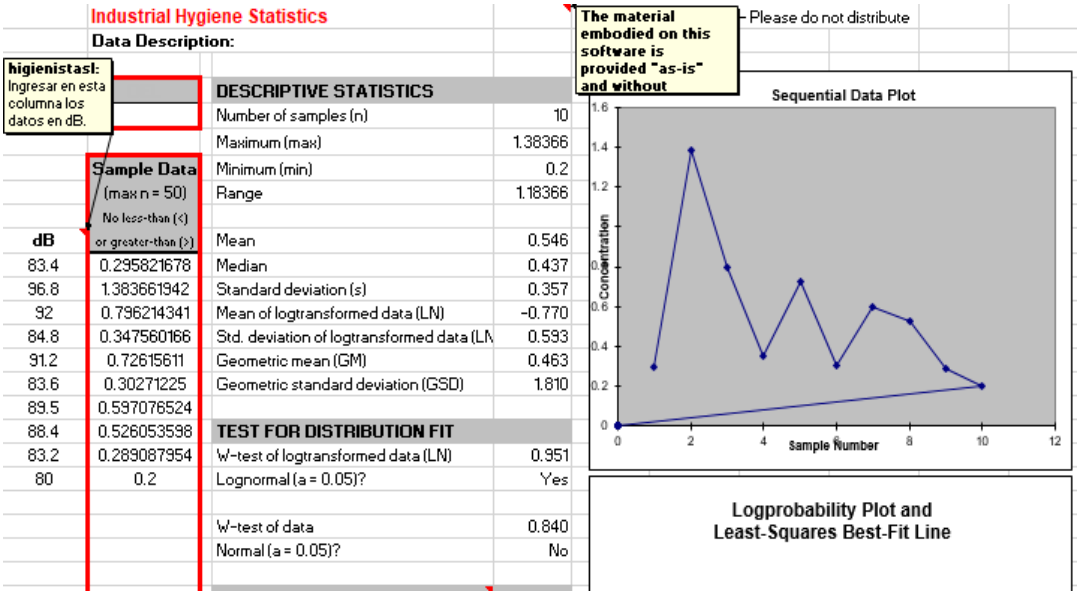
En la Tabla 3, se puede observar la muestra (n) para cada población (N) de los GES.

Tabla 3: La cantidad de muestras elegida

Descripción del GES	Código del GES	N	n
Almaceneros	CGES-001	6	2
Analistas de control de calidad	CGES-002	11	2
Artes gráficas	CGES-003	2	2
Operador de servicios generales	CGES-004	2	1
Mecánicos-Eléctricos	CGES-006	7	5
Operadores de Producción	CGES-011	20	10
Reguladores de Producción	CGES-012	9	10
Verificadores	CGES-014	38	10
Jefes de planta	CGES-015	8	3

Fuente: Elaboración propia

.



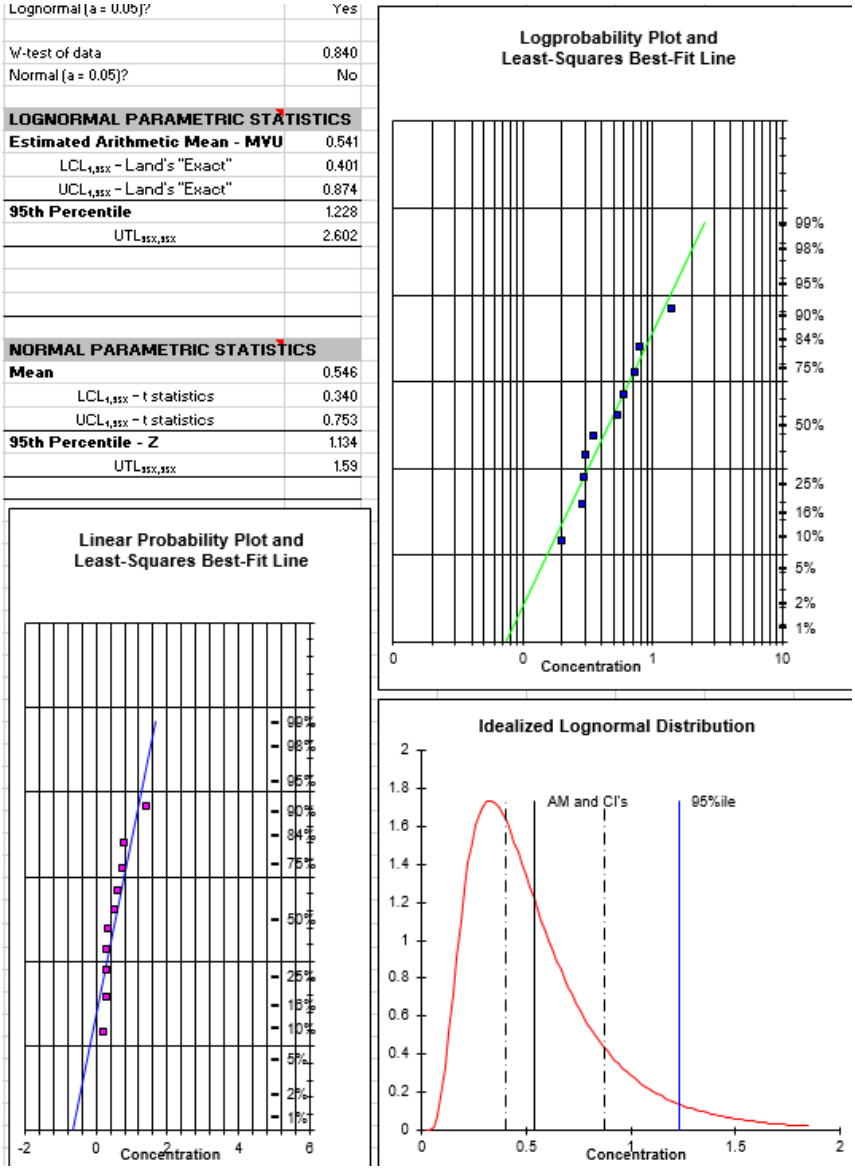


Figura 2: Herramienta usada para cálculo de. Límite de confianza superior (UCL).

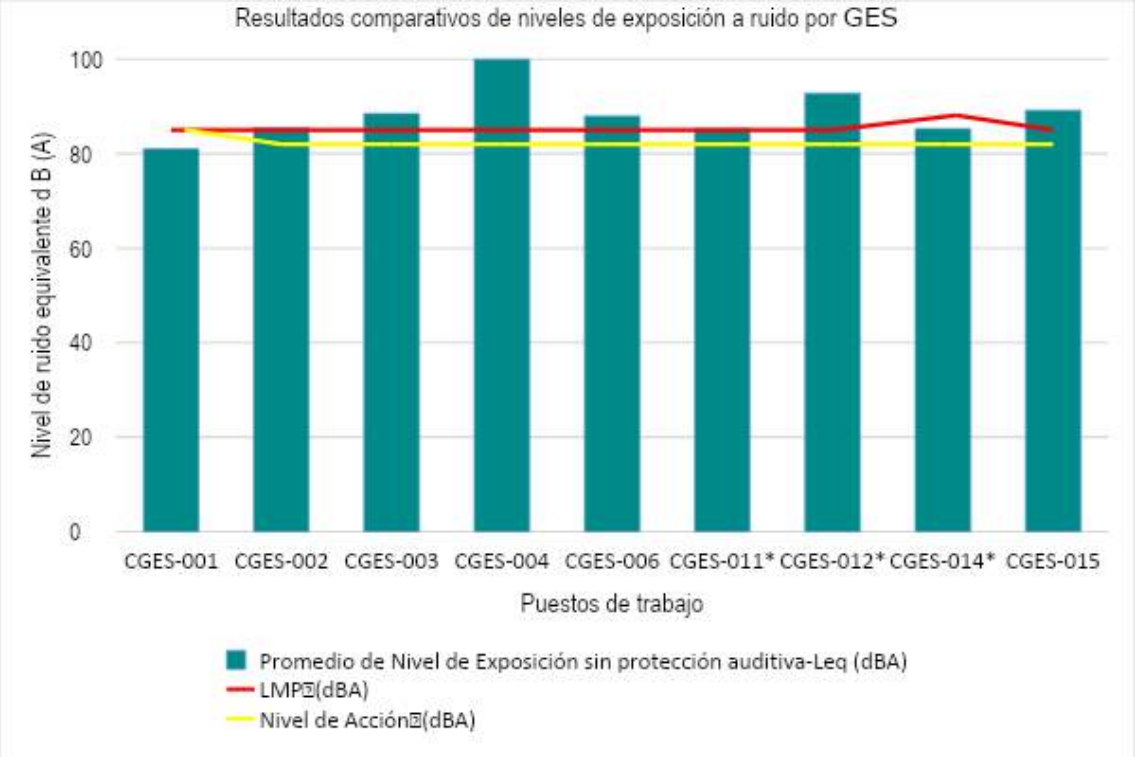
III. Resultados

Tabla 4: Nivel diario de exposición al ruido ponderado A, LEX, 8h, para cada GES y con indicador correspondiente según el criterio de elección de muestra

Descripción del GES	Código del GES	n	Nivel de exposición por GES, sin protección auditiva		Nivel de Riesgo
			Max	UCL	
Almaceneros	CGES-001	2	81	N.A	Bajo
Analistas de control de calidad	CGES-002	2	85.5	N.A	Alto
Artes gráficas	CGES-003	2	88.5	N.A	Alto
Operador de servicios generales	CGES-004	1	100.8	N.A	Alto
Mecánicos-Eléctricos	CGES-006	5	88	N.A	Alto

Operadores de Producción	CGES-011	10	N.A	85.3	Alto
Reguladores de Producción	CGES-012	10	N.A	92.8	Alto
Verificadores	CGES-014	10	N.A	85.3	Alto
Jefes de planta	CGES-015	3	89.2	N.A	Alto
Límite Máximo Permisible (LMP) para 8 Hrs			85.0		
Nivel de Acción (NA)			82.0		

Fuente: Elaboración propia



Fuente: Elaboración propia

Figura 3: Resultados comparativos de niveles de exposición a ruido por GES.

IV. Discusión

a) Grupos de Exposición Similar (GES)

Como se muestra en la Tabla 2, se agrupó a los puestos en nueve (09) GES, estos conformados por Almaceneros (CGES-001), Analistas de control de calidad (CGES-002), Artes gráficas (CGES-003), Operador de servicios generales (CGES-004), Mecánicos-Eléctricos (CGES-006), Operadores de Producción (CGES-011), Reguladores de Producción (CGES-012), Verificadores (CGES-014) y Jefes de planta (CGES-015).

b) Resultado de las Evaluaciones de Dosimetrías

Los resultados se muestran en la Tabla 4, asimismo se muestra la semaforización de niveles de exposición conforme la Figura 1.

En la Figura 3, se realizó una comparación entre el nivel de exposición ponderado sin protección auditiva-LEX, 8h (dBA) con el Límite Máximo permisible (LMP), asimismo cada barra se indica el resultado reportado, es decir el máximo (Max) o el límite de confianza superior (UCL). Para los GES CGES-011, CGES-012 y CGES-014 se comparó el valor UCL y en los 3 casos supera el LMP, en los demás GES se concluyó con el valor máximo registrándose valores superiores al LMP.

c) Análisis de Resultados

El análisis de resultado se realizó conforme al criterio de elección de la muestra, para aquellos GES que presentan una cantidad de muestras menores a seis se concluye bajo la metodología de la peor condición, es decir con valor máximo y para los grupos de exposición similar que superen la cantidad de muestras igual a seis, se analizó los resultados bajo el indicador de límite de confianza superior al 95% (UCL, 95%).

El procedimiento "exacto" de Land se usó para calcular el límite de confianza superior (UCL1, 95%), esto consiste en introducir nivel de exposición ponderado, el software convierte en forma automática a

Pascales cuadrado $(Pa)^2$ y analiza los resultados bajo una Estadísticas Paramétricas Normal o Log-Normales, asimismo sugiere que parámetro estadístico se debería usar

V. Conclusiones

1. Las fuentes de ruido para los GES evaluados están conformados por máquina de moldeo viales 3BS30-10/2 y 9 motores de extracción de potencia 2HP, Marca Weg., 2 motores de extracción de potencia 2HP, Marca Weg, asimismo tiene una influencia importante por las fuentes de la zona de aire de inyección ubicados en la azotea conformados por 2 motores de 10Kw.
2. El 89% de los Grupos de Exposición Similar (GES) evaluados, presenta un nivel de exposición sin protección auditiva mayor al Límite Máximo Permisible (LMP). Este panorama resulta bastante desfavorable y evidencia que 08 de los GES tienen categoría de alto riesgo, lo que supone un trabajo de riesgo y probablemente, a futuro cercano, causará daño en la salud de los trabajadores.
3. Los grupos de exposición similar, evaluados, permiten una oportunidad de mejora, en caso de los GES reportados con valores máximos tener en cuenta las evaluaciones anuales año tras año para generar los perfiles de exposición y en caso de los GES reportados bajo el indicador UCL, entendiéndose que el nivel ponderado sin protección auditiva-LEX, 8h (dBA) con mayor cercanía al LMP son los de mayor interés se está considerando la aplicación del método NIOSH en la próximas elección de muestras para aquellos valores de UCL – RUIDO que estuvieron en el rango siguiente: $0.5\ LMP \leq UCL \leq 2\ LMP$. Así como la elaboración de estándar de Equipos de protección Auditiva homogéneo para cada GES, a fin de considerarse en los cálculos de riesgos residuales de ruido en los próximos estudios.
4. En el cálculo de UCL, para el GES Operadores de Producción (CGES-011), Reguladores de Producción (CGES-012) y verificadores (CGES-014), se obtuvo una desviación geométrica estándar la variabilidad de baja el cual indica que existe poca variabilidad entre los resultados, asimismo el UCL quiere decir que se tiene el 95% de confianza que la proporción de individuos con promedio de exposición por debajo del LMP es menos del 5%.
5. En los próximos estudios se debe considerar factores sociales, laborales y biológicos, diferenciados en función del sexo, incorporando la dimensión de género en la evaluación y prevención de los riesgos en la salud laboral, conforme al principio de prevención de la Ley N°29783, Ley de Seguridad y Salud en el Trabajo.
6. De acuerdo con la Norma Básica de Ergonomía y de Procedimiento de Evaluación de Riesgo (R.M. N° 375-2008-TR), los Grupos de Exposición Similar (GES) estén expuestos a niveles por encima de 85 dB (A), no podrán estar expuestos un tiempo mayor a 8 horas.

Agradecimientos

Para mi familia, compañeros y a nuestro querido pueblo, que me ayudaron a iniciar, persistir y culminar el presente trabajo.

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FSSRC/ASSRC Memberships

Introduction

FSSRC/ASSRC is the most prestigious membership of Global Journals accredited by Open Association of Research Society, U.S.A (OARS). The credentials of Fellow and Associate designations signify that the researcher has gained the knowledge of the fundamental and high-level concepts, and is a subject matter expert, proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice. The credentials are designated only to the researchers, scientists, and professionals that have been selected by a rigorous process by our Editorial Board and Management Board.

Associates of FSSRC/ASSRC are scientists and researchers from around the world are working on projects/researches that have huge potentials. Members support Global Journals' mission to advance technology for humanity and the profession.

FSSRC

Fellow of Social Science Research Council

FELLOW OF SOCIAL SCIENCE RESEARCH COUNCIL is the most prestigious membership of Global Journals. It is an award and membership granted to individuals that the Open Association of Research Society judges to have made a 'substantial contribution to the improvement of computer science, technology, and electronics engineering.

The primary objective is to recognize the leaders in research and scientific fields of the current era with a global perspective and to create a channel between them and other researchers for better exposure and knowledge sharing. Members are most eminent scientists, engineers, and technologists from all across the world. Fellows are elected for life through a peer review process on the basis of excellence in the respective domain. There is no limit on the number of new nominations made in any year. Each year, the Open Association of Research Society elect up to 12 new Fellow Members.

Benefit

To the institution

Get letter of appreciation

Global Journals sends a letter of appreciation of author to the Dean or CEO of the University or Company of which author is a part, signed by editor in chief or chief author.

Exclusive Network

Get access to a closed network

A FSSRC member gets access to a closed network of Tier 1 researchers and scientists with direct communication channel through our website. Fellows can reach out to other members or researchers directly. They should also be open to reaching out by other.

Career | Credibility | Exclusive | Reputation

Certificate

Certificate, LOR and Laser-Momento

Fellows receive a printed copy of a certificate signed by our Chief Author that may be used for academic purposes and a personal recommendation letter to the dean of member's university.

Career | Credibility | Exclusive | Reputation

Designation

Get honored title of membership

Fellows can use the honored title of membership. The “FSSRC” is an honored title which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., FSSRC or William Walldroff, M.S., FSSRC.

Career | Credibility | Exclusive | Reputation

Recognition on the Platform

Better visibility and citation

All the Fellow members of FSSRC get a badge of "Leading Member of Global Journals" on the Research Community that distinguishes them from others. Additionally, the profile is also partially maintained by our team for better visibility and citation. All fellows get a dedicated page on the website with their biography.

Career | Credibility | Reputation

Future Work

Get discounts on the future publications

Fellows receive discounts on future publications with Global Journals up to 60%. Through our recommendation programs, members also receive discounts on publications made with OARS affiliated organizations.

Career | Financial

GJ Account

Unlimited forward of Emails

Fellows get secure and fast GJ work emails with unlimited forward of emails that they may use them as their primary email. For example,
john [AT] globaljournals [DOT] org.

Career | Credibility | Reputation

Premium Tools

Access to all the premium tools

To take future researches to the zenith, fellows receive access to all the premium tools that Global Journals have to offer along with the partnership with some of the best marketing leading tools out there.

Financial

Conferences & Events

Organize seminar/conference

Fellows are authorized to organize symposium/seminar/conference on behalf of Global Journal Incorporation (USA). They can also participate in the same organized by another institution as representative of Global Journal. In both the cases, it is mandatory for him to discuss with us and obtain our consent. Additionally, they get free research conferences (and others) alerts.

Career | Credibility | Financial

Early Invitations

Early invitations to all the symposiums, seminars, conferences

All fellows receive the early invitations to all the symposiums, seminars, conferences and webinars hosted by Global Journals in their subject.

Exclusive

Publishing Articles & Books

Earn 60% of sales proceeds

To take future researches to the zenith, fellows receive access to all the premium tools that Global Journals have to offer along with the partnership with some of the best marketing leading tools out there.

Exclusive | Financial

Reviewers

Get a remuneration of 15% of author fees

Fellow members are eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get a remuneration of 15% of author fees, taken from the author of a respective paper.

Financial

Access to Editorial Board

Become a member of the Editorial Board

Fellows may join as a member of the Editorial Board of Global Journals Incorporation (USA) after successful completion of three years as Fellow and as Peer Reviewer. Additionally, Fellows get a chance to nominate other members for Editorial Board.

Career | Credibility | Exclusive | Reputation

And Much More

Get access to scientific museums and observatories across the globe

All members get access to 5 selected scientific museums and observatories across the globe. All researches published with Global Journals will be kept under deep archival facilities across regions for future protections and disaster recovery. They get 10 GB free secure cloud access for storing research files.

ASSRC

ASSOCIATE OF SOCIAL SCIENCE RESEARCH COUNCIL

ASSOCIATE OF SOCIAL SCIENCE RESEARCH COUNCIL is the membership of Global Journals awarded to individuals that the Open Association of Research Society judges to have made a 'substantial contribution to the improvement of computer science, technology, and electronics engineering.

The primary objective is to recognize the leaders in research and scientific fields of the current era with a global perspective and to create a channel between them and other researchers for better exposure and knowledge sharing. Members are most eminent scientists, engineers, and technologists from all across the world. Associate membership can later be promoted to Fellow Membership. Associates are elected for life through a peer review process on the basis of excellence in the respective domain. There is no limit on the number of new nominations made in any year. Each year, the Open Association of Research Society elect up to 12 new Associate Members.

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Organize seminar/conference

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Exclusive

Publishing Articles & Books

Earn 60% of sales proceeds

Associates can publish articles (limited) without any fees. Also, they can earn up to 30-40% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.

Exclusive | Financial

Reviewers

Get a remuneration of 15% of author fees

Associate members are eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get a remuneration of 15% of author fees, taken from the author of a respective paper.

Financial

And Much More

Get access to scientific museums and observatories across the globe

All members get access to 2 selected scientific museums and observatories across the globe. All researches published with Global Journals will be kept under deep archival facilities across regions for future protections and disaster recovery. They get 5 GB free secure cloud access for storing research files.

Associate	Fellow	Research Group	Basic
$4800 **lifetime designation**	$6800 **lifetime designation**	$12500.00 **organizational**	APC **per article**
Certificate, LoR and Momento **2** discounted publishing/year **Gradation** of Research **10** research contacts/day **1 GB** Cloud Storage **GJ** Community Access	**Certificate,** LoR and Momento **Unlimited** discounted publishing/year **Gradation** of Research **Unlimited** research contacts/day **5 GB** Cloud Storage **Online Presense** Assistance **GJ** Community Access	**Certificates,** LoRs and Momentos **Unlimited** free publishing/year **Gradation** of Research **Unlimited** research contacts/day **Unlimited** Cloud Storage **Online Presense** Assistance **GJ** Community Access	**GJ** Community Access

Preferred Author Guidelines

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from https://globaljournals.org/Template.zip

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

Before and during Submission

Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

1. Authors must go through the complete author guideline and understand and *agree to Global Journals' ethics and code of conduct,* along with author responsibilities.
2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s') names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
5. Authors should submit paper in a ZIP archive if any supplementary files are required along with the paper.
6. Proper permissions must be acquired for the use of any copyrighted material.
7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

Declaration of Conflicts of Interest

It is required for authors to declare all financial, institutional, and personal relationships with other individuals and organizations that could influence (bias) their research.

Policy on Plagiarism

Plagiarism is not acceptable in Global Journals submissions at all.

Plagiarized content will not be considered for publication. We reserve the right to inform authors' institutions about plagiarism detected either before or after publication. If plagiarism is identified, we will follow COPE guidelines:

Authors are solely responsible for all the plagiarism that is found. The author must not fabricate, falsify or plagiarize existing research data. The following, if copied, will be considered plagiarism:

- Words (language)
- Ideas
- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures

- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

Authorship Policies

Global Journals follows the definition of authorship set up by the Open Association of Research Society, USA. According to its guidelines, authorship criteria must be based on:

1. Substantial contributions to the conception and acquisition of data, analysis, and interpretation of findings.
2. Drafting the paper and revising it critically regarding important academic content.
3. Final approval of the version of the paper to be published.

Changes in Authorship

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

Copyright

During submission of the manuscript, the author is confirming an exclusive license agreement with Global Journals which gives Global Journals the authority to reproduce, reuse, and republish authors' research. We also believe in flexible copyright terms where copyright may remain with authors/employers/institutions as well. Contact your editor after acceptance to choose your copyright policy. You may follow this form for copyright transfers.

Appealing Decisions

Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

Declaration of funding sources

Global Journals is in partnership with various universities, laboratories, and other institutions worldwide in the research domain. Authors are requested to disclose their source of funding during every stage of their research, such as making analysis, performing laboratory operations, computing data, and using institutional resources, from writing an article to its submission. This will also help authors to get reimbursements by requesting an open access publication letter from Global Journals and submitting to the respective funding source.

Preparing your Manuscript

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

Tips for writing a good quality Social Science Research Paper

Techniques for writing a good quality homan social science research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of homan social science then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.
Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

19. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

20. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

21. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

22. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

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Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
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Approach:

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Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

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The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
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- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
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Approach:

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- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

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Describe generally acknowledged facts and main beliefs in present tense.

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Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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