Max PLANCK (Alemania, 1858-1947):"La ciencia es la progresiva aproximación del hombre al mundo real."

4-Cuba-Venezuela Earthquakes of 1766: Part I- General Historic Data Review and Treatment

4-Cuba-Venezuela Earthquakes of 1766: Part I- General Historic Data Review and Treatment {*Terremotos de Cuba-Venezuela de 1766: Parte I- Revisión y tratamiento de datos históricos generales*}

Abstract- The two strongest documented historic earthquakes in Cuba and Venezuela are studied from the historical and seismic point of view. These territories, as colonies of Spain, had different economic level, being more weighted in Cuba. Both colonies were the main ports of the royal monopoly and where the conquest of the mainland began. Earthquakes occurred in 1766 in two different plate boundary zones: (a) North American-Caribbean (11.06 in Santiago de Cuba), (b) South American-Caribbean (21.10 in Cumana). No tsunami occurred with them. The Orient fault was responsible for the earthquake in Cuba. The epicenter of the second earthquake is a seismic active area (NVA knot) in the vicinity of Trinidad, where the faults El Pilar-El Soldado-Los Bajos' system are combined in the subduction zone of the Lesser Antilles.

Keywords: Caribbean, Cuba, earthquake, historical seismicity, Venezuela

Introduction

The study area, Caribbean region, has two large island arches (Antilles: Greatest (E-W) and Lesser (N-S), with 7.020 islands and area ~300.000 km^2) (**Figure 1**). The first one in the northern zone is composed by Cuba [**C**], Jamaica, Hispaniola (Haiti and Dominican Republic) and Puerto Rico. The Lesser Antilles at E link Puerto Rico and Venezuela [**V**]. These islands separate Caribbean Sea of Atlantic Ocean. In the S are V and Colombia in South America. The Lesser Antilles and V have a complex geodynamic interaction with earthquakes and tsunamis. A proven scientific source, Alexander von Humboldt (1769-1859), was used to compare the historical context of the 1766 earthquakes in Cuba (11.06) and Venezuela (21.10). It is our proposal. The naturalist visited (1799-1804) Colombia, C, Ecuador, Mexico, Peru and V and carried out the task with different means and many privations. He is recognized: (a) as Father of Universal Modern Geography; (b) like second discoverer of C; (c) been more useful for America than all conquerors. Also, he assured that: (a) agriculture and not just mining is a source of prosperity; (b) existed a real differentiation of agriculture in terms of variety of products and production type of Mexico and from slavery-monopoly in C and Jamaica; (c) scientific knowledge requires experimentation. This extraordinary scientist: (a) lived and valued the earthquake of Cumana (04.11.1799) and related it with that one of Quito; (b) also survived earthquakes in Colombia, Ecuador, Mexico and Peru; (c) described the earthquakes` characteristics using the types of ground movement, sound, time and duration time; (d) related faults and earthquakes; (e) showed that the natives were excellent geographers; (f) located Juan de la Cosa's world map in 1832.

Humboldt about: (a) Cuba (19.12.1800-15.03.1801/ 1804) assured that: (a.1) "…we find the noblest and most generous hospitality…"; (a.2) it has tradition as a settlement place, strong national identity and being the most European; (a.3) the increase of slaves from 1763 (32.000) to 1791-1823 (260.000) was related with the sugar cane; (a.4) earthquakes are stronger and more frequent in the East Region than in the Center-West one; (a.5) there

is a new large geological formation. It was denominated Güines; (b) V argued that: (b.1) "I came by accident and was shocked (…for a long time our eyes were fixed on this earth where we have not had to complain about men…)"; (b.2) "…the Orinoco River is one of the most majestic…"; (b.3) Bourbon flexibility was advantageous ("…after the time when the neutrals have been admitted from time to time in the colonies ports. Actually, they has been allowed to climb to Caracas more easily…"); (b.4) "…the colonies, in the period of greatest activity, had a gross income of 180.10^6 francs but internal administration absorbed ~145.10^6, while ~40.10^6 flowed to Madrid…"; (b.5) "…the Jesuits had 20-30 thousand head of cattle…today is cultivated some yucca and bananas… horses and cows have disappeared…"

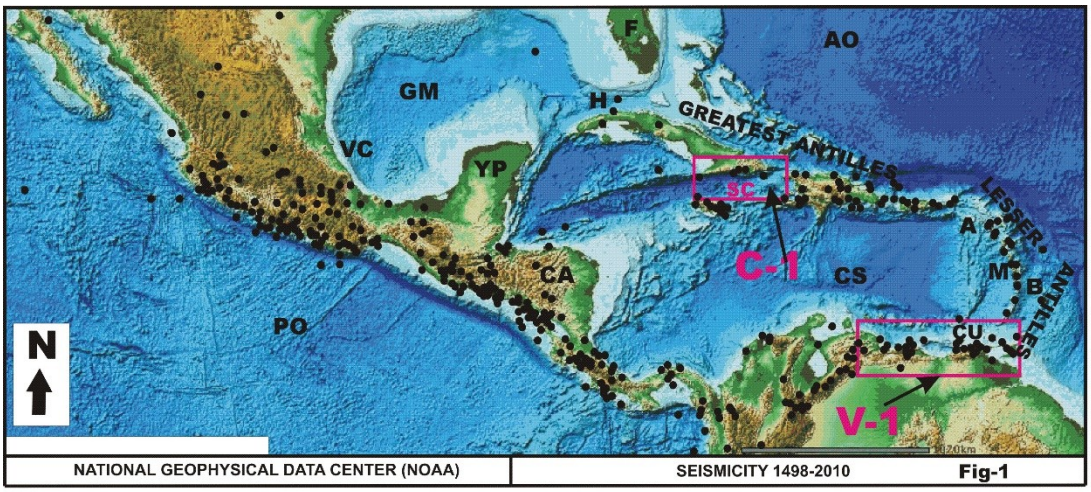

Figure 1. The study areas and their seismicity (NGDC). (a) epicenters (black circles); (b) study areas (red rectangles: C-1=Cuba/ V-1=Venezuela); (c) A=Antigua, B=Barbados, CA=Central America, CS=Caribbean Sea, CU=Cumana, F=Florida, GM=Gulf of Mexico, H=La Habana, M=Martinica, Ocean (AO=Atlantic, PO=Pacific), SC=Santiago de Cuba, VC=Veracruz; YP=Yucatan.

4.1 Historic Framework

The following references were used for this section [3, 4, 6-9, 12-14, 16, 32, 35, 37, 39, 41, 42, 48, 49, 51, 54-56, 60, 62, 67, 68, 76, 77, 79, 80, 91, 95, 97, 98, 99, 100, 107, 109-112, 114, 115, 118, 119, 123, 142, 154-156, 161-164, 167, 173, 177, 178, 186, 188, 193]. From them it can be argued that: (a) the Europeans arrived to America at the end of the XV century; (b) Admiral Columbus came in 1492 followed by Portugal in 1500, France in 1607, England in 1608 and Netherlands in 1625; (c) at the beginning Spain-Portugal (Figure 2A) were situated in the south of North America and Central America, and northern of the Andean zone; (d) Spain had the largest presence and dominance in the Caribbean islands and the Florida Peninsula, and spread Spanish and the Catholic religion (Table 1); (e) the expeditions came out of Santo Domingo and C; (f) they explored, mapped and colonized (Table 2); (g) the West Indies is called New Spain. Some relevant facts are related with the Spanish colonies: (a) Cuba's Bishopric established in Baracoa; (b)

King Felipe II (1527-1598) annexed Portugal (1580-1640) and constituted the Iberian Union. The relation was broken by Felipe IV (1605-1665); (c) C was separated from the Santo Domingo Viceroyalty (1537) and the King appointed its governors; (d) Juan de Pimentel in 1578 made a plane of Caracas; (e) C imposed (1607) two governorates (La Habana and Santiago de Cuba); (f) Athanasius Kircher S.J. [17] published a South America map (1664) and included Venezuela and Lesser Antilles; (g) C significantly increased tobacco exports (1740); (h) The Royal General Inspectorate of the Army and the Treasury was established in Santiago de Cuba; (i) Spain forced to leave Jamaica for England (1670); (j) in 1726, the province of Cumana was created, consisting of the territories of Cumana, Guayana, Barcelona, Maturin and the island of Trinidad; (k) Mejía and Badaraco [122] published a scheme of S. Domingo and its surroundings; (l) England (1762) occupied one year La Habana and increased from 3 to 96 trading ships; (m) economic income in Cuba (1764-1774) increased (316.029 to 532.029 strongest pesos); (n) Cuba was significantly fortified (La Habana (Atares, El Morro, El Principe, La Cabaña, La Fuerza, La Punta), Matanzas (San Sobrino), Cienfuegos (Jagua)); (o) Spain defeated England in Tolon (1744); (p) the movement of fleets (1766-1776) was 8.176 trading ships with a value of ~44 million francs; (q) Thomas Jeffreys (1719-1771) published in 1760 maps and plans of Havana and Cuba; (r) the last fleet was in 1776; (s) Cramer and Mañeras [68] published a map of Cumana; (t) took place the independence of Venezuela (1811) and Cuba (1898); (u) Spain abandoned Florida in favor of USA (1821).

Table 1. Main data of Cuba and Venezuela.

Characteristic	Cuba	Venezuela
Arrival Europeans/ capital city	27.10.1492/ La Habana (San Cristobal de La Habana)	2.08.1498/ Caracas (Santiago de Leon de Caracas)
Language/ religion (%)	Spanish/ catholic (40)	Spanish/ catholic (96)
Area (km^2)/ highest altitude (m)	110.922/ Pico Turquino (1.974)	912.050/ Pico Bolivar (5.007)
Main River (Longitude km)	Cauto (343)	Orinoco (2.140)
Inhabitants	11.338.138	28.870.195
Rate of development Consumer prices	0,777 (high) 84,69	0,726 (high) 87,50

The conquest and colonization of Venezuela (**Figure 2B**): (a) took more than a century and population was irregular over time, but with an increasing tendency. **Tables 3-7** prove it and the estimation data of Humboldt (late 18^{th} century ~900.000 inhabitants) in the General Captaincy of V confirms it; (b) promoted the development of agriculture, livestock, mining (gold and silver) and trade. This was a real monopoly that executed with the Indian fleets (the Spanish treasury) and under the House of Contracting of Cadiz control (1503). The Indies Council (1524) was in charge of the government; (c) the colonies of the mainland, in terms of the economy, were not important to compare with the islands; (d) the provinces of V depended first of Santo Domingo (1717) and after of Santa Fe of Bogota; (e) in 1742 Felipe V (1683-1746) signed independence of that viceroyalty. They did not possess gold or silver, so they focused since 1620 on agriculture (cocoa and tobacco

plantation and trade) and livestock; (f) the economy stood out (1750-1786) when: (f.1) the Guipuzcoana Company was modified; (f.2) Carlos III (1759-1788) created the Caracas Intendancy (8.12.1776) and the General Captaincy of V (8.09.1777). Humboldt annotated that Venezuela at the beginning of 19th century imported ~35.10^6 francs and most of the products were European. Data showed that port-cities (La Habana and Veracruz, Mexico) were control points of the Spain economy (Table 8). Thus, the Caribbean Sea was known as the Mediterranean of America.

Table 2. Selection of period data 1492-1766.

Year	Event	Year	Event
1492	Columbus arrived to Cuba and S. Domingo	1513	J.Ponce set up in La Florida
1493	Columbus arrived to Puerto Rico		V.Nuñez Balboa reached to Pacific Ocean
1494	Columbus arrived to Jamaica	1515	D. Velazquez conquered Cuba
1498	Columbus arrived to Granada and Venezuela		J.Diaz de Solis reached La Plata River
1499	A.de Ojeda reached Cabo de la Vela	1519	H.Cortes conquered Mexico
1500	P.Alvares Cabral arrived to Brasil	1531	F. Pizarro conquered Peru
1502	A.de Ojeda founded Santa Cruz	1534	P.Alvares founded San Francisco de Quito
1512	J.Ponce de Leon landed La Florida	1591	Cumana acquired the status of city

Table 3. Foundation of cities in Cuba and Venezuela.

Cuba		Venezuela	
Year	City (Founder)	Year	City (Founder)
1511	Nuestra Señora de la Asuncion de Baracoa (a)	1500	Puerto de las Perlas (Cumana) (g)
1513	San Salvador de Bayamo (a)	1502	Santa Cruz (La Guajira) (h)
1514	Sancti Spiritus, Santisima Trinidad (a)	1510	Nueva de Toledo
1515	Santiago de Cuba (b)	1528-1544	Nueva Cadiz
1519	San Cristobal de La Habana (c)	1529	Nueva Zamora de la Laguna de Maracaibo, Santa Ana de Coro (**i**)
1528	Sta. Mª de Puerto Principe (d)	1545	Isla Margarita**,** Nuestra Señora de la Pura y Limpia Concepción de El Tocuyo
1539	Baitiquiri	1548	Nuestra Señora de la Concepción de la Borburata
1545	San Juan de los Remedios (e)	1552	Nueva Segovia
1689	Gloriosa Santa Clara	1555	Nueva Valencia del Rey
1735	Sagua de Tanamo (f)	1557	Nuestra Señora de la Paz de Trujillo
1751	San Isidro de Holguin	1558	Santiago de los Caballeros de Mérida

Notes: (a) Diego Velazquez, (b) Hernan Cortes, (c) Panfilo de Narvaez, (d) Diego de Ovando, (e) Vasco Porcallo, (f) Hilario Frometa, (g) Gonzalo de Ocampo, (h) Alfonso de Ojeda, (i) Antonio Ehinger.

Spain under Carlos III had an economic recovery period. In the governments of Esquilache and Grimaldi (1759-1766) there were opposition to the reforms; and provoked the "Esquilache Mutiny" and the Jesuits deportation in 1767. The King (11.09.1766) accepted the indigenous people in the religious communities and for civil positions. At the beginning Felipe V and later on Simón Bolívar (1783-1830) promoted the Colombia, Ecuador, Panama and Venezuela union (~2.403.145 km^2). They had in common culture and economy). It was in the so called century of "The Lights" (*La Razón*) (step of tradition-revolution equilibrium (society was the enlightened and protectionist economy)).

Table 4. First religious (catholic) buildings of Cuba and Venezuela.

CUBA		VENEZUELA	
Year	**Enclosure**	**Year**	**Enclosure**
1512	Nuestra Señora de la Asuncion de Baracoa	1568	La Basilica Menor Santa Capel
1513	San Salvador de Bayamo	1614	Nuestra Señora de Las Mercedes
	San Juan de los Remedios	1621	Dulce Nombre de Jesus
1514	Santa Catalina	1665	Caracas Cathedral
1638	Santa Clara Convent	1696	Santa Rosalia
	Espiritu Santo	1708	La Candelaria
1644	Santiago de Cuba Cathedral	1769	San Jose de Chacao
1702	Belen Convent	1781	Santisima Trinidad
1722	San Basilio Magno	1788	Parroquial San Juan Bautista
1730	San Francisco de Asis Convent		
1748	La Habana Cathedral		
1767	San Carlos Seminar		
1789	Santo Angel Custodio		

Table 5. Population in Cuba and Venezuela.

Cuba				Venezuela			
Year	**Population**	**Year**	**Population**	**Year**	**Population**	**Year**	**Population**
1552	~3.000	1810	600.000	1783	580.000	1873	1.784.194
1608-1616	20.000	1827	704.487	1800	785.000	1920	2.479.525
1655	~40.000	1841	1.007.624	1810	800.000	1941	3.850.771
1757	149.000	1842	1.037.624	1822	766.000	1950	5.094.000
1774	171.620	1852	984.042	1825	785.000		
1792	205.000	1862	1.179.713	1839	887.000		
1804	432.000	1953	5.829.029	1847	1.267.962		

Table 6. Growth index.

Year	Cuba	Venezuela	Year	Cuba	Venezuela
1845	0 *	0 *	1877	59	18
1860	34	20	1895	118	50

* Initial reference

Table 7. First universities.

Year	Denomination/ country	Year	Denomination/ country
1538	Santo Tomas de Aquino/ Dominican Republic	1675	San Carlos/ Guatemala
1551	San Marcos/ Lima, Peru	1677	San Cristóbal de Huamanga/ Perú
1551	Real y Pontificia U. de México/ México	1721	Real y Pontificia U. de San Jerónimo/ Cuba
1580	Pontificia U. Santo Tomaá de Aquino/ Colombia	1721	Real y Pontificia U. de Caracas/ Venezuela
1603	Pontificia U. de San Fulgencio/ Ecuador		

Table 8. Economic data (import-export) of Cuba (1824-1831).

City	Currency (Cuban pesos)
La Habana	Import= 13.374.343/ Export = 9.609.858/ Total amount= 22.984.201
Santiago de Cuba	Import= 1.278.697/ Export= 1.412.358/ Total amount= 2.690.955
Cuba	**Import= 14.653.040/ Export= 11.025.216/ Total amount= 25.675.156**

4.2 Tectonics

The following bibliography was used for the chapter [2, 10, 22, 23, 26, 30, 38, 43, 50, 52, 63-66, 69, 70, 75, 94, 102, 104, 105, 113, 121, 124, 129, 140, 143-147, 157-159, 168-171, 179, 183, 187, 190, 191, 194, 195]. Figures 1 and 6 of Cotilla and Udias [62] show a block model of the Caribbean contemporary dynamic and deformation zones, where C and V are located. Tectonics and seismicity are due to the interaction of different plates (Caribbean, Cocos, Nazca, North and South American) (**Figures 1 and 3**). Caribbean is a microplate that has different speeds, 20-80 mm/year, and the northern margin is characterized by a fault system with left lateral displacement (Motagua fault (in Guatemala), the Septentrional and Plantain Garden-Enriquillo faults (in Jamaica-Hispaniola) and Oriente (southern C)). All they demonstrate seismic activity [**S-A**]. There is an oceanic crust spreading center (Mid Cayman). The microplate is subdued by the North American plate with S-A and volcanism at the E. The subduction is oblique (Puerto Rico, -8.340 m). In the Pacific Ocean area (Mexico-Panama) another convergence of plates is known with a more active subduction process, ~81 mm/year, and a greater angle than the above mentioned. On that edge are located the subduction process (Cocos-Rivera-Nazca under Caribbean). Much of the S-A is associated with that process and produces earthquakes up to 300 km deep and there is also volcanic activity.

Cuba is an emerged microplate of the southern of North American plate and has a differential uplift structure. It is associated with a set of active faults (Oriente, Nortecubana, Cauto-Nipe and Baconao) that make up a system of morpho-structures and seismic active knots. It interacts directly with active faults and where the dominant structure is the Orient trench (-7.646 m). This belongs to a larger underwater structure of pull-apart (longitude ~1.000 km/ wide ~110 km) that initiate at Cayman Islands. That center is active from the Middle Eocene (expansion rate ~15 mm/year). These elements are framed in a plate boundary zone [PBZ] where there are frequent earthquakes. A second significant S-A zone, also in the maritime area, is Cabo Cruz (**Figure 4B**). In that area there is an active intersection (knot) of the Oriente and Cauto-Nipe faults with six strong earthquakes (18.10.1551 (M6,6)/ 7.07.1852(M7,7)/ 26.08.1990 (M5,1)/ 25.05.1992 (M6,9)/ 4.02.2007 (M6,2)/ 28.01.2018 (M7,7)) that affected Cabo Cruz and Bayamo city). The fractal dimension estimates [**FD**] of strong earthquakes occurrence show differences for Cabo Cruz {0,89}, S. de Cuba {0,97}, Puerto Principe {1,28} and the northern Puerto Rico {1,35}. The values of Puerto Principe- Puerto Rico are similar to those obtained by Toro-Salas *et al.* [186] in the SW Colombia {1, 27-1,40}. Also the seismic potentials of the N Caribbean [65] show that the large values are in the E. It is relevant that there are tsunami data in Hispaniola-Puerto Rico but no to southeastern Cuba.

Subduction of the North and South American plates under the Caribbean produces volcanic activity and S-A. In V the movement of the Caribbean plate is right lateral and there are important faults (El Pilar (Serrania del Interior), San Sebastian (Cordillera de la

Costa), Oca-Ancon and Boconó (Los Andes)) with earthquakes (26.03.1812(M8,0)/ 29.10.1900(M7,7)/ 30.07.1967(M6,6)) (**Figure 5B**). They are the ones with the most activity and sliding course displacements oriented to the E-W, 100-150 km, and produces another PBZ (width of ~100 km) in South American-Caribbean. Associated with this system is another of lesser category and activity (faults: Valera/ La Victoria/ Tacagua-El Avila/ Urica). The entire coastal environment (4.000 km/ >200 islands/ 16 cities (with more than 100.000 inhabitants each one)/ ~50 inhabitants/km^2) has a high level of S-A. In western zone (V-Central Colombia) are located the Caribbean and Nazca plates that converge, ~65 mm/year, and produces important S-A (quantity and magnitude) and affect V. The structures segmentation has been verified in Cuba also discussed in Venezuela [22, 23, 86] and Mexico-Panama [64, 66]. It is known that (**a**) the fragmentation favors the deformation and transmission of regional and local efforts and blocks configuration; (**b**) northern PBZ (in Cuba) is less fragmented than the southern one at Venezuela; (**c**) the PBZ sinuosity coefficient value is different around the southeastern Cuba (0,91) and Venezuela (0,72); (**d**) the distances of SE Cuba to the Pacific and Virgin Islands is similar (~2.500 km). Thus, by observing the location of the two study areas (C-1/ V-1) (**Figure 1**) it can be assured that Venezuela receives a greater influence from the converging of Pacific and Atlantic oceanic plates. This is also reflected in the **figure 3**.

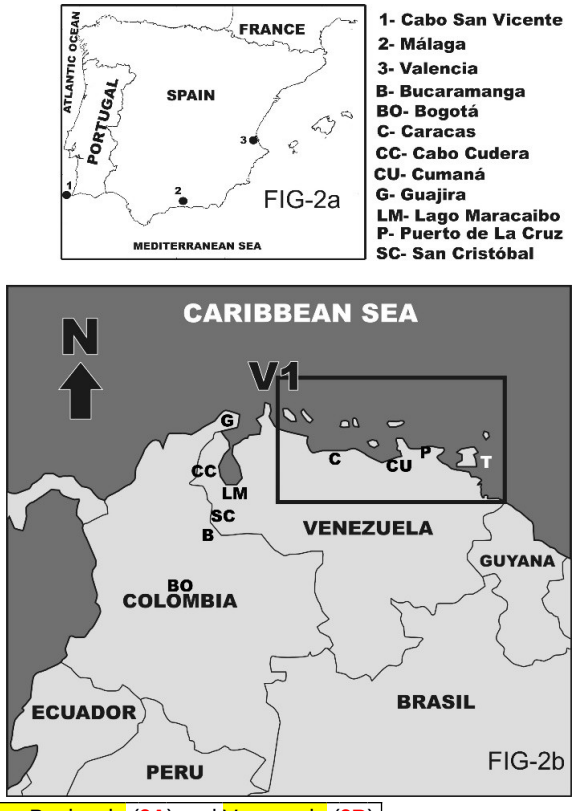

Figure 2. Schemes of the Iberian Peninsula (**2A**) and Venezuela (**2B**).

4.3 Seismicity

The following results have been used in the section [1, 4, 5, 11, 18-22, 24, 25, 27, 31, 32, 34, 45, 46, 53-59, 69, 71-74, 76, 79, 82-89, 96, 101, 106, 108, 112, 116, 117, 120, 125-128, 130-133, 135, 137-139, 141, 142, 144, 148-151, 153-157, 160, 165, 166, 172, 174, 176, 178, 180-182, 185, 189, 192, 197]. With these, it can argued that: (a) in 1766 five strong earthquakes occurred in the world, three of them in America (Table 9); (b) since the arrival of the Spaniards to America in October 1492 they faced tropical cyclones. It is nowadays known that these natural organisms are common on those dates; (c) early tested the strength and frequency of earthquakes and tsunamis. Although they were not new to them (Table 10). In the Spanish Cortes, news (or studies) of American earthquakes were relatively frequent (examples: 1502=Santo Domingo/ 1516=Panama/ 1524=El Salvador/ 1526 and 1541=Guatemala/ 1528=Cuba and Nicaragua); as well as requests to repair the damage and also appeared some compilations and catalogues (Table 11). After that, Spanish governors had information about earthquakes and procedures.

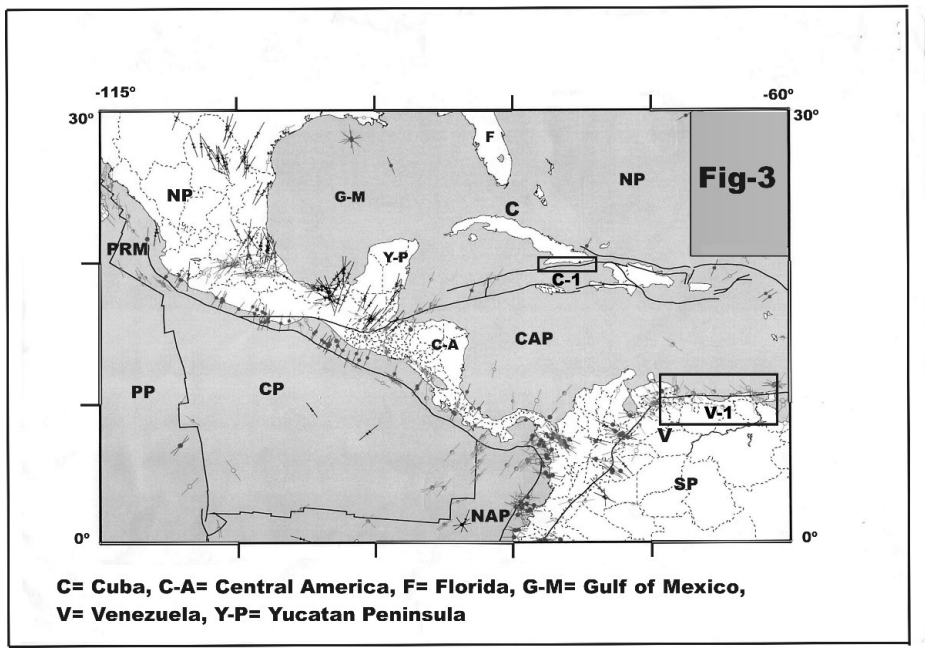

Figure 3. Simplified tectonic scheme with the World Stress Map-2000. (a) plates (CP=Cocos, CAP=Caribbean, NP=North American, NAP=Nazca, PP=Pacific, PRM=Rivera, SP=South American); (b) stress symbols.

Table 9. **Earthquakes of 1766 on the World.**

Nº	Date	Locality	M/I	Characteristics
1	.03.8	Homori, Japan	7,3/ 9	?
2	.05.22	Istanbul, Turquois	7,1/ 9	4.500 deaths
3	.06.11	Santiago de Cuba, Cuba	6,8/ 9	~40 deaths
4	.07.9	Santiago de Cali, Colombia	/ 8	Several aftershocks (until 07.19)
5	.10.21	Cumana, Venezuela	8,0/ 9	No significant damage in Caracas

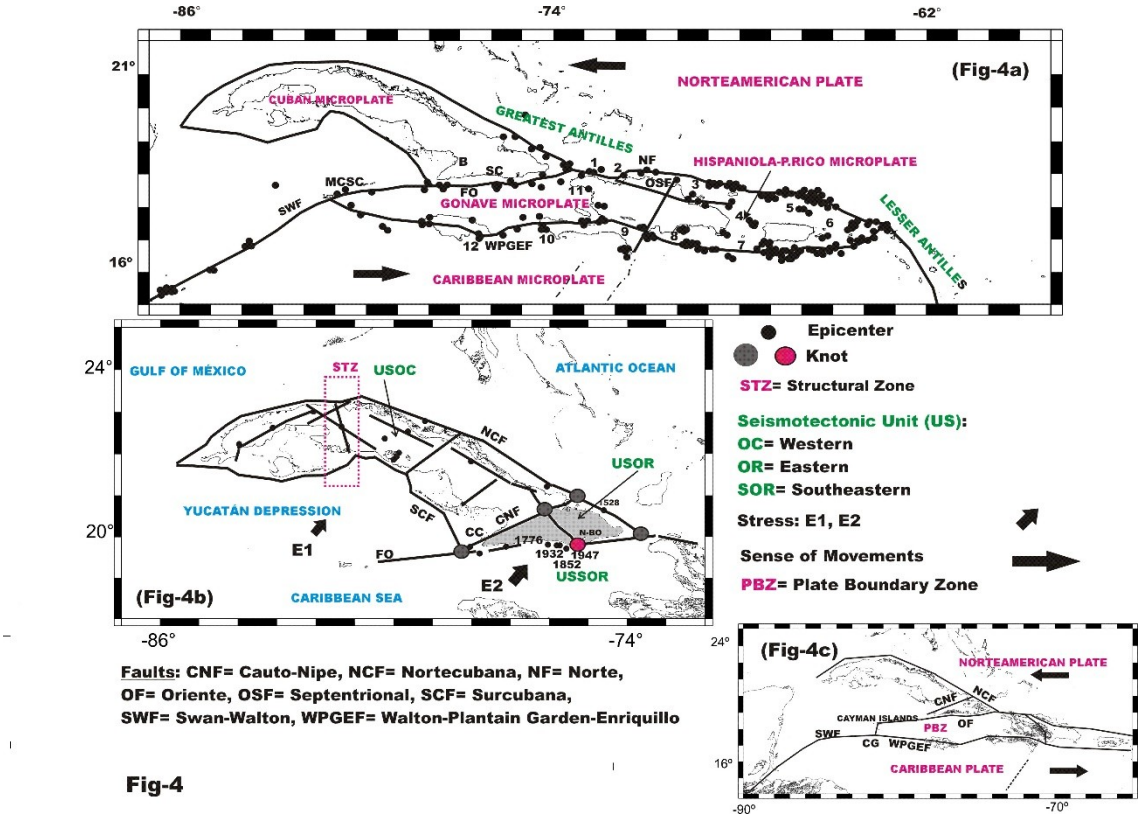

Figure 4. Seismotectonic of the northern Caribbean. Figure 4A. Earthquakes (year (M)) (a) 1842(6,2), (b) 1897(7,5), (c) 1946(7,8), (d) 1943(7,5), (e) 1787(8,0), (f) 1867(7,3), (g) 1918 (7,3), (h) 1673(7,5), (i) 2010(7,0), (j) 1770(7,8), (k) 1887(7,9), (l) 1692(7,5)); Localities: B=Bayamo, CC=Cabo Cruz, SC=Santiago de Cuba. Figure 4B. Four earthquakes around Santiago de Cuba (black circles-year (Table 18)). Figure 4C. Mid Cayman Center (CG).

Table 10. Some strong earthquakes around Spain and Portugal.

Date	Characteristic	Date	Characteristic
1169.02.4	Italia, Sicilia/ 15.000 deaths	1428.02.2	Spain, Girona (M9,0)/ 800 deaths
1693.01.11	Italia y Malta/ 60.000 deaths	1531.09.30	Baza/ 400 deaths
1755.11.1	Portugal/ (M_w8,7)/ ~100.000 deaths	1680.10.9	Malaga/ (M6,8)/ 70 deaths
1761.03.31	Cabo San Vicente/ (M6,7)	1748.03.23	Valencia/ (M6,2)/ 38 deaths

Capel [46] and Ortiz-Gallardo [136] provide information on the earthquakes knowledge in the 18th century. In 1732 earthquake was defined as: "Violent and impetuous movement of the earth. Regularly it gets from exhalations, and thick winds in concavities of it, that cracking with humidity, prevents them from coming out, or sprout; and looking for the exit cause with its impetus the tremor. Which is more often the case in ports, or places near the sea" [152]. We highlight two results of "seismic regionalization" surprising for that time: (a) Benito Viñes-Martorell, SJ distinguished in 1880 the differential S-A of the Western and Eastern Cuba; (b) Montessus de Ballore [132] used its catalogue to publish the first map with the seismic areas of the northern Venezuela indicating the most dangerous sites;

(c) Table 12 has 18 earthquakes' analyses and their historic-social-seismogenetic comparative. They are similar to our work.

Table 11. First earthquakes' catalogues of Cuba and Venezuela.

Year	Author	Text
1855 and 1857 [148-150]	A.Poey y Aguirre	Cuba - Caribbean (3 catalogues)
1940 [45]	M.Centeno	Venezuela catalogue

Table 12. Authors with similar papers.

Author (s)	Year	Author (s)	Year	Author (s)	Year
Humboldt	1819	Christl and Altez	2000	Sarabia-Gomez *et al.*	2010
Brito-Figueroa	1961	Astroza *et al.*	2002	Ros-Magán	2011
Ambraseys	1971, 2001	Altez	2003, 2005, 2014, 2017	Ruiz and Madariaga	2012
Lopez-Marinas	1977	Amodio	2005	Udias *et al.*	2012
Guidoboni and Stucchi	1993	Campos *et al.*	2005	Buforn *et al.*	2017
Christl	1993	Cisternas and Valera	2008	Allier-Montaño	2018

The first two earthquakes, well documented in Cuba and Venezuela (Table 13) occurred after the arrival of the Spaniards (C=36 years/ V=32 years). The strong and perceptible S-A in the surroundings of C (Figs. 4a-b) and V (Figure 5B) is quite known. In table 14 is showed the strongest earthquakes in America before 1766; none of them has affected C or V. Table 15 contains several of the heavy and dangerous earthquakes that have occurred in the southeastern Cuba within the S. de Cuba tectonic segment. All of them are of surface type and without tsunamis. The most important local tsunamis of V are in table 16. A tsunami (1.11.1755) from far away source (Portugal) was slightly perceived in S. de Cuba, Antigua, Barbados and Martinica (Figure 1, Table 16). **Figure 2** of Fukuoka *et al.* [74] shows the 1492-2000 tsunamis in the Caribbean. Table 17 has the strongest events in Venezuela.

Table 13. First earthquakes in Cuba and Venezuela.

Year	Country	Location and description
1528	Cuba	(Figure 4B) Nuestra Señora de la Asunción de Baracoa was the locality where the arrival of Columbus is supposed. The epicenter was in the surrounding marine zone, associated with the Nortecubana fault. People went out in procession with the Virgin
1530	Venezuela	(Figure 5A) The coastal town of Cumana (Nueva Toledo) of eastern V was destroyed by an earthquake (10:30/ M_b7,3). It affected Cariaco Gulf and the land opened and sprouted salt water mixed with asphalt. The sea suddenly withdrew leaving the beach dry and when returning it exceeded the limits in height ~500 m

Audemard [22] presented several arguments about the strong seismicity of the northern Venezuela. He maintained that: (a) the events of 1530 and 1853 had tsunamis and were spatially related to those of 1797 and 1929. They took place to the E of Cumana in Punta Baja-El Peñon; (b) six earthquakes (1530, 1629, 1684, 1766, 1787 and 1853) destroyed Cumana, where soil conditions are quite different; (c) the 1684 and 1997 earthquakes are

related to Cariaco town (between Cariaco and Paria Gulfs); (d) there are two main zones of S-A in the subduction zone of the Greater Antilles and the El Pilar fault; (e) the earthquake of 1766 is similar to that of 29.07.1967 (Tables 16-17); (f) the 1766 event happened to 60-200 km depth and more to the E of the El Pilar fault; (g) no tsunamis in 1766 occurred. From Perez and Mendoza [144] figures we can see that: (a) figures 1 and 3 have two major epicenter concentrations with: (a.1) an intersection of active faults occurs where h~160 km (Bucaramanga, Colombia vicinity); (a.2) in the NW edge (close to Trinidad) h>40 km where are active faults (El Pilar, Los Bajos and El Soldado); (b) figure 2 indicates the 18.05.1875 earthquake epicenter in Cucuta (near Bucaramanga); (c) figure 4 includes 21 focal mechanisms (1983-1995) of the right-hand type movement; (d) figure 5 has four mechanisms of compressive type with right lateral displacement. Four earthquakes (1967-2018) recorded by the USGS were located in the Caribbean-South American PBZ (Figure 1) and three of them around Sucre, where the NVA knot. Several authors [15, 28, 29, 33, 58, 61, 65, 81, 90, 92, 93, 134, 198] have related earthquakes to faults intersection (or knot); while Audermard [18, 24], Jouanne *et al.* [103] and VanDecar *et al.* [191] indicated the significant S-A of the center-north and NE of Venezuela. Bonive *et al.* [34] used the seismic data (1995-2001) of the Venezuelan Northeastern Seismological Network and determined different fault systems (Pedernales thrust- El Soldado-Los Bajos) where there are changes from shallow to deep, and assured a transition tectonic regimen. From this area there is information which confirms the known data [78, 116, 127, 184].

Altez [8] used in his table 1 four strong earthquakes of Caracas (Table 17) and indicated that: (a) the fatalities were 2.221; (b) their percentage values of deaths from earthquakes in relation to the population varies from 0,035 % to 10 %.

Table 14. Some strong earthquakes (before 1766) in America.

Date	Location/ description	Date	Location/ description
1575.12.16	Chile, Valdivia/ (M_w8,5)/1.200 deaths	1700.01.26	California-British Columbia/ (M_L8,7)
1730.07.8	Valparaiso/ (M_w8,7)/ 300 deaths	1701.11.9	Haiti/ (M6,1)/ 7/ several deaths
1615.09.7	Puerto Rico/ (M_w8,7)/ 300 deaths	1751.09.16	Haiti/ (M6,8)/ 9/
1687.10.20	Peru/ (M_w8,5)/ 5.000 deaths	1751.10.18	Haiti/ (M7,8)/ 9/ ~200 deaths
1746.10.28	Peru/ (M_w9,0)/ ~10.000 deaths	1751.11.21	Haiti/ (M6,5)/ 8/
1692.06.7	Jamaica/ -3.000 deaths	1770.06.3	Haiti/ (M7,5)/ 10/ ~300 deaths

Table 15. Strong earthquakes of Southeastern Cuba.

Date	Brief description	Date	Brief description	Date	Brief description
1578.08.	I=8/ (M6,75)	1766.06.11	I=9/ (M6,8)/ 40 deaths	1842.07.7	I=8/ (M6,8)
1678.02.11	I=8/ (M6,75)	1800.10.14	I=8/ (M6,4)/ 5 deaths	1852.08.20	I=8/ (M6,4)/ 2 deaths
1760.07.11	I=8/ (M6,75)	1826.09.18	I=8/ (M6,4)/ 1 death	1932.02.3	I=8/ (M6,75)/ 25 deaths

Note: I (MSK-1978 scale)

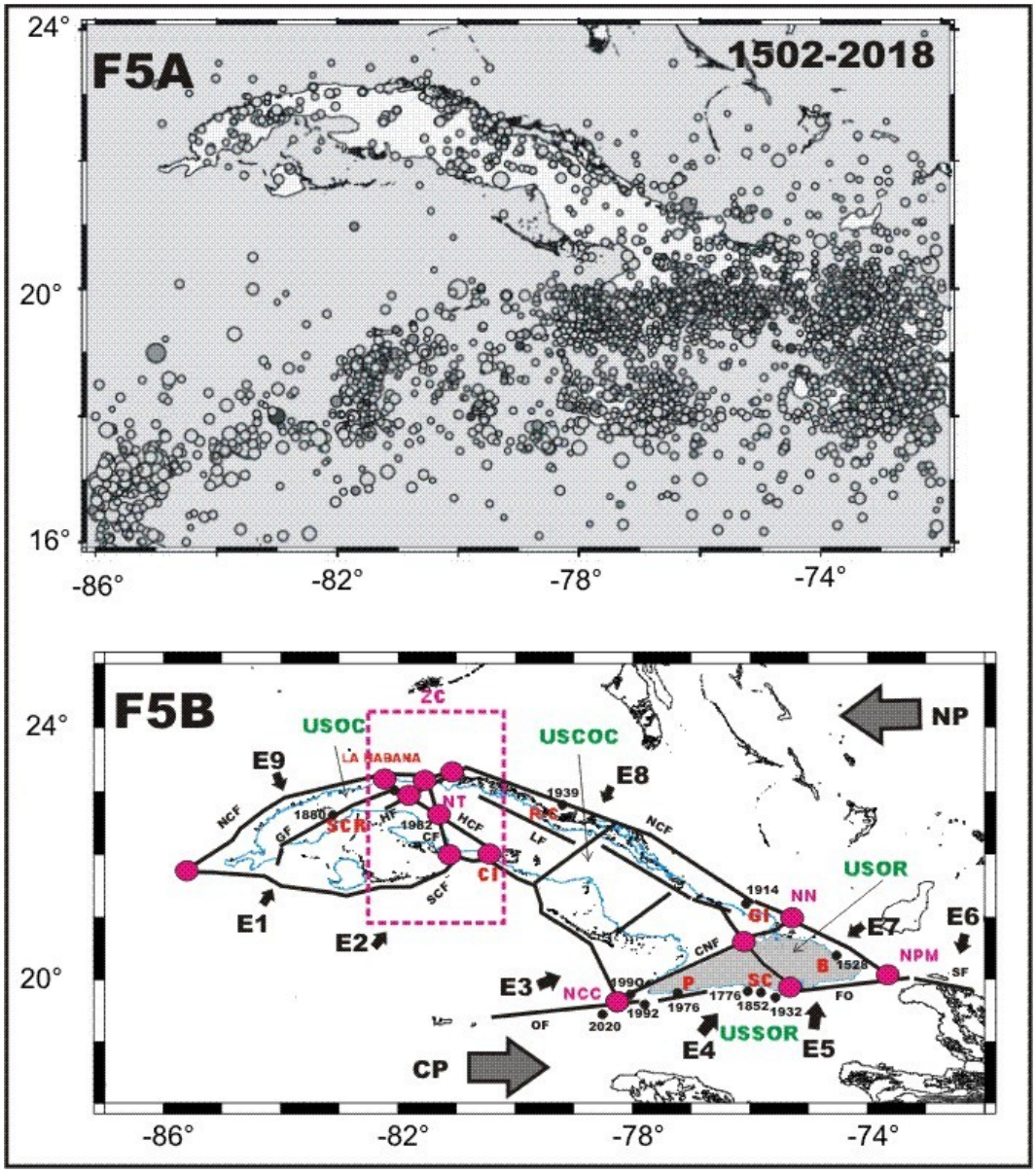

Figure 5. Seismotectonics of Cuba. A) Seismicity map of CENAIS [14]; B) Seismotectonic province of Cuba. Appear: 1) Seismotectonic Units (green leteers: USOC=Western, USCOC=Centre-Western, USOR=Eastern, USSOR=Southeastern); 2) Fault (black lines: CF, CNF, GF=Guane. HF=Hicacos, HCF=Habana-Cienfuegos, LF=Las Villas, NCF, OF, SF=Septentrional, SCF); 3) Epicenters (black circle with year (see Table 3)); 4) Stress axis $\sigma_{hmáx}$ (heavy black arrow with letter and number (E1-5)); 5) localities (orange letters); 6) Knots (red circles and letters (NCC=Cabo Cruz, NN=Nipe, NPM=Punta de Maisí, NT=Torriente-Jagüey Grande)); 7) Plates; 8) Sense of movement of the plates (heavy grain arrows); 9) ZC=Zone of structural change (discontinue red rectangle).

Table 16. Tsunamis.

Date	Event	Date	Event	Date	Event	Date	Event
1530.09.1	Cumana	1906.01.31	Cumana	1541.12.25	Nueva Cadiz	1867.11.18	Margarita
1853.07.15	Cumana	1929.01.17	Cumana	1802.05.5	Orinoco River	1997.07.9	Margarita
						1900.10.29	Macuto

Table 17. **Significant earthquakes for Venezuela.**

Date	(M) I/ Location	Date	(M) I/ Location	Date	(M) I/ Location
1641.06.11	7/ Caracas	1766.10.21	(8,0)/ Cumana	1874.08.17	(7,1) 8/ El Pilar
1812.03.26	(7,7) 9/	1797.12.14	(6,5-6,6) 9/	1986.06.11	7/
1900.10.29	(7,7) 7/	1853.07.16	(6,2-6,3) 9/	1875.05.18	(6,9-7,1)/Cucuta, Colombia
1967.07.29	(6,5-6,7) 6/	1927.01.17	9/	1878.12.4	(6,4-6,5)/ Cua
1823.08.	(6,0-6,3)/Cariaco	1610.02.3	(7,3)/ Merida	1888.11.17	(6,0-6,3)/ Guanare
1997.07.9	(7,0)/	1812.03.26	(6,5-6,7)/	1900.10.29	(7,6-7,8)/ Cabo Codera
1530.09.1	(7,3)/ Cumana	1834.12.8	(6,2-6,3)/	1932.03.14	(6,75)/ Southern Andes
1684.05.4	8/	1894.04.28	(7,1-7,3)/	1541.12.25	8/ Nueva Cadiz
				2018.08.21	(7,3)8/ 24 km ENE Caribe River

4.3.1 *Data from the 1766 Earthquake in Cuba*

The design of Santiago de Cuba city until end of the 18th century corresponds to the urban planning of the Conquest period. It was distinguished by the similarity to the military camps in Spain. The design was made of ruler-twine with a grid figure. The predominant constructions were of straw and boards of cedar, and fenced by *cañabrava* (*bambusa vulgaris Schrad arundo donax*). The majority furniture was very rudimentary with sebum candle lighting. Quarry buildings were very rare and only associated to religious and military entities. The vast majority of roads were dirt, embankments and few paved with rounded river pebbles, wooden pavements. Santiago's urban design responded to its complex topography until 1947. In this sense the streets were narrow and most houses had one or two levels. Outside of downtown had few buildings.

On 11.06.1766 (00:00 h) there was an earthquake in Santiago de Cuba (Ms6,8 - from Cotilla and Udías [63]; M_s7,5 from Álvarez *et al*. [11] (**Figure 4**). It was perceptible in La Habana (~800 km), Bayamo (~100 km), Haiti and Jamaica. There were 34-40 deaths and 700 injured; and more than 60 perceptible aftershocks, but no tsunami. The epicenter, estimated at (19,9 N 76,1 W) is on the Oriente fault, depth (25 km from Cotilla and Udías [62] and 30 km from Álvarez *et al*. [11] and maximum seismic intensity (MSK) 9 degree was reported.

Their main buildings: (**a**) destroyed: Morro Castle and Socapa Fortress (both at the bay entrance), San Francisco Castle, Hospital, Governor House, and a large number of warehouses, the port dock and small houses; (**b**) affected: the Cathedral. In the new collected information Cotilla [53]: (**b.1**) it is ensured that the dock of eastern platform collapsed; (**b.2**) the flames consumed the carriages, wagons, warehouses and goods, and caused the beasts stampede; (**b.3**) on the port shore was mud and sand that flooded all; (**b.4**) the Indies Council sent 2.10^6 Cuban pesos; (**b.5**) decreased the sugar production; (**b.6**) destruction of the Ermita Virgen del Cobre; (**b.7**) very affected postal mail on horseback S. de Cuba-La Habana; (**b.8**) miscellaneous impacts on Copper Mines; (**b.9**) there was widespread hysteria and panic in the population; (**c**) Bayamo city was severely affected, without dead. The destroyed and affected buildings were: churches (Santo Domingo, Parroquial), Padre Serafico San Francisco Convent, Parishes (San Juan, Santo Cristo del

Buen Viaje, Nuestra Señora de la Luz, Nuestra Señora de Regla and Santa Ana), San Roque Hospital, houses of stones (263), adobe (487), woods (71); (d) Jamaica (Montego Bay, Port Antonio) and Haiti (Puerto Principe) reported this earthquake; (e) the King Carlos III gave 10.000 gold pieces; (f) the foreign press [78] wrote about it.

It is now possible to indicate that: (a) At southern of S. de Cuba (1528-1932) other strong earthquakes occurred (Figure 4, Table 14); (b) in Table 18A there is a comparison of three well studied earthquakes; (c) data made possible to estimate two periods for strong earthquakes in Santiago de Cuba: (c.1) 96 years (16^{th}-18^{th} centuries); (c.2) 93 years (16^{th}-20^{th} centuries); (d) the design of Santiago de Cuba city and the time of occurrence of the 1766 earthquake explains the low number of deaths in relation to the total inhabitants.

Table 18A. Comparison of three strong earthquakes in Santiago de Cuba (Cotilla [56]).

	Date		
Characteristic	**1766.06.11**	**1852.08.20**	**1932.02.3**
Foreshocks/ aftershocks (days)	Few/ 50 (66)	4/ 60 (1.095)	4/ 122 (365)
Duration of the main event (s)	Few	4	4
Time of origin (hh:mm)/ tsunami	00:00/ No	14:05/ No	12:35/ No
Intensity (MSK)/ magnitude	9/ 6,8	8/ 6,4	8/ 6,75
Area of perceptibility (10^3 km^2)/ isoseismics	1/ Yes	0,8/ Yes	0,9/ Yes
Coordinates (N W)/ depth (km)	19,9 76,1/ 30	19,75 75,32/ 30	19,75 75,58/ 35
Population/ Deaths/ Injured	5.149/ 40/ 700	41.230/ 2/ 200	500.000/ 25/ 350
Loos (millions of pesos/ economic aids)	10/ Yes (Spain)	20/ Yes (Spain)	20/ Yes (some)
Destruction of Morro Castle	Yes	No	No
Destruction of religious buildings	Yes	Yes	Yes
Civil buildings affected (%)	75	85	80
Perceived at La Habana/ Jamaica/ Haiti	Yes/ Yes/ Yes	No/ Yes/ Yes	No/ Yes/ Yes
Sense of seismic wave perceptibility	E-W	SE-NW	E-W
Coverage of the international press/ source	Yes/ GAI	Yes/ GAI	Yes/Committee C-USA
Political system	Colony	Colony	Republic
Period between two earthquakes (years)		1852-1766 (86)	1932-1852 (80)

There were published some intensity data from this earthquake [47, 53]. The last one is very complete (Table 18B). It has a discussion of the sources of original data available and the evaluation of felt intensities in different settlements. When original intensities has the kind "I - I + 1", there were substituted by "I + 0.5".

There are different methods of tracing isolines over a felt intensity map from a simple eye`s trace to statistical interpolation. Now, we present an isoseismal map (Figure 6) made by using the set of intensity values of table 18B. It was used the Delaunay triangulation method [175] included in GMT`s software package [196]. This method considers that a set of points on a plane is processed under the rule that no point appear inside of the circumcircle of any formed triangle.

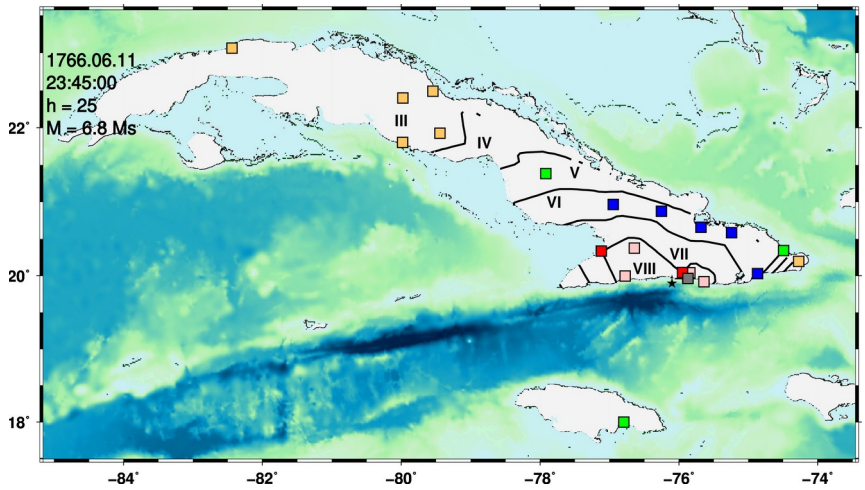

Figure 6. New isoseismal map of 1766 in Santiago de Cuba: Rectangles in color and isolines of felt intensity points (MSK scale) and epicenter (black star).

4.3.2 *Data from the 1766 Earthquake in Venezuela*

After 127 days of the Cuban earthquake occurred another strongest one in Venezuela. In the literature appears: "…On 21.10.1766 the city of Cumana was completely destroyed…" (figures 1-3 of Grases [86]) "…within a few minutes all the houses were sunk and the shaking repeated for 14 months in hours…" It is known that since 1638 the Saint Patron of Cocoa in Venezuela, is "Our Lady of Mercy`s". The image was taken out in procession to implore the sick with smallpox plague, which two years before affected them, and which in 1766 reappeared. At the end of the procession stood the Virgin in the Cathedral. Then the day mentioned (4:30 a.m.) all the South America coast shook. People heard a thunder and saw a lightning bolt. In Cumana there were flames on the bank of the Manzanares River and serious damages in churches and forts. An islet near the Peña Aranacoto of Orinoco River disappeared. Houses sank and temples were heavily damaged. People spent months on the streets. It was felt at different localities as Barcelona, Caniagua, Caracas, Cariaco, Cayanea, Ciudad Bolivar, El Cumanaco, El Pilar, Guarenas, Isles (Barbados, Guadalupe, Margarita, Martinica and Trinidad), La Guaira, Pao, Puerto Cabello, Macuro, Maracaibo, Maturín, N Colombia, Petare, Surinam, Taguay and Yaguaparo. Panic took hold of Caracas but no one was killed or wounded. Some large buildings suffered from the tremors and the houses were practically intact. Therefore, the devotees assured that "Mercy`s" was the "Protective Virgin of Venezuela".

The bishop indicated to make a painting with the title of "Our Lady of Venezuela" in homage to Mary and according with Carlos III decree. The King named her as the patroness of all his kingdoms. A plaque with the inscription was placed at the foot of the *Servatrici Nostrae* image (Our Savior). Humboldt commented: "…that the earthquake was once, the most fatal for the settlers and the most remarkable for the physical history of the

country…" With the data Grases: (a) Assured it was the beginning of historic seismicity in V (240 years); (b) said it's probably the strongest (Ms~8,0); (c) drew the isoseismics (63 localities) with ~3,6.10^6 km^2 perceptibility area; (d) estimated the speed of Caribbean and South American plates (14 mm/year); (e) indicated that from the N of Cucuta to La Güira was affected; (f) determined the dimension of the active fault zone (longitude=1.200 km/ wide=80-100 km/ depth=4 km); (g) included a set of strong earthquakes in the interaction area (Table 17). Also, Perez *et al*. [147] indicated in its figure 9 this earthquake associated with El Pilar fault. In this area there is ~2,0.10^6 people.

Table 18B. Felt intensities of 1766.06.11 earthquake in Cuba (modified from Cotilla [2003]).

Longitude	Latitude	Intensity MSK-78	Settlement	Longitude	Latitude	Intensity MSK-78	Settlement
-75,8750	19,9730	9	La Socapa	-75,2410	20,5850	6	Sagua de Tánamo
-75,8700	19,9660	9	El Morro	-76,2520	20,8780	6	Holguín
-75,8410	20,0430	8	S. de Cuba	-74,550	20,3440	5,5	Baracoa
-76,7750	19,9980	8	Mar Verde	-77,9190	21,3860	5	Camagüey
-76,6430	20,3780	8	Bayamo	-76,7940	17,9970	5	Kingston
-75,6410	19,9210	8	Playa Daiquirí	-79,9830	21,8050	3	Trinidad
-75,9480	20,0450	7,5	El Cobre	-79,4450	21,9270	3	Sancti Spíritus
-77,1170	20,3380	7,5	Manzanillo	-79,5450	22,4910	3	Remedios
-74,8670	20,0310	6	Baitiquirí	-74,2760	20,1980	3	Vertientes
-76,9480	20,9680	6	Las Tunas	-79,9760	22,4000	3	Santa Clara
-75,6810	20,6590	6	Mayarí	-82,4400	23,0680	3	La Habana

Although there are a lot of studies or reports about this earthquake, some of them with isoseismal maps, intensity data are present only in two of them: in the on-line catalogue of felt earthquakes in South America [44] and by Mocquet [127]. In the first case, the author of the report for Venezuela was Grases [83]. Nevertheless, they can be associated to J. Grases, the person that made the more detailed studies of historic earthquakes in Venezuela. In CERESIS [44] catalogue there are present 46 points with intensity evaluation. Mocquet [127] reevaluate the intensity for several of them and add 16 new points with intensities evaluated by him. For drawing an isoseismic map we took the CERESIS data and complemented them with additional Mocquet data. As these last data have in some cases not an unique value but an interval, we transformed them to unique values using the criteria: "I - I+1" is substituted by "I + 0,5", "< I" is substituted by "I - 1", "> I" is substituted by "I + 1" and "I - I +2" is substituted by "I + 1". In table 19 there are presented the intensity values resulting for the combination of data from both sources. The isoseismal map prepared with these data is presented in figure 7. As in the case of Cuban earthquake the map was drown using the Delaunay triangulation method [175] included in GMT`s software package [196]. Figure 7 shows an intersection of two linear structures (NNE and W-E).

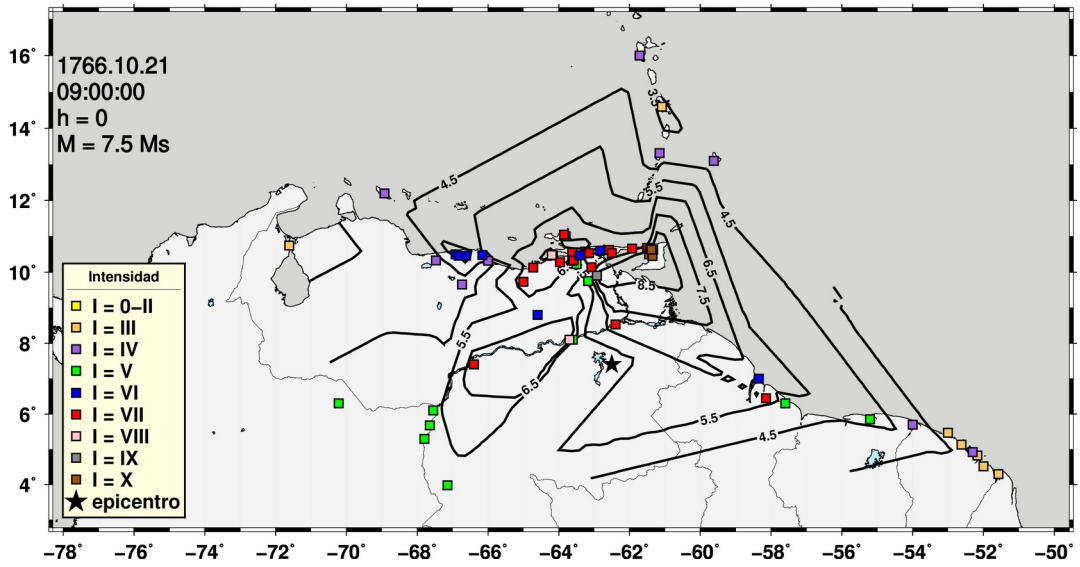

Figure 7. New isoseismal map of 21.10.1766 earthquake. It was prepared by combining data from CERESIS [44] and Mocquet [127].

There were published different interpretations about the source of this earthquake, between them: (a) Grases [84] considers a Ms7,9, intermediate depth at epicentral coordinates (10,7 N -62,5 W); (b) CERESIS considers a Ms7,5 at 0 km depth and epicentral coordinates (7,4 N -62.5 W); (c) Mocquet [127] considers a magnitude range Ms6,5-7,5, at depth 85±20 km and epicentral coordinates (11,0 N -62,5 W); (d) Audemard [22] considers that is incorrect to associate this earthquake to El Pilar fault due to the fact that it was not observed liquefaction in Cumaná, and no tsunamis was detected. He agrees with coordinates of Grases and estimates a magnitude close to 7,5.

We don't agree with the hypothesis of an intermediate earthquake. Instead of that, we consider that high isolated intensities in Trinidad, together with long elongated isoseismal of intensity VII toward the west, are characteristic of a low depth strike-slip earthquake with an epicenter more to the east, close to Trinidad, and magnitude M≥ 7,5 (which explain the big felt area). By the other hand, we agree with Grases [84] and Mocquet [127] that high intensities along Orinoco River should respond to soil conditions. The argument that no tsunami implies an intermediate depth earthquake can't be sustained, because strike-slip earthquakes in general do not generate tsunamis.

It was prepared table 19 using on-line intensity data from CERESIS and Mocquet [127]. CERESIS data [**CE**] are in MMI and Mocquet data [**MO**] are in EMS. As the differences between these scales are not very appreciable, there are processed together as a single intensity scale. In the original CE data was a place named as "Surinam" without coordinates. As in Surinam at this time only Paramaribo has importance, this intensity was assigned to it.

Table 19. Intensity data from CERESIS [44] and Mocquet [22].

Source= CE							
Longitude	**Latitude**	**Intensity**	**Settlement**	**Longitude**	**Latitude**	**Intensity**	**Settlement**
-64,2000	10,4800	8	Altos Marina de Cumaná	-62.8300	10.6000	6	Yaguaraparo
-64,1700	10,4700	8	Cumaná	-63,5000	10,2200	5	Caripe
-63,6200	10,5500	7	Cariaco	-67,6400	5,6800	5	Atures
-63,9700	10,2800	7	Cumanacoa	-63,6000	8,1000	5	Ciudad Bolívar
-63,2500	10,5700	7	El Rincón	-67,5500	6,1000	5	Macuco
-66,4000	7,4000	7	La Encaramada	-67,8000	5,3000	5	Raudal Maipures
-63,6200	10,3200	7	Cocuisas	-63,8000	11,0000	5	Margarita
-61,9300	10,6600	7	Macuro	-63.1700	9.7500	5	Maturín
-65,0000	9,7300	7	San Lorenzo	-57.6000	6.3000	5	Berbice
-63,2000	10,5300	7	San Pablo De Coicu	-55.2040	5.8520	5	Paramaribo
-63,5800	10,3300	7	Santa Clara de Payacu	-66,0000	10,3200	4	Caucagua
-63,8500	11,0500	7	Pampatar	-67,4700	10,3300	4	Maracay
-62,5800	10,6200	7	Irapa	-61.7200	16.0000	4	Guadalupe
-63.0800	10.1400	7	Teresén	-59.6200	13.1000	4	Barbados
-62.5000	10.5400	7	Soro	-52.3000	4.9200	4	Cayena
-63.1400	10.5400	7	N.S. de El Pilar	-54.0000	5.7000	4	Marony
-62.4000	8.5300	7	Antigua Guayana	-71,6200	10,7400	3	Maracaibo
-64.7200	10.1300	7	Barcelona	-52.1700	4.8300	3	Oyac
-61.5100	10.6800	7	Port of Spain	-52.6200	5.1300	3	Couron
-66,9200	10,5000	6	Caracas	-52.0000	4.5200	3	Kaw
-64,6000	8,8000	6	El Pao	-61.0800	14.6000	3	Martinica
-66,6200	10,4600	6	Guarenas	-51.5800	4.3000	3	Oyapoc
-63.4100	10.4700	6	Tierra Hueca	-53.0000	5.4700	3	Sinnamary
Source= MO							
-61,4500	10,5000	9,5	Guairía	-58,3500	7,0000	6	Essequebo
-61,3500	10,4500	9,5	N.S. de Monserrate	-66,1600	10,4800	5,5	Higuerote
-61,3300	10,6300	9,5	San Agustín Arauca	-66,8300	10,4600	5,5	Petare
-61,4200	10,6500	9,5	San Joseph Oruña	-70,2200	6,3000	5	Río Casanare
-61,3800	10,6300	9,5	San Pablo Tacarigua	-67,1500	3,9800	5	Río Ventuari
-62,9200	9,9000	9	Río Guarapiche	-68,9300	1,2000	4	Curacoa
-63,7000	8,1000	7,5	Buena Vista	-61,1500	13,3200	4	Saint Vincent
-58,1500	6,4500	6,5	Temerari River	-66,7300	9,6500	4	Taguay

Some macro-seismic estimates were made, based on statistical suggestions by Prof. Dr. G. Grünthal, some applied in Cotilla *et al*. [67]. They indicate that: (**a**) the latitude / longitude range (higher - lower) of the intensity values (III-VIII) gives a perceptibility grid of 4,5º-16º N / 50º-72º W; (**b**) the weights of each intensity are: III=0,152; IV=0,130; V=0,196; VI=0,109; VII=0,370; VIII=0,043; (**c**) the reliability of the perceptibility area is quite sure (~90 %) in the range VII-VIII; (**d**) the asymmetry of the axes of the zones varies significantly: III-VIII=0,35; VII-VIII=0,58; $I_{average}$=0,70; (**e**) the deformation rate of the isolines is also different: III=0,17; VII-VIII=0,55; $I_{average}$=0,38; (**f**) there are two main axes of propagation: N-S and E-W. The second one is the main axis. So the source can be an intersection of structures.

Conclusions

The authors consider that the retrospective study of strong earthquakes is very important for a reliable modeling of the seismic danger. In this sense, the comparative analysis obtained for the case of the 1766 seismic events in two different areas of the Caribbean, Cuba and Venezuela, confirms it.

Our main results are the following:

(1) The 1766.06.11 Santiago de Cuba earthquake was the greatest tragedy to date (75 deaths/ 700 injured/ 75 % buildings affected) in Cuba (Mw7,2/ I= IX/ h= 30 km/ 19,9 N -76,1 W/ perceptible up to La Habana city [~800 km]). The epicenter is associated to the Oriente fault zone

(2) The 1766.10.21 Venezuelan earthquake is characterized by Mw7,5/ I= X/ h= 30 km/ 10,7 N -62,5 W/ ~3,6.106 km^2 perceptibility area/ the seismic source can be an intersection of two active structures (NVA knot)

(3) The NVA knot is defined for the first time

(4) New isoseismal maps were drawn up for these earthquakes

(5) The isosists made, from the original data, for Cuba and Venezuela are very different as expected

(6) These earthquakes produced panic but did not local tsunami

(7) The 1766 Cuban earthquake occurred in the area of greatest seismic activity

(8) There are different recurrence periods of strong earthquakes (Cuba [1766-1852= 86 years]/ Venezuela [1766-1797= 31 years])

(9) The strongest earthquakes in Venezuela are associated with Caracas

(10) Spaniard Crown aided to Cuba but no Venezuela.

We confirm that Venezuela related to Cuba have: (**a**) larger population; (**b**) greatest magnitude of earthquakes; (**c**) much greater number of strong earthquakes; (**d**) larger number of fatalities and affected by earthquakes; (**e**) more quantity of local tsunami reports; (**f**) the largest linear extension of seismic activity in the Caribbean plate contact; (**g**) greater seismic hazard; (**h**) much less economic development in 1766; (**i**) taken its first catalog of

earthquakes in 1940 and Cuba in 1855; (j) had the first earthquake report in approximately the same year.

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