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Map and Database of Quaternary Faults in Venezuela and its Offshore Regions

By

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A project of the International Lithosphere Program Task Group II-2, Major Active Faults of the World

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INTRODUCTION

As part of the International Lithosphere Program's "World Map of Major Active Faults," the U.S. Geological Survey (USGS) is assisting in the compilation of a series of digital maps of Quaternary faults and folds in Western Hemisphere countries. The maps show the locations, ages, and activity rates of major earthquake-related features such as faults and fault-related folds. They are accompanied by databases that describe these features and document current information on their activity in the Quaternary. The project is a key part of the Global Seismic Hazards Assessment Program (ILP Project II-0) for the International Decade for Natural Hazard Disaster Reduction.

The project is sponsored by the International Lithosphere Program and funded by the USGS's National Earthquake Hazards Reduction Program. The primary elements of the project are general supervision and interpretation of geologic/tectonic information (Michael N. Machette, Project Chief), data compilation and entry for fault catalog (all personnel), database design and management (Kathleen M. Haller), and digitization and manipulation of data (Richard L. Dart) in [†]ARCINFO. For the compilation of data, we engaged experts in Quaternary faulting, neotectonics, paleoseismology, and seismology. These experts are the primary authors of this report, and questions about individual fault descriptions should be directed to them. Questions about the project, its status, and the GIS map should be directed to the USGS authors.

Prior to initiating this project, no modern or digital map of active or Quaternary faults existed for Venezuela or any other country within South America, even though understanding the extent and character of active and older Quaternary faults are critical elements of seismic hazards analysis. Creation of this map and the accompanying database will help extend the relatively short record of instrumental and felt seismicity in Venezuela by creating a paleoseismic record of surface deformation associated with large (M>6.5) earthquakes.

Although basic fault data are available for most of the country, the degree of completeness varies greatly and often is a function of the degree of remoteness and vegetation cover. A few faults have been the subject of recent investigations involving modern paleoseismic techniques (see for example, Audemard and others, 1999a; Audemard and others, 1999b). Other regions and faults have been studied in some detail, usually in association with concerns about hazards to urban areas or the safety of critical facilities such as lifelines, oil-and-gas pipelines, or power-generating facilities.

Owing to limitations of time and resources, the senior author was not able to discuss all of the known major faults in Venezuela. For example, the Caparo, Uribante, San Simon, Seboruco and Quenicuea faults are mentioned under the Boconó fault system (VE-06) but not described separately. This is a comprise that we have made in order to insure that we obtained reasonable (but not perfect) coverage for Venezuela within the time frame of the project (which ends in 1999).

Nevertheless, the general state of knowledge for faulting in Venezuela is probably best described as being of a better than reconnaissance nature. A substantial amount is known in a collective sense about the overall rates of fault activity and fault chronology: information that is difficult to acquire but critical to seismic hazard assessments. Hopefully, additional paleoseismic studies will help augment this map and database. However in retrospect, there is probably more known about the paleoseismology of faults in Venezuela than the remainder of South America. Hopefully, future revisions of the database for Venezuela can describe the lesser (but still important) faults.

[†] Any use of trade names (such as this and others in the report) does not imply endorsement by the U.S. Geological Survey or Department of Interior.

STRATEGY AND PURPOSE

For the map of Venezuela, we relied on known, productive experts with strong local or regional knowledge of Venezuela who were willing to participate in this international project. Given the limited time to produce the map, the project was restricted to compilation of just those elements needed for ILP's Global Seismic Hazards Assessment Program (see database). We anticipate that the project will point out the shortcomings of past and current research on Quaternary faulting in Venezuela in terms of quantity, quality, scope, and regional coverage and should help promote new efforts to collect paleoseismological data in previously neglected or known critical areas.

In many cases, seismicity has been used to define some potentially active faults, especially along active plate margins. However, recent faulting events in the Western Hemisphere have shown that much of the faulting away from active plate margins occurs along faults with no significant level of seismicity and that only a fraction of active faults are characterized by ongoing seismicity. Thus, the information on Quaternary faulting included within this database should help extend the modern (past several hundred years) record of seismicity into prehistoric time, and allow better assessments of active and potentially active faults in Venezuela and other Western Hemisphere countries.

Fault segmentation has been a popular concept in the United States and elsewhere in the world, especially where more active faults exist. Several of the major faults in Venezuela have been "segmented" by authors, including the senior author of this report. However, the criteria of the ILP project requires that segments show distinct and different rupture histories in order to prove these segmentation models. It is our belief (Machette and Haller) that insufficient dating has been done to prove segmentation of the faults in Central and South America. Thus, for the purposes of the is compilation, we use the non-genetic term section as a substitute for previously determined segments. If and when sufficient documentation exists, we will change the appropriate sections to segments (see also the "Definition of Database Terms" later in this report).

TECTONIC SETTING

Northern Venezuela lies in the interaction zone between the Caribbean plate (to the north) and South America plate (to the south). Although it is generally accepted that the Caribbean Plate moves eastward with respect to South America (Bell, 1972; Malfait and Dinkelman, 1972; Jordan, 1975; Pindell and Dewey, 1982; Sykes, McCann and Kafka, 1982; and Wadge and Burke, 1983 among others), this plate boundary is not of the simple dextral type, but instead is really a 100-km-wide active deformation zone resulting from a long-lasting process of oblique collision between the plates (Audemard, 1993). Nevertheless, a large portion of this right-lateral motion seems to take place along the dextral Boconó-San Sebastián-El Pilar fault system (Molnar and Sykes, 1969; Minster and Jordan, 1978; Perez and Aggarwal, 1981; Stephan, 1982; Aggarwal, 1983, Schubert, 1984; Soulas, 1986; Beltrán and Giraldo, 1989), and the remainder of deformation is distributed across lesser but associated faults within and offshore of Venezuela.

In the past (i.e., the Miocene) the plate boundary may have been simpler, taking the form of a mainly dextral shear zone formed by east-west trending Oca-Ancón, San Sebastián, El Pilar fault systems. The Oca-Ancón fault system, once a major active fault, is now considerably less active, the majority of motion being taken up by the Boconó and associated (thrust) faults on the northwest and southeast flanks of the Andes. Changes in plate motions, stress directions, and/or the affects of cumulative offset apparently have caused the plate boundary to become reorganized across the northwestern margin of South America. This "new plate boundary" (which is still controversial) incorporates the Boconó fault system and has caused profound changes to the landscape of western Venezuela.

As a result of these plate's interaction, a backbone of mountain ranges has formed that stands out from a rather flat surrounding countryside. This backbone is composed (from west to east) by the Andes chain that trends SW-NE in western Venezuela, and the Cordillera de la Costa and Interior ranges, that trend almost east-west along the Caribbean (north) coast of Venezuela. Despite these mountains, about 3/4 of Venezuela's total surface area is either low plains (Venezuelan Llanos and Maracaibo basin)

or high plateaus (Guayana shield). The highest peaks of Cordillera de la Costa are close to 3,000 m whereas they are nearly 5,000 m high in the Andes chain. These major geographic units roughly match geologic units as follows: the backbone mountain chains comprise Paleozoic-Mesozoic igneous and metamorphic rocks but faulted-folded sedimentary sequences of the same age also crop out extensively (mainly in the Andes chain and Interior range); the lowlands are Tertiary and Quaternary in age and they are composed of only sedimentary rocks; and the Guayana shield comprises plateau-shaped Precambrian cratonic rocks.

The modern Caribbean-South American plate boundary along northern Venezuela is under a stress field characterized by NNW-SSE maximum horizontal stress and ENE-WSW minimum horizontal stress (strike-slip regime). This present stress tensor, which is calculated from microtectonic data collected at various sites in Pliocene-Pleistocene formations of northern Venezuela (Beltrán & Giraldo, 1989; Audemard, 1993) and confirmed by focal mechanism solutions, is responsible for the present kinematics and activity of five sets of faults within a100-km-wide deformation belt. The belt contains east-west right-lateral faults, NW-SE right-lateral faults (synthetic to the east-west faults), NNW-SSE normal faults, north-south to NNE-SSW left-lateral faults, and ENE-WSW reverse faults (sub-parallel to fold axes). It is worth mentioning that most of these secondary faults have slip rates that are one order or more of magnitude less than the major right-lateral strike-slip boundary faults that are described herein.

Between South America and the Maracaibo block, the maximum horizontal stress turns counterclockwise progressively from a NNW-SSE trend to a more east-west orientation when meeting the Andes, inducing simultaneous left lateral and right-lateral slip along the north-south striking Valera [VE-04] and the NE-SW striking Boconó [VE-06] faults (respectively) and northward extrusion of the Maracaibo Block. The Maracaibo Block is overriding the rest of the Caribbean Plate offshore north of Venezuela, along with other amalgamated blocks of northwestern South America that are squeezed between the Caribbean and South America plates.

BOCONÓ FAULT

The NE-SW trending right-lateral strike-slip (RLSS) Boconó fault [VE-06]—the fastest and most seismogenic fault in Venezuela—runs slightly oblique to the main axis of the Venezuelan Andes and bounds the Caribbean Coast range of northern Venezuela on the west, thus extending for about 500 km between the Tachira depression (at the border between Colombia and Venezuela) and Morón (on the Caribbean coast of Venezuela). At its north end, the Boconó fault system, after leaving the Yaracuy depression and entering the Caribbean Sea, bends 45° to the east in order to connect to the east-west trending El Pilar [VE-13] and San Sebastián [VE-16] faults: the whole system is here considered to be the modern southern wrench boundary of the Caribbean Plate. To the south, the Boconó fault connects to a left lateral-reverse fault system formed by the Bramón fault in Venezuela and the Chinacota and Chucarima faults in Colombia. This fault system forms the southwestern part of the Pamplona indenter, which is formed by two opposite right-angle bends (an “S” shape pattern). From the Pamplona indenter in eastern Colombia, the plate boundary extends as far south as the Jambeli graben in the Guayaquil Gulf of Ecuador, thereby disconnecting the northwestern corner of South America (most mountainous regions of Colombia, northwestern Venezuela and part of Ecuador) from the rest of the continent.

Important thrusting also occurs subparallel to and on both sides of the right-lateral strike-slip Boconó fault; this thrusting accommodates important E-W compression across the Andes (Gonzalez de Juana, 1952; Rod, 1956b; Hospers and Van Wijnen, 1959; Schubert, 1968; Kellogg and Bonini, 1982; Henneberg, 1983; Soulas, 1985; Audemard, 1991; Alezones and others, 1992; De Toni and Kellogg, 1993; Jácome, 1994; Sánchez, 1994; Sánchez and others, 1994). Geomorphic evidence of the Boconó fault’s youthfulness has been described by many authors over the past several decades and consists in a continuous series of aligned 1-to-5-km wide valleys and linear depressions, passes, saddles, trenches, sag ponds, scarps and sharp ridges (for example, Rod, 1956b; Schubert, 1980a; 1980b; 1982; Giraldo, 1985; Soulas, 1985; Soulas and others, 1986; Soulas and Singer, 1987; Singer and Beltrán, 1990; Casas, 1991; Ferrer, 1991). As much as 75 km of dextral offset of Mesozoic rocks has been measured , although a more reliable value is about 30 km (for more details refer to Giraldo, 1989, and Audemard and Giraldo, 1997). Offset of Quaternary features (mountainous ridges, drainages, alluvial deposits, shutter

ridges, etc.) ranges from 60 m to 1,000 m depending on their age; these data have been used to estimate its Quaternary slip rate at between 3 and 14 mm/yr (for a complete review see Schubert, 1982). However, in recent times most authors agree on a slip rate of about 5 to 9 mm/yr for the Boconó fault. These rates are based primarily on measurements of 60 m to 100 m of dextral offset (depending on authors) of Los Zerpa moraines, which are radiocarbon-dated at about 13,000 yr B.P. These rates are consistent with those predicted by plate motion models of about 10 mm/yr, assuming that the Boconó fault is really part of the main boundary between the Caribbean and South American plates (for example, Molnar and Sykes, 1969; Minster and Jordan, 1978; Soulas, 1986; Freymueller and others, 1993; Lundgren and Russo, 1997).

As Rod (1956a) initially observed, the Boconó fault and El Pilar fault [VE-13] are responsible for most of the Venezuelan seismicity. The present-day seismicity along the Boconó fault occurs within a broad zone that generally comprises the entire width of the Andean range, suggesting that other subparallel faults may be also seismogenic, such as the thrust structures that are presently elevating the mountain chain. For instance, the Mb 5.5 Guanare earthquake of March 5, 1975, and the Mb 5.6 Ospino earthquake of December 11, 1977 are the most recent and largest events associated with the southern Andean Foothills thrust system [VE-07], which is also known as the Piedemonte Oriental fault.

Several large historical earthquakes have been ascribed to the Boconó fault zone, such as those of 1610, 1812, 1849, 1894, 1932 and 1950 (Imax IX-XI, MMI scale; Soulas *and others,* 1987). The 1610 and 1894 earthquakes have been directly associated with the southern section of the fault [VE-06a] using paleoseismological investigations (Audemard, 1997). The 1812 earthquake devastated the town of Mérida and other Andean localities and also produced extensive damage to Caracas, some 500 km to the NE. Although this event has been interpreted as having 2- to-3 foci (subevents), it is thought to have ruptured the Boconó fault from Mérida to the north on the basis of several intensity maps (see for example, Soulas and others, 1987; Grases, 1990; Rodríguez and others, 1997).

EL PILAR FAULT

The El Pilar fault [VE-13] is the most important sesimogenic fault in northeastern Venezuela, as proven by the recent Ms 6.8 Cariaco earthquake of July 9, 1997. This earthquake caused about 36 km of surface rupturing along a major portion of the onshore section [VE-13b] of the dextral El Pilar fault, extending between the Gulfs of Cariaco and Paria (Audemard, 1999a). Moreover, northeastern Venezuela has been struck by several destructive earthquakes since the Spanish conquest, in the early 16th century. The first recorded seismic event in this area was the 1530 earthquake that heavily destroyed Cumaná. This city has been repeatedly damaged by the 1684, 1766, 1797, 1853, 1929 and 1997 events. All of the pre-20th Century earthquake have been ascribed to the El Pilar fault without any geological corroboration. A reassessment of the seismic history of this fault (Audemard, 1999b) has found that: a) the 1766 event seems to have been generated in a source different from the El Pilar fault because the size of the felt area suggests that it is an intermediate-depth earthquake; b) damage to Cumaná produced by the 1797 event suggests that this was a local earthquake, perhaps equivalent to the 1929 earthquake, which ruptured just east of Cumaná into the Gulf of Cariaco for some 30 km in length; and c) the seismogenic association of the 1530 and 1853 earthquakes still remains unclear, but it is very likely that these ruptures occurred underwater as suggested by tsunami waves that both events generated, thereby placing their hypocenters west of Cumaná in the Cariaco trough.

The El Pilar fault extends eastward some 350 km from the Cariaco trough (located south of La Tortuga Island) to the Gulf of Paria, cropping out for a short (about 80 km long) portion at the land bridge between the Gulfs of Cariaco and Paria (State of Sucre). This fault has been subdivided by Beltrán and others (1994) into four different sections: a) submarine trace west of Cumaná that bounds the Cariaco trough (a pull-apart basin) and dies at the Caigüire Hills in a restraining stepover, at Cumaná; b**)** the second portion extends from the north side of the above-mentioned stepover to the Casanay-Guarapiche restraining bend. This portion has been ruptured in this century by the combination of the January 17, 1929 Cumaná and July 09, 1997 Cariaco earthquakes (Audemard, 1999a); c) a 30-km-long section that slightly diverges to the ENE and extends between Casanay and El Pilar; and d) a fourth east-west trending section that cuts across the swampy areas of the Sabanas de Venturini and runs offshore south

of the Paria Peninsula, before connecting and transferring its motion to the NW-SE striking Los Bajos [VE-15] and Soldado faults. These three faults are considered as the eastern portion of the major RLSS plate boundary fault system between the Caribbean and South American plates.

OCA-ANCÓN FAULT SYSTEM

After the Boconó fault [VE-06], which is considered by many as the main boundary within the deformation belt at the southern margin of the Caribbean Plate, the Oca-Ancón fault system [VE-01] is the second major tectonic feature of this transpressive belt. Both faults define the southeastern and northern boundaries of the triangular Maracaibo block (northwestern Venezuela and northern Colombia), which is bounded on its west side by the Santa Marta-Bucaramanga fault [CO-02]. Extrusion of this block to the north caused it to be thrust over the Caribbean Plate, as suggested by tomographic studies carried out by Van der Hilst (1990) and by many submarine features revealed by bathymetric studies and seismic profiling. The east-west, right-lateral Oca-Ancón fault system extends about 650 km from Santa Marta (in Colombia) to Boca de Aroa (in the eastern coastlands of the State of Falcón). It has been structurally subdivided into five different sections (A-E; modified from Audemard and others, 1994) which are described in the following database.

The Oca-Ancón fault system is the largest potential seismic source of northwestern Venezuela: trenches dug across individual active traces of the Oca and Ancón faults on section B [VE-01b] revealed evidence of Ms 7.4 to 7.5 earthquakes on both faults (Audemard, 1996). The recurrence of such events is 1752±133 yr on the Ancón fault and 4300±1000 yr on the Oca fault. Nevertheless, as the Oca fault has a continuous trace for some 400 km along sections A and B, the coseismic fault-rupture length is probably only a third of the total Oca fault length. Consequently, the Oca fault's recurrence is longer as well, since the most recent event only seems to have ruptured its 120-130 km-long easternmost part, between the Sinamaica lagoon and Mene de Mauroa about 1920±780 yr. B.P. Therefore, the next Ms 7.5 earthquake on the Oca fault for the Maracaibo region should not be expected within 2,500 years. On the other hand, the most recent rupture on the Ancón fault occurred at 2467±843 yr. B.P., implying that a 100% likelihood of occurrence of a Ms 7.5 earthquake has been reached. In conclusion, we should point out that assessment of maximum credible earthquake magnitude for those fault sections by means of segmentation criteria coincides fairly well with estimates from paleoseismic trench data.

PREPARATION OF THE DATABASE AND MAP

This compilation shows evidence for activity on Quaternary faults in Venezuela and its offshore region in the Caribbean, using guidelines published by Haller and others (1993). The fault data were compiled by Franck Audemard during 1998, building on a 1993 Quaternary fault map of Venezuela that Funvisis published (Beltran, 1993). However, Franck Audemard used unpublished (proprietary) reports, published literature, and recent geological investigations to describe sixteen of the most important faults. Of these, 9 are faults that contain sections (27) so the database really contains descriptions of 36 faults and fault sections. No separate descriptions of Quaternary folds were made for Venezuela, although several are known in association with blind thrust faults (which are described, herein). Franck also interpreted aerial photographs and used new mapping to revise Beltan's 1993 map. Michael Machette edited most of the text and map data and provided guidance for the project under the International Lithosphere Program's Task Group II-2 "Major Active Faults and Folds of the World," for which he is the Co-chairman (Western Hemisphere). The surface traces of the Quaternary faults were digitized from Audemard's compilation, which was on a planimetric base map at a scale of 1:2,000,000. Offshore traces are based primarily on marine geophysical studies and bathymetric maps; these traces are inherently less well defined and located, and should be considered approximate.

Jonathan Cox and Richard Dart used GIS (Geographic Information System) technology to produce the fault map. The traces of Quaternary faults were digitized, attributed for age, sense of slip, and line type (continuous, discontinuous, and concealed or inferred), and reprojected using a Mercator projection. The maps were prepared with ARC/INFO version 7.1.2 running under Solaris version 2.5.1 on a Unix workstation. The GIS data is scale independent but should not be used at scales greater (more detailed)

than about 1:1,000,000 (twice the digitized scale). Data for the fault endpoints, length, and average strike were generated from the ARC/INFO files.

A note about the 1993 FUNVISIS base map. The base map used by Beltran (1993), and later by Audemard for this compilation appears to be a hand-drawn planimetric map based on a prior map of unknown projection. As such, the geologic and selected cultural and geographic data were digitized and their locations adjusted (rubber sheeted) to our digital base map. The base-map information for the enclosed map was taken from the Digital Chart of the World, which was created for use with ARC/INFO (copyright 1993 by the Environmental Systems Research Institute, Inc.). The Digital Chart of the World was compiled at a scale of 1:1,000,000, twice the scale as the printed scale of the map (1:2,000,000). However, owing to the small scale of the base map, many of the place names mentioned in the description of faults cannot be shown. The reader should consult more detailed (i.e., 1:250,000 scale) maps of Venezuela, or a road atlas for Venezuela (which is probably more easily obtained outside of Venezuela). The Digital Chart of the World was originally developed for the United States Defense Mapping Agency (DMA) and is primarily derived from the DMA Operational Navigation Chart (ONC) Series.

MAP

The map of Quaternary faults of Venezuela was digitized from Audemard's (1998) compilation, which was on the 1:2,000,000-scale planimetric base map used by Beltan (1993). This scale allows output as a single-country map (1:1,000,000 to 1:2,000,000 scale) or provincial and regional maps (1:500,000 to 1:1,000,000 scale) while retaining all significant digital information. The fault map and accompanying base are not adequately detailed for display or printing at scales greater than 1:500,000. The fault map shows the location and style of Quaternary faults, time of most recent movement, and estimates of slip rate (as a proxy for fault activity).

Although as many as five time categories of Quaternary faults can be depicted on the Western Hemisphere maps, only three categories were used in Venezuela:

Historic (generally <450 years),

Holocene and latest Pleistocene (<15,000 years or <15 ka),

Quaternary (<1,600,000 years or <1.6 Ma).

Categories for the late Quaternary (<130 ka) and late and middle Quaternary (<750 ka) were not used owing to the general lack of stratigraphic and chronological control needed to make these age differentiations. This categorical time scheme allows some flexibility in reporting between countries owing to the differing levels of investigation and abilities to date prehistoric faulting.

Three ranges of slip rates depicted by differing lines are shown on the map in order to differentiate known rates of fault activity:

>5 mm/yr—Plate-boundary faults and subduction zones,

1-5 mm/yr—Lesser strike-slip and major extensional faults,

<1 mm/yr—Most extensional and intraplate faults.

Most faults in Venezuela with "unknown slip rates" are not described herein, but are drawn with the <1-mm/yr line thickness to depict their probable low slip rates.

DATABASE

The purpose of the database is to provide large quantities of fault data that can be readily accessed using a variety of search parameters. For this database, we anticipate that the user would want search-and-retrieve capabilities from a personal computer. The user may want to sort the data by such parameters as fault name, time of most recent movement (one of three categories), slip rate (one of three categories), sense of movement, or by multiple parameters.

The process of data compilation starts with data acquisition and synthesis. In the case of faults, the compiler must determine if the structure is a simple one, or if it qualifies as having sections (increasing complexity of geometry or fault history). Then using the appropriate form, the compiler tabulates information on the fault's parameters. The forms were built in Microsoft Word for the Macintosh.

After this report is released, we will incorporate suggested changes and additions; then import the data to the computer database. Each of the fields is a potential search object. The use of a computer database program allows us to custom format the reporting of data and to collapse unused fields or notes. The basic fields are restricted to 256 characters, but we use the note option for more explanatory information (shown under comments in this report).

The fault data will be released in several forms. This open-file report constitutes a traditional hard-copy catalog (database and map) for Venezuela. The Venezuela data will eventually be part of a larger relational computer database for the Western Hemisphere that should be available on the World Wide Web (WWW). This interactive WWW product allows the user to browse, sort, and print the data. However, we do not anticipate allowing the database to be altered using only the run-time WWW version of the database program.

DEFINITION OF DATABASE TERMS

The following terms, which are shown in Spanish and English in the fault descriptions, provide data for specialized fields, most of which will be searchable when the computer database is released. In addition specialized fields, more detailed information is provided in the "Comments" section that follows some fields. If a field is empty, marked unknown, or has been deleted, no pertinent information was found in the published literature. The following description provides definitions of fields (in alphabetic order) and indicates where various information, if known, can be found. Citations of references are in a traditional (USGS) format, although foreign language citations are as provided by the compilers.

Average dip General down-dip direction of the structure, where known.

Average strike The length-weighted average strike of the trace of the fault (or fault section) is reported in the northwest and northeast quadrants of the compass (*i.e.*, N. 30° W., versus S. 30° E.). In some cases we refer to the azimuth of the strike, which is the direction in degrees measured in a clockwise manner from north (i.e., S. 60° E. is 120° azimuth). The error limits that follow the strike describe the range for all vectors contained with the trace of that particular fault or collection of faults. These values are included only to provide a general impression of the sinuosity or variability in strike of the mapped structures. Some fault zones include a number of faults with a wide variety of strikes, and thus the error limits are not meaningful.

Compiler, affiliation and date of compilation The name and affiliation of the person(s) primarily responsible for compilation or update of data presented for the structure. Also shown is the date when data were compiled for this project (*e.g.*, January 1997).

Fault geometry This heading includes geographic information pertinent to the fault or fault section being described. The data include length, average strike, average dip, and sense of movement.

Geomorphic expression General description of the structure's geomorphic expression including information on the the presence or absence of fault scarps, offset streams, monoclines, shutter ridges, associated landslides, etc.

Historical surface faulting When the timing of most recent movement on a fault is historic, then this field(s) describes evidence for surface faulting associated with historical earthquakes. Also included is seismological information for the historical earthquake.

Length This field specifies the end-to-end length of the Quaternary-age fault (or fault section) as measured from the most distal ends of the trace. The ends of overlapping or echelon traces are projected to a line defined by the average strike and the length is then determined from those projected end points. Also shown (in parentheses) is the cumulative length of all surface traces included in the fault, fault zone, or collection of faults.

Name (**Fault name** or **Section name**) The earliest referenced name for a structure or fault section (where appropriate) generally is given preference, except in cases where a more commonly accepted name is widely used in the recent literature. "Comments" may also contain other names and references in which they are used, the geographic limits of the structure, north to south or west to east, as shown in this compilation; various geographic limits that are different than in other studies are also included. Minor changes in original name may have been made for reasons of clarity or consistency (such as segment to section) where appropriate. We have found no faults in Venezuela that justify using the term "segment", owing to a lack of precise timing information.

Number

Structure number The structure (fault or fold) is assigned a number that is preceded by a two character abbreviation (Venezuela fault number 1 is VE-01) that is unique to each of the countries in the Western Hemisphere. References to the same structure shown in other compilations, such as CO-01 or PE-01 are included in "Comments".

Section number An alpha character is assigned to the northernmost or westernmost section of a fault (*e.g.*, fault VE-01 has five sections: VE-01A, VE-01B, VE-01C, VE-01D, and VE-01E).

Number of sections (only used for faults with sections) Numeric value for number of sections (*e.g.*, 2) defined in studies that do not meet the minimum requirements for segments established for this compilation. "Comments" include reference in which sections are discussed; if the term "segment" is used in the literature, an explanation of why "section" is used in the database is provided.

Recurrence interval Time interval in yr (based on historic data, calendric or calibrated radiocarbon dates), in ^{14}C yr (based on uncalibrated radiocarbon dates), or in k.y. (thousand years, based on less precise dating methods, stratigraphy, or geomorphology). Unknown is shown if there is no published recurrence interval value. Alternative published recurrence intervals, starting with that which applies to the most recent time interval, are included in "Comments." Very few faults in Venezuela have established recurrence intervals.

References A bibliographic citation is included for all references pertinent to each structure. Papers published in Spanish are cited in Spanish, and may not conform to USGS style.

Section A geographic, geometric, structural portion of a fault or collection of faults that appear(s) to have a different character than adjacent portions of the fault (or fold). Typically, not enough information exists to show that this portion of the fault acts independently of adjacent portions, and thus does not qualify as a bona fide "segment" of a fault in a paleoseismic sense. There are no known faults with proven segments (nor are the segment boundaries known) in Venezuela, although several faults are described as having sections. Further research is needed to document additional faults with sections or those with sections that may in fact be segments.

Section name (see Name)

Section number (see Number)

Sense of movement Includes thrust, less than 45° dip; reverse, greater than 45° dip; right-lateral strike slip (dextral); left-lateral strike slip (sinistral); or normal faults. For oblique slip, the principle sense of movement is followed by secondary sense (*i.e.*, dextral, normal).

Slip rate The primary field shows an actual value or one of several slip-rate categories used for the map part of this compilation: <1 mm/yr, 1-5 mm/yr, or >5 mm/yr. Very few faults in Venezuela have established slip rates. “Unknown" precedes the suspected slip-rate or slip rate category if no published slip rate is known. "Comments" may include a synopsis of published slip rates and pertinent documentation. Generally speaking, there are two types of slip rates. The first type is termed a “Geologic slip rate” and is derived from the age and amount of offset of surficial geologic deposits. These rates are not precise, but allow one to place broad limits on possible slip rates, and hence characterize the fault in one of the above-mentioned categories. Most slip rates from Venezuela are geologically determined. The second type of slip rate is termed a “Paleoseismic slip rate” and is derived from times of faulting events and amounts of offset of geologic datums or piercing point. This type of slip rate is more precise, but are rare owing to the extensive amount of work involved (*i.e.*, detailed paleoseismologic studies involving trenching and numeric dating).

Fault/fold name (see Name)

Fault/fold number (see Number)

Synopsis and geologic setting This field provides a short summary that describes the level of study, provides a snapshot of the scope of data that follows in the database and provides a generalized perspective of the fault in terms of its regional geologic setting, amount of total offset, and general age of offset strata. Not all faults in the database have a synopsis and discussion of geologic setting.

Timing of most recent event (faulting or folding event) The primary field shows one of the two prehistoric time categories: latest Quaternary (Holocene and latest Pleistocene, <15 ka) or Quaternary (<1.6 Ma). This field may document historic surface faulting, although details of the earthquake related to the faulting will follow.

Type of studies: This field briefly summarizes the types of studies conducted on the fault.

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DATABASE FOR VENEZUELA

VE-01, OCA-ANCÓN FAULT SYSTEM

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-01

FAULT NAME/*NOMBRE DE LA FALLA*: Oca-Ancón fault system (sistema de fallas de Oca-Ancón)

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: The Oca-Anc Ancón fault system extends eastward from Santa Marta on the Caribbean coast of northern Colombia to the town of Boca de Aroa, located on the eastern coast of Falcón State (northwestern Venezuela). This fault system crosses the Guajira Peninsula, the outlet of Lake Maracaibo, the coastal plains of Buchivacoa (northwestern Falcón State) and

central Falcón Range. It sharply truncates the north ends of the Santa Marta Block (northern Colombia) and the Perijá Range; both units are mainly composed of Mesozoic rocks whereas the remainder of the trace cuts across Quaternary alluvial units in the Maracaibo basin and Tertiary sedimentary rocks of the Falcón Range. Between the middle Miocene and the Pliocene this fault system played a leading role as part of the Caribbean-South America right-lateral strike-slip plate boundary: it now plays a secondary role to the Boconó fault.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*: Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS); June 1998.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Regional neotectonic and seismotectonic studies for seismic-hazard assessment of oil facilities based on aerial photointerpretation, field confirmation and helicopter verification. Additional information from available seismic profiles and three trenches.

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:
LENGTH/*LONGITUD* : End-to-end 563 km (cumulative 1120 km)
Comments/*Comentarios*: GIS values for fault in Venezuela; continues west into Colombia as CO-01.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 67° E. ± 84°
Comments/*Comentarios*: GIS values for Venezuela. Large variation in strike, but roughly east-northeast (60° to75° azimuth) for most of length.

NUMBER OF SECTIONS/*NUMERO DE SECCIONES:* 5
Comments/*Comentarios*: Five faults or sections are defined for the Oca-Ancón fault system for this compilation.

VE-01A, OCA FAULT OF OCA-ANCÓN FAULT SYSTEM

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-01a

SECTION NAME/*NOMBRE DE LA SECCION*: Oca fault of Oca-Ancón fault system
Comments/*Comentarios*: This fault extends from the town of Santa Marta (Colombia [CO-01]) on the Caribbean coast to the west, east to north of Maracaibo.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 325 km (cumulative 359 km)
Comments/*Comentarios*: GIS values for Venezuela. Continues west into Colombia as CO-01 and overlaps with VE-01b and VE-01c to east.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 84° W. ± 10°
Comments/*Comentarios*: GIS values for Venezuela.
AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical
Comments/*Comentarios*: High south dip with either reverse component (at fault contact between the northern tip of the Perijá Range and the flexural sedimentary basin of the Guajira Peninsula) or normal component (at releasing stepover between the Oca [VE-01a] and Ancón [VE-01b] faults).
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO*: Right-lateral (confirmed by fault-plane kinematic indicators).
Comments/*Comentarios*: Occasionally has significant reverse component (along northern boundary of the Santa Marta Block and northern termination of the Perijá Range) or normal component (at releasing stepover between the Oca and

Ancón faults, east of Lake Maracaibo). Has highly transpressive character at Toas Island (a positive flower structure) in El Tablazo Bay.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: About fifteen kilometers long, south-facing scarp on Quaternary alluvial units of the Buchivacoa Plains (east of Lake Maracaibo). Scarp is about 30 cm high and shows right-lateral offset of late Holocene beach strandlines at Sinamaica lagoon, and of early Pleistocene alluvial fans in Colombia.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 1-1.5 k.y. to 4.3±1 k.y. (variable)
Comments/*Comentarios*: From paleoseismic studies, an Ms 7.4 earthquake is expected every 4295±1020 yr B.P. for the easternmost portion and between 1000 and 1500 yr ago for the entire section in Venezuela considering that the fault is very long and there may be at least 3 portions that could rupture separately. The recurrence interval should be less to the west based on high slip rate estimated from features in Colombia (Río Ranchería alluvial fans).

SLIP RATE/*TASA DE MOVIMIENTO*: 0.45-2.0 mm/yr (variable)
Comments/*Comentarios*: In Venezuela, the slip rate seems to decrease eastward, from about 2 mm/yr where the fault has a single strand (extrapolated from the releasing stepover that was assessed by trenching) to 0.45 mm/yr where the fault splays into two strands at the releasing stepover (value estimated from trench studies). In Colombia, the slip rate could be as high as 4.3±1 mm/yr based on the amount of offset of early Pleistocene alluvial fans.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Holocene and post glacial (<15 ka)
Comments/*Comentarios*: Two trenches, about 100 km apart, have revealed evidenc e for deformation between 1140-2700 yr ago on the easternmost portion at Sinamaica Lagoon (1920±780 yr B.P.) and between 1315-2575 yr ago at Hato el Guayabal (1945±630 yr B.P.) in the Buchivacoa Plains.

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VE-01b, Ancón fault of Oca-Ancón fault system

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-01b

SECTION NAME/*NOMBRE DE LA SECCION*: Ancón fault of Oca-Ancón fault system
Comments/*Comentarios*: The Ancón fault extends from El Tablago Bay (on the west) to Dabajuro (on the east).

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 105 km (cumulative 111 km)
Comments/C*omentarios*: GIS values. Overlaps with VE-01a to north.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N.77° W. ± 22°
Comments/C*omentarios*: GIS values. Western part is SW-trending, eastern part is E-trending.
AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical
Comments/*Comentarios:* High north dip with local normal component
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral
Comments/*Comentarios:* Perfectly horizontal striations at Hato-La-Pica trench. Occasionally has significant normal component within the releasing stepover between the Oca [VE-01a] and Ancón [VE-01b] faults. Together, the faults form an active pull-apart basin. The most active portion of this basin is associated with a transtensive horse tail splay at the western tip of this section, which is responsible for the active subsidence of El Tablazo Bay within the area between the Oca [VE-01a] and Ancón [VE-01b] faults.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Several kilometer long, north-facing scarp on Quaternary alluvial units of the Buchivacoa Plains (east of Lake Maracaibo outlet).

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: An Ms 7.4 earthquake every 1.9 k.y.
Comments/Comentarios: A 1.2 m horizontal offset has been estimated on the basis of coseismic vertical offset of 4 cm and perfectly horizontal strations on a fault plane that deforms an alluvial surface that dips less than 1° west. Using this calculated offset amount and the fault length yields a Ms 7.4 earthquake every 1.9 k.y, the recurrence of which is based on radiocarbon dating of samples collected in the Hato-La Pica trench

SLIP RATE/*TASA DE MOVIMIENTO*: 1.6 mm/yrTIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Holocene and post glacial (<15 ka)
Comments/*Comentarios:* From assessment of Hato-La Pica trench (see recurrence interval).

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VE-01c, CAMARE-PARAISO FAULT OF OCA-ANCÓN FAULT SYSTEM

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-01c

SECTION NAME/*NOMBRE DE LA SECCION*: Camare-Paraiso fault of Oca-Ancón fault system

Comments/*Comentarios*: This section of the fault extends from Camare (on the west) to Paraiso (on the east), and is newly named here.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:

LENGTH/*LONGITUD* : End-to-end 139 km (cumulative 338 km)

Comments/C*omentarios*: Contains multiple subparallel strands.

AVERAGE STRIKE/*RUMBO PROMEDIO* : N 86° W. ± 47°

Comments/C*omentarios*: Contains multiple subparallel strands; reported as roughly east-west (90° azimuth) along Camare-Paraiso Range.

AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical

SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral with significant reverse component.

Comentarios/Comments: Transpressive section has significant reverse component on subparallel external splays (about 6-km-wide positive flower structure). Confirmed from microseismic activity.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Consistent and persistent geomorphic features that show evidence of transcurrent faulting (fault scarps, right-lateral offset drainages, sag ponds, fault trenches, shutter ridges, fault saddles, etc.) in Neogene to middle Pleistocene sedimentary units of the Falcón Range. Also, the fault forms flexural scarps affecting middle Pleistocene alluvial units on both sides of the Camare-Paraiso Range.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: Every 670 yr for a maximum credible earthquake of Ms 7.1.

Comentarios/Comments: This return period (interval) is estimated for a rupture as long as the length of the fault section, taking into account the slip rate listed below.

SLIP RATE/*TASA DE MOVIMIENTO*: About 2 mm/yr

Comentarios: Extrapolated from contiguous-to-the-west section that has been assessed by paleoseismic investigations.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO:* Holocene and post glacial (<15 ka)

Comentarios/Comments: The fault affects Neogene to middle Pleistocene sedimentary units of the Falcón Range. However, based on its high slip rate, short recurrence interval and clear geomorphic expression, the fault is probably young (<15 ka).

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VE-01D, UNNAMED SECTION OF OCA-ANCÓN FAULT SYSTEM

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-01d

SECTION NAME/*NOMBRE DE LA SECCION*: Unnamed section of Oca-Ancón fault system

Comments/*Comentarios*: This fault section extends from Paraiso (on the west) to Socremo (on the east).

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:

LENGTH/*LONGITUD* : End-to-end 126 km (cumulative 348 km)

Comments/C*omentarios*: GIS values; contains multiple subparallel strands..

AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 68° W. ± 40°.

Comments/C*omentarios*: GIS values; also reported as ESE-trending (115° azimuth).

INCLINACION PROMEDIO/AVERAGE DIP: Either SW or NE, high-angle.

SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral

Comments/*Comentarios:* Transtensive section has significant normal component on subparallel (and/or en echelon) short (generally <25-km-long) strands.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: There are few geomorphic features (generally fault scarps with apparent normal component) on Quaternary sedimentary units because the fault system cuts through the Paleogene core of the Falcón Range (anticlinorium); however, the fault has very frequent shallow seismic activity with focal mechanisms that confirm a transtensional regime.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: Maximum credible earthquake of Ms 6.7 every 390 yr. Comments/*Comentarios:* This return period (interval) is estimated for a maximum credible rupture length of 40 km along any fault strand in this section.

SLIP RATE/*TASA DE MOVIMIENTO*: About 2 mm/yr
Comments/*Comentarios:* Extrapolated from section that has been assessed by paleoseismic investigations. This slip rate is distributed across several subparallel fault strands.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO:* Holocene and post glacial (<15 ka)
Comentarios/Comments: The fault cuts through the Paleogene core of the Falcón Range, and thus affects few Pleistocene units . However, based on its high slip rate and short recurrence interval, the fault is probably young (<15 ka).

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VE-01E, SOCREMO FAULT OF OCA-ANCÓN FAULT SYSTEM

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-01e

SECTION NAME/*NOMBRE DE LA SECCION*: Socremo fault of Oca-Ancón fault system

Comments/*Comentarios*: This newly named fault extends east from Socremo to Quebrada Agua Linda, located on the eastern coast of Falcón State (northwestern Venezuela). GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:

LENGTH/*LONGITUD* : End-to-end 46 km (cumulative 47 km)

AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 90° E. ± 13°

Comments/*Comentarios:* Primarily E-W striking

AVERAGE DIP/*INCLINACION PROMEDIO*: Intermediate angle dip to north.

SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Mainly reverse with right-lateral component.

Comments/*Comentarios:* Confirmed by fault-plane kinematic indicators.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Conspicuous south-facing flexural scarps affecting early Pleistocene alluvial units. Possible late Pleistocene (or younger) flexural depressions on the footwall block.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: Maximum credible earthquake of Ms 6.7 with return period longer than 390 yr.

Comments/*Comentarios*: This *r*eturn period has been calculated for a rupture as long as the fault section, taking into account the slip rate listed below.

SLIP RATE/*TASA DE MOVIMIENTO*: About <2 mm/yr

Comments/*Comentarios:* Extrapolated from adjacent section that has been assessed by paleoseismic investigations.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Quaternary (<1.6 Ma)

Comments/*Comentarios*: Certainly has middle Pleistocene and possibly even late Pleistocene (or Holocene) movement

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VE-02, URUMACO FAULT

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-02

FAULT NAME/*NOMBRE DE LA FALLA*: Urumaco fault

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: This fault affects the Neogene sedimentary sequence of the Urumaco trough (part of the Falcón basin) and its Quaternary cover, west of Coro (capital of the Falcón State, northwestern Venezuela). The Urumaco fault extends inland from the seashore at Arroyo Salado Bay to the Mosqueda Range. The fault is composed of two subparallel strands about 10 km apart that form a left-step echelon pattern with a reverse fault connection: this geometry is evidence of a restraining step.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*: Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS); June 1998.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Regional neotectonic and seismotectonic studies for seismic-hazard assessment of oil facilities based on aerial photointerpretation, field confirmation and helicopter verification. Also based on available seismic profiles, microtectonic evaluation (fault-plane kinematic studies), and paleoseismic assessment.

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:
LENGTH/*LONGITUD* : End-to-end 33 km (cumulative 38 km)
Comments/*Comentarios*: Includes connecting thrust fault between two sections
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 16° W. ± 64°
NUMBER OF SECTIONS/*NUMERO DE SECCIONES:* 2
Comments/*Comentarios*: Two sections (strands) of the Urumaco fault are defined for this compilation. These sections are discussed by Audemard and others (1999).

VE-02a, West section of Urumaco fault

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-02a

SECTION NAME/*NOMBRE DE LA SECCION*: West section of Urumaco fault
Comments/*Comentarios*: This section (strand) of the fault extends inland from the sea coast at Arroyo Salado Bay to north of La Concepción.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 17 km (cumulative 20 km)
Comments/*Comentarios*: GIS values. Reported as onshore portion including thrust; length unknown where it may extend offshore. Total length may be twice as long as the mapped length.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 18° W ± 52°
Comments/*Comentarios*: GIS values; main fault is roughly NW-trending (N. 35° W.) whereas thrust connecting with VE-02b is roughly ENE-trending (N. 70° E.).
AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical.
Comments/*Comentarios:* Dip may be to either side of fault (which is typical of strike slip faults)
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral.
Comments/*Comentarios:* It may show some normal component onshore.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Several-kilometer-long, north-facing scarp on early Quaternary alluvial units.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: ≥14,000 yr for a maximum credible earthquake of Ms 6.6
Comments/*Comentarios:* Recurrence based on a slip rate of 0.05 mm/yr along this strand. Recurrence reduces to half (≥7000 yr) if entire fault is considered, or to a fourth (≥3500 yr) if slip rate is closer to 0.1 mm/yr.

SLIP RATE/*TASA DE MOVIMIENTO*: 0.05 mm/yr
Comments/*Comentarios:* This slip rate has been estimated on the eastern strand of the Urumaco fault. A value of <0.1 mm/yr is the upper bound.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Quaternary (<1.6 Ma)
Comments/*Comentarios:* Geomorphic deformational features are preserved on early Pleistocene alluvial ramps.

REFERENCES/*REFERENCIAS*:

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MENDEZ, J. & GUEVARA, E. (Comp.), 1969. Geological compilation map of N.W. Venezuela, Guajira and Aruba. scalee 1:250,000.

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VE-02B, EAST SECTION OF URUMACO FAULT

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-02b

SECTION NAME/*NOMBRE DE LA SECCION*: East section of Urumaco fault

Comments/*Comentarios*: This section of the fault extends inland from south of the Cuajaracume Bay to the Mosqueda Range.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:

LENGTH/*LONGITUD* : End-to-end 19 km (cumulative 19 km)

AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 50° W

Comments/C*omentarios*: GIS values; also reported as roughly NW-SE.

AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical.

Comments/*Comentarios:* Dip may be to either side of fault (which is typical of strike slip faults)

SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral.

Comments/*Comentarios:* It may show some normal component. Both slip components confirmed by fault-plane kinematic indicators.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Several geomorphic features (fault scarps, offset drainages, linear drainages, fault trenches) of middle Pleistocene or younger age are present along the different subparallel splays of this east strand. Transtensive horse-tail splays at northern tip on northern block are evidenced by 160°-striking, east-facing fault scarps, whereas it dies out at both ends as reverse faults on the opposite blocks. Connected to the west strand [VE-02a] by a reverse fault that is associated with a 25-m-high, north-facing flexural scarp that is preserved on early Quaternary alluvial deposits.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 12-15 k.y. for an earthquake of Ms 6.4.
Comments/*Comentarios:* Recurrence along this strand is based on a slip rate of 0.05 mm/yr. Recurrence of 7000 yr for the entire fault. Values obtained from paleoseismic assessment by Audemard and others (1998).

SLIP RATE/*TASA DE MOVIMIENTO*: 0.05 mm/yr
Comments/*Comentarios:* Estimated on this strand of the Urumaco fault from paleoseismic assessment by Audemard and others (1998). The upper bound is <0.1 mm/yr.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Holocene and post glacial (<15 ka)
Comments/*Comentarios:* Late Pleistocene alluvial terrace (<20 k.y.) deformed twice by one of the fault splays of this east strand (paleoseismic assessment).

REFERENCES/*REFERENCIAS*:

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VE-03, RÍO SECO FAULT

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-03

FAULT NAME/*NOMBRE DE LA FALLA*: Río Seco fault
Comments/*Comentarios*: This fault extends from the Gulf of Venezuela shelf to the Mitare River.

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: This fault affects the Pliocene sedimentary sequence of the Urumaco Trough (part of the Falcón Basin) and its Quaternary cover, west of Coro (capital of Falcón State, northwestern Venezuela). The fault has a subparallel anticline on the hangingwall (SW) block. This fold is considered active since it controls the present submarine sedimentation of the Mitare River delta.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*: Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS); June 1998.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Regional neotectonic and seismotectonic studies for seismic-hazard assessment of oil facilities based on aerial photo interpretation, field confirmation and helicopter reconnaissance. Supplemented by microseismic evaluation and available seismic data.

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:
LENGTH/*LONGITUD* : End-to-end 30 km (cumulative 30 km)
Comments/C*omentarios*: GIS values; also reported to be about 110 km (onshore and offshore portions).
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 56° W. ± 22°
Comments/C*omentarios*: GIS values; also reported as roughly SE-trending (135° azimuth).
AVERAGE DIP/*INCLINACION PROMEDIO*: High dip to south.
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral.
Comments/*Comentarios:* Shows some reverse component. Both slip components confirmed by fault-plane kinematic indicators. Subparallel-to-slightly-oblique anticline in hangingwall block is due to transpression along this fault.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Several geomorphic features (fault scarps, trenches, benches and saddles, offset and linear drainages) of middle Pleistocene or younger age are present onshore. Sea floor bulging (uplift) due to active anticline growth that controls submarine sedimentation.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 1500 yr for maximum credible earthquakes of Ms 7.0.
Comments/*Comentarios:* Corresponds to return period for maximum credible rupture length (entire fault).

SLIP RATE/*TASA DE MOVIMIENTO*: 0.35 mm/yr
Comments/*Comentarios*: Long-term (average) slip rate estimated from 675 m of post-Pliocene dextral offset of Pliocene beds.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Holocene and post glacial/Holoceno y post glacial(<15 ka)
Comments/*Comentarios*: Holocene movement offshore (underwater sedimentation is tectonically controlled) and middle Pleistocene or younger movement onshore (early Pleistocene alluvial ramps are deformed).

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VE-04, VALERA FAULT SYSTEM

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-04

FAULT NAME/*NOMBRE DE LA FALLA*: Valera fault system

Comments/*Comentarios*: This fault extends southward from the Serranía de Ziruma (south of Cerro Socopo) to the Páramo de Miranda.

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: The Valera and associated Río Momboy faults extend roughly north-south through different geographical regions (Ziruma-Trujillo Range, northern Andes Foothills, and Andes Mountains) and geological units (Tertiary sedimentary sequence of the Maracaibo Basin, Mesozoic sedimentary units, and the Precambrian core of the Andes Mountains). The Valera fault system is one of the north-south faults that rupture the Maracaibo Block into smaller discrete blocks that are rotated clockwise by dextral shear (*i.e.*, bookshelf rotation) produced by the Oca-Ancón [VE-01] and Boconó faults [VE-06] on the N and SE, respectively. The Maracaibo Block is also bounded by the Santa Marta-Bucaramanga fault [CO-02] on the west.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*: Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS); June 1998.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Regional neotectonic and seismotectonic studies for seismic hazard-assessment of oil facilities based on aerial photointerpretation, field confirmation and helicopter verification. Additional information from available seismic profiles, microtectonic evaluation (fault-plane kinematic indicators), and paleoseismic assessment.

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:
LENGTH/*LONGITUD* : End-to-end 164 km (cumulative 171 km)
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 9° E. ± 22°
NUMBER OF SECTIONS/*NUMERO DE SECCIONES:* 2
Comments/*Comentarios*: For this compilation, two faults (or sections) have been defined for the Valera fault system.

VE-04a, Valera fault of Valera fault system

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-04a

SECTION NAME/*NOMBRE DE LA SECCION*: Valera fault of Valera fault system
Comments/*Comentarios*: This section of the fault extends southward from the Serranía de Ziruma (south of Cerro Socopo) to the town of Valera, which it is named after.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 108 km (cumulative 110 km)
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 2° W. ±18°
AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical.
Comments/*Comentarios:* Dip may be to either side of fault (which is typical of strike slip faults)
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Left-lateral.
Comments/*Comentarios:* It shows an important reverse component in the western block at the southern tip of the fault that is in perfect agreement with fault kinematics.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Abundant geomorphic features (fault scarps, trenches, benches and saddles, sag ponds, shutter and linear ridges, left-laterally offset and linear drainages) of middle Pleistocene or younger age. The fault trace shows an echelon pattern with restraining stepovers.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 2000 yr for an earthquake of Ms 6.9
Comments/*Comentarios:* Based on paleoseismic assessment carried out where the fault is the fastest (north of Agua Viva). Along the northern portion of this fault, the recurrence interval may be >15,000 yr.

SLIP RATE/*TASA DE MOVIMIENTO*: 1.0 mm/yr (variable along strike).
Comments/*Comentarios:* The slip rate is at its maximum north of Agua Viva and decreases towards both ends.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Holocene and post glacial/Holoceno y post glacial(<15 ka).
Comments/*Comentarios:* Holocene alluvial deposits are faulted in trench walls (a paleoseismic assessment was carried out north of Agua Viva). Last event could be historical.

REFERENCES/*REFERENCIAS*:

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VE-04B, RÍO MOMBOY FAULT OF VALERA FAULT SYSTEM

NUMERO DE LA FALLA: VE-04b

SECTION NAM/NOMBRE DE LA SECCION: Río Momboy fault of Valera fault system

Comments/*Comentarios*: This fault extends southwestward from the town of Valera to the Páramo de Miranda; along most of its trace, it is in the Río Momboy valley for which it is named.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:

LENGTH/*LONGITUD* : End-to-end 61 km (cumulative 61 km)

AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 27° E ± 15°

AVERAGE DIP/*INCLINACION PROMEDIO*: High SE dip. Antithetic fault dips in opposite direction.

SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Left-lateral and normal (rake close to 45°).

Comments/*Comentarios:* Both (main and antithetic) faults bound the 22-km-long, narrow Río Momboy graben, along the northern portion of this section. Transtension of this fault section is considered to be a corner effect (mass deficiency) near the intersection with the Boconó fault [VE-06], produced by the clockwise rotation induced by bookshelf rotation mechanism that is partly accommodated by this fault. The kinematics of the Tuñame fault [VE-05] are also explained in the same way.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Several geomorphic features (numerous faceted spurs, fault scarps, offset drainages, linear drainages and valleys) of Pleistocene age.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 1600 to 5000 yr for an earthquake of Ms 6.7.

Comments/*Comentarios:* Further south (at Páramo Miranda), the recurrence may be three times longer (>10 k.y.) for the same magnitude earthquake. These estimates are for the maximum credible earthquake, which would rupture the entire fault length, taking into consideration the slip rate variablity mentioned below.

SLIP RATE/*TASA DE MOVIMIENTO*: 0.7 mm/yr.

Comments/*Comentarios:* Estimated slip rate at the Río Momboy graben. At Páramo Miranda, located further south, the slip rate drops to 0.1 mm/yr or less.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Quaternary(<1.6 Ma)

REFERENCES/*REFERENCIAS*:

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VE-05, TUÑAME FAULT

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-05

FAULT NAME/*NOMBRE DE LA FALLA*: Tuñame fault
Comments/*Comentarios*: This fault extends from the region of Apartaderos in the southwest to the Páramo Chorro Blanco.

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: The Tuñame fault is an active arcuate (convex to the north) normal fault within the central Venezuelan Andes. The kinematics of this fault results from a corner effect (mass deficiency) at the divergence of the Valera fault [VE-04] from the Boconó fault [VE-06], produced by clockwise rotation induced by bookshelf rotation mechanism that is partly accommodated by the neighboring left-lateral strike-slip Valera [VE-04] fault. The Tuñame fault used to be a reverse fault that juxtaposed Precambrian and Paleozoic rocks of the Andes core.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*: Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS); June 1998.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Regional neotectonic and seismotectonic studies for seismic-hazard assessment of oil facilities based on aerial photointerpretation, field confirmation and helicopter verification.

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:
LENGTH/*LONGITUD* : End-to-end 65 km (cumulative 66 km)
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 51° E. ± 11°

NUMBER OF SECTIONS/*NUMERO DE SECCIONES:* 2
Comments/*Comentarios*: Two sections the Tuñame fault are defined for this compilation.

VE-05A, SOUTH SECTION OF TUÑAME FAULT

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-05a

SECTION NAME/*NOMBRE DE LA SECCION*: South section of Tuñame fault
Comments/*Comentarios*: This section of the fault extends from north of Apartaderos to north of the village of Chachopo, along the Río Motatán valley.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 20 km (cumulative 20 km)
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 38° E. ± 3°.
Comments/*Comentarios:* It extends parallel to and south of the Río Momboy fault [VE-04b].
AVERAGE DIP/*INCLINACION PROMEDIO*: High SE dip.
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Normal and dextral(?).
Comments/*Comentarios:* This fault was formerly a reverse fault.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Poor geomorphic expression along most of fault, but clear expression in several localities. Main trace obsured within Río Motatán valley.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: >100 k.y. for an earthquake of Ms 6.5.
Comments/*Comentarios:* Interval estimated from maximum credible rupture length, which is consistent with the presence of undeformed early Pleistocene deposits.

SLIP RATE/*TASA DE MOVIMIENTO*: <0.5 mm/yr
Comments/*Comentarios*: Low slip rate based on lack of faulted Pleistocene deposits. Covered partly by early Pleistocene deposits.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Quaternary (<1.6 Ma)
Comments/*Comentarios*: Probably Quaternary based on geomorphic expression. If most recent movement was pre-Quaternary, there would be no clear expressions of the fault trace.

REFERENCES/*REFERENCIAS*:

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SOULAS, J. P., 1985. Neotectónica del flanco occidental de los Andes de Venezuela entre 70°30' y 71°00'W (Fallas de Boconó, Valera, Piñango y del Piedemonte). VI Cong. Geol. Venezolano, Caracas, (4): 2690-2711.

SOULAS, J. P., 1986. Neotectónica y tectónica activa en Venezuela y regiones vecinas. VI Cong. Geol. Venezolano, Caracas, (10): 6639-6656.

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VE-05b, North section of Tuñame fault

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-05b

SECTION NAME/*NOMBRE DE LA SECCION*: North section of Tuñame fault
Comments/*Comentarios*: This section of the fault extends from north of the village of Chachopo to the Páramo Chorro Blanco, pasing by the village of Tuñame.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 46 km (cumulative 46 km)
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 57° E. ± 10°.
AVERAGE DIP/*INCLINACION PROMEDIO*: High SE (60-80° dip)
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Normal.
Comments/*Comentarios:* Also shows minor right-lateral component.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Several geomorphic features (fault scarps, trenches and benches, sag ponds, shutter ridges, right-laterally offset drainages) of middle Pleistocene to Holocene age. Fault trace shows an en echelon pattern.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 1500 yr for an earthquake of Ms 6.4.
Comments/*Comentarios:* This interval is for an earthquake that may rupture the entire fault length.

SLIP RATE/*TASA DE MOVIMIENTO*: 0.5 mm/yr.
Comments/*Comentarios:* Estimated at the Tuñame alluvial terrace. Some ^{14}C dates support this estimate.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Holocene and post glacial (<15 ka).
Comments/*Comentarios:* Early Holocene (8775±460 yr BP) alluvial fan is faulted with 3-4 m of vertical throw.

REFERENCES/*REFERENCIAS*:

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SOULAS, J. P., 1986. Neotectónica y tectónica activa en Venezuela y regiones vecinas. VI Cong. Geol. Venezolano, Caracas, (10): 6639-6656.

SOULAS, J. P.; GIRALDO, C.; BONNOT, D. & LUGO, M., 1987. Actividad cuaternaria y características sismogénicas del sistema de fallas Oca-Ancón y de las fallas de Lagarto, Urumaco, Río Seco y Pedregal. Afinamiento de las características sismogénicas de las fallas de Mene Grande y Valera. (Proyecto COLM). FUNVISIS Unpubl. Co. Rpt. for INTEVEP. 69 p.

SOULAS, J. P.; ROJAS, C. AND SCHUBERT, C., 1986. Neotectónica de las fallas de Boconó, Valera, Tuñame y Mene Grande. Excursión N° 4. VI Cong. Geol. Venezolano, Caracas, (10): 6961-6999.

SOULAS, J. P.; ROJAS, C.; SINGER, A. & BELTRAN, C., 1985. Actividad cuaternaria y caracaterísticas sismogénicas de las Fallas de Boconó, Valera, Tuñame, Piñango, Piedemonte, Burro Negro, Mene Grande. Primera Fase Proyecto COLM. FUNVISIS Unpubl. Co. Rpt for MARAVEN, S.A. 58 p. + 2 appendices.

VE-06, BOCONÓ FAULT SYSTEM

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-06

FAULT NAME/*NOMBRE DE LA FALLA*: Boconó fault system

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: This major NE-SW trending right-lateral strike-slip fault system runs slightly oblique to the main axis of the Venezuelan Andes and bounds the Caribbean Coast Range of northern Venezuela on the west, thus extending for about 500 km from the Tachira depression (at the Venezuela-Colombia border) to Morón (on the Caribbean coast of Venezuela). At its north end, the Boconó fault system, after leaving the Yaracuy depression and entering the Caribbean Sea, bends 45° to the east to connect to the east-west San Sebastián [VE-16] and El Pilar [VE-13] faults, the whole system being considered as the major southern boundary of the Caribbean Plate. To the south, the Boconó fault connects to a left lateral-reverse fault system formed by the Bramón fault in Venezuela andthe Chinacota and Chucarima faults in Colombia. This fault system forms the southwestern part of the Pamplona indenter, which is formed by two opposite right-angle bends (an "S" shape pattern). From the Pamplona indenter in eastern Colombia, the plate boundary extends as far south as the Jambeli Graben in the Guayaquil Gulf of Ecuador.

Important thrusting also occurs subparallel to the Boconó fault on both sides of the Andes chain, which sustains the mountain's height. Therefore, shear (and slip) partitioning occurs here due to an oblique (east-west) maximum horizontal stress. Several active pull-apart basins are associated with releasing bends and stepovers along the Boconó fault trace (Las González, Mucuchíes?, Cabudare, and Yaracuy? basins, among others). The Yaracuy basin seems to be associated with a 45° clockwise bend of the Boconó fault, and the basin's formation may be explained by another mechanism than transtension.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*: Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS); June 1998.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Regional neotectonic and seismotectonic studies for seismic-hazard assessment of oil facilities based on aerial photointerpretation, field confirmation, and helicopter verification. Refined by paleoseismic assessment of four trenches.

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:
LENGTH/*LONGITUD* : End-to-end 620 km (cumulative 694 km)
Comments/*Comentarios*: GIS values for fault in Venezuela; fault continues west into Colombia.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 42° E. ± 84°
Comments/*Comentarios*: GIS values for fault in Venezuela; fault continues west into Colombia.

NUMBER OF SECTIONS/*NUMERO DE SECCIONES:* 5
Comments/*Comentarios*: For this compilation, the Boconó fault is defined as having five fault sections. Audemard has considered these to be segments on the basis of his and others work.

VE-06A, SOUTH OF MÉRIDA SECTION OF BOCONÓ FAULT SYSTEM

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-06a

SECTION NAME/*NOMBRE DE LA SECCION*: South of Mérida section of Boconó fault system
Comments/*Comentarios*: This section of the fault extends from the Colombian border on the southwest to the town of San Juan de Lagunillas on the northeast (at the Gónzales pull-apart basin).

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 181 km (cumulative 186 km)
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 59° E. ± 38°.
AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical?
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral (confirmed by fault-plane kinematic indicators).
Comments/*Comentarios:* Part of the strike-slip motion shown by the Boconó fault in its central sections is accommodated in the southern Venezuelan Andes by secondary subparallel faults such as Caparo, Uribante and San Simón faults (not described herein). Slip on the Boconó fault is transferred to the Colombian southern foothills system by a left lateral-reverse fault system formed by the Chinacota and Chucarima faults in Colombia and the Bramón fault in Venezuela (Boinet, 1985). This fault system forms the southwestern part of the Pamplona indenter.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: A continuous series of impressive aligned geomorphic features, such as 1-to-5-km wide valleys and linear depressions, passes, saddles, trenches, sag ponds, scarps and sharp ridges. Measured dextral offset of Mesozoic rocks are as much as 75 km, although the most reliable value probably is about 30 km (from outcrops of the Tovar Granite).

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 300 yr to 3.0-3.5 k.y. (variable along strike).
Comments/*Comentarios:* Interval based on paleoseismic studies. Interval is about 300 yr at La Grita trench for M 7.1-7.3 earthquakes (between La Grita and Mérida). The return period on the southermost part of the Boconó fault (Mis Delirios trench, north of San Cristobal) is ten times longer (3.0-3.5 k.y.) than at La Grita locality (for M7+ earthquakes). Recurrence is much longer towards San Cristobal because the fault splays into different strands and part of the dextral slip is also accommodated by other sub-parallel faults (Caparo, Seboruco, Queníquea, Uribante, San Simón faults, among others).

SLIP RATE/*TASA DE MOVIMIENTO*: 5.2±0.9 mm/yr (south of Mérida; variable along strike)
Comments/*Comentarios:* Slip rate seems to decrease southward from Mérida to San Cristobal.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Historic/Historico (1610 A.D. and 1894 A.D.)
Comments/*Comentarios:* See descriptions below.

1610 SURFACE FAULTING ON VE-06A, SOUTH OF MÉRIDA SECTION

NAME OF EARTHQUAKE/*NOMBRE DEL TERREMOTO*: 1610 Mocotíes earthquake (Terremoto de Mocotíes de 1610)
Comments/*Comentarios:* This earthquake heavily damaged the town of La Grita and triggered a huge debris slide that dammed the Mocotíes River at El Volcán-La Playa that later broke, sweeping away everything downstream.

DATE/*FECHA*: February 03, 1610

MAGNITUDE OR INTENSITY/*MAGNITUD O INTENSIDAD*: Ms 7.1 to 7.3 (from trench assessment). Maximum Io of X (MMI).
Comments/*Comentarios:* At La Grita (Táchira state).

MOMENT MAGNITUDE/*MAGNITUD POR MOMENTO*: Unknown

LENGTH OF SURFACE RUPTURE/*LONGITUD DE RUPTURA* : 80-100 km
Comments/*Comentarios:* Estimated from size of MMI VIII isoseismal.

MAXIMUM SLIP AT SURFACE/*DESPLAZAMIENTO MAXIMO EN SUPERFICIE*: 30 cm of vertical throw
Comments/*Comentarios:* Measured on walls of trench excavated within the meizoseismal area; calculated net coseismic slip ranges between 1.2 and 1.7 m

SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO*: Dextral>normal
Comments/*Comentarios:* Normal dextral slip at trench site (striations pitch 10° to 15° NE).

1894 SURFACE FAULTING ON VE-06A, SOUTH OF MÉRIDA SECTION

NAME OF EARTHQUAKE/*NOMBRE DEL TERREMOTO*: The Great Earthquake of the Venezuelan Andes (El Gran Terremoto de los Andes Venezolanos)
Comments/*Comentarios:* This earthquake heavily damaged the towns of Santa Cruz de Mora, Zea, Mesa Bolívar, Tovar, San Juan de Lagunillas, Chiguará and Mérida.

DATE/*FECHA*: April 28, 1894

MAGNITUDE OR INTENSITY/*MAGNITUD O INTENSIDAD*: Ms 7.3 or higher. Maximum Io of XI (MMI).
Comments/*Comentarios:* Between Tovar and Santa Cruz de Mora (Mérida State)

MOMENT MAGNITUDE/*MAGNITUD POR MOMENTO*: Unknown

LENGTH OF SURFACE RUPTURE/*LONGITUD DE RUPTURA* : 140-170 km
Comments/*Comentarios:* Estimated from size of MMI VIII isoseismal. It may have ruptured both sections 6a and 6b, with nucleation at a releasing bend(?) in the González pull-apart basin southeast of Merida.

MAXIMUM SLIP AT SURFACE/*DESPLAZAMIENTO MAXIMO EN SUPERFICIE*: 30 cm of vertical throw (measured in walls of trench excavated away from the meizoseismal area). Net coseismic slip should have been about 2.0 m.

SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO*: Dextral>normal
Comments/*Comentarios:* Normal dextral slip at trench site (slickensides pitch of 10° to 15° NE).

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VE-06b, Santa Cruz de Mora to Los Frailes section of Boconó fault system

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-06b

SECTION NAME/*NOMBRE DE LA SECCION*: Santa Cruz de Mora to Los Frailes section of Boconó fault system
Comments/*Comentarios*: This section of the Boconó fault extends from Santa Cruz de Mora (on the southwest) to Los Frailes (on the northeast).

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 83.8 km (cumulative 86.6 km)
Comments/*Comentarios:* Overlaps with VE-06a and VE-06c.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 63° E. ± 18°.
AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral.
Comments/*Comentarios:* The northern part of this section clearly shows a normal component as well as a dextral (right-lateral) component. Several south-facing fault scarps are observed on middle to late Pleistocene alluvial fans between Mucuchíes and Apartaderos.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Impressive and numerous aligned geomorphic features characteristic of active strike slip faults, such as elongated valleys and linear depressions, fault scarps, passes, saddles, trenches, sag ponds, shutter and linear ridges. Dextral offset of drainages and of moraines radiocarbon dated at about 15 k.y. confirm the sense of slip.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 1.1-1.5 k.y. (maximum) for Ms 7+ earthquakes
Comments/*Comentarios:* Between Mucuchíes and Los Frailes, the Boconó fault is comprosed of two main strands that bound a releasing stepover. The maximum return period is based on a paleoseismic assessment of the northern strand (carried out at Morros de los Hoyos trench). The southern branch (section 6c) accommodates about 75 percent of the fault slip in this area, whereas the northern one (section 6b) carries the remaining (25 percent). However, recurrence intervals should be shorter where the section has a simplier, single trace and a larger slip rate (southern part of section 6b; between Mérida and Mucuchíes).

SLIP RATE/*TASA DE MOVIMIENTO*: Probably 6-9 mm/yr (variable, dependent upon fault geometry and number of strands)
Comments/*Comentarios:* Slip rate probably between 6 mm/yr (as seen on section VE-06a) and 9 mm/yr (as seen on section VE-06c). At releasing bend in the Mucubají area, this section shows a slip rate of about 2.6 mm/yr, whereas the remainder of the slip is carried by the main southern strand (section 6c). In this neighboring section, the slip rate should be near its maximum value. This is because the Boconó fault north of Santo Domingo [VE-06c] has to accommodate all the slip along strike, since there are no other right-lateral faults within the Andes chain. For section VE-06b, the slip rate increases northerly from Mérida and reaches its maximum value of 9 mm/yr on overlapping section 6c in the Santo Domingo-Aracay area; a figure that is essentially consistent with those predicted by plate motion models of about 10 mm/yr.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Holocene and post glacial (<15 ka)
Comments/*Comentarios:* Multiple movements in the Holocene from trench assessment (Morros de Los Hoyos trench). This timing is also confirmed by 40 m of right lateral offset of El Desecho moraine, which formed during the last glacial epoch. However, the most recent rupture could be historical if the 1894 earthquake also ruptured VE-06b in the Apartaderos area, as suggested by the size and shape of its MMI VIII isoseismal.

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VE-06c, MUCUCHÍES TO ANZOÁTEGUI SECTION OF BOCONÓ FAULT SYSTEM

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-06c

SECTION NAME/*NOMBRE DE LA SECCION*: Mucuchíes to Anzoátegui section of Boconó fault system
Comments/*Comentarios*: This section of the Boconó fault extends from Mucuchíes (on the southwest) to Anzoátegui (on the northeast).

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 89 km (cumulative 90 km)
Comments/*Comentarios*: GIS values; also reported to be about 100 km long (Mucuchíes to Anzoátegui).
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 54° E. ± 5°
AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical.
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral.
Comments/*Comentarios:* Dextral offset of last glacial moraines and drainages (among those the 33-km right-lateral offset of the Boconó River) confirm the sense of slip.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Numerous aligned geomorphic features characteristic of active strike slip faults, such as elongated valleys and linear depressions, fault scarps, passes, saddles, trenches, sag ponds, shutter and linear ridges.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: About 200 yr for Ms 7.3 earthquakes.
Comments/*Comentarios:* This estimate is derived from the maximum rupture length combined with the slip rate shown below.

SLIP RATE/*TASA DE MOVIMIENTO*: 9 mm/yr
Comments/*Comentarios:* Based on 100 m of dextral offset of late Pleistocene (15 k.y.) Los Zerpa moraines; this figure is consistent with that predicted by plate motion models of about 10 mm/yr. At releasing bend in the Mucubají area, this section shares the above-estimated slip rate with a slower (2.6 mm/yr) secondary northern strand [VE-06b] that was trenched at Morros de los Hoyos. In section 6c there are no other right-lateral faults within the Andes chain. Thus, the slip rate on this section is the highest along the Boconó fault northeast of Santo Domingo, where it has to accommodate all the strike slip motion.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Holocene and post glacial (<15 ka)
Comments/*Comentarios*: The fault offsets late Pleistocene (15 k.y.) moraines at Los Frailes and Aracay Pass. The last movement could be historical (1812 earthquake?) since the fault has a high slip rate and shows very fresh scarps on morainal deposits at the Aracay Pass. However, since there is no historical or scientific confirmation of an 1812 rupture on this section, so we do not show the fault as historical.

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VE-06D, ANZOÁTEGUI TO BARQUISIMETO SECTION OF BOCONÓ FAULT SYSTEM

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-06d

SECTION NAME/*NOMBRE DE LA SECCION*: Anzoátegui to Barquisimeto section of Boconó fault system
Comments/*Comentarios*: This section of the Boconó fault extends from Anzoátegui (on the southwest) to Barquisimeto (on the northeast).

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 150 km (cumulative 150 km)
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 48° E. ± 7°
AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical.
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral

Comments/*Comentarios:* Confirmed by fault-plane kinematic indicators (tectoglyphs) observed at the Buena Vista trench. Dextral (right-lateral) offset of drainages confirms the sense of slip.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Several aligned geomorphic features characteristic of active strike slip faults, such as elongated valleys and linear depressions, fault scarps, saddles, trenches, sag ponds, shutter and linear ridges. This section ends in transtension at the Cabudare pull-apart basin (a releasing stepover).

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 400 yr for Ms 7.5 earthquakes.
Comments/*Comentarios:* Corresponds to a maximum recurrence interval if the entire section length would rupture at once.

SLIP RATE/*TASA DE MOVIMIENTO*: 5 mm/yr.
Comments/*Comentarios:* Slip rate is not well constrained and results from an interpolation between contiguous sections.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Holocene and post glacial (<15 ka).
Comments/*Comentarios:* Confirmation by paleoseismic assessment: E-trending (30 m) open cracks at the Buena-Vista trench (SW of Barquisimeto) are filled by organic-rich Holocene deposits.

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VE-06e, Cabudare to Morón section of Boconó fault system

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-06e

SECTION NAME/*NOMBRE DE LA SECCION*: Cabudare to Morón section of Boconó fault system

Comments/*Comentarios*: This section of the Boconó fault extends from Cabudare (on the southwest) to Morón (on the northeast) and some distance offshore. An alternate name for the secion might be Yaracuy, which could be confused with the entire Yaracuy State, or San Felipe, which is for a prominent town near the fault.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:

LENGTH/*LONGITUD* : End-to-end 176 km (cumulative 182 km)

Comments/C*omentarios*: GIS values for entire section. Also listed as about 130 km, on shore from Cabudare to Morón.

AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 70° E. ± 15°

Comments/C*omentarios*: GIS values for entire section, including offshore.

AVERAGE DIP/*INCLINACION PROMEDIO*: High-angle to north.

SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral and reverse

Comments/*Comentarios:* Sense of slip confirmed by fault-plane kinematic indicators measured along the southern border of the Aroa Range (NE-SW trending). Across the coastal areas of the Yaracuy Basin, the fault shows normal vertical component (almost east-west trending).

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Several aligned geomorphic features characteristic of active strike slip faults, such as fault scarps, faceted spurs, benches, trenches, sag ponds, pop-ups, shutter and linear ridges on middle to late Pleistocene alluvial units. Dextral offset of drainages and alluvial fans (*i.e.,* the Yaritagua fan) confirm the sense of slip. This section connects to the east-west trending, predominately offshore San Sebastián fault [VE-16] after undergoing a 45° clockwise bend. This bend is responsible for formation of the Yaracuy basin, whereas it was previously proposed to have a pull-apart origin.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 700 to 2000 yr for a Ms 7.4-7.5 earthquake.
Comments/*Comentarios*: This interval corresponds to a return period for an earthquake generated by rupturing of the entire section length.

SLIP RATE/*TASA DE MOVIMIENTO*: 1-3 mm/yr.
Comments/*Comentarios:* Uncertainty in slip rate is due to the low precision of the relative chronology of alluvial units in the Yaracuy Basin. Also, other faults may contribute to the net slip across the plate boundary.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Holocene and post glacial (<15 ka).
Comments/*Comentarios:* Most recent movement seems to be Holocene at the northern onshore tip of the fault where the fault crosses the coastal areas of the Yaracuy Basin.

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VE-07, ANDES SOUTHERN FOOTHILLS FLEXURE

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-07

FAULT NAME/*NOMBRE DE LA FALLA*: Andes Southern Foothills Flexure (Flexura Frontal Surandina)
Comments/*Comentarios*: The Andes Southern Foothills Flexure extends from the Batatuy River on the southwest to the city of Acarigua-Araure (on the northeast). It is named for its location along the southern foothills of the Venezuelan Andes.

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: This SE-vergent blind thrust fault, which is rooted under the Venezuelan Andes, deforms the Neogene sedimentary (mainly molassic) sequence along the southern foothills of the Andean mountain chain. This structural feature comprises flats and ramps, but does not crop out since it has a blind fault tip that is responsible for flexing Quaternary alluvial terraces that form these foothills. This fault is an outer thrust of the much wider main thrust system, which forms the mountain-foothills boundary closer to the Andes. Similar NE-vergent thrusts exist on the NW side of the Venezuelan Andes (as shown on the map), but they are not described in this database. However, we believe that they are symmetrically opposed analogs to the Southern Foothills Flexure.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*: Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS); June 1998.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Regional neotectonic and seismotectonic studies for seismic-hazard assessment of oil facilities based on aerial photo interpretation, field confirmation and helicopter reconnaissance. Additional information comes from fault-plane kinematic indicators (microtectonic evaluations) and seismic-reflection data.

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:
LENGTH/*LONGITUD* : End-to-end 373 km (cumulative 590 km)
Comments/C*omentarios*: GIS values. Main fault includes four flexural scarps between 40 and 85 km in length along most eastward trace. Cumulative value for length includes westward strand.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 47° E. ± 50°
Comments/C*omentarios*: GIS values for entire fault set.
AVERAGE DIP/*INCLINACION PROMEDIO*: Low dip to north.
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Reverse

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Very conspicuous 250-km-long, south-facing flexural scarp that is as much as 200 m high. This feature divides the Andeanfoothills from the Llanos plains. It is interrupted at several points by large water gaps that are located at geometric boundaries that may mark discrete

seismogenic parts of the fault (i.e., fault segments). Quaternary terraces show progressive tilting and/or unconformities (the older the terraces, the steeper the gradient). In association with the flexure, other geomorphic features are observed: wind gaps, diverted rivers, rivers flowing in opposite direction to the general trend, dammed channels and rivers, abandoned alluvial fans and broom-shaped river patterns.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 2-3 k.y.

Comments/*Comentarios:* 2-3 k.y. value is for a maximum credible earthquake between Ms 6.9 and 7.2 on any of the 4 sections. For the entire 250-km-long flexure, one M 7 earthquake should occur more frequently, perhaps every 500 to 750 yr. The longer the rupture length, the larger the earthquake and the longer the return period should be. The return period is a function of the maximum length of individual fault sections and of slip rate.

SLIP RATE/*TASA DE MOVIMIENTO*: 0.5 mm/yr.

Comments/*Comentarios:* Estimated net slip rate from the vertical uplift of Quaternary alluvial terraces taking into account the sub-surface geometry of the thrust.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Quaternary (<1.6 Ma)

Comments/*Comentarios:* The flexural scarp affects the entire Pleistocene alluvial terrace sytem to a certain extent.

REFERENCES/*REFERENCIAS*:

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VE-08, LA VICTORIA FAULT SYSTEM

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-08

FAULT NAME/*NOMBRE DE LA FALLA*: La Victoria fault system

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: La Victoria fault system extends eastward for 350 km from south of Barquisimeto to Cabo Codera; it crosses the Coast Range of northern Venezuela, mainly cutting Mesozoic metamorphic nappes emplaced during oblique collision between the proto-Caribbean arc and South America passive margin. The fault system bounds the River Tuy basin on the north and cuts across the Lake Valencia basin. The fault system is parallel to the structural grain of the Coast Range and is considered to be a "P" shear to the main Caribbean-South America right-lateral strike-slip plate boundary.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*: Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS); June 1998.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Regional neotectonic and seismotectonic studies for seismic-hazard assessment of urban areas based on aerial photointerpretation, field confirmation and helicopter verification, supplemented by several shallow seismic profiles and studies of fault-plane kinematic indicators and present stress tensors.

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:
LENGTH/*LONGITUD* : End-to-end 354 km (cumulative 466 km)
Comments/*Comentarios*: GIS values for entire fault.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 78° E. ± 17°
Comments/*Comentarios*: GIS values for entire fault.

NUMBER OF SECTIONS/*NUMERO DE SECCIONES:* 5
Comments/*Comentarios*: Five sections of La Victoria fault system are defined for this compilation.

VE-08A, GUACAMAYA FAULT OF LA VICTORIA FAULT SYSTEM

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-08a

SECTION NAME/*NOMBRE DE LA SECCION*: Guacamaya fault of La Victoria fault system
Comments/*Comentarios*: The Guacamaya fault extends from Gamelotal (close to the Andes chain) to Valencia, northwest of Valencia Lake.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 146 km (cumulative 235 km)
Comments/*Comentarios*: GIS values. Previously reported as 110 km or more; possibly as much as 170 km long if one includes the horse-tail splay on the west end and blind portion on the east end.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 80° E. ± 22°
AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical.
Comments/*Comentarios:* Probable high north dip if the fault has reactivated features of the previous oblique-collisional stage.
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral (confirmed by fault-plane kinematic indicators).

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Forms several geomorphic features on Mesozoic metamorphic rocks and early Pleistocene deposits of the Lake Valencia basin, southwest of Valencia, such as right-lateral offset drainages, trenches, faceted spurs, and linear drainages. It seems to be the metamorphic-sedimentary contact in the subsurface along the northern margin of the Lake Valencia basin. The fault seems to die out in a transtensional horse-tail splay on the northern side of its western tip. This transtensional horse-tail splay is responsible for the formation of an irregular depression (basin) between the Andes Chain and the Coast Range of northern Venezuela; this basin is filled with Pliocene and Pleistocene alluvial deposits (Guamasire Formation, among others).

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 2 k.y. for an earthquake of Ms 7.0.
Comments/*Comentarios:* This value corresponds to a return period for which the entire fault length would rupture. If the fault is longer than about 100 km, the maximum credible earthquake could be as large as a Ms 7.5.

SLIP RATE/*TASA DE MOVIMIENTO*: 0.6 mm/yr.
Comments/*Comentarios:* Estimated from right-lateral drainage offset as measured at the Guataparo Dam, adjacent to the Guacamaya Range (SW of Valencia).

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Quaternary (<1.6 Ma)
Comments/*Comentarios:* The fault cuts early Pleistocene alluvial units of the Lake Valencia basin (activity confirmed by evaluation of fault-plane kinematics).

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VE-08B, LA CABRERA FAULT OF LA VICTORIA FAULT SYSTEM

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-08b

SECTION NAME/*NOMBRE DE LA SECCION*: La Cabrera fault of La Victoria fault system
Comments/*Comentarios*: This fault lies below the surface of Lake Valencia and is entirely within its Quaternary basin.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 26 km (cumulative 26 km)
Comments/C*omentarios*: GIS values; overlaps with VE-08c.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 72° E. ± 0°
Comments/C*omentarios*: GIS values reflect linear trace.
AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical.
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Trace is entirely underwater. The fault disrupts the lake bottom and its Holocene lacustrine deposits.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: An Ms 6.3 earthquake every 545 yr.
Comments/*Comentarios:* Interval based on maximum credible rupture length (as long as the recognized section length).

SLIP RATE/*TASA DE MOVIMIENTO*: 1.1 mm/yr.
Comments/*Comentarios:* Estimated from vertical rate that has been calculated from seismic profiling of Lake Valencia and assuming that the pitch (rake) of striations (about 25° azimuth) observed at Pichao can be extrapolated to this section of the fault.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Holocene and post glacial (<15 ka).

REFERENCES/*REFERENCIAS*:

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VE-08c, El Horno fault of La Victoria fault system

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-08c

SECTION NAME/*NOMBRE DE LA SECCION*: El Horno fault of La Victoria fault system
Comments/*Comentarios*: This fault lies below the surface of Lake Valencia and is entirely within its Quaternary basin.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 34 km (cumulative 34 km)
Comments/C*omentarios*: GIS values; overlaps with VE-08b and VE-08d.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 72° E. ±2°
AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical.
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Concealed, trace is entirely underwater. The fault disrupts lacustrine deposits on the floor of Lake Valencia.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: An Ms 6.4 earthquake every 1.2 k.y.
Comments/*Comentarios:* Interval based on eventual rupture along entire length of fault section.

SLIP RATE/*TASA DE MOVIMIENTO*: 0.5 mm/yr.
Comments/*Comentarios:* Estimated from vertical rate that has been calculated from seismic profiling of Lake Valencia and assuming that the oblique pitch (about 25°) of striations observed at Pichao [VE-08e] can be extrapolated to this section of the fault.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Quaternary (<1.6 Ma)
Comments/*Comentarios:* The fault affects late Pleistocene lacustrine sediment of Lake Valencia.

REFERENCES/*REFERENCIAS*:

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PLANESA, 1978. Estudio geosísmico del lago de Valencia por el método de reflexión sísmica con fuente Uniboom de poca energia. Informe inédito, Caracas. 43pp.

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VE-08D, LA VICTORIA FAULT OF LA VICTORIA FAULT SYSTEM

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-08d

SECTION NAME/*NOMBRE DE LA SECCION*: La Victoria fault of La Victoria fault system
Comments/*Comentarios*: This section of the fault extends between the towns of Maracay (on the west) and Las Tejerias (on the east). It is named for La Victoria, a city west-southwest of Caracas.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 52 km (cumulative 52 km)
Comments/*Comentarios*: GIS values; overlaps with VE-08c and VE-08e.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 77° E. ± 3°
Comments/*Comentarios*: GIS values; low range indicates nearly linear trace.
AVERAGE DIP/*INCLINACION PROMEDIO*: Sub-vertical
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Forms geomorphic features on Mesozoic metamorphic rocks, east of Maracay: These include right-lateral offset of drainages, diversion of rivers, trenches (grabens), pop-ups, faceted spurs, linear drainages and valleys (such as Aragua Valley). Expression in Quaternary sediment along the Aragua Valley is poor due to sedimentation rates that are faster than fault slip rates.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: Maximum credible earthquake of Ms 6.7 every 1500 yr.
Comments/*Comentarios:* Interval assumes that the entire fault section would rupture at once.

SLIP RATE/*TASA DE MOVIMIENTO*: 0.55 mm/yr.
Comments/*Comentarios:* Slip rate is based on 1.2 km of dextral offset of drainage.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Quaternary (<1.6 Ma)

REFERENCES/*REFERENCIAS*:

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VE-08E, PICHAO FAULT OF LA VICTORIA FAULT SYSTEM

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-08e

SECTION NAME/*NOMBRE DE LA SECCION*: Pichao fault of La Victoria fault system
Comments/*Comentarios*: This section of the fault extends from Las Tejerias (on the west) to Cabo Codera (on the coast, to the east).

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:

LENGTH/*LONGITUD* : End-to-end 118 km (cumulative 118 km)

Comments/C*omentarios*: GIS values. Reported length about 70 km or more. Total length could be longer if fault extends beyond Cabo Codera.

AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 76° E. ± 3°

Comments/C*omentarios*: GIS values; low range indicates nearly linear trace.

AVERAGE DIP/INCLINACION PROMEDIO: Sub-vertical.

SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral; some normal component.

Comments/*Comentarios:* Modern sense of movement is confirmed by fault-plane kinematic indicators (tectoglyphs). However, the fault had a normal component along northern margin of the River Tuy basin during its formation in Pliocene to early Pleistocene time.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Forms geomorphic features on Mesozoic metamorphic rocks and along the Mesozoic metamorphic-Neogene sedimentary contact on the northern margin of the River Tuy basin. Fault features include right-lateral offset drainages (350-m dextral offset of Guaire River), trenches (grabens), faceted spurs, linear drainages and linear valleys, shutter ridges, and diverted rivers. The fault is responsible for formation of the River Tuy basin, although some controversy still remains about its origin (graben formed by orogenic collapse vs. pull-apart basin owing to fault divergence). The strongest evidence for a collapse origin is based on subvertical striations observed on fault planes at Pichao Bridge on the Caracas-Santa Lucia Road.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: Maximum credible earthquake of Ms 6.9 every 2300 yr.

Comments/*Comentarios:* Assuming that the entire length of the fault section would break at once and taking into account the slip rate mentioned below.

SLIP RATE/*TASA DE MOVIMIENTO*: 0.4 mm/yr.

Comments/*Comentarios:* Estimated from 350-m right-lateral offset of the Guaire River in the past 1 Ma (estimated age).

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Quaternary (<1.6 Ma)

REFERENCES/*REFERENCIAS*:

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VE-09, RÍO GUÁRICO FAULT

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-09

FAULT NAME/*NOMBRE DE LA FALLA*: Río Guárico fault

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: The Río Guárico fault crosses the Coast Range of northern Venezuela in an oblique direction, mainly cutting Mesozoic metamorphic rocks (nappes) emplaced during the oblique collision between the proto-Caribbean arc and the South America passive margin. This fault extends southeasterly from the Lake Valencia basin to the overturned (thrust) belt located at the front of the Coast Range nappes (southwest of Altagracia de Orituco). The fault is composed of two NW-SE striking sections connected by a thrust fault; this geometry suggests a restraining stepover. The Rió Guárico fault seems to act as a lateral ramp and constitutes a "R" shear of the Caribbean-South America plate boundary.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*: Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS); June 1998.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Regional neotectonic and seismotectonic studies for seismic-hazard assessment of urban areas based on aerial photointerpretation, field confirmation and helicopter verification. Additional information from stress tensors derived from populations of active faults with reliable fault-plane kinematic indicators.

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:
LENGTH/*LONGITUD* : End-to-end 120 km (cumulative 131 km)
Comments/*Comentarios*: GIS values for entire fault. Does not include thrusts to south and east.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 71° W. ± 19°
NUMBER OF SECTIONS/*NUMERO DE SECCIONES:* 2
Comments/*Comentarios*: Two sections of the Río Guarico fault are defined for this compilation.

VE-09A, NORTH SECTION OF RÍO GUÁRICO FAULT

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-09a

SECTION NAME/*NOMBRE DE LA SECCION*: North section of Río Guárico fault
Comments/*Comentarios*: This section of the fault extends from the southeast shore of Lake Valencia to the town of San Juan de Los Morros.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 33 km (cumulative 40 km)
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 59° W. ± 2°
AVERAGE DIP/*INCLINACION PROMEDIO*: Unknown.
Comments/*Comentarios:* However, if the fault acts as a lateral ramp, it should have a high to intermediate north dip (dip should decrease progressively with depth).
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral
Comments/*Comentarios:* Fault shows some normal component at releasing stepover, near town of Villa de Cura.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Displays numerous geomorphic features characteristic of transcurrent faults, such as shutter ridges, fault saddles, trenches, benches, linear drainages and valleys, sag ponds, faceted spurs, right-lateral offset drainages. At Villa de Cura, the fault forms a small (about 2-km-wide) pull-apart basin at a releasing stepover.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: ≥2300 yr for a maximum credible earthquake of Ms 6.6.
Comments/*Comentarios:* This estimate results from assuming that the entire length of this section would break during a single rupture event.

SLIP RATE/*TASA DE MOVIMIENTO*: ≤0.3 mm/yr.
Comments/*Comentarios:* Estimated by comparison with similar synthetic Riedel shears that extend across the same region (Tácata).

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Quaternary (<1.6 Ma)
Comments/*Comentarios:* Pull-apart basin at releasing stepover is filled by Pleistocene alluvial deposits.

REFERENCES/*REFERENCIAS*:

AUDEMARD, F. A.; DE SANTIS, F.; LUGO, M.; SINGER, A. & COSTA, C., 1988. Sismotectónica y Sismicidad Histórica in SINGER, A. (coord.) Estudio de Amenaza Sísmica para las Urbanizaciones La Punta y Mata Redonda, al Sur de Maracay. FUNVISIS Unpubl. Co. Rpt. for MINDUR. 2 Vol.

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VE-09B, SOUTH SECTION OF RIÓ GUÁRICO FAULT

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-09b

SECTION NAME/*NOMBRE DE LA SECCION*: South section of Rió Guárico fault
Comments/*Comentarios*: This section of the fault extends from San Sebastián de Los Reyes to the Camatagua Reservior.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 89 km (cumulative 91 km)
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 77° W. ± 18°
AVERAGE DIP/*INCLINACION PROMEDIO*: Unknown.
Comments/*Comentarios:*: However, if the fault acts as a lateral ramp, it should have a high to intermediate north dip (dip should decrease progressively with depth).
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Displays numerous geomorphic features characteristic of transcurrent faults, such as shutter ridges, fault benches, faceted spurs, and right-lateral offset of drainages and alluvial fans.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: ≥2300 yr for a maximum credible earthquake of Ms 6.6.
Comments/*Comentarios:* This estimate results from assuming that the entire length of this section would break during a single rupture event.

SLIP RATE/*TASA DE MOVIMIENTO*: ≤0.3 mm/yr.
Comments/*Comentarios:* Estimated by comparison with similar synthetic Riedel shears that extend across the same region (Tácata).

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Quaternary (<1.6 Ma)
Comments/*Comentarios:* Offsets Pleistocene alluvial fan.

REFERENCES/*REFERENCIAS*:

AUDEMARD, F. A.; DE SANTIS, F.; LUGO, M.; SINGER, A. & COSTA, C., 1988. Sismotectónica y Sismicidad Histórica in SINGER, A. (coord.) Estudio de Amenaza Sísmica para las Urbanizaciones La Punta y Mata Redonda, al Sur de Maracay. FUNVISIS Unpubl. Co. Rpt. for MINDUR. 2 Vol.

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VE-10, TACAGUA-EL AVILA FAULT SYSTEM

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-10

FAULT NAME/*NOMBRE DE LA FALLA*: Tacagua-El Avila fault system

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: The Tacagua-El Avila fault system crosses the Coast Range of northern Venezuela in an oblique manner. It is exclusively within the Coast Range belt, mainly cutting Mesozoic green schist meta-sedimentary rocks emplaced during oblique collision of the proto-Caribbean arc and the South America passive margin. This fault system extends southeasterly from the town of Arrecife (on the coast) to Araira. The system bounds the Caracas and Guarenas-Guatire depressions on the north.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*
Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS); June 1998.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Regional neotectonic and seismotectonic studies for seismic-hazard assessment of railways and oil facilties based on aerial photointerpretation, field confirmation and helicopter verification. Additional information from assessment of fault-plane kinematic indicators .

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:
LENGTH/*LONGITUD* : End-to-end 67.6 km (cumulative 70.2 km)
Comments/*Comentarios*: GIS values for entire fault.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 77° W. ± 13°.
Comments/*Comentarios*: Approximate value for entire fault.

NUMBER OF SECTIONS/*NUMERO DE SECCIONES*: 2
Comments/*Comentarios*: For this compilation, the El Tacagua-El Avila fault system is defined as having two sections.

VE-10A, TACAGUA FAULT OF TACAGUA-EL AVILA FAULT SYSTEM

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-10a

SECTION NAME/*NOMBRE DE LA SECCION*: Tacagua fault of Tacagua-El Avila fault system
Comments/*Comentarios*: This fault extends from Arrecife (on the coast) to Caracas.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 19.7 km (cumulative 20.1 km)
AVERAGE STRIKE/*RUMBO PROMEDIO* : About N. 71° W.
AVERAGE DIP/*INCLINACION PROMEDIO*: High dip to the south.
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral with significant normal component.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Forms geomorphic features characteristic of transcurrent faults with normal component, such as shutter ridges, fault saddles, trenches, benches, linear valleys, sag ponds, large faceted spurs. Drainages show persistent right-lateral offset.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 4 k.y. for a maximum credible earthquake of Ms 6.5.
Comments/*Comentarios:* This estimate results from assuming that the entire length of this section would break during a single rupture event.

SLIP RATE/*TASA DE MOVIMIENTO*: 0.17 mm/yr.
Comments/*Comentarios*: Rate derived from the offset and estimated age of geomorphic features (Acosta, 1997).

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Quaternary (<1.6 Ma)

REFERENCES/*REFERENCIAS*:

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VE-10B, EL AVILA FAULT OF TACAGUA-EL AVILA FAULT SYSTEM

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-10b

SECTION NAME/*NOMBRE DE LA SECCION*: El Avila fault of Tacagua-El Avila fault system
Comments/*Comentarios*: The fault extends from Caracas to Araira.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 48.8 km (cumulative 50.1 km)
AVERAGE STRIKE/*RUMBO PROMEDIO* : About N. 83° W.
AVERAGE DIP/*INCLINACION PROMEDIO*: High dip to the south.
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral with significant normal component.
Comments/*Comentarios:* Fault forms a bedrock/alluvial contact on the north boundaries of the Pliocene-Quaternary Caracas and Guarenas-Guatire valleys (depressions).

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Trace of fault is marked by geomorphic features characteristic of strike-slip faults, such as shutter ridges, fault saddles, trenches, benches, linear valleys, sag ponds, faceted spurs, and lateral offset drainages.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: ≥2300 yr for a maximum credible earthquake of Ms 6.8.
Comments/*Comentarios:* This estimate results from assuming that the entire length of this section would break during a single rupture event.

SLIP RATE/*TASA DE MOVIMIENTO*: ≤0.4 mm/yr.
Comments/*Comentarios*: This slip rate is estimated by comparison with other regional faults of similar geomorphic expression and structural style (with other synthetic Riedel shears to the boundary).

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Quaternary (<1.6 Ma)

REFERENCES/*REFERENCIAS*:

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VE-11, TÁCATA FAULT

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-11

FAULT NAME/*NOMBRE DE LA FALLA*: Tácata fault
Comments/*Comentarios*: The Tácata fault has been mistakenly named the "Charallave" fault on some maps.

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: The Tácata fault crosses the Coast Range of northern Venezuela in an oblique manner, mainly cutting the Mesozoic metamorphic rocks (nappes) emplaced during oblique collision between the proto-Caribbean arc and the South America passive margin. This fault diverges from the La Victoria fault [VE-08] at Las Tejeras and extends southeasterly to Altagracia de Orituco. The Tácata fault bounds the Pliocene-Quaternary River Tuy basin on the southwest and is responsible for its formation, although controversy still remains about this basin's origin (graben by orogenic collapse vs. pull-apart basin at fault divergence). This fault is a "R" shear of the Caribbean-South America plate boundary.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*: Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS); June 1998.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Regional neotectonic and seismotectonic studies for seismic-hazard assessment of urban areas and railways based on aerial photo interpretation and field confirmation. Fault has also been subject to an evaluation of fault-plane kinematics.

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:
LENGTH/*LONGITUD* : End-to-end 78 km (cumulative 80 km)
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 64° W. ± 10°
AVERAGE DIP/*INCLINACION PROMEDIO*: High dip to the north.
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral.
Comments/*Comentarios:* Fault shows a significant normal component between Cúa and Ocumare del Tuy, where the fault bounds the River Tuy basin on the southwest. Both slip components have been confirmed from fault-plane kinematic indicators.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: The trace of the fault is marked by geomorphic features such as right-lateral offset drainages, trenches, faceted spurs, linear drainages and linear valleys, shutter ridges, and diverted rivers and crest lines characteristic of normal-dextral faults. These features are on Mesozoic metamorphic rocks along the course of the Tuy River (between Tácata and Cúa) and along the Mesozoic metamorphics-Neogene sedimentary contact on the southwestern margin of the River Tuy basin.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: ≥2 k.y. for a maximum credible earthquake of Ms 6.7.
Comments/*Comentarios*: This estimate results from assuming that the entire length of this section would break during a single rupture event. This fault may rupture in two portions of about 40 km in length, reducing the return period for the entire fault (80 km) by half (≥1000 yr).

SLIP RATE/*TASA DE MOVIMIENTO*: ≤0.4 mm/yr.
Comments/*Comentarios*: Unpublished report where the information was taken from is poorly documented, but states

that the dextral slip rate is calculated from measured offset of geomorphic features (F.A. Audemard, written commun., 1999).

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Quaternary (<1.6 Ma)

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VE-12, PÍRITU FAULT

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-12

FAULT NAME/*NOMBRE DE LA FALLA*: Píritu fault

Comments/*Comentarios*: Also known incorrectly as the Santa Inés or La Costa fault.

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: The Píritu fault runs offshore along the coast of the Barlovento depression in central Venezuela. A short section of the fault crops out east of the town of Píritu, where the lateral slip fault ramps into a reverse fault and associated folding on the northern block at its eastern tip". The transpressional tip demonstrates the dextral character of this fault.

Offshore, the location of the fault has been established from both seismic profiling and correlation of wells with outcrops. The Píritu fault juxtaposes Mesozoic metamorphic rocks (nappes) and frontal Tertiary sedimentary rocks of the Coast Range (on the western block) against the Neogene-Quaternary shelf sedimentary sequence of the Barcelona Bay basin (on the eastern block). This fault is responsible for formation of the Barcelona Bay basin. The fault is considered as a “R” shear of the Caribbean-South America plate boundary.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*: Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS); June 1998.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Regional neotectonic and seismotectonic studies for seismic-hazard assessment of oil-industry facilities based on aerial photo interpretation, field confirmation and helicopter verification. Quaternary stress tensor derived from fault-plane kinematic indicators.

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:
LENGTH/*LONGITUD* : End-to-end 157 km (cumulative 166 km)
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 65° W. ± 14°
AVERAGE DIP/*INCLINACION PROMEDIO*: High dip to the north.
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral.
Comments/*Comentarios:* Fault has a significant normal component along the southern margin of the Barcelona Bay basin.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Onshore, three short subparallel splays show geomorphic evidence of Quaternary activity: right-lateral offset drainages and crest lines, benches, faceted spurs, linear drainages, shutter ridges, and diverted rivers and crest lines.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 3,250 yr for a maximum credible earthquake of Ms 7.1.
Comments/*Comentarios:* This estimate results from assuming that the entire length of this section would break during a single rupture event. However, since it is unlikely that the fault ruptures the entire (140 km) length at once, it is more probable for the fault to break in two individual portions of about 70 km length. Therefore, the return period may only be half of the above value.

SLIP RATE/*TASA DE MOVIMIENTO*: 0.3-0.4 mm/yr.
Comments/*Comentarios:* Estimated from vertical slip, which has been calculated from seismic profiling of sediment on the Unare Shelf. Net slip rate probably higher, but <1 mm/yr.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Quaternary (<1.6 Ma)
Comments/*Comentarios:* Early Pleistocene molassic deposits east of Píritu are faulted and tilted.

REFERENCES/*REFERENCIAS*:

AUDEMARD, F. A., 1998. Estudio de Neotectónica y Geología de Fallas Activas donde se construirá el Patio de Tanques Sur-Jose. FUNVISIS Unpubl. Co. Rpt. for INTEVEP, S.A. 37 pp.

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VE-13, EL PILAR FAULT

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-13

FAULT NAME/*NOMBRE DE LA FALLA*: El Pilar fault

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: The El Pilar fault extends roughly east-west between the Cariaco Trough and the Gulf of Paria, in northeastern Venezuela. It runs mainly offshore, although a 70-km-long section can be followed onshore in the Sucre State, between the Gulfs of Cariaco and Paria, where it mainly juxtaposes Mesozoic metamorphics rocks exposed in the Araya and Paria Peninsulas on the north against the Mesozoic sedimentary foreland sequence of the Interior Range. Important geothermal activity is associated with the onshore portion of the fault. The fault is herein divided into four different sections that are separated by geometric anomalies of its trace: a first westernmost section extending from the Cariaco pull-apart basin located at a large releasing bend to the restraining stepover of the Caigüire Hills at Cumaná, a second section from the Caigüire Hills to the Casanay-Guarapiche restraining bend, a third from Guarapiche to the town of El Pilar, and a fourth from El Pilar to the connection with the Los Bajos fault in the Paria Gulf shelf. The El Pilar fault, along with the Boconó [VE-08] and San Sebastián [VE-16] faults, is considered to be the main boundary between the Caribbean and South America plates. However, the plate boundary is a ca. 100-km-wide zone where active transpression is accommodated and partitioning is occurring (strike-slip mostly along Boconó-San Sebastián-El Pilar fault system and transverse compression accommodated by the entire transpressional zone). Transcurrent slip along this fault has been estimated at as much as 1,000 km, although a new reconstruction of the Southern Caribbean boundary amounts to only 55 km of strike-slip along this major fault system. This new, much smaller offset seems to be in close agreement with the width of the Cariaco trough as measured along the opening direction (east-west) of the associated releasing bend.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*: Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS);June 1998.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Regional neotectonic and seismotectonic studies for seismic-hazard assessment of oil facilities based on aerial photointerpretation, field confirmation and helicopter verification. Additional information from fault-plane kinematics and paleoseismic assessments.

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:
LENGTH/*LONGITUD* : End-to-end 408 km (cumulative 439 km)
Comments/C*omentarios*: GIS values for entire fault.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 90° E. ± 19°
Comments/C*omentarios*: GIS values for entire fault.

NUMBER OF SECTIONS/*NUMERO DE SECCIONES:* 4
Comments/*Comentarios*: Four fault sections are defined for the El Pilar fault for this compilation.

VE-13A, OFFSHORE SECTION OF EL PILAR FAULT

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-13a

SECTION NAME/*NOMBRE DE LA SECCION*: Offshore section of El Pilar fault
Comments/*Comentarios*: Exclusively offshore, except for a very short portion onshore that forms the south side of the Caigüire Hills restraining stepover.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 212 km (cumulative 215 km)
Comments/C*omentarios*: GIS values. Length is reported tobe at least 120 km to more than 200 km depending which offshore faults are included in the section.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 85° W. ± 20°
AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical.
Comments/*Comentarios:* High north dip along the southern edge of the Cariaco trough.
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral.
Comments/*Comentarios*: The fault should have a significant normal component along the southern edge of the Cariaco trough.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Sea bottom floor of Cariaco trough is faulted down-to-north (normal component).

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: About 400 yr for a maximum credible earthquake of Ms 7.5.

Comments/*Comentarios* This estimate results from assuming that the entire length of this section would break during a single rupture event.

TASA DE MOVIMIENTO SLIP RATE/*TASA DE MOVIMIENTO*: 5 mm/yr (average); variable along strike
Comments/*Comentarios*: The fault has an exstimated 5 mm/yr (average) slip rate that is variable along strike. The rate increases easterly along the southern margin of the Cariaco pull-apart basin and reaches a maximum value at the Caigüire Hills restraining steopver. This slip rate is shared with the northern margin fault of the Cariaco pull-apart basin.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Holocene and post glacial (<15 ka).
Comments/*Comentarios:* Quaternary basin fill and sea bottom floor sediment of Cariaco trough are faulted

REFERENCES/*REFERENCIAS*:

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VE-13B, CUMANÁ TO CASANAY SECTION OF EL PILAR FAULT

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-13b

SECTION NAME/*NOMBRE DE LA SECCION*: Cumaná to Casanay section of El Pilar fault

Comments/*Comentarios*: This section of the El Pilar fault extends from Cumaná to Casanay.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:

LENGTH/*LONGITUD* : End-to-end 103 km (cumulative 105 km)

Comments/*Comentarios*: GIS values. Reported length is about 80 km between Cumaná and Casanay.

AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 85° E. ± 20°

AVERAGE DIP/*INCLINACION PROMEDIO*: High dip to the north (between 60° and 70°).
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral (confirmed by fault-plane kinematic indicators).
Comentarios/Comments: Historical (1997) surface rupture confirmed the right-lateral sense of this fault (100°-110° striking synthetic Riedel shear connected by folds at restraining stepovers; 130°-140° striking tension cracks). No visible vertical component along the 1997 surface rupture.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Between Muelle de Cariaco and Casanay, this major fault strand is marked by a continuous series of aligned geomorphic features such as linear rivers, fault saddles, pop-ups, offset drainages, aligned springs, ecotones (vegetational changes), trenches, sag ponds, scarps, and shutter ridges. The fault also has hot springs at San Antonio del Golfo. Offshore in the Cariaco Gulf, it may splay in several strands.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: About 180 yr for a maximum credible earthquake of Ms 7.2.
Comments/*Comentarios*: Paleoseismic assessment (2 trenches) is under way at the present time (June 1998) in order to refine this recurrence interval. However, it is worth mentioning that two recent earthquakes (Cumaná 1929 and Cariaco 1997) have ruptured the entire length of this section.

SLIP RATE/*TASA DE MOVIMIENTO*: 9 mm/yr
Comments/*Comentarios*: Slip rate is extrapolated from the Boconó fault [VE-06], since the Boconó-San Sebastián-El Pilar faults comprise the main-strike slip boundary between the Caribbean and South American plates. Besides, this value closely matches the plate motion vectors that show about 10 mm/yr of east-west motion.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Historic/Historico (1929 A.D. and 1997 A.D.)
Comments/*Comentarios*: See comments below.

1929 Surface Faulting on VE-13b, Cumaná to Casanay section

NAME OF EARTHQUAKE/*NOMBRE DEL TERREMOTO*: 1929 Cumaná earthquake (Terremoto de Cumaná de 1929)
Comments/*Comentarios:* This earthquake heavily damaged the city of Cumaná.

DATE/*FECHA*: January 17, 1929

MAGNITUDE OR INTENSITY/*MAGNITUD O INTENSIDAD*: Maximum Io of VIII (MKS). Ms 6.3 to 6.9.
Comentarios/comments: Strong site effects at Cumaná (Sucre State) may have lead to overestimation of the magnitude (Ms 6.9).

MOMENT MAGNITUDE/*MAGNITUD POR MOMENTO*: Unknown

LENGTH OF SURFACE RUPTURE/*LONGITUD DE RUPTURA* : 25-30 km
Comments/*Comentarios:* Length estimated from aftershock distribution (40 km would be an upper bound). Four km of the rupturing was observed onshore, east of Cumaná. The remainder of the rupture must have occurred offshore, farther to the west on the Cariaco Gulf shelf.

MAXIMUM SLIP AT SURFACE/DESPLAZAMIENTO MAXIMO EN SUPERFICIE: Unknown

SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO*: Dextral slip
Comments/*Comentarios:* Based on trend of open cracks observed at the Punta Delgada, east of Cumaná.

1997 Surface Faulting on VE-13b, Cumaná to Casanay section

NAME OF EARTHQUAKE/*NOMBRE DEL TERREMOTO*: The 1997 Cariaco earthquake (El sismo de Cariaco de 1997)
Comments/*Comentarios:* This earthquake caused heavy damage in the town of Cariaco, but the towns of Chiguana, Casanay, Cumaná, and Guarapiche also suffered significant damage. The death toll was about 80, mainly due to collapse of four buildings.

DATE/*FECHA*: July 9, 1997

MAGNITUDE OR INTENSITY/*MAGNITUD O INTENSIDAD*: Maximum Io of VIII (MMI); Ms 6.8
Comments/*Comentarios:* Instrumental epicenter was located between Cariaco and Casanay, slightly north of the fault trace. The macroseismic epicenter coincides well with the instrumental epicenter.

MOMENT MAGNITUDE/*MAGNITUD POR MOMENTO*: Mw 6.9
Comments/*Comentarios:* Mo 2.53 E+26 dyne/cm.

LENGTH OF SURFACE RUPTURE/*LONGITUD DE RUPTURA* : About 40 km onshore.
Comments/*Comentarios:* From aftershock distribution, rupture must be nearly 60 km long, located between San Antonio del Golfo and Río Casanay (15-20 km of surface rupture are offshore on the Cariaco Gulf shelf). This earthquake rupture, combined with the 1929 rupture, has managed to break the entire length of the section VE-13b (Cumaná to Casanay) and part of section VE-13c. The 1997 earthquake nucleated at the Casanay-Guarapiche restraining bend, producing a major rupture to the west along section VE-13b and a secondary rupture to the east along part of section VE-13c.

MAXIMUM SLIP AT SURFACE/*DESPLAZAMIENTO MAXIMO EN SUPERFICIE*: 40 cm (right-lateral)
Comments/*Comentarios:* Maximum coseismic slip along section VE-13b was measured on a country road west of Pantoño; there was no visible vertical component. The mean coseismic slip was 20-25 cm along the 30 km of rupture in section 13b. Slip released after the main shock has been important: slip at one site near the main shock's epicenter (west of Casanay) has increased by almost 150 percent (from 25 cm to 61 cm) in the first 5 months after the earthquake. Maximum slip on a secondary rupture (beyond restraining bend and into section VE-13c) is 20 cm in a right-lateral sense (also no vertical component).

SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO*: Pure dextral-slip.
Comments/*Comentarios:* Pure dextral-slip except at local geometric anomalies (such as at Guarapiche pop-up at restraining bend, the fault shows 7°W rake of reverse-dextral slip in the third trench that was excavated). Surface rupture of this event confirmed the right-lateral character of this fault (strike 100°-110°, synthetic Riedel shear connected by folds at restraining stepovers; also some 130°-140° striking tension cracks). Outside geometric anomalies, no vertical component was seen along the 1997 surface rupture.

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VE-13c, Casanay to El Pilar section of El Pilar fault

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-13c

SECTION NAME/*NOMBRE DE LA SECCION*: Casanay to El Pilar section of El Pilar fault
Comments/*Comentarios*: This section of the fault extends from Casanay to El Pilar.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:
LENGTH/*LONGITUD* : End-to-end 17 km (cumulative 18 km)
Comments/*Comentarios*: GIS values; also reported to be about 30 km. Includes several anastomosing fault strands not shown at map scale.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 61° E. ± 8°
AVERAGE DIP/*INCLINACION PROMEDIO*: High dip to the north.
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral.
Comments/*Comentarios:* Sense confirmed by fault-plane kinematic indicators at Las Toscanas trench (striations at less than 10° rake).

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Consistent and persistent geomorphic features of transcurrent faulting (fault scarp, right-lateral offset drainage, pop-ups, sag pond, fault trench, shutter ridge, fault saddle, etc). Also, the fault is associated with strong geothermal activity around Mundo Nuevo.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 50 yr for maximum credible earthquakes of Ms 6.2.
Comments/*Comentarios:* This is the estimated recurrence of this single section [VE-13c], but the 1997 Cariaco earthquake demonstrated that the fault can break across contiguous sections (or seismogenic segments). This observation also confirms the idea that geometric boundaries, such as restraining bends, can become nucleation points of future larger earthquakes generated by the simultaneous rupture of two “discrete or individual” seismogenic segments.

SLIP RATE/*TASA DE MOVIMIENTO*: 9 mm/yr.
Comments/*Comentarios:* Slip distributed across three to five subparallel fault strands. Only one of those strands was trenched at Las Toscanas in 1994, prior to the most recent earthquake. One additional trench has been excavated across this section at the Guarapiche pop-up (results are under way).

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Holocene and post Glacial /Holoceno y post Glacial (<15 ka).
Comments/*Comentarios*: Holocene organic-rich soils are present in 130°-striking open cracks (at Las Toscanas and the Guarapiche trenches). In addition, during the 1997 Cariaco earthquake a maximum of 20 cm of right-lateral slip (with no vertical component) occurred on a secondary rupture on this fault section. This rupture formed east of the restraining bend that separates the section VE-13b and Ve-13c.

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VE-13D, GUARÁUNOS SECTION OF EL PILAR FAULT

SECTION NUMBER/*NUMERO DE LA SECCION*: VE-13d

SECTION NAME/*NOMBRE DE LA SECCION*: Guaráunos section of El Pilar fault

Comments/*Comentarios*: The Guaráunos section of El Pilar fault extends eastward from El Pilar to the connection with the Los Bajos fault [VE-15] in the Paria Gulf shelf. This section name is newly applied herein.

GEOMETRY OF THE SECTION/*GEOMETRIA DE LA SECCION*:

LENGTH/*LONGITUD* : End-to-end 102 km (cumulative 102 km)

AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 89° E. ±2°

Comments/C*omentarios*: GIS values indicate nearly linear trace.

AVERAGE DIP/*INCLINACION PROMEDIO*: Unknown, probably near vertical

SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: There are few geomorphic features (such as fault scarps and linear drainages) on Holocene alluvial plains owing to high sedimentation rates (Sabanas de Venturini o Guaráunos.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 220 yr for a maximum credible earthquake of Ms 7.3.

Comments/*Comentarios*: This estimate results from assuming that the entire length of this section would break during a single rupture event.

SLIP RATE/*TASA DE MOVIMIENTO*: 9 mm/yr

Comments/*Comentarios*: Slip rate is extrapolated from the Boconó fault [VE-06], since the Boconó-San Sebastián-El Pilar faults comprise the main-strike slip boundary between the Caribbean and South American plates. Besides, this value closely matches the plate motion vectors that show about 10 mm/yr of east-west motion.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Holocene and post glacial (<15 ka).

Comments/*Comentarios:* There is no diagnostic geomorphic evidence of Holocene activity even though El Pilar fault has a very high slip rate. This relation is explained by high sedimentation rates in this area, which is influenced by a delta. The fault is considered to be younger than 15 ka, largely because of its high slip rate (see above).

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VE-14, SAN MATEO FAULT

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-14

FAULT NAME/*NOMBRE DE LA FALLA*: San Mateo fault
Comments/*Comentarios*: This fault is also known as the Jose fault.

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: This fault diverges southeasterly from El Pilar fault [VE-13] at the Cariaco trough and extends to the coast, near Jose, where it derives one of its names. The San Mateo fault bounds the Barcelona Bay (basin) at sea (on the northeast) and the El Juncal Lagoon onshore (on the southwest). This fault is a “R” or “R-T” shear of the Caribbean South America plate boundary. The Barcelona Bay basin may be related to active transtension on the southern block of the La Victoria fault [VE-08] at its eastern tip. Several other young faults are imaged on the sea floor between the San Mateo fault and El Pilar [VE-13a] faults.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*: Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS); June 1998.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Regional neotectonic and seismotectonic studies for seismic-hazard assessment of oil-industry facilities based on aerial photo interpretation, field confirmation and helicopter reconnaissance. Existing shallow- and refraction-seismic surveys provide essential information about the fault.

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:

LENGTH/*LONGITUD* : End-to-end 78 km (cumulative 80 km)

AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 48° W. ± 9°

AVERAGE DIP/*INCLINACION PROMEDIO*: High dip to the south.

SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral and normal.

Comments/*Comentarios:* The fault shows a significant down-to-south normal component on the Unare shelf, where the fault bounds the Barcelona Bay basin on the northeast. Sedimentation is still controlled by this fault. Vertical and horizontal components of slip are subequal.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: The sea-bottom (floor) of the Unare shelf shows evidence of down-to-south normal faulting.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 1 k.y. for maximum credible earthquake of Ms 6.7.

Comments/*Comentarios:* This estimate results from assuming that the entire length of this section would break during a single rupture event. If the fault is actually two 40-km-long sections, then the return period for the entire fault is half as much (about 500 yr).

SLIP RATE/*TASA DE MOVIMIENTO*: 0.8 mm/yr.

Comments/*Comentarios:* Estimated from vertical offset calculated from shallow offshore seismic data. Net slip rate is probably higher (>1 mm/yr)

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Holocene and post glacial (<15 ka).

Comments/*Comentarios:* Holocene transgressional sediment and the sea bottom (floor) of the Unare shelf are faulted.

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VE-15, LOS BAJOS FAULT

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-15

FAULT NAME/*NOMBRE DE LA FALLA*: Los Bajos fault

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: Los Bajos fault diverges southeasterly from El Pilar fault [VE-13] at its eastern tip on the Paria Gulf shelf. Los Bajos fault only crops out in southwestern Trinidad for about 30 km in length, but is rather well-known elsewhere from oil-industry seismic data. It is considered to be the prolongation of the Boconó [VE-6], San Sebastián [VE-16], El Pilar [VE-13] fault system and connects (in an unidentified manner) the main strike-slip southern Caribbean Plate boundary to the lesser Antilles subduction zone. Nevertheless, it is clear that Los Bajos fault bounds two different seismogenic domains: an actively-seismic NW-dipping subduction slab on the northeast and a shallow crustal seismogenic province on the southwest.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*: Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS); June 1998.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Bibliographic compilation and preliminary seismogenic assessment.

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:
LENGTH/*LONGITUD* : End-to-end 155 km (cumulative 158 km)
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 64° W. ± 12°
AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical.
Comments/*Comentarios:* It dips to either side, as do most major transcurrent faults.
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral.
Comments/*Comentarios:* It shows a significant down-to-the-north offset on seismic profiles of southwestern Trinidad.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Unknown, trace mainly offshore

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: 290 yr for maximum credible earthquake of Ms 7.1.
Comments/*Comentarios:* This estimate results from assuming that the entire length of this section would break during a single rupture event and taking into account the slip rate listed below. If the fault is divided into two 65-km-long sections, the return period for the entire fault is half as much(about 145 yr).

SLIP RATE/*TASA DE MOVIMIENTO*: Roughly 5-7 mm/yr.
Comentarios: Estimated from 10-11 km of right-lateral slip in post-Pliocene time (<1.6 to 2 m.y.).

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Probably Holocene and post glacial (<15 ka)
Comments/*Comentarios:* Quaternary (<1.6 Ma) movement is proved by Pliocene sedimentary units of southwestern Trinidad that are faulted and folded. However, on the basis of the high long-term slip rate, we suspect that the fault is young (<15 ka).

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VE-16, SAN SEBASTIÁN FAULT

FAULT NUMBER/*NUMERO DE LA FALLA*: VE-16

FAULT NAME/*NOMBRE DE LA FALLA*: San Sebastián fault

Comments/*Comentarios*: A short portion of the San Sebastián fault is also known as the Bruscas fault. The San Sebastián fault extends offshore (north) of the Coastal Range of Venezuela; its location is poorly known, primarily from unpublished marine geophysical surveys.

SYNOPSIS AND GEOLOGIC SETTING/*SINOPSIS Y AMBIENTE GEOLOGICO*: Little is known about the age or activity rates of the nearly 500-km-lomg San Sebastián fault. The fault runs offshore along the north-central coast of Venezuela, bounding (on the north) the green schist metamorphic rocks of the Coast Range belt. It is considered as part of the main strike-slip boundary between the Caribbean and South American plates, together with the Boconó [VE-06], El Pilar [VE-13], and Los Bajos [VE-15] faults. It only crops out for a very short distance at the Caracas International Airport, where it is known as the Bruscas fault. In this area, the fault brings Miocene-Pliocene marine sedimentary rocks to the surface.

COMPILER, AFFILIATION, & DATE OF COMPILATION/*COMPILADOR, AFILIACION Y FECHA DE COMPILACION*: Franck A. Audemard M.; Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS); June 1999.

TYPE OF STUDIES/*TIPOS DE ESTUDIOS*: Most of the trace of the fault is offshore on the Caribbean sea floor, but its location has been identified by seismic profiling. However, it cuts Miocene-Pliocene marine sedimentary rocks where it comes onshore for a very short distance at the Caracas International Airport.

GEOMETRY OF THE FAULT/*GEOMETRIA DE LA FALLA*:
LENGTH/*LONGITUD* : End-to-end 483 km (cumulative 529 km)
Comments/*Comentarios*: GIS values (most is basically offshore); includes subparallel strand that overlaps El Pilar fault [VE-13]. Also reported as about 230 km between the Bocono [VE-06] and El Pilar [VE-13] faults.
AVERAGE STRIKE/*RUMBO PROMEDIO* : N. 86° E. ± 11°
AVERAGE DIP/*INCLINACION PROMEDIO*: Subvertical
SENSE OF MOVEMENT/*SENTIDO DE MOVIMIENTO:* Right-lateral
Comments/*Comentarios:* Inferred from position along Caribbean-South American plate boundary.

GEOMORPHIC EXPRESSION/*EXPRESION GEOMORFOLOGICA*: Fault mostly on sea floor bottom. However, Hans Diederix (pers. commun., 1999) says that a short portion of this fault is on land at the Maiquetia International Airport of Caracas. It formerly displayed geomorphic features such as offset drainages, fault scarps, shutteridges, linear fault ridges and sagponds. This expression is best seen on older aerial photographs taken before modernization and expansion of the airport, which has obliterated most of the geomorphic features.

RECURRENCE INTERVAL/*INTERVALO DE RECURRENCIA*: Unknown

SLIP RATE/*TASA DE MOVIMIENTO*: 3-5(?) mm/yr
Comments/*Comentarios:* Slip rate is a portion of that extrapolated from the Boconó fault [VE-06], since the Boconó-San Sebastián-El Pilar faults comprise the main-strike slip boundary between the Caribbean and South American plates. The 3-5 mm/yr rate is based on about half of the slip from plate motion (about 10 mm/yr) being distributed on other parallel (but offshore) structures that form the 100 km wide plate-boundary zone.

TIME OF MOST RECENT MOVEMENT/*EDAD DEL ULTIMO MOVIMIENTO*: Probably Holocene and post glacial (<15 ka)
Comments/*Comentarios:* The fault deforms Miocene-Pliocene marine sediment along the northern side of the Caracas International Ariport at Maiguetia. Inferred slip rate of 3-5 mm/yr across this plate boundary fault and former geomorphic expression at the airport suggests that movement is young (<15 ka).

REFERENCES/*REFERENCIAS*:

None supplied by compiler

TABLE 1. QUATERNARY FAULTS OF VENEZUELA

(LAS FALLAS CUATERNARIAS DE VENEZUELA)

Number Número	Name of structure Nombre de estructura	Sense of movement (major/minor) Sentido de movimiento (mayor/menor)	Time of most recent movement Edad del último movimiento	Slip rate (mm/yr) Tasa de movimiento (mm/año)
VE-01	**Oca-Ancón fault system**			
VE-01a	Oca fault	Right-lateral	<15 ka	0.45-2.0
VE-01b	Ancón fault	Right-lateral	<15 ka	1.6
VE-01c	Camare-Paraiso fault	Right-lateral/reverse	Probably <15 ka	About 2
VE-01d	Unnamed section	Right-lateral/normal	Probably <15 ka	About 2
VE-01e	Socremo fault	Reverse/right-lateral	<1.6 Ma	<2
VE-02	**Urumaco fault**			
VE-02a	West section (strand)	Right-lateral	<1.6 Ma	0.05
VE-02b	East section (strand)	Right-lateral	<15 ka	0.05
VE-03	**Río Seco fault**	Right-lateral	<15 ka	0.35
VE-04	**Valera fault system**			
VE-04a	Valera fault	Left-lateral	<15 ka	=1.0
VE-04b	Río Momboy fault	Left-lateral/normal	<1.6 Ma	0.7
VE-05	**Tuñame fault**			
VE-05a	South section	Normal/dextral(?)	<1.6 Ma	<0.5
VE-05b	North section	Normal	<15 ka	0.5
VE-06	**Boconó fault system**			
VE-06a	Section south of Mérida	Right-lateral	Historic (1610 A.D., 1894 A.D)	5.2±0.9
VE-06b	Santa Cruz de Mora to Los Frailes section	Right-lateral	<15 ka (possibly historic, 1894)	6-9
VE-06c	Mucuchíes to Anzoátegui section	Right-lateral	<15 ka (possibly historic, 1812)	9
VE-06d	Anzoátegui to Barquisimeto section	Right-lateral	<15 ka	5
VE-06e	Cabudare to Morón section	Right-lateral/reverse	<15 ka	1-3
VE-07	**Andes Southern foothills flexure**	Reverse	<1.6 Ma	0.5
VE-08	**La Victoria fault system**			
VE-08a	Guacamaya fault	Right-lateral	<1.6 Ma	0.6
VE-08b	La Cabrera fault	Right-lateral	<15 ka	1.1
VE-08c	El Horno fault	Right-lateral	<1.6 Ma	0.5
VE-08d	La Victoria fault	Right-lateral	<1.6 Ma	0.55
VE-08e	Pichao fault	Right-lateral/normal	<1.6 Ma	0.4

TABLE 1—CONTINUED. QUATERNARY FAULTS OF VENEZUELA

(LAS FALLAS CUATERNARIAS DE VENEZUELA)

Number Número	Name of structure Nombre de extructura	Sense of movement (major/minor) Sentido de movimiento (mayor/menor)	Time of most recent movement Edad del último movimiento	Slip rate (mm/yr) Tasa de movimiento (mm/año)
VE-09	**Rió Guárico fault**			
VE-09a	North section	Right-lateral	<1.6 Ma	≤0.3
VE-09b	South section	Right-lateral	<1.6 Ma	≤0.3
VE-10	**Tacagua-El Avila fault system**			
VE-10a	Tacagua fault	Right-lateral/normal	<1.6 Ma	0.17
VE-10b	El Avila fault	Right-lateral/normal	<1.6 Ma	≤0.4
VE-11	**Tácata fault**	Right-lateral	<1.6 Ma	≤0.4
VE-12	**Píritu fault**	Right-lateral	<1.6 Ma	0.3-0.4
VE-13	**El Pilar fault**			
VE-13a	Offshore section	Right-lateral	<15 ka	5 (average)
VE-13b	Cumaná to Casanay section	Right-lateral	Historic (1929 A.D., 1997 A.D)	9
VE-13c	Casanay to El Pilar section	Right-lateral	<15 ka	9
VE-13d	Guaráunos section	Right-lateral	<15 ka	9
VE-14	**San Mateo fault**	Right-lateral/normal	<15 ka	0.8
VE-15	**Los Bajos fault**	Right-lateral	Probably <15 ka	5-7
VE-16	**San Sebastián fault**	Right-lateral	Probably <15 ka	3-5(?)