Geofísica Internacional (2001), Vol. 40, Num. 4., pp. 285-292

The El Tocuyo, Venezuela, earthquake of 3 August, 1950: Focal parameters and tectonic implications

José E. Choy
Laboratorio de Geofísica, Facultad de Ciencias, Universidad de Los Andes, Mérida, Venezuela

Received: February 11, 2000; accepted: September 17, 2001

RESUMEN

El terremoto del El Tocuyo de 1950 estuvo asociado con el sistema de fallas de Boconó. La magnitud Ms tuvo un valor de 6,3; la profundidad focal (determinada a partir pP – P y sP – P) fue de 18 ± 1 km. El mecanismo focal corresponde a fallamiento rumbo deslizante, y los planos nodales vienen dados por:

Plano	Acimut	Buzamiento	Deslizamiento
A	206	72	-166
B	112	77	-19

El plano nodal A es el plano de falla, lo que corresponde a un fallamiento rumbo deslizante dextral. No se ha reportado ruptura superficial.

El epicentro del terremoto se ubica en una zona limitada por las fallas de Boconó y Carache, y que incluye la ciudad de Carora. Todos los mecanismos publicados para sismos con mb > 5.0 y epicentros dentro de la zona presentan mecanismos rumbo-deslizantes. Al sureste de esta zona, la falla de Boconó constituye el limite con el régimen de fallamiento inverso asociado al piedemonte surandino. Esta distribución del fallamiento difiere de la de otras áreas de los Andes Merideños. La actividad sísmica de la zona se confina, en su mayor parte, a los primeros 18 km de profundidad. Los sismos de magnitud mb > 5,0 y de fallamiento rumbo deslizante tienden a nuclearse a profundidades de 16 a 20 km, lo cual indica que el comportamiento sismogénico de las fallas rumbo deslizantes en esta área podría alcanzar los 18 km o más.

PALABRAS CLAVE: Terremoto de El Tocuyo, tectónica Andina, parámetros focales.

ABSTRACT

The El Tocuyo earthquake of 1950 event was associated with the Boconó fault system. The Ms magnitude was 6.3; the focal depth was (from pP – P and sP – P) 18 ± 1 Km. The focal mechanism was strike-slip with the nodal planes as follows:

Plane	Strike	Dip	Slip
A	206	72	-166
B	112	77	-19

Nodal plane A was the fault plane, which corresponds to right-hand strike-slip faulting. No surface rupture has been reported.

The epicenter is located in an area limited by the Boconó and Carache faults, and that includes the town of Carora. All published mechanisms for events with mb > 5.0 in this area correspond to strike-slip faulting. However, southeast of this area, the Boconó fault borders on a reverse faulting regime associated with the southern Andean foothills. The partitioning of faulting differs from other areas of the Mérida Andes. Most seismic activity in the region is confined to the upper 18 km of the crust. Strike-slip events with mb > 5.0 tend to nucleate at depths of 16 – 20 km. The depth of the seismogenic zone for strike- slip faults may reach to 18 km or more.

KEY WORDS: El Tocuyo earthquake, Andean tectonic, focal parameters.

INTRODUCTION

The 3 August 1950 El Tocuyo earthquake (9.74º N, 69.83º W, Figure 1) was one of the most damaging seismic events in western Venezuela during the twentieth century. The town of El Tocuyo (7746 inhabitants in 1950) was severely damaged. Two hundred and fifty houses were destroyed, two churches suffered heavy damage and seven hundred houses were partially destroyed (Ponte *et al.*, 1950). Martínez Olavarría (1951) points out that 93% of houses and

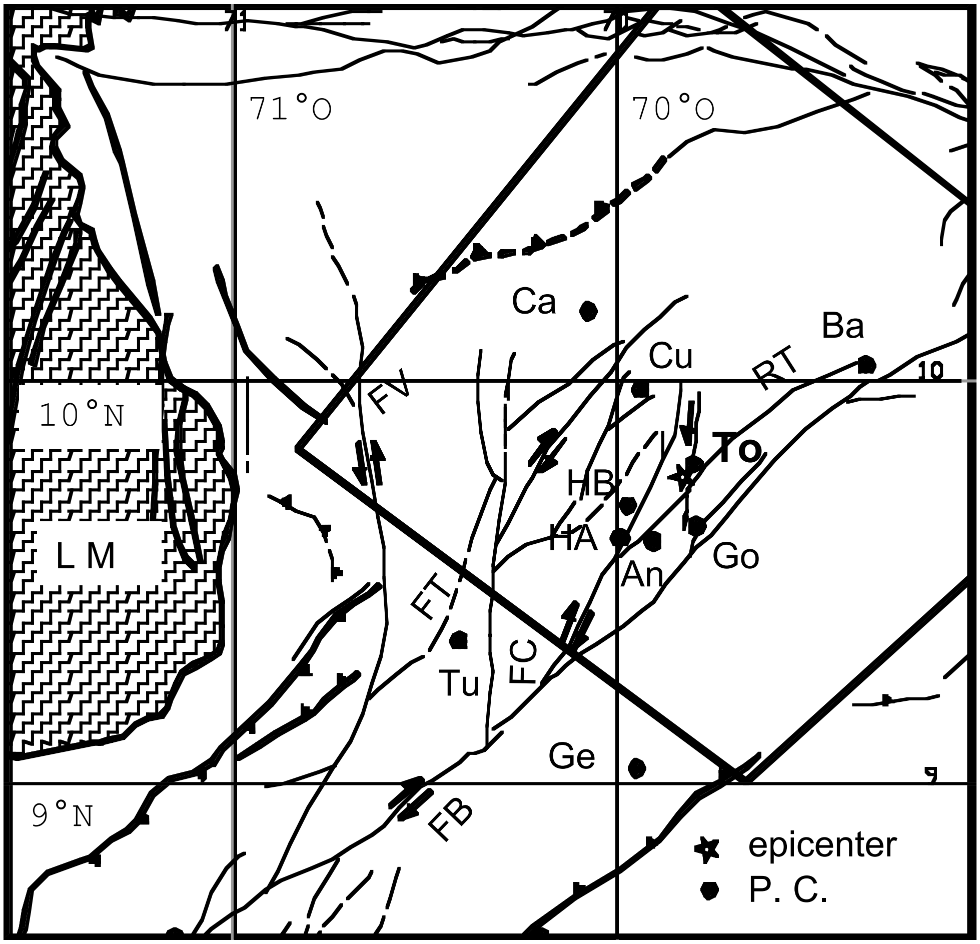

Fig. 1. Neotectonic map of the study area (Beltrán, 1993). Faults are identified as follows: FV: Valera; FT: Trujillo: FC: Carache; FB: Boconó; RT: Río Tocuyo. The latter was added after Giraldo (1985). The population centers (P. C.) are: Tu: Trujillo; Ge: Guanare; Go: Guarico; To: El Tocuyo; Ba: Barquisimeto; HA: Humocaro Alto; HB: Humocaro Bajo; Ca: Carora; Cu: Curarigua: An: Anzoátegui. LM stands for Maracaibo Lake. The star stands for the epicenter of El Tocuyo event. The rectangle enclose the area which contains the epicenters of the events used to examine the depth distribution of the hypocenters (see text).

buildings collapsed and that only 3% remained habitable. In the neighboring localities of Guárico, Anzoátegui, Humocaro Alto and Guaitó half the houses were destroyed (Fiedler, 1960). The damage was influenced significantly by the poor condition of housing (Herrera *et al.,* 1951; Martínez Olavarría, 1951).

The earthquake is one of the largest events instrumentally recorded near the Boconó fault zone. As defined by Schubert (1980) and Schubert and Vivas (1993), the "Boconó fault zone" is a wide zone of faulting with a width of 1 to 5 km and a length of approximately 500 km and "Boconó fault" proper is the fault trace where the main Quaternary deformation has occurred. Some of the largest known earthquakes in western Venezuela, such as the 1812 earthquake (magnitude 8 approximately) and the earthquake of 1894 (magnitude 7 approximately), were probably associated with this fault. The epicenter calculated by Dewey (1972) is off the Boconó fault, as is the one inferred by Von der Osten and Zozaya (1957) from intensity data. On the other hand, Fiedler (1960) attributed the event to the Boconó fault.

In this work we recompute the mechanism, focal depth and surface wave magnitude of the event using available data, and we comment on the seismotectonic implications of this important earthquake.

DATA

An initial attempt to determine the focal mechanism was made by using polarities from the I.S.S. Bulletin (International Seismological Summary). However, an equal area projection suggested that the number of inconsistencies was too large. Copies of records of only five seismological stations were obtained, as some seismological stations active in 1950 were closed or have lost the El Tocuyo records. Seismograms were obtained from stations PAS, TUC, STL, FLA and LPB. In addition, stations CAR, BOG, CHN and GAL reported P wave first motion polarities. The available records are of high quality and they clearly show phases such as direct P, pP, sP, PP and pPP, needed to constrain the focal depth and the mechanism of the earthquake. Figure 2 shows part of the vertical component records from Pasadena and Tucson.

Published focal mechanisms include Dewey (1972), Pennington (1981), Pérez *et al.* (1997), and the Harvard CMT solutions. The seismicity catalogs from Pérez *et al.* (1997) and from the Laboratorio de Geofísica, Universidad de Los Andes, were also found to be useful.

FOCAL DEPTH AND MAGNITUDE

In the Pasadena and Tucson seismograms the depth phases are clear (Figure 2). In the FLA record, P and sP can be distinguished. The readings from these records are given in Choy (1997). Three crustal velocity models were used to calculate the focal depth: those of the Universidad de Los Andes, FUNVISIS, and Pérez *et al.* (1997). The focal depths for these three models are: 18 ± 1 km.

Magnitude values for this event are as follows: 6.75 (PAS), 6,9 (Fiedler, 1960) and 6,25 (Dewey, 1972, after Gutenberg and Richter, 1954).

We recomputed the magnitude following the U.S. Geological Survey *Earthquake Data Report*, using only the vertical components (Willmore, 1979). The result from Rayleigh waves recorded at PAS, TUC and STL, was Msz= 6.3.

FOCAL MECHANISM

The only published focal mechanism of the earthquake is by Fiedler (1960), from P-wave first motions at CAR, BOG, CHN and GAL. Fiedler obtained right-lateral strike-slip, parallel to the trend of the Boconó fault (Figure 3). The P wave polarity at GAL is inconsistent with this mechanism (Figure 3).

We recompute the focal mechanism with P, pP, sP, PP and SH polarities from the available seismograms, and with pP and sP amplitudes from the PAS Benioff 1 – 20 seconds vertical component record. This set of data was supplemented with P-wave first-motion polarities reported by CAR, BOG, GAL and CHN stations.

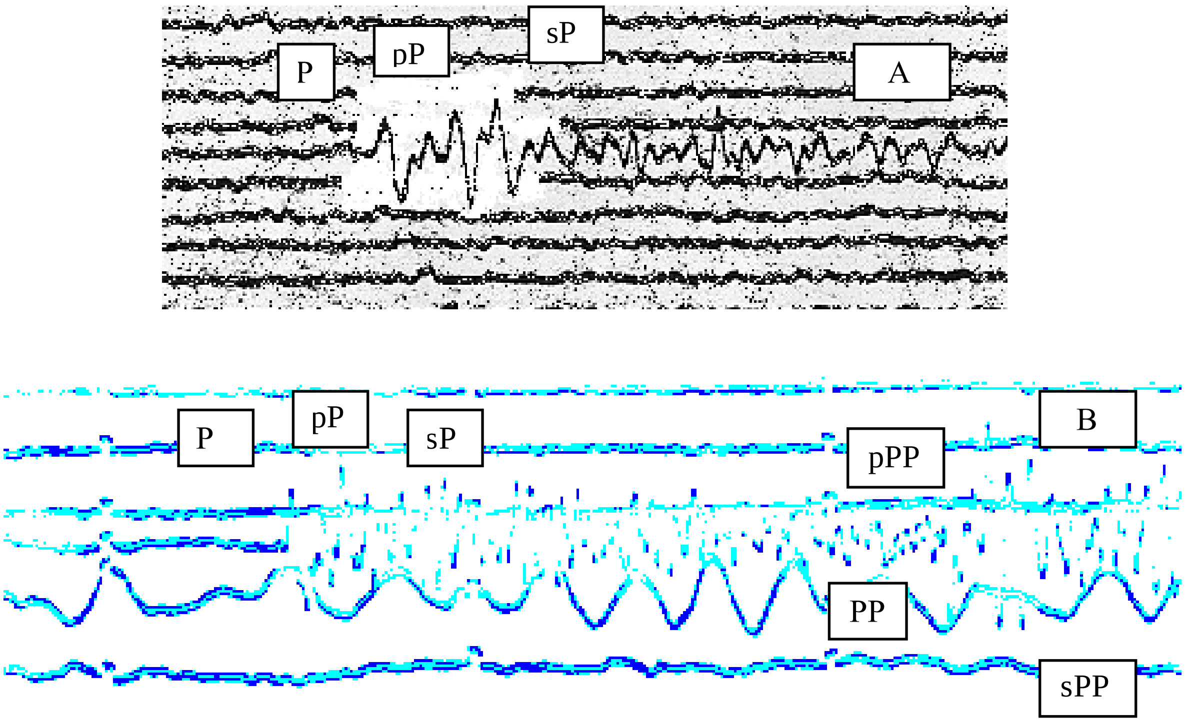

Fig. 2. Sample of seismic records of El Tocuyo earthquake. Record A corresponds to Pasadena (California,U.S.A). The instrument is a Benioff vertical component, with a 1-second pendulum and a 20 second galvanometer. Phases P, pP and sP are clearly identified. Record B corresponds to Tucson (Arizona, U.S.A.). The instrument is also a Benioff vertical component, with a 1-second pendulum and a 90 second galvanometer. Phases P, pP, sP, PP, pPP and sPP are clearly identified.

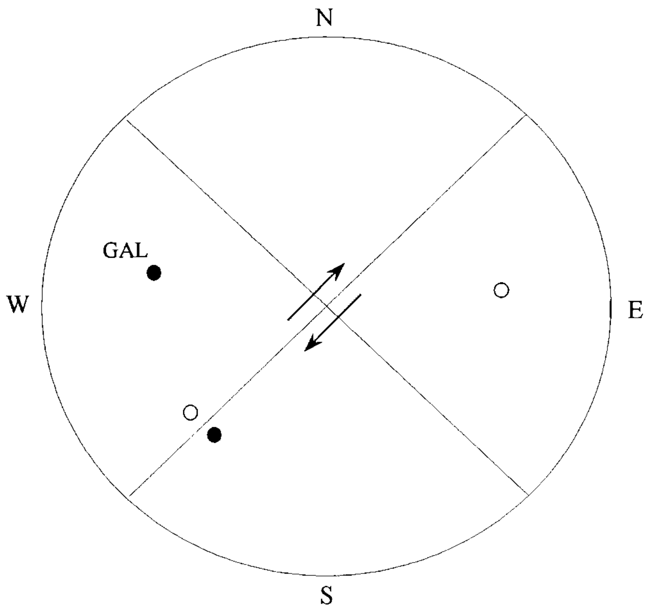

Fig. 3. Focal mechanism of El Tocuyo 1950 earthquake as determined by Fiedler (1960). A lower hemisphere equal area projection is used. Circles represent first motions P wave polarities. Solid ones are compressional; open ones, dilatational. The SE-NE nodal plane is interpreted as the fault plane. Note that the polarity of Galerazamba (GAL) is inconsistent with this solution.

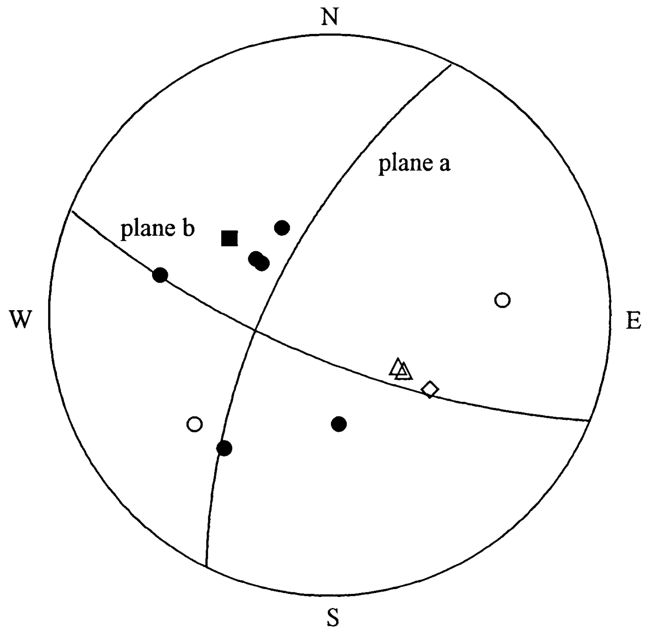

Fig. 4. Lower hemisphere equal area projection of the P nodal planes for the El Tocuyo 1950 earthquake. Solid symbols represent compressions, open symbols, dilatations. Circles: P direct phases, squares: PP, triangles: pP, diamonds: pPP.

Polarities and amplitudes are given in Choy (1997). The search for a solution is done through a three dimensional discrete net of points following the procedure described in Pearce (1977) and Choy (1989). The search for the solution starts at an arbitrary point of the net. Polarities and pP/P (or P/pP) amplitude ratios are computed for every seismic station, and compared with the whole dataset. If there are inconsistencies, the mechanism is rejected. The procedure is repeated until a consistent focal mechanism is found. Figure 4 shows the lower hemisphere projection for the P nodal planes. The resulting focal mechanism is predominantly strike-slip. It is right handed if the nodal plane A corresponds to the fault plane. Notice that the P, pP and PP polarities suffice to constrain the mechanism. Additional information adds reliability to the solution. Thus, in Figure 2 the polarity of the sP phase is unambiguous. This phase propagates upwards as an SV pulse and is reflected as P at the free surface. Hence the polarity of the SV pulse can be obtained from the polarity of the sP pulse, following the notation given in Figure 5.5 and Table 5.1 of Aki and Richards (1980). All SV polarities used in this work were inferred from sP polarities as shown in Figure 5, where the lower hemisphere projection for the SV nodal surfaces corresponding to the mechanism of the El Tocuyo earthquake is also shown.

Strike-slip faults near El Tocuyo trend from N-S to SW-NE (Stephan, 1977; Giraldo, 1985). Thus, nodal plane A is likely to be the fault plane. The azimuth of the fault is N26E. The intensity distribution also supports this assumption. Herrera *et al.* (1951) mention that the highest damage occurred in El Tocuyo and Anzoátegui. Damaged decreased away from the El Tocuyo – Anzoátegui line, which is close to the azimuth of nodal plane A. The observations by Ponte

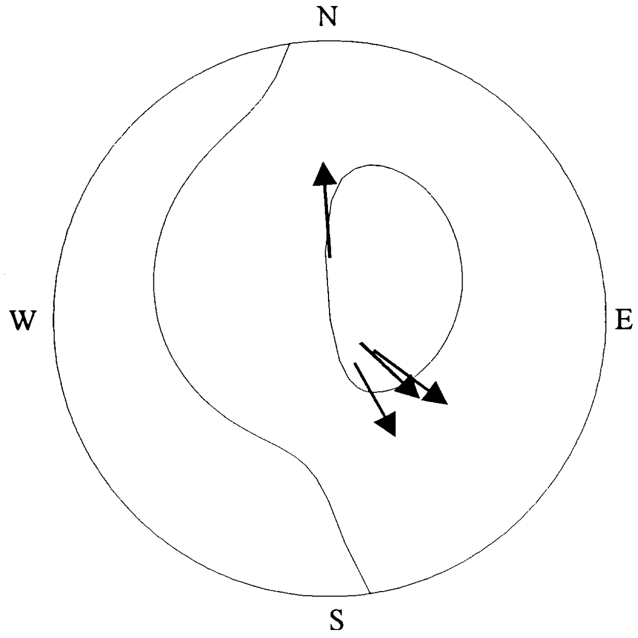

Fig. 5. Lower hemisphere equal area projection of the SV nodal surfaces for the mechanism of El Tocuyo earthquake. Arrows indicate the sense of first motions for SV radial components as the rays leave the focal sphere. These first motions were inferred from sP phases, following the notation and sign convention given in Figure 5.5 and Table 5.1 of Aki and Richards (1980).

et al. (1950) agree with this interpretation. However, it is not possible to determine conclusively which fault was the source of the earthquake, as there are no reports of surface rupture given the relatively modest size of the event.

It is unlikely that the Boconó fault itself was the causative fault, because: (1) the epicenter obtained by Dewey (1972) falls outside this fault, (2) The highest intensities occurred in locations away from its trace, (3) the epicenter as calculated by Dewey (1972) is close to El Tocuyo, where the intensities reached the highest values, (4) the trend of the Boconó fault in this area is approximately N50E, whereas the azimuth of nodal plane A is N26E. This is a significant difference as the focal mechanism is well constrained, (5) note also the consistency between the observations of Ponte *et al.* (1950) and Herrera *et al.* (1951), with the azimuth of nodal plane A.

Nearby El Tocuyo there are many mapped faults (*Mapa Geológico, Ministerio de Minas e Hidrocarburos, 1976*). Some are long enough to generate magnitude 6+ events (Stephan, 1977; Giraldo, 1985). The El Tocuyo depression may be a pull-apart basin between two north-south striking faults (Giraldo, 1985). These faults, however, cannot be associated with the earthquake. However, Río Tocuyo fault is close to El Tocuyo (Figure 1). This fault was added to Figure 1 from Giraldo (1985). About 16 km SW of El Tocuyo it offsets a quaternary alluvial fan in a right lateral sense (Giraldo, 1985). The azimuth of this fault is subparallel to the Boconó fault; however, its trend is not constant.

DISCUSSION

Figure 6 shows several focal mechanisms from Dewey (1972), Pennington (1981), Pérez *et al.* (1997), Harvard CMT catalog, and this work. The hypocentral parameters are given in Table 1. The focal mechanism for event # 3 was recomputed with P and SH first motion polarities, from WWSSN records, supplemented with P wave first motion polarities reported in the ISC bulletin. Only impulsive arrivals at epicentral distances less than 67° were used. Figure 7 shows the focal mechanism, which corresponds to a thrust faulting with a small strike-slip component.

In Figure 6 strike-slip events are located north of the Boconó fault up to about Carora, and between Trujillo and Barquisimeto. Events 10, 11, 12 and 13, are roughly aligned with a major strike-slip fault, thus confirming the right-hand character of the motion. The fault is shown as left-handed on some maps.

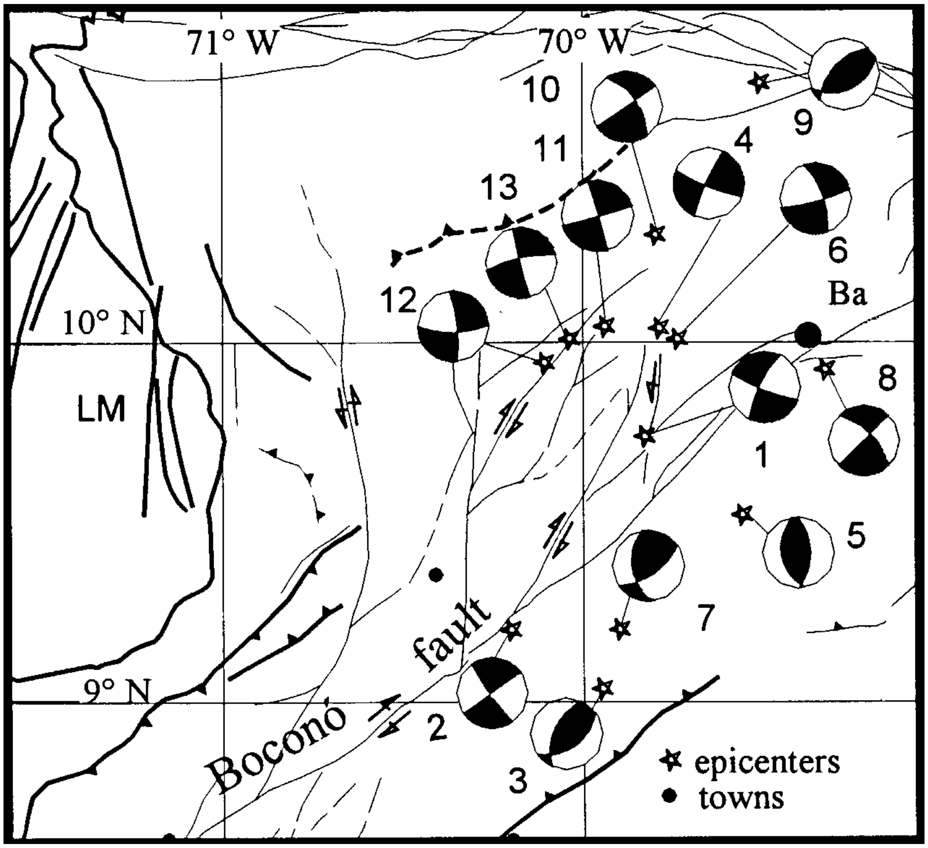

Fig. 6. Focal mechanisms compiled in this work. The numerals next to each focal sphere are keyed to the ones given in the first column of Table 1. Note that strike slip events are located from the Boconó fault to the northwest. LM = Maracaibo lake, Tu = Trujillo, Ba = Barquisimeto.

Table 1

N	year	month	day	Lat. N	Lon. W	h	A1	B1	D1	A2	B2	D2	mb	Ms
1	1950	August	03	9,74	69,83	18	206	72	-166	112	77	-19		6,3
2	1965	July	19	9,2	70,2	20	235	90	-170	145	80	0	5,3	
3	1975	March	05	9,037	69,985	25	204	50	70	54	44	112	5,6	
4	1975	April	05	10,04	69,76	22	204	80	11	112	79	170	5,6	6,1
5	1977	December	11	9,52	69,56	18	170	38	83	359	52	95	5,6	5,0
6	1984	June	14	10,01	69,74	18	340	65	-11	75	80	-155	5,2	4,5
7	1986	———	—-	9,2	69,9	< 20	170	40	53	55	59	117	< 4	
8	1986	———	—-	9,9	69,5	< 20	45	90	-150	315	60	0	< 4	
9	1986	July	16	10,72	69,51	15	64	41	106	223	51	76	5,6	4,9
10	1988	———	—-	10,3	69,8	< 20	55	90	-145	325	55	0	< 4	
11	1991	August	17	10,045	69,94	16	344	86	-3	74	87	-176	5,3	5,2
12	1995	December	29	9,944	70,106	15	88	70	-167	354	78	-21	5,5	5,2
13	1995	December	31	10,01	70,036	15	257	74	-175	166	86	-16	5,1	4,8

Focal mechanisms for events in the study area. Sources for the focal mechanisms: 1 and 3, this work; 2 and 4, Pennington (1981); 5, 6, 9, 11, 12 and 13 Harvard's CMT; 7, 8 and 10 Pérez *et al.* (1997). Lat = latitude, Lon = longitude, h = focal depth, in kilometers, A1 y A2 = nodal plane azimuths, B1 y B2 = nodal plane dips, D1 y D2 = slip angles, mb = body-wave magnitude, Ms = surface-wave magnitude. The convention used for azimuths, dips and slip angles follows Hermann (1975) and Aki & Richards (1980).

The events with thrust mechanism are located along the southeastern Andean foothills. A single thrust mechanism (# 9) is located to the north of the study area, away from the Mérida Andes. Thus, there is a northwest domain where most major faults are strike-slip, and a southeast domain where most major ones are thrust faults (Beltrán, 1993). Domains of faults separated by through-going boundary faults have been observed in other areas (Scotti *et al.*, 1991). However, strike-slip faults (e.g., Río Turbio) are found in the southeastern domain while thrust faults are present in the northwestern domain (Giraldo, 1985). The geological history of the area is complex (Stephan, 1977)

Rod (1960) notes right-lateral faulting along the Boconó fault and reverse faulting in the Mérida Andes foothills. Palme & Choy (1996) studied seismic swarms occurred within a zone that extends from 8.75° to 9.00º north latitude and from 70.75° to 70.90º west longitude. They found that events near the Boconó fault zone exhibit right-hand strike-slip mechanism, while events located to the northwest and to the southeast of this fault zone show reverse faulting.

The pattern is consistent with the shear partitioning model as applied to the Mérida Andes by Colletta *et al.* (1997) and Pérez *et al.* (1997). This model agrees with dominantly right-lateral faulting along the Boconó fault and reverse faulting in the Mérida Andes foothills, because of decoupling of the oblique convergence between the Caribbean and the South American plates in central Venezuela. However, the shear partition in our study area differs from the one observed toward the southwest, where the Mérida Andes reach their highest elevations. There, no broad zone with predominance of strike-slip faulting exist; instead, reverse faults occur relatively close to the NW and SE sides of the Boconó fault zone (Palme y Choy, 1996; Colletta *et al.*, 1997).

In Table 1 strike-slip events with magnitude mb > 5 have focal depths between 15 and 22 km. Event N° 3 with a depth of 25 km has a thrust mechanism. To support these results we examine the depth distribution of earthquakes within the rectangular area shown in Figure 1 (Pérez *et al.*, 1997) from January 1983 up to June 1995. It is found that about 90% of the 300+ events located within this area are confined to the top 18 km of the crust. For larger depths the reported seismic activity decays drastically.

Sibson (1982, 1986) points out that $M_L > 5.5$ events tend to nucleate near the base of the seismogenic zone. In California and Nevada, with the exception of thrust events in the Transverse Ranges, large shocks appear to originate at depths of 10 ± 2 km. The seismogenic layer in California is limited to the upper 15 km of the crust (Udías, 1991). In Table 1, some mb > 5.0 events occurred at 20 km of depth or more. Thus, the depth of the seismogenic zone may reach 20 km or more. However, the seismicity for strike-slip events is shallower than for dip-slip events (Sibson, 1982, 1986; Scholz, 1990). In Table 1, most mb > 5.0 strike-slip events occurred between 16 and 18 km. This situation may be valid for western Venezuela and, in particular, for the Boconó fault.

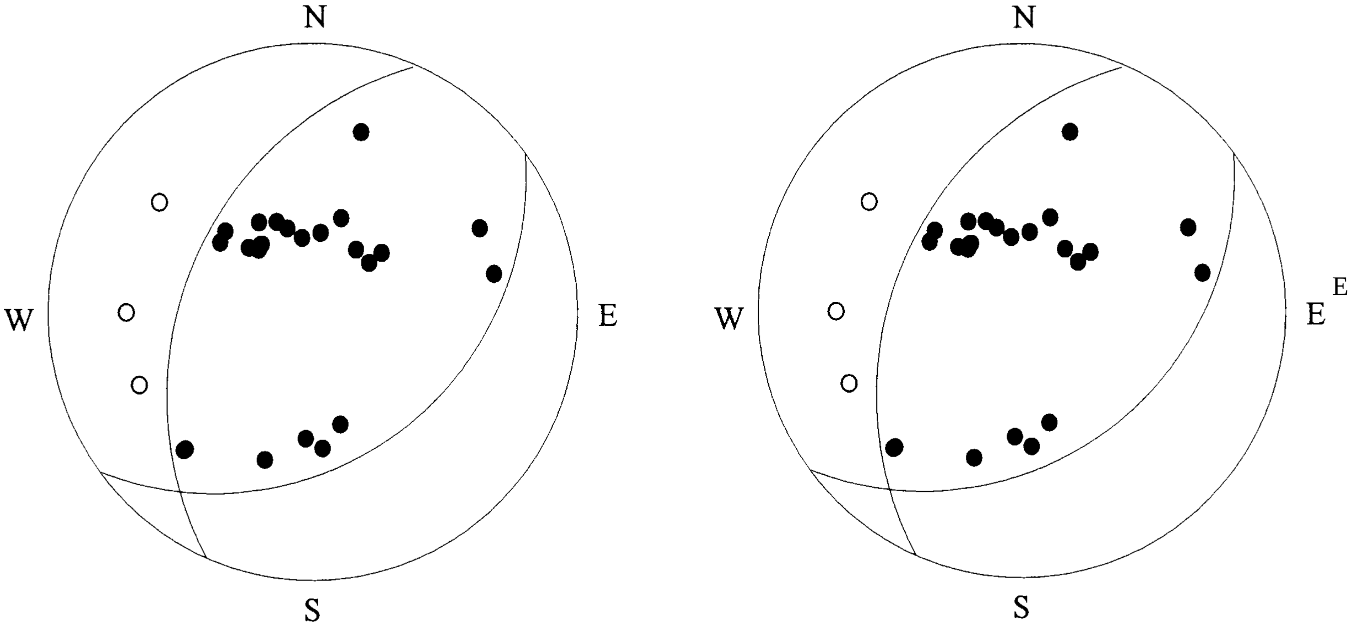

Fig. 7. Focal mechanism for event N° 3 of Table 1. (March 5, 1975). Left: lower hemisphere projection of the P nodal planes. Symbols as in Figure 3. Right: Lower hemisphere projection for the SH nodal surfaces. Arrows indicate the sense of SH first motions.

CONCLUSIONS

The focal parameters of the 1950 earthquake, which damaged El Tocuyo and neighboring towns, were redetermined. The fault associated with this event is a right-lateral strike-slip one, and its strike is approximately N26E. The Boconó fault itself was probably not the source of the earthquake. Some faults in the epicentral area, including the Río Tocuyo fault, are likely candidates, but the present information is inadequate to identify the causative fault.

Between Trujillo and Barquisimeto the Boconó fault separates into two domains of faulting. To the southeast, most mb ≥ 5.0 events are predominantly thrust events, whereas to the northwest up to Carora they are predominantly strike-slip events. This separation is the attributed to slip partitioning in the northeastern Mérida Andes.

The seismogenic zone for dip-slip events extend down to 20 km depth or more. For strike-slip faults it could be of the order of 18 km.

ACKNOWLEDGMENTS

The author thanks M. Morandi for discussions and observations, and for drafting Figures 1 and 5. O. J. Pérez made available a copy of his seismic catalog. Several references were consulted at FUNVISIS library. CDCHT from Universidad de Los Andes supported this work (project code C – 734 – 95 – 02A).

BIBLIOGRAPHY

AKI, A. and P. G. RICHARDS, 1980. Quantitative Seismology. Freeman, San Francisco, Vol. 1, 557 pp.

BELTRÁN, C., 1993. Mapa Neotectónico de Venezuela, escala 1:2.000.000, Fundación Venezolana de Investigaciones Sismológicas (FUNVISIS), Caracas, Venezuela.

CHOY, J. E., 1989. Determinación de mecanismos focales de sismos pequeños usando polaridades y cocientes de amplitud, *Act. Cient. Venez., 40,*138-145.

CHOY, J. E., 1997. Profundidad y mecanismo focal del Terremoto de El Tocuyo, 1950. Memorias de las Primeras Jornadas de Sismicidad Histórica en Venezuela, Trujillo, Venezuela, 15 al 16 de Mayo de 1997. Ferrer C, Laffaille, J. y Rengifo, M. (editores) Revista Geográfica Venezolana, Vol. 39, 1998, 203-217.

COLLETTA, B., F. ROURE, B. DE TONI and H. PASSALACQUA, 1997. Tectonic inheritance, crustal architecture, and contrasting structural styles in the Venezuelan Andes. *Tectonics, 16,* 777-794.

DEWEY, J. W., 1972. Seismicity and Tectonics of western Venezuela. *Bull. Seism. Soc. Am., 62,* 1711-1751.

FIEDLER, G., 1960. El gran terremoto de El Tocuyo del 3 de Agosto de 1950 y el fenómeno mecánico en el foco.

Memorias del III Congreso Geológico Venezolano, tomo IV, Ministerio de Minas e Hidrocarburos, Caracas, Venezuela, 1787-1791.

GIRALDO, C., 1985. Neotectónica y sismotectónica de la región de El Tocuyo - San Felipe (Venezuela Centro – Occidental). VI Congreso Geológico Venezolano, 4, 2415-2451, 29 de Septiembre – 6 de Octubre de 1985. Caracas, Venezuela.

HERRERA UMÉREZ, G., A. VEGAS, S. AGUERREVERE, P. PAOLI and E. PARDO STOLK, 1951. Informe que presenta al Colegio de Ingenieros la Comisión nombrada por éste para estudiar los efectos del terremoto ocurrido en la población de El Tocuyo el 3 de Agosto de 1950. Revista de Colegio de Ingenieros de Venezuela, Nº 178, Enero, 2-8.

MARTÍNEZ OLAVARRÍA, 1951. Factores económicos y humanos en la reconstrucción de El Tocuyo. Apuntes tomados en la conferencia dictada por el Dr. Martínez Olavarría el 19 de Diciembre en el Colegio de Ingenieros de Venezuela. *Revista de Colegio de Ingenieros de Venezuela, Nº 178, Enero,* 9-10.

PALME, C. and J. E CHOY, 1996. Estudio de unas tormentas sísmicas en la región de El Águila y de Piñango, Andes Venezolanos, entre octubre de 1989 y abril de 1990, *Acta Científica Venezolana, 47,* 89-102.

PEARCE, R. G., 1977. Fault plane solutions using relative amplitudes of P and pP, *Geophys. J.R Astr. Soc. 50,* 381-394.

PENNINGTON, W. D., 1981. Subduction of the Eastern Panama Basin and seismotectonics of northwestern South America. *J. Geophys. Res., 86,* 10753-10770.

PÉREZ, O.J., M. A. JAIMES and E. GARCIARCARO, 1997. Microseismicity evidence for subduction of the Caribbean plate beneath the South American plate northwestern Venezuela. *J. Geophys. Res., 102,* 17,875 – 17,882.

PONTE, R. L., A. SCHWARCK, L. MIRANDA, J. MAS VALL and R. C. PONTE, 1950. Observaciones geológicas de la región afectada por el terremoto del 3 de Agosto de 1950. Instituto Nacional de Minería y Geología, Ministerio de Fomento, Caracas, 20 pp.

ROD, E., 1960. Comments on “The gravity field of the Venezuelan Andes and adjacent basins”. *Bol. Inf. Asoc. Venez. Geol. Min. Pet., 3,* 170-175.

SCHOLZ, C. H., 1990. The Mechanics of Earthquakes and Faulting. Cambridge Univ. Press, New York, 439 pp.

SCHUBERT, C., 1980. Morfología Neotectónica de una falla rumbo-deslizante e informe preliminar sobre la falla de Boconó, Andes Merideños. *Act. Cient. Venez., 31,* 98-111.

SCHUBERT, C. and L. VIVAS, 1993. El Cuaternario de la Cordillera de Mérida, Andes Venezolanos. Universidad de Los Andes / Fundación Polar, Mérida, Venezuela, 345 pp.

SCOTTI, O., A. NUR and R. ESTÉVEZ, 1991. Distributed deformation and block rotation in three dimensions. *J. Geophys. Res, 96,* 12,225-12,243.

SIBSON, R. H., 1982. Fault zone models, heat flow, and the depth distribution of earthquakes in the continental crust of the United States. *Bull. Seism. Soc. Am. 72,* 151-168.

SIBSON, R. H., 1986. Earthquakes and rock deformation in crustal fault zones. *Ann. Rev. Earth Planet. Sci., 14,* 149-175.

STEPHAN, J. F., 1977. El contacto Cadena Caribe-Andes Merideños entre Carora y el Tocuyo (Edo. Lara). Memorias del V Congreso Geológico Venezolano, 2, 789-816.

UDÍAS, A., 1991. Source mechanism of earthquakes. *Advances in Geophysics, 33,* 81-140.

VON DER OSTEN, E. and D. ZOZAYA, 1957. Geología de la parte suroeste del Edo. Lara, región Quíbor. Boletín de Geología, vol. IV, N° 9, Enero de 1955 a Diciembre de 1957.

WILLMORE, P. L., 1979. Manual of Seismological Observatory Practice. Report SE-20. World Data Center A for Solid Earth Geophysics, NOAA, Boulder, Colorado, U.S.A., pp 165.

José E. Choy

Laboratorio de Geofísica, Facultad de Ciencias,
Universidad de Los Andes, Mérida, Venezuela,
VENEZUELA
Email: choy@ciens.ula.ve