# Seismic Hazard of an Area near San Rafael del Sur, Western Nicaragua

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2008

# ABSTRACT OF THE STUDY

*Title:* Seismic Hazard of an Area near San Rafael del Sur, Western Nicaragua

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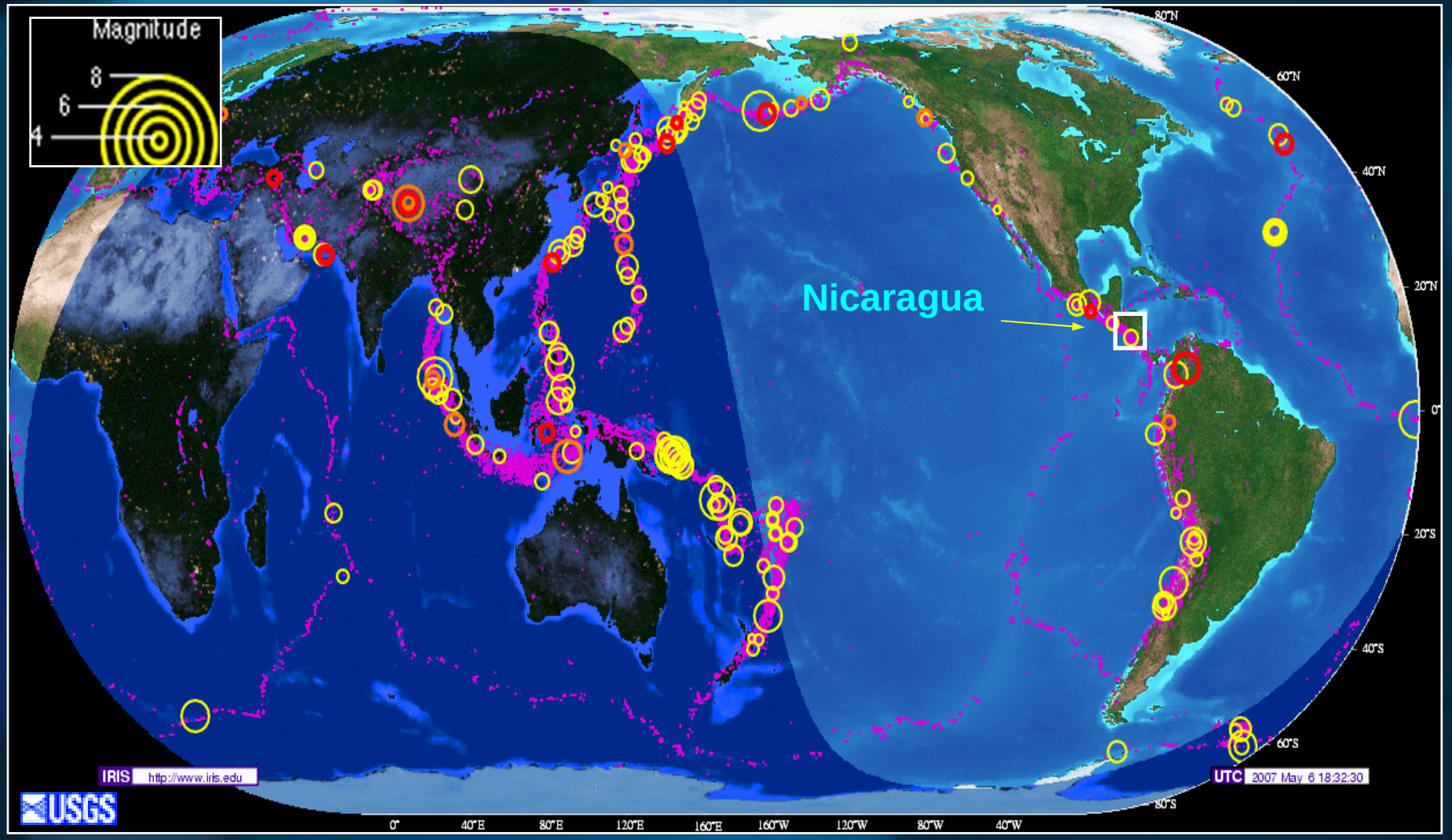
*Supervisor :* Fabio Segura, Seismology /Geophysical

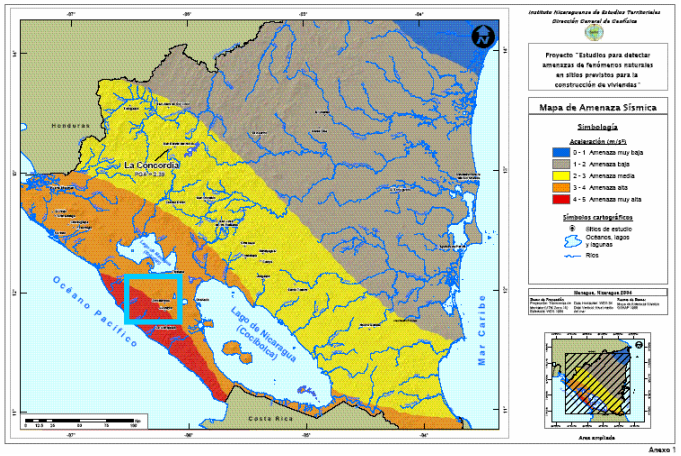
*Place y year presentation:* Managua, Nicaragua, 2006

# INTRODUCTION

## GLOBAL SEISMIC SITUATION

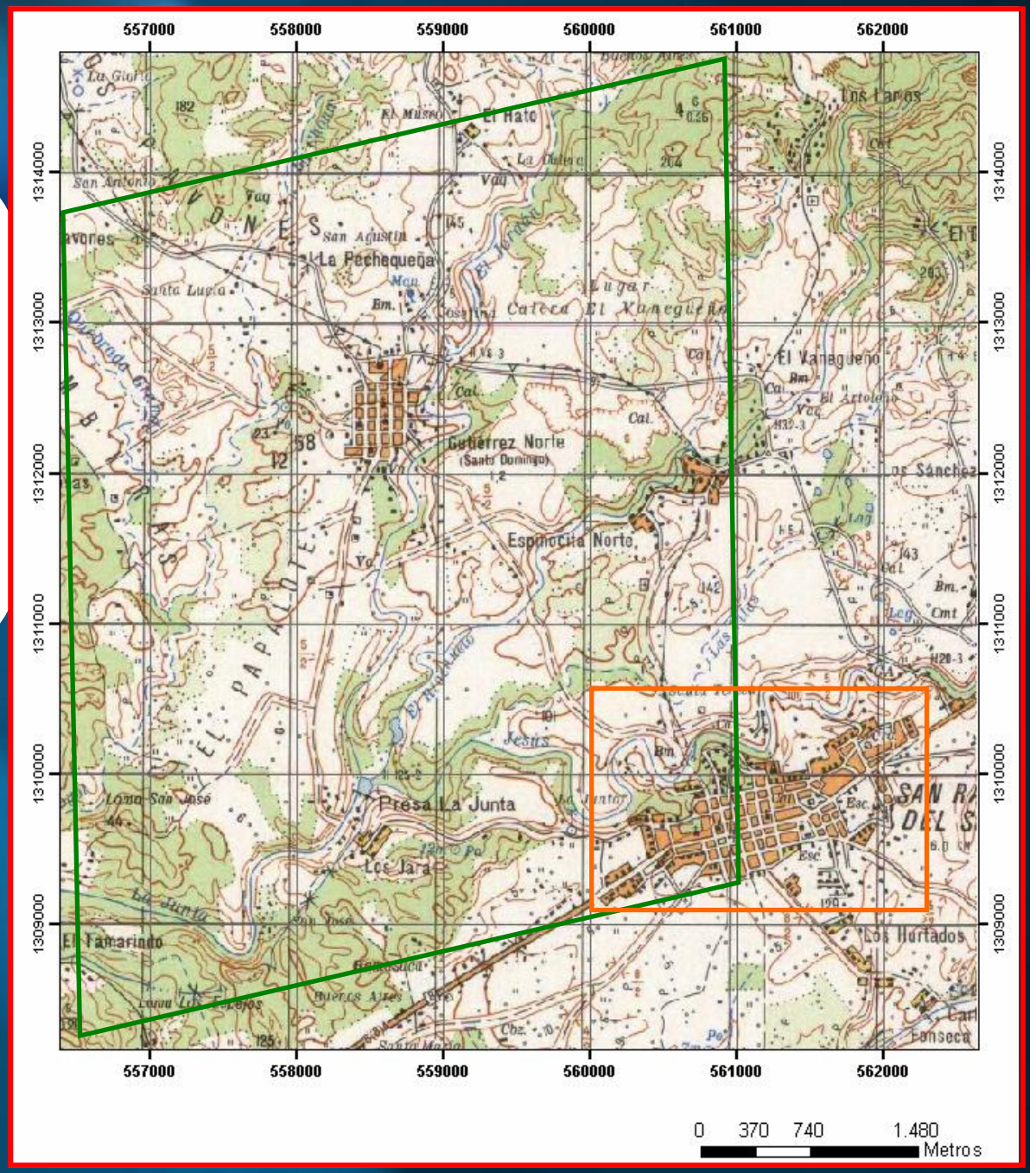


# GEOGRAPHICAL LOCATION
# SCALE 1:37,000




San Rafael del Sur

Study Site



## Seismic Hazard of an Area near San Rafael del Sur, Western Nicaragua

*Objetives:*

Determine the seismic hazard in an area northwest of the Municipality of San Rafael del Sur. Determine seismic and structural elements of the site applying focal mechanisms. Relate geology field with seismic data instrumental local. Classify and evaluate the specific buildings according to use and category of materials used in its construction. Spatial relations results of the evaluation of buildings with the results of seismic hazard. Finally, prepare a seismic zoning map scale detail using Software ArcGis 9.3

*Methodology:*

In the investigation conducted, was performed the compilation and analysis of documentary information and mapping available in the country, and consultations with specialists Nicaraguans; were interpreted geo-structural models of the terrain; parameters were measured and interpreted geological fieldwork and geo-located Interest seismotectonic supported elements of electronic equipment in places accessible terrain; were analyzed historical earthquakes - instrumental using software ArcGis 9.3, AutoCad and others.

*Results:*

That was seismic and geological mapping at 1:30000 of the study area. consecutively, seismic zoning was realize by applying numerical model predictive [0015e0, 868M / (R + 0060e0, 7M) 1.09]. Similarly, space and geometry was obtained from sources breaks earthquake-generating software using local SUN-SYSTEM X-WIN 32. Also, profiles were achieved in geological 1:600 scale vertical and horizontal scale 1:1000, and estratigraphy column at 1:10 horizontal and vertical scale 1:1000 using AutoCad 2006. Finally, iconographic was obtained documentation that showed evidence of activity telluric sources sismogenic incidence locally.

*Conclusions:*

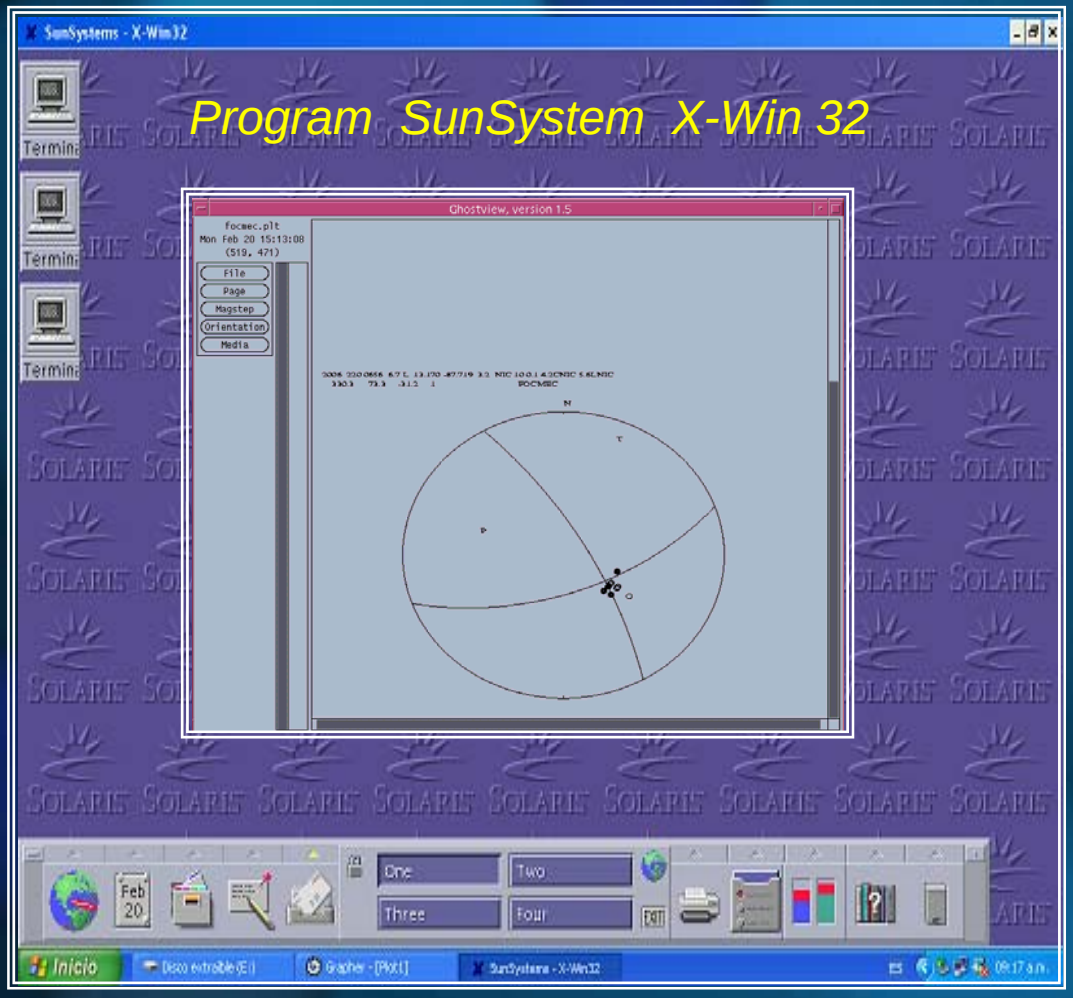
Based on the results, we conclude that the main source quake-generating local identified fault with what constitutes horizontal and vertical displacement of soil, but their delivery of surface movement are limited to the field observation. 24 quakes surface and perpendicular recent under 8km deep with magnitudes between 2.7 to 3.3 Richter-eighth capable of causing damage in homes of local low quality due to quake-resistant materials and constructive typology, the site is affected by 3 steering axles of effort Two northeast-southwest and one north-south whose activity is printed on rocky outcrops and terraces of Jesus and Jordan Rivers; density for the structural area of interest, is 0.52km/km2 for geological faults and fractures 0.29km/km2 tectonic. In applying numerical models predictive [0015e0, 868M / (R + 0060e0, 7M) 1.09], reveal soil texture clay-silt fragile, singly or alluvial not consolidated with seismic intensity between 0.4 - 0.5g in El Tamarindo and Los Jaras with high levels of Seismic Hazard, contrary to sandy soil texture firm and stable in San Rafael Sur, Sanchez Norte y Gutierrez Norte attenuator with effect from 0009 to 0.01 g with low levels of Seismic Hazard.

*Keywords:*

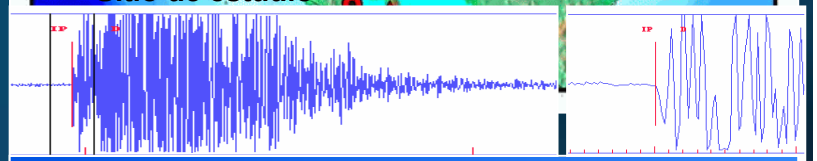
Hazard seismic, geological fault, sismogenic source, left side fault, normal fault, right side fault

# RESULTS

A) DETERMINATION OF STRUCTURAL ELEMENTS APPLYING FOCAL MECHANISMS




Seismic Stations

SunSystems - X-Win32

Terminal

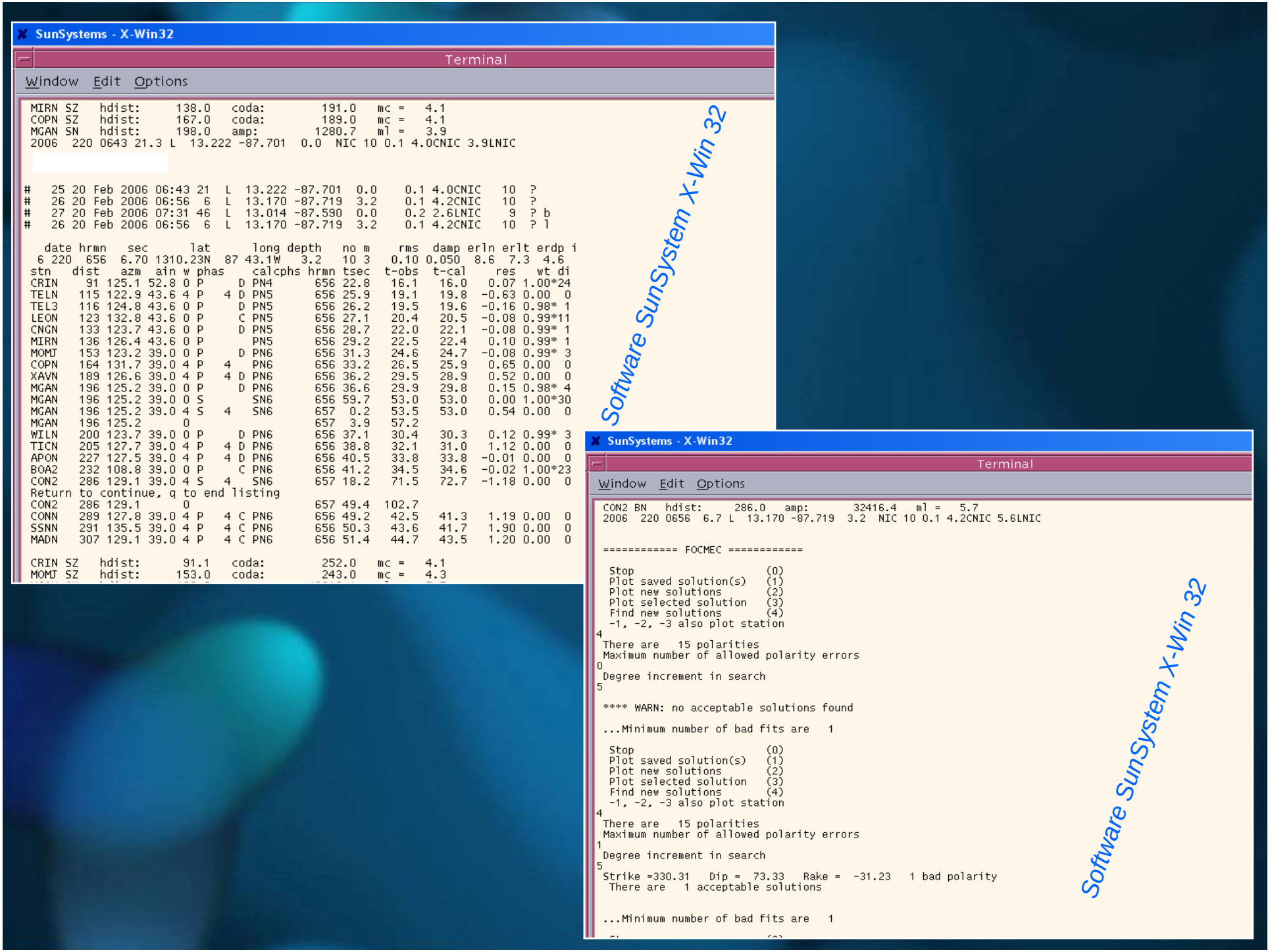
Window Edit Options

```
     91.0000    0.840000
     96.0000    0.920000
 Plot results (y/n)
y
  Plot file is rmsdep.plt
#   25 20 Feb 2006 06:43 21   L  13.222 -87.701   0.0     0.1 4.0CNIC   10  ? 1

   date hrmn    sec       lat       long depth   no m     rms  damp erln erlt erdp i
  6 220  643 21.30 1313.30N  87 42.1W   0.0    11 3    0.13 0.050  9.1  9.3  2.1
stn   dist   azm  ain w phas    calcphs hrmn tsec  t-obs  t-cal    res   wt di
CRIN    93 128.6 19.2 0 P     D PN4       643 38.6   17.3   17.2   0.15 0.99* 1
TELN   117 125.8 16.5 0 P     C PN5       643 41.9   20.6   20.9  -0.28 0.98* 1
TELN   117 125.8 16.5 0 S       SN5       643 58.4   37.1   37.1  -0.04 1.00*25
TEL3   117 127.6 16.5 0 P     D PN5       643 42.0   20.7   20.7  -0.06 1.00* 1
TEL3   117 127.6 16.5 4 S   4   SN5       643 55.8   34.5   36.9  -2.44 0.00  0
LEON   125 135.3 16.5 0 P     D PN5       643 43.0   21.7   21.7  -0.03 1.00*14
CNGN   135 126.2 16.5 0 P     D PN5       643 44.3   23.0   23.2  -0.21 0.99* 1
MIRN   138 128.7 16.5 0 P       PN5       643 44.9   23.6   23.5   0.10 1.00* 2
MOMJ   155 125.4 15.0 0 P     D PN6       643 47.2   25.9   25.8   0.08 1.00* 2
COPN   167 133.6 15.0 4 P   4   PN6       643 49.1   27.8   27.1   0.75 0.00  0
APYN   182 126.5 15.0 4 P   4 D PN6       643 51.4   30.1   29.1   1.02 0.00  0
XAVN   191 128.3 15.0 4 P   4 C PN6       643 52.2   30.9   30.1   0.84 0.00  0
XAVN   191 128.3 15.0 4 S   4   SN6       644 15.6   54.3   53.5   0.75 0.00  0
MGAN   198 126.8 15.0 0 S       SN6       644 16.3   55.0   54.9   0.05 1.00*14
MGAN   198 126.8       0                 644 19.0   57.7
WILN   202 125.4 15.0 4 P   4 C PN6       643 52.1   30.8   31.4  -0.61 0.00  0
WILN   202 125.4 15.0 4 S   4   SN6       644 17.7   56.4   55.8   0.61 0.00  0
TICN   207 129.3 15.0 0 P     D PN6       643 53.6   32.3   32.1   0.16 0.99* 4
Return to continue, q to end listing
APON   229 128.9 15.0 4 P   4 D PN6       643 57.0   35.7   35.0   0.79 0.00  0
BOA2   232 110.2 15.0 0 P     D PN6       643 56.8   35.5   35.5   0.06 1.00*36
BOA2   232 110.2 15.0 4 S   4   SN6       644 24.9   63.6   63.1   0.51 0.00  0
CONN   291 128.9 15.0 4 P   4 C PN6       644  4.1   42.8   42.4   0.34 0.00  0
SSNN   294 136.5 15.0 4 P   4 C PN6       644  6.0   44.7   42.9   1.85 0.00  0
MADN   310 130.2 15.0 4 P   4 C PN6       644 11.4   50.1   44.6   5.41 0.00  0
MADN   310 130.2 15.0 4 S   4   SN6       644 46.7   85.4   79.5   5.89 0.00  0

CRIN SZ   hdist:      93.0   coda:       183.0   mc =   3.9
TEL3 SZ   hdist:     117.0   coda:       196.0   mc =   4.0
LEON SZ   hdist:     125.0   coda:       190.0   mc =   4.0
MIRN SZ   hdist:     138.0   coda:       191.0   mc =   4.1
```

Software SunSystem X-Win 32


SunSystems - X-Win32
Terminal
Window Edit Options
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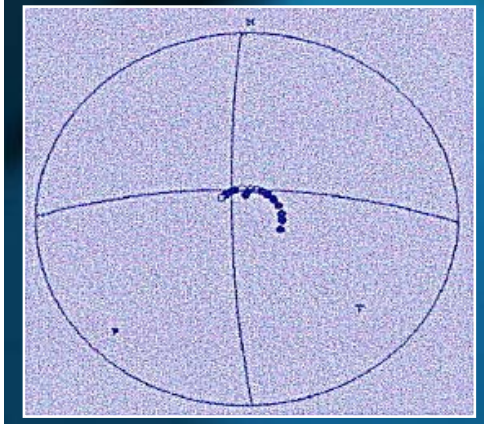
COPN SZ hdist: 167.0 coda: 189.0 mc = 4.1
MGAN SN hdist: 198.0 amp: 1280.7 ml = 3.9
2006 220 0643 21.3 L 13.222 -87.701 0.0 NIC 10 0.1 4.0CNIC 3.9LNIC
# 25 20 Feb 2006 06:43 21 L 13.222 -87.701 0.0 0.1 4.0CNIC 10 ?
# 26 20 Feb 2006 06:56 6 L 13.170 -87.719 3.2 0.1 4.2CNIC 10 ?
# 27 20 Feb 2006 07:31 46 L 13.014 -87.590 0.0 0.2 2.6LNIC 9 ? b
# 26 20 Feb 2006 06:56 6 L 13.170 -87.719 3.2 0.1 4.2CNIC 10 ? l
date hrmn sec lat long depth no m rms damp erln erlt erdp i
6 220 656 6.70 1310.23N 87 43.1W 3.2 10 3 0.10 0.050 8.6 7.3 4.6
stn dist azm ain w phas calcphs hrmn tsec t-obs t-cal res wt di
CRIN 91 125.1 52.8 0 P D PN4 656 22.8 16.1 16.0 0.07 1.00*24
TELN 115 122.9 43.6 4 P 4 D PN5 656 25.9 19.1 19.8 -0.63 0.00 0
TEL3 116 124.8 43.6 0 P D PN5 656 26.2 19.5 19.6 -0.16 0.98* 1
LEON 123 132.8 43.6 0 P C PN5 656 27.1 20.4 20.5 -0.08 0.99*11
CNGN 133 123.7 43.6 0 P D PN5 656 28.7 22.0 22.1 -0.08 0.99* 1
MIRN 136 126.4 43.6 0 P PN5 656 29.2 22.5 22.4 0.10 0.99* 1
MOMJ 153 123.2 39.0 0 P D PN6 656 31.3 24.6 24.7 -0.08 0.99* 3
COPN 164 131.7 39.0 4 P 4 PN6 656 33.2 26.5 25.9 0.65 0.00 0
XAVN 189 126.6 39.0 4 P 4 D PN6 656 36.2 29.5 28.9 0.52 0.00 0
MGAN 196 125.2 39.0 0 P D PN6 656 36.6 29.9 29.8 0.15 0.98* 4
MGAN 196 125.2 39.0 0 S SN6 656 59.7 53.0 53.0 0.00 1.00*30
MGAN 196 125.2 39.0 4 S 4 SN6 657 0.2 53.5 53.0 0.54 0.00 0
MGAN 196 125.2 0 657 3.9 57.2
WILN 200 123.7 39.0 0 P D PN6 656 37.1 30.4 30.3 0.12 0.99* 3
TICN 205 127.7 39.0 4 P 4 D PN6 656 38.8 32.1 31.0 1.12 0.00 0
APON 227 127.5 39.0 4 P 4 D PN6 656 40.5 33.8 33.8 -0.01 0.00 0
BOA2 232 108.8 39.0 0 P C PN6 656 41.2 34.5 34.6 -0.02 1.00*23
CON2 286 129.1 39.0 4 S 4 SN6 657 18.2 71.5 72.7 -1.18 0.00 0
Return to continue, q to end listing
CON2 286 129.1 0 657 49.4 102.7
CONN 289 127.8 39.0 4 P 4 C PN6 656 49.2 42.5 41.3 1.19 0.00 0
SSNN 291 135.5 39.0 4 P 4 C PN6 656 50.3 43.6 41.7 1.90 0.00 0
MADN 307 129.1 39.0 4 P 4 C PN6 656 51.4 44.7 43.5 1.20 0.00 0
CRIN SZ hdist: 91.1 coda: 252.0 mc = 4.1
MOMJ SZ hdist: 153.0 coda: 243.0 mc = 4.3
Software SunSystem X-Win 32
SunSystems - X-Win32
Terminal
Window Edit Options
CON2 BN hdist: 286.0 amp: 32416.4 ml = 5.7
2006 220 0656 6.7 L 13.170 -87.719 3.2 NIC 10 0.1 4.2CNIC 5.6LNIC
============ FOCMEC ============
Stop (0)
Plot saved solution(s) (1)
Plot new solutions (2)
Plot selected solution (3)
Find new solutions (4)
-1, -2, -3 also plot station
4
There are 15 polarities
Maximum number of allowed polarity errors
0
Degree increment in search
5
**** WARN: no acceptable solutions found
...Minimum number of bad fits are 1
Stop (0)
Plot saved solution(s) (1)
Plot new solutions (2)
Plot selected solution (3)
Find new solutions (4)
-1, -2, -3 also plot station
4
There are 15 polarities
Maximum number of allowed polarity errors
1
Degree increment in search
5
Strike =330.31 Dip = 73.33 Rake = -31.23 1 bad polarity
There are 1 acceptable solutions
...Minimum number of bad fits are 1
Software SunSystem X-Win 32

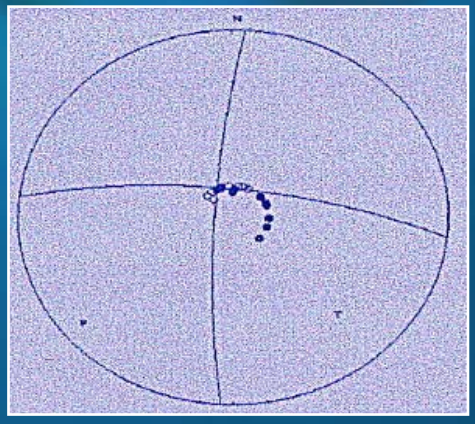
# A.1. Telemetric Seismic Stations near San Rafael del Sur

| Nº | Location | Code | Instrument | Latitude | Longitude | Elevation | Observation |
|---|---|---|---|---|---|---|---|
| 1 | Managua(INETER) | MGA | S-13 | 12º08.81'N | 86º14.83'O | 80 | 3 comp. |
| 2 | Playitas | PYT | SS-1 | 12º32.26'N | 86º03.46'O | 460 | - |
| 3 | Poneloya | PYN | S-13 | 12º22.93'N | 87º01.34'O | 50 | - |
| 4 | Gruta_Xavier | XAVN | SS-1 | 12º08.92'N | 86º19.58'O | 160 | Repetidora |
| 5 | San_Juan_del_Sur | SSN | SS-1 | 11º17.27'N | 85º50.97'O | 415 | Repetidora |
| 6 | V. Cerro Negro | CNGN | L-4 | 12º30.00'N | 86º41.91'O | 515 | volcano |
| 7 | V. Telica | TELN | L-4 | 12º36.25'N | 86º49.88'O | 850 | volcano |
| 8 | V. Momotombo | MOMJ | L-4 | 12º24.50'N | 86º32.40'O | 500 | volcano |
| 9 | V. San Cristóbal | CRIN | L-4 | 12º42.00'N | 87º03.00'O | 685 | volcano |
| 10 | V. Concepción | CONN | SS-1 | 11º33.85'N | 85º37.54'O | 250 | volcano |
| 11 | Boaco | BOA | SS-1 | 12º29.23'N | 85º41.67'O | 734 | - |
| 12 | Somoto | SOMN | SS-1 | 13º25.22'N | 86º36.83'O | 1200 | - |
| 13 | Américas_#2 | WILN | L-4 | 12º09.64'N | 86º11.25'O | 60 | 3 comp. |
| 14 | Ticuantepe | TICN | L-4C | 12º02.01'N | 86º13.90'O | 400 | - |
| 15 | León_(Fortín) | LEON | S-13 | 12º24.96'N | 86º53.55'N | 160 | Repetidora |
| 16 | V._Maderas | MADN | SS-1 | 11º24.50'N | 85º32.00'N | 50 | volcano |
| 17 | Ciudad_Sandino | CSAN | | 12º10.60'N | 86º25.20'W | 300 | - |

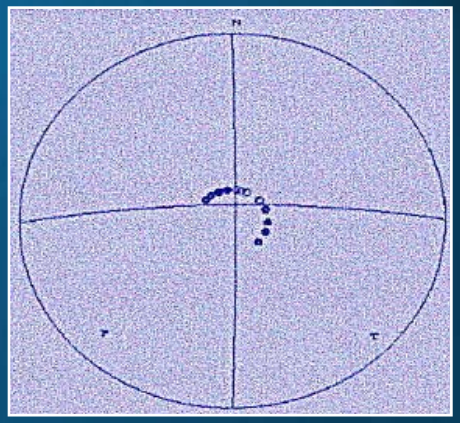
# A.2. Geometry space rupture for local quake occurred in years 2000 - 2002 based on historical records and styles of movement



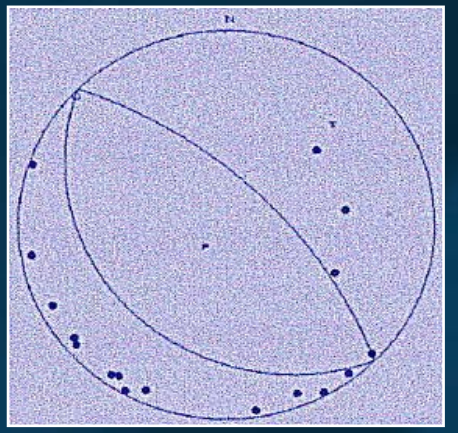
ML = 3.5; h = 0.1km; 05:24Hrs (271º, 72º, 9º); Rumbe side left. (I)



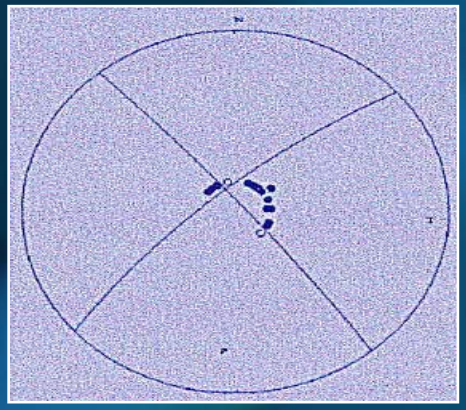
ML = 3.3; h = 0.0km; 05:24Hrs (277º, 73º,10º); Rumbe side left.(II)



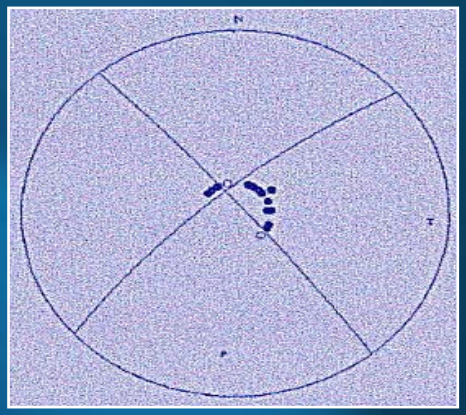
ML = 3.0; h = 0.0km; 05:24Hrs (270º, 80º, -1.8º); Rumbe side left. (III)



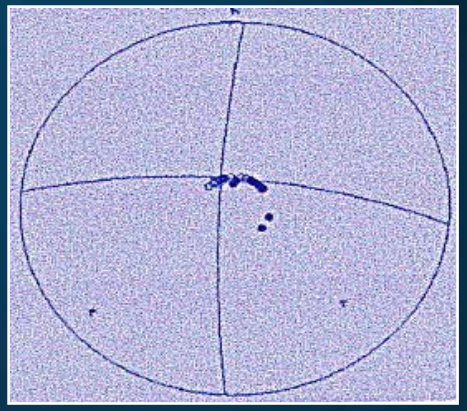
ML = 2.6; h = 8.5km; 05:20Hrs (220º, 10º, -90º); Normal Fault. (IV)



ML = 2.8; h = 8km; 05:20Hrs (315º, 65º, -90º); Rumbe side right (V)

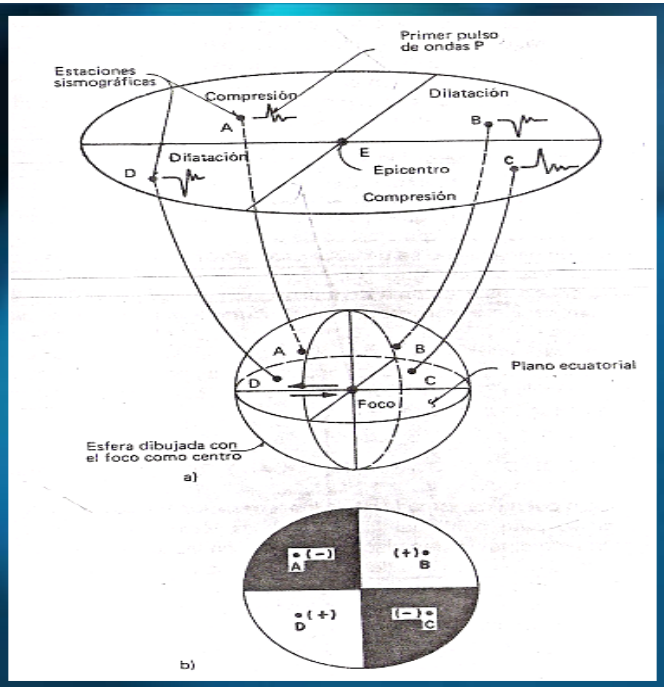


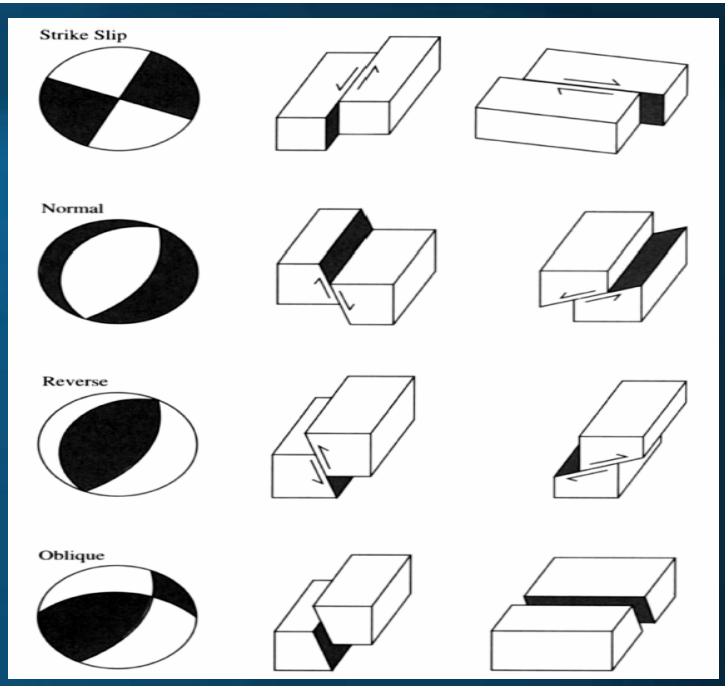
ML = 2.5; h = 1.1km; 05:20Hrs (229º, 76º, -5º); Rumbe side left (VI)



ML = 3.6; h = 1km; 04:21Hrs (276º, 72º, 9º); Rumbe side left (VII)

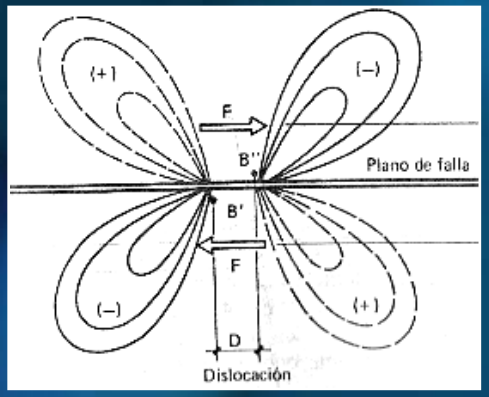
*Software SunSystem X-Win 32*

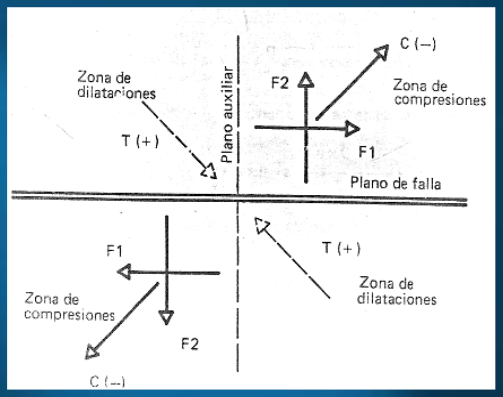


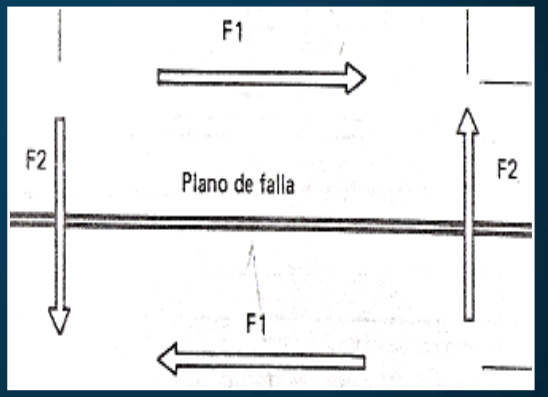




a) b)

A.2.1 Graphic. a) Sphere focal projection on a horizontal plane of the areas of compression and expansion. b) Type characteristic of geological faults and focal hemisphere lower projected on a horizontal plane.



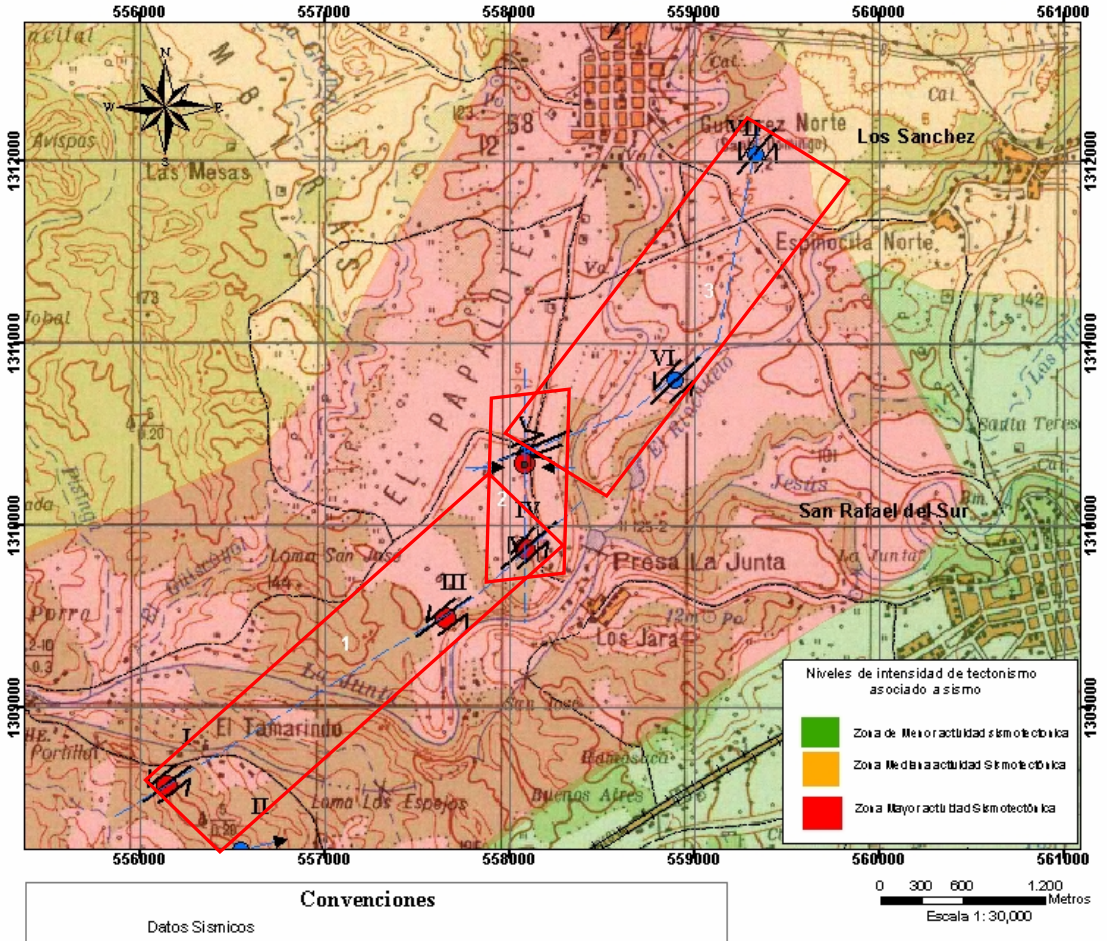




a) b) c)

A.2.2 Graphic. a) Par Force F produces areas of compression and expansion. b) Equivalence between a pair of double forces and two dipoles perpendicular to 45º with the plane crashes: one of compression and expansion of another. c) Effort shear acting on both sides of the fault occurring on deformation and displacement.

# B) SEISMOTECTONIC MODEL




## Convenciones

Datos Sismicos

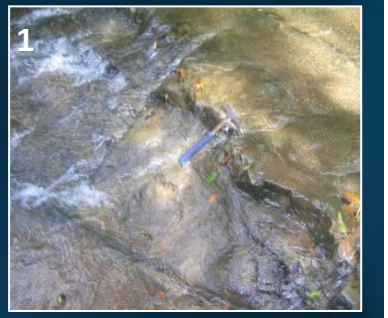
| Eventos sismicos (2000 - 2002) | Magnitud Sismica (°R) | Profundidad focal (Km) |
|---|---|---|
| | 0 - 2 | 0 - 1 |
| | 2 - 3 | 1 - 4 |
| | > 3 | > 4 |

Falla Inversa
Falla Normal
Falla Lateral Derecha
Falla Lateral Izquierda
Fuente generadora de sismos
Carretera
Caminos

Líneas Sismogeneradoras:
1. Dirección SO - NE
2. Dirección N-S
3. Dirección SO - NE

Los Números en Romano corresponde a mecanismos focales de sismos ocurridos en el área que se explican en texto

## Physical evidence on the terrain of the local seismic activity

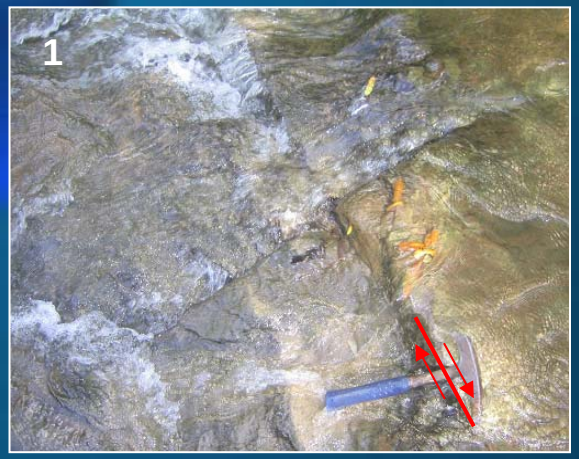





*Software ArcGis 9.3*

Continued……..

# Other local Geological Efect

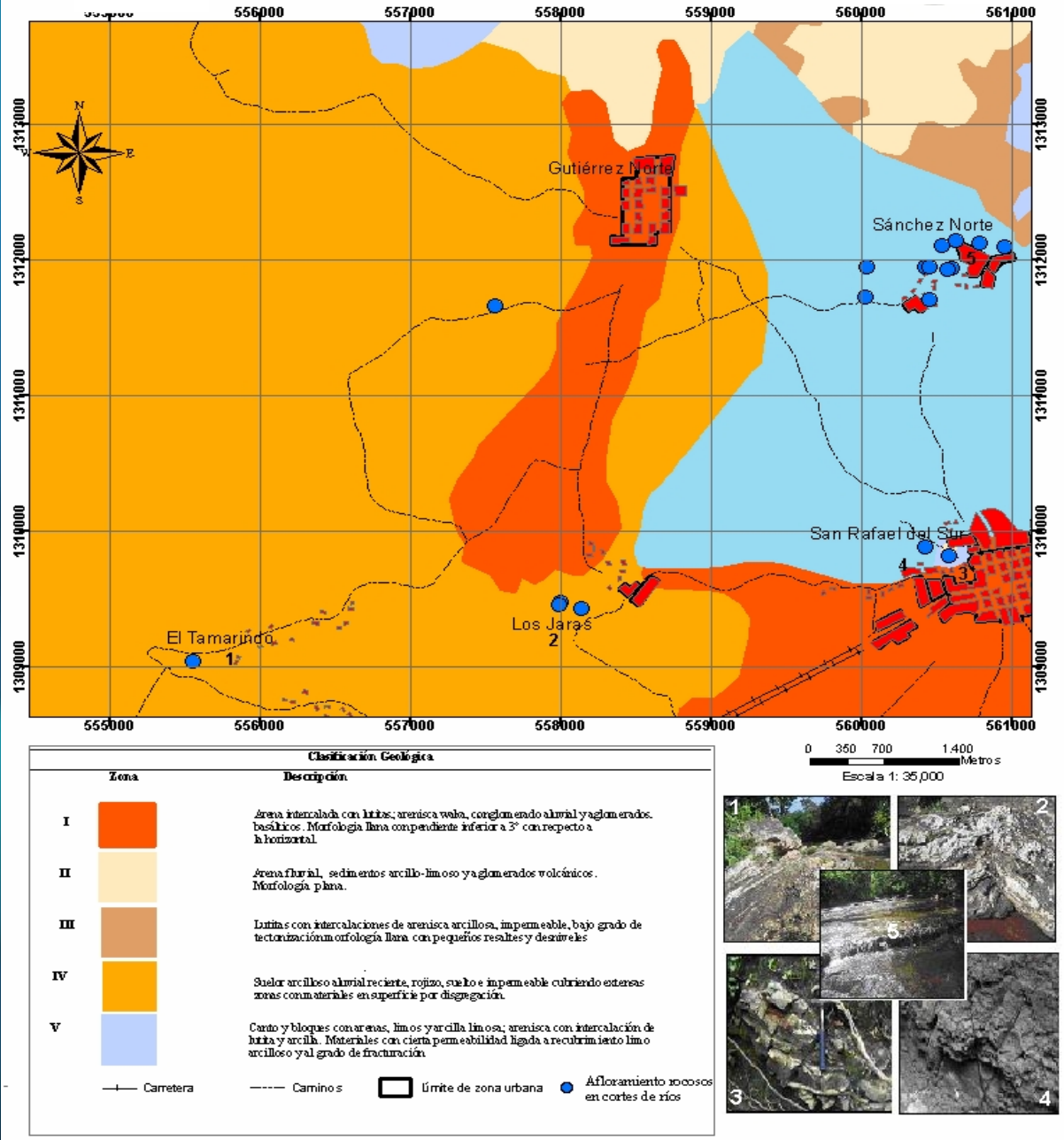




Camera OLYMPUS
Resolution 4 mega-píxeles
Modelo IR-500

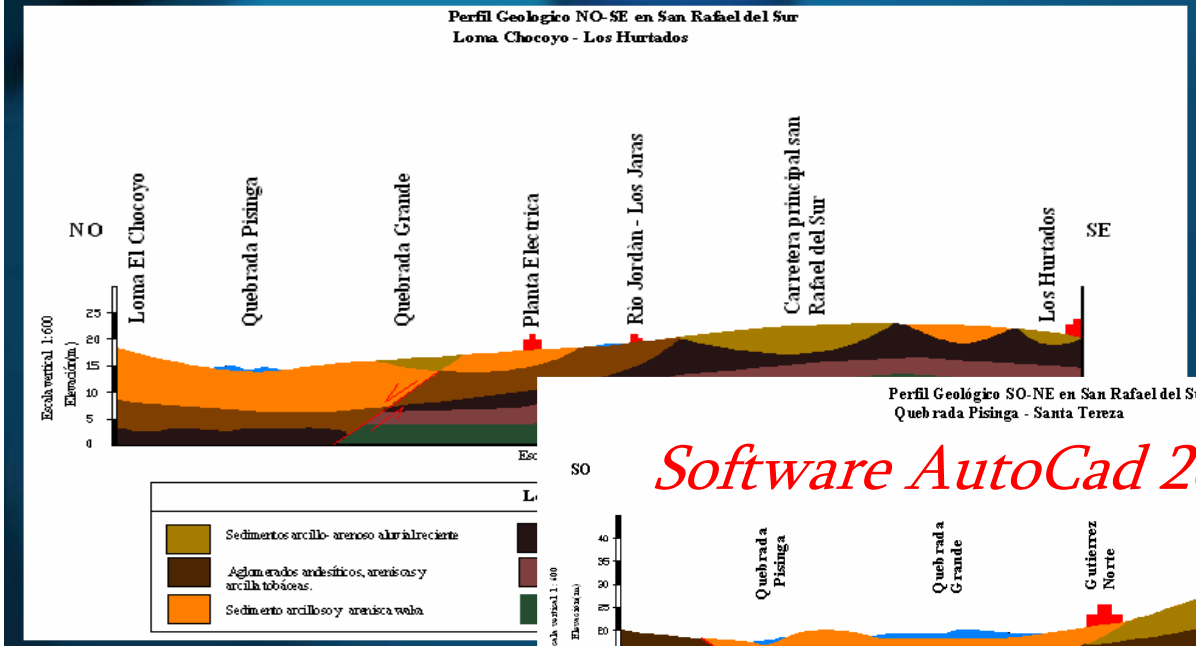
Software ArcGis 9.3

# C) LOCAL GEOLOGICAL MAPPING, SCALE 1:35,000

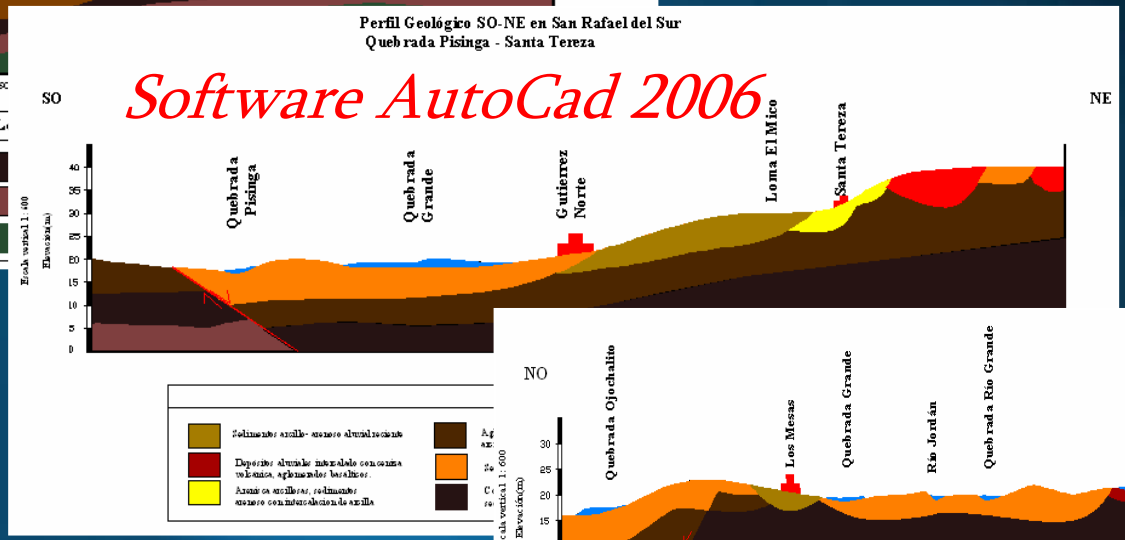


# D) PROFILES SUBSOILS GEOLOGY IN THE STUDY AREA. SCALES:

VERTICAL 1:600
HORIZONTAL 1:1,000

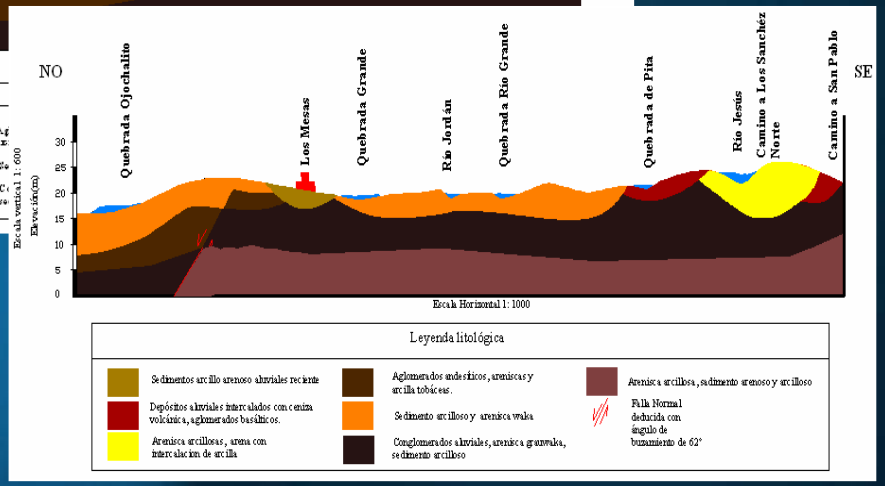



Loma Chocoyos – Los Hurtados
en direction Northwest-Southeast




*Software AutoCad 2006*

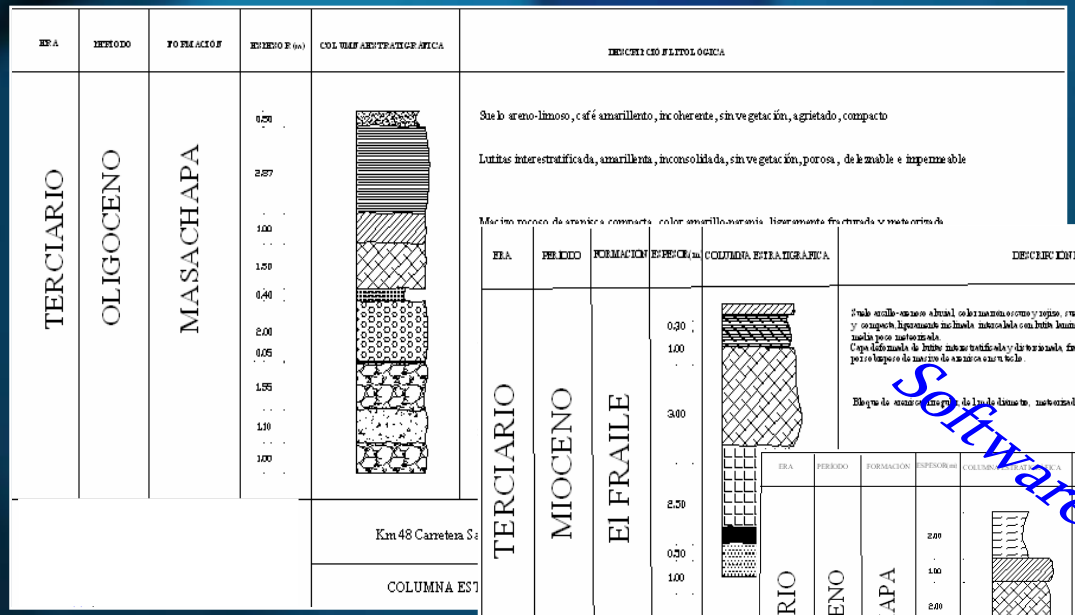
Quebrada Pisinga-Santa Teresa en direction Northeast - Southwest



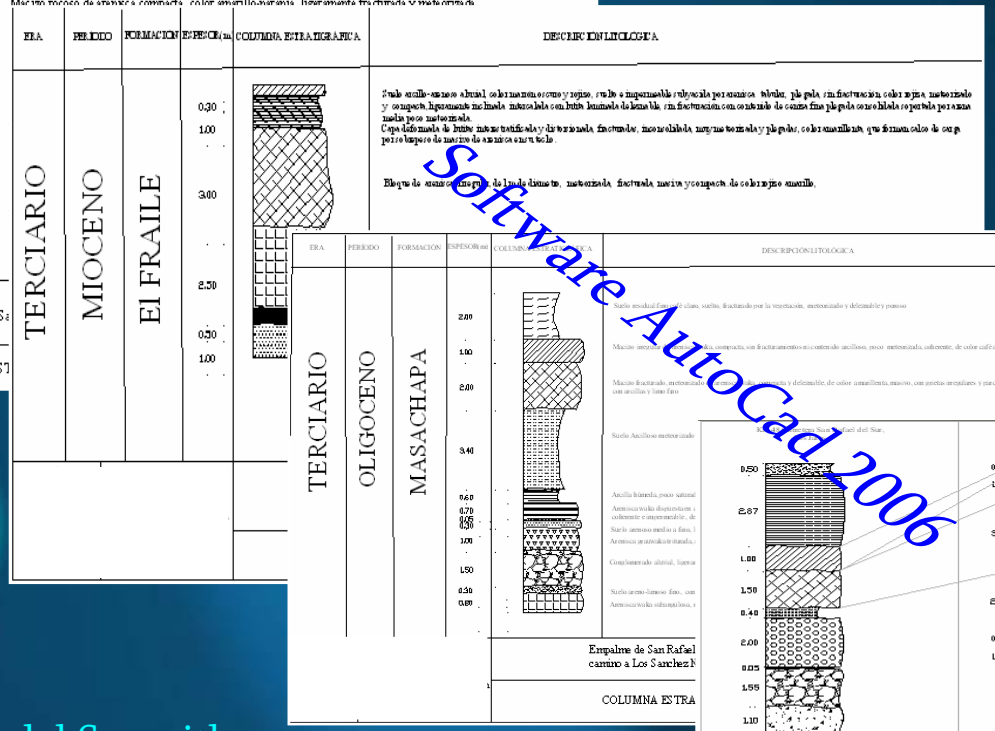

Quebrada Ojochalito-Camino a San Pablo en direction Northwest-Southeast

# E) COLUMNS OF STRATIGRAPHIC LOCAL WITH SCALES:

VERTICAL 1:10
HORIZONTAL 1:1,000




Km 48 Road San Rafael del Sur, Community Los Jaras

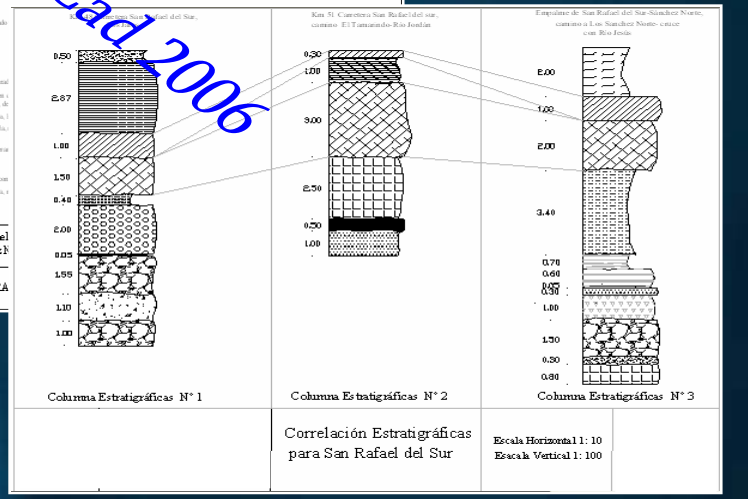






Software AutoCad 2006

Km 51 Road San Rafael del Sur, Road El Tamarindo - Río Jordán

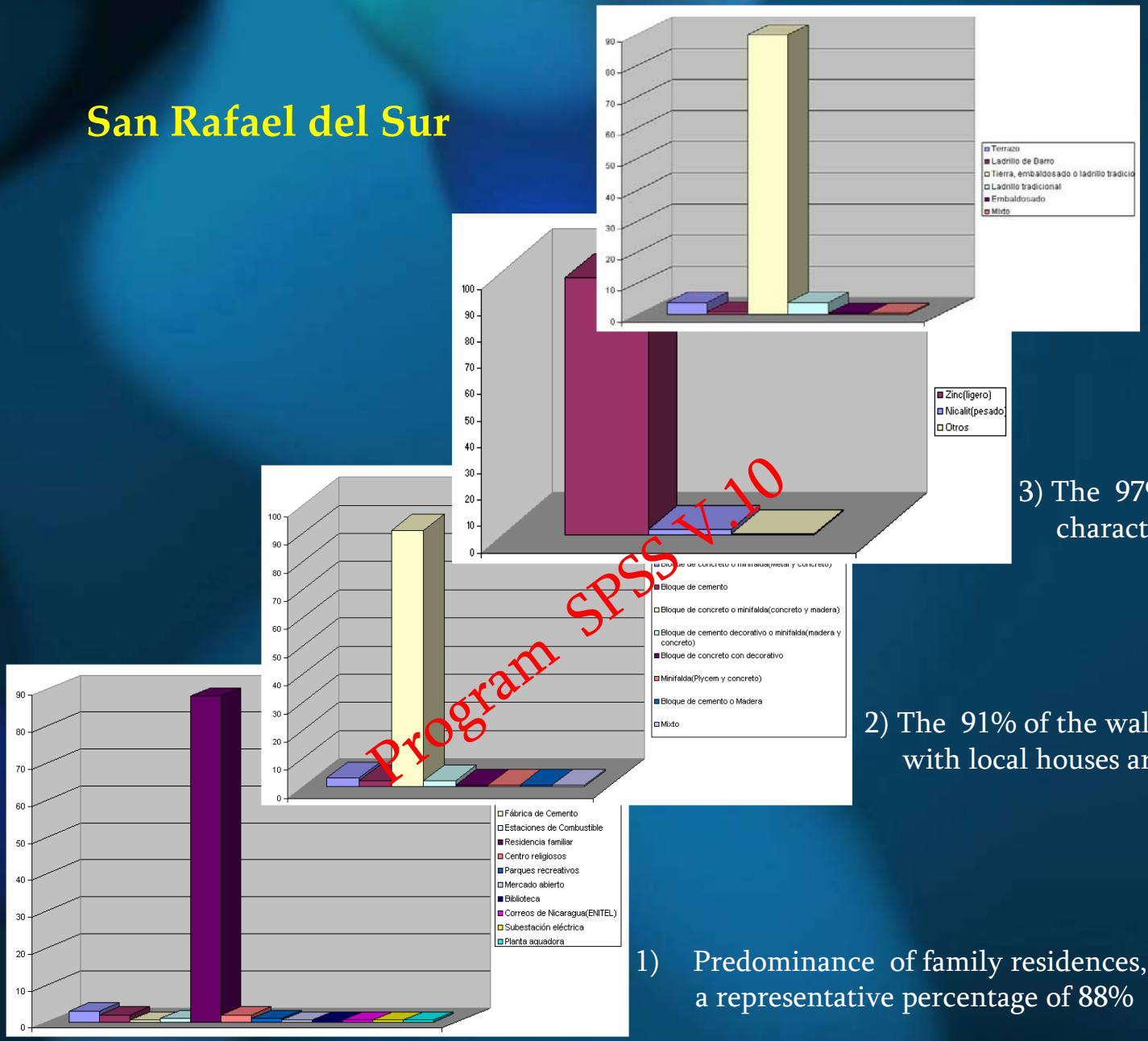



Union of San Rafael del Sur with Sánchez Norte, Road Sánchez conection con Río Jordán.

Local Stratigraphic Sequence

# F) STATISTICS OF PHYSICAL INFRAESTRUCTURE STUDY SITE

## San Rafael del Sur




4) In 90% the physical structures are traditional brick floor

3) The 97% of the local construction are characterized by using zinc roof

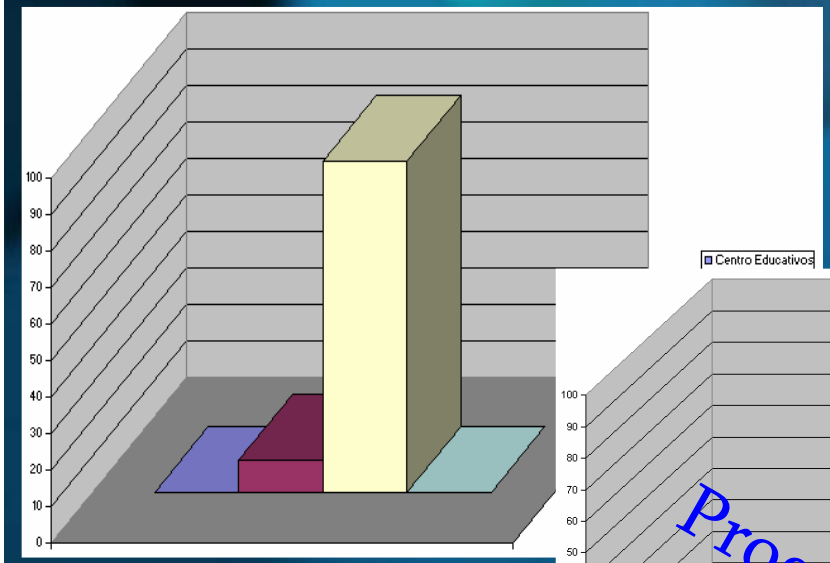
2) The 91% of the wall or parapet that are formed with local houses are in masonrry

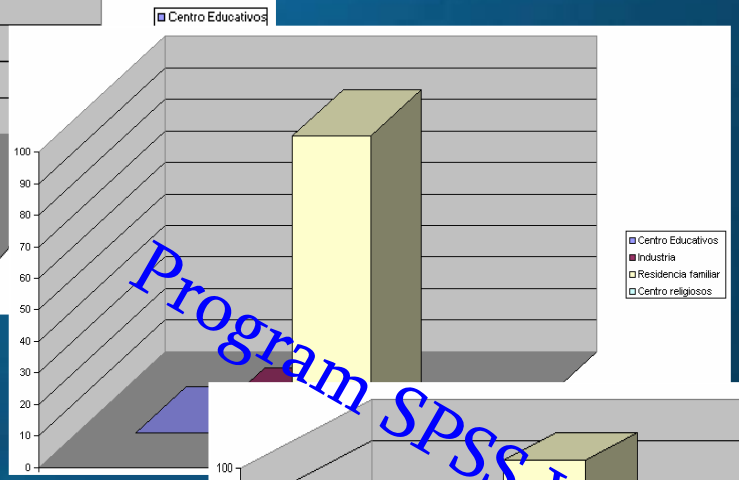
1) Predominance of family residences, with a representative percentage of 88%

Continued…….

## Los Jaras.

The 91% of the buildings are family-type, consisting of zinc roof, cement block walls and wood and dirt floor or brick traditional.

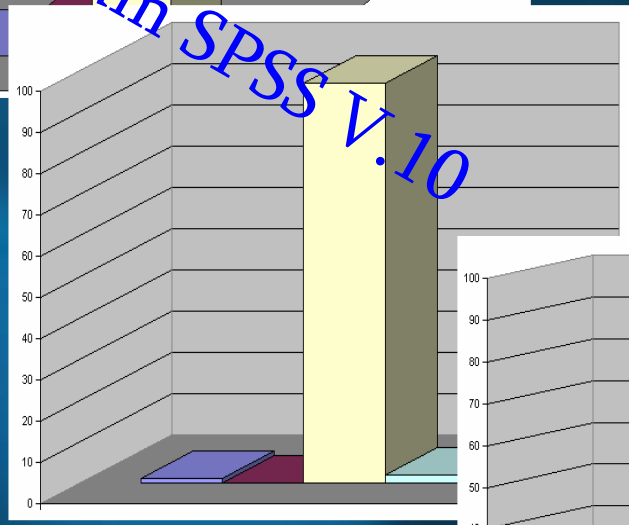



Program SPSS V.10

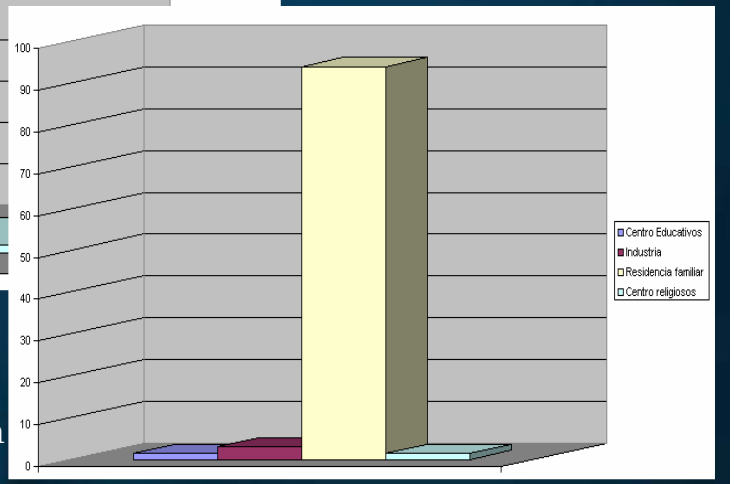
## El Tamarindo.

The 94% of the construction are family-type with poor construction materials.




## Los Gutiérrez Norte

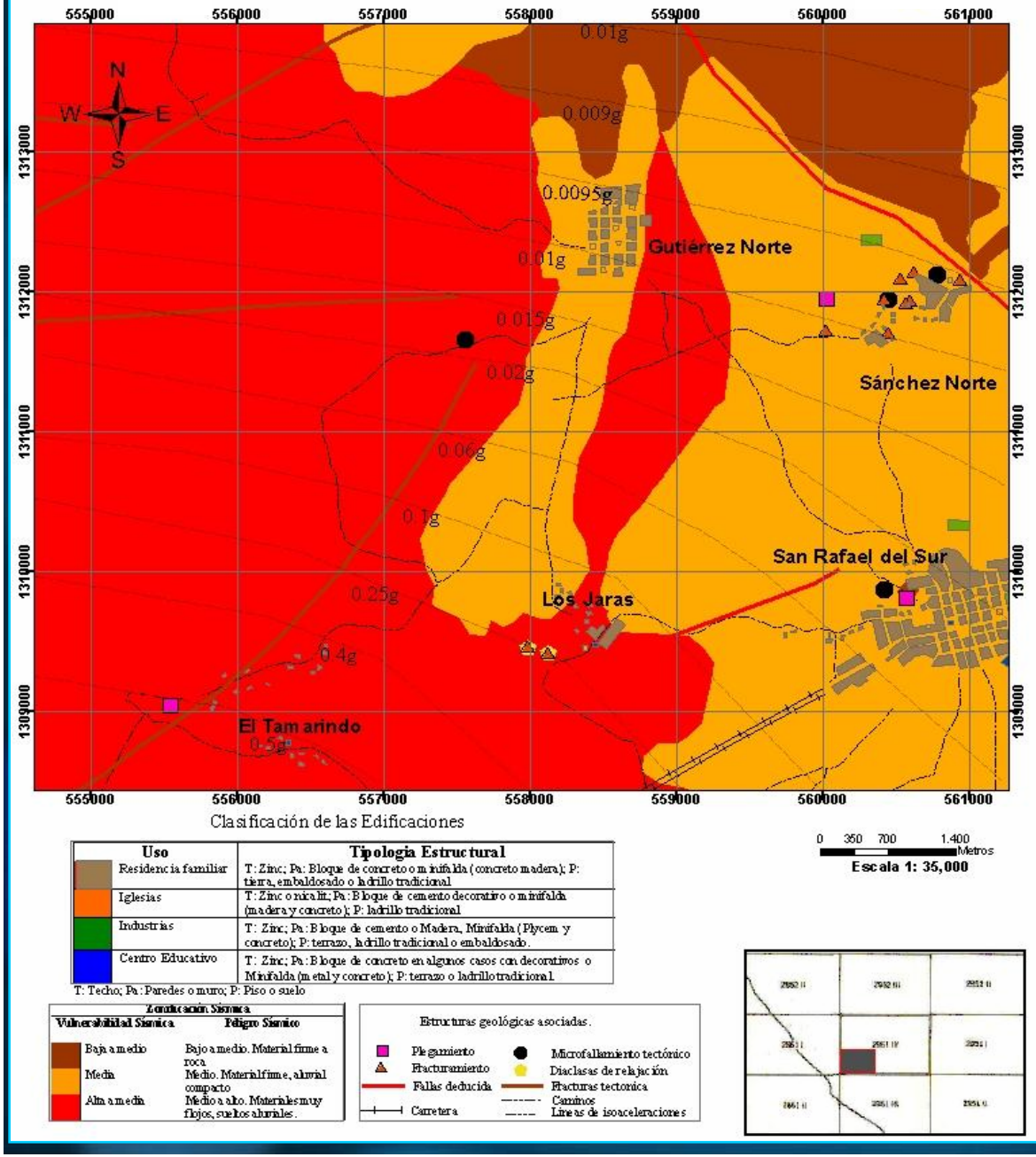
In a 97% family-type construction Stand out with good materials constructive.




## Los Sánchez Norte.

Formed by 94% by the predominance of households with regular state of construction materials.

# G) SEISMIC MICROZONATION, SCALE 1:35,000




Determination of seismic accelerations, applying NUMERICAL MODELS

- $A = 0.0159\, e^{0.868M}/(R + 0.060e^{0.7M})^{1.09}$
- **Mb = 3.30 + 0.40Ms** (Castillo, 1993)

Where:

A: peak acceleration of ground (gals)
M: magnitude seismic (ºRitcher)
R: focal depth (km)
e: exponencial function with value adimensional equal to 2.718281828.

Unit of measure Acceleration soil is the gals (cm/s2).

Based on the historical record of quake occurred in San Rafael del Sur

**Software ArcGis 9.3**

"The joy to see and understand is the most perfect gift of nature"

Albert Einstein

# ¡THANK YOU!

"Don't let extinguish the enthusiasm, as required under so valuable; works, aims, always tends toward the heights."

Rubén Darío

"We don't have another world which we can move."

Gabriel García Márquez