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The New Colombian Seismological Network

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RESUMEN
El Instituto de Investigaciones en Geociencias, Minería y Química de Colombia (INGEOMINAS) ha empezado a instalar la Red Sismológica Nacional de Colombia -RSNC- bajo los auspicios de la Agencia Canadiense para el Desarrollo Internacional (CIDA), el Programa de las Naciones Unidas para el Desarrollo (UNDP), la Dirección Nacional para la Atención y Prevención de Desastres (DNPAD), y la Empresa Nacional de Telecomunicaciones de Colombia (TELECOM). La meta del sistema es la adquisición de datos sísmicos originados en un grupo de sitios estratégicamente localizados en el territorio colombiano susceptibles a actividad sísmica y volcánica, e investigar el origen y los procesos que causan los terremotos. Esta información es transmitida desde cada estación remota vía satélite al Centro de Control localizado en Santafé de Bogotá, en donde la información es procesada. El sistema comprende tres subsistemas: Sísmico, Comunicación Satélite y Energía. La Red cubre actualmente 15 sitios con una capacidad de expansión hasta 24 estaciones. La reciente Red ha sido orientada hacia el incremento de la predicción y capacidades de alerta respecto a sismos y erupciones volcánicas; a estudiar la distribución sísmica espacial y temporalmente; a identificar las fuentes sismogénicas, su mecanismo y geometría; y también, a crear conciencia pública acerca de las causas, efectos y mitigación de los riesgos naturales. Una importante parte del proyecto es la Red de Acelerógrafos, con más de 130 instrumentos distribuidos en el territorio colombiano. INGEOMINAS emprenderá los estudios sismológicos nacionales, y alentará la distribución de la información entre la comunidad en general, científicos e ingenieros, así como también entre los planeadores y los tomadores de decisiones.

PALABRAS CLAVE: Datos sísmicos, fuentes sismogénicas, riesgos naturales.

ABSTRACT
The Institute of Geosciences, Mining and Chemical Research of Colombia (INGEOMINAS, the former Colombian Geological Survey) has deployed the National Seismological Network under the auspices of the Canadian International Development Agency (CIDA), the United Nations Development Program (UNDP), the National Direction for Prevention and Attention of Disasters (DNPAD), and the Colombian Telecommunications Company (TELECOM). The goal of the system is the acquisition of seismic data originated in a set of strategically located sites in the Colombian territory susceptible to seismic and volcanic activity, and to investigate the origin of processes that cause earthquakes. This information is transmitted from each remote station through satellite link to a Control Center located in Bogotá, where the information is processed. The system comprises three major subsystems: Seismic, Satellite Communications and Power. The net covers 15 sites with an expansion capability of up to 24 remote sites. The new seismological network has been oriented toward forecasting and warning capabilities concerning earthquakes and volcanic eruptions, to study the spatial and temporal seismic distribution to identify seismogenic sources, its mechanism and geometry; and to create public awareness about the causes, effects and mitigation of natural hazards. An important part of the project is the accelerograph network with more than 130 instruments distributed in the Colombian territory.

KEY WORDS: Seismic data, seismogenic sources, natural hazards.

INTRODUCTION

Colombia is located in a very complex tectonic environment, where three tectonic plates are converging (Figure 1). Many earthquakes and volcanic eruption have occurred in the past.

Until recently, there were not enough data to evaluate seismic hazard, mainly for lack of a Seismological Network operating full time with an acceptable quality.

Since 1987 the Colombian Geological Survey (INGEO MINAS) started the Colombian Seismological Network (RSNC) with support from the Canadian International Development Agency (CIDA), the United Nations Development Program (UNDP), the National Direction of Prevention and Attention of Disasters (DNPAD), and the Colombian Telecommunications Agency (TELECOM).

The instrumentation used by RSNC has the highest technology in seismic observation in real time currently available.

BACKGROUND

Destructive earthquakes in Caldas and Tumaco (1979), Cúcuta (1981) and Popayán (1983) highlighted the need to install a permanent seismological and volcanic network. The Instituto Geofísico de los Andes which belongs to the Universidad Javeriana, was the only Colombian institution that was doing some seismic detection. Because of low budget and few stations, they were inadequate for earthquake location in the entire Colombian territory.

In November 13, 1985 the volcanic eruption at Nevado del Ruiz volcano killed 20000 people and caused millions of dollars in economical losses. The Colombian government created the National System of Prevention and Atten-

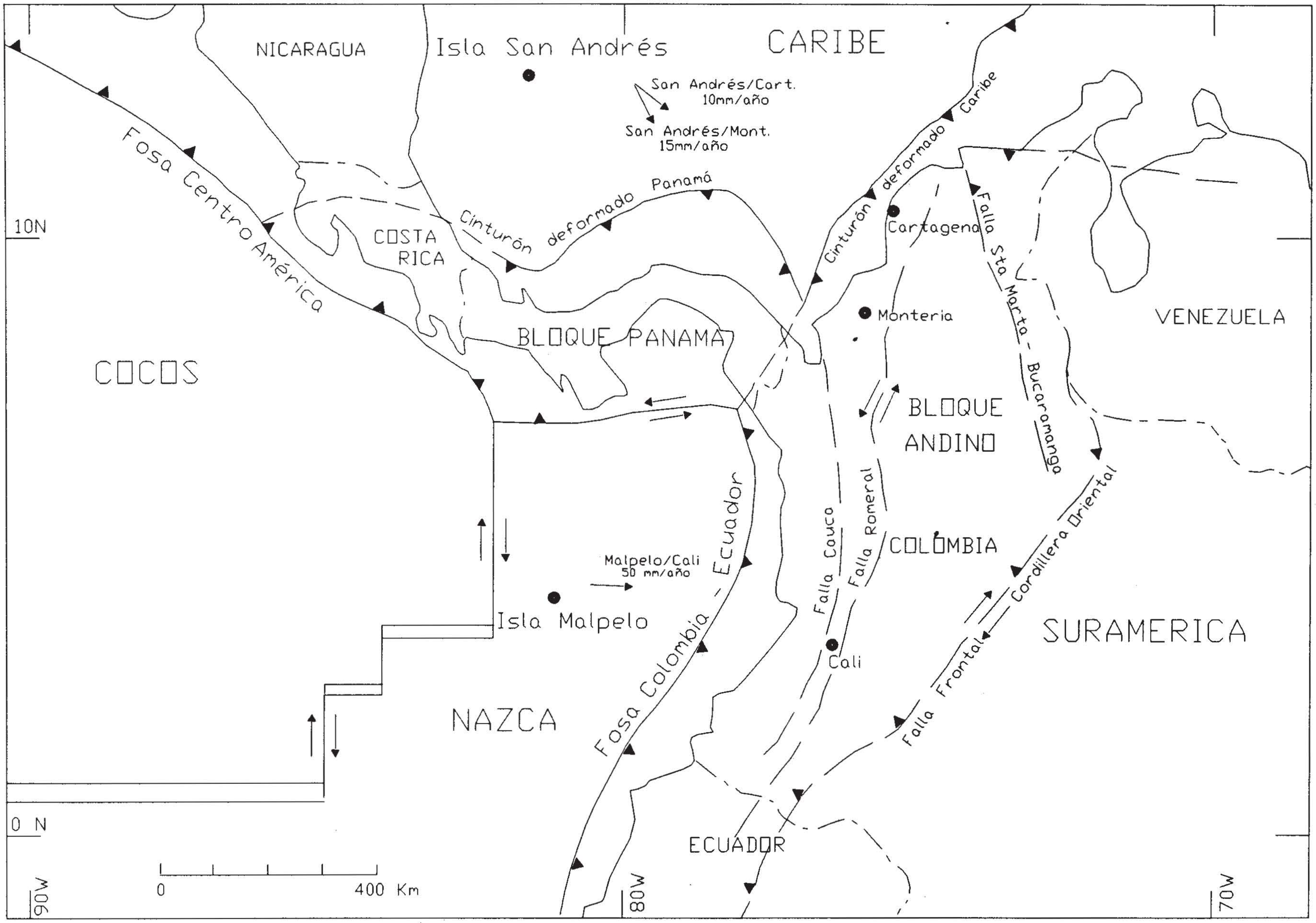

Fig. 1. General tectonic map of northwestern South America (modified after Kellog and Vega, 1995).

tion of Disasters (SNPAD) which consists of a group of institutions in charge of earthquake emergencies.

In 1987 started the preliminary activities of the network, consisting in selecting sites. Because of the topography, the data transmission to Bogotá is by satellite, incorporating TELECOM to the Project (Sarria, 1987).

The equipment installation at remote sites started in 1992. In October 1992, tests were made at five pilot stations under the supervision of Canadian experts. In April 1993, the first seismic signal was received and in December, 1993, 13 out of 14 remote stations sites were working in Phase I.

The Network has now 15 stations covering the priority areas. In Phase II, stations will be installed along the borders of the country.

Parallel to the RSNC Project, the National Accelerograph Network is operating to record strong motions. It has been financed by UNDP and will study seismic wave attenuation across the Colombian Andes.

3. DESCRIPTION OF THE SEISMOLOGICAL NETWORK

The RSNC has 15 remote stations (RES) and one master station (MES) located in Santafé de Bogotá. The Project has two phases depending on priorities (Figure 2 and Table 1). Phase I is completed and in operation, covering the Andean zone with the highest seismicity and the largest population. Phase II (Figure 2 and Table 2) started in 1995 and covers important sites with less population and minor seismic activity.

Table 1

RSNC Project stations. Phase I.

CODE	Nº	SITE	DEPARTMENT	Latitude (°N)	Longitude (°W)
ROSC	1	El Rosal	Cundinamarca	4.86	74.33
CHIC	2	Chingaza	Cundinamarca	4.63	73.73
BARC	3	Barichara	Santander	6.64	73.18
RUSC	4	La Rusia	Boyacá	5.93	73.08
PRAC	5	Prado	Tolima	3.70	74.90
TOLC	6	Nev. Tolima	Tolima	4.59	75.34
CUMC	7	Cumbal	Nariño	0.86	77.84
FLOC	8	Florencia	Caquetá	1.51	75.63
HELC	9	Santa Helena	Antioquia	6.23	75.55
NORC	10	Norcasia	Caldas	5.60	74.89
BETC	11	Betania	Huila	2.68	75.44
CRUC	12	La Cruz	Nariño	1.50	76.95
MUNC	13	Munchique	Cauca	2.47	76.96
MALC	14	Bahía Malaga	Valle	4.1	77.35
SOLC	15	Bahía Solano	Chocó	6.37	77.46

The System has two main parts: the **remote stations,** where the seismic data are originated and transmitted, and **the master station** where the data are received and processed. The diagram is shown in Figures 3 and 4 (Muñoz and Escallón, 1994).

3.1 Master Station

The Master Station is located in Santafé de Bogotá, where INGEOMINAS has its headquarters. The data are received via satellite and the information is transferred to a computer system for analysis, storage and production of bulletins and maps.

Table 2

RSNC Project stations. Phase II.

CODE	Nº	SITE	DEPARTMENT	Latitude (°N)	Longitude (°W)
TUMC1	16	Tumaco	Nariño	1.83	78.77
CAPC1	17	Capurganá	Chocó	8.41	77.11
GUAC1	18	San José del Guaviare	Guaviare	2.60	72.68
PEDC1	19	San Pedro de la Sierra	Magdalena	10.91	74.05
OCAC1	20	Ocaña	N. Santander	8.20	73.40
BTLC	21	Betulia	Antioquia	6.10	76.00
PAMC	22	Pamplona	N. Santander	7.40	72.70
BCAC	23	B/bermeja	Santander	7.00	73.80
CARC	24	San Carlos	Antioquia	6.20	75.00
COCC	25	Cocuy	Boyacá	6.50	72.40
MOCC	26	Mocoa	Putumayo	1.20	76.70
ITSC	27	Itsmina	Chocó	5.20	76.80
LEGC	28	Puerto Leguízamo	Putumayo (Sur)	0.12	74.85

3.1.1 Satellite Data Reception

A 9.1 m diameter antenna receives the signal of all channels (Figure 3), and through a pressure wave-guide the signals are conducted to a dual demodulated system. There is an alternate system for backup. The system has a capability of receiving up to 24 channels. A communications computer verifies the signal quality and executes routine operations.

3.1.2 Timing System

After the signals have been demodulated by the communications system, they are sent to the time system (Figure 5). Two precise GOES clocks receive a time signal from Colorado (USA) and set the time on the seismic signal.

3.1.3 Seismogram Printer

After receiving the time, the signal goes to the print-

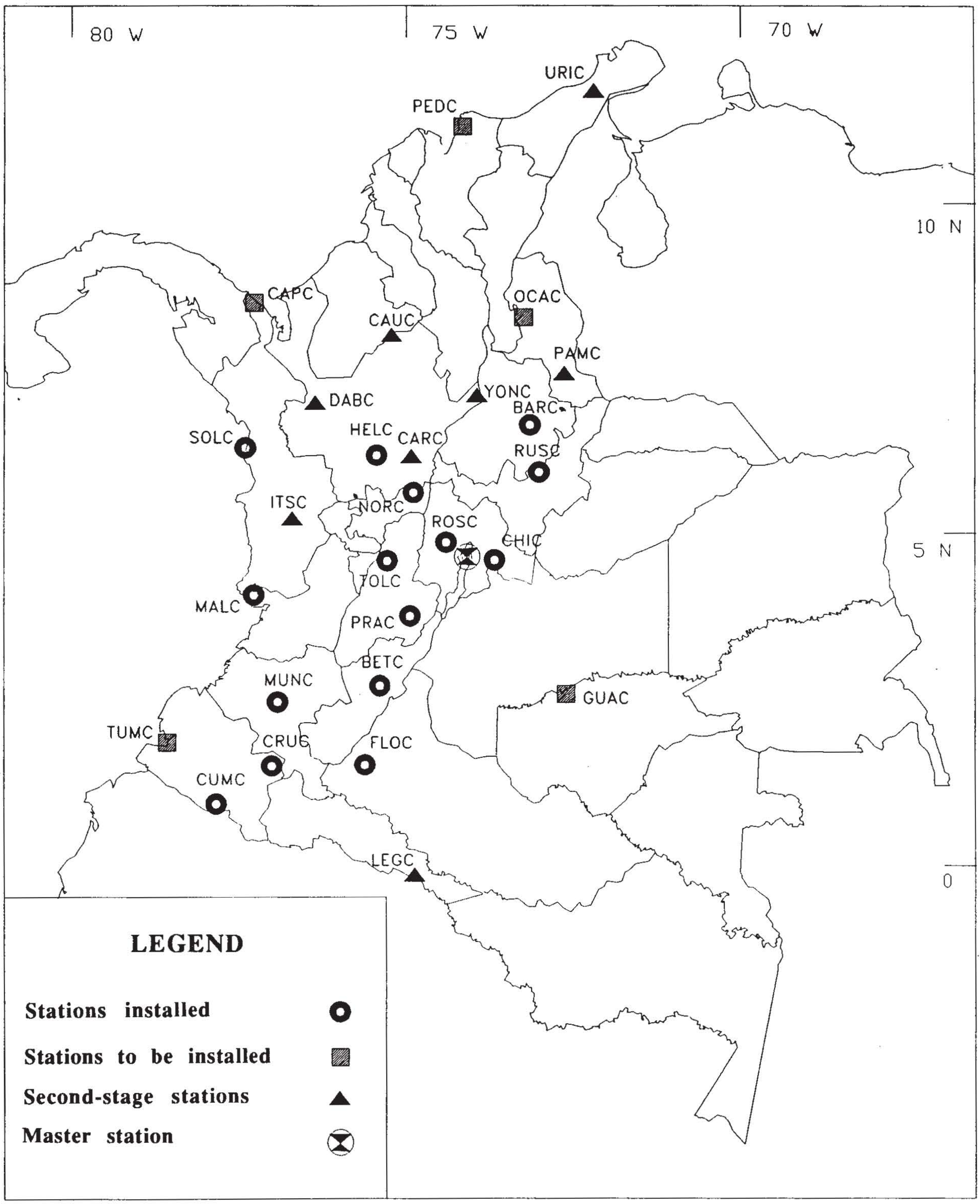

Fig. 2. Project National Seismological Network, phases I and II.

ers. This enables us to evaluate quickly the seismic activity and the remote station data quality.

3.1.4 Data Acquisition System (DAQS)

The seismic data go to two identical computers, which execute a special acquisition software called DAQS. The information is recorded on a hard disk in files type FIFO (First Input First Output) with 36 hours length. The seismic activity is continually recorded for each station. Additionally, a *backup* is done on 4 mm digital tapes every 15 min. The acquisition system detects earthquakes depending on the signal/noise relation.

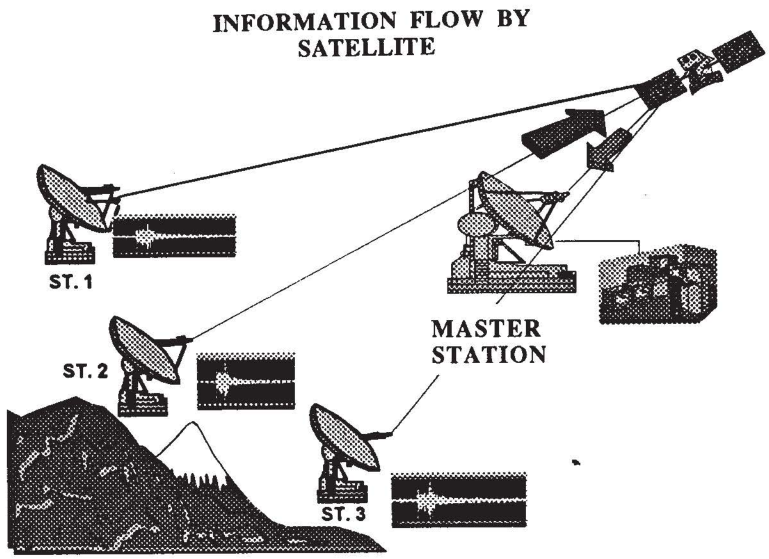

Fig. 3. Diagram of communications system.

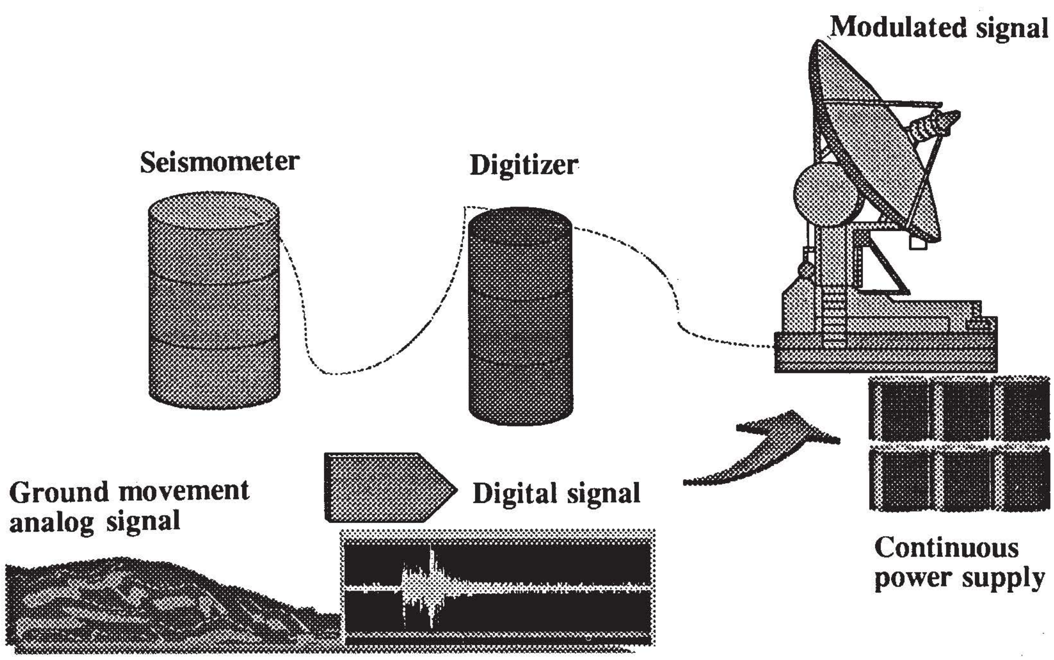

Fig. 4. Diagram of data flow.

3.1.5 State of Health (SOH) Verification System

DAQS executes permanently a check of the operation for the remote stations and for the communications system. It includes five checks:

Batteries: Battery voltage in each remote station.
Electrical Power: With commercial power or on batteries.
Remote System Communications Power: Verifies the system communication power at the remote site.
Satellite Communications stage: Checks the communications system.
Intruder: Detects intruder in a station.

3.1.6 Alarm System

The DAQS has an automatic system to check the remote stations or the master station, and the seismicity activity level. There are sound and light alarms with green, yellow and red colors.

The DAQS also has a hardware unit for checking out the acquisition programs. When a problem occurs, the unit restarts automatically the system.

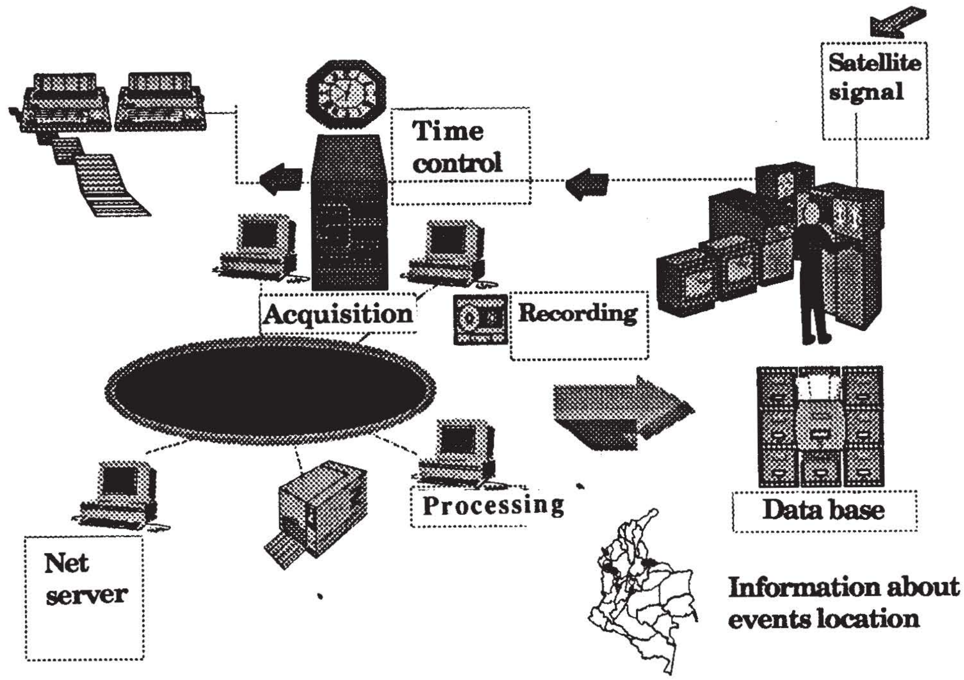

Fig. 5. Diagram of data processing in the Master station.

3.1.7 Data Analysis System

To process and locate the earthquakes, we use a software called DAN (Data Analysis System) by Nanometrics. It works under OS/2 in 32 bits.

3.1.8 Data Base System

There is a data base to store all information in a very flexible way, including event phases, velocity models, magnitudes and coordinates of the events.

3.2 REMOTE STATION (RES)

The Remote Stations (RES) are on quiet site good reception. Each RES has a seismometer, a digitizer and a satellite communications equipment supported by commercial energy or batteries (Figure 4).

The seismometer is a Teledyne Geotech S-13 vertical component with a period of 1.33 to 0.91 segs. (0.75-1.1 Hz).

The data are digitized with a dynamic range of 136 db, 16 bits resolution, 60 sps, SOH system information plus additional sensors like humidity and temperature.

The communication system works with INTELSAT VI satellites via TELECOM. This system gives a 99.9% operation, which is better than UHF transmission. The satellite communication system has a *transceiver* by IDC which satisfies power requirements, temperature changes and two-way data transmission.

If there is a power failure, 11 batteries can work up to 36 hours. Also there is lightning and power protection.

4. CONCLUSIONS

Our country is exposed to large earthquakes. Thousands of people have died and many other have had economical losses. With the operation of the Colombian Seismological Network, the nation has begun a new stage in the knowledge and study of seismic activity, which will help in the Colombian people well-being.

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