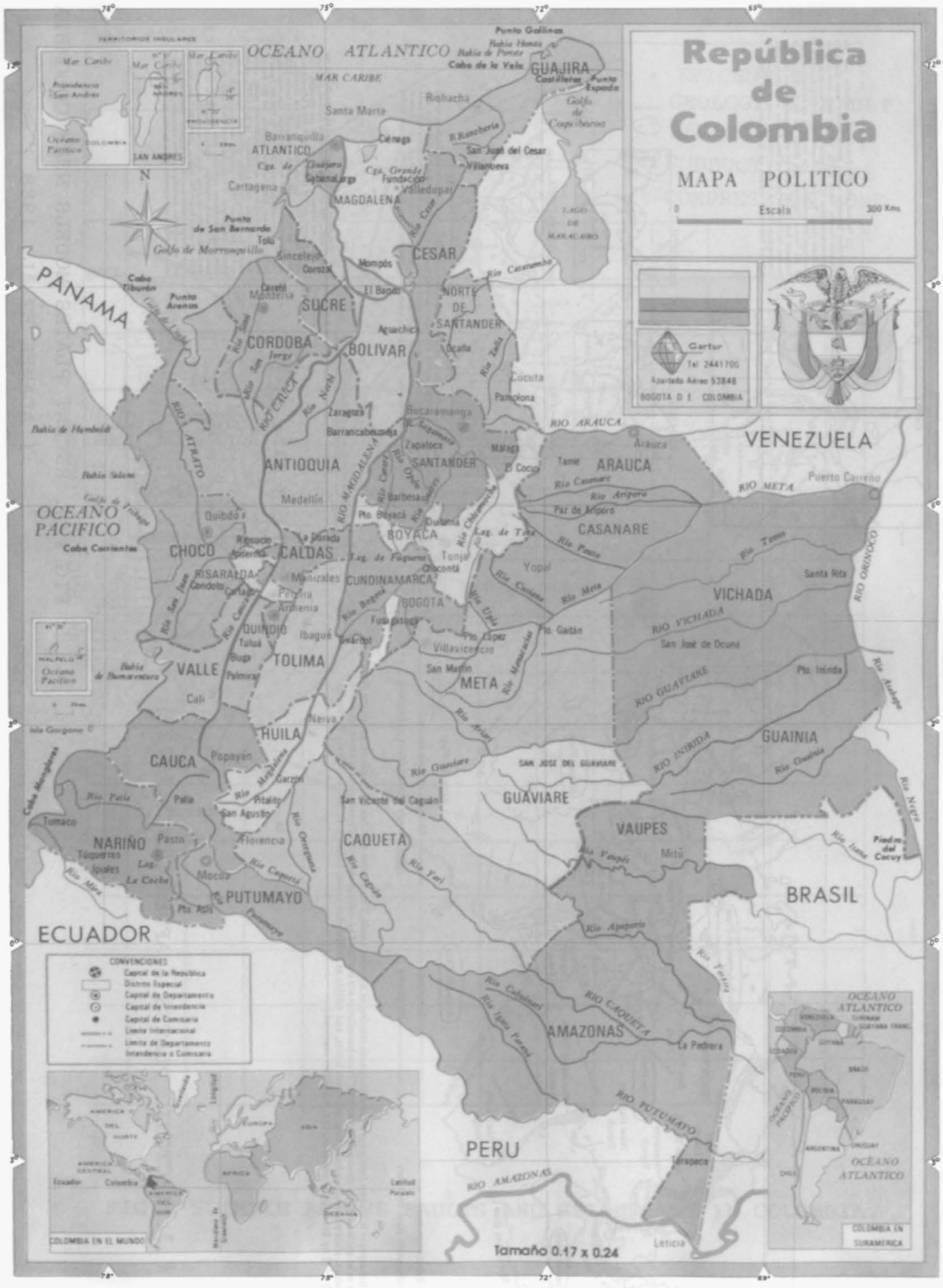
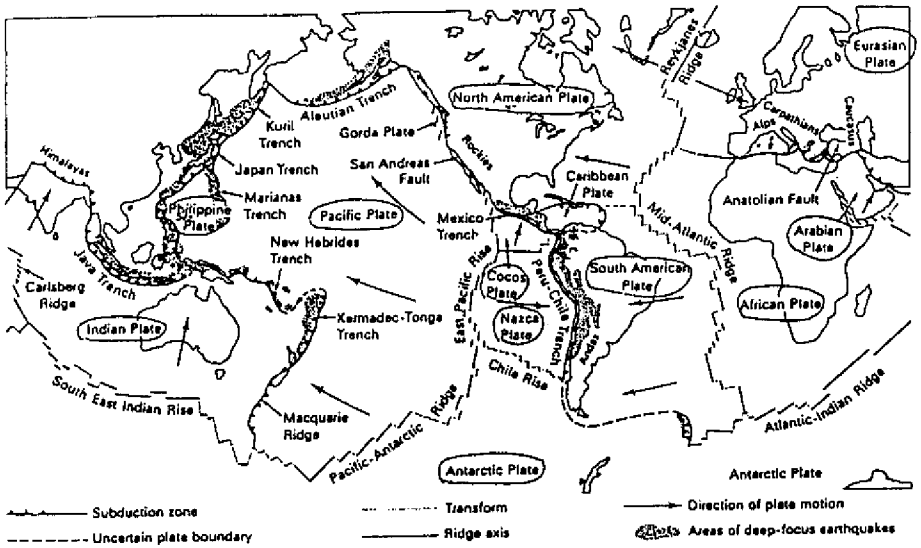


FIG # 2. POLITICAL MAP OF COLOMBIA.



The earth's lithosphere is broken into large rigid plates, each moving as a distinct unit. The relative motions of the plates, assuming the African plate to be stationary, are shown by the arrows. Plate boundaries are outlined by earthquake belts. Plates separate along the axes of mid-ocean ridges, slide past each other along transform faults, and collide at subduction zones. [After J. F. Dewey, "Plate Tectonics." Copyright © 1972 by Scientific American, Inc. All rights reserved.]

FIG # 3. TECTONIC PLATES (AFTER DEWEY,1972)

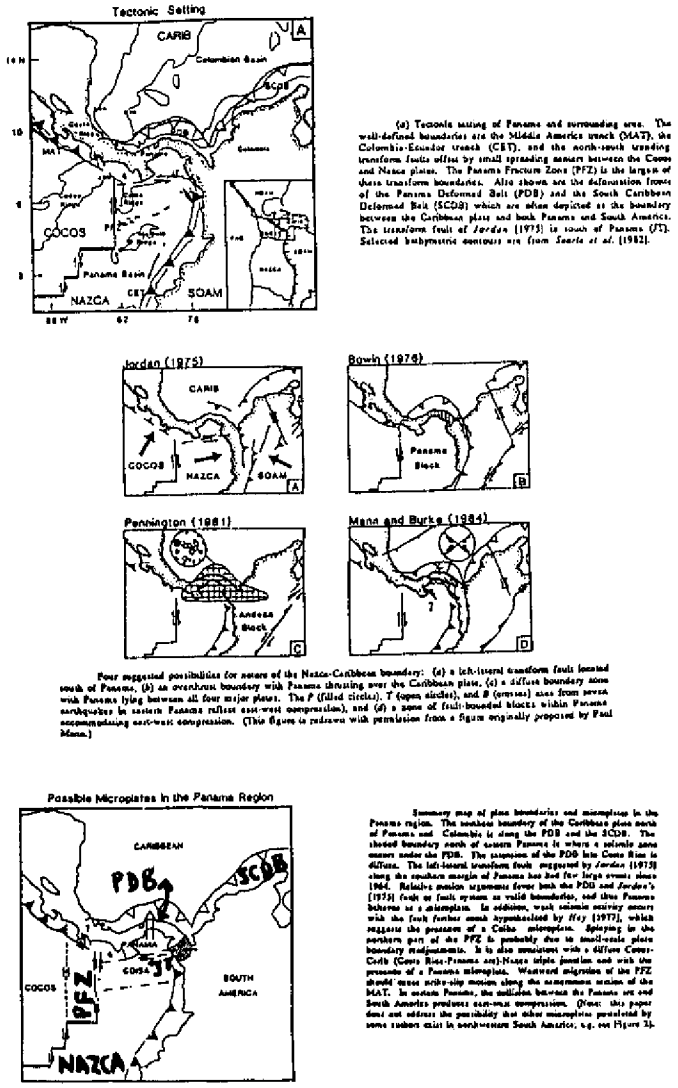


FIG # 4. RECENT PLATES MODELS NEAR COLOMBIA
(ADAMEK ET AL, 1988)

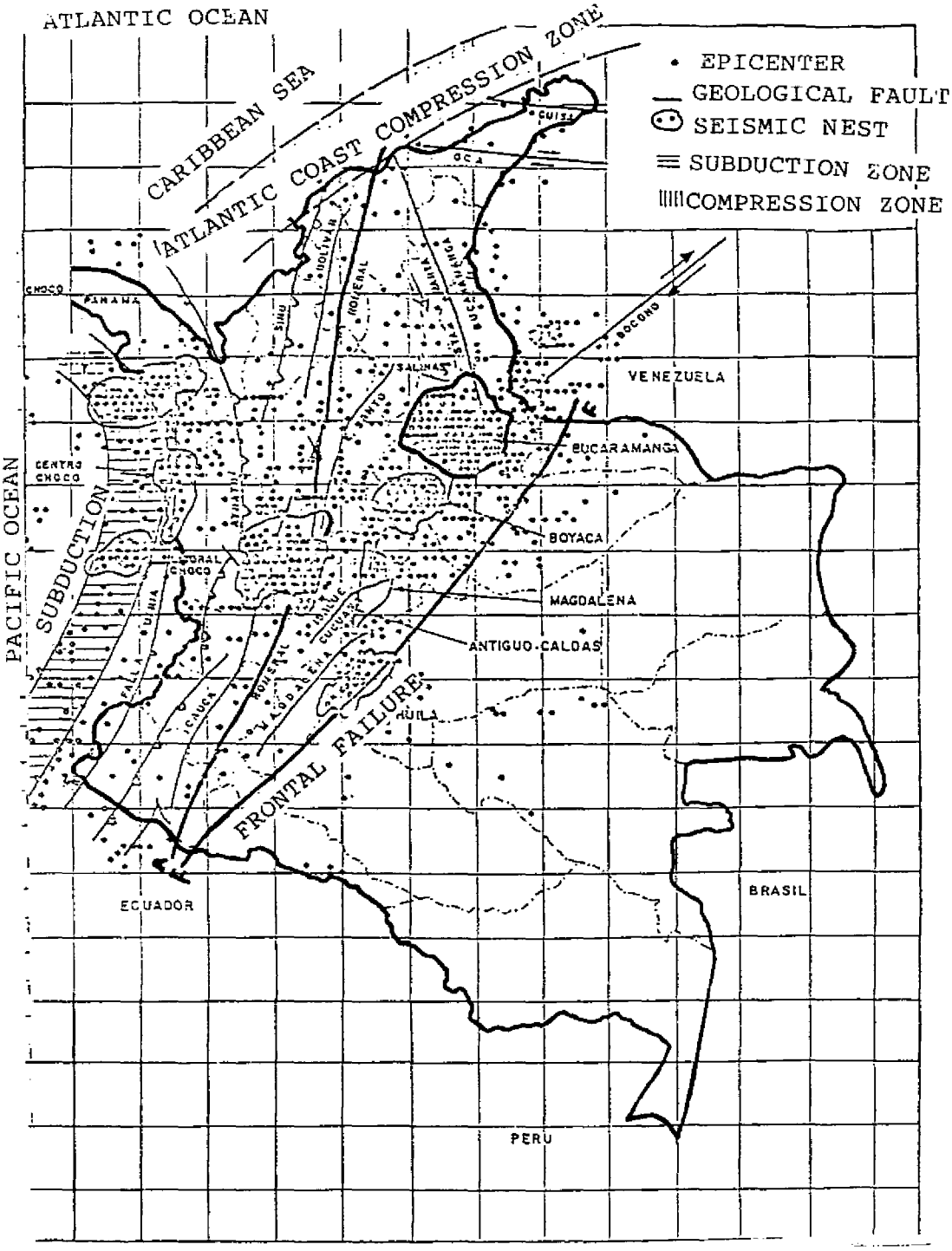


FIG # 5. MAIN ACTIVE FAULTS AND SEISMICITY IN COLOMBIA.

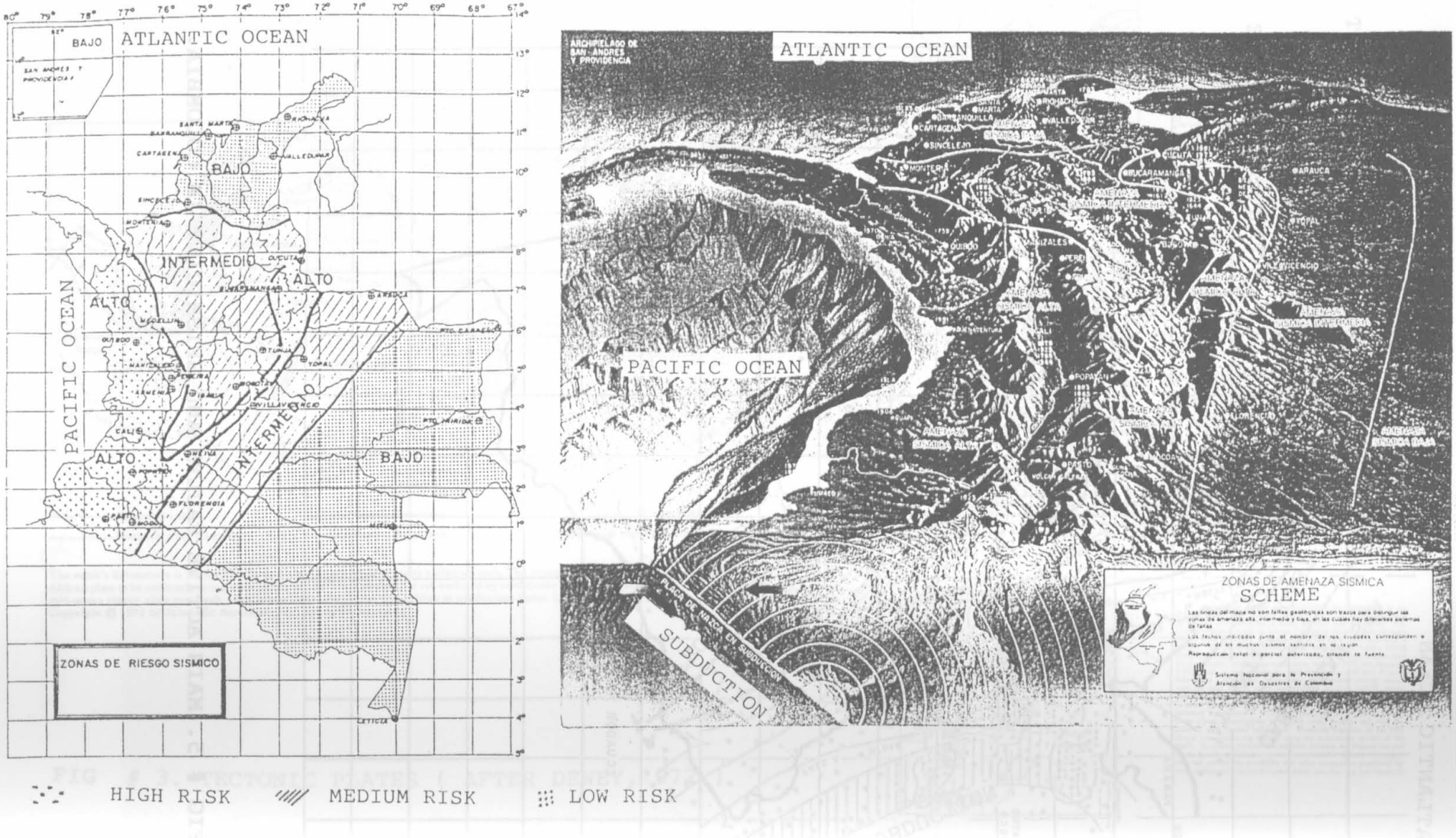


FIG # 6. SEISMIC RISK ZONATION OF COLOMBIA (1984)

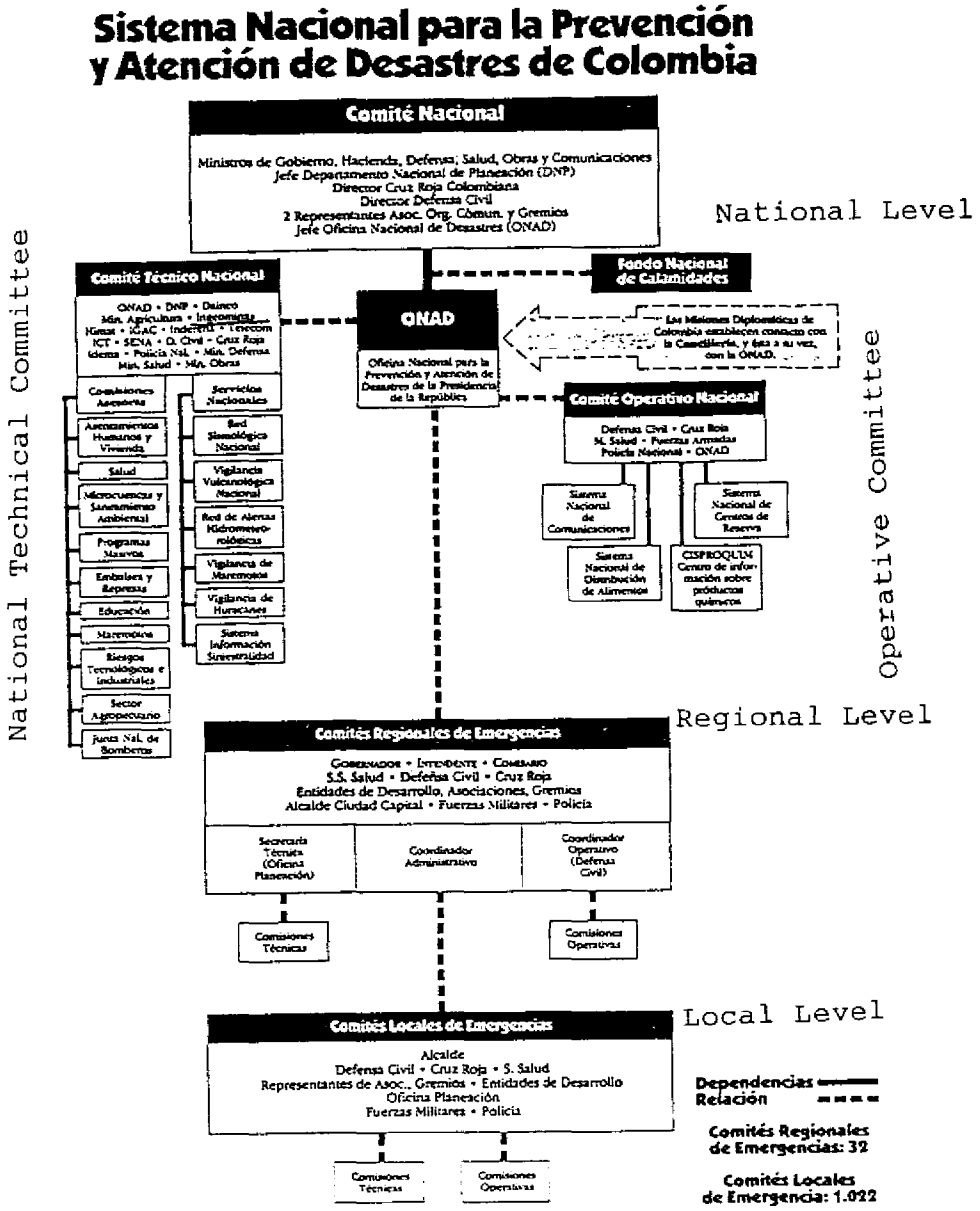


FIG # 7. NATIONAL SYSTEM FOR DISASTER PREVENTION AND ASSISTANCE.

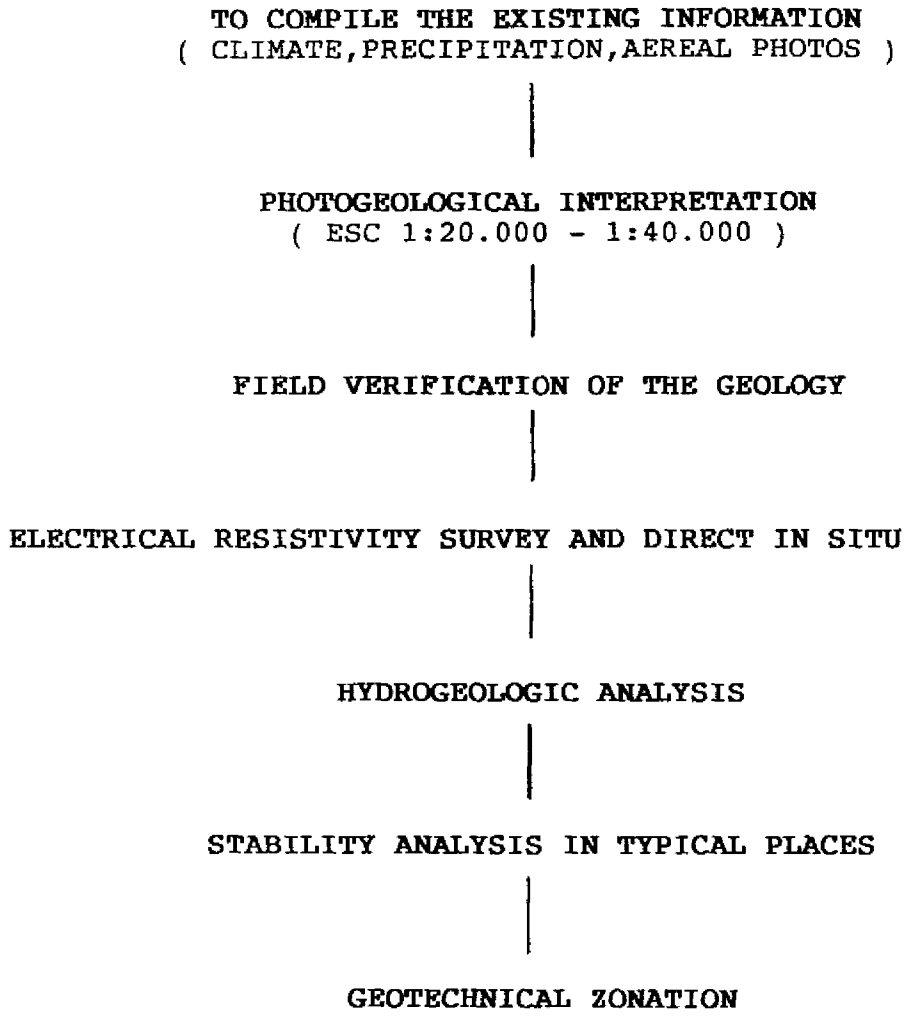


FIG # 8. METHODOLOGY OF THE ZONATION OF SANTAFE DE BOGOTA.

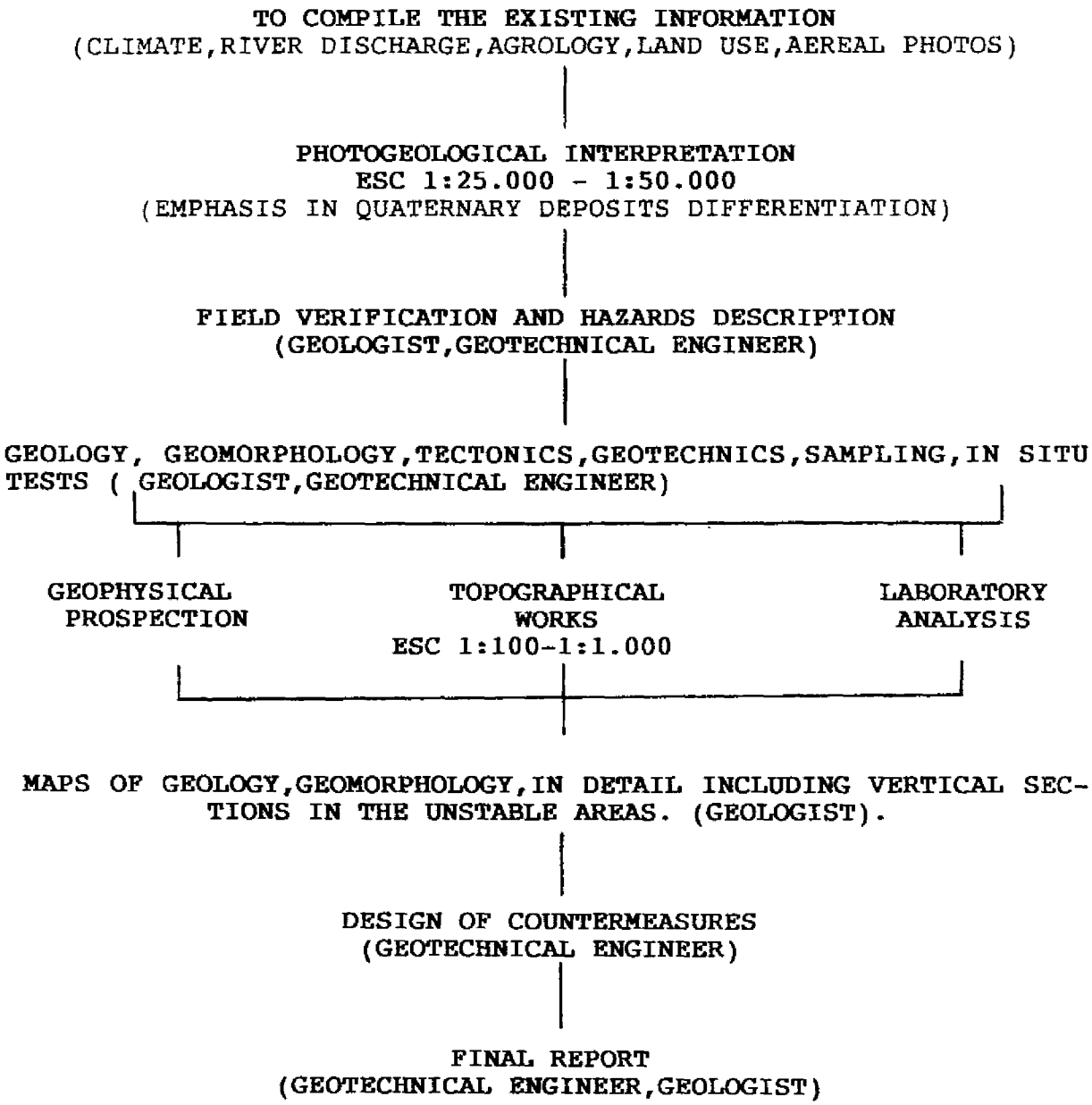


FIG # 9. METHODOLOGY OF THE LANDSLIDE STUDY AND STABILIZATION IN CUNDINAMARCA,1st PHASE.

AVALANCHE RISK EVALUATION AT UTICA (COLOMBIA)

SPECIFIC METHODOLOGY

1.- EVALUATION OF MAIN TRIGGERING EVENTS

1.1.- Seismology

a) Seismic Hazard Evaluation (rock level horizontal accelerations) for different return periods.

1.2.- Hydrology

1.2.1.- Rainfall

a) Data analyses, evaluation and complementation of existing raingage stations for monthly and daily rainstorms.

b) Isohyetal maps
-For October-November 1988
-Mean annual rainfall
-Mean monthly rainfall for April, October and November

c) Intensity-Duration-Frequency Curves.
-Rainstorms for return periods between 1 and 100 years and durations of 0.5 and 24 hours.

d) Periodicity and Cycles of Intense Rainy Seasons

1.2.2.- Streamflows

a) Data analyses, evaluation and complementation of existing flowgage stations in Rio Negro for mean and extreme annual, monthly and daily flows.

b) Maximum and Mean Flows: for different return periods at Utica and at other 7 stations between Villeta and Puente Libre

c) Peak flows due to river dam breaks at Sta. Bárbara

d) Calculation of runoff and peak streamflows in 13 sub-basins of Quebrada Negra Basin. Flow routing along the stream and hydrographs of annual and 100-year peak streamflows.

e) Estimation of solid transport in Quebrada Negra and its effects in peak streamflows.

2.- GENERAL SUSCEPTIBILITY AND STABILITY EVALUATIONS

a) General stability zoning.

b) General stability evaluation of movements and main potential unstable zones, with semiquantitative indexes.

c) Probabilistic hillslope stability analyses by means of Sharp's Natural Slope Methodology (NSM) and total probability theorem.

3.- HAZARD EVALUATION IN QUEBRADA NEGRA

a) Identification of dangerous dam-producing landslides.

b) Calculation of various probable dam heights and impounded volumes of water.

c) Estimation of possible avalanche peakflows and levels at the entrance to Utica, including damping due to distance, hydrological peakflows and sediment transport.

d) Probabilistic analyses of occurrence of avalanche peakflows.

4.- HAZARD EVALUATION DUE TO SANTA BARBARA LANDSLIDE

a) Calculation of possible landslide volumes and corresponding dam heights and reservoir volumes.

b) Evaluation of possible sequence of landslide volumes.

c) Probabilistic analyses of river damming.

d) Estimation of avalanche levels and peakflows at Utica.

e) Estimation of arrival times.

5.- NOMINAL RISK EVALUATION AT UTICA

a) Exposition to Floods

b) Nominal Material Risk due to Rio Negro

c) Nominal Material Risk due to Quebrada Negra

d) Joint Nominal Material Risk

6.- IDENTIFICATION AND PREDIMENSIONING OF WORKS IN QUEBRADA NEGRA

a) Predimensioning of Protective Measures for Utica:
- Avalanche Control Rockfill Permeable Dam and Tunnel
- Diversion Channel

b) Identification of Corrective Measures in Landslides (drainage, earthmoving, foresting)

c) Identification of Preventive Measures to Reduce Avalanches:
- Torrent control works in tributary streams
- Bridge-dams in main stream

d) Preliminary cost estimation

7.- IDENTIFICATION AND PREDIMENSIONING OF WORKS IN RIO NEGRO

a) Predimensioning of measures to avoid river damming (tunnels, pipes)

b) Predimensioning of measures to increase the stability at Santa Bárbara:
- Horizontal drains
- Drain galleries

c) Predimensioning of protective measures at Utica
- River dyke.

d) Preliminary cost estimation

8.- MONITORING SYSTEMS AND ALARMS

a) Extensometers

b) Water-level sensors

c) Alarms

d) Education and Awareness of Population

9.- SIMPLIFIED COST-BENEFIT ANALYSIS

10.- CONCLUSIONS AND RECOMMENDATIONS

a) Short Term Works and Studies
b) Medium and Long Term Works and Studies

FIG # 10. METHODOLOGY IN THE DEBRIS FLOW AVALANCHE RISK EVALUATION IN UTICA TOWN.