(a) Study of recent tectonic deformations

Photogeological and fieldwork together with stereographic processing have been used in studies of recent geological deformations. These were used as a basis for efforts to pinpoint signs of faulting resulting from recent tectonic activity, to establish the relative chronology of the tectonic events revealed in the faults discovered, and to determine the directions of the forces and identify faults that had moved in the recent past.

(b) Three-dimensional model of surface formations in the City and erosive processes

Surface formations in the city and environs have been identified, classified and situated in space-time. A preliminary identification has been made of the areas offering the best conditions for urban development. The findings have been submitted to the Town Planning Office for incorporation into its development plan.

At the same time, erosive processes are being analysed on the basis of aerial photographs depicting three different periods at different scales and seasons. The causes considered for the increase in erosion are both natural (relief, high rainfall, high ground water content, inclined rock structural faces, and a pyroclastic overburden with physical properties rendering it vulnerable to erosion) and man-made (cutting and filling for housing development and roads, interference with natural drainage patterns, the spread of substandard housing in unsuitable areas).

(c) Geology and surface formations at Sector Km 41

These studies were carried out with assistance from the Geology Faculty at the University of Caldas as degree projects, and served to evaluate the most suitable areas for future city growth. The area in question will be proposed as the site of an industrial-cum-residential complex.

2. Studies of seismic effects

Two agreements were struck between the City of Manizales and the National University campus in Manizales on the conduct of seismic studies. The studies covered the following areas:

(a) Studies of geodynamic geophysics

Geophysical soundings were taken in the built-up portion of the city. When they have been analysed and interpreted, a preliminary map of the dynamic characteristics of surface formations will be produced. Most of the inputs for this work are financed by the University.

When the triaxial dynamic device, financed with resources from the DHA-UNDRO/CIDA/DNPAD programme and supported by CORPOCALDAS, was set up at the Soils Laboratory, work began on determining the dynamic properties of the ground in Manizales. The findings will serve to flesh out the preliminary map referred to above.

(b) Study of seismic accelerations

Study and analysis of existing accelerometer records and additional ones obtained during the project period from three accelerographs installed in the city thanks to financial support from the National Disaster Fund, to obtain typical response spectra in different parts of the built-up portion of the city and amend building design and reinforcement parameters.

(c) Study of building vulnerability

Surveys were designed and carried out on a sample of typical one- and two-storey buildings in the city. The findings were analysed and presented with a view to establishing buildings' susceptibility to damage in an earthquake. The results are currently being processed.

(d) Vulnerability assessment of key buildings

The National University, with support from the Town Planning Office, studied the vulnerability of key buildings by means of analysis, calculation and surveys supported by special «one-off» studies of vital buildings.

(e) Assessment of vulnerability to fire

Besides the pursuit of the studies mentioned above, the second agreement, signed in 1995, includes studies to assess vulnerability to fire based on a project submitted by the Industrial Engineering Department at the National University campus in Manizales. The susceptibility to fire of buildings of typical height, sector, predominant materials and use will be established, together with public and private capacity to respond to events of this kind.

3. Design of the Regional Seismological Network

INGEOMINAS' Vulcanological Observatory and the National University produced the terms of reference and called a meeting to establish a Regional Seismological Network comprising 16 fixed and four mobile stations. This project for the coffee-growing belt enjoys inter-institutional support and has expanded in 1994 and 1995 as universities in the region, development corporations, departments and regional capitals have joined in. The Network is currently engaged in a preliminary study of seismic hazards in the region, and is pursuing undertakings with the Departments of Caldas, Risaralda, Quind'o and Tolima to conduct more extensive and detailed regional investigations in order to improve it.

4. City Building and Urban Development Code

Through the Town Planning Office, the Mayor's Office has pressed for the city's Building and Urban Development Code to be brought up to date, taking into account some features of the studies already carried out and leaving open the possibility that new findings may be incorporated once the research into soil dynamics, begun with the arrival of the triaxial dynamic device acquired with resources from the DHA-UNDRO/CIDA/DNPAD Programme, has been completed. Meanwhile, research into seismic accelerations means that an acceleration spectrum specific to the city of Manizales can be incorporated into the new Code (1996).

5. Incorporation of risk into town planning

The Manizales Council has agreed to the inclusion of the Emergency Response Plan into the Manizales «Quality 21st Century» Municipal Development Plan, which defines urban development zones and their environmental properties, improved institutional arrangements for risk mitigation and preparations for emergency response, sectoral and institutional budgets, the technical and scientific research required to back up development planning decisions, and strategies for participatory community ed-