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Mr. Raul E. Truffat, President
RET Corporation
P.O. Box 366
Herndon, VA 22070-0366

Re: 1988 Annual Report for the Volcanic and Earthquake Hazards Study of the Valle Central, Costa Rica
Contract No. 2906-01-02-0001

Dear Mr. Truffat:

Transmitted with this letter is the 1988 Annual Report for the Volcanic and Earthquake Hazards Study of the Valle Central, Costa Rica. The report summarizes Fiscal Year 1988 activities and accomplishments, and outlines planned activities for Fiscal 1989. The major accomplishments of 1988 are summarized below:

- ratification of the Memorandum of Understanding (MOU) between the Universidad de Costa Rica (UCR), the Universidad Nacional Autonomo (UNA), the Instituto Costarricense de Electricidad (ICE), the Comision Nacional de Emergencia (CNE), and the U.S. Agency for International Development (USAID);

- establishment of the Comision de Mitigacion de Riesgos Volcanicos y Sismicos (MIRVYS Commission) under the CNE to coordinate all technical and administrative activities;

- identification of responsibilities and detailed tasks and schedules for the activities to be completed under the MOU;

- development of final equipment lists and purchase of major portions of the equipment;

- completion of computer literature search and initiation of a technical library of pertinent documents for the program;

- initiation of earthquake database integration between the three Costa Rican technical organizations;

- preparation of preliminary fault lineament maps; and

- preparation of preliminary hazard map of the Poas volcano.

WESTON

R. Truffat

While it took longer than anticipated to ratify the MOU, significant progress has been made on the technical tasks. Further details on Fiscal Year 1988 activities can be found in December 1987, April 1988, and June 1988 trip reports transmitted to you earlier. The field season for Fiscal 1989 has been initiated and considerable work is underway.

If you have any questions concerning this report, please contact me on (202) 646-6654.

Sincerely,

Roy F. Weston, Inc.

K. Michael Cline
Project Manager, P.G.

Approved by

R. Jackson, Vice President, P.G.

cc: D. Siefken

1988 Annual Report on the Volcanic and Earthquake Hazards Mitigation Program for the Valle Central, Costa Rica

January 1989

Prepared by:
Roy F. Weston, Inc.
with support from:
Universidad Nacional Autonoma de Costa Rica
Universidad de Costa Rica
Instituto Costarricense de Electricidad
Comisión Nacional de Emergencia

Prepared for:
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1988 ANNUAL REPORT:
VOLCANIC AND EARTHQUAKE HAZARDS MITIGATION PROGRAM FOR THE VALLE CENTRAL, COSTA RICA

1.0 INTRODUCTION

At the request of the Office of Foreign Disaster Assistance (OFDA) of the U.S. Agency for International Development (USAID) and the Comision Nacional de Emergencia (CNE) of the Government of Costa Rica (GCR), RET Corporation and its contractors (Roy F. Weston, Inc. and independent consultants) are conducting a volcanic and earthquake hazards mitigation program for the Valle Central, the population center of Costa Rica. This report reviews Fiscal Year 1987 (FY87) activities, summarizes Fiscal Year 1988 (FY88) activities, and outlines planned activities for Fiscal Year 1989 (FY89). A twelve-month calendar of planned activities for FY89 is attached (Attachment 1). This calendar includes the major tasks and subtasks detailed in Appendix A of the Memorandum of Understanding signed in October, 1987 by the participating organizations. Further details of the technical activities during FY88 can be found in the December 1987, April 1988, and June 1988 trip reports, copies of which were previously submitted to CNE and USAID.

1.1 Review of FY87 Activities

Fiscal Year 1987 (FY87) activities primarily consisted of developing a working agreement, the Memorandum of Understanding (MOU), between the Costa Rican technical counterparts (Counterparts): the Universidad de Costa Rica (UCR); the Universidad Nacional Autonoma (UNA); and the Instituto Costarricense de Electricidad (ICE). FY87 activities also focused on developing an organizational structure through the CNE. The organizational structure, known as the Comision de Mitigacion de Riesgos Volcanicos y Sismicos (MIRVYS Commission), consists of an Executive Committee made up of the Vice Rectors from the Universities, the Technical Director of ICE and representatives of CNE and the Colegio de Ingenieros; and a Technical Committee made up of technical leads from UNA, UCR and ICE. Near the completion of FY87, the CNE requested that RET Corporation and its contractors (collectively referred to as the Consultants) modify the contract with USAID to provide additional management support to the MIRVYS Commission for the Counterparts. This contract modification was approved by USAID for FY88.

The MIRVYS Commission identified a series of technical subtasks to be completed by the Counterparts with support from the Consultants. Completion of these subtasks will provide data and analyses for a preliminary evaluation of volcanic and earthquake hazards. Attachment 1 lists all of these subtasks and identifies those subtasks that have been completed. The schedule has been modified periodically to meet the needs of the program.

1.2 Overview of FY88 Activities

Fiscal Year 1988 activities consisted primarily of the following work and achievements:

- signature of the MOU in October, 1987;
- finalization of equipment lists and partial purchase of equipment for the Universities and ICE.
- aerial photo interpretation and field studies to identify late Quaternary faulting and fault lineaments in the Valle Central and region surrounding the Valle Central;
- field investigations to identify and correlate the late Quaternary volcanic stratigraphy, focusing on the Holocene (last 10,000 yr), to evaluate the eruptive volcanic histories of Poas, Barva, Irazu and Turrialba volcanoes.
- compilation of the historical (instrumentally recorded) earthquake record of the Valle Central utilizing the data from the UNA, UCR and ICE, and evaluation of that database.

Attachment 1 identifies what has been completed in FY88 and the schedule with projected milestones for FY89. The milestones will vary as the program proceeds into FY89. Because the MOU required more time than anticipated and due to funding constraints and the complexity of the geology, it is anticipated that some activities of this program will extend into Fiscal Year 1990. The schedule (Attachment 1) reflects the extension into Fiscal 1990.

2.0 SUMMARY OF ADMINISTRATIVE ACTIVITIES

At the beginning of FY88, the MOU was signed and ratified by all participant organizations. The MOU details the agreements reached between the participants as to lead responsibilities for each subtasks. Some of the subtasks were initiated immediately, including a review of the equipment needs listed by the Counterparts. The initial equipment lists supplied by the Counterparts were priced by the Consultants.

2.1 Project Management

The Consultants played a key role in developing the structure of the MOU and the assignment of lead responsibilities for the technical subtasks identified in it. Recognizing the need for close project management, Dr. Herman Kruse, the Director of the CNE, requested that the Consultants modify their work plan to provide more management support. Consequently, more of the Consultants time was allocated to project management.

After ratification of the MOU, the Colones (Costa Rican national currency) budget needed to be allocated consistent with the task responsibilities. The Consultants provided guidance to CNE concerning this allocation. Subsequent to that, the Consultants provided guidance to the Counterparts in developing their budget proposals for their subtasks.

2.2 Equipment Purchases

The Consultants provided support to the Counterparts in identifying equipment needs and purchase of equipment. During FY88, Consultants met with representatives of the Escuela Centroamericano de Geologia (ECG) and the Instituto Nacional de Investigaciones Ingenieria (INII) of UCR, and the Observatorio Volcanologico y Sismologico de Costa Rica (OVSICORI) at UNA to evaluate equipment lists and develop purchase and shipping orders. Considerable effort went into evaluating equipment lists generated by the Counterparts relative to the status of existing equipment and specific needs for this program. New equipment purchases were found to be less essential than repairing and providing spare parts inventories for existing equipment.

A partial equipment order was completed for the Escuela Centroamericano de Geologia. The balance of the list, which includes geological field equipment such as stereoscopes, altimeters, etc., will be purchased and shipped in early FY89. Equipment purchases for INII have been deferred until FY 89 because of changing needs and costs. The equipment lists prepared in 1987 were not fully representative of the needs. The lists, designed to acquire additional accelerographs, exceeded the budget available by a considerable amount. A new list identifying highest priority items was completed in late FY88. The components of the list are currently being priced by the Consultants. The remaining equipment list is to be purchased and shipped in FY89.

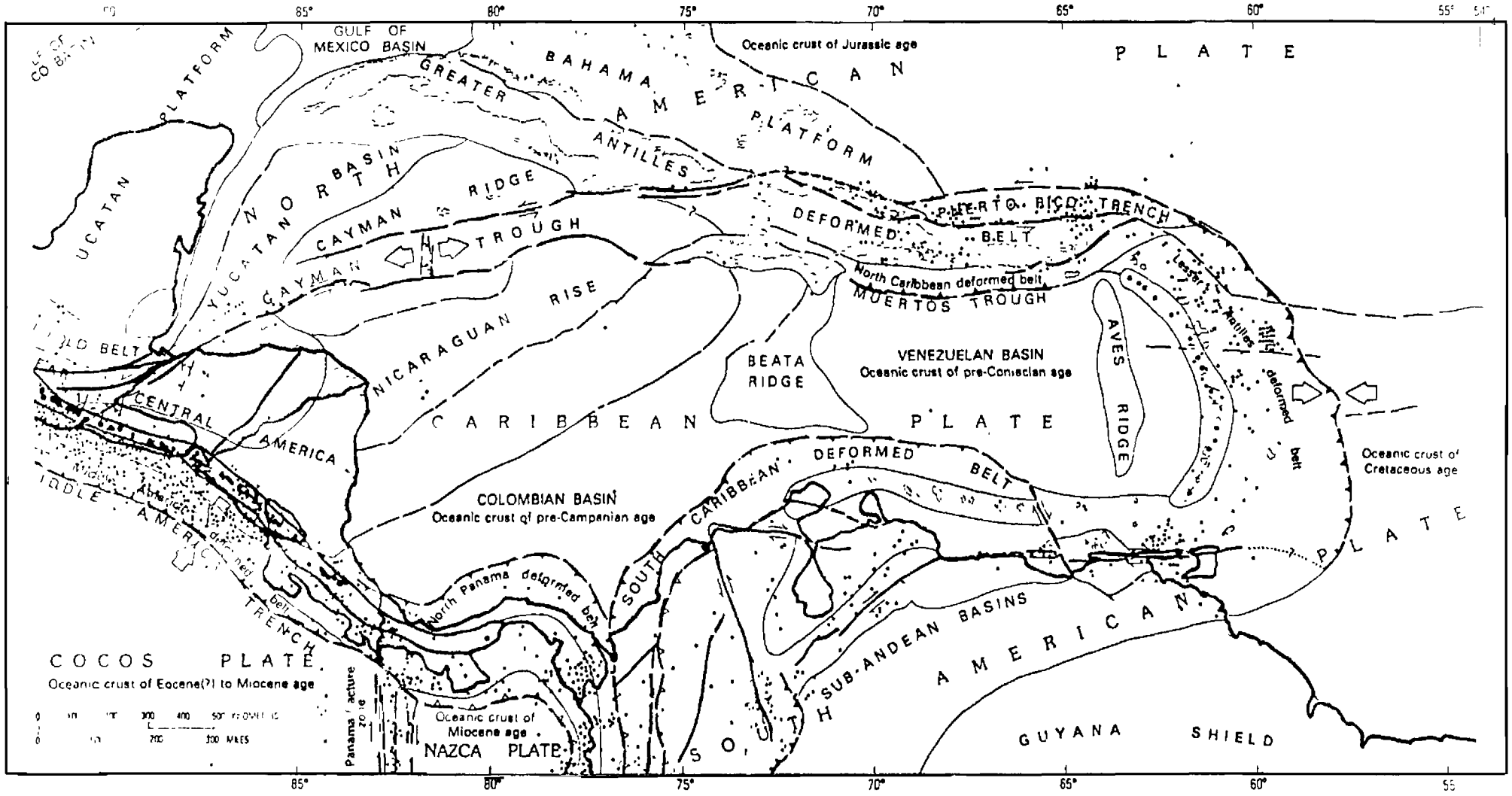
The UNA equipment was evaluated, and most of the equipment requested was ordered, purchased and shipped in FY88. This included primary components for completing a twelve-station regional seismic network, equipment for monitoring volcanic activity, maintenance equipment and spare parts.

In addition to supporting UCR and UNA on equipment purchases, the Consultants began to evaluate the status and needs of the ICE equipment used for their regional seismologic network. A report on this evaluation will be prepared in FY89.

3.0 SUMMARY OF FY88 TECHNICAL ACTIVITIES AND PRELIMINARY FINDINGS

3.1 Geologic Overview

The Valle Central is a complex regional tectonic feature whose origin is both structural and volcanic. It is a structural basin filled with a thick volcanic sequence that separates the Cordillera Central volcanic chain to the north and the uplifted Talamanca mountain chain to the south. The Holocene volcanism prevalent in Central America terminates at the Valle Central. The Valle Central trends westward and coincides with an apparent west trending break in the dip of the subducting Cocos plate at the Middle Americas Trench (see Figure 1). The Cocos plate dips at a much greater angle under the volcanic chain to the north. The tectonic origin of the Valle may be due, in part, to evacuation of magma and subsequent subsidence. The structural pattern and extent of faulting in the Valle Central is unknown; however, faulting has been observed bounding the Valle. The south side of the Valle appears to be bound by a complex series of west-trending range front faults. The north side is bound by faults on the flanks of the volcanoes that include the Alejuela escarpment fault. Faulting on the north side of the Valle is more difficult to recognize because of the thick blanket of recent volcanic deposits that mask the geomorphic expression of faulting.



MAP OF CARIBBEAN REGION SHOWING SOME MAJOR TECTONIC-GEOMORPHIC PROVINCES

MAJOR FAULTS

COUNTY BOUNDARIES

VOLCANIC CENTERS

HISTORIC EARTHQUAKES

"Oceanic" crust, as used below, denotes mafic to ultramafic crust, 5–20 km thick, probably formed at spreading ridges. "Continental" crust denotes crust having substantial components of Precambrian and(or) Paleozoic intermediate to felsic igneous and metamorphic rocks. Continental crust tends to be 25–45 km thick. On land segments of oceanic crust tend to have positive (+25 to +150 mgal) Bouguer anomalies, segments of continental crust negative (−25 to −150) Bouguer anomalies.

NEOGENE VOLCANIC BELT -Shows active or recently active volcanoes

Figure 1. Regional tectonic map after J. case, and T.L. Holcombe (USGS) 1980

The valley is filled with a thick sequence of Quaternary volcanic deposits consisting of lava flows, pyroclastic flows, lahars and ashfall tuffs. The active volcanoes of Poas, Irazu, and Turrialba, and the dormant volcano Barva bound the northern flanks of the valley. Historic volcanism has been limited to localized lahars and relatively small ash eruptions on the flanks of the volcanoes. Currently, geyser eruptions are occurring on Poas and fumaroles are present on Irazu and Turrialba. Little is known about the recent activity of Barva.

The rapid deposition of young volcanic materials, active tectonism, and extensive erosion have produced a landscape with strong relief that is prone to landsliding and large-scale mass wasting. The landsliding and mass wasting generally occurs in the young surficial materials which are generally pyroclastic on the north side of the valley, and thick laterite soils on the south side of the valley onto the flanks of the Talamanca range. The landsliding in the Valle Central poses significant potential hazards to numerous population centers in the Valle Central.

3.2 Fault Hazard Studies (Task I)

During FY88, fault hazard studies were focused on completion and review of relevant documentation, and mapping of photo lineaments suggestive of late Quaternary faulting. The latter was accomplished through the use of 1:80,000 scale infrared imagery and 1:60,000 scale black and white imagery, followed with both air and ground reconnaissance. The lineaments identified are subparallel to known mapped faults and represent possible late Quaternary activity along those faults. In addition, work also focused on earthquake-triggered landsliding. This section summarized the activities of UCR and the Consultants in FY88.

3.2.1 Compilation of Existing Data

Various geologic literature and reports have been compiled and reviewed and are on file either in the project office at CNE or in the UCR library. A bibliography of geologic literature using Geo-Ref was prepared for the study area, and is on file in the project office. Copies were provided to the Counterparts. The bibliography was useful in identifying pertinent geologic literature. Existing geologic maps of the study area and topographic maps at different scales were purchased from Instituto Geografico Nacional (IGN) and are available in the project office.

A fault map of the Valle Central and surrounding region was compiled by W. Montero and P. Denyer (UCR). The map has been printed in color by IGN at a scale of 1:150,000. A preprint was obtained for the project and is available in the project office. The map also provides a list of references that were used in the compilation.

S. Mora (ICE) compiled a geologic and fault map of the Rio Parrita drainage basin which includes southern portion of the study area. The map is at a scale of 1:50,000 and includes a list of references. It was prepared as part of an internal report for ICE, and was made available to the project by S. Mora. A copy is also on file in the project office.

S. Kussmaul (UCR) has prepared a compilation of existing age dates for Costa Rica. The compilation has been made available to the project. This compilation will be used to aid in evaluation of fault and volcanic activity.

3.2.2 Preparation of a Preliminary Map of Faults and Lineaments

False-color infrared positive transparency images (1:80,000 scale) of the study area were interpreted by the Consultants. The Consultants prepared a project report in June of 1988 in which eight major lineaments that may represent Quaternary faulting were identified, described and plotted. Lineament plots on the 1:200,000 and 1:50,000 project maps are maintained in the project office. Discussion of this activity and a description of the lineaments are presented in Attachment 2. A reduction of the 1:200,000 scale preliminary fault lineaments map is shown in Figure 2.

Black and white aerial photographs of the study area at a scale of 1:60,000 were interpreted by R. Madrigal (UCR consultant) and used to prepare both a preliminary fault lineament map and a photo-geologic map of the study area (scale 1:100,000). A reduced version of this map is shown in Figure 3. The aerial photography interpretation did not identify any major faults or lineaments that had not been previously mapped. The map does show a number of shorter lineaments and more detail that is helpful in evaluating faults.

Field reconnaissance of known faults and mapped lineaments was carried out in July and August of 1988 by W. Montero of UCR, and the Consultants. Geomorphic evidence of possible Quaternary activity was identified on several of the faults. It is important to note that these faults appear to be broad zones (up to 1-2 kms) of deformation consisting of multiple traces within each zone. These faults are discussed in more detail in the following paragraphs.

Agua Caliente fault: This fault, possibly associated with the 1910 Cartago earthquake, projects from Rio Agua Caliente northwestward across the valley south of Cartago and may continue westward south of San Jose (see Figure 2). The eastern trace of the fault is not well understood. The fault may project southeast and connect to the Orosi fault, or it may project more easterly toward the Cachi area. The late Quaternary evidence of faulting along the segment south and southwest of Cartago is expressed by an alignment of apparent sag ponds and hot springs, and an east-facing scarp on the west side of the valley. In the Coris Valley, apparent active traces are observed on both sides of the valley. This suggests a more complex fault zone than previously recognized. Potential trench sites were identified at several locations along the fault segments in the Coris Valley. Final trench site selections will be made after further reconnaissance of the fault.

Rio Orosi fault: This fault has been mapped on the west side of Orosi Valley (see Figure 2). The fault is characterized by well-developed triangular facets, an alignment of hot springs, and apparent breaks in alluvial fans crossing the surface projections of the fault. Because of the relatively high level of microseismicity in the area, more detailed investigations are planned to help define the activity of the fault. The structural relationship between the Orosi fault and the Agua Caliente fault to the north are presently not well understood. Plans have been made to investigate this relationship in more detail.

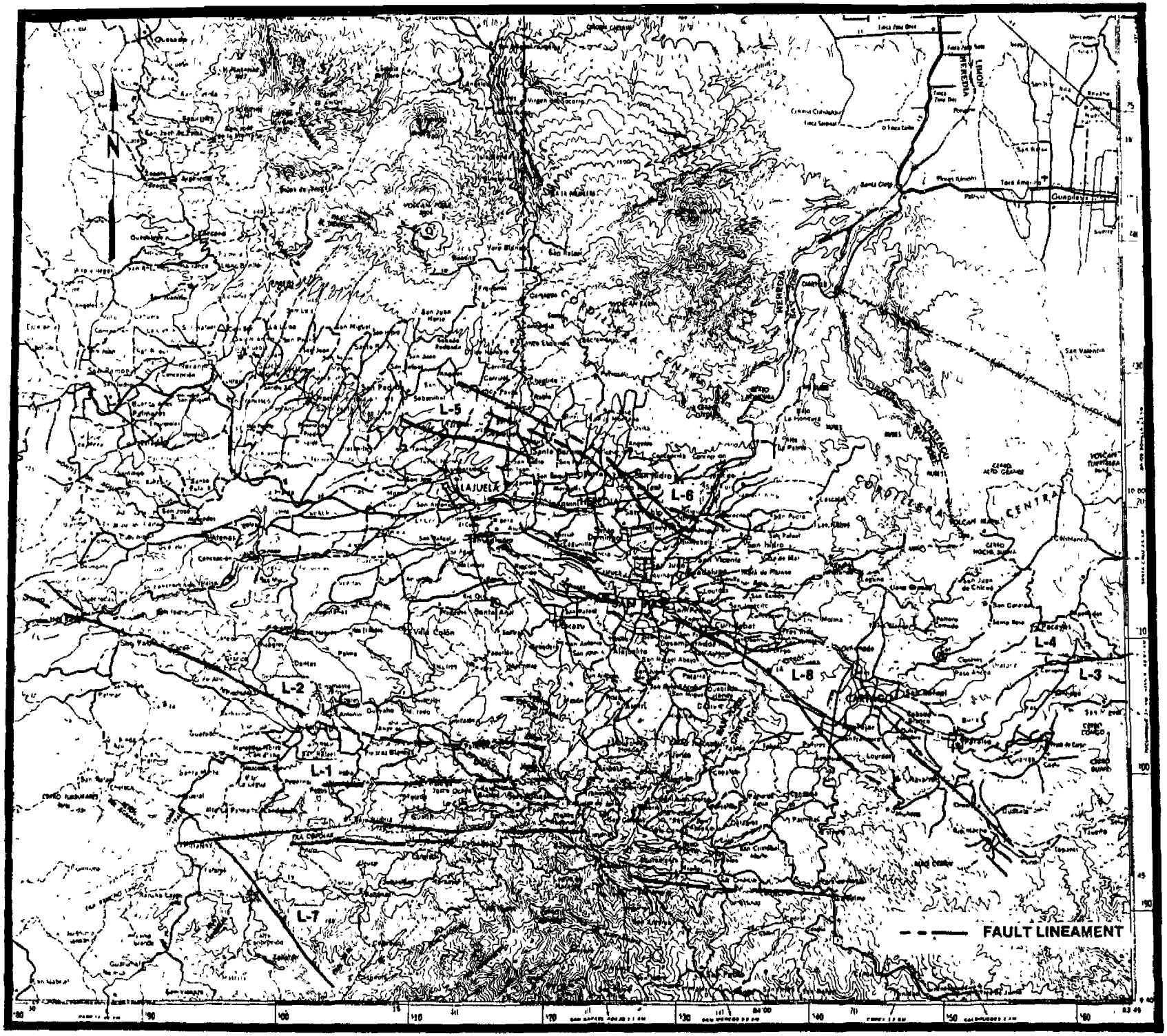


Figure 2. Preliminary fault lineament map based on 1:200,000 topographic map San Jose quadangle.

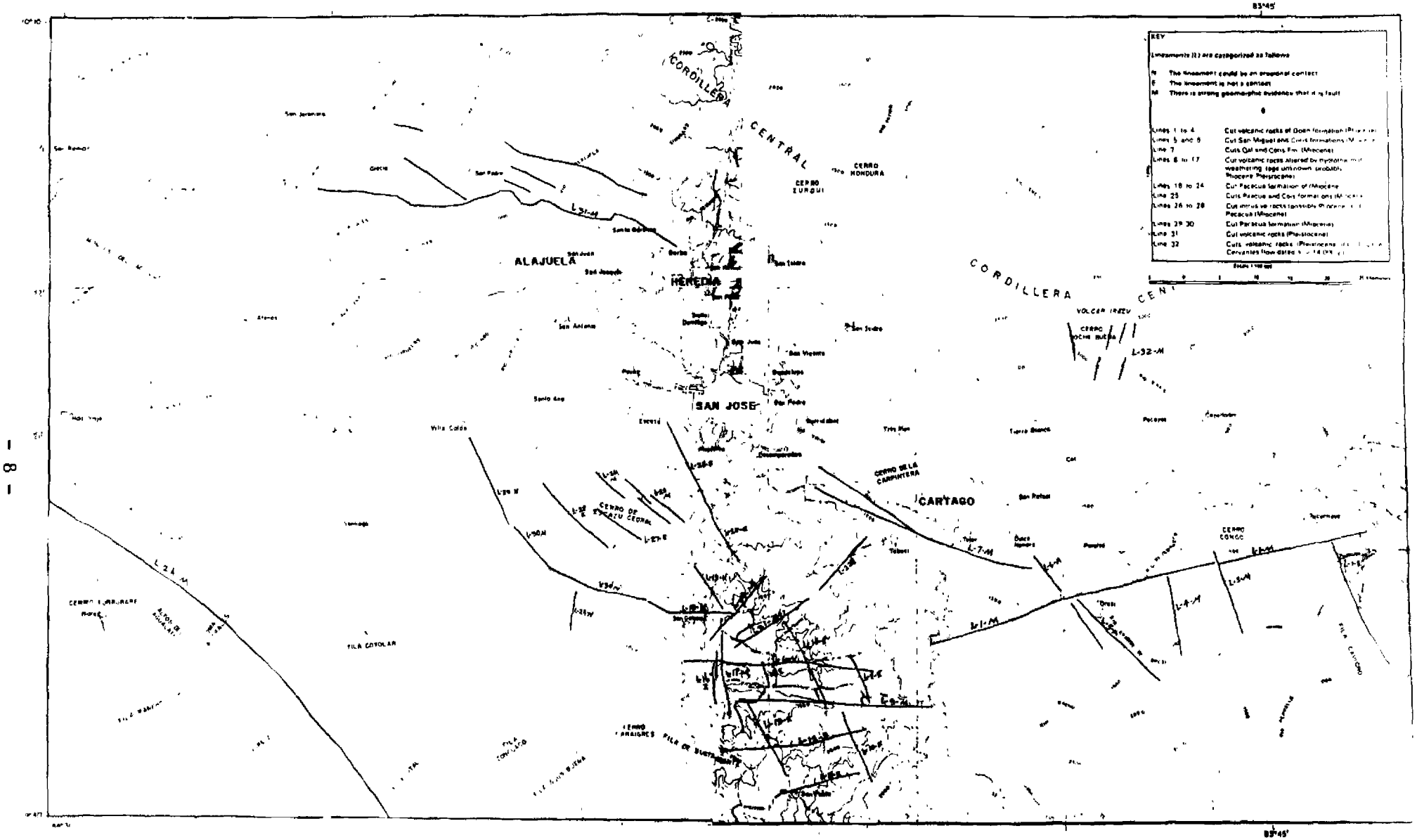


Figure 3. Preliminary lineament map of the Valle Central at scale of 1:100,000 prepared by H. Madrigal, UCR.

Alajuela fault: Investigations of the Alajuela fault scarp continue. Early reconnaissance and aerial photo interpretation studies suggest the fault zone is very broad, up to two kilometers, and that the style of faulting is very complex. Inflection points in alluvial fans coming off the volcanoes suggest that traces of the fault break young material. Charcoal was recovered at the base of a recent pyoclastic flow that crosses several of the lineaments associated with the Alajuela fault zone. The charcoal will be collected for age dating to provide information on the maximum age of an overlying ashfall tuff (see Section 2.3). If applicable, the dated unit will be used in evaluating fault activity. A quarry near Tacares provides an excellent exposure of the Alajuela fault. With additional investigations including detailed mapping, significant data should be compiled on the displacement history of the fault at the quarry.

Talamanca Range-front fault: A reconnaissance was made of this fault west of the study area. The fault strikes north-northwest and appears to be a reverse fault associated with the forearc system along the western margin of the Caribbean plate where active subduction of the Cocos plate along the Middle Americas Trench is occurring. There is some geomorphic evidence to suggest that there is also a component of left-laterial slip along this fault. The geomorphic expression of Quaternary movement along this fault is supported by strong relief, offset river terraces, discordant bedding, anomalous terrace slopes, and aligned valleys. The geomorphic expression suggests that the fault has a relatively high slip rate and a very broad zone consisting of fault segments.

Rio Candelaria fault: Air reconnaissance and photo interpretation of this fault suggests it parallels the strike of Cretaceous bedding in the Talamanca Range. The fault trends west and is defined by aligned river valleys, ridges, and ridge saddles.

3.2.3 Earthquake-related Landslide Mapping

An earthquake in 1888 (estimated Richter magnitude of 6) caused numerous landslides in the Fraijanes area on the south flank of Poas. One of the slides resulted in the formation of Laguna Fraijanes. Mapping of these and other recent landslides has been started by R. Mora of UCR. R. Mora is mapping the landslides using the 1:60,000 aerial photographs purchased by the project. Field checking is being done for selected locations.

In order to evaluate the potential of landsliding related to future earthquakes, several types of maps presenting basic slope stability data are being prepared. Presently, the maximum slope angle is being digitized from the 1:50,000 quads in the study area using a 500M grid. These data are being compiled by R. Mora with input and advice from S. Mora of ICE. The slope angle data will be evaluated with respect to other data, such as rock type, to identify areas with the highest potential for slope failure.