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SECOND ANNUAL REPORT

of

the

VOLCANO EARLY WARNING AND DISASTER ASSISTANCE PROGRAM

-- VDAP --

1 October 1987 -- 31 December 1988

by

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ORGANIZATION OF THE REPORT

This is the Second Annual Report of the U. S. Geological Survey (USGS) and Office of Foreign Disaster Assistance (OFDA) Volcano Early-Warning and Disaster Assistance Program (VDAP). The report is organized for reader convenience into six main sections:

I. HIGHLIGHTS OF RESULTS AND ACCOMPLISHMENTS OF THE REPORT PERIOD, 1 OCTOBER 1987 - 31 DECEMBER 1988
II. CHANGES IN EMPHASIS AND PROPOSED ADDITIONS FOR 1989 - ADAPTATIONS FROM 1987-1988 OPERATIONS
III. SUMMARY OF ACTIVITIES, ACCOMPLISHMENTS, AND EXPENDITURES OF THE REPORT PERIOD, PROJECTED AND ACTUAL
IV. FY89 PROJECTED ACTIVITIES AND BUDGET
V. SUMMARY OF ACTIVITY AT LATIN AMERICAN AND CARIBBEAN VOLCANOES
VI. SUPPORTING APPENDICES

It is recommended to those wishing only an overview of the accomplishments, problems, and recommendations of VDAP's second year's experiences that they read sections I and II. Those wishing more detail can refer to the following sections of interest and the appropriate supporting Appendix. A KEY TO DEFINITIONS of agency and other abbreviations is found in APPENDIX 1. Please NOTE that budgets are reported on a fiscal year (FY) basis, but that the activities and accomplishments are reported for the period 1 October 1987 - 31 December 1988.

I. HIGHLIGHTS OF RESULTS AND ACCOMPLISHMENTS OF THE REPORT PERIOD, 1 OCTOBER 1987 - 31 DECEMBER 1988

FY88 was the second year of operation of VDAP. Although the program by charter and design must be flexible enough to respond to unanticipated emergencies, the actual activities, accomplishments, and expenditures were remarkably close to those projected for FY88 in last year's Report to OFDA.

Composition of the Core Team - In mid-FY88, the core team reached the full staffing planned originally for October 1987. In addition an assistant was obtained in mid-FY88 to assist core members efforts on Guatemala Addendum (Task 7 added to the PASA August 1987).

Previous USGS Funded Team (Assigned)

- o Program Chief and Volcanologist - Norman Banks
- o Volcanological Seismologist - David Harlow and Randy White (half-time each)
- o Operational Geologist - Michael Doukas

Previous OFDA Funded Positions

- o Electronics/Seismic Operational Geophysicist - Andrew Lockhart
- o Operational Geologist Deformation Specialist - John Ewert

New Temporary Positions

- o Geologist Database Specialist (OFDA-VDAP funded) - Cynthia Stine. This position, deferred in FY87, was filled in March 1988 to begin full-time assembly of the information files, maps, and computer databases required for VDAP readiness in Latin America and for rapid reference to volcano behavioral patterns.
- o Computer Specialist (USAID Guatemala funded) - Judy Howard. Ms. Howard tracks VDAP expenditures and equipment, and also provides computational skills to speed development of the databases (expanded to world wide scope by OFDA in 1988). This position, filled in March 1988, was designed into the Guatemalan Addendum to the PASA to free the core group to execute the program with INSIVUMEH (Guatemala) and still complete the long-term program objectives.

Development of the Rapid-Response Equipment

- o Seismic system - The seismic system now consists of 6 telemetered field seismometers (2 spares), the receiving hardware, 4 recording seismographs (+2 additional one on loan), and the computers and USGS-developed software for digital recording and processing. The equipment can be prepared for crisis-response and departure with 2-4 days. Progress on this phase of the program in FY88 included:

  - Purchase of the fourth of the 6 projected seismographs required for the telemetered net (Six additional seismographs remain on loan to the project from other USGS projects).
  - The PC-based real-time processing system, cofunded with other USGS projects, progressed to completion

of the second edition of receiving software and development of interactive analytical software. A prototype unit runs in Menlo Park and at CVO. IG (Ecuador) has purchased components to develop the first system for export to Latin America.
- Redesigned the field telemetry VCO/Amplifier package to a more environmental-resistent unit with strong lightning protection.

o Deformation system - is now fully crisis-ready for measurement of vertical, horizontal, and tilt deformation. In FY88, VDAP:

- Developed several computer programs to assist error-minimum data acquisition and processing in Latin America.
- Completed conventional spirit-leveling tilt system.
- Upgraded EDM to lighter-weight instrument.
- Through CVO cooperation, brought on line a PC-based graphics/analysis program similar to that used by the VAX computers at CVO.

o Digital telemetry system - is built on 2 telemetry platforms developed at CVO, one of them with programmable, 2-way communication capabilities. VDAP has used and adapted these platforms to build a crisis-ready package of 4 telemetered tiltmeters with appropriate repeaters and receiving stations. VDAP also is developing a new mudflow alarm system. In FY88:

- Developmental problems and the response to the Guagua Pichincha crisis slowed completion of the first-edition mudflow alarm system with "smart" telemetry; at present, the field station and repeater software is completed, base station software nearing completion, 5 sensor units are under construction.
* The tiltmeter inventory was depleted by response to Guagua Pichincha, Ecuador, but is under reconstruction.

o Hazard Evaluation and Eruption Observation Kit - VDAP currently has the equipment and personnel necessary to make rapid evaluation of hazards and potential risk prior to and during volcano unrest and eruptions. Acquisitions for these activities in this report period included:

- Upgrading of cameras - purchased more databack cameras.
- Purchased depth sounder to enable crater lake depth

mapping.
- Purchased Fluxgate Magnetometer for deposit correlation.

o Safety Equipment - VDAP has built a small cache of personnel safety equipment for field and helicopter safety, including communications. Additions to this inventory during the report period included:

- Repeater stations for the hand-held radios.

o Geochemistry system - VDAP has built a modest crisis-ready inventory of sampling and chemical analysis to monitor fumaroles and hot springs and provide the capability to detect health hazards associated with ash contamination of food and water supplies. In FY88, VDAP:

- Purchased the basic geochemistry sampling kit; developed analytical techniques and the crisis-ready response kit.

Development of Computer (and information/map/photo) Database
The effectiveness of crisis response is linked to ready availability to supporting maps, photos and information files that can be accessed and queried rapidly. Progress in this task area was strong in FY88 because of the hiring of the required staff, who:

- Researched commercial programs for best applicable database for VDAP needs; chose and converted all previous databases to Advance Revelation.
- Designed bibliographic, agency/name, and ledger databases.
- Began compilation of quick-reference files on volcano behavior.
- Computer-listed all maps on file.
- Began annotated bibliography of deformation and seismic monitoring.
- Completed working draft of "country profile" of Peruvian volcanoes and hazard mitigation agencies.
- Began several other databases required for VDAP tracking of Latin American Volcanoes and rapid response to unrest.

Assessment of Activity, Latin American High-risk Volcanoes - is a charter task of VDAP. During the report period, VDAP:

o Made on-site visits in Colombia, Ecuador, Peru, and Guatemala.

- o Provided USAID, Peru, a preliminary assessment of volcano hazards facing Peru.
- o Supported construction of Guatemala's fourth volcano-hazard evaluation map and two additional hazard reports.
- o Supported assessment of the sector-collapse hazards of Colima Volcano in Mexico.

Response to Volcano Unrest - is another charter task of VDAP. During the report period, VDAP:

- o Fielded 2, 2-person crews (11 person weeks) in response to a request from Ecuador to evaluate and assist monitoring of unrest at Guagua Pichincha Volcano at the capital city of Quito, and Cotopaxi Volcano, which threatens 150,000 people in the fertile Los Chillos and Latacunga Valleys.
- o Provided USAID, UNSA, and IGP of Peru preliminary evaluation to unrest at Sabancaya Volcano.
- o Provided USAID-Bogota and OVC, Manizales, several memorandums, many phone calls, and three visits to assist understanding of the continuing high level of activity at Ruiz Volcano, Colombia.

Coordination with International Hazard Mitigation Groups - is necessary for effective VDAP operation. During the report period VDAP:

- o Coordinated on site with UNDRO evaluation of hazards preparedness in Ecuador and Peru.
- o Coordinated use of UNESCO/WOVO funds made available to assist response to unrest at Guagua Pichincha, Ecuador.
- o Coordinated and assisted equipment and systems development and acquisition for UNDRO in response to unrest at Guagua Pichincha, Ecuador.
- o Proposed UNESCO/WOVO support for a workshop on volcano hazard and risk evaluation in Peru in 1989.
- o Attended by invitation a CERESIS workshop on Latin American volcano hazards held in Nazca, Peru.
- o Maintained voluminous cable, letter, and phone contact with UNDRO, WOVO, and CERESIS on Latin American volcano hazards.

Liaison/Evaluation Visits and Activities - Development of liaisons and assistance of volcanologic agencies in developing countries is a necessary requirement for improvement in future hazard mitigation efforts. In the report period, VDAP made:

- o Three visits to Ecuador to assist IG (ESPONA)
- o Three visits to Colombia to assist OVC
- o Three visits to Guatemala to train INSIVUMEH
- o Two visits to Peru to stimulate establishment of volcano hazards programs where now there is none.
- o Extensive telephone, telex, and letter traffic, including provision of technical literature, data, equipment, and other requested assistance throughout Latin America and other developing countries.
- o Presentations during invitational attendance at a workshop on volcanoes and volcano-hazards programs in Costa Rica, held in Virginia.

Establishment of Baselines and Other Monitors - is a charter task of VDAP to increase early-warning detection and better evaluation of future periods of unrest of high-risk volcanoes. During the report period, VDAP:

- o Upgraded deformation monitors on 2 Guatemalan volcanoes.
- o Upgraded deformation monitors on 2 Ecuadorian volcanoes.
- o Installed three telemetered tiltmeters on Guagua Pichincha, Ecuador, during a seismic crisis.
- o Assisted purchase of PC-based real-time seismic system for Ecuador.
- o Assisted purchase of EDM-Theodolite system for Ecuador.
- o Lent deformation monitoring equipment to Costa Rica, Ecuador; and Guatemala.

Training and Educational Efforts - VDAP requires training and educational tools to promote more effective technology transfer and better understanding in the lay and professional community about the nature of volcano hazards and the activities required to mitigate them. During this report period, VDAP:

- o Produced together with Maurice Krafft (France) and Bill Rose (University of Michigan), a professional draft of an educational video on the hazards of pyroclastic flows (in English and Spanish). This video has had wide distribution and use in Ecuador, Colombia, and Guatemala.
- o Produced preliminary draft of video script describing how to establish benchmarks used in deformation monitoring.
- o Wrote part of the manual for a workshop on volcano hazards to be sponsored by IAVCEI and the International Geological Congress in 1989 in Santa Fe, New Mexico.

Progress on the Guatemala Addendum to the PASA - Training and purchases (see APPENDICES III and IV) went generally as scheduled on the Task 7 Addendum to the PASA to assist INSIVUMEH and to increase hazard preparedness in Guatemala. However, there were political and financial developments in INSIVUMEH that, associated with INSIVUMEH staffing problems, indicates the need for a change in favor of longer-term on-site USGS training in lieu of additional seismographs and seismic-specific training. It is also obvious at this point in the project that a lower-level support program should follow STAGE I if permanence is to be expected in the technology transfer. During the report period, VDAP:

- o Completed the hazards mapping (2 volcanoes) and training phases of the program (ahead of schedule).
- o Completed the deformation purchases and training on schedule.
- o Made scheduled purchases for geologic and geochemical kits.
- o Began but then terminated the seismic phase of the program (see above and APPENDIX III).
- o Maintained contact and progress through evaluation visits to INSIVUMEH.

SUMMARY EXPENDITURES IN FY87-88 ON TASK 7, UNOFFICIAL TRACKING LEDGER OF (STAGE I GUATEMALA) PASA

Travel and Personal Services	$ 52,492
Equipment Purchases	48,264
Overhead at 40% (travel, per diem, personnel)..	20,999
Overhead at 20 % (equipment).....	9,653
	$131,413
Balance in Program	$206,727

Additional Activities, Not Projected by 1987 Report to OFDA

- o Assisted design and application for an emergency equipment grant ($100,000) by USAID, Ecuador to upgrade response to unrest at Guagua Pichincha.
- o Obtained $17,000 from UNESCO through the WOVO for assistance to unrest at Guagua Pichincha, Ecuador.
- o Obtained UNESCO/WOVO support of Ecuadorian and Chilean participation in Peru to plan a VDAP/UNESCO workshop in volcano hazards mapping.

Changes in Emphasis and Additions to VDAP - are proposed as adjustments due to experience and information

gained during the first 2 1/2 years of VDAP operation. [The background for this summary is found in Chapter II of this Report and supporting Appendices].

- o Experience of FY87 and FY88 indicates that there are too many problems and agencies in need of assistance in Latin America to be properly addressed with VDAP's present resources unless those resources are directed through one shared institution, herein called the Pan-Andean Volcanological Center. VDAP efforts in FY89 will focus on the attempt to establish such an institute.
- o Experience of FY87 and FY88 also indicates the necessity of adding $50,000 per year (at the operational level) to VDAP funds for use as a discretionary fund to assist and influence development of the hazard mitigation agencies in Latin America.
- o There is also need for a one-time funding supplement of $250,000 (at the operational level) to purchase loan and emergency equipment to assist monitoring and response to unrest by the agencies that have been trained by VDAP but do not have the funding to buy and maintain this equipment.
- o VDAP also proposes additional one-time funds (at the operational level) of $25,000 to upgrade VDAP video equipment and line-item addition of a video specialist and a $50,000 per year to support generation of educational and training volcano-hazards videos by VDAP and other groups.
- o The USGS proposes to cofund with OFDA a programmatic augmentation of VDAP to generate a mudflow/debris-flow component in VDAP.

Summary of Financial Statements FY88 (not including Task 7)

UNOFFICIAL TRACKING LEDGER

USGS FUNDS	PROJECTED	ACTUAL
Salaries	$ 115,260	118,987
Overtime	$ 1,500	0
Benefits	$ 16,140	16,685
Contracts	$ 9,000	2,914
Travel	$ 3,900	909
Equipment	$ 12,000	22,300
Operations	$ 7,600	3,282
Overhead including Administrative and Technical Services	$ 99,250	99,030
	$ 264,650	264,079
OFDA		
Salaries	$ 68,690	59,281
Overtime	$ 0	132
Benefits	$ 9,617	8,318
Contracts	$ 15,000	0
Equipment	$ 58,850	35,552
Travel + Perdiem	$ 29,000	25,576
Operations/Expendable Equipment	$ 9,300	5,219
Overhead 20% Equip./Oper./Contract	$ 16,620	8,154
Overhead 40% Salary/Benefits/Travel	$ 42,923	37,323
	$ 250,000	179,555 #

= Carryover of $70,445 includes salary for Stine (not hired until late March) obligated travel, contract expenditures, obligations for equipment, and related overhead..

Summary of Estimated PASA Expenditures FY89 (not including Task 7)

USGS FUNDS	PROJECTED FY89	1986 WORKPLAN
Salaries	$ 120,000	
Benefits	$ 16,800	
Contracts	$ 9,000	
Equipment	$ 9,804	
Travel	$ 4,400	
Operations	$ 9,680	
Overtime/Hazard Duty	$ 1,000	
Overhead including Administrative and Technical Services	$ 102,560	
	$ 273,244	
OFDA FUNDS		
Salaries	$ 74,431	
Overtime/Hazard Duty	$ 3,000	
Benefits	$ 10,840	
Travel + Perdiem	$ 50,000	
Overhead 40% Salary/Benefits/Travel	$ 55,309	
Contracts	$ 30,000	
Equipment	$ 50,000	
Operations/Expendable Equipment	$ 15,000	
Overhead 20% Equip./Oper./Contract	$ 19,000	
FY 89 Projected Expenditures	$ 307,580	$ 214,000
FY 87 Carryover		71,260#
FY 88 Carryover		70,445#
FY 89 Available		$341,705#

= Owing to absence of the Database Specialist (Stine) for first 20 months of the project, expenditures in contracts plus related equipment and travel have been deferred for use in FY89-91.

REQUESTED ADDITIONAL FUNDING FOR FY89-91

ONE-TIME INCREASE TO PASA, FY89

Contract to Eduardo Malavassi (Costa Rica)	$ 10,000
Overhead waived on Malavassi Contract	------
One time purchase of video production equipment	$ 25,000
One time purchase for loan equipment for Developing Countries (this could be spread over several years)	$ 250,000
Overhead on One-time Funding (20%)	$ 55,000

YEARLY INCREASE TO PASA, FY89

Developing Country Assistance funds (requested yearly supplement	$	50,000
Overhead on Country Assistance (20%).	$	10,000
Addition of Video Production (either staff addition or yearly contract)	$	50,000
Overhead on Video Assistance (40%)...	$	20,000
TOTAL ADDITIONAL REQUEST	$	470,000

OFDA CO-SUPPORT IS SUGGESTED FOR THE PROPOSED PAN-ANDEAN VOLCANOLOGICAL CENTER - Organizational meetings in FY89 and FY90, equipment and operations in FY90 and after.

ADDITIONAL UGSS AND OFDA PASA FOR MUDFLOW CAPABILITIES -- SEE APPENDIX VI.

II. CHANGES IN EMPHASIS PROPOSED IN 1989 - ADAPTATIONS FROM 1987-1988 OPERATIONS

Restructuring Proposed for VDAP in 1987 Report

VDAP's maiden year (1987) established that the PASA's Workplan (1986) of a complete emergency umbrella and eventual independence of all of Latin America in volcano hazards are overly optimistic objectives in view of the size of funding and the staffing of VDAP. Thus the VDAP's 1987 Yearly Report recommended:

- That VDAP be viewed, at least in principle, as a 15-20 year, multiphase program.
- That VDAP, during the current phase, concentrate efforts on liaison contact, database development, training, and system building in South America, particularly the main four (Colombia, Ecuador, Peru, Chile) countries which have developing experience in volcano hazards and where VDAP/OFDA have already invested heavily in volcano hazard programs (i. e., Colombia and Ecuador).

This restructuring does not remove the emergency-response umbrella for Central America; however, it allows emphasis on more development of baselines and monitoring programs, more-lasting transferal of expertise, more-thorough knowledge of the subject volcanoes, and hastened development of the associated volcano-hazard agencies. It also clearly announces that the USGS-OFDA effort is long-term and serious with respect to the almost overwhelming problems in volcano hazards faced by Latin America, a posture that all of our Latin American associates have assured us will generate good will for the U.S. and its' interests. South American is indicated as the logical first-effort area because the ice and snow fields that cap South American volcanoes provide greater potential for large mudflows that can reach a larger population compared with Central American volcanoes. In addition, political limitations on field access are currently less in South American than in Central America.

Additional Restructuring Proposed for VDAP in 1989

The Pan-Andean Volcanology Center

In effect, except for the Guatemala project, VDAP did concentrate on South America in 1988, which decreased VDAP operational overload to some extent. However, there are perhaps more than 50 high-risk volcanoes in the 6 South American countries (Colombia, Ecuador, Peru, Chile, Argentina, and Bolivia), and there is very limited expertise and equipment in the 15-20 agencies responsible for the mitigation of the related

hazards. Thus, based on the second year of VDAP operation, probably at least 200-500 person-years of expert assistance, support, and repetitive training is necessary to achieve full volcano coverage and real agency independence in South America. VDAP's charter does not include this level of effort, and to continue to dilute attention at all the agencies, will not generate lasting independence in any of them. Therefore, VDAP proposes:

- o That during the remaining first phase of it's activity, VDAP coordinates and assists establishment and development of a Pan-Andean Volcanology Center (PAVC) where training efforts are focused on one institution that is shared by all concerned agencies in South America.

At first, the host nation of the PAVC would achieve independence more rapidly than it's neighbors; however through long-term assignments of trainees from, and division of the targeted volcanoes among, the member nations, all would develop independence in parallel with diminishing need for non-Latin participation. Possibly, the location of the center could be rotated among member nations, as long as this was done on a schedule that assured permanence of expertise in the previous host nation.

Funds would be needed to assemble the potential member agencies for the 2-3 conferences that will be necessary to develop the charter and agreements for the PAVC. Hopefully, much of the funding will come from the supporting countries themselves, but there also must be strong participation by South American USAID Missions, international organizations, and perhaps nations other than the US. Possibly the International Decade of Natural Hazards Reduction would also assist the initial phase of the PAVC.

For wide success, initial and long-term funds must be located to buy and maintain necessary training equipment in the host nation, to support the training programs and the specialists, to establish baseline and monitoring programs, and to react to emergencies. Again, it would be best if these funds came from member nations, but ideally OFDA leadership should be visible, and realistically other funding sources may be necessary (or may find the project of interest). Member-nation systems building should develop in stages and focus on those members which most actively pursue funding for their own programs.

Importantly, if eventual independence in South America is to be achieved, there is critical need to support advanced degrees for the more accomplished trainees of the PAVC. Conceptual independence must parallel development of technical competence if progress is to be rapid and permanent. Hopefully, OFDA or

USAID will also fill a leadership role here.

Location of the First PAVC

Since the primary goal of the PAVC is to develop complete and durable independence, the PAVC must be associated with a teaching institution. Weak areas in mathematics, physics, engineering, electronics, and English language of the trainees must be handled in parallel with the technology transfer in volcanology. Of the four main South American countries, Colombia's and Ecuador's teaching institutions and volcano hazards/monitoring programs are the most advanced and best equipped. Of these two, Ecuador provides the safest political climate for the necessary field studies, and the Instituto Geofisico (IG) of the Escuela Politecnica Nacional (ESPONA) has the longest lived hazards-evaluation and monitoring program. In addition, recent augmentation of equipment (OFDA-funded) elevated IG to (and in some fields, above) capabilities present in Colombia's best equipped facility, the Observatorio Volcanologicos de Colombia (OVC), which is not formally affiliated with a university.

IG has expressed interest and apparently has the support of the parent institution (ESPONA) to explore provision of space and other support for PAVC. However, an offer of significant support by another member nation might influence the eventual location of the PAVC, and, as noted above, periodic rotation of the location between member nations might also have some advantages as long as the continuity of trainees, staff, support, and program is maintained. Wherever the initial location, the field studies that teach evaluation, establish baselines studies, and develop monitoring would, of political necessity, have to be fairly distributed throughout all member nations, which hopefully would be all 6 South American countries with volcanoes.

Impact of the Restructured Scope on VDAP, OFDA, and the USGS

VDAP's role would be to assist planning, establishment, and maintenance of momentum through frequent short- and moderate-length visits to the PAVC, longer teaching tours, and lobbying efforts with the supporting agencies. VDAP would also assist program development and identification of the training subjects and recruited expert trainers. Paramount in this effort is the need to assure that the other experts recruited will attend for sufficient time to develop positive reinforcement of concepts and that the focus of their interest is the PAVC rather than individual scientific gain though use of the PAVC.

This proposed restructuring of the scope of VDAP should have little overall effect on funding needs of the original VDAP PASA other than the potential need to extend the length of the PASA in response to the PAVC's development and perhaps a need to

contribute to the organizational meetings. The USGS, however, should anticipate the need to supply a variety of experts for significant temporary tours of duty to the PAVC, although instructors from U.S. universities and from other nations could substitute and in some cases would be needed.

Impact of PAVC on other Significant VDAP Obligations

VDAP has significant obligations to OVC (Colombia), IG (Ecuador), and INSIVUMEH (Guatemala). There is no formal agreement governing the U.S. obligations to OVC; however, there are significant unwritten obligations based on OFDA and USGS activities in 1985-86. The continuing unrest at Ruiz and the combined problems of equipment degradation and insufficient training keep the Nevado del Ruiz in the highest-risk category (see memorandums to USAID-Bogota APPENDIX II). VDAP has been attempting, through VDAP funding, to meet these obligations. However, VDAP optional support resources are not sufficient for the task. Thus, VDAP has suggested several initiatives that Colombia and USAID, Bogota might follow to secure the long-term commitment needed to meet the risk still present at Ruiz: however, these remain unfunded. The PAVC will help meet U.S. obligations at Ruiz by providing opportunity for long-term training and more frequent stops by PAVC instructors in neighboring Colombia, perhaps as part of training course-work of the PAVC. A support package for OVC by COLCIENCIAS (Colombia) and USAID-Bogota suggested in the memorandums of APPENDIX II (and other earlier VDAP memorandums) would fit easily into the framework of the PAVC.

Obligations to IG (Ecuador) involve ongoing unrest at Pichincha and Cotopaxi as well as potential unrest at Ecuador's other high-risk volcanoes; thus, like Colombia, establishment of PAVC will directly and positively impact these obligations, particularly, as suggested below, if Ecuador is the first host nation.

Written obligations to INSIVUMEH will be satisfied in FY90 (see APPENDIX III). Should USAID-Guatemala elect to begin a STAGE IA or STAGE II program with INSIVUMEH (APPENDIX III), VDAP would continue general oversight of the program. However, if VDAP is heavily involved with PAVC, some of the work-units might have to be performed through trainee attendance and development of instrumentation at the PAVC. Alternatively, some of the work units of a more extensive volcano hazards program in Guatemala could be performed by other groups or through contract.

Overall, the PAVC would delay wide-spread hands-on activities by VDAP in Central America. This actually makes logistical sense. Although Central American volcanoes erupt more often than those in South America, it is virtually impossible to do field work in Nicaragua and El Salvador at this time; Costa

Rica has a viable volcano hazards unit already addressing their own problems; Mexico has shown general reluctance to invite U. S. government agencies to assist in their hazards crises; and neither Panama nor Honduras have large populations at risk to volcanoes. Eventually, however, when the PAVC has assured that true independence in volcano hazards mitigation is occurring in South America, establishment of a Central American Volcanological Center would be the next logical step for VDAP activities. In the interim, VDAP could work to assist Central American trainees and projects through the PAVC.

The Need for Discretionary Funds

At almost every point of contact (telephone, letter, telex, visits) with hazards mitigation groups in developing countries, there are requests for assistance for repair, replacement, or upgrading of components of monitoring instruments of American manufacture. Some of these requests are opportunistic; however, most of them are critical to ongoing monitoring and mitigation programs. The VDAP PASA did not provide funds to assist in these requests, and inability to rapidly and positively satisfy them on the basis of no funding hurts VDAP (and U.S.) effectiveness and stature in Latin America.

Because of the critical need, VDAP has been satisfying some of the requests by donations from sister organizations, purchases if possibe, and passing still others on as initiatives to USAID Missions, OFDA, UNDRO, UNESCO, and in-country agencies. However, most of the requests are not satisfied and those that are experience critical delays and consume considerable time and effort in setting up the proper bureaucratic channels for decision and supply. Thus VDAP not only loses stature and influence with the agencies that it is charted to assist, it has diminished productivity because of the inefficiency of establishing repetitive one-time supply routes, most of which never get filled.

VDAP effectiveness in Latin America would be measurably improved with the establishment of a discretionary fund (at the operational level) of about $50,000 per year (about $4,000 each for the 12 countries with volcanoes) that could be used to rapidly and positively respond to legitimate requests for assistance. UNDRO has such a fund, that allows on-site evaluation and solution by Tomblin of critical shortages and needs. This increases Tomblin's success and influence immensely, and at the same time allows immediate solution of real or potential problems in hazard mitigation programs. He also can avoid the usually insoluble problem of converting in-country funds to buying power in outside markets. Such a fund within VDAP would likewise significantly improve the use of OFDA/USGS efforts and interests in Latin America, while at the same time diminishing the workload on the project.

The Need for Budget Addition for Loan and Emergency Equipment

Several Latin American countries now have the experience in one or more categories required to provide monitoring in emergency situations but not the equipment to do so. With further VDAP progress, additional expertise will become available. In fact VDAP now regularly receives requests for loan of equipment that do not require on-site presence of VDAP personnel, and undoubtedly this trend will continue. However, many of these requests must be turned down because the PASA did not provide for a backup system that could be loaned to establish baseline data and respond to emergencies. Thus we propose that a one-time addendum of $250,000 (at the operational level) be added to the PASA to provide for a cache of 6 seismometers, mobile computing facility, 4 tiltmeters, an EDM system, leveling instruments, and communication gear.

Presence of this cache would greatly increase monitoring activity and hazards mitigation efforts in Latin America, stimulate individual and cooperative effort by the in-country agencies, increase effectiveness and appreciation for VDAP, and diminish the need for full VDAP response in some emergency situations. Moreover, presence of the loaner cache would provide the backup equipment not now available to immediately reestablish monitoring on a volcano that destroys the front-line VDAP equipment during a small eruption that might proceed a catastrophic one.

The Need for a Budget Addition for Hazards-related Educational and Instructional Videos

There is minimal value if awareness provided through monitoring and evaluations by volcanologists concerning approaching risk is not understood and acted upon. The awareness must be accompanied by functional understanding within the exposed community and responsible public, clerical, and military agencies. This functional awareness, the most necessary and effective ingredient in the mitigation of uncertain hazards, is only obtained through communication and education.

The most effective communication medium today is television and videos. It is used in almost every area of society from technology to sales. If done professionally, the combined impact of video on sight and hearing can educate, instruct, and move large blocks of people into action in a fashion not achievable through any other mean besides direct personal contact or through personal experience.

A recent and tragic example of awareness of approaching risk, the failure in communication, and the absence of functional understanding was seen in association with the

eruption of Ruiz Volcano in Colombia in 1985. There an entire town disappeared and approximately 27,000 people lost their lives because the people and the on-site mitigation system did not comprehend the risk and act upon the short-term warnings that in fact were made.

The absence of such communication and educational tools in VDAP's response capabilities led to production during this report period of the video describing the hazards of pyroclastic flows. The tragic destruction of St. Pierre, Martinique, was used as an example because it occurred in 1903 due to the of absence of functional awareness of the approaching catastrophe. This video was done at minimum cost to OFDA through international cooperation and has already returned more than it's cost to all producers in education of non-technical audiences. It is an indispensable tool that is now available to help educate exposed populations and responsible officials prior to or in the few remaining hours before some future devastating eruption.

VDAP, USAID Missions, OFDA, and similar groups have urgent need for additional educational videos that describe the other major hazards of volcanoes, so that the appropriate video is on hand to instruct and motivate timely action in the face of the variety of eruptive scenarios that face Latin America and the world. In addition, training videos are necessary to promote more rapid and more lasting transfer of technology to developing hazard mitigation groups than is possible with the current level of staffing in VDAP. Too often, the techniques are taught to individuals who do not fully understand the methods taught and then pass on the training in modified, frequently erroneous, form to their associates. Training videos also provide a low-cost, constant reminder and refresher that helps avert mutation of technological knowledge into ineffective and possibly failure-prone misinformation in hazards mitigation.

Because the highest quality is not necessary, most of the script and technical consultation for the training videos can be done by VDAP staff or as part of training future courses by students of VDAP and hopefully the PAVC. In addition, part of the feed-in footage can be generated by VDAP. However, this will require:

- A one-time purchase of $25,000 (at the operational level) of the required camera, taping, and editing equipment.

- Amendment of the PASA to add a full time video specialist to VDAP to assure timely production, or alternatively these services could be contracted at about the same yearly cost.

Even with a full-time specialist, regular production of educational videos is beyond the scope of VDAP time and talent.

This would require cooperative efforts with other volcanologists and groups who are actively designing videos of direct use to VDAP and OFDA. However, it is recommended that OFDA act in its leadership role in hazards mitigation by funding through VDAP:

- o production of 1-2 education videos on volcano hazards per year for the next few years.

The cost to produce each professional educational video of 20-30 minute length is approximately $50-80,000 (at the operational level), if there is little need to obtain new on-site footage and, as it would be in this case, the script technical expertise is provided. Alternatively a separate multi-year PASA could be generated that assures sufficient staff to generate scripts, contracts, and distribution routes for these relatively low-cost, but very high-return tools in hazards mitigation.

The Need of a Mudflow-Hazards Mitigation Component in VDAP

The VDAP PASA should have but did not include provision of in-depth expertise in mudflow evaluation, monitoring, and alarm systems. The 1986 VDAP PASA was organized on the basis of a proposal made to OFDA in 1983, before Ruiz had demonstrated anew that mudflows account for about 1/2 of the fatalities known from volcanoes. Thus VDAP began with a known deficiency in mudflow hazard mitigation which should be addressed by the addition to the staff of at least one person experienced in mudflow evaluation and analysis and one person to develop, maintain, and deploy the alarm systems. This was pointed out to the USGS in a review of its volcano-hazards programs (1987) by the Shoemaker committee.

The USGS Water Resources Division proposes to cofund this augmentation of VDAP with OFDA in the same manner as the original PASA with the Geologic Division of the USGS. Details of this proposal are found in APPENDICES V and VI.

III. SUMMARY DETAILS OF ACTIVITIES AND ACCOMPLISHMENTS OF THE REPORT PERIOD, PROJECTED AND ACTUAL

This section provides detail to the highlights of activities and accomplishments of this report period cited in Chapter I. Below are the 10 major target objectives listed in VDAP's 1987 Annual Report for this report period. Each is followed by the actual activities, accomplishments, and problems in each area for the period 1 October 1987 through 31 December 1988. More detail on some of the target objectives are listed in the APPENDICES.

(a) To identify additional funding (in-country and international agencies, USAID/OFDA) that is not present in the VDAP program but is necessary to train and provide instrumentation for those groups in Latin America interested in achieving self-sufficiency in eruption early-warning and hazard mitigation.

- Funding was obtained from UNESCO/WOVO to support a meeting that planned production of hazard and risk maps of Misti and Chichani volcanoes, Peru. These funds supported one representative each from IG and Defensa Civil (Ecuador) and a representative from Chile to join VDAP in Arequipa Peru to map strategies and logistics with IGP, UNSA, and Defensa Civil (Peru) for the workshop that will produce the maps (see APPENDIX XIX for summary of trip activities). The tentative workshop date is April 1989, with expenses for non-VDAP personnel coming again from UNESCO/WOVO.

- UNESCO/WOVO provided approximately $17,000 to fund the purchase of 3 telemetered tiltmeters with repeaters and base stations emplaced by VDAP on Pichincha Volcano, Ecuador, in November-December 1988. The funding also supported purchase of a real-time seismic amplitude monitor for Pichincha and installation of the system by a USGS electronics/computer specialist. The new instrumentation and monitoring was put in the care of the IG of ESPONA in Quito (see APPENDIX XXI for summary of trip activities).

- VDAP assisted IG (Ecuador)in meetings and writing of position papers that obtained approximately $100,000 from USAID-Quito to make other equipment upgrades necessary for the unrest (August 1989 to present) at Pichincha.

- VDAP also assisted UNDRO purchases of an EDM/theodolite system and PC-seismic recording system for IG during the emergency period in 1988.

- Michigan Technological University cofunded production of the educational video on pyroclastic flows and Mont Pelee.

(b) To maintain already established scientific and governmental liaisons required for efficient emergency responses, with

emphasis on Colombia and Ecuador.

- A total of three visits were made to Ecuador during this report period: 3 VDAP people visited IG, INEMIN, and Defensa Civil in October 1987 to establish and further necessary contacts; 2 people responded to unrest at Pichincha Volcano by assisting IG in September-October 1988 to evaluate the volcano, upgrade and conduct deformation monitoring, and plan for other necessary upgrades financed by USAID, Quito; in November-December 1988, a second 2-person team established a real-time seismic amplitude monitor, installed 3 telemetered tiltmeters with repeaters and a base station, and upgraded the computer and seismic receiving facility at IG (see APPENDICES XVI, XX, and XXI for summary of trip activities).

- Three visits were made to Colombia: The first trip consisted of 3 persons who visited OVC in October 1987 to assess Observatory progress and assist interpretation of activity of the volcano (see APPENDIX XVI for summary of trip activities); the second in March-April 1988 included 2 VDAP persons (see APPENDICES XVIII and XIX for summary of trip activities)that participated in the workshop on Nevado del Ruiz, assisted OVC in data interpretation, and provided OFDA and USAID Bogota with updates and recommendations about the volcano and the Observatory (APPENDIX II); the third trip (see APPENDIX XX for summary of trip activities)was a brief one in October 1988 by the program leader in response to a request from USAID and the Presidente's office of Emergency Preparedness for assistance in interpreting prolonged high levels of fumarolic and seismic activity at Ruiz and unrest at Cumbal Volcanoes (APPENDIX II).

- Three visits were made to Guatemala during the report period (see APPENDICES XVII, XVIII, and XXII) for summary of trip activities): the project seismologist twice visited Guatemala in 1988, once to assist development of the PASA Addendum (ITEM 7) with INSIVUMEH and the second to begin the seismic training aspects of the project; in October, the project deformation specialist went to Guatemala to confer with USAID and INSIVUMEH on the project and complete the STAGE I deformation training program with INSIVUMEH including equipment transfer, field work, and upgrading the existing monitor nets and procedures.

- The VDAP program manager attended a workshop on Costa Rica volcanism (in Virginia) arranged by the Smithsonian Institution.

- VDAP maintained heavy mail, telex, and telephone contact that included provision of technical literature, data, equipment, and other requested assistance throughout Latin

America (particularly Mexico, Guatemala, Costa Rica, Colombia, Ecuador, Peru, and Chile).

- VDAP also maintained mail, telex, and telephone contact with VOI (Iceland), UNDRO, and other third world countries (Pagan, Marianas; Rwanda, Africa; Rabaul, Papua New Guinea).

(c) To establish preliminary scientific and governmental liaisons required for efficient emergency responses, with emphasis on Chile and Peru.

- VDAP made two trips to Peru: the first made in October 1987 involved three VDAP members and centered around establishing initial contact with Defensa Civil, USAID, and the major earth science and mapping groups (Instituto Geofisico del Peru (IGP), Instituto Geografica Militar (IGM), the Instituto Geologico Minero y Metalurgico (IBGEMET) Minas, and the Universidad Nacional de San Augustine (UNSA) (see APPENDIX XVI for summary of trip activities); the second was made in June 1988 by VDAP's program chief to attend a meeting on Latin American Volcanism with representatives of Nicaragua, Colombia, Ecuador, Peru, and Chile and to plan the UNESCO/WOVO/VDAP workshop to generate hazard and risk maps of Misti and Chichani Volcanoes (see APPENDIX XIX for summary of trip activities).

- Initial direct contact with Chilean volcanologists was made in Peru during the June 1988 trip and through correspondence; heavy telex, mail, and telephone contact was maintained with Peru, fewer electronic and mail contacts were made with Chile.

(d) To acquire, develop, and maintain additional portable monitoring equipment needed for safe and capable emergency responses to volcanic crises, with emphasis on commissioning of the mudflow alarm system, software for real-time earthquake locations, development on film/video monitoring techniques, development of telemetered crater-lake monitors, and development of telemetered fumarole monitors.

- Work on the mudflow alarm system did not progress to hoped-for completion of field-ready units because of delays encountered in hardware and software development in the revolutionary design. Additional delay occurred because of the VDAP response to the Guagua Pichincha unrest and subsequent activities related to replacement of the equipment deployed at the volcano. However, all parts are on hand to construct 5 robust field units (each with two valley sensors connected by radio to one repeater) and 2 base stations. One of the base stations and one field unit

has been bench tested since September 1988 to perfect the valley unit and repeater software. The completion of the base-station software and the hardware of the remaining 4 valley/repeater units is expected in early 1989.

- Radio-telemetered seismograph system. All components for a six-station radio-telemetered seismograph network (2 spares), receiver hardware, and 4 portable seismographs were ordered and received in FY87 and FY88. VDAP also has 6 additional portable seismographs on call loan from the Branch of Seismology. The hardware is not yet in a crisis-ready mode, in part owing to a decision to increase the lightning protection system, but can be assembled for depature in 3-4 days.

- The portable computer hardware and software system necessary to process and analyze incoming seismological data in real time was completed and then upgraded to operational status. This major development in technology allows rapid and sophisticated processing and comparison of seismological data by VDAP at any location on the globe. Perhaps of more importance, this development allows transfer and operation of sophisticated seismic analysis at agencies responsible volcano hazard mitigation in almost all developing countries. In late FY88, the second edition of software was developed and field tested at both Menlo Park and CVO. In early 1989, UNDRO/OFDA purchases and VDAP training will result export and commissioning of this new seismic processing system in Latin America at IG, Ecuador.

- Development of telemetered fumarole and TV monitoring techniques was not begun as anticipated owing to priority given to the mudflow alarms and the response to the unrest of Guagua Pichincha, Ecuador.

- To develop and service the growing electronic and telemetry capabilities of VDAP, several additional tools and instruments were added to the cache in FY88. In addition, a library of necessary repair manuals and technical information on the monitoring equipment was acquired or developed.

- The EDM equipment was upgraded by purchase of a Geodimeter

6000 which has nearly the same distance measuring capabilities as the K&E Ranger V, slightly better precision, and much less volume and weight. Under mutual agreement, the Ranger V, because of the greater power and advantage of a visible laser, is now with INSIVUMEH, Guatemala.

- To assist foreign agencies in generating error-minimum data, VDAP produced or upgraded several additional IBM-PC data reduction programs for deformation monitoring.

- Because of VDAP's need and encouragement, CVO produced IBM-PC BOB, a time series graphics and statistics plot program unavailable in the commercial market. This system will have wide application in developing countries and was installed in Ecuador and Guatemala by VDAP during the report period.

- VDAP's precise leveling capability was achieved during the report period with the purchase of 3 precise level rods.

- Action as per the other major and anticipated equipment purchases went as follows:

  - o Upgrading of cameras - purchased more databack cameras.
  - o Purchased depth sounder to enable crater lake depth mapping.
  - o Purchased Fluxgate Magnetometer for deposit dating.
  - o Modest upgrading of the Automatic Data Processing hardware and software - augmented laptop inventory and purchased software necessary to convert databases to more advanced system.
  - o Modest upgrading of the gas/water geochemistry kit.
  - o Addition of voice repeaters -- purchased 2.
  - o Modest upgrading of training aids.

(e) To continue development of the map/photo library and analytical data bases of currently- and potentially-active foreign volcanoes, with emphasis on Colombia, Chile, Ecuador, and Peru.

- Obtained aerial photographs of Fuego and Santiaguito Volcanoes, Guatemala;
- Obtained LANDSAT images and all unrestricted maps and geologic reports available for the volcanic areas of Peru.
- Upgraded the map inventory of Ecuador volcanoes.
- Evaluated all commercial database programs to determine which program best fits VDAP's current and projected future needs in databases; Advanced REVELATION (the PC version of PIC) was selected for its power and compatibility with the Smithsonian's databases.
- Adoption of REVELATION required program development to

convert and apply REVELATION subroutines on VDAP's ledgers, computerized reference list, and Names/Affiliation lists; 1609 references were converted to REVELATION from the old DBASEIII files, 783 entries in the Names file were also converted.

- 180 new reference entries (REFMAST) were made in FY88.
- 150 new names entered the NAMES/affiliation file.
- A database was created to track VDAP equipment location.
- Computer files were made to organize the VDAP map files of El Salvador, Costa Rica, Nicaragua, Guatemala, Peru, and Ecuador.
- SEAN Bulletin entries on Latin American volcanoes over the past 10 years were transcribed so that all recent data is in portable, retrievable, and usable form on VDAP field computers.
- Thirty drainages of high-risk volcano were digitized to provide computer-accessed stream profiles for future mudflow crises.
- A preliminary but extensive search was made of the literature as the preliminary step in compiling a reference list and annotated bibliography of deformational behavior of explosive volcanoes. Several LOTUS and REVELATIONS databases were experimented with to convert the information file into quick-recall computer files and graphs for use in future emergency response efforts.
- A literature search for volcanic seismicity related to eruptive activity was begun FY88 with the goal of identifying the types of activity that signify coming eruptive activity. The hope was that the literature contained the quantitative criteria that could be used to assess the potential of eruption during a volcanic crisis by comparing data from instruments installed by VDAP with that compiled from the literature. The study found some useful data, but also many instances of seemingly identical seismic activity at volcanoes that were not followed by eruptions. In general, the basic data amendable to careful analysis are not usually available in the literature because of the wide range of instruments and instrumental coverage. Thus VDAP's PC-recording system takes on greater significance in providing data that in the future be used to develop sound statistical models useful for better forecasts in a crisis situation.
- Working drafts of the "Preliminary Country Report of Volcanoes and Hazard Preparedness in Peru" and the "Preliminary Report of Cotopaxi Volcano and Related Hazards, Ecuador" were designed and brought to draft form. When edited and rewritten, these reports will be submitted to appropriate in-country reviewers and issued to OFDA, AID-Missions, and the USGS. Copies also will be provided to appropriate agencies and

Missions in other Latin American with the suggestion that they cooperate with VDAP to produce similar reports for all countries and high-risk volcanoes.
- Working drafts of hierarchy charts of Civil Defense and geologic organizations in several Latin America were prepared for later review by in-country sources (see APPENDIX XV).
- A database of frequency and duration eruption of high-risk volcanoes was compiled for future use during emergency responses to explosive volcanoes.
- Several other databases were begun, including a precursor file using gas geochemistry and visual phenomena and a database of meteorological conditions around high-risk volcanoes.
- A handout file of references on "How to do a hazards map" was compiled.

(f) To add and train 2 additional team members (CVO Team Members):

- Hired the Database Specialist listed on the 1986 PASA Workplan
- Hired a Computer Specialist to assist the Guatemalan Project by freeing other core members to execute the Guatemalan Project and still obtain program objectives.

(g) To continue the development of training and educational videos and pamphlets.

- Co-produced a working and, later, the final draft of an educational video about the hazards and effects of pyroclastic flows (English and Spanish editions). "The 1902 eruption of Mont Pelee, the interaction between man and volcanoes; the devastation produced by pyroclastic flows "
  This 20 minute video has been well-received by both lay and professional audiences in the U.S. and abroad.
- Wrote the teaching text for an IGC/IAVCEI workshop to be given in Santa Fe, July 1989: "Banks, N. G., Tilling, R. I., Harlow, D. H., Ewert, J. W., 1989, Volcano monitoring and short-term forecasts: IGC Workshop Proceedings, 62 pp. 21 figs." [in press].

(h) To provide assistance to requests for emergency response and teaching/baseline studies by foreign and national agencies.

- See also (b) above and (j) below.
- Evaluated and provided reports about the unrest at Sabancaya Volcano, Peru.
- Fielded 2 teams and several reports in response to the unrest at Pichincha Volcano, Ecuador (described in (a)

and (b) above).

- Assisted purchase, quality control, and shipment of UNDRO/OFDA monitoring equipment for IG (Ecuador).
- VDAP members and contract workers made 3 trips to and provided several reports about Santiaguito Volcano in 1988 in response to AID and Guatemalan requests for assistance in evaluation the continuing unrest at this high-risk volcano.
- Supported a student to work with Mexican volcanologists on the hazards and risks of Colima Volcano, Mexico.
- 2 members of OVISCORI (Costa Rica) received 1 week of training by VDAP at CVO during the report period.
- The HP 3808A EDM saw extensive use when on loan to OVSICORI of Costa Rica and IG of Ecuador to upgrade monitoring networks and, in Ecuador, to assist evaluation of unrest of Guagua Pichincha Volcano.
- VDAP's 2 T16/Citation theodolite-EDM pairs are on loan to Ecuador and Guatemala to assist in their monitoring networks.
- Copies of and instruction about VDAP's data processing and graphics/statistics programs were given to ESPONA (Ecuador), INSIVUMEH (Guatemala), and OVSICORI (Costa Rica).
- Remeasured part of the deformation network on Cotopaxi, Ecuador and remeasured and augmented the deformation network on Guagua Pichincha, Ecuador.
- Installed a precise level line on Fuego, Guatemala and set up monitoring of Santiaguito, Guatemala with triangulation baselines.
- Trained three personnel from ESPONA in use of theodolites and EDMs for deformation monitoring of Ecuadorian volcanoes.
- Provided instructional material to Universidad de San Augustine, Aeriquipa, Peru and Universidad del Valle, Cali, Colombia.

(i) To continue USGS guidance, training, counseling at the volcano monitoring groups established previously through VDAP support in Colombia.

- Assisted OVC (Colombia) in interpretation of deformation data and designed a new program of monitoring based on the data analysis and changing activity at Ruiz.
- Assisted OVC in evaluation of the seismic monitoring program at Ruiz.
- Provided memorandums to and about (USAID-Bogota and OFDA/USGS) OVC to assist maintenance and development of the Observatory (see APPENDIX II).

(j) -- To implement work 8 units of Stage I improvement of volcanological capabilities of the Instituto Sismologia, Vulcanologia, Meteorologia y Hidrologia (INSIVUMEH, Guatemala) (TASK 7

of the VDAP PASA).

- Accomplishments progressed as expected on the Guatemala project with the exception of that planned for the seismological section and some problems encountered in INSIVUMEH funding support and in the overall low level of background in geological and scientific training within INSIVUMEH. Details of progress, problems, and suggested solutions to successful completion of STAGE I of the Guatemala Program are found in APPENDIX III.

SUMMARY EXPENDITURES IN FY87-88 ON TASK 7 (STAGE I GUATEMALA PASA) -- For details of past and projected future expenditures, see APPENDIX IV.

UNOFFICIAL TRACKING LEDGER

	EQUIPMENT	TRAVEL AND SERVICES
SEISMIC PROGRAM		
Parts and supplies	$ 270	
VDAP training in Guatemala		$ 2,266
DEFORMATION PROGRAM		
Parts and supplies	$ 34,742	
VDAP training in USA		$ 9,048
TELEMETERED TILTMETER PROGRAM		
Parts and supplies	$ 3,477	
HAZARDS MAPPING PROGRAM (Completed)		
Parts and supplies	$ 9,775	
VDAP training in USA		$ 7 662
VDAP training in Guatemala		17,872
PROGRAM SUPPORT BY VDAP		
Temporary Assistant		$ 12,210
Benefits		$ 1,709
VDAP overview in Guatemala		$ 1,730
OVERHEAD (20% -- 40%)	$ 9,653	$ 20,999
TOTALS	57,917	73,396
GRAND TOTAL TO DATE	$ 131,413	

FY88 VDAP PASA BUDGETS, PROJECTED AND ACTUAL

As seen in the Summary Table below, VDAP expenditures in FY88 were below those projected. This resulted (as in FY87) from the fact that the Database and Computer Specialists did not join the staff until mid FY88. The carryover of funds of both FY88 and FY87 will be utilized in FY89 and FY90 through expanded activities in travel and contracts made now possible with the full compliment of staff. Details of the FY88 expenditures may be seen in APPENDICES XXIV and XXV. Note that the figures in

the ACTUAL column for OFDA represent bookkeeping by VDAP members. Final Official FY88 figures will be furnished by the Office of International Geology, U. S. Geological Survey.

SUMMARY TABLE OF VDAP PROJECTED AND ACTUAL EXPENDITURES
FUNDING PERIOD - 10/1/87 - 9/30/88 (FY88)
-- UNOFFICIAL TRACKING LEDGER --

	PROJECTED	ACTUAL
USGS [for details see APPENDIX XXIV]		
Salaries and Benefits	$ 115,260	118,987
Banks, Norman - Volcanologist (26 PP)		
Doukas, Michael - Physical Science Technician (26 PP)		
Harlow, David - Seismologist (26 PP)		
Benefits	$ 16,140	16,685
Contracts	$ 9,000	2,914
Equipment	$ 12,000	22,300
Travel	$ 3,900	909
Operations	$ 7,600	3,282
Overtime	$ 1,500	0
Overhead including Administrative and Technical Services	$ 99,250	99,030
	$ 264,650	264,079
OFDA [for details see APPENDIX XXV]		
Salaries	$ 68,690	59,281
Lockhart, Andy - Operational geophysicist (26 PP)		
Ewert, John - Operational Geologist (26 PP)		
Cindy Stine - Database Specialist (14.5 PP)		
Judy Howard - Computer Specialist (14.5 PP)		
Overtime	$ 0	132
Benefits	$ 9,617	8,318
Contracts		
Translation and data entry	$ 10,000	0
Software development	$ 5,000	0
Equipment	$ 58,850	35,552
Travel	$ 29,000	25,576
Operations	$ 9,300	5,219
Overhead 20% Equip./Oper./Contract	$ 16,620	8,154
Overhead 40% Salary/Benefits/Travel	$ 42,923	37,323
	$ 242,720	179,555 #

= Owing to absence of the Database Specialist (Stine) for first 20 months of the project, expenditures in contracts plus related equipment and travel have been deferred for use in FY89-91.

IV. FY 89 PROJECTED ACTIVITIES, ACCOMPLISHMENTS, AND BUDGET

Projected FY89 Activities

Overall Program activities will be essentially the same in FY89 as in FY87 and FY88, with focus directed toward establishment of the Pan Andean Volcanology Center (see Chapter II) and maintenance of the emergency response umbrella for Latin America. Failure to obtain national and international consensus and support for PAVC might require additional operational restructuring of VDAP emphasis, perhaps toward more concentrated assistance for OVC (Colombia) or INSIVUMEH (Guatemala). As in any year, a significant crisis response in FY89 could restructure the projected objectives.

Anticipated Emphasis in FY89 will be:

Composition of the Core Team

- o Maintain existing staffing, solve problem of separation of VDAP seismologist from the main VDAP activities at CVO.
- o With concurrence of and budget assistance by OFDA, add a video specialist to VDAP (see Chapter II)
- o With concurrence of and budget assistance by OFDA, add staff members for DHAT (see APPENDICES V and VI).

Development of the Rapid-Response Equipment

- o Seismic system
  - Complete the field and analytical seismic system to crisis-ready status.
  - Upgrade the PC-based real-time processing system, cooperatively with other USGS projects.
  - Develop a coherent plan for volcano-related seismological systems in Latin America.
- o Deformation systems
  - Continue development of computer programs to assist error-minimum data acquisition and processing in Latin America.
  - Perform required maintenance, replacements, and upgrading of existing systems
- o Digital telemetry system
  - Complete development of the mudflow alarm system with repeaters, base station and 5 valley units and software functional.
  - Rebuild tiltmeter inventory (depleted by response

to Guagua Pichincha, Ecuador) to 4 operational units with repeaters and base station.

- Develop lake and fumarole sensors and integrate these with existing telemetry.

o Geochemistry system

- Continue development of methodology and operational manuals for VDAP geochemical system.
- Purchase of titanium tubing and "Giggenbach" bottles to allow sampling of hot fumaroles.
- Purchase Dreager type gas bottles for sampling low-temperature fumaroles.

Assessment of Activity, Latin American High-risk Volcanoes.

o Make on-site visits when necessary.
o Provide OFDA, USAID Missions, USGS, and in-country agencies necessary evaluations volcano hazards and unrest that occurs during the report period.

Response to Volcano Unrest

o Field when necessary advisory or full team to assist monitoring of volcano unrest worldwide but with emphasis on Latin America.
o Provide OFDA and USAID with council and evaluation of general and specific volcanic unrest with emphasis on South America.

Coordination with International Hazard Mitigation Groups

o Continue field coordination and execution activities with UNDRO, WOVO, UNESCO, CERESIS, and other international and bilateral hazard-mitigation assistance agencies.

o Continue cable, letter, and phone contact with UNDRO, WOVO, and CERESIS on Latin American volcano hazards.

Liaison/Evaluation Visits and Activities

o To maintain already established scientific and governmental liaisons required for efficient emergency responses, with emphasis on Colombia, Ecuador, and Peru.

o To begin on-site scientific and governmental liaisons required for efficient emergency responses in Chile, Bolivia, and Argentina.

- o To continue program development with INSIVUMEH, Guatemala

- o To continue telephone, telex, and letter traffic, including provision of technical literature, data, equipment, and other requested assistance throughout Latin America and other third world countries.

- o To attend hazards sections of the CIRCUMPACIFIC COUNCIL MEETING in Costa Rica.

Establishment of Baselines and Other Monitors

- o Deformation monitor upkeep in Colombia
- o Deformation monitor upkeep in Ecuador
- o Assisted installation of PC-based real-time seismic system for Ecuador.
- o Continue assistance of monitoring efforts through loan of backup and loan equipment.
- o Tiltmeter installation in Guatemala

Development of Computer (and information/map/photo) Database

- o Continue development of usable precursor and information databases for deformation monitoring.
- o Design and develop precursor and information databases for seismic and geochemical monitoring.
- o Produce and submit country profiles for Costa Rica and Peru.
- o Add to Reference database, annotated bibliographies, maps, photographs, and name files.
- o Begin contracting database entry and country profile development in "pathfinder" studies with Latin American agencies.

Establishment of the PAVC

- o With OFDA and other agencies, identify the funding (member nations, donor nations, and international groups) and develop the commitment and charter necessary to establish and maintain the Pan American Volcano Center.

Training and Educational Activities

- o Continue development of manuals, videos, and workshops on hazard evaluation and monitoring techniques for high risk volcanoes.
- o Present part of a training course in volcanology to international participants at the IAVCEI and IGC meeting in Santa Fe, New Mexico.

o To conduct a workshop in how to produce volcano hazards and risk maps in Peru.

PROJECTED FY 89 BUDGET

As in previous years, VDAP will adhere as closely as possible to the budget submitted with the 1986 WORKPLAN, but will maintain the flexibility required of major emergency responses, a reawakening volcano, a new avenue in technology, or development of a more innovative method of monitoring.

VDAP did not fully utilize allocated FY87 and FY88 owing to the absence of the Database and Computer Specialists from the staff mid FY88. The carryover of funds of both FY88 and FY87 will be utilized in FY89 and FY90 through expanded activities in travel and contracts made possible with full staffing.

SUMMARY
USGS/OFDA FY 89 PROJECTED EXPENDITURES
1 October 88- 1 October 89
(not including Task 7)

USGS FUNDS	PROJECTED FY89	1986 WORKPLAN
Salaries	$ 120,000	
Benefits	$ 16,800	
Overtime/Hazard Duty	$ 1,000	
Travel	$ 4,400	
Contracts	$ 9,000	
Equipment	$ 9,804	
Operations	$ 9,680	
Overhead including Administrative and Technical Services	$ 102,560	
	$ 273,244	
OFDA FUNDS		
Salaries	$ 74,431	
Overtime/Hazard Duty	$ 3,000	
Benefits	$ 10,840	
Overhead 40% Salary/Benefits/Travel	$ 55,309	
Contracts	$ 30,000	
Equipment	$ 50,000	
Travel + Perdiem	$ 50,000	
Operations/Expendable Equipment	$ 15,000	
Overhead 20% Equip./Oper./Contract	$ 19,000	
FY 89 Projected Expenditures	$ 307,580	$ 214,000
FY 87 Carryover		71,260
FY 88 Carryover		70,445
FY 89 Available		$ 341,705#

= Owing to absence of the Database Specialist (Stine) for first 20 months of the project, expenditures in contracts plus related equipment and travel have been deferred for use in FY89-91.

REQUESTED ADDITIONAL FUNDING FOR FY89-91
ONE-TIME INCREASE TO PASA, FY89

Contract to Eduardo Malavassi (Costa Rica)	$ 10,000
Overhead waived on Malavassi Contract	------
One time purchase of video production equipment	$ 25,000
One time purchase for loan equipment for Developing Countries ..... (this could be spread over several years)	$ 250,000
Overhead on One-time Funding (20%)...	$ 55,000

YEARLY INCREASE TO PASA, FY89

Developing Country Assistance funds (requested yearly supplement	$ 50,000
Overhead on Country Assistance (20%).	$ 10,000
Addition of Video Production (either staff addition or yearly contract)	$ 50,000
Overhead on Video Assistance (40%)...	$ 20,000
TOTAL ADDITIONAL REQUEST	$ 470,000

OFDA CO-SUPPORT IS SUGGESTED FOR THE PROPOSED PAN-ANDEAN VOLCANOLOGICAL CENTER - Organizational meetings in FY89 and FY90, equipment and operations in FY90 and after.

ADDITIONAL UGSS AND OFDA PASA FOR MUDFLOW CAPABILITIES -- SEE APPENDIX VI.

V. ACTIVITY AT LATIN AMERICAN AND CARIBBEAN VOLCANOES

This section provides a brief description of the volcanoes that have VDAP's attention because of recurrence interval or unrest during the report period or recent past. Rather than assuring a tranquil state, absence of a volcano from this list may be a reflection of poor monitoring or infrequent observation. Listing of countries and volcanoes are arranged in north-south order.

MEXICO

Paricutin - Simple andesitic cone formed between 1943-1952 (1.3 cu. km lava and 0.7 cu. km of tephra produced). Continued fumarolic activity in 1988.
People at risk = low

Colima - Composite volcano composed of several dacite domes. Dome growth continued with periodic rockfall avalanches and phreatic explosions. Fumarolic activity continued during 1988 with temperatures and sulfur deposition about the same as in previous years.
People at risk = unknown but significant.

Tacana - Dacitic dome complex, with no known historic eruptions. Increased fumarolic activity in 1988; continued seismicity.
People at risk > 50,000

GUATEMALA

Tacana - see Mexico

Santiaguito - Active dacite dome on the flanks of Santa Maria. Continued steam and gas explosions from the active vent; continued small block and ash avalanches from the active lava flow associated with the most voluminous production episode in the 66 years of dome growth. Mudflows during the rainy season caused some flooding and road damage below the El Palmar area. Agradation of streams owing to continual addition of material from the active dome and lava flow are increasing the hazards of stream capture, stream damming, and levee collapse, one or all of which could cause gradual or catastrophic encroachment on adjacent agriculture and living areas.
People at risk = many thousands.

Fuego - Basaltic-andesite strato-volcano, current repose period exceeds average interval, continued unrest, increased fumarolic activity plus gas plumes with some sand-sized ash.
People at risk = unknown but many thousands.

Pacaya - Composite volcano composed of basalt and andesite with dacite domes. Explosive and fumarolic activity and lava flows continued.
People at risk > 10,000.

EL SALVADOR

San Miguel - Basaltic strato-volcano. Unconfirmed newspaper report of a small tephra eruption in 1988. No details available.
People at risk = unknown.

NICARAGUA

San Cristobal - last eruption in 1987 was brief; gas emission continues from main crater.
People at risk = unknown
Telica - Basaltic strato-volcano, erupts frequently, most recent eruption was in November 1987; increased fumarolic activity in 1988.
People at risk = unknown
Cerro Negro - Cinder cone, erupts frequently, most recent eruption was in 1971; fumarolic activity continued in 1988.
People at risk = unknown
Las Pilas - Composite volcano, no historic activity until fumaroles opened in 1952. Gas emission continues.
People at risk = unknown
Masaya - Caldera containing twin basaltic volcanoes and 6 cinder cones. Continuously active since first observed in 1529. Degassing continues since 1979 with occasional small tephra eruptions and crater collapse. Lava still visible in crater.
People at risk = unknown
Mombacho - Basaltic composite volcano with a large summit crater breached to the west. Last known explosive episode was 1560; fumarolic activity reported since 1986.
People at risk = unknown
Concepcion - Composite volcano that erupts frequently; gas hazes observed downwind from cone.
People at risk = unknown

COSTA RICA

Rincon de la Vieja - Andesitic composite volcano with collapse craters. Small eruptions in December 1986 and April 1987 indicate recent unrest.
People at risk = unknown.
Arenal - Andesitic strato-volcano with long periods of repose. Continuous eruptions since 1968 including seismicity, lava flows, explosions, tephra eruptions, and pyroclastic flows. On July 6, a climber died near the crater rim when caught in an explosion.
People at risk = unknown, impact on hydroelectric project low but possible.
Poas - Basaltic-andesite strato-volcano with a crater lake. Continued phreatic eruptions since 1986, fumarolic activity and seismicity (mostly shallow B-type). The acidity of the

air around the crater is affecting plants and causing some discomfort to National Park visitors. EDM and tilt monitors both indicate measurable inflation occurred in 1988. In-country agencies suspect high likelihood of eruption during this period of unrest, now into the 3rd year.
People at risk = unknown

Irazu - Basaltic composite volcano, last erupted in 1964. Fumarolic activity continues unchanged.
People at risk = significant

PANAMA

Not reports of recent activity, little known about the volcanic chain.

CARIBBEAN

Mt. Liamuiga (Mt. Misery, St. Kitts) - Andesitic strato-volcano with a small seasonal crater lake. Moderate earthquake swarm in Oct. 1988. No change in crater hot springs.
People at risk > 22,000.

Micotin (Dominica) - Lava domes. Intermittent shallow seismicity in 1987 indicates recent unrest.
People at risk = unknown.

Morne Patates (Dominica) - Composite volcano. Occasional swarms in 1986-1987 indicates recent unrest.
People at risk = unknown.

Mont Pelee (Martinique) - Strato-volcano with lava domes. Seismic swarms periodically reported (none in 1987 or 1988).
People at risk > 100,000.

COLOMBIA

Ruiz - Snow-capped strato-volcano composed of andesite and dacite. Significant increase occurred in 1988 seismic activity (5-10 times 1986-87 levels), gas emission and small eruptions; no deformation since 1985, however, another serious eruption in this cycle is still possible.
People at risk > 50,000.

Tolima - Snow-capped strato-volcano composed of andesite and dacite. Last eruption in 1943; fumarolic and seismic activity recorded during periodic visits in both 1987 and 1988. Very high catastrophic mudflow hazard.
People at risk = number unknown but >150,000.

Cumbal - Strato-volcano. Has not erupted for 500 years; increased seismicity and fumarolic activity in 1988. INGEOMINAS hazard assessment is that any eruption would likely produce lava flows and tephra.
People at risk = unknown

ECUADOR (not including the Galapagos Islands)

Guagua Pichincha - Strato-volcano with caldera breached to the west. Dramatic increase in seismicity in August-October, thereafter a decrease. Last phreatic eruption in 1985, last major eruption in 1660.
People at risk = ~5,000 in near field to pyroclastic flows and airfall, >1,000,000 in Quito area, mostly to heavy airfall and smallish mudflows.

Cotopaxi - Snow-capped compound strato-volcano. Average period of quiescence exceeded; seismic activity in the past few years; no deformation on VDAP nets 87-88. High-risk volcano of great concern.
People at risk = 150,000 or more, significant economy at risk.

Sangay - Remote strato-volcano erupting continuously since 1934; lava flow, lava avalanches, and explosions reported in 1988.
People at risk = unknown but low.

PERU

Sabancaya - Snow-capped strato-volcano. Continuation of strong fumarolic activity noted in 1986-1988; snow and ice clad; most likely hazards are lava flows and tephra; needs hazards assessment to determine field of potential hazards.
People as risk = possibly ~50,000 people and the Majes irrigation project canal system.

Misti - Strato-volcano in it's longest repose interval in recorded history; increased seismic and fumarolic activity reported since 1984. Hazards are lava flows, pyroclastic flows, mudflows, damming of Rio Chillos, airfall, sector collapse.
People at Risk = >1,000,000; city of Arequipa.

CHILE

Guallatiri - Snow-capped strato-volcano, crater breached to the north and west. Increased fumarolic activity in 1985 and impulsive plumes.
People at risk = unknown

Lascar - Composite volcano, dacite domes and andesite flows. NE cone is active. Erupts frequently; continued steam and ash emission with brief eruptions on March 11, 18, and July 13, 15, 1988.
People at risk = unknown.

Tupungatito - Andesitic strato-volcano. Increase in fumarolic activity and weak emissions of ash began in 1986; volcano is snow and ice clad. November 29, 1987 avalanche generated in a small valley in the volcanic area caused a mudflow resulting in 41 deaths and destruction of roads, machinery and the Los Maitenes hydroelectric plant; 500,000 persons had no water for 48 hours.

People at risk = many thousands including parts of the capital of Chile (Santiago) and Medoza, Argentina.

Peteroa - Strato-volcano breached to the south. New fumarole field opened in January 1987, last eruption in 1967, average repose interval = 27 years.
People at risk = unknown.

Tolguaca - Active fumarolic field discovered, previously considered dormant.
People at risk = unknown.

Lonquimay - Strato-volcano with lava domes and andesitic/dacitic block lava flows. Following 2 weeks of seismicity the volcano erupted lava flows and tephra after 100 years quiescence.
People at risk = To airfall: 10,000 in Chile, more in Argentina. Risk to pyroclastic flows and mudflows reported to be low. 2,000 people evacuated from the near-field in December 1988.

Llaima - Snow-capped strato-volcano that erupts frequently. New fumarolic activity noted in 1987 and 1988; volcano last erupted in 1984.
People at risk = unknown

Villarrica - Basaltic to andesitic strato-volcano. Intermittent seismicity in 1987, snow and ice clad.
People at risk = unknown.

BOLIVIA

No activity reported, little information compiled on Bolivian Volcanoes and population at risk.

ARGENTINA

No activity reported, little information compiled on Argentina Volcanoes and population at risk.

APPENDIX I. -- Definitions of Agency and other abbreviations.

CERESIS -- Center Regional de Sismologia para America del Sur
CNMI -- Commonwealth of the Northern Mariana Islands
COLOCIENCIAS - Colombian Academy of Sciences
CVO -- Cascades Volcano Observatory (USGS)
EDM -- Electronic Distance Measurement, deformation monitoring
ESPONA -- Esquela Politecnica Nacional Autonoma (Ecuador)
FY -- Fiscal year 1 October to 30 September
GREDES -- Group de Estudios para Desarrollo (Peru)
HVO -- Hawaiian Volcano Observatory (USGS)
IAVCEI -- International Association for Volcanology and Chemistry of the Earth's Interior
IG -- Instituto Geofisico Nacional (affiliated with ESPONA, Ecuador)
IGC -- International Geological Congress
IGP -- Instituto Geofisico del Peru
INEMIN --Instituto Ecuatoriana de Minerologia
INGEMET -- Instituto Geologico Minero y Metalurgico (Peru)
INSIVUMEH -- Instituto Sismologia, Vulcanologia, Meterologia y Hidrologia (Guatemala)
IPAGEHI-- Instituto Panamericano de Geografia e Historia
NVI -- Nordic Volcanological Institute (Iceland)
OFDA -- U.S. Department of State Office of Foreign Disaster Assistance
OVC -- Observatorio Volcanologicos de Colombia
PASA -- Participating Agency Service Agreement, OFDA funding document
PAVC -- Pan-Andean Volcanological Center
PC -- Personal computer, usually IBM or an IBM clone.
SEAN -- Scientific Event Alert Network, Smithsonian Institution
USAID -- U. S. Agency for International Development
UNDRO -- United Nationsl Disaster Relief Organization
UNESCO -- United Nations Educational, Science, and Cultural Organization
UNSA -- Universidad Nacional de San Augustine (Arequipa, Peru)
USGS -- United State Geological Survey
VCAT -- Volcano Crisis Assistance Team (USGS)
VDAP -- Volcano Early-Warning and Disaster Assistance Program (USGS/OFDA)
VCO -- Variable controlled Oscillator, telemetry equipment
VOI -- Volcano Observatroy of Iceland
WOVO -- World Organization of Volcano Observatories

APPENDIX II. -- Evaluation/Recommendation Memorandums by VDAP to USAID and INGEOMINAS - Bogota

U. S. GEOLOGICAL SURVEY
5400 MacArthur Blvd.
Vancouver, Washington 98661
Phone 206-696-7961, 7967
TELEX 7400860 CVOL UC

MEMORANDUM

TO: James Smith, USAID, Bogota, Colombia
THROUGH: Bob Christiansen, Chief Branch of Igneous and Geothermal Processes, USGS
John Filson, Office of Earthquakes Volcanoes and Engineering, USGS
Mary Ellen Williams, Office of International Geology, USGS
Alan Swan and Paul Krumpe, OFDA, Washington
FROM: Norman G. Banks and David Harlow, USGS/OFDA Volcano Early Warning and Disaster Assistance Program
SUBJECT: The Observatorio Vulcanologico de Colombia
DATE: 15 April 1988

Attached are two memoranda submitted to Eduardo Parra and one for transmission through you to Lobo-Guerrero that describe specific problems now facing the Observatorio Vulcanologico de Colombia (OVC) in seismic and deformation monitoring. We understand that Stanley Williams also intends to provide a similar memorandum to OVC concerning geochemical monitoring. The problems at Manizales are very significant, and some of them are critical. They appear to result from:

- Less-than-sufficient support by Colombia for existing equipment.
- Less-than-sufficient long-term support and training in volcanology from the international community.
- Logistical difficulties in obtaining needed parts and equipment.

Because we and the other participants of the recent workshop agree that Ruiz may still present a significant hazard, we feel it necessary to make these problems obvious to all agencies that now have or have had a significant role in hazard mitigation efforts at Ruiz. We are therefore using this memorandum as the vehicle to inform the USGS, OFDA, and USAID (Bogota) of our concerns.

Very obviously, OVC is in trouble. It's hazard forecasting/warning system is seriously degraded from the original installed largely by the USGS/OFDA in 1985. Just as obviously, OVC needs assistance from the international community in acquisition of equipment and, particularly, in long-term training. The original US involvement was intended for a 6-12 month emergency response, not to a 3-10 year commitment to a continuously-active, very hazardous volcano. The original investment simply did not include enough training, equipment, and

spare parts to cope with the long-term activity of Ruiz. Reference to the memoranda written in 1985-1986 by the original USGS advisors will show that, even then, it was anticipated that Ruiz presented long-term problems that required long-term solutions. It was apparent then, that it was unrealistic to think that lasting and fully responsible monitoring and hazard forecasting could be assumed by INGEOMINAS when there was absolutely no in-house or even in-country experience and training in volcanology. An example of recognition of need for long-term support is the 5-year program being developed by the Swiss in Calle to develop a 10-station network that includes no currently-threatening volcanoes (versus the post-Ruiz US program of less than 1 year for a threatening one).

We ourselves are not in a position to initiate the initiatives needed for Ruiz's activity. We have neither the funds, manpower, and needed mandates. However, our judgement is that initiatives definitely are required by the situation. Hopefully, our memorandum to Lobo-Guerrero will generate Colombian initiatives, that will assure full cooperation and intent by INGEOMINAS. Ideally any initiatives from INGEOMINAS will generate the necessary full commitment of one or more assistance agencies to the needs in Manizales.

It is our personal view that leadership in this assistance to Manizales should come from the US, from our status of neighbor and from our comparative depth of knowledge in the Ruiz situation. However, a multinational support program might be a more pragmatic solution that would minimize large fluctuations in funding and premature termination of assistance. Realistically, we estimate that minimum assistance for Ruiz (and the other high-risk Colombian Volcanoes) will cost more than 1.5 million US dollars and take a minimum of 5 years. Even a stop-gap program to return surveillance to the 1985 level would require substantial financial support and significant commitment of personnel.

We are certain that if no assistance is provided, the current low level of support and continued deterioration of the monitoring systems could and possibly would result in failure to detect premonitory signs of eruption at Ruiz. For the immediate lack of parts and inoperative equipment, establishment of a parts/repair pipeline supplied by both Colombian and external funding is badly needed. From our conversations with Eduardo Parra, we understand that between $10,000 and $50,000 of Colombian funds are currently available for purchases. Also, as described in the memorandum to Lobo-Guerrero, there is $250,000 (BID loan) that is going to be spent, owing to a lost political battle, on equipment that does not fully address the situation at Ruiz. Could these funds be rescheduled and channeled through the Embassy to US suppliers? Such a pipeline would be a real pathfinder to the needs throughout Latin America, where we find identical problems of parts, repairs, and equipment upgrades ubiquitous.

For the longer-term needs, perhaps the Ambassador might find it interesting to establish, under US leadership, the Observatorio as an international volcanological center supported by several nations interested in volcanology and with desires to study more active volcanoes than found in their own lands. Colombia would benefit from having multiple funding sources and training opportunities, and the contributing nations would have the opportunity to interact with a live volcano at a fraction of the cost of unilateral assistance. Obviously, this would require much diplomatic work, desire for such assistance by the Colombia interests, and very careful planning, rules, and documentation to minimize rivalry and to keep the interests of Colombia the main focus of the joint efforts.

U. S. GEOLOGICAL SURVEY
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MEMORANDUM

TO: Dr. Alberto Lobo-Guerrero, Director INGEOMINAS, Bogota
Eduardo Parra, Director OVC, Manizales
THROUGH: Bob Christiansen, Chief Branch of Igneous and Geothermal Processes, USGS
John Filson, Office of Earthquakes Volcanoes and Engineering, USGS
Mary Ellen Williams, Office of International Geology, USGS
Alan Swan and Paul Krumpe, OFDA, Washington
James Smith, USAID, Bogota, Colombia
FROM: Norman G. Banks and David Harlow, USGS/OFDA Volcano Early Warning and Disaster Assistance Program
SUBJECT: The Observatorio Vulcanologico de Colombia
DATE: 15 April 1988

We would like to take this opportunity to make a brief report on our recent evaluations on the status of Nevado del Ruiz and the Observatorio Vulcanologico de Colombia. We made these evaluations and observations during the Ruiz Workshop and a stay of one additional week in Manizales following the Workshop.

Currently, seismic activity at Ruiz is at the highest level recorded since late 1986. This elevated activity began in January 1988 and reached a high point just prior to the most recent ash eruption on March 21, 1988. The increased seismicity, which was continuing when we departed Colombia, suggests an increase in the level of activity of the volcano. Although this renewed activity can not, at this time, be interpreted as a definite precursor to another devastating eruption, the elevated activity strongly emphasizes the consensus of the Workshop that Ruiz has not begun to show signs that this eruptive cycle is over, and that, therefore, the volcano still presents high potential risk. For these reasons, we approached our just-completed working visit with the Observatorio with a strong sense of need that all monitoring networks on Ruiz should be at full operational capacity, because now is not the time to reduce vigilance of the volcano.

In the attached memorandums to Eduardo Parra, we outlined what we feel are significant problems now facing the Observatorio in Manizales in seismic and deformation monitoring. We understand that Stanley Williams also intends to present Eduardo with suggestions with regard to geochemical monitoring at Ruiz. We add here that although preparation for future mudflows has been much improved, we would like to see all drainages monitored by error-checking monitors radioed directly to the Observatorio.

Please accept this and the attached memoranda as constructive evaluations that do not imply serious fault at the operational level in Manizales. As attached memoranda state, we have high admiration for the progress and abilities of the Observatorio and the staff. The current facility, the formal position of the Observatorio in INGEOMINAS structure, and the continuing high esprit and dedication of the staff have kept a very high level of responsible surveillance of Ruiz. We remain expectant that OVC will develop into the model volcano observatory of Latin America.

However, the original instrumentation has deteriorated through constant use. Moreover, the studies over the past 2 1/2 years have recognized the need for additional monitors and alarms and a solid program of training of staff in volcanology, including advanced-degrees. Obviously, a lack of response to these conditions and needs at Manizales could and possibly may result in failure to detect premonitory signs of eruption. An example of system deterioration is that there are only 3 fully operational (one other operates intermittently) telemetered seismic stations on Ruiz of the original 6 (plus one back-up) stations. This condition results from a lack of spare parts, and although OVC is commended for its skills in keeping the 3.5 stations going through cannibalization of inoperative stations, the current system is not a sufficient seismic monitor for Ruiz. An example of the need for advanced training or presence of a long-term advisor is the recent movement of the far-field telemetered tiltmeter (Inderena) to a location that removed the possibility of early detection of the precursory advance of magma from depth. The move was in response to a suggestion by a visiting deformation expert who had little long-term experience at Ruiz and was not aware of the need to monitor deformation produced from magma at multiple depths. Thus, lacking sufficient training to argue otherwise, nor the council of a long-term advisor, the visiting expert's suggestion was adopted by the Observatorio.

Given the continuing activity at Ruiz, the Observatorio monitoring systems simply must function at adequate levels, data must be processed in real time from properly located monitors, and analysis must occur on a daily and interactive basis between the several monitoring groups to avoid failures in eruption forecasting.

It is our perception that most of these problems could be corrected with:

- Sufficient support for repair and upgrading of monitoring equipment.
- A long-term program of training and association with one or more groups in the international volcanology community.
- Training of staff in formal course work and advanced degrees in volcanology.

These suggestions will require initiatives from Colombia. However, should you find it necessary to look for resources that do not reside in Colombia, we speak for ourselves, and probably also for other national and international groups with investments of material, labor, and concern in the Observatorio, that we will be happy to advise and assist your initiatives should they arrive on our desks. For example, we had the opportunity to see the original request by the Observatorio for the $250,000 loan for equipment by the Bank for International Development and to compare it with the recommendation made by the University for the same funds. This amount is approximately 1/2 to 1/3 of the funding we feel that is required for purchase of needed equipment for Manizales. Both of us strongly agree that the equipment list drawn up by the Observatorio directly addressed the needs at Ruiz better than the list prepared by the University, given the current state of the Observatorio and the activity at Ruiz. In the light of the findings of the Workshop, we ourselves would make a few changes in the list drawn up by the Observatory, and if the purchases have not yet been initiated (and you so request), we would be happy to formally review both the OVC and University lists and furnish our recommendations.

APPENDIX II. --Continued

U. S. Geological Survey
5400 MacArthur Blvd.
Vancouver, Washington 98661

MEMORANDUM

TO: Laraine Mansfield, AID, Colombia
FROM: Norman Banks, Project Chief, USGS Volcano Crisis Assistance Team (VCAT), USGS/OFDA Volcano Early Warning and Disaster Assistance Program (VDAP)
SUBJECT: Ruiz Volcano and volcanology in Colombia
DATE: 13 October 1988

As you requested, this memorandum reviews some of the items we discussed this morning and provides you with hard copy for your notes and action.

I stopped in Bogota on my way back from evaluating the activity at Pichincha Volcano, Ecuador, for the following reasons:

1. To review the recent monitoring data produced by the Observatorio Volcanologico de Colombia (OVC) and assist their evaluation of the current status of activity at Ruiz and Cumbal Volcanoes. I have done so, and my concern about the increased activity at Ruiz was strengthened by my review of the recent data provided at the meeting at INSIVUMEH this afternoon. I feel that we must not rule out a scenario where Ruiz develops to a death-dealing eruption with very little lead-time. I will provide you with a separate summary of my findings when I arrive in Portland and have access to a xerox to copy some of their data for your records.

2. To review the status of and needs in the monitoring being carried out at OVC (Manizales) and the Universidad del Valle (Cali), and to report the findings to AID, Bogota. For this see below.

3. To provide AID, INGEOMINAS, the Presidente's Office, and other interested groups, copies of a VDAP-produced educational video on pyroclastic flows and to solicit financial assistance for a multinational working group of volcanologists producing similar educational material (See memorandum to Frank Almaguer (AID, Quito, 11 October 1988 for more detail).

4. To suggest that AID, Bogota, join with other AID Missions in South America in co-sponsoring an Inter-Andean Center for Volcanologic studies. This Center should be based at a university with long-term interest in volcanology and be associated with a group actively

conducting monitoring of volcanoes. At this time my vote would be the Esquela Politecnica Nacional in Quito as the best place because it meets both of these requirements and it is still safe to work in the field throughout the country. Among the other candidates/participants for the Center are Univ. del Valle, Univ. de Caldas, and INGEOMINAS (Colombia) IGP, Univ. San Augustine, CERESIS (Peru); and INEMIN (Ecuador). There may be others, particularly in Chile. National, bilateral, and international support, training, and use of the Center should provide a showcase product that eventually develops independence and leadership in volcanology in the Andes through on-site training and monitoring programs.

With respect to Item # 2, if you review the trip reports of past USGS advisors plus quite a few letters and memorandums from myself and other senior volcanologists (USGS, Universities, UNDRO, WOVO, etc) who have worked on Ruiz, you find the recurrent themes that (A) equipment at OVC is always working at a fraction of the appropriate level because of lack of parts, (B) there is no resident, professional volcanological experience at OVC to assure early and confident recognition of short-term warnings of impending eruption, and (C) there is need for real-time seismic and deformation analysis at Ruiz to assure timely forecasts, particularly in view of the increasing seismic activity and continuous gas and ash emissions that are occurring now. These conditions arise because:

- Almost all parts and supplies for the monitoring activities at OVC have their origin in the US and there HAS NOT BEEN an avenue established to fund and facilitate purchase/delivery of the critical parts, supplies, and systems-upgrade material. Such a systems support effort would probably cost about $50,000 a year, should last about 5 years, and should include short-term training and emergency assistance trips. The cost may be lower if AID makes direct purchases, higher is the USGS and/or a contractor is required to make purchases and construct non-commercial components.

- OVC does not have a trained volcanologist on the staff (actually there is no formally-trained senior volcanologist in Colombia). Failure in hazard mitigation may result from this condition (Item B above). OVC desires and has always needed 2 experienced volcanologists (one a senior volcanologist, the other a high quality operational volcanologist/technician) to establish residence for about 2 years in Manizales to provide better quality data, provide more in-depth analysis of the behavior of the volcano, and complete the training begun in 1985-1986 by the US when the observatory was established. Probably these residents will have to be rotated in on

a 3-4 month schedule, but their presence should be constant and of high quality. Concurrently, there should be 2-4 high-quality Colombian candidates given advance-degree training in volcanology. They need not all be drawn from OVC, but should sign papers obligating post-grad service to the country at a University and/or OVC for a significant period as repayment. The cost here would be significant, but not in comparison with another loss as large as Armero.

- o OVC needs much better real-time data gathering/analysis capabilities, given mudflow travel-times of 1/2-3 hours to the major cities still threatened. They have too few electronic tiltmeters (they had too few at the onset and some have died since 1985) and need an on-line seismic system. They already have part of the parts needed, but there will need to be more purchased plus a hefty among of training plus some support to produce good documentation and operational manuals since the system is only now being developed by the USGS. I don't have the actual figures at hand on this one, but the Universidad del Valle, OVC, Universidad San Augustine (Peru), INSIVUMEH (Guatemala), and ESPONA (Ecuador) all have strong interest in the PC-based system. Perhaps a consortium of LA Missions might wish to contribute to completion of the system and one training class with all countries participating.

- o I specifically asked Cesar Carvajal (Director of OVC) and Fernando Munoz (Scientist in charge at OVC) if they felt comfortable with the mudflow early-warning system at Ruiz. Both answered yes, but I have reservations that would be alleviated by investigation by a qualified panel of the early-warning devices and the evacuation planning and apparatus. Upgrading naturally would have a cost.

Finally, I encourage you to find and read all of the memorandums, reports, and recommendations that the various US volcanologists have provided for AID, Bogota. Many more aspects are covered in these older efforts to help volcano hazards mitigation in Colombia than in this short memo, and many of the concerns expressed in the older memorandums still apply to Colombia. In particular, we all remained concerned with the need to promote and maintain an open and cooperative atmosphere of mutual assistance and studies between INGEOMINAS and the various Universities that are also active and interested in volcanology in COlombia. In particular, the geophysical group in the Universidad del Valle under Hans Meyer is an accomplished and high-quality group that desires, needs, and should have US assistance in their studies of the volcanoes of southern Colombia. Any assistance that the US might provide Meyer in maintaining his strong program and assuring healthy collaborating with INGEOMINAS would go far in providing good hazard mitigation

to the southern volcanoes of Colombia, two of which (Cumbal and Galeras) are also showing bothersome signs of unrest.

In closing, let me establish that although I have herein listed, as you requested, some of the needs and solutions to volcanologic problems in Colombia, I am, in no way, in a position to commit or authorize USGS personnel or resources to solve these needs. For this you would have to formally petition the USGS for appropriate consideration, decisions, and formal negotiations.

If I can be of more help. Please do contact me. I have a deep personal interest in the needs in volcanology in Colombia, and in my position as the OFDA/USGS program chief of VDAP, I have a certain amount of authority to provide information and guidance as, for example, this memorandum.

APPENDIX III. -- Summary of Obligations, Accomplishments, and Problems encountered during the report period on the PASA Addendum for INSIVUMEH, Guatemala.

In August 1987, a cooperative program to initiate volcano hazards evaluation and monitoring in Guatemala was established with the Instituto Nacional de Sismologia, Vulcanologia, Meteorologia y Hidrologia (INSIVUMEH). This program was conceived to progress in stages, each dependent upon success of the preceding stage. STAGE I was funded (by AID Guatemala) and appended as TASK 7 to VDAP's PASA with OFDA, to be completed approximately 12/89. Details of the 8 work units of TASK 7 (STAGE I) and of the necessary concurrent activities and obligations by INSIVUMEH are found in a report to OFDA and USAID-Guatemala by Banks and others (1987) and are outlined below.

Accomplishments progressed as expected in FY88 on 8 work units of STAGE 1, with the exception of that planned for the seismological section (see A. of this APPENDIX) and some problems encountered in INSIVUMEH support of some aspects of the program (see B. of this APPENDIX). There were also some difficulties encountered that relate to the overall low level of background in geological and scientific training within INSIVUMEH see C. of this APPENDIX). Suggested solutions to successful completion of STAGE I of the Guatemala Program are found in D. of this APPENDIX. The main program change suggested is that more intensive training in overall volcanology be substituted for the planned upgrade of the seismic program. Also recommended is implementation of a STAGE IA in 1990 at the completion of STAGE I.

A. WORK UNITS OF TASK 7 (STAGE I) -- VDAP OBLIGATIONS AND ACCOMPLISHMENTS TO DATE

Work Units

a - Provide preliminary hazards maps of Fuego [FY88 Objective] and Santiaguito [FY89 Objective] Volcano.

- This Unit is now completed, ahead of schedule and with greater input/results than anticipated.
- Provided a basic geology kit for geologic studies.
- Provided 2 months of U. S. training to Otoniel Matias, INSIVUMEH geologist, in volcanology at Michigan Tech. University, CVO, HVO, and Menlo Park.
- Obtained attendance of Alvarez in an UNDRO course in Volcano Hazards in Ecuador 1987, and of Matias in a second UNESCO course in Ecuador in 1988.
- Contracted hands-on training, preparation, and publication of a preliminary hazard maps of Santiaguito Volcano:

"Rose, W. I., Mercado, Reinaldo, Matias, Otoniel, and Giron, Jorje, 1987, Evaluacion de riesgo del domo de Santiaguito, Guatemala: INSIVUMEH Informe Preliminar, 13 pp., 7. figs. " [English and Spanish]

- Contracted hands-on training, preparation, and publication of a preliminary hazard maps of Fuego Volcano:

  "Rose, W. I., Mercado, Reinaldo, Matias, Otoniel, and Giron, Jorje, 1988, Volcanic Hazards of Fuego Volcano, Guatemala: INSIVUMEH Preliminary Report, 10 pp, 15 figs., 2 maps." [English and Spanish]

- Produced unanticipated spin-off publications:

  "Vallance, J. W., Giron, J. R., Rose., W. I., Siebert, Lee, Banks, N. G., 1988, Volcanic edifice collapse and related hazards in Guatemala: INSIVUMEH Preliminary Report, 15 pp." [English and Spanish]

  "Mercado, Reinaldo, Rose, W., I., Najera, Lionel, Matial, Otoniel, Giron, Jorge, 1988, Volcano ashfall hazards and upper wind patterns in Guatemala: INSIVUMEH Preliminary Report, 15 pp." [English and Spanish]

b - Upgrade the seismic surveillance of the 4 targeted volcanoes (Menlo Park Team Members [FY88 objective]):

- Unit is not complete and may be restructured (see PROJECT EVALUATION (C.) and PROPOSED RESTRUCTURING (D.) below).
- The VDAP seismologist visited INSIVUMEH to begin this unit, but the unit was not completed as planned, in part owing to organizational problems in VDAP and in part owing to political, organizational, and financial developments in INSIVUMEH that failed to identify the volcanological seismologist and establish the 4 observational posts to house the 2 existing and 2 additional portable seismographs scheduled for purchase.
- The VDAP seismologist, on two visits to INSIVUMEH, assisted improvement of the national seismic network and redirection (and commissioning) of some of seismic stations to improve early-warning surveillance of the volcanic chain

APPENDIX III. --Continued

c - Establish limited but useful capabilities in deformation monitoring [FY88 Objective]:

- Except for perhaps a few more minor purchases in FY89, this Unit is now completed, on schedule.
- An INSIVUMEH technician (Rudolfo Morales) received his scheduled 2 months of training in deformation monitoring in the U.S. Oscar Poras was also provided the opportunity of attending a 1-month training course by VDAP-UNESCO in Ecuador in 1987.
- Several INSIVUMEH personnel also received in-country training in deformation monitoring.
- All scheduled purchases of deformation equipment were made and transferred to INSIVUMEH; note that with concurrence of Mr. Sanchez, Subdirector of INSIVUMEH, the short-range EDM system was upgraded to a medium-range system, and the repair of the gravimeter was substituted by purchase of a precise levelling system which is more accurate, compared with gravimetry, in detecting volcano deformation.
- VDAP cooperatively established or upgraded EDM and dry tilt monitoring on Fuego, Santiaguito, Pacaya, and Tacana Volcanoes.

d - To establish limited but useful real-time deformation monitoring a the 4 targeted volcanoes [FY89 Objective].

- This Unit is on schedule for completion in FY89, the training of an INSIVUMEH technician, construction of 3 additional tiltmeter systems, and installation in Guatemala.
- Part of the VDAP equipment used to establish a telemetered tiltmeter and receiver base station for Fuego (FY87) was replaced in VDAP cache; Fuego instrument continues to send good data.
- The computer program of the base station receiver was upgraded in-country by VDAP personnel to decrease data interruption through uninformed attendance to the system.
- The INSIVUMEH computer system was optimized in-country by VDAP personnel by installation of and instruction in PC-BOB, a volcano tracking graphics/statistics program developed for VDAP at CVO.

e - To provide a basic field kit for geology studies [FY89 Objective]

- This Unit in now completed, ahead of schedule.

- Designed, purchased, and transferred geologic equipment required scheduled for FY89.

f - To Provide basic geochemistry kit to monitor hot springs, condensates, and health hazards of ash-contaminated surface waters [FY89 Objective]

- This Unit is ahead of schedule; all purchases have been made, a training manual is in progress, and the equipment transfer and in-country training is projected for early 1989.

g - To provide the basic necessary reference materials for general volcanology and monitoring [FY88 Objective].

- This Unit is completed; all reference material was purchased and transferred as scheduled to INSIVUMEH.

h - Provide basic training and support required to service, operate, and interpret the new systems [FY88 and FY89 Objectives].

- Scheduled training and support were provided in FY88 all four systems (seismic, hazards mapping, deformation monitoring, telemetered tiltmeters, and geochemistry.

- Although this unit has received the scheduled input to date, there have been problems related to the overall low level of basic training in INSIVUMEH and a high turn-over of this staff. Thus it is obvious that this work unit will require long-term support after the conclusion of STAGE I. As noted in the PROJECT EVALUATION and PROPOSED RESTRUCTURING sections below, higher emphasis than anticipated in 1987 will be applied in this work unit during the remainder of STAGE 1.

B. INSIVUMEH COOPERATIVE GOALS AND ACTIVITIES -- STAGE I OBLIGATIONS AND ACCOMPLISHMENTS TO DATE

1 - To establish a new section, SECCION VOLCANOLOGIA to receive the equipment and training provided by USAID/VDAP and to staff the SECCION with:

A full-time Seismologist
A full-time Geologist
A full-time Deformational Specialist
5 full-time support people as stated on p. 22 of the

30 March 1987 VDAP report to AID-Guatemala and in several memorandums to Sanchez of INSIVUMEH.

In FY88 INSIVUMEH did establish the SECCION VOLCANOLOGIA; however there have been substantial shortfalls in staffing. There is 1 geologist (the Section Head, Fernando Alvarez), a civil engineer (an Assistant Section Head, assigned late in FY88), a designated Deformation Specialist (Rudolfo Morales, another civil engineer), two Technical Geologists (Matias and Giron), an illustrator, and a technical assistant (Roberto Solis). However, the key positions of the seismologist and electronic technician have not been filled, and most of the assignments to the SECCION were not permanent until late in 1988. The late assignments delayed progress in the deformation program, and the continued absence of the two remaining key positions delays development of seismological and telemetered tiltmeter aspects of the program.

On the other hand, the Matias and Giron are making up for part of the staffing deficiency by working with the seismic records and the tiltmeter data as well as in the geologic program. Giron and possibly also Matias will also participate in developing a geochemical program. Both technical geologists deserve commendation for their high esprit, hard work, and high level of interest and accomplishments in all parts (geologic, seismic, geochemical, and deformation) of the SECCION. Morales and Solis have also proved to be active, interested, and productive members of the Seccion.

Nonetheless, there has been slower-than planned progress in technology transfer through absence or delayed assignment of staff as trainees to the VDAP program. In the two key positions of seismologist and electronics technician, this problem still exists.

2 - To provide a dedicated four-wheel drive vehicle of sufficient size to carry both crew and equipment on frequent, sometimes extended trips to the field.

INSIVUMEH, as anticipated in our 30 March 1987 report, has not provided this crucial element to the volcano hazards program. As a result progress in monitoring has been very much slower than needed for successful, on-schedule completion of STAGE I. Provision of this vehicle may require assistance or at

least perseverance by the USAID-Guatemala Mission. VDAP has no position for persuasion in this mater, having no budget for the vehicle and being based thousands of miles from the SECCION.

3 - To establish an adequate budget for salaries, operations, per diem for the frequent field work required of hazards evaluations and volcano monitoring and response, and gradual upgrading of the SECCION.

INSIVUMEH provides the salary for the SECCION members, adequately supported most in-country VDAP-related field work, and has supported some, although scarce, independent field work by the SECCION. There has been minimal contribution to operations and systems upgrades. This less-than-needed-budget has slowing achievement of benchmarks set for STAGE I.

4 - To repair and reprogram part of the national seismic net to improve early-warning monitoring of more volcanoes.

With the assistance of VDAP's seismologist this unit has been partially accomplished. Many more stations came on line and at least one was commissioned or relocated to improve coverage of the volcanoes. However, full implementation of this reorganization (as described in a January 1988 memorandum between Sanchez [INSIVUMEH] and Harlow [VDAP] had not been accomplished by November 1988.

5 - To establish and staff on-site Observatories on the 4 targeted volcanoes to observe daily changes in the activity and operate (1 each) the 2 existing and 2 additional seismographs scheduled for purchase by VDAP.

Late in 1988 INSIVUMEH did establish an observer on Pacaya and is planning to establish one on Fuego. However, the delay in completion in this area plus the absence of a seismologist has stopped the purchase of the seismometers and completion of training of the observers and seismologist.

C. PROJECT EVALUATION

In all Obligations, excepting that pertaining to the seismological training and purchases, VDAP has met (deformation) or is ahead of or exceeded (hazards evaluations; geochemistry) all benchmarks of the Project. VDAP is not able to begin either of the two remaining major Obligations (seismology and

telemetered tilt) until full-time INSIVUMEH personnel are identified for the training and subsequent running of these parts of the STAGE 1 program. In addition, some of the benchmarks already achieved were done so under the restrictions of late assignment of many of the personnel, less-than-ideal background of some assignees, and a severely restricted INSIVUMEH budget for operations and upgrading.

Part of these problems result from possibly unsolvable realities related to funding and staffing of INSIVUMEH. In addition, part of the problems relate to internal problems associated with the Section Head which included refusal by some key personnel to join the SECCION, sequestering of equipment provided by the STAGE I project, and unexplained restrictions on access to data by VDAP advisors pertaining to STAGE I projects. VDAP also is aware of a period in the last year when substantial political unrest occurred throughout INSIVUMEH, and this also led to disruption of STAGE I goals.

D. PROPOSED RESTRUCTURING OF STAGE I

In order to complete STAGE I Objectives, INSIVUMEH must provide or be provided with a vehicle and an appropriate operational budget including per diem and vehicle expenses for field work. In addition, in light of the above evaluations and listing of accomplishments and lacking the seismologist and electronics technician in the SECCION VOLCANOLOGIA, VDAP has concluded that some restructuring of STAGE I is necessary:

- o Defer additional work on the seismology program to STAGE II. INSIVUMEH has already received considerable support in seismic studies through an earlier USAID-supported program that established the national net. Thus, less training is needed in this sector than in any other required by the SECCION VOLCANOLOGIA

- o To assure that adequate seismological data is available to VOLCANOLOGIA, encourage INSIVUMEH in the strongest terms possible to develop formal paperwork that establishes specified and regular reports on volcanologic seismicity by the SECCION SISMOLOGIA to the SECCION VOLCANOLOGIA and unrestricted access of the SECCION VOLCANOLOGIA to the seismic records and data of interest to VOLCANOLOGIA. This access will train VOLCANOLOGIA geologists in seismology and gradually reduce the added strain on SISMOLOGIA presented by the new SECCION. VDAP will offer assistance to INSIVUMEH in the development of this paperwork upon the next visit by the project manager to Guatemala.

- o Divert the placement site of the Tacana tiltmeter to Fuego or Santiaguito. The Guatemala side of Tacana is too remote, given INSIVUMEH funding, to assure full operation of the instrument at Tacana. Moreover, Fuego and Santiaguito present higher hazard to Guatemala (Tacana's hazard is less certain and directed mostly toward Mexico). VDAP will assist INSIVUMEH in this reprogramming. However, an existing or new person must be identified by INSIVUMEH to receive the training in tiltmeter construction, maintenance, and operation.

- o Use the funds freed by restructure of the seismology program to:

  - Buy a computer and printer for the SECCION VOLCANOLOGIA. Currently only one AT computer is available to 3 SECCIONS. The existing computer was purchased for and should return to the SECCION SISMOLOGIA because of the processing of the seismic data requires almost full-time use. The proposed new computer should be likewise reserved to the exclusive use and authority of VOLCANOLOGIA. Use of either SISMOLOGIA's or VOLCANOLOGIA's computer by GEOFISICA (who should be encouraged to discover the funding for yet a third computer) should occur only when time is allotted for their use by the controlling SECCION.

  - Send a USGS volcanologist to reside and work with INSIVUMEH for about 4 months. The most difficult parts of the technology transfer attempted by STAGE I was to teach methodical and accurate measurements and analysis of monitoring data. This has been the major problem in every VDAP training program because of the dissimilarities of culture and background of the advisors and the trainees in the developing countries. This inherent problem is magnified when, as in the case of INSIVUMEH, the proper background may not be available to absorb the new techniques, A proper schedule of measurements, of data accuracy, and of understanding must develop in INSIVUMEH to match existing volcanologic realities, or STAGE 1 will not achieve the desired effect in hazards mitigation in Guatemala. VDAP opinion holds that this can not occur with existing staffing without the longer-term reinforcement that can result from this 4-month stay of the USGS advisor.

- o If an electronics person is not assigned to VOLCANOLOGIA,

use the funds intended for the U. S. training to build and buy back-up electronics that one of the other SECTION personnel (assigned responsibility for the tiltmeters) can replace without specialized training. If after completion of this and other Units, there are excess funds in STAGE I, use these funds toward more residence time at INSIVUMEH for VDAP advisors.

E. THE NEED FOR A STAGE 1A PROGRAM.

According to the course of events to date and conversations with the Subdirector, Sanchez, the personnel, with the qualifications already developed to maintain the hazards-mitigation program, are unlikely to come to, or remain with, INSIVUMEH because of the non-competitive pay compensation of government jobs, unless there are some other incentives. In addition, INSIVUMEH must have, but probably will have difficulty providing a budget adequate for upkeep and upgrading of the monitoring systems provided by STAGE 1. Because all components have finite life, particularly those exposed to weather and vandalism, this situation puts the project in the potential position of having equipment and technology available but not in a position to use at necessary levels for proper hazard mitigation.

With these realities in mind, and wishing to assure optimum use of the technology and equipment supplied and to-be-supplied to INSIVUMEH in STAGE I, VDAP reminds USAID-Guatemala that on page 21 of the 30 March 1987 report, it was anticipated that a $50,000 per year, 3 year maintenance program (STAGE IA, to provide parts, upgrading, continued close contact between VDAP and already-trained personnel) would be needed at the conclusion of STAGE I.

VDAP proposes that STAGE IA be formally expanded and adopted by USAID-Guatemala as follows:

- o Provide INSIVUMEH a 3 year $50,000/year (+overhead) maintenance program 1/90 through 1/93. The program would include parts, system upgrades, and support on VDAP required for procurement, quality control, and delivery.

- o Support of 6, 4-month residences of USGS (and other) volcanologists in Guatemala over the period 1/90-1/93). This program would cost approximately $35,000 (+overhead) for each residence.

- o Support 3 SECCION VOLCANOLOGIA personnel to procure BS degrees in geology and 1 SECCION person through an MS program over the next 3-6 years.

APPENDIX IV -- Unofficial Tracking Ledger of Guatemala Addendum (Item 7) - OFDA/VDAP Program, FY 87-88 Expenditures and 89-90 Projected.

[NOTE: This is an unoffical ledger used by project personnel to track and check expenditures at the operational level]

LEDGER PRINTOUT 31-Dec-88

SUMMARY TRACKING LEDGER

OPERATIONS	
FY87-88 EXPENDITURES	
Travel/Salary-Benefits	$52,497
FY87-88 Overhead 40%	$20,999
Equipment/Contracts	$48,264
FY87-88 Overhead 20%	$9,653
FY87-88 Total	$131,413
OVERHEAD	
FY89-90 ESTIMATED EXPENDITURES	
Travel/Salary-Benefits	$107,230
FY89-90 Overhead 40%	$42,892
Equipment/Contracts	$47,000
FY89-90 Overhead 20%	$9,400
FY88-89 Total	$206,522
TOTAL EXPENDED + PROJECTED	$337,935
TOTAL BUDGETED	$337,940

H	GUAT NO.	GUAT CATEGORY	GUAT SORT	ITEM DESCRIPTION	VENDOR	NO. PUR	PRICE EACH	SHIP COST	PURCHASE COST	CATEGORY TOTAL
FY87-88 PLANNED/EXPENDED										
SEISMIC - Terminate and substitute with 4 month in-country advisor										
INSIVUMEH SEISMOLOGIST TRAINING IN USA										---
VCAT TRAINER EXPENSES, USA TRAVEL WITH INSIVUMEH SEISMOLOGIST										---
SEISMOGRAPHS AND PARTS (2), SEISMOMETERS (3) + SHIPPING										---
SEISMIC - PARTS/SUPPLIES										$270.00
	GBB-052	SEISMIC SUPPLIES		MANUAL - GUATEMALA	APPL. TECH.	1	$50.00		$50.00	
	GBB-061	SEISMIC SUPPLIES		IMPREST FUND	IMPREST	2	$110.00		$220.00	
SEISMIC - VCAT TRAINER TO GUATEMALA										
	GBB-048B	TRAIN	PROGRAM	PERDIEM - HARLOW	VOUCHER	1	$766.30		$766.30	$2,266.30
	GBB-048A	TRAIN	PROGRAM	AIRFARE - HARLOW	VOUCHER	1	$1,500.00		$1,500.00	
SEISMIC - PRICE NEED CHANGES										---
DEFORMATION - FY88 OBJECTIVE - Complete except for canceled orders										
DEFORM - TRAINING INSIVUMEH SPECIALIST IN USA										$6,344.00
	GBB-064A	DEFORM	TRAIN	PENA, AIRFARE		1	$1,996.00		$1,996.00	

688-064B	DEFORM	TRAIN	PENA, embassy advance		1	$200.00		$200.00	
688-064C	DEFORM	TRAIN	PENA, VOUCHER		1	$1,850.00		$1,850.00	
688-064D	DEFORM	TRAIN	PENA, VOUCHER		1	$120.00		$120.00	
688-064E	DEFORM	TRAIN	PENA, VOUCHER		1	$1,815.00		$1,815.00	
688-064F	DEFORM	TRAIN	PENA, AIRFARE		1	$200.00		$200.00	
688-014	DEFORM	TRAIN	WRD RIG RENTAL	WRD-VANCOUVER	1	$163.00		$163.00	
VCAT TRAINER EXPENSES, USA TRAVEL WITH INSIVUMEH SPECIALIST									$2,703.76
688-038B	TRAIN	DEFORM	PERDIEM - JOHN	VOUCHER	1	$2,174.75		$2,174.75	
688-038	TRAIN	DEFORM	AIR FARE - JOHN	VOUCHER	1	$529.01		$529.01	
DEFORM-REFLECTORS									
688-045	DEFORM	EDM	LIETZ EDM REFLECTOR PRISMS	LEWIS & LEWIS	30	$85.00	$0.00	$2,550.00	$2,550.00
DEFORM - SHORT RANGE EDM									
688-026	DEFORM	EDM	RANGER 5-A SYSTEM	GEODIMETER	1	$17,724.00	$0.00	$17,724.00	$17,724.00
DEFORM - REFRACTION KIT (2)									$916.46
688-009C	DEFORM	REFRACT	A/C ADAPTOR+BATTS	PEET BROS	2	$25.00		$50.00	
688-009B	DEFORM	REFRACT	EXTENSION CABLE	PEET BROS	2	$20.00		$40.00	
688-024A	DEFORM	REFRACT	THREE-METER TAPE MEAS	PORTLAND PRECIS	2	$8.14		$16.28	
688-022A	DEFORM	REFRACT	MOUND CITY TEMP ROD	NESSCO	2	$135.00		$270.00	
688-024B	DEFORM	REFRACT	THERMOMETERS	PORTLAND PRECIS	3	$5.20		$15.60	
688-046	DEFORM	REFRACT	SIGNAL MIRRORS	KENLO WAREHOUSE	4	$5.15	$7.00	$27.60	
688-025	DEFORM	REFRACT	INST.ACCESSORY BAGS	REI	2	$27.00		$54.00	
688-022B	DEFORM	REFRACT	SURVEYING UMBRELLA	NESSCO	1	$80.00		$80.00	
688-009A	DEFORM	REFRACT	ULTIMETER II+	PEET BROS	2	$179.00	$4.98	$362.98	
DEFORM-MOVEABLE REFLECTOR KIT									$1,275.40
688-033C	DEFORM	REFLECT	TRICLUSTER W/PRISMS	NESSCO	1	$476.00		$476.00	
688-006C	DEFORM	REFLECT	GST20-9 TRIPOD	NESSCO	1	$221.00		$221.00	
688-033D	DEFORM	REFLECT	TRIBRACH ADAPTOR	NESSCO	1	$60.00		$60.00	
688-033B	DEFORM	REFLECT	WILD TRIBRACH	NESSCO	1	$468.00		$468.00	
688-033E	DEFORM	REFLECT	TRICLUSTER TARGET	NESSCO	1	$50.40		$50.40	
DEFORM - LEVEL/TILT SYSTEM (SUBSTITUTE FOR GRAVIMETER REPAIR)									$10,271.75
688-033A	DEFORM	GRAV	GST20-9 TRIPOD	NESSCO	1	$221.00	$0.00	$221.00	
688-007D	DEFORM	GRAV	BULLSEYE LEVEL	KERN	3	$36.00	$0.00	$108.00	
688-007A	DEFORM	GRAV	3-M KERN RODS	KERN	3	$1,595.00		$4,785.00	
688-007B	DEFORM	GRAV	3-M ROD STAYS	KERN	3	$674.00	$0.00	$2,022.00	
688-006B	DEFORM	GRAV	MICROMETER PLATE	NESSCO	1	$1,165.00	$0.00	$1,165.00	
688-007C	DEFORM	GRAV	BASE PLATE	KERN	2	$130.00	$0.00	$260.00	
688-031	DEFORM	GRAV	SHIPPING 3M RODS AIR FREIGHT	UNITED AL	1	$185.00	$0.00	$185.00	
688-006A	DEFORM	GRAV	NAK2 LEVEL	NESSCO	1	$1,525.75	$0.00	$1,525.75	
DEFORM - MISCL PARTS/SUPP									$2,004.78
688-028A	DEFORM	MISC	1/2 INCH STAR DRILL	PARKROSE HDWR	1	$4.59	$0.00	$4.59	
688-010D	DEFORM	MISC	3/4" BIT	BOSCH POWER TO	1	$17.56	$0.00	$17.56	
688-029B	DEFORM	MISC	HEX SET SCREW	VANC. BOLT	70	$0.35	$0.00	$24.62	
688-027D	DEFORM	MISC	COUPLING NUTS	VANC BOLT	25	$0.28	$0.00	$6.99	
688-030B	DEFORM	MISC	27/64 DRILL BIT	VANC BOLT	1	$2.65	$0.00	$2.65	
688-028B	DEFORM	MISC	3/4-INCH STAR DRILL	PARKROSE HDWR	1	$6.48	$0.00	$6.48	
688-032C	DEFORM	MISC	SYNTHEX CHARGER	HAWA	3	$69.00		$207.00	
688-029A	DEFORM	MISC	STAINLESS MOLY BOLTS	VANC BOLT	100	$3.36	$0.00	$335.73	
688-004	DEFORM	MISC	STANDARDS & SPECS-LVL	NOAA	1	$11.75	0	$11.75	
688-010C	DEFORM	MISC	1/2 INCH BIT	BOSCH POWER TO	2	$5.96	$0.00	$11.92	

G88-032A	DEFORM	MISC	VHF SYNTHEX RADIOS	HAWA	3	$335.00		$1,005.00	
G88-030A	DEFORM	MISC	ALUM HEX CAP SCREW	VANC BOLT	5	$1.59	$0.00	$7.97	
G88-028D	DEFORM	MISC	HALF-ROUND FILE	PARKROSE HDWR	1	$10.59	0	$10.59	
G88-034	DEFORM	MISC	DHL EWERT IN HVO	DHL	1	$4.94	$0.00	$4.94	
G88-027C	DEFORM	MISC	1/2-INCH HEX NUTS	VANC BOLT	200	$0.03	$0.00	$5.14	
G88-035	DEFORM	MISC	DHL TO HVO	DHL	1	$4.94	0	$4.94	
G88-010A	DEFORM	MISC	BORSCH ROTARY HAMMER	BORSCH POWER TO	1	$223.44	$0.00	$223.44	
G88-010B	DEFORM	MISC	SPARE BATTERY	BORSCH POWER TO	1	$49.45	$0.00	$49.45	
G88-027F	DEFORM	MISC	1/4-INCH HEX KEY	VANC BOLT	2	$0.54	$0.00	$1.08	
G88-027G	DEFORM	MISC	COMBINATION WRENCH	VANC BOLT	2	$7.09	$0.00	$14.18	
G88-027E	DEFORM	MISC	HEX SET SCREWS	VANC BOLT	31	$0.35	$0.00	$10.90	
G88-028C	DEFORM	MISC	PLASTIC TUBE	PARKROSE HDWR	10	$0.24	$0.00	$2.40	
G88-027B	DEFORM	MISC	BOTTOM AND TAPER TAPS	VANC BOLT	2	$6.90	$0.00	$13.80	
G88-027A	DEFORM	MISC	RATCHET TAP WRENCH	VANC BOLT	1	$21.66	$0.00	$21.66	
DEFORM - TELEM. TILTMETER TO REPLACE FUEGO INSTALLATION									$2,106.50
G88-011	TELEM	FIELD	TILTMETER, REPLACEMENT TO	APPLIED GEOMECH	1	$2,106.50		$2,106.50	
G88-047	TELEM	FIELD	PLATFORM TILTMETER	APPLIED GEOMECH	1	DUPE LISTING		VOID	
	TELEM	FIELD	SYNTHEX LM4400	HAWA	1	$415.00	OBLIGATION MISSED YEAR END		
	TELEM	FIELD	MPU BOARD AND CASE	HAWA	2	$800.00	OBLIGATION MISSED YEAR END		
	TELEM	FIELD	SOLAR PANEL/ANTENNA/PARTS	HAWA	1	$500.00	OBLIGATION MISSED YEAR END		
DEFORM - RECEIVER STATION REPLACMENT FOR ONE LEFT IN INSIVUMEH									$1,370.28
G68-055	TELEM	RECEIVER	UHF ANTENNA	LARSEN	2	$39.70		$79.40	
G88-056A	TELEM	RECEIVER	LIGHTNING ARRESTORS	RF IND	2	$16.85		$33.70	
G88-056B	TELEM	RECEIVER	N M. CRIMP RG58	RF IND	4	$2.87		$11.48	
G88-056C	TELEM	RECEIVER	N M. SOLDER RG8	RF IND	2	$2.65		$5.30	
G88-56D	TELEM	RECEIVER	N F. TEE	RF IND	2	$6.53		$13.06	
G83-057	TELEM	RECEIVER	UHF M. - N M.	PASTERNACK	2	$13.95		$27.90	
G68-058A	TELEM	RECEIVER	TOSHIBA T1000		1	$849.00		$849.00	
G68-058B	TELEM	RECEIVER	T1000 MODEM		1	$229.00		$229.00	
G88-059	TELEM	RECEIVER	SYNTHEX LM4400	HAWA	1	$415.00	OBLIGATION MISSED YEAR END		
G88-002	TELEM	RECEIVER	3.5"SS DISKS, 10/BOX	RADIO SHACK	4	$30.36		$121.44	
DEFORM-VCAT TRAINER TO GUATEMALA				Deferred to FY89					---
DEFORM - PRICE NEED CHANGES				Included as buffer to price/item changes					---
DEFORM - SHIPPING AND EXCESS BAGGAGE				Included in shipping and travel					---
HAZARDS - FY88 OBJECTIVES - Completed									
HAZARDS FY88 - INSIVUMEH GEOLOGIST TRAINING IN USA									$5,782.87
G88-065A	TRAIN	PROGRAM	MATIAS, AIRFARE	VOUCHER	1	$2,685.59		$2,685.59	
G88-065B	TRAIN	PROGRAM	MATIAS, EMBASSY	VOUCHER	1	$400.00		$400.00	
G88-065C	TRAIN	PROGRAM	MATIAS, EXPENSES	VOUCHER	1	$120.00		$120.00	
G88-065D	TRAIN	PROGRAM	MATIAS, EXPENSES	VOUCHER	1	$1,540.00		$1,540.00	
G88-065E	TRAIN	PROGRAM	MATIAS, EXPENSES	VOUCHER	1	$375.00		$375.00	
G88-065F	TRAIN	PROGRAM	MATIAS, HELICOPTER?	VOUCHER	1	$369.90		$369.90	
G88-065G	TRAIN	PROGRAM	MATIAS, EMBASSY ADVANCE	VOUCHER	1	$200.00		$200.00	
G88-065H	TRAIN	PROGRAM	MATIAS, HEALTH INS	VOUCHER	1	$92.38		$92.38	
HAZARDS FY88 - VCAT ADVISOR TRAVEL EXPENSES WITH INSIVUMEH GEOLOGIST IN USA									$1,879.16
G88-036B	TRAIN	PROGRAM	PERDIEM NORM 11/87	VOUCHER	1	$1,100.11		$1,100.11	
G88-036A	TRAIN	PROGRAM	CLASS 45 NORM-HI	VOUCHER	1	$58.10		$58.10	

688-036C TRAIN	PROGRAM	AIRFARE NORM	VOUCHER	1	$720.95	$720.95	
HAZARDS FY88 - MAPS AND PHOTOS							$1,899.67
688-015 HAZARD	GEO/OBS	9.5" AERIAL FILM	KODAK	2	$213.91	$427.82	
688-053C HAZARD	MAPS	MERCADO - 7/87	VOUCHER	1	$1,326.36	$1,328.36	
688-054C HAZARD	MAPS	ROSE - 7/87	VOUCHER	1	$143.49	$143.49	
HAZARDS FY88 - 2 TRAINERS FOR FUEGO MAP							$5,566.45
688-053A TRAIN	HAZARD	AIRFARE - MERCADO 7/87	VOUCHER	1	$892.56	$892.56	
688-053B TRAIN	HAZARD	PERDIEM - MERCADO 7/87	VOUCHER	1	$3,020.24	$3,020.24	
688-054A TRAIN	HAZARD	AIRFARE - ROSE 7/87	VOUCHER	1	$1,006.45	$1,006.45	
688-054B TRAIN	HAZARD	PERDIEM - ROSE 7/87	VOUCHER	1	$647.20	$647.20	
HAZARDS FY88 PRICE NEED CHANGES			Included with above				---
OTHER TRAINING/SUPPORT FY88 - Part deferred to FY89-90							
VCAT PROGRAM ADVISOR TO GUATEMALA							$1,729.67
688-060A TRAIN	PROGRAM	AIRFARE - HARLOW	VOUCHER	1	$908.00	$908.00	
688-062A TRAIN	PROGRAM	PERDIEM - HARLOW	VOUCHER 258	1	$821.67	$821.67	
CONTRACT HELP/TEMPORARY EMPLOYEE ASSISTANT TO PROGRAM + OVERTIME - SALARY						$12,210.00	$13,919.40
BENEFITS (14%)						$1,709.40	
MISCELLANEOUS TRAINING COSTS			Deferred to FY89-90				---
FY89-90 OBJECTIVES (Some completed in FY88, includes some FY88 Deferred)							
DEFORMATION - TELEMETRY							---
	TELEM	TILT	Tilt stations and telemetry, base station, training				
	TELEM	TILT	Purchase of cancelled FY88 orders				
	EDM	DEF	Additional Prisms				
HAZARDS FY89 -- Complete, expenditures and work in FY88							
HAZARDS FY87 - GEOLOGY KIT (PLANNED FOR FY89)							$5,781.82
688-016 HAZARD	GEOL/BOOKS	GEO HAZ BOOKS	PROBOOKSTOR	1	$406.80	$406.80	
688-001N HAZARD	GEOL/KIT	PACK, KELTY	USGS GSA	1	$60.43	$60.43	
688-001K HAZARD	GEOL/KIT	BAG, SEALER	USGS GSA	2	$1.62	$3.24	
688-001A HAZARD	GEOL/KIT	HAMMER, CHISEL	USGS GSA	2	$7.42	$14.84	
688-005 HAZARD	GEOL/KIT	MAGNETOMETER	FG ELECTRONICS	1	$900.86	$900.86	
688-001J HAZARD	GEOL/KIT.	BAG, SAMPLE, 8x14"	USGS GSA	500	$0.06	$30.00	
688-023 HAZARD	GEOL/KIT	BINOCULARS	FRED MEYER	3	$46.97	$140.91	
688-018 HAZARD	GEOL/KIT	GLOVES, HIGH TEMP	VWR	2	$31.20	$62.40	
688-001Q HAZARD	GEOL/KIT	MIRROR, SIGNAL	USGS GSA	4	$5.15	$20.60	
688-001I HAZARD	GEOL/KIT	BAG, SAMPLE, 6x8"	USGS GSA	500	$0.04	$20.00	
688-008A HAZARD	GEOL/KIT	RITE IN RAIN PAPER	USGS GSA	1	$30.85	$30.85	
688-021A HAZARD	GEOL/KIT	SHOVEL, TRIPLE FOLD	USGS GSA	1	$12.08	$12.08	
688-001M HAZARD	GEOL/KIT	TRUNK, FOOTLOCKER	USGS GSA	1	$25.50	$25.50	
688-001H HAZARD	GEOL/KIT	TAPE, 100 FT	USGS GSA	4	$35.94	$143.76	
688-001C HAZARD	GEOL/KIT	HAMMER, 3 LB SLEDGE	USGS GSA	2	$5.94	$11.88	
688-019B HAZARD	GEOL/KIT	CR/AL 1/16-3m,THERMCOUP	OMEGA ENG.	4	$35.94	$143.76	
688-001D HAZARD	GEOL/KIT	COMPASS, BRUNTOn	USGS GSA	4	$103.39	$413.56	
688-019E HAZARD	GEOL/KIT	CR/AL THERMCOUPLE WIRE	OMEGA ENG	2	$30.00	$60.00	
688-001E HAZARD	GEOL/KIT	LENS, HAND	USGS GSA	4	$20.95	$83.80	

G88-001F	HAZARD	GEOL/KIT	ALTIMETER, METRIC	USGS GSA	4	$114.34		$457.36
G88-021B	HAZARD	GEOL/KIT	STEREOSCOPE, POCKET	USGS GSA	2	$13.60		$27.20
G88-001G	HAZARD	GEOL/KIT	TAPE, 3m	USGS GSA	4	$3.55		$14.20
G88-019F	HAZARD	GEOL/KIT	SOFT CARRYING CASE	OMEGA ENG.	1	$10.00		$10.00
G88-003	HAZARD	GEOL/KIT	KIT, IST AID, INDIV	USGS GSA	1	$18.90		$18.90
G88-019C	HAZARD	GEOL/KIT	CR/AL 1/4-3m, THERMCOUPL	OMEGA ENG.	4	$81.50		$326.00
G88-032B	HAZARD	GEOL/KIT	SYNTHEX BATTERY	HAWA	3	$59.00		$177.00
G88-017	HAZARD	GEOL/KIT	GEOL. SCI BOOKS	PROBOOKSTOR	1	$194.90		$194.90
G88-021D	HAZARD	GEOL/KIT	COVER, PHOTOGRAPH, 10x12	USGS GSA	5	$11.19		$55.95
G88-019G	HAZARD	GEOL/KIT	CALIBRATOR, CL-300	OMEGA ENG.	1	$160.00		$160.00
G88-013	HAZARD	GEOL/KIT	STEREOSCOPE	BEN MEADOWS	1	$706.84		$706.84
G88-019D	HAZARD	GEOL/KIT	CR/AL 1/16-10m, THERMOCOU	OMEGA ENG.	1	$64.38		$64.38
G88-001B	HAZARD	GEOL/KIT	HAMMER, PICK	USGS GSA	2	$15.44		$30.88
G88-021C	HAZARD	GEOL/KIT	GRAINSIZE, CARD	USGS GSA	2	$3.50		$7.00
G88-019A	HAZARD	GEOL/KIT	THERMOMETER DIGITAL	OMEGA ENG.	1	$228.00	$1.94	$229.94
G88-042	HAZARD	GEOL/KIT	STEREOSCOPE BINOCS	BEN MEADOWS	1	$650.00		$650.00
G88-019H	HAZARD	GEOL/KIT	STRIPPING TOOL	OMEGA ENG.	1	$66.00		$66.00

HAZARDS FY89 - GEOCHEMISTRY KIT - Partially coopleted in FY88 $2,092.94

G88-037B	HAZARD	GEO/CHEM	0.45UM FILTERS	VWR	1	$38.70		$38.70
G88-050	HAZARD	GEO/CHEM	CL - pH	MARKSON	1	$49.45		$49.45
G88-044C	HAZARD	GEO/CHEM	PH METER	WHATMAN SCIENC	1	$290.00		$290.00
G88-037A	HAZARD	GEO/CHEM	SYRINGE FILTERS HOLDER	VHR	6	$4.95		$29.70
G88-044B	HAZARD	GEO/CHEM	SOAKER BOTTLES	WHATMAN SCIENCE	3	$17.50		$52.50
G88-044A	HAZARD	GEO/CHEM	CONDUCTIVITY METER	WHATMAN SCIENCE	1	$250.00		$250.00
G88-051	HAZARD	GEO/CHEM	CHEM PARTS	DAIGGER	1	$170.07		$170.07
G88-043	HAZARD	GEO/CHEM	ELECTRODES/SOLUTIONS	OMEGA	1	$1,154.00	7.87	$1,161.87
G88-049	HAZARD	GEO/CHEM	PH CAPSULES	DAIGGER	1	$50.65		$50.65

Additional FY89 Purchases

HAZARDS FY89 - MAPS AND PHOTOS
Detailed Topographic Map, Santiaguito
Additional Maps/Photos

HAZARDS FY89 - VCAT ADVISORS TO MAP SANTIAGUITO - Completed, expeditures in FY88 $12,305.87

G88-041A	TRAIN	GEOL	MERCADO FARE	VOUCHER	1	$1,219.22	$1,219.22
G88-041B	TRAIN	GEOL	MERCADO PERDIEM/EXP	VOUCHER	1	$4,519.11	$4,519.11
G88-040B	TRAIN	GEOL	VALLANCE PERDIEM/CAR	LETTER	1	$3,278.25	$3,278.25
G88-040A	TRAIN	GEOL	VALLANCE FARE	LETTER	1	$1,219.22	$1,219.22
G88-039B	TRAIN	GEOL	ROSE PERDIEM	VOUCHER	1	$850.85	$850.85
G88-039A	TRAIN	GEOL	ROSE FARE	VOUCHER	1	$1,219.22	$1,219.22

HAZARDS FY89 - VCAT ADVISOR TO TRAIN GEOCHEMISTRY

OTHER TRAINING AND SUPPORT - FY89-90
Contract and temporary assistance
Eruption duty
Advisor in country 4 months (substitute for seismic)
Short-term training and advisor visits (substitute for seismic)
Other advisors for long-term training (substitute for seismic)

APPENDIX V -- Summary of USGS DHAT proposal for USAID/OFDA.

* A new U.S. Geological Survey Debris Hazard Abatement Team (DHAT), fully integrated with USGS Volcano Crisis Assistance Team (VCAT), is needed to help developing nations better understand and mitigate volcanic landslide, debris flow, and flood hazards. The existing VCAT deals with these phenomena only peripherally because of other commitments.

* Massive landslides, debris flows, and floods are some of the deadliest and most destructive of volcanic phenomena. Incidental observations made during various volcanic crises in the 1980's indicate that these phenomena are more widespread, frequent, and persistent than previously thought.

* Increased understanding of landslide and debris flow processes has allowed for more precise hazard definitions through field mapping and computer modeling.

* Improved instrumentation has created opportunities for effective low-cost hazard monitoring and warning systems.

* Despite improved knowledge and instrumentation, landslide and debris flow hazards are actually increasing because population pressures cause people to move into ever more hazardous areas.

* Large segments of the populations-at-risk are not fully aware of these hazards or chose to ignore them. Informed public officials in some developing nations lack the scientific, technical, and equipment resources needed for effective mitigation.

* The U.S. Geological Survey is well equipped to help reduce volcanic landslide, debris flow, and flood hazards in developing nations for the following reasons:
  - -- An appropriate mix of scientific and technical skills.
  - -- Long experience in assessing and mitigating geologic and hydrologic hazards in a wide variety of physical and cultural settings.
  - -- Sufficient personnel and logistical bases to assure sustained effort and rapid response.
  - -- Leadership role in debris flow sedimentology, modeling, and warning systems.

* The proposed approach to these problems is two fold--
  A. Develop local awareness, expertise, and preparedness.
     + Training classes and demonstration projects on hazard definition (type, area, travel,

etc.) through detailed mapping and computer modeling.
+ Provide critical equipment, particularly state-of-the-art warning systems.
+ Assist preparation of educational materials (brochures, videos, etc.).

B. Develop rapid response team for crisis assistance
+ Update and/or refine hazard assessments.
+ Install warning systems.
+ Case study documentation; data base entry.

* Initial year total costs for DHAT are $310,000; the USGS Water Resources Division (WRD) is willing to commit $160,000 toward this start-up cost providing a long-term cooperative program appears feasible. The WRD is also willing to make a long-term (5 year minimum) commitment of funds and personnel to sustain this program.

* For additional information, contact Richard J. Janda at the U.S. Geological Survey, 5400 Mac Arthur Blvd., Vancouver, WA 98661 (telephone 206-696-7892).

PROPOSED WRITTEN PRODUCTS

An annual written summary of project activities will be presented to OFDA. That summary will include an updated assessment of short- and long-term goals and priorities.

Hazard reports and maps designed for rapid release to populations-at-risk will be prepared at times of volcanic unrest or other types of precursory activity. Initial releases will be memoranda to public safety officers or their scientific advisors, with subsequent release as formal USGS publications as the data warrant.

Training manuals will be prepared in English and Spanish on the following topics:

1. Lahar hazard definition
   a. Recognizing and dating lahar deposits.
   b. Reconstructing lahar dynamics.
   c. Computer models for estimating future lahar inundation and travel time.
2. Flood and lahar warning systems
   a. Design criteria
      i. Detection of precursors, initiation, and actual movement.
      ii. Installation and maintenance of sensors, telemetry, and notification systems.
3. Post-eruption sedimentation--monitoring and prediction

APPENDIX V. --Continued

An educational, photographic essay of eruption-induced and persistent sedimentation hazards at youthful composite volcanoes will be prepared for release as a formal USGS publication.

Journal articles documenting major findings will be prepared in collaboration with international colleagues in order to disseminate new knowledge and to encourage additional research on potentially hazardous geologic and hydrologic processes.

APPENDIX VI. -- Proposed Budgets for DHAT

PROJECTED BUDGET FOR USGS/OFDA DHAT FOR FY89
(Proposed 50-50 cost sharing basis)

	USGS	OFDA
SALARIES		
Project Chief	64,834	
Others		22,750
BENEFITS	8,010	3,100
TRAVEL		
GTRs	2,000	4,500
Per Diem	850	3,400
MOVEMENT OF THINGS	150	800
OTHER		
Supplies and Equipment	400	35,200
Computer procurement and support	14,205	5,041
Report support	8,741	3,102
Laboratory analyses	380	1,060
Programing and translation	1,500	7,000
OVERHEAD	62,267 [1]	60,319 [2]
TOTAL	163,337	146,272

[1] Computed at 7% of salaries and benefits, plus 34.6% of total.
[2] Computed at 7% of salaries and benefits, plus 40.1% of total.

PROJECTED BUDGET FOR USGS/OFDA DHAT FOR FY90-FY91
(Proposed 50-50 cost sharing basis)

	1990	1991
SALARIES		
Project Chief	56,550	56,550
Others	50,000	55,000
BENEFITS	13,070	14,070
TRAVEL		
GTRs	10,500	8,500
Per Diem	10,600	9,500
MOVEMENT OF THINGS	2,500	2,500
OTHER		
Supplies and Equipment	18,000	10,000
Computer procurement and support	23,326	24,496
Report support	14,354	15,074
Laboratory analyses	3,500	3,500
Programing and translation	5,000	2,500
OVERHEAD	164,620 [1]	161,2100[1]
TOTAL	372,020	362,900

[1] Computed at 7% of salaries and benefits, plus 42% of total.

APPENDIX VI. --Continued

PROJECTED BUDGET FOR USGS/OFDA DHAT FOR FY92-FY93
(Proposed 50-50 cost sharing basis)

	1992	1993
SALARIES		
Project Chief	56,550	56,550
Others	55,000	55,000
BENEFITS	14,070	14,070
TRAVEL		
GTRs	7,500	6,000
Per Diem	8,500	8,000
MOVEMENT OF THINGS	1,500	1,500
OTHER		
Supplies and Equipment	5,000	5,000
Computer procurement and support	24,496	24,496
Report support	15,074	15,074
Laboratory analyses	2,500	2,500
Programing and translation	1,500	1,500
OVERHEAD	153,970 [1]	152,5200 [1]
TOTAL	345,660	342,210

[1] Computed at 7% of salaries and benefits, plus 42% of total.

APPENDIX VII. -- Description of VDAP's Seismic System at the end of FY88

Radio-telemetered seismograph system. [NOTE: hardware assembly for rapid departure and deployment is near but not at completion, the software is operational and being tested]

- 8 Seismometers
- 10 Radio pairs (to telemeter and repeat the seismometers)
- Solar panels, VCO's, and antenna for the telemetry
- Descriminators, rack, radios, and antennas for receiving the telemetered signals
- Summing amps for repeater stations
- 4 PS2 seismographs for visual recording of the telemetered signal (plus 6 additional PS2's available for loan from the Branch of Seismology to VDAP)
- 1 Laptop computer for data and report manipulation
- 1 Portable 386 computer to process the seismic data
- 1 PS2 computer for realtime processing and locating seismic events
- -- Peripheral computer equipment (A/D boards, drives, etc.)
- -- USGS software to process the data
- -- USGS software to analyze the data

Background to the PC seismic receiving system -- The VDAP PC seismic receiving system is a portable-computer-based data acquisition and analysis system that allows real-time, automated event picking, location, and analysis. In addition, the recorded data can be compared with theoretical results and data from other volcanoes to develop quantitative eruption forecasting. A PC-based system was chosen because the more sophisticated computer systems already in wide use in developed countries are too bulky to deploy and generally have no service/software support in developing countries.

Four USGS groups at Menlo Park joined forces to implement PC-based data acquisition and analysis system which consists of: (1) an on-line 16-channel A to D seismic data acquisition system that performs real time digitizing of analog seismic data and automatic earthquake location, and (2) an off-line seismic analysis system for more sophisticated analysis of the digital seismic waveform data from the acquisition system.

The two main groups in this effort were (and are) the Microearthquake Data Analysis Group and VDAP. The Alaska Network Group are involved technically but provided no official funds or staff on the project. The fourth group actively programs PC's to analyze waveform data collected by their GOES systems. Software developed by the GOES Group was indirectly useful to VDAP through availability of programming techniques and applicable subroutines. Additionally, groups outside of the USGS, are developing related programs.

APPENDIX VIII. - Description of VDAP's Deformation Monitoring System at the end of FY88.

VDAP currently has the capability of precisely measuring both horizontal and vertical deformation with several complete systems. IN FY88, EDM equipment was upgraded by purchase of A Geodimeter 6000 which has nearly the same distance measuring capabilities as the K&E Ranger V, slightly better precision, and much less volume and weight. Computer programs were added and upgraded, and 3 precise level rods were added to the cache. There was some depletion of the reflector prism stock resulting from the response to Guagua Pichincha, but this deficiency was solved by replacement with WOVO/UNESCO funds.

CURRENT CACHE

Horizontal Measurements
- Geodimeter 6000 EDM, 25 km range
- * HP 3808A EDM, 10 km range
- * 2 Citation 450 EDMs, 2 km range
- 2 Mobile reflector systems
- 5 kits to enable refraction corrections of the data
- Permanent reflectors adequate for a full-scale response
- Benchmark installation equipment

Vertical Measurements
- 1 Total station, consisting of:
  - Wild T2000 electronic theodolite (0.5 seconds of arc)
  - DI-5 EDM (also can serve as a short-range EDM for horizontal measurements)
- * 1 Wild NAK-2 precision level and micrometer plate
- 3 KERN precise 2m level rods
- * 4 Wild T16 theodolites (6 seconds of arc)

* = frequently loaned to agencies in Latin America when full VDAP response is not needed.

Computer Assistance

VDAP-produced IBM-PC data reduction programs.
CVO-produced IBM-PC BOB, a time series graphics and statistics plot program.

APPENDIX IX. -- Description of VDAP's Digital Telemetry Monitoring System at the end of FY88.

Digital telemetry systems are used to acquire slow-data-rate information in real time such as tilt, fumarole, crater lake, and temperature data. Presently VDAP has the ability to telemeter tilt data, and hopes to acquire and developed other sensors in this and future fiscal years.

VDAP deployed 3 of it's tiltmeters in November on Guagua Pichincha, Ecuador, leaving 1 fully deployable unit in the equipment cache. The three commercial tiltmeters and their radios were replaced by purchase of the original tiltmeters by UNESCO/WOVO while the team was in the field, and purchase of the components to replace the electronics have also been made. Full return to readiness in this sector is expected by 1 March 1989.

CURRENT CACHE

4 Applied Geomechanics precise (0.1 microradian) tiltmeters
1 USGS-designed digital telemetry platforms constructed and fitted with radios, weatherproof cases, and solar charging backup -- down 4 owing to Guagua Pichincha response.
1 Computer-receiver base station -- down 1 owing to the Guagua Pichincha response.
0 Repeater stations, with radios and solar charging -- down 2 owing to the Guagua Pichincha response.

APPENDIX X. -- Description of VDAP's Mudflow Alarm System at the end of FY88.

THE VCAT MUDFLOW DETECTOR - PRELIMINARY

VDAP, with the assistance of CVO, is currently developing a low-cost, error-checking mudflow detector. Perhaps more than any system now being developed by VDAP, this is the one for which there is the most pressing need and interest in all volcanic regions of the world including Latin America and the United States.

Mudflows are one of the major causes of fatalities at erupting volcanoes (Blong, 1984). For example, in 1985 mudflows from Ruiz Volcano in Colombia killed over 25,000 people, as far from the volcano as 40 km only 45 minutes after initiation of the flow. In addition, mudflows are a common cause of destruction and fatalities at non-erupting volcanoes because of mobilization of loosely-consolidated debris during periods of strong seismic activity, such as the 1987 earthquakes in Ecuador.

The short lead times and the high cost in lives resulting from late alarms necessitate rapid and reliable warning systems for mitigation of mudflow hazards from volcanoes. The warnings should be triggered within minutes of onset of an event with sufficient redundancy to ensure a high degree of confidence in the warning transmitted. In addition, the sensors will often be deployed in deep mudflow channels and thus need repeated by radio to the base station receiver. Also, developing countries require that the system is inexpensive and uses serviceable technology.

The mudflow detector currently being developed at CVO is designed to give rapid, error-checked warning of dangerous mudflows as well as to provide information on their velocity and volume. The system will detect the onset of a mudflow within a few minutes of initiation, provide redundant volume and velocity measurements, relay the information through a smart repeater to the base station receiver where it is analyzed by a small computer, which in turn sets off alarms giving estimated times of arrival at population centers along the course of the mudflow. Cross-checking abilities and a high level of redundancy are built into the system, which is designed around a low-cost microprocessor-based digital telemetry platform developed at CVO by Richard LaHusen, Water Resources Division.

The system consists of three major components linked by radio: multi-fingered sacrificial sensors (2 each in a system), the smart telemetry unit, and the receiver, which is either manned or connected to an observatory alarm system. Simple tripwires are used as detectors (fingers). standard UHF radios as links between the base station, the repeater, and smart telemetry unit, and inexpensive computer-printer combination as the receiver/warning device. All these components are simple to use,

and are either available in-country or of technology in common use by volcano monitoring groups in the United States and developing countries. The microprocessor-based digital telemetry unit is relatively sophisticated, but comes pre-programmed and set up for quick and inexpensive repair by minimally trained technicians in the event of failure. The basic sequence of events resulting from a mudflow is as follows:

1. The on-board microprocessor of the sensor monitors each of as many as six tripwires thousands of times a second and sends status reports to the smart telemetry unit at specified intervals of one to ten minutes.

2. A mudflow breaks loose from the flank of a volcano and courses down a channel. Impinging on the sensor, the mudflow breaks the first tripwire. This information is immediately telemetered to the smart telemetry unit. When the second tripwire is broken, this new status is also telemetered, and so on.

3. Upon receipt of a transmission from any sensor, the smart telemetry checks it for an identifying code keyed to each tripwire, which uniquely identifies the originating sensor and guards against spurious transmissions being mistaken for a triggered tripwire. It also labels the data with the time of receipt, and stores it. The smart telemetry unit listens for a short time to receive any other transmissions from the first sensor that indicate the cutting of other wires (all within a few seconds), labelling each one with the time of receipt. Next, the smart telemetry sends the data back to the base station, and returns to listening mode for the tripwire status transmissions of the second sensor. The base-station computer will at this time query the smart telemetry unite.

4. The base station receives the block of data from the smart telemetry unit containing tripwire breakage times from the first sensor. It has been in a wait mode, recording the periodic status reports transmitted by the sensors via the smart telemetry unit. Now, noting that tripwires have been broken, it activates a program which calculates the mudflow's velocity, estimates it's volume and arrival times at population centers along the expected path of the mudflow (using parameters previously determined by a hydrologist for the specific drainage). This data is printed, and if warranted, an alarm is issued to the printer, computer beeper, and if available, the Observatory bell or phone alarm. The base-station operator can recheck the alarm at this point by calling the field units and verifying the status of the trip wires and telemetry links.

5. The system then awaits confirmation of the mudflow from the second sensor located 0.5-1.0 minute downstream. If the sequence

is repeated, the warning is reissued with a confirmation flag on occurrence, velocity, volume, and expected arrival times. Redundancy and cross-checking are thus built into the system to prevent false alarms due to system failure, tampering, and telemetry problems. These features also allow polling by the base station if a tamper alarm, unclear transmission, or an unexpected sequence of tripwire status reports is received. The operator polling allows immediate system diagnosis, establishes more confidence in the system, reduces down-time of the alarm system, and makes it virtually impossible to have a system break-down without the operator knowing of the malfunction within minutes.

VDAP/CVO has a bench model of this mudflow alarm working and is currently developing the base-station program. A fully-operational first-edition unit is expected to be field-tested in the spring of 1989. The test-modified units are expected to be ready for incorporation in the equipment cache by early fall.

For Latin American countries, the mudflow detector will provide a high level of vigilance against mudflows at a low cost. The estimated cost of systems configured for use in Latin American countries is shown in the follows.

APPENDIX XI. - Description of VDAP's Tool kit at the end of FY88.

The VDAP field-ready tool cache is fundamentally operational. As the seismic cache is developed, further needs may arise, but at this point VDAP has the tools on hand with which to develop and construct the new electronic devices, maintain the cache of equipment, and construct field sites. All of our tools are portable so that maintenance and repairs may be done in-country, if not in the field. In cases where development or maintenance is beyond the capabilities of the portable VDAP tool cache, we have access to the larger and more sophisticated tools at CVO. Most of these are not portable or considered to be removable by VDAP.

The VDAP tool cache includes:

2 oscilloscopes, one of which is portable
1 audio frequency signal generator
1 radio frequency generator
1 frequency counter
1 USGS VCO tester
1 EPROM programmer
2 12 volt lab power supplies
2 Fluke DVM's
1 heat gun
1 hot melt gun
1 soldering station
2 coax crimpers (RG58)
1 electric drill and bits
various hole punches and drills
1 wood saw
1 wonderbar
various wire cutters and strippers
various pliers and wrenches
various screwdrivers and hex drivers
assorted other hand tools
various test leads and electrical adapters

APPENDIX XII. -- Description of VDAP's Hazard Evaluation and Eruption Observation Kit at the end of FY88.

VDAP currently has the capability to do preliminary hazard evaluations at volcanoes showing unrest using standard geologic field equipment. We also have the capability to monitor and record volcanic eruptions as they progress.

Field Studies/Hazard Mapping:

- Stereoscopes
- Brunton Compasses
- 1:50,000 scale maps for most volcanic areas in Latin America
- 1 Flux gate magnetometer
- 1 Sonar depth sounder for mapping crater lakes
- 1 Set of range poles and hand levels for rapid channel crossection determination for mudflow calculations.
- Various field packs
- Various altimeters (digital and analog)

Eruption Observation:

- 4 5mm cameras with data backs
- 1 1/2-inch VHS VCR
- 1 Optical pyrometer
- 2 Rangefinders
- Various thermocouples

Saftey equipment:

- Gas masks for a crew of 5
- Climbing helmets for a crew of 5
- First aid kits for a crew of 5
- 3 Emergency breathing air tanks
- 7 VHF handie-talkies
- 2 Voice communications repeaters

APPENDIX XIII. -- Description of VDAP's Geochemistry kit at the end of FY88.

VDAP's geochemical monitoring cache has the capability of performing on site, field chemical analyses for ionic concentrations of chloride, fluoride, magnesium, calcium, potassium, sodium, sulfate and sulfide. Also the cache has the capability for measuring solution conductivity, pH, and temperature. Spreadsheets in LOTUS 123 format are used to enter results of analyses and to calculate the concentration of ions. Sample location/description sheets and are also in LOTUS 123 format and available to supply to participating agencies.

Instruments include:

Bosch and Lomb Mini-20 photospectrometer- to measure sulfate and sulfide concentration in waters, condensates, and gas traps.

Hanna battery-operated pH-mv-temperature meter - used to measure concentrations of fluorine, chlorine, calcium, sodium, magnesium, and potassium with ion specific electrodes; measuring ph with a pH electrode; and temperature (up to 100 C).

Hanna battery-operated conductivity meter - used to measure ionic activity in sample waters.

Support equipment and supplies:

Portable, ion-exchange column for producing deionized local water for use during analyses.
Sufficient plastic and glassware to hold temporary samples, prepare standards, sample conditioning and testing.
Syringes, filters, and droppers are used to sample, transfer and condition water samples.
Chemical reagents are used to prepare pre-weighed packets of dry to be mixed with deionized water when on deployment.

APPENDIX XIV. -- Status of VDAP Databases at end of FY88.

This sector of VDAP activity involves compilation of databases and information files necessary to target and define the character of high-risk volcanoes and assist interpretation of their behavioral characteristics during periods of unrest. Full-time work on this aspect of VDAP objectives began in late March 1988 when a Geologist and Computer Specialist at last joined the staff. In the succeeding 9 months, progress included:

- Evaluation of available commercial database programs and the decision to convert previous VCAT databases to the Advanced REVELATION database program. Advanced REVELATION was selected because of its speed, condensed data storage capabilities, great versatility, and its compatibility with the Smithsonian Institute's database structure. Datafiles now accessible by REVELATION include:

  REFMAST (bibliographic records) - 1789 entries.
  NAMES (name and address file of people and international institutes associated with volcano hazards) --783 entries.
  LEDGERS (to build budgets and track expenditures of VDAP projects)

- A preliminary but extensive search was made of the literature to compile a reference list and annotated bibliography concerning deformational behavior of explosive volcanoes. Several LOTUS and REVELATIONS databases were experimented with to convert the information file into quick-recall computer files and graphs for use in future emergency response efforts.

- A similar search was begun on a seismic reference list and database compilation.

- Working drafts of country profiles:

  Preliminary Country Profile of Volcanoes and Hazard Preparedness in Peru

- Working drafts of volcano profiles:

  Preliminary Profile of Cotopaxi Volcano and Related Hazards, Ecuador

- Preliminary hierarchy charts of Civil Defense

  Guatemala
  El Salvador
  Costa Rica
  Peru

APPENDIX XIV. -- Continued

- Preliminary hierarchy charts of geologic organizations

  Mexico
  West Indies
  Colombia
  Ecuador.
  Chile

- Constructed eruption frequency (14) and duration graphs (12) of high-risk volcanoes.

Frequency	Duration
Ruiz	Guagua Pichincha
Colima	Colima
Cotopaxi	Cotopaxi
San Cristobal	San Cristobal
San Miguel	San Miguel
Fuego	Fuego
Masaya	Masaya
Pacaya	Pacaya
Mt. Pelee	Mt. Pelee
Poas	Poas
Villarrica	Villarrica
El Misti	Vulcano
Guagua Pichincha	
Vulcano	

- Collected meteorological data - rainfall, and wind direction, around high-risk volcanoes (11).

  Irazu
  Pacaya
  Poas
  Izalco
  Fuego
  Colima
  Masaya
  Cotopaxi
  San Miguel
  Etna
  Kilauea

- Computer listing of map files:

  Guatemala
  El Salvador
  Nicaragua
  Costa Rica
  Ecuador
  Peru

APPENDIX XIV. -- Continued

- Digitized stream profiles to assess lahar risk (30).

- Mapping aerial photographic coverage now includes:

  Guatemala
    Fuego/Acatenango (1954, B/W)
    Agua (1954, B/W)
  Ecuador
    Pichincha (1982, B/W)
    Cotopaxi (1977, B/W)
    Cuicocha (1978, B/W)
    Tungurahua (1977, B/W)
  Peru
    Misti (1955, B/W)

- Oblique and Landsat aerial coverage

  Guatemala
    Fuego/Acatenango
    Agua
    Pacaya
  Colombia
    Ruiz
  Peru
    Sara Sara
    Solimana
    Coropuna
    Hualco Hualco
    Ampato
    Sabancaya
    Misti
    Chachani
    Pichu Pichu
    Ubinas
    Huaynaputina
    Yucumane
    Tutupaca
    Nocarane
    Casiri
    Aguada de Cajon Puquio

- On-ground Photographic coverage
  Guatemala
    Tacana
    Santiaguito/Santa Maria
    Atitlan group
    Fuego/Acatenango
    Agua
    Pacaya
  El Salvador

APPENDIX XIV. -- Continued

Nicaragua
Costa Rica
- Arenal
- Poas
- Barba
- Irazu
- Turrialba

Colombia
- Ruiz

Ecuador
- Cuicocha
- Cotacache
- Cayambe
- Pichincha
- Cotopaxi

Peru
- Chachani
- Misti
- Ubinas
- Sabancaya
- Ampato

- Partial electronic compilation of SEAN entries on activity at Latin American volcanoes over the past 10 years.

- Preliminary volcanic precursor datafile compiled to aid in the identification of pre-eruptive patterns of behavior.

APPENDIX XV. -- Summary of VDAP activities in Peru, Ecuador and Colombia, 3 October - 25 October, 1987.

10/3-4/87

Travel to Quito

10/5/87

Meeting with Neil Merriwether USAID
  Discussion about USAID/VDAP work in Ecuador, needs/resources
Meetings at IG, ESPONA
  Getting reacquainted
Notetaking, officework
Meeting at Defensa Civil
  Jefe - Moral Moral
Note catchup
Meeting at USAID about UNDRO?OFDA project

10/6/8
Meeting at Government building
  General Jirrin Jerrin - Secretary General Consuelo de Securidad Nacional
  General Moral Moral - Director Nacional de Defensa Civil
  General ???? - Aide of Jerrin Jerrin
  John Tomlin - UNDRO
  Norman Banks - USGS
  Andrew Lockhart - USGS
  Patti Mothes - Hazard mapping for Defensa Civil through ESPONA
  General topics were the need to complete the Planaficacion Emergencia de 1 Volcan Cotopaxi and to strengthen Defensa Civil.
Meeting at INEMIN
  Antendees:
    Gerente Tecnico -- Bernardo Salazar
    Jefe Disaster Naturales -- Miguel Pozo, Ing.
    Renan Herra C., Ing., geologist
    John Tomblin
    Norman Banks
    Patti Mothes
    Andy Lockhart
  Main topic was the Convenio to be signed 15 October 1987 with the Italian group from Piza under Franco Barberi to establish INEMIN monitoring of Pichinca
Catching up on notes

10/7/87

Travel to Guayaquil
Meeting at Universidad Ecuador Gualaquil
  Attendees:

Jefe de Departmento Geologia -- Raphael Valdez
Geologo Joaquin Garcia
Norman Banks
Topics:
U G desire to begin an Observatorio for seismicity and southern volcanoes of Ecuador
U G desire for training in seismology and volcanology
Meeting at INOCAR
Talks with Espanosa (INOCAR), Tomlin, and Dr. Julio Kuroiwa (Peruvian expert on tsunamis working on UNDRO project).
Meeting at Government Building
Attendees:
General Coordinator de Defensa Civil- Eduardo Estrada
John Tomblin - UNDRO
Norman Banks - USGS
Topics
- what is the state of Defensa Civil in Guayaquil,
Travel to Lima
Packing and note catchup

10/8/87
Packing
Note taking
travel to Lima

10/8/87

Travel to Peru

10/9/87

Briefing at USAID
Purchase of photographic maps at IGN
Meeting with Julio Kuroiwa (Universidad Nacional del Ingenerio)

10/10/87

Travel to Arequipa
Meetings with Prefect, Police, and Civil Defense
Meetings with:
Prefect de Aerequipa - Raul Diaz
Director Observatorio Geofisica a Charataco - Ing. Melicio Lazo
Dr. Alberto Parodi - Volcanologist
Geologist of Defensa Civil - Mario Tejada
USGS - Norman Banks
Andrew Lockhart
UNDRO - John Tomblin

APPENDIX XV. -- Continued

Topics:
Introduction of VDAP
Introduction of UNDRO
Purpose of the visit
Reconnaissance to learn volcano hazards in Aerequipa from Misti Volcano and establish the staus and needs at Aeriquipa for volcano hazard monitoring
How to begin work with Defensa Civil and other agengies responsible for hazards mitigation in Aerequipa
Misti Geologic History, as given by Parodi
Inventory of the Observatory at Charcato
Visit to Characato Observatory

11/11/87

Note catchup
Meeting
Attendees:
Hipolito Portilla Portilla -- Professor at Univ. August. del Sur.
Mario Tejada -- Defensa Civil Geologist
Melecio Lazo -- Director Instituto Geoficsica, Univ. August. del Sur
Guido Salas -- Professor of geology, Univ. August. del Sur
Topic:
Misti Geology
Field trip up Chachani Volcano

10/12/87

Note catchup
Fieldtrip up Misti Volcano with Salas and Portillo Portillo

10/13/87

Note catchup
Meeting at University Nacional de San Augustine del Sur
General introduction to the school, meeting of faculty, inspection of facilities
Field trip, clockwise drive around Chichani Volcano
Note catchup, packing

10/14/87

Fianl talks with Parodi, Tajada, Lazo, Salas
Travel to Lima
Briefings at USAID
Airport to meet Mary Ellen Williams

APPENDIX XV. -- Continued

10/15/87

Orientation and strategy meeting
USAID, arranging meetings through Emillo Guerra
Meeting IGP - Instituto Geoficica del Peru
  Attendees:
    Director Mateo Casaverde
    Norman Banks
    Mary Ellen Willimas
    Andy Lockhart
    Emillio Guerra, USAID
  Topics:
    Profile of VDAP
    VDAP activities and findings in Peru to date
    IGP's history, role, and intentions in volcanology and volcanology hazards

10/16/87

USAID Mailing and arranging meetings
INGEMMET Meeting
  Attendees:
    Director Executivo -- Ing. Juan Zegarra Wuest
    Director General de Geologia -- Ing. Gregorio Flores Nanez
    Geologo -- David Davol
    Norman Banks
    Mary Ellen Williams
  Topics:
    Profile of VDAP
    VDAP activities and findings in Peru to date
    INGEMMET's history, role, and intentions in volcanology and volcanology hazards
Ordered all available Geologic maps
USAID, Packing and mailing INGEOMMET material
IGN, Checking on status maps ordered
Meeting at Groupo de Estudios para el Desarrollo GREDES
  Attendees:
    Director -- Dr. Bruno Podesta, Socialogist
    Norman Banks
  Topics:
    Profile of VDAP
    VDAP activities in Peru to date
    Activitites of the CERESIS Study Group for Ruiz
Meeting at Defensa Civil by Williams and Lockhart

10/17/87

Travel to Quito, Ecuador

APPENDIX XV. -- Continued

10/18

Meeting with Minard Hall
Topics: Lee/Harlow IBM system,
Reviewed the trip to The Univerisity Nacional at Guayaquil
Future IG/VDAP cooperative work

10/19/89

Travel to Bogota

10/20/89

Preparation for meeting with Ambassador
Meeting with Director Pablo Medina, Oficina Nacional para la Atencion de Emergencias del Departmento Administrivo de la Presidencia de la Republica
USGS -- Norman Banks
Mary Ellen Williams
Andrew Lockhart
Topics:
Review of VDAP
Review of Pablo Medina's Department, situation at Ruiz
Security Briefing at Embassy
Meeting with Ambassador Guillespie
Attendees:
Ambassador Guillespie
Vivian Guilespie
Norman Banks
Mary Ellen Williams
Andy Lockhart
Topics: (In part coveyed to Vivian later)
Purpose of trip to Colombia:
Maintain contact with Ingeominas
Check status of El Observatorio
Encourage establishment of good relations with Cali
Investigate the strengths of the new Oficina Nacional para Atencion de Emergencias
VDAP Profile
VDAP recommnedations concenring Ruiz

10/21/87

Travel to Manizalles
Inventory of Observatory
Data review with OVC staff

10/22/87

Continue data and program review with OVC staff

APPENDIX XV. -- Continued

10/23/87

Travel to Cali
Inventory of Universidad de Valle seismic observatory and other department equipment that might be used in volcano monitoring

10/24/87

Continue inventory and liaison activities at Universidad de Valle

10/25/87

Travel to Portland Oregon and CVO, Washington

APPENDIX XVI. -- Summary of VDAP activities in Guatemala, January 1988.

Uncompiled -- available upon request.

APPENDIX XVII -- Summary of VDAP activities in Colombia, March-April, 1988.

Uncompiled -- available upon request.

APPENDIX XVIII. -- Summary of VDAP activities in Guatemala, June 1988.

Uncompiled -- available upon request.

APPENDIX XIX -- Summary of VDAP activities in Peru, June 1988.

Uncompiled -- available upon request.

APPENDIX XX. -- Summary of VDAP activities in Ecuador, Colombia; 27 September - 14 October 1988.

09/27-28/88 TUES-WEDS

Travel to Quito

09/29/88 THURSDAY

Organizing for the day
Travel to and getting acquainted at Esquela Politecnica Nacional(ESPONA), Instituto Geofisico (IG).
Staff meeting to present and discuss the Pichcha data describing the current unrest...made some recommendations
Meeting at USAID Quito, describing and interpreting the activity at Pichincha.

09/30/88 FRIDAY

Field work on Pichincha
- Reshot El Cinto to Lava and Gordo...no changes
- Partial read of Refugio dry-tilt..changes within probable noise

Picked up Stanley Williams briefed him on Pichincha at dinner

10/01/88 SATURDAY

Field work on Pichincha
- Reshot El Cinto to Lava and Gordo...no changes
- Established 3 tangential EDM shots from El Cinto
- Established a 1 km level line near Lloa

10/02/88 SUNDAY

Field trip with ESPONA to Cotocachi seismic station to reestablish the station and look at Cotacachi and Cuicocha..

10/03/88 MONDAY

Meeting with Stanley Williams

- Main topic = concern for the possible rift/fight between INEMIN and the Instituto, the current events on Pichincha

- Asked for 9 new positions, 3 professional, 3 technical, 3 helpers: the Rector said there was no $ for anyone new, that all $ in the Esquella is for salaries already and thus not easily moved, offered to entertain a proposal from the Instituto to transfer a civil engineer into the Institute to help with the deformation

APPENDIX XX. (continued)

10/07/88 FRIDAY

Response to swarm on Pichincha
Fieldwork at Cotopaxi
- Shot the lower and middle reflector of the North Flank EDM line
- Remeasured the smaller North Flank tilt station
- Read the larger tilt triangle on the West Flank
- Shot the lower Reflector on the West Flank line

Weather was poor, many clouds and high winds

10/08/88 SATURDAY

Organizing for the Pichincha Crater climb.
Pichincha Crater Climb.
- Reshot the El Cinto lines to two of the radial reflectors and one tangential refelctor
- Established Theodolite instrument station and a Refelctor Station on the dome; bad weather prevented shooting the backshot.
- Stanley Williams, ESPONA Geochemist Luis LaMarie and Patti Mothes mapped the fumarole fields.

10/09/88 SUNDAY

Organized equipment after field work
Meeting with ESPONA staff, VCAT, and Colonel Hernandez, Defensa Civil
Conference with Minard and Patti Mothes on the need to write information releases for the press, write a SEAN article, and a Report and Recommendations to USAID.

10/10/88 MONDAY

Banks -- Working on final report with. Dr Hall
Ewert -- reading El Cinto EDM lines, reading Llla level line

10/11/88 TUESDAY

Banks -- Work on memorandums, packing, writing final report.
USAID contacting Menlo Park USGS, CVO, and Reston, Va.
Consulting with Dr. Minard Hall of the Politechnica

Ewert -- more deformation measurements in the field

APPENDIX XX. (continued)

10/12/88 WEDNESDAY

Banks -- Packing, writing memos, writing report
Talking with Peters and Reed, USAID
Brief report of the VDAP mission
Status of volcano
Recommendations as stated in Memo to Almaguer
Meetings at Politecnica, last minute coordinations and advice,transfered programs to Politecnica Computer
Travel to Bogota
Meeting with Dr. Hans Meyer, Universidad de Valle
Topics: state of Ruiz, program at Valle and needs.

Ewert -- Field work on Pichincha

10/13/88 THURSDAY Banks in Colombia, Ewert traveling to Portland from Ecuador)

Meetings at USAID, Bogota
With Lorraine Mansfield about stautus of Ruiz activity
With Economic Officer and Deputy Director of the Mission
Points made:
- Activity of Ruiz is high compared to 1987, this makes volcanologists nervous...although there is no way of differentiating between scenarios, an eruption equal to or greater than the NOV 85 eruption is certainly possible, with very short lead-time in terms of warning
- OVC has never had a parts/supply/training conduit, as a result almost always the instruments operate at a fraction of their potential, They need someone in Embassy to take on this conduit problems as an act of love and keep at it..establishing funding and the transfer mechanisms.
- OVC never received proper levels of training in the original program...there are no professsional volcanologists at OVC, many of our trainees have left or been transferred from the observatory, thus my and all other senior volcanologists agree that we have no confidence that the early warning signs of impending eruption will be recognized and if they are that the confidence exists to issue the warning in timely fashion..SOLUTION = assign a senior volcanologist and a senior techniccian (possibly in rotation) for 2 years to OVC while training 2-4 Colombians in advanced degrees in US for the job.

APPENDIX XX. (continued)

Meetings at INGEOMINAS with Director, subdirector for Geophysics and Director of the Observatory in Manizales
-- all wish USGS help because of deteriorating equipment
-- surprisingly (distrubingly) confident that they know the volcano and that it is not too dangerous.
Wrote summary memo and recommendations solicited by Mansfied

10/14/88

Banks Packing and travel to Portland

APPENDIX XXI. -- Summary of VDAP activities in Ecuador, November - 2 December 1988

AL = Andy Lockhart, TM = Tom Murray, IG = Instituto Geofisico

11/4-11/5

AL,TM Travel to Quito

11/6

AL,TM Field work to El Cinto and Lloa to inspect telem sites
inspect seismic recorders at IG

11/7

AL Field Work - install tilt tile at Lloa
TM Begin work on seismic wiring

11/8

AL Field Work - inspect tilt site at Glacial Valley (GLAC)
TM Receiver installation, IG

11/9

AL Field Work - install tile at GLAC
TM Receiver installation, IG

11/10

AL Lloa tilt installation
TM Receiver installation, IG

11/11

AL Field Work - tiltmeter in at Lloa
TM Computer purchase consultation, IG

11/12

AL Field Work - cassetta installation at GLAC
TM commputer purchase consultation, IG

11/13

AL Cable construction, instruction for IG
TM Receiver installation IG

11/14
APPENDIX XXI.

APPENDIX XXI. -- Continued.

11/14

AL Field Work - install meter at GLAC, ETERNIT asbestos top broke under weight of soil, site re-excavated and meter removed

TM Receiver installation, IG

11/15

AL Field Work - search for best telem site at EL CINTO

TM Receiver installation, IG

11/16

AL Field Work - reinstall meter at GLAC, remove meter and make adjustments to the concrete pad.

TM Software transfusion, IG

11/17

AL Field Work - install Yagi antenna at LLOA, inspect lightning damage

TM Software transfusion, IG

11/18

AL,TM Field Work - to Cayambe to repairactice ground tilt triangle at INSIVUMEH.

Worked on the computer system.

11/6 - Prepared to spend following week working at Santiaguito.
Began progress report on VDAP work with INSIVUMEH.

11/7 - Drove to San Felipe on the south side of Santiaguito.
Observed changes which have occured in the river bed of the Rio Nima II since the last wet season.

11/8 - Spent day on Finca El Faro observing the triangulation procedures on Santiaguito.

11/9 - Spent day observing the dome from the triangulation baseline.
Suggested some procedural changes and located a new baseline.
from which the active flow could be monitored.
Drove to Quetzaltenango.

11/10 - Triangulation work on highland side of Santiaguito.

APPENDIX XXI. -- Continued.

11/11 - Finished triangulation work.
Discussed siting of prisms on Santiaguito to be shot with INSIVUMEH's EDM.
Return to Guatemala City..

11/12 - Spent day at INSIVUMEH working up the weeks data and that of several months ago.
Showed some of the techs. how to process the data in the program written for them and then set up PC-BOB to display and cross-compare the data.
Jim Vallance arrived from Michigan Tech. to continue work on debris avalanches from Pacaya.

11/13 - Drove out to Fuego to do reconnaissance for the following week's field work.

11/14 - Met with Sub-director of INSIVUMEH in the morning.
Field work on Fuego Volcano. Located a site for a level line at Finca La Candelaria. Began setting benchmarks.

11/15 - Field work on Fuego. Finished setting benchmarks on level line route. Gave instruction on how to level.

11/16 - Field work on Fuego. Began leveling level line. Spent entire day teaching leveling.

11/17 - Completed level line on Fuego. Return to Guatemala City..

11/18 - Completed setting up PC-BOB and other computer utilities.
Made inventory of equipment turned over to INSIVUMEH and gave it to the Sub-director.
Meeting at AID to discuss progress of the project, problems etc. Discussed the current situation at Santiaguito and the need for more action in both monitoring and warning systems there.

11/19 - Return to U.S.

APPENDIX XXII. -- List of deformation equipment on temporary loan to Costa Rica, Guatemala, Ecuador, and Mexico.

COSTA RICA - Since September, 1986

1. 1 ea. EDM - Infrared Distance Meter "Citation 450", with mounting yoke for T-16 theodolite, s.n. 513.
2. 1 ea. Theodolite "WILD T-16" s.n. 216377 w/ tribrach.
3. 6 ea. prisms
4. 2 ea. battery chargers with cables
5. 3 ea. batteries
6. 1 ea Altimeter

Short term 1988

1. 1 ea. HP3808A EDM and tribrach

EXPENDABLE
April, 1987

1. 3 ea. 6 conductor phone jacks.
2. 4 ea. prisms
3. 10 ea. bench marks,
4. 12 ea. rock anchors,
5. 1 ea. measuring tapes, etc.

GUATEMALA

Since March 1987

1. 1 ea. EDM - Infrared Distance Mweter "Citation 450", with mounting yoke for T16 theodolite, SN 813.
2. 5 ea. Batteries for Citation
3. 3 ea. Battery Chargers for Citation batteries.
4. 1 ea. Theodolite WILD T16, SN 217012, with tribrach.

Short term in 1988

1. 3 ea. Voice communication radios.

ECUADOR

Since August 1987

1. 1 ea. EDM - Infrared Distance Mweter "Citation 450", with mounting yoke for T16 theodolite, SN 6153.
2. 5 ea. Batteries for Citation
3. 3 ea. Battery Chargers for Citation batteries.
4. 1 ea. Theodolite WILD T16, SN 223969, with tribrach.

Since Octobewr 1988

APPENDIX XXII -- Continued.

5. 1 ea. Cr/Al theomocouple and Omega meter.
6. 1 ea. HP3808A EDM, yoke, tribrach, 3 batteries, charger.

MEXICO

Since March 1987

1. 3 ea. EDM reflector prisms.

APPENDIX XXIII. -- Unofficial Tracking Ledger of USGS - VCAT Operational Expenditures, FY88.

LEDGER PRINTOUT DATE 31-Dec-88

SUMMARY LEDGER

Salaries	$118,987
Overtime	$0
Benefits	$16,658
Travel	$909
Contracts	$2,914
Equipment	$22,300
Operations	$3,282
Overhead	$99,030
	$264,079

LEDGER NO.	SORT	SORT2	DESCRIPTION	VENDOR	NO.	UNIT COST	SHIPPING	COST
SALARY, BENEFITS, OFFICE COSTS								
PROJECT STAFF, SALRY AND BENEFITS								
			M. G. Banks, project/program chief					$54,692.00
			M. P. Doukas, geologist					$24,435.00
			D. W. Harlow, seismologist					$39,860.00
BENEFITS (14%)								$16,658.18
BRANCH AND OFFICE COSTS								$19,700.00
OPERATIONS EXPENSES					TOTAL	$155,345.18		
CONTRACT - ADMIN								
V88-040	CONTRACT	DATABASE	JUDY LOPAS-database entry	VOUCHER	1	$1,425.00		$1,425.00
V88-041	CONTRACT	TRAIN	SURVEYING CLASS - EWERT	VOUCHER	1	$122.50		$122.50
V88-017	CONTRACT	TRAIN	SURVEYING CLASS - DOUKAS	POB PUBLISHING	1	$95.00		$95.00
V88-007	CONTRACT	TRAIN	SPANISH 201, NORM	CLARK COLLEGE	1	$118.05		$118.05
V88-010	CONTRACT	TRAIN	SPANISH 103, ANDY	CLARK COLLEGE	1	$144.00		$144.00
V88-008	CONTRACT	TRAIN	SPANISH 202, MIKE	CLARK COLLEGE	1	$60.40		$60.40
V88-009	CONTRACT	TRAIN	SPANISH 201, JOHN	CLARK COLLEGE	1	$111.10		$111.10
V88-056	CONTRACT	TRAIN	SPANISH 207, JE	PORTLAND STATE	1	$112.50		$112.50
V88-060A	CONTRACT	TRAIN	SPANISH 103, CS/JH	CLARK COLLEGE	2	$193.00		$386.00
V88-060B	CONTRACT	TRAIN	SPANISH BOOKS CS/JH	CLARK COLLEGE	2	$34.70		$69.40
V88-065	CONTRACT	TRAIN	SPANISH 207, al	PORTLAND STATE	1	$223.00		$223.00
V88-078	CONTRACT	TRAIN	SPANISH BOOK AL	PORTLAND STATE	1	$46.70		$46.70
	CONTRACT	TRAIN	SPANISH BOOK	CLARK COLLEGE	1	$25.50		
					TOTAL	$2,913.65		
EQUIP - ADMIN								
V88-001	EQUIP	ADMIN	US WEST INFO. SYS.	PHONE CO.	1	$84.00		$84.00
V88-039	EQUIP	ADMIN	JUDY/CINDY PHONE	PHONE CO	1	$161.89		$161.89
					TOTAL	$245.89		
EQUIP - AUTODATA/DATABASE								

APPENDIX XXIII. -- Continued

V88-021	EQUIP	AUTODATA	DICONIX PRINTER	GTS INC.	1	$500.00		$500.00
V88-054A	EQUIP	AUTODATA	TOSHIBA 1200	1ST CHOICE	1	$2,379.32		$2,379.32
V88-054B	EQUIP	AUTODATA	TOSHIBA BATTERY PACK	1ST CHOICE	2	$53.72		$107.44
V88-054C	EQUIP	AUTODATA	TOSHIBA Modem	1ST CHOICE	1	$189.72		$189.72
V88-043	AUTODATA	DBASE	REVELATION SOFTWARE	GOVT. TECH	1	$510.00		$510.00
V88-061	AUTODATA	DBASE	SIDEKICK PLUS	GOVT. TECH	1	$122.00		$122.00
					TOTAL	$3,808.48		

EQUIP - DEFORM

V88-014B	EQUIP	DEFORM	2-M ROD STAYS	PUGET SOUND BLUEP	3	$695.00		$2,085.00
V88-011	EQUIP	DEFORM	STANDARDS, LEVELING	NGIC NOAA	1	$11.75		$11.75
V88-014C	EQUIP	DEFORM	BUBBLE LEVELS	PUGET SOUND BLU	3	$40.00		$120.00
V88-030	EQUIP	DEFORM	UPGRADE TO 6000 GEODIMETER	VOUCHER	1	$1,528.36		$1,528.36
V88-014A	EQUIP	DEFORM	2-M KERN RODS	PUGET SOUND BLUEP	3	$1,615.00		$4,845.00
					TOTAL	$8,590.11		

EQUIP - TELEMETRY

V88-057	EQUIP	TELEM	MPU BOARDS - TELEMETRY	NESTAR	20	$14.30		$286.00
V88-064	EQUIP	TELEM	SYNTEX - TELEMETRY RADIO	BOWITZ	3	$375.00		$1,125.00
V88-068	EQUIP	TELEM	SYNTEX - TELEMETRY RADIO	BOWITZ	8	$415.00		$3,320.00
					TOTAL	$4,731.00		

EQUIP - GAS/GEO

EQUIP - GEO/OBS

V88-015	EQUIP	GEO/OBS	MAGNOTOMETER	F G ELECTRONIC	1	$900.86		$900.86
V88-034	EQUIP	TELEM	FORTRAN COMPILER UPGRADE	MICROSOFT	1	$150.00		
V88-044	EQUIP	GEO/OBS	FIBERGLASS LEVELING RODS	PORTLAND PRES.	2	$169.15		$338.30
V88-047	EQUIP	GEO/OBS	CLEAR POLAROID	TYNERS	1	$69.95		$69.95
V88-048	EQUIP	GEO/OBS	CAMERA BODIES	CAMERA WORLD	2	$189.85	8.45	$388.15
V88-050	EQUIP	GEO/OBS	SUPER 8 FR. COUNT EDITOR	FRANKS CAMERA	1	$165.00		$165.00
V88-052	EQUIP	GEO/OBS	STEIN'S FIELD EQUIP	WEST REGION SUP	1	$235.90		$235.90
V88-059A	EQUIP	GEO/OBS	DATABACKS FOR CAMERS	MINOLTA	2	$123.45		$246.90
V88-059B	EQUIP	GEO/OBS	CAMERA CASE	MINOLTA	2	$12.78		$25.56
V88-051	EQUIP	GEO/OBS	DEPTH SOUNDER - CRATER LAKES		1	$1,041.00		$1,041.00
V88-045	EQUIP	GEO/OBS	FIRST AID KITS	GSA	4	$22.99		$91.96
					TOTAL	$3,503.58		

EQUIP - LOGIS

	EQUIP	LOGIS	JENSEN TRUNKS	JENSEN	3	$193.50		$580.50
					TOTAL	$580.50		

EQUIP - SAFETY

EQUIP - TELEM

EQUIP - TRAIN

V88-063	EQUIP	TRAIN	OSU VIDEO - TRAINING DEFORM OSU		5	$168.00		$840.00
					TOTAL	$840.00		

OPERAT - ADMIN

APPENDIX XXIII. -- Continued

V88-002	OPERAT	EQUIP	STORAGE - VDAP EQUIPMENT	SAFEGUARD STOR	3	$78.00		$234.00
V88-033	OPERAT	REPAIR	FIX KEY STORAGE LOCKER #G-11	HARRY'S LOCKSMITH	1	$32.00		$32.00
V88-006	OPERAT	SHIP	OFDAWPA - MEW	DHL	1	$4.94		$4.94
V88-024	OPERAT	OFFICE	OVERHEAD PHS, POLARBLU	TYMERS	1	$29.52		$29.52
V88-031	OPERAT	EQUIP	STORAGE - VDAP EQUIPMENT	SAFEGUARD	1	$78.00		$78.00
V88-004	OPERAT	SHIP	OFDAWPA - CHRIS	DHL	1	$4.94		$4.94
V88-003B	OPERAT	OFFICE	TRIANGLE, 60	GSA AUBURN	2	$0.40		$0.80
V88-003F	OPERAT	TOOLS	POUCH, TOOL	GSA AUBURN	1	$6.60		$6.60
V88-022	OPERAT	SHIP	OFDAWPA - MEW	DHL	1	$4.94		$4.94
V88-042	OPERAT	EQUIP	STORAGE - VDAP EQUIPMENT	SAFEGUARD	5	$78.00		$390.00
	OPERAT	EQUIP	STORAGE - VDAP EQUIPMENT	SAFEGUARD	1	$54.88		$54.88
V88-003A	OPERAT	OFFICE	TRIANGLE, 45	GSA AUBURN	2	$0.61		$1.22
V88-003G	OPERAT	OFFICE	PIN, PUSH	GSA AUBURN	1	$0.58		$0.58
V88-005	OPERAT	SHIP	OFDAWPA - HARLOW	DHL	1	$4.94		$4.94
V88-003E	OPERAT	OFFICE	ALCOHOL	GSA AUBURN	1	$1.54		$1.54
V88-025	OPERAT	SHIP	SEND JOB ADVERT	DHL	1	$4.94		$4.94
V88-048	OPERAT	OFFICE	OFFICE SUPPLIES	GSA	1	$8.28		$8.28
V88-062a	OPERAT	OFFICE	PAPER, COMPUTER	GSA	20	$20.56		$411.20
V88-062b	OPERAT	OFFICE	PENCILS	GSA	2	$19.75		$39.50
V88-069	OPERAT	SHIP	FED EXP to DLA	FED EXP	1	$14.00		$14.00
V88-070	OPERAT	SHIP	FED EXP to DLA	FED EXP	1	$14.00		$14.00
V88-071	OPERAT	SHIP	DHL - 89 BOD.	DHL	1	$4.94		$4.94
V88-072	OPERAT	SHIP	DHL - FRANCIS	DHL	1	$4.94		$4.94
V88-073	OPERAT	COPY	XEROX	PSU	1	$10.00		$10.00
V88-081	OPERAT	SHIP	DHL - FRANCIS	DHL	1	$4.94		$4.94
V88-076	OPERAT	SHIP	DHL - BABICZ	DHL	1	$4.94		$4.94
V88-077	OPERAT	SHIP	DHL - FRANCIS	DHL	1	$4.94		$4.94
V88-079	OPERAT	SHIP	DHL - MEW	DHL	1	$4.94		$4.94
V88-080	OPERAT	SHIP	P88-113 ADD POSTAGE	LANDMARK	1	$7.25		$7.25
V88-058	OPERAT	OFFICE	off sup		1	$8.28		$8.28
V88-037	OPERAT	OFFICE	misc		1	$11.82		$11.82
	OPERAT	SHIP	IMPREST	LANDMARK	1	$4.50		$4.50
	OPERAT	SHIP	IMPREST	LANDMARK	1	$2.00		$2.00
	OPERAT	SHIP	IMPREST	LANDMARK	1	$0.75		$0.75
	OPERAT	REFUND	PRICE DECREASE	VOUCHER	1	($63.03)		($63.03)
	OPERAT	REFUND	TOTAL PRICE ADJUSTMENTS	VOUCHER	1	-188.23		($188.23)
					TOTAL	$1,163.80		

OPERAT - AUTODATA/DATABASE

V88-029	OPERAT	AUTODATA	TABN. PAPER	GSA AUBURN	1	$15.18		$15.18
V88-018A	OPERAT	AUTODATA	3 1/2 DISKETTE	INMAC	20	$3.75	$5.30	$80.30
V88-003D	OPERAT	AUTODATA	PAPER, PRINTER	GSA AUBURN	2	$14.39		$28.78
V88-003C	OPERAT	AUTODATA	DISKETTE BOX	GSA AUBURN	2	$5.85		$11.70
V88-038	OPERAT	AUTODATA	PRINT RIBBON	GSA AUBURN	1	$9.17		$9.17
V88-018B	OPERAT	AUTODATA	3 1/2 DISKETTE, BOXES	INMAC	3	$8.50		$25.50
V88-053	OPERAT	DATABASE	8/10 ENLARGEMENTS	TYMERS	60	$2.99		$179.40
V88-055A	OPERAT	AUTODATA	3 1/2 DISKETTES	GSA	40	$1.32		$52.80
V88-055B	OPERAT	AUTODATA	5 1/4 DISKETTES	GSA	40	$2.40		$96.00
V88-055C	OPERAT	AUTODATA	DISKETTE STORE BOX	GSA	10	$2.50		$25.00
					TOTAL	$523.83		

OPERAT - DEFORM

V88-012	OPERAT	DEFORM	BAND IRON-TRIPOD	PARKROSE	6	$2.75		$16.50

APPENDIX XXIII. -- Continued

					TOTAL	$16.50		
OPERAT - GEO/OBS								
V88-036	OPERAT	GEO/OBS	SLIDE MOUNTS	TYMERS	1	$7.96		$7.96
V88-020	OPERAT	GEO/OBS	RITE IN RAIN	GSA MENLO	1	$16.43		$16.43
V88-013	OPERAT	GEO/OBS	MAPPING SCALE	BEN MEADOWS	5	$7.50		$37.50
V88-023	OPERAT	GEO/OBS	FILM	TYMERS	1	$22.80		$22.80
V88-035	OPERAT	GEO/OBS	FILM	TYMERS	1	$39.26	3.82	$43.08
V88-066	OPERAT	GEO/OBS	FILM	TYMERS	1	$837.00		$837.00
V88-049	EQUIP	GEO/OBS	HOT SHOT REPAIR	CAPINTEC	1	$400.00		$400.00
					TOTAL	$1,364.77		
OPERAT - LOGIS								
OPERAT - SAFETY								
V88-016	OPERAT	SAFETY	MONITRON MAINTENANCE	MOTOROLA	1	$81.60		$81.60
V88-075A	OPERAT	SAFETY	MOTOTOLA BATTS	CENTURION	2	$42.27		$84.54
V88-075B	OPERAT	SAFETY	TAD BATTERIES	CENTURION	7	$17.08		VOIDED
					TOTAL	$166.14		
OPERAT - TELEM								
V88-074	OPERAT	TELEM	LIGHTNING BOXES	NORVAC	6	$7.85		$47.10
					TOTAL	$47.10		
OPERAT - TOOLS								
OPERAT - TRAINING								
OPERAT - TRAVEL								
V88-038B	TRAVEL		NORM/MENLO - PERDIEM	VOUCHER	1	$50.87		$50.87
V88-038A	TRAVEL		NORM/MENLO - FARE	VOUCHER	1	$178.00		$178.00
V88-026	TRAVEL	GAS/GEO	MIKE/MENLO	VOUCHER	1	$200.00		$200.00
V88-032A	TRAVEL	TRAIN	ANDY/MENLO - FARE	VOUCHER	1	$178.00		$178.00
V88-032B	TRAVEL	TRAIN	ANDY/MENLO - PD	VOUCHER	1	$301.86		$301.86
					TOTAL	$908.73		

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APPENDIX XXIV. -- Unofficial Tracking Ledger of Operational Expenditures
OFDA/VDAP Program FY88.

GRAND TOTAL $134,078.07
LAST UPDATE 28-Feb-89

SUMMARY LEDGER

Salaries	$59,281	
Overtime	$132	
Benefits (14%)	$8,318	
Travel	$25,576	
Overhead (40%)	$37,323	(Salary/Benfits/Travel)
Contracts	$0	
Equipment	$35,552	
Expendable/Opera	$5,219	
Overhead	$8,154	(Contracts/Equipment/Expendables)
	$179,555	

VDAP NO.	VDAP CATEGORY	VDAP SORT	ITEM DESCRIPTION	VENDOR	NO. PUR	PRICE EACH	SHIP COST	TOTAL COST
PERSONAL SERVICES			$63,017.00 SALARY					
Lockhart, Andrew								$24,033.00
Ewert, John								$23,038.00
Stine, Cynthia								$12,210.00
Overtime								$132.00
BENEFITS								$8,317.82
CONTRACT								$0.00
EQUIP - ADMIN								
P88-104C	EQUIP	ADMIN	X-ACTO KNIFE	HORVAC	1	$3.40		$3.40
P88-104D	EQUIP	ADMIN	BLADES	HORVAC	1	$1.65		$1.65
P88-123	EQUIP	ADMIN	KEYS	HARRY'S LOCKSMITH	5	$1.35		$6.75
P88-115	EQUIP	ADMIN	VOLTAGE CONVERT.220-110	1ST CLASS	4	$29.95		$119.80
						TOTAL	$131.60	
EQUIP - AUTODATA/DATABASE								
P88-001	DATABASEMAPS		MAPS COTOPAXI HAZARD	GEO. SURVEY	1	$92.00		$92.00
P88-014E	DATABASEMAPS		PERU MAPS-HORM	TRAV-VOUCHER	1	$226.85		$226.85
P88-027B	EQUIP	AUTODATA	POWER SUPPLY, EAGLE-PC	JAMECO	1	$69.95		$69.95
P88-036A	EQUIP	AUTODATA	TOSHIBA 1200	WESTCOM	1	$2,970.00		$2,970.00
P88-036B	EQUIP	AUTODATA	TOSH 1200 SPARE BATT	WESTCOM	2	$79.00		$158.00
P88-036C	EQUIP	AUTODATA	TOSH1200 MODEM	WESTCOM	1	$340.00		$340.00
P88-036D	EQUIP	AUTODATA	PRINTER SERIAL PORT	WESTCOM	1	$90.00		$90.00
P88-037A	EQUIP	AUTODATA	PRINTER CABLE	JAMECO	2	$11.95		$23.90
P88-037C	EQUIP	TRAIN	POWER SUPPL. EAGLE/PC-3	JAMECO	1	$69.95		$69.95
P88-055	EQUIP	AUTODATA	INTEGRATED CIRCUIT	WEST. MICROTECH	16	$5.50		$88.00
P88-104A	EQUIP	AUTODATA	POWER SUPPLY, EAGLE-PC	HORVAC	1	$69.95		$69.95
						TOTAL	$4,198.60	
EQUIP - GAS/GEO								

APPENDIX XXIV. -- Continued

P88-002A	EQUIP	GAS/GEO	HOT-STIR	VWR	1	$185.15	$2.22	$187.37
P88-002B	EQUIP	GAS/GEO	MINI-SPECTOPHOTO	VWR	1	$1,088.65	$6.58	$1,095.23
P88-004	EQUIP	GAS/GEO	SYRINGE, 30cc	FISHER	20	$1.01	$3.19	$23.39
P88-005	EQUIP	GAS/GEO	TISAB III	FISHER	1	$50.00		$50.00
P88-006	EQUIP	GAS/GEO	RESEARCH CARTRIDGE	COLE-PARMER	2	$50.00		$100.00
P88-006	EQUIP	GAS/GEO	UNIVERSAL CARTRIDGE	COLE-PARMER	2	$46.57		$93.14
P88-006	EQUIP	GAS/GEO	INCREASE TO EST.	COLE-PARMER	1	$46.43		$46.43
P88-006	EQUIP	GAS/GEO	DEIONIZER BRACKET	COLE-PARMER	1	$50.00	$11.14	$61.14
P88-058A	EQUIP	GAS/GEO	NaNO3, 500 GM	VWR	1	$26.71		$26.71
P88-058B	EQUIP	GAS/GEO	NaCl, 500 GM	VWR	1	$13.05		$13.05
P88-058C	EQUIP	GAS/GEO	CaCo3, 500 GM	VWR	1	$31.43		$31.43
P88-058D	EQUIP	GAS/GEO	LAMP ASSEM., MINI 20	VWR	1	$69.00		$69.00
P88-058E	EQUIP	GAS/GEO	CaCl2	VWR	1	$20.65		$20.65
P88-058F	EQUIP	GAS/GEO	TRIS	VWR	1	$13.35		$13.35
P88-058G	EQUIP	GAS/GEO	NITRIC ACID	VWR	1	$10.46		$10.46
P88-058H	EQUIP	GAS/GEO	IMIDAZOLE	VWR	1	$13.35		$13.35
P88-058I	EQUIP	GAS/GEO	HYDRODHLORIC ACID	VWR	1	$15.72		$15.72
P88-058J	EQUIP	GAS/GEO	SPECT KIT, SULFATE	VWR	1	$64.98		$64.98
P88-058K	EQUIP	GAS/GEO	SPECT KIT, HYDROGEN	VWR	1	$64.98		$64.98
P88-058L	EQUIP	GAS/GEO	POTASSIUM CHLORIDE	VWR	1	$9.52		$9.52
P88-058M	EQUIP	GAS/GEO	DECREASE FROM EST.	VWR	1	($89.75)		($89.75)
P88-079	EQUIP	GAS/GEO	BATTERY STIRRER	COLE PARMER	1	$80.00	$2.55	$82.55
P88-104	EQUIP	GAS/GEO	handle, screw	NORVAC	1	$16.76		$16.76
						TOTAL	$2,019.46	
EQUIP - GEO/OBS								
P88-061	EQUIP	GEO/OBS	BINOCULARS, CINDY	FRED MEYER	2	$46.97		$93.94
						TOTAL	$93.94	
EQUIP - LOGIS								
P88-003	EQUIP	LOGIS	TRUNK, JENSEN	JENSEN	1	$199.00		$199.00
						TOTAL	$199.00	
EQUIP - SAFETY								
P88-046	EQUIP	SAFETY	VHF REPEATER	RITRON	1	$1,067.00	$10.88	$1,077.88
P88-105	EQUIP	SAFETY	CLIMBING HELMET	RECREAT. EQUIP.	5	$40.50		$202.50
P88-114A	EQUIP	SAFETY	VHF ANTENN	LARSEN	3	$39.70		$119.10
P88-120B	EQUIP	SAFETY	UHF M.- 'N'M.	PASTERNACK	3	$13.95		$41.85
P88-121B	EQUIP	SAFETY	COAX LIGHTNING ARRESTOR	RF IND	3	$16.65		$49.95
P88-121D	EQUIP	SAFETY	N' M. CRIMP RG58	RF IND	6	$2.87		$17.22
P88-121F	EQUIP	SAFETY	N' M. SOLDER RG8	RF IND	3	$2.65		$7.95
P88-121I	EQUIP	SAFETY	N' F. TEE	RF IND	3	$6.53		$19.59
P88-125	EQUIP	SAFETY	VHF REPEATER	RITRON	1	$1,043.00		$1,043.00
						TOTAL	$2,579.04	
EQUIP - SEISMIC								
P88-007A	EQUIP	SEISMIC	MICROSOFT FORTRAN V.4	PROGRAMER'S CON.	1	$285.00		$285.00
P88-007B	EQUIP	SEISMIC	TURBO PASCAL, V.4	PROGRAMER'S CON.	1	$64.00		$64.00
P88-007C	EQUIP	SEISMIC	MICROSOFT QUICK C	PROGRAMER'S CON.	1	$63.00		$63.00
P88-007D	EQUIP	SEISMIC	MICROSOFT C-COMPILER V.5	PROGRAMER'S CON.	1	$281.00		$281.00
P88-007E	EQUIP	SEISMIC	HALO GRAPHICS	PROGRAMER'S CON.	1	$205.00		$205.00

APPENDIX XXIV. -- Continued

P88-007F	EQUIP	SEISMIC	MICROSOFT WINDOWS V.2	PROGRAMER'S CON.	1	$63.00		$63.00
P88-011	EQUIP	SEISMIC	COUPLER/CABLE STRIPPER	RADIO SHACK	1	$37.31		$37.31
P88-047A	EQUIP	SEISMIC	PS-2	KINEMETRICS	1	$4,500.00	$29.01	$4,529.01
P88-047B	EQUIP	SEISMIC	SMOKE STYLUS	KINEMETRICS	1	$28.00		$28.00
P88-047C	EQUIP	SEISMIC	INK PEN	KINEMETRICS	1	$36.00		$36.00
P88-047D	EQUIP	SEISMIC	INK	KINEMETRICS	1	$3.00		$3.00
P88-047E	EQUIP	SEISMIC	SEIS PAPER	KINEMETRICS	1	$115.00		$115.00
P88-047F	EQUIP	SEISMIC	SPARE DRUM	KINEMETRICS	1	$435.00		$435.00
P88-047G	EQUIP	SEISMIC	DRUM CASE	KINEMETRICS	1	$275.00		$275.00
P88-075A	EQUIP	SEISMIC	UNINTER. POWER SYS.	BEST POWER	1	$1,270.00		$1,270.00
P88-075B	EQUIP	SEISMIC	EXTERNAL CABLE	BEST POWER	1	$137.00		$137.00
P88-075C	EQUIP	SEISMIC	BATTERY (12V, 100AMP)	BEST POWER	4	$225.00		$900.00
P88-075D	EQUIP	SEISMIC	CABINET FOR 4 BATTERIES	BEST POWER	1	$150.00		$150.00
P88-075E	EQUIP	SEISMIC	EXTERNAL 20 AMP CHARGER	BEST POWER	1	$495.00		$495.00
P88-075F	EQUIP	SEISMIC	SOFTWARE FOR CONTROLLING	BEST POWER	1	$100.00		$100.00
P88-116	EQUIP	SEISMIC	TRUNKS	JENSEN	5	$224.00		$1,120.00
P88-121G	EQUIP	SEISMIC	N' M. SOLDER RG8	RF IND	100	$2.65		$265.00
P88-121J	EQUIP	SEISMIC	N' F. TEE	RF IND	20	$6.53		$130.60
P88-121K	EQUIP	SEISMIC	COAX LIGHTNING ARRESTOR	RF IND	20	$16.65		$333.00
						TOTAL		$11,319.92

EQUIP - TELEM

P88-016	EQUIP	TELEM	RELAY, 4PDT	DIGI-KEY	2	$52.40	$1.59	$106.39
P88-024	EQUIP	TELEM	ANTWORK, 502 VCO	TYNERS	1	$26.00		$26.00
P88-026	EQUIP	TELEM	UART MC6350	FUTURE ELECT	10	$4.84	$1.91	$50.31
P88-027A	EQUIP	TELEM	CAPS, .01 UF	JAMECO	1000	$0.15	$3.99	$153.99
P88-027C	EQUIP	TELEM	PERF BOARD	JAMECO	2	$13.49		$26.98
P88-027D	EQUIP	TELEM	MAX232 CHIP	JAMECO	5	$5.19		$25.95
P88-028B	EQUIP	TELEM	RG58 BNC MALE	PASTERNACK	150	$1.28		$192.00
P88-028C	EQUIP	TELEM	BNC F TO N MALE	PASTERNACK	35	$4.14		$144.90
P88-028D	EQUIP	TELEM	N'TO 'N' FEMALE CONN	PASTERNACK	10	$4.95		$49.50
P88-028E	EQUIP	TELEM	BNC FEMALE-FEMALE CONN	PASTERNACK	60	$3.78	1.36	$228.16
P88-035B	EQUIP	TELEM	MOLEX CONNS	NORVAC	1	$2.20		$2.20
P88-035D	EQUIP	TELEM	MOLEX CONN	NORVAC	1	$1.92		$1.92
P88-035F	EQUIP	TELEM	CARD-EDGE CONN	NORVAC	4	$4.50		$18.00
P88-037D	EQUIP	TELEM	BUZZER	JAMECO	2	$6.49		$12.98
P88-037E	EQUIP	TELEM	BUZZER	JAMECO	1	$0.65		$0.65
P88-041A	EQUIP	TELEM	MC14575 CHIP	FUTURE	4	$2.96	$0.83	$12.67
P88-041B	EQUIP	TELEM	VN10KM MOSFET	FUTURE	10	$0.60	$17.00	$23.00
P88-041C	EQUIP	TELEM	2N2905 TRANSISTOR	FUTURE	10	$0.32		$3.20
P88-041D	EQUIP	TELEM	CD4511 CHIP	FUTURE	10	$0.45		$4.50
P88-045A	EQUIP	TELEM	3" PVC CAP	PARKROSE	2	$1.39		$2.78
P88-045B	EQUIP	TELEM	3" TEST CAP	PARKROSE	2	$0.29		$0.58
P88-045C	EQUIP	TELEM	HOT MELT CAULK	PARKROSE	1	$2.59		$2.59
P88-045D	EQUIP	TELEM	HOT MELT GLUE	PARKROSE	1	$2.59		$2.59
P88-048	EQUIP	TELEM	SYNTHEX RADIO UHF	HANA	6	$375.00	13	$2,263.00
P88-050A	EQUIP	TELEM	AMPHENOL CONNS	NEWARK	16	$4.15		$66.40
P88-050B	EQUIP	TELEM	AMPHENOL CONNS	NEWARK	20	$4.24	$3.46	$88.26
P88-051A	EQUIP	TELEM	ICL7662	NEWARK	10	$2.94	$3.12	$32.52
P88-051B	EQUIP	TELEM	ICL7665	NEWARK	10	$3.55	$3.49	$38.99
P88-051C	EQUIP	TELEM	LM4250	NEWARK	10	$1.68	$3.49	$20.29
P88-051D	EQUIP	TELEM	LM741	NEWARK	25	$0.63		$15.75
P88-052	EQUIP	TELEM	XFORMER	NEWARK	2	$27.44	$3.39	$58.27
P88-053	EQUIP	TELEM	GAS TUBE SURGE PROT.	JOCELYN	100	$4.40	$1.98	$441.98
P88-054A	EQUIP	TELEM	7.5V TRANZORB	FUTURE	150	$1.39		$208.50

APPENDIX XXIV. -- Continued

P88-054B	EQUIP	TELEM	18V TRANZORB	FUTURE	25	$1.39	$1.91	$36.66
P88-056A	EQUIP	TELEM	DB-9 MALE PLUG	MOUSER	30	$1.56	$4.81	$51.61
P88-056B	EQUIP	TELEM	DB-9 FEMALE SOCKET	MOUSER	30	$2.12		$63.60
P88-056C	EQUIP	TELEM	DB-9 HOOD	MOUSER	30	$1.71		$51.30
P88-070	EQUIP	TELEM	WHIP ANTENNA	LARSEN	21	$39.70		$833.70
P88-071A	EQUIP	TELEM	LIGHTNING ARRESTOR	RF IND.	8	$18.50		$148.00
P88-071B	EQUIP	TELEM	'N' M. CRIMP RG58	RF IND.	50	$3.19	3.33	$162.83
P88-071C	EQUIP	TELEM	'N' M. SOLDER RG8	RF IND.	25	$3.27	1.8	$83.55
P88-071D	EQUIP	TELEM	'N' T F.	RF IND.	25	$7.26	1.36	$182.86
P88-072	EQUIP	TELEM	UHF M.-'N' M.	PASTERNACK	25	$12.97	$3.06	$327.31
P88-073	EQUIP	TELEM	4GAL. METAL DRUM	DLA	25	$15.00		$375.00
P88-074	EQUIP	TELEM	UHF SYNTHEX RADIO	HAMA	3	$375.00		$1,125.00
P88-088	EQUIP	TELEM	LAPLINK SOFTWARE	EGGHEAD	1	$77.00		$77.00
P88-091A	EQUIP	TELEM	ROUND HOLE PUNCH 3/4"	MOUSER ELECT.	1	$16.40		$16.40
P88-093C	EQUIP	TELEM	PARTS	NORVAC	1	$82.96		$82.96
P88-096A	EQUIP	TELEM	1/4" STANDOFFS	NEWARK	2	$33.21	$7.96	$74.38
P88-096B	EQUIP	TELEM	3/4" STANDOFFS	NEWARK	2	$35.99		$71.98
P88-099	EQUIP	TELEM	ELECT. SUPPLIES	NORVAC	1	$123.86		$123.86
P88-101	EQUIP	TELEM	ELECT. SUPPLIES	NORVAC	1	$27.67		$27.67
P88-102	EQUIP	TELEM	MDL100 CONNS	HIRSCHMANN	30	$2.18		$65.40
P88-103	EQUIP	TELEM	SYNTHEX PWR JACKS	RADIO SHACK	20	$0.70	DUPLICATE	= VOID
P88-104D	EQUIP	TELEM	DIKES	NORVAC	1	$8.95		$8.95
P88-106	EQUIP	TELEM	ADC CHIPS	JAMECO	10	$19.95		$199.50
P88-107	EQUIP	TELEM	MPU, A-D CHIPS	N. MICRO	1	$250.00	$2.33	$252.33
P88-107A	EQUIP	TELEM	MPU, A-D CHIPS	MARSHALL	1	$135.50	$2.00	$137.50
P88-108	EQUIP	TELEM	MPU, A-D CHIPS	HAM.- AV.	1	$363.00		$363.00
P88-109	EQUIP	TELEM	MPU, A-D CHIPS	DIGIKEY	1	$160.00		$160.00
P88-110	EQUIP	TELEM	MPU, A-D CHIPS	MOUSER	1	$198.25		$198.25
P88-111B	EQUIP	TELEM	SHIELDED 2-COND WIRE-TRP	DLA	10	$0.10		$1.00
P88-111C	EQUIP	TELEM	10-PIN BULK (ENV)	DLA	50	$4.57		$243.25
P88-114B	EQUIP	TELEM	UHF ANTS	LARSEN	8	$39.70		$317.60
P88-118	EQUIP	TELEM	RG58/U COAX	NEWARK	1	$110.00		$110.00
P88-119	EQUIP	TELEM	RADIO PWR JACKS	RADIO SHK.	20	$0.70		$13.90
P88-120A	EQUIP	TELEM	UHF M. - 'N' M.	PASTERNACK	15	$13.95		$209.25
P88-121A	EQUIP	TELEM	COAX LIGHTNING ARRESTOR	RF IND	30	$16.65		$499.50
P88-121C	EQUIP	TELEM	N' M. CRIMP RG58	RF IND	30	$2.87		$86.10
P88-121E	EQUIP	TELEM	N' M. SOLDER RG8	RF IND	35	$2.65		$92.75
P88-121H	EQUIP	TELEM	N' F. TEE	RF IND	15	$6.53		$97.95
P88-122	EQUIP	TELEM	GLAND CONN	ROFF	25	$2.52		$63.00
P88-126	EQUIP	TELEM	PLASTIC CAPS	PARKROSE	1	$8.92		$8.92
P88-127	EQUIP	TELEM	SYNTHEX UHF	HAMA	1	$375.00	Not obligated in time	
P88-128	EQUIP	TELEM	Sockets	NORVAC	1	$116.97		$116.97
P88-130	EQUIP	TELEM	10 PIN ENV. CONNS	ARROW	43	$10.50	$6.99	$458.49

TOTAL $11,945.08

EQUIP - TOOLS

P88-025	EQUIP	TOOLS	OSCILLOSCOPE	TEKTRONICS	1	$2,095.00	$6.89	$2,101.89
P88-028A	EQUIP	TOOLS	COAX CRIMPER	PASTERNACK	1	$69.95		$69.95
P88-033A	EQUIP	TOOLS	MOLEX EXTRACTOR	NEWARK	1	$13.85		$13.85
P88-033B	EQUIP	TOOLS	MOLEX CRIMPER	NEWARK	1	$18.02	$3.02	$21.04
P88-035A	EQUIP	TOOLS	HEAT GUN	NORVAC	1	$33.95		$33.95
P88-035C	EQUIP	TOOLS	COAX CRIMPER	NORVAC	1	$39.95		$39.95
P88-037B	EQUIP	TOOLS	CHIP EXTRACTOR	JAMECO	1	$13.29	$5.57	$18.86
P88-037F	EQUIP	TOOLS	OUTLET STRIP	JAMECO	4	$11.95		$47.80
P88-039	EQUIP	TOOLS	DISKS,CVO EXCHANGE FOR IC&	WINTEX	1	$203.33	$1.34	$204.67

P88-056D	EQUIP	TOOLS	DB-9 HOLE PUNCH	MOUSER	1	$139.99		$139.99
P88-091B	EQUIP	TOOLS	ROUND HOLE PUNCH 1-1/16"	MOUSER ELECT.	1	$18.83		$18.83
P88-092	EQUIP	TOOLS	HANDTOOLS	VANCOUVER BOLT	1	$47.38		$47.38
P88-104E	EQUIP	TOOLS	HANDLE	NORVAC	1	$2.76		$2.76
P88-124	EQUIP	TOOLS	7/8 HOLESAW	VAN. BOLT	1	$7.23		$7.23
						TOTAL	$2,768.15	

EQUIP - TRAINING

P88-009	EQUIP	TRAIN	CONVERT, GULUNGONG TAPE	AMER. VIDEO LAB	1	$83.00	$2.64	$85.64
P88-019	EQUIP	TRAIN	HAZARDS SOURCEBOOK	UNESCO	10	$10.00		$100.00
P88-059A	EQUIP	TRAIN	GEOL STUDIES, ASHFLOW	GEO.SOC.AM	1	$25.00		$25.00
P88-059B	EQUIP	TRAIN	GEOL STUDIES, DOMES	GEO.SOC.AM	1	$18.75		$18.75
P88-059D	EQUIP	TRAIN	GEOL STUDIES, ASIA VOLC	GEO.SOC.AM	1	$13.00		$13.00
P88-059E	EQUIP	TRAIN	GEOL STUDIES, BATH, CHILE	GEO.SOC.AM	1	$18.50		$18.50
P88-059F	EQUIP	TRAIN	GEOL STUDIES, MAP ATITLAN	GEO.SOC.AM	1	$11.00		$11.00
P88-090	EQUIP	TRAIN	REVISTA GEOFISICA SUB.	MEXICO	1	$25.00		$25.00
						TOTAL	$296.89	

EXPEND - ADMIN

P88-022A	EXPEND	ADMIN	REPT TO CHRISTIANSEN	DHL	1	$21.52		$21.52
P88-022B	EXPEND	ADMIN	REPT TO NEW OFDA	DHL	1	$6.82		$6.82
P88-029	EXPEND	ADMIN	AA BATTERIES	GSA	144	$0.24		$34.56
P88-062	EXPEND	ADMIN	DHL HAGAN	DHL	1	$4.94		$4.94
P88-063	EXPEND	ADMIN	DHL, HARLOW	DHL	1	$4.94		$4.94
P88-064	EXPEND	ADMIN	F.G.B. 3/4 35MM	F & H MARKETING	240	$0.40		$96.00
P88-066A	EXPEND	ADMIN	OVERHEAD TRANSPAR	US GOV	2	$26.77	$17.74	$71.28
P88-066B	EXPEND	ADMIN	HEAD CLEANING	US GOV	1	7.85		$7.85
P88-076	EXPEND	ADMIN	DHL-VIDEO TO FGB	DHL	1	$10.00		$10.00
P88-077	EXPEND	ADMIN	DHL VIDEO SLIDES	DHL	1	$6.82		$6.82
P88-082	EXPEND	ADMIN	PRINTING PAPER	GSA AUBURN	3	$21.01		$63.03
P88-100A	EXPEND	ADMIN	PAPER. LASER	GSA SUPPLY	20	$20.56		$411.20
P88-100B	EXPEND	ADMIN	PENCIL, 5 MM	GSA SUPPLY	2	$19.75		$39.50
P88-140	EXPEND	ADMIN	DHL FROM Ecuador, coll.	DHL	1	$41.00		$41.00
						TOTAL	$819.46	

EXPEND - AUTODATA/DATABASE

P88-020	EXPEND	AUTODATA	INK RIBBON	GSA	1	$9.17	$2.65	$11.82
P88-035E	EXPEND	AUTODATA	PRINTER CABLE	NORVAC	1	$15.00		$15.00
P88-042	EXPEND	DBASE	REPAIR TOSHIBA	WESTCOM	1	$274.16		$274.16
P88-093A	EXPEND	AUTODATA	DATA CABLE	NORVAC	1	$28.33		$28.33
P88-093B	EXPEND	DBASE	GENDER CHANGER	NORVAC	1	$20.00		$20.00
P88-093C	EXPEND	DBASE	3.5 DISKS - DYSAN	NORVAC	1	$22.40		$22.40
P88-094	EXPEND	AUTODATA	3 1/2 DISKETTES	GSA	40	$1.32		$52.80
P88-136A	EXPEND	AUTODATA	3 1/2 DISKETTES	GSA	4	$15.18		$60.72
P88-136B	EXPEND	AUTODATA	5 1/2 DISKETTES	GSA	4	$17.60		$70.40
						TOTAL	$1,047.33	

EXPEND - DEFORMATION

P88-112	EXPEND	DEFORM	EXPAN. BOLTS	VANCOUVER BOLT	100	$3.55		$355.00
P88-113	EXPEND	DEFORM	SURVEY BOOKS (6)	LANDMARK	1	$263.00		$263.00
P88-132	EXPEND	DEFORM	EDM PRISMS	LEWIS & LEWIS	12	$105.00		$1,260.00

APPENDIX XXIV. -- Continued

						TOTAL	$1,878.00	
EXPEND - GAS/GEO								
P88-078A	EXPEND	GAS/GEO	AG/AGCL SOLUTION	MARKSON	1	$28.80		$28.80
P88-078B	EXPEND	GAS/GEO	STORE SOLUTION	MARKSON	1	$12.15		$12.15
P88-078C	EXPEND	GAS/GEO	SAFE PIPETTE FILLER	MARKSON	1	$8.40		$8.40
P88-078D	EXPEND	GAS/GEO	CONTAINER, LIQUID	MARKSON	1	$47.50		$47.50
P88-078E	EXPEND	GAS/GEO	GLASS, 25MM PIPETTE	MARKSON	4	$2.88		$11.52
P88-078F	EXPEND	GAS/GEO	POLYPROP BOTTLE	MARKSON	2	$9.00		$18.00
P88-083	EXPEND	GAS\GEO	PH CAPSULES	DAIGGER	1	$71.40		$71.40
P88-084	EXPEND	GAS\GEO	BURET,FUNNEL,BOTTLE	DAIGGER	1	$34.27		$34.27
P88-086	EXPEND	GAS/GEO	CL QUANT	MARKSON	1	$34.50	$1.91	$36.41
P88-095	EXPEND	GAS/GEO	CHEM PARTS	DAIGGER	1	$261.40		$261.40
						TOTAL	$529.85	
EXPEND - GEO/OBS								
P88-057B	EXPEND	GEO/OBS	20 MIN, 1/2 VIDTAPE		20	$4.00		$80.00
P88-069B	EXPEND	GEO/OBS	20 MIN JVC TAPE	R D MACARTHUR	20	$4.98		$99.60
P88-008	EXPEND	GEO/OBS	FILM DEVELOP, LYN	TYMERS	1	$20.92		$20.92
P88-023	EXPEND	GEO/OBS	SLIDE PROTECTOR	TYMERS	1	$27.76		$27.76
P88-097	EXPEND	GEO/OBS	8 ROLLS/PERU TRIP	TYMERS	8	$4.92		$39.36
						TOTAL	$267.64	
EXPEND - LOGIS								
P88-003	EXPEND	LOGIS	TRUNK, JENSEN	JENSEN	2	$199.00		$398.00
P88-065A	EXPEND	LOGIS	ROCK BOX	USGS-Menlo	1	$7.53		$7.53
						TOTAL	$405.53	
EXPEND - SAFETY								
P88-038	EXPEND	SAFETY	TAD RADIO PARTS	TAD USA	1	$12.00	$1.34	$13.34
P88-049	EXPEND	SAFETY	REPAIR MOTOROLA	VEL	1	$0.00		$0.00
						TOTAL	$13.34	
EXPEND - SEISMIC								
EXPEND - TELEM								
P88-035G	EXPEND	TELEM	HEAT SHRINK TUBING	NORVAC	1	$2.64		$2.64
P88-085A	EXPEND	TELEM	2 PIN JACKS	DLA	14	$5.24		$73.36
P88-085B	EXPEND	TELEM	2 PIN PLUGS	DLA	18	$7.35		$132.30
P88-089A	EXPEND	TELEM	CMOS COOKBOOK	NORVAC	1	$18.95		$18.95
P88-089B	EXPEND	TELEM	LINEAR DATABOOK	NORVAC	1	$19.95		$19.95
						TOTAL	$247.20	
EXPEND - TOOLS								
P88-031	EXPEND	TOOLS	HDL102 SERVICE MAN.	RADIO SHACK	1	$9.88		$9.88
						TOTAL	$9.88	
EXPEND - TRAIN								

APPENDIX XXIV. -- Continued

P88-010	EXPEND	TRAIN	LEVELING STANDARDS	GOV'T PRNT. OFF.	1	$96.00		$96.00
P88-043	EXPEND	TRAIN	1/2"VHS CAMERA RENTAL	CAMCORDER CITY	1	$25.00		$25.00
P88-057A	EXPEND	TRAIN	60 MIN 1/2" VIDTAPE	GSA-AUBURN	10	$5.00		$50.00
P88-065B	EXPEND	TRAIN	120M VID CAS	GSA-AUBURN	20	$4.65		$93.00
P88-069A	EXPEND	TRAIN	3/4 VID TAPE	R D MACARTHUR	10	$8.44		$84.40
P88-080	EXPEND	TRAIN	KILAUEA ERUPT PHENOM	KA IO PRO.	1	$39.95	$5.00	$44.95
P88-087A	EXPEND	TRAIN	1/2 VHS PROFESSIONAL	R.D. MacArthur As	10	$6.64		$66.40
P88-087B	EXPEND	TRAIN	1/2 VHS STANDARD	R.D. MacArthur	10	$3.32		$33.20
						TOTAL	$492.95	

TRAVEL

P88-014A	TRAVEL	AIRFARE	NORM, SO. AM.	VOUCHER	1	$1,918.00		$1,918.00
P88-014B	TRAVEL	PERDIEM	NORM, SO. AM.	VOUCHER	1	$1,479.50		$1,479.50
P88-014C	TRAVEL	AIRFARE	NORM, SO. AM.	VOUCHER	1	$63.13		$63.13
P88-014D	TRAVEL	VEHICLE	NORM, SO. AM.	VOUCHER	1	$262.34		$262.34
P88-044P	TRAVEL	PERDIEM	NORM, COLOMB 4/88	VOUCHER	1	$1,229.35		$1,229.35
P88-044T	TRAVEL	AIRFARE	NORM, COLOMB 4/88	TICKET	1	$1,547.00		$1,547.00
P88-067A	TRAVEL	AIRFARE	ANDY, SO.AM.	TICKET	1	$1,918.00		$1,918.00
P88-067B	TRAVEL	PERDIEM	ANDY, SO.AM.	VOUCHER	1	$1,488.25		$1,488.25
P88-067C	TRAVEL	PERDIEM	ANDY, SO.AM.	VOUCHER	1	$236.50		$236.50
P88-067D	TRAVEL	PERDIEM	ANDY, SO.AM.	VOUCHER	1	$38.50		$38.50
P88-067E	TRAVEL	PERDIEM	ANDY, SO.AM.	VOUCHER	1	$1,763.25		$1,763.25
P88-068A	TRAVEL	AIRFARE	MARY ELLEN WILLIAMS	TICKET	1	$1,335.00		$1,335.00
P88-068B	TRAVEL	PERDIEM	MARY ELLEN WILLIAMS	VOUCHER	1	$1,024.33		$722.25
P88-068C	TRAVEL	PERDIEM	MARY ELLEN WILLIAMS	VOUCHER	1	$1,024.33		$96.95
P88-068D	TRAVEL	PERDIEM	MARY ELLEN WILLIAMS	VOUCHER	1	$1,024.33		$200.13
P88-068E	TRAVEL	PERDIEM	MARY ELLEN WILLIAMS	VOUCHER	1	$1,024.33		$1,024.33
P88-098A	TRAVEL	PERDIEM	NORM - PERU 6/88	VOUCHER	1	$680.25		$680.25
P88-098B	TRAVEL	PERDIEM	NORM - PERU 6/88	TICKET	1	$1,902.00		$1,902.00
P88-098C	TRAVEL	PERDIEM	NORM - PERU 6/88	VOUCHER	1	$184.00		$184.00
P88-098D	TRAVEL	PERDIEM	NORM - PERU 6/88	VOUCHER	1	$55.00		$55.00
P88-098E	TRAVEL	PERDIEM	NORM - PERU 6/88	VOUCHER	1	$76.48		$76.48
P88-098F	TRAVEL	PERDIEM	NORM - PERU 6/88	VOUCHER	1	$14.90		$14.90
P88-134A	TRAVEL	PERDIEM	HARLOW, COLOMBIA 3/88	VOUCHER	1	$1,011.75		$1,011.75
P88-134A	TRAVEL	AIRFARE	HARLOW, COLOMBIA 3/88	TICKET	1	$1,199.14		$1,199.14
P88-134B	TRAVEL	PERDIEM	HARLOW, COLOMBIA 3/88	VOUCHER	1	$31.80		$31.80
P88-134C	TRAVEL	PERDIEM	HARLOW, COLOMBIA 3/88	VOUCHER	1	$198.66		$198.66
P88-134D	TRAVEL	PERDIEM	HARLOW, COLOMBIA 3/88	VOUCHER	1	$700.00		$700.00
P88-134E	TRAVEL	PERDIEM	HARLOW, COLOMBIA 3/88	VOUCHER	1	$141.63		$141.63
P88-134F	TRAVEL	PERDIEM	HARLOW, COLOMBIA 3/88	VOUCHER	1	$21.00		$21.00
P88-138A	TRAVEL	AIRFARE	NORM,ECUADOR 9/88	VOUCHER	1	$1,455.00		$1,455.00
P88-138B	TRAVEL	PERDIEM	NORM,ECUADOR 9/88	VOUCHER	1	$895.00		$895.00
P88-139A	TRAVEL	AIRFARE	JOHN, ECUADOR 9/88	VOUCHER	1	$1,455.00		$1,455.00
P88-139B	TRAVEL	PERDIEM	JOHN, ECUADOR 9/88	VOUCHER	1	$232.00		$232.00
						TOTAL	$25,576.09	

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