PDGAC-086

SOUTHERN ITALY SEISMIC/VOLCANIC MONITORING PROJECT PAPER (SISM)

BEST AVAILABLE DOCUMENT

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT DATA SHEET

1. TRANSACTION CODE: A (A = Add, C = Change, D = Delete) — Amendment Number: 4 — DOCUMENT CODE: 4

2. COUNTRY/ENTITY: Italy

3. PROJECT NUMBER: 145-0001

4. BUREAU/OFFICE: Bureau for Near East

5. PROJECT TITLE (maximum 40 characters): S. Italy Earthquake Reconstruction

6. PROJECT ASSISTANCE COMPLETION DATE (PACD): MM 09 DD 30 YY 97

7. ESTIMATED DATE OF OBLIGATION (Under 'B.' below, enter 1, 2, 3, or 4)
A. Initial FY 81 B. Quarter 4 C. Final FY 85

8. COSTS ($000 OR EQUIVALENT $1 =)

A. FUNDING SOURCE	FIRST FY B. FX	C. L/C	D. Total	LIFE OF PROJECT E. FX	F. L/C	G. Total
AID Appropriated Total	45,765		45,765	63,921		63,921
(Grant)	(45,765)	( )	(45,765)	(63,921)	( )	(63,921)
(Loan)	( )	( )	( )	( )	( )	( )
Other U.S. 1.						
Other U.S. 2.						
Host Country		9,000	9,000		12,700	12,700
Other Donor(s)						
TOTALS	45,765	9,000	54,765	63,921	12,700	76,621

9. SCHEDULE OF AID FUNDING ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	C. PRIMARY TECH. CODE 1. Grant	2. Loan	D. OBLIGATIONS TO DATE 1. Grant	2. Loan	E. AMOUNT APPROVED THIS ACTION 1. Grant	2. Loan	F. LIFE OF PROJECT 1. Grant	2. Loan
(1) IDA#	930	940		62,265		1,656		63,921	
(2)									
(3)									
(4)									
TOTALS				62,265		1,656		63,921	

10. SECONDARY TECHNICAL CODES (maximum 6 codes of 3 positions each)

11. SECONDARY PURPOSE CODE

12. SPECIAL CONCERNS CODES (maximum 7 codes of 4 positions each)
A. Code
B. Amount

13. PROJECT PURPOSE (maximum 480 characters)

To assist Italy in its reconstruction efforts related to the damage done by the November 23, 1980 earthquake that devastated a widespread area in Southern Italy. The project funds the reconstruction of school buildings and related facilities together with other services in Southern Italy including the Provinces of Avellino, Potenza and Salerno. *International Disaster Assistance

14. SCHEDULED EVALUATIONS
Interim MM 09 YY 85 MM YY
Final MM 09 YY 97

15. SOURCE/ORIGIN OF GOODS AND SERVICES
☒ 000 ☐ 941 ☒ Local ☐ Other (Specify)

16. AMENDMENTS/NATURE OF CHANGE PROPOSED (This is page 1 of a 17 page PP Amendment.)
This amendment increases funding for the project and adds a new element - activities to improve predictive capacity of scientific institutes studying siesmic activity in the Pozzuoli area.

17. APPROVED BY
Signature: [signature]
Title: Director, NE/PD
Date Signed: MM DD YY

18. DATE DOCUMENT RECEIVED IN AID/W, OR FOR AID/W DOCUMENTS, DATE OF DISTRIBUTION
MM DD YY

SOUTHERN ITALY SEISMIC/VOLCANIC MONITORING
PROJECT PAPER

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ABBREVIATIONS USED IN PROJECT PAPER

A.I.D.	Agency for International Development
AID/Naples	Agency for International Development/Naples
AID/Rep	AID Representative
ESF	Economic Support Funds
FX	Foreign Exchange
FY	Fiscal Year
GOI	Government of Italy
IFB	Invitation For Bids
IUN	University Navale Institute
LC	Local Currency
OFDA	Office of Foreign Disaster Assistance
OV	Vesuvius Observatory
PACD	Project Activity Completion Day
PASA	Participating Agency Services Agreement
RFP	Request for Proposals
USGS	United States Geological Survey

PART I.

SUMMARY AND RECOMMENDATIONS

A. Recommendations. AID/Naples recommends that the Assistant Administrator for the Near East Bureau authorize that $2.0 million of OFDA FY 81 funds, either from unprogrammed or from the $1.6 million deob/reob Emergency Relief funds be used to improve the early warning capability with respect to the volcanic eruptions in the Campi Flegrei region of Southern Italy and that a categorical exclusion from an initial environmental examination be granted for this project. The project is technically, economically, financially and administratively sound.

B. Project Description. The goal of this project is to enable Italy to develop more fully its disaster preparedness program in Southern Italy by increasing the early warning capability for potential volcanic eruptions in the Campi Flegrei region (purpose). This will be accomplished by improving both the quantity and the quality of data available to scientists through the provision of high technology instrumentation and associated state of the art software, such as a seismic network, a tiltmeter network, a magnetotelluric station, geochemical monitoring equipment, data acquisition processing equipment, and baseline offshore structure of the caldera and associated research efforts. At the end of the project a data center will be in full operation, which will receive, monitor and make available all data from this project to the scientific organizations concerned with the monitoring of the Campi Flegrei volcanic activity.

The project will be implemented and managed with the assistance of a U.S. contractor or through a USGS/PASA (Participating Agency Services Agreement). The feasibility of the USGS filling this role has yet to be discussed with line authority managers within the USGS. The U.S. contractor staff will be augmented by at least 2 persons seconded from both the Osservatorio Vesuviano and the Instituto Universitario Navale. A project steering committee composed of representatives from the Osservatorio Vesuviano (OV), the Instituto Universitario Navale (IUN), Campania Assesone for Science, AID and the contractor will monitor all activities and give technical advice and approvals.

C. Summary Findings. This project is funded from OFDA FY 81 funds as a substitute for deobligated ESF money from Syria under appropriation for Section 491 of the Foreign Assistance Act of 1961 as amended. These ESF (FY84) were obligated for School Construction with the understanding that this seismic monitoring project would be funded from prior year obligations. Thus the OFDA FY81 funds can be used for disaster preparedness assistance, which is the goal of this project.

The Project activities selected are those considered to be technically necessary to achieve the project purpose. Because the data collection and processing and the associated research on the Campi Flegrei activity may continue into the indefinite future, the technical team was asked to provide two packages for AID/Naples to consider in its final design of the project. The first, Phase I, was a low budget, minimal package, costing approximately $2 million (and is the package AID/Naples has selected). The second mainly added more research, additional geochemical monitoring, and installation of the magnetotelluric equipment and the off-line data processing equipment to the initial project. Annex H contains additional activities the Italian Scientists would like to undertake but these are not necessary for project success.

D. Project Issues

1. Housing of the Data Center. As detailed in Parts III & IV, the two principal Italian institutions may each be housing some of their facilities in one building, the Centro Geremicca at Posillipo, Naples.

Ideally this AID financed project data center should be housed in the same building. A Condition Precedent will be put into the Project Agreement for the establishment of a data center, if the Center is not operational at the time of signing the Project Agreement.

2. Data Control. Much of the data to be collected and shared could be important in terms of an early alert system. The project assumes that all data will be shared between all Italian government institutions having a need for this information. Other access would be contingent on the consent of the Italian government.

3. Ownership of Equipment. Ownership of the equipment remains to be decided. After the second year of the project, the Italian authorities will decide which institution will be responsible for maintenance. Until that time all equipment will be under the control of the U.S. contractor, who will be responsible for its maintenance. But, prior to disbursement a commitment to maintain and operate the equipment will be obtained.

4. Taxation. Because there is no overall bilateral with Italy, A.I.D. will rely on the standard tax provision in Annex 2 to the Project Agreement.

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E. AID Project Committee

Engr. Tibor Nagy Chairman	
Prof. Paolo Gasparini	Geophysicist
Dr. David Hill (USGS)	Geophysicist
Dr. Enrico Bonatti	Geologist
Dr. Leonardo Seeber	Seismologist
Dr. James Scheimer	Seismologist
Dr. Nathalie Silver	Geochemist
Ms. Denise Poole Committee member	
Ms. Rosanna Gatta	Committee member

F. Government of Italy Contributors

Eng. Alfredo Pozzi	Assessore Regione Campania
Prof. Lorenzo Mirabile	Director Instituto Univ. Navale
Prof. Giuseppe Luongo	Director Osservatorio Vesuviano
Prof. Francesco Barberi	Universita' di Pisa
Prof. Marcello Carapezza	Universita' di Palermo

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PART II. PROJECT RATIONALE AND DETAILED DESCRIPTION

A. Background

1. Earthquake Disaster in Southern Italy and Congressional Response. On November 23, 1980, a severe earthquake struck the southern part of the Italian Peninsula. The quake, with its epicenter in Irpinia, registered 6.8 on the Richter Scale and has been characterized as the most devastating disaster to strike Western Europe since World War II. It killed approximately 3,000 people and injured 7,700. Living quarters for approximately 250-300,000 people were destroyed, as well as about 100,000 other structures such as schools and public buildings.

The United States Government responded with immediate assistance worth about $2,5 million. Immediately after that, the Congress appropriated an initial amount of $50 million (including the original $2.5 million) for relief and reconstruction for the victims of the earthquake. This amount was increased in subsequent years to $70 million which was divided between assistance to Private Voluntary Organizations for their reconstruction work in Southern Italy and the AID program of assistance to the regions of Campania and Basilicata for the construction of schools.

In 1984 Congress provided an additional $10,000,000 for Italy in Section 101(b)(1) of the Further Continuing Appropriations 1984; Public Law 98-151 as follows:

Twenty five million dollars for "International Disaster Assistance", to remain available until expended, of which $10,000,000 shall be used only for earthquake relief and reconstruction in southern Italy, which amount may be derived either from amounts appropriated to carry out the provisions of section 491 of the Foreign Assistance Act of 1961 or from up to $10,000,000 of amounts heretofore appropriated pursuant to chapter 4 of part II of such Act for Syria which are, if deobligated, hereby continued available for the purposes of section 491 or for other programs for Italy consistent with Sections 103 through 106 of such Act.

2. Rationale for Project. It is within this context that the current project has been developed. In mid-1984, the Italian Authorities approached AID/Naples and asked whether a portion of the additional assistance could be used for disaster preparedness assistance in Southern Italy. They expressed particular interest in the volcanic hazards presented by increased earthquake activity and ground deformation in the Campi Flegrei area. While current monitoring programs initiated but Italian scientists are tracking this activity, several of the monitoring activities should be

augmented to enhance the effectiveness of the early warning system for an imminent volcanic eruption. Section 491 (b) of the Foreign Assistance Act of 1961, as amended, permits the use of disaster assistance funds for "assistance relating to disaster preparedness". Thus AID/Naples was able to agree to such a use of the funds deobligated from the Syria program or using excess FY81 OFDA funds.

This Project Paper presents a program for improving monitoring and research relative to tectonic and magmatic activity in the Campi Flegrei, aimed at limiting the hazards risk by increasing the effectiveness of the Early Warning capability for potential eruptions of this volcanic system. The activities presented are those considered necessary for a base monitoring program. Additional activities which would augment the basic system might be proposed in a Phase II of this project, if funds become available. Phase II activities are presented in Annex H.

3. Historical Record and Recent Changes. The Campi Flegrei volcano is located (Figure 1) on the northwestern flank of the 20 mile wide embayment which is contained within the perimeter of the Campi Flegrei (fiery fields) caldera and may be structurally controlled by this caldera (Fig. 2). The Campi Flegrei are located in the hinterland of the Appenine fold belt which has been affected by Plio-Pleistocene, primarily longitudinal (i.e. parallel to the north-western trend of the Appenines), normal and transversal faults. Probably the faults are associated with considerable extension and crustal thinning and with the foundering of the portion of the Appenines along the Tyrrenian coast. During this extensional stage complex volcanic systems including the one around the Bay of Naples, have grown along this foundering Appenine hinterland. Petrochemically these volcanic systems can be broadly characterized as alkaline-potassic.

The oldest out-cropping products have an age of 45,000 years and the Campi Flegrei caldera were probably formed with a major explosive eruption 35,000 years ago. This eruption expelled 80 cubic kilometers of material (compared with 1.5 cubic kilometers in the 1981 Mt. St. Hellen eruption) and is by far the largest known to have occurred in the area. Several periods of extrusive activity followed this eruption. The last one is the relatively minor Monte Nuovo eruption in 1538 when 0.03 cubic kilometers of material was extruded.

Most of the Volcanic products from the Campi Flegrei are pyroclastics such as braccias, base-surge and ash flow deposits, tuffs, hydromagmatic tuffs. Lava flows and domes represent a small portion of the volcanic products. This assemblage suggests a predominance of explosive activity probably associated with shallow depth interaction between water and magma.

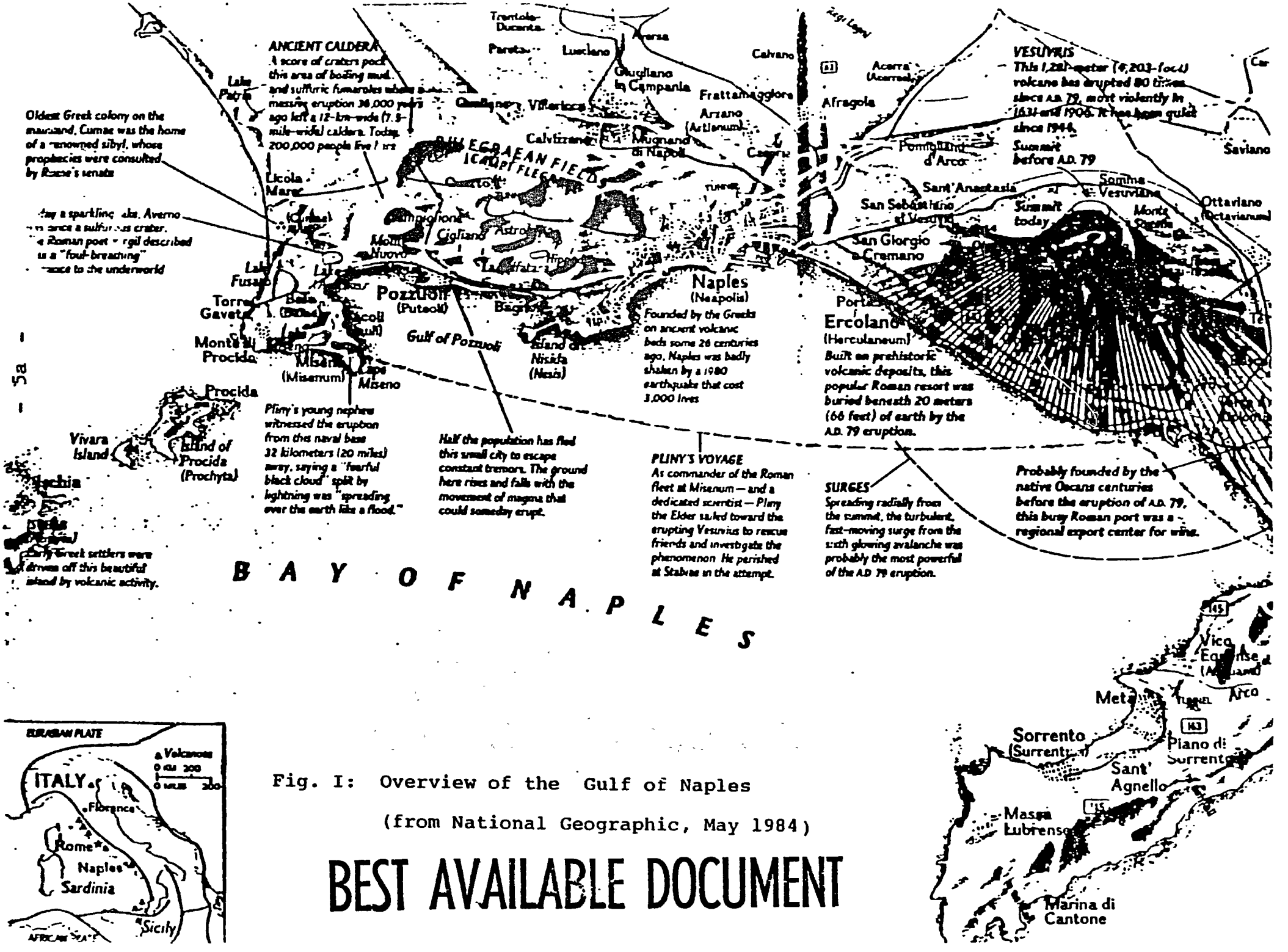

Fig. I: Overview of the Gulf of Naples

(from National Geographic, May 1984)

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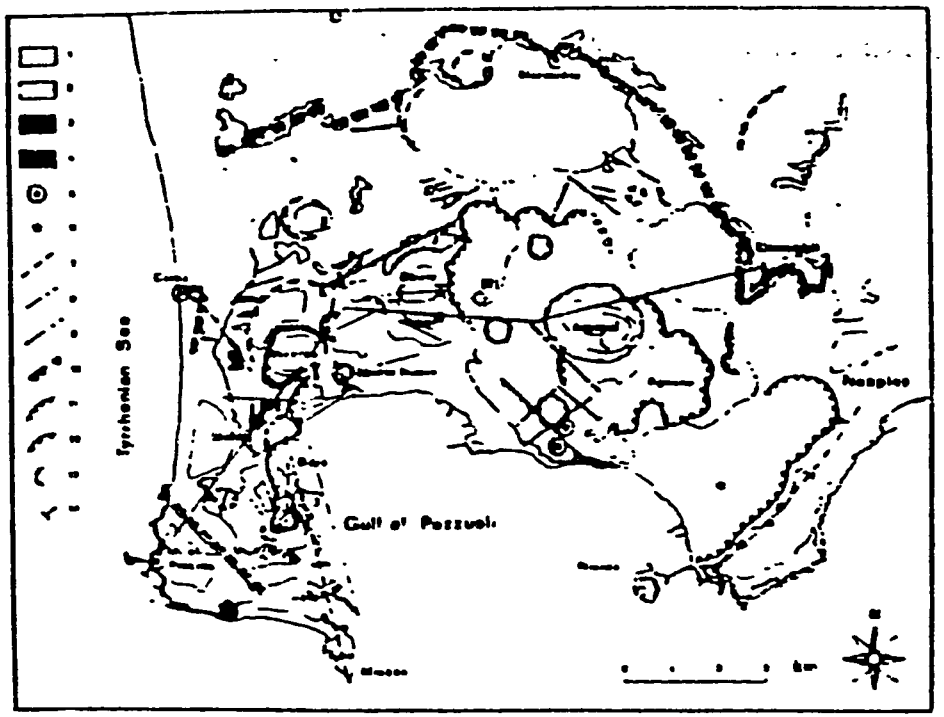

Fig. 2 - Geological sketch map of Phlegraean Fields: 1. urban areas and soil cover, 2. post-caldera deposits, mostly subaerial tephra and minor lavas, age 10,500 years b.p. to 1538 A.D.; 3. post-caldera mostly submarine activity, age comprised between 35,000 and 10,5000 years b.p., yellow chaotic tuffs and yellow layered tuffs; 4. pre-caldera activity, age older than 35,000 years b.p., lava domes, tephra and products of Campanian Ignimbrite eruptions; 5. lava domes; 6. inferred eruptive centers; 7. feeding fractures, 8. fractures; 9. faults; 10. caldera rim. 11-12. volcano-tectonic collapses related to post-caldera activity (full squares 35,000-10,500 yr.; open squares 10,500-present); 13. crater rim;

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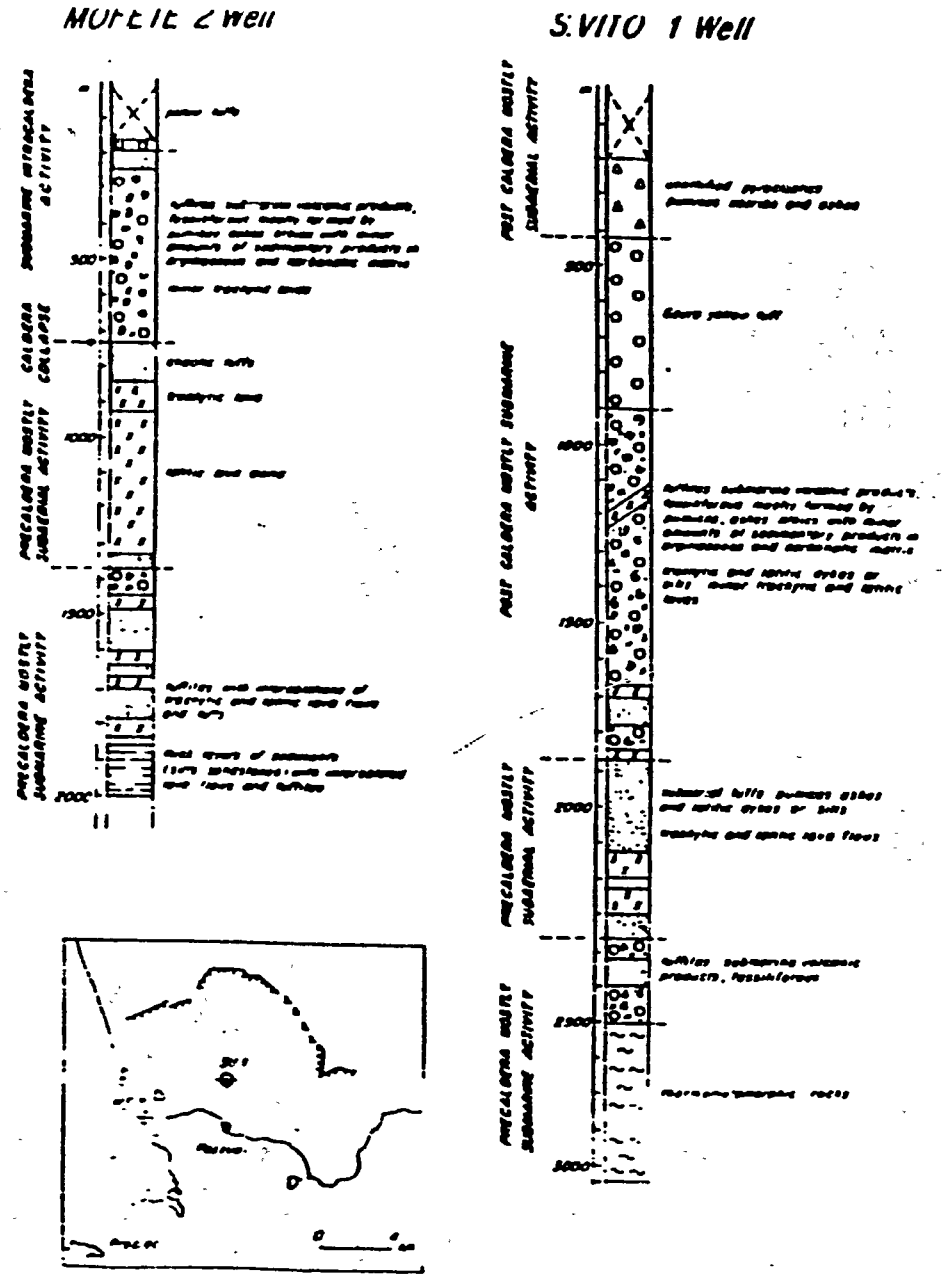
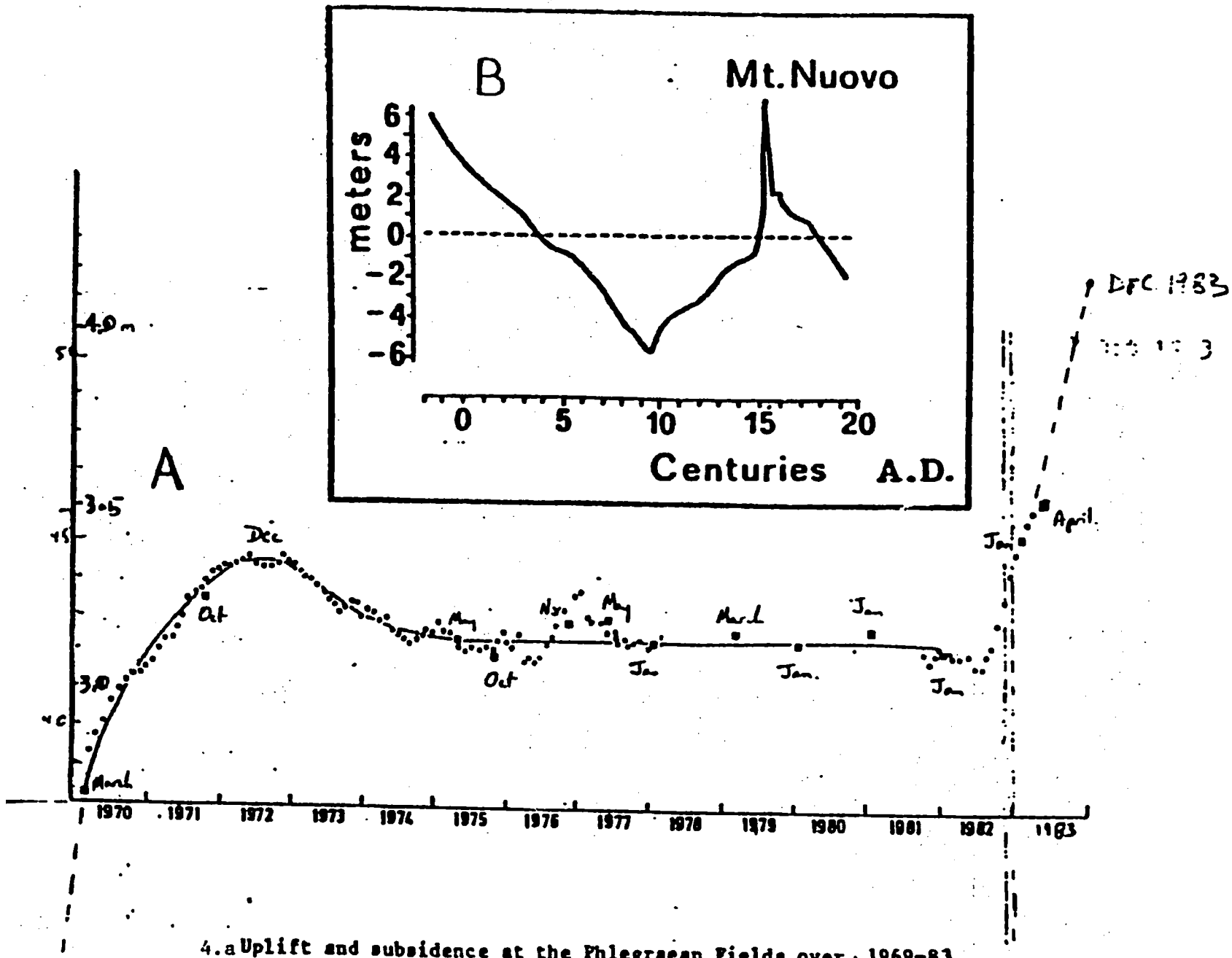


Fig. 3 Schematic subsurface stratigraphy of Mofete and S. Vito areas (from geothermal well data)

Figs.2&3



4.a Uplift and subsidence at the Phlegraean Fields over 1969-83.

4.b. Vertical ground movements at the Phlagraean Fields since inferred from sea level changes at the Roman market place Serapeo

Fig. 4

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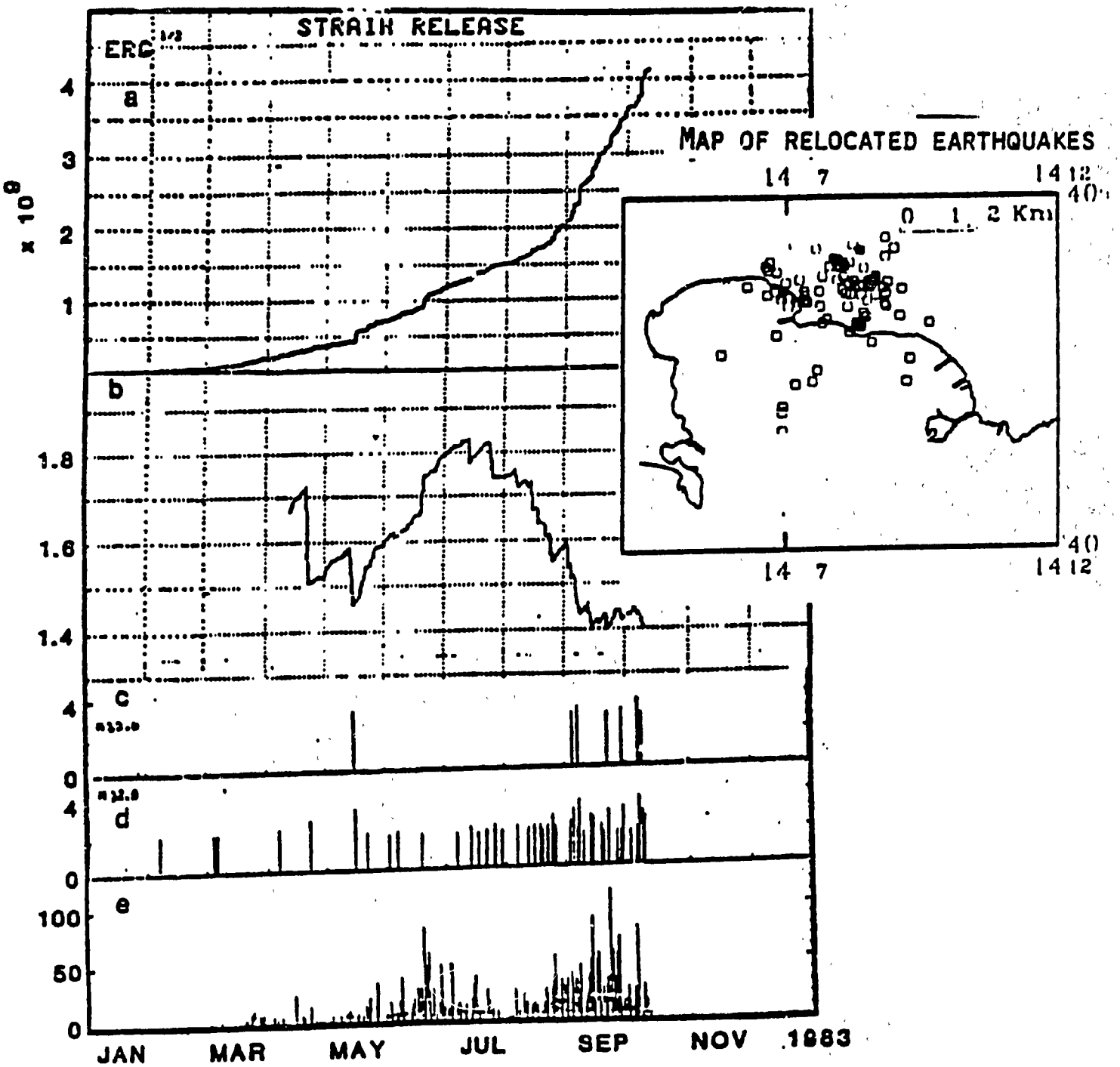

gure 5 Earthquake activity at the Phlagraean Fields during nuary-September 1983: a) strain release; b) b-value; c) number of akes larger than magnitude 3.0; d) number of quakes larger than gnitude 2.0; e) total number of recorded quakes. Unpublished data from Luongo and F. Barberi.

Fig.5

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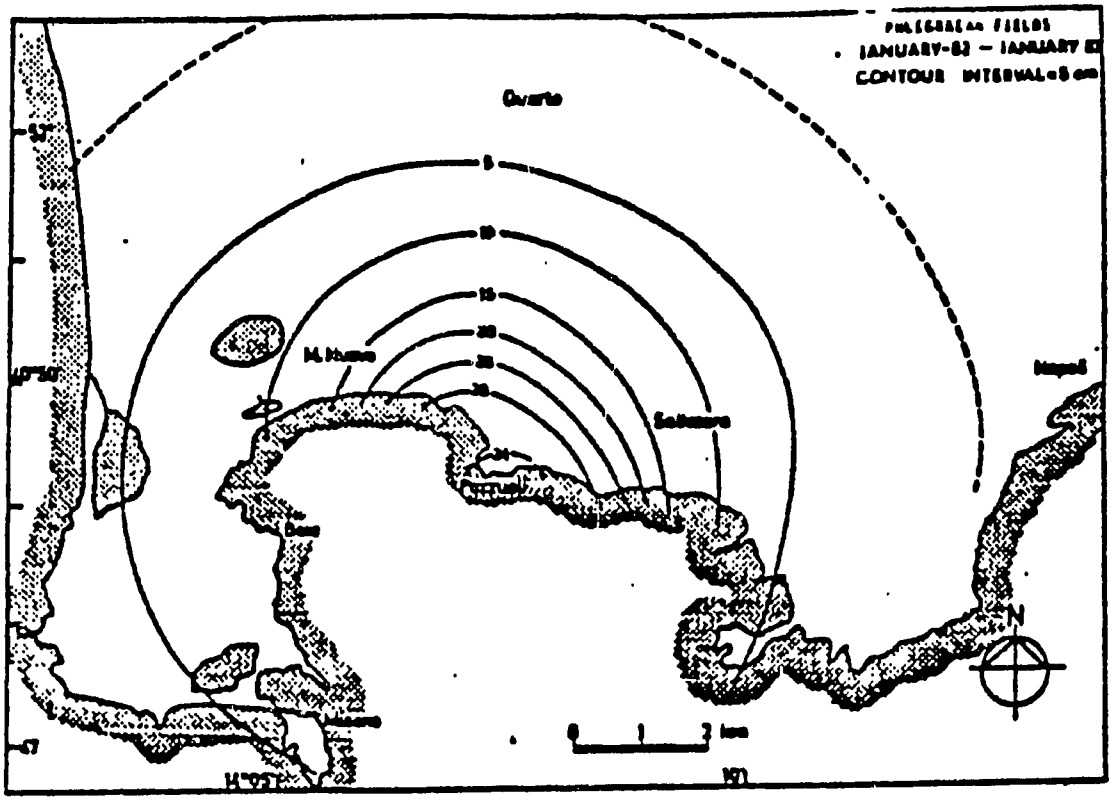

Figure 6.a Contour map of Phlagraean Fields uplift during 1982 from repeated leveling surveys. Contour interval = 5 cm. Unpublished data from G. Luongo and F. Barberi.

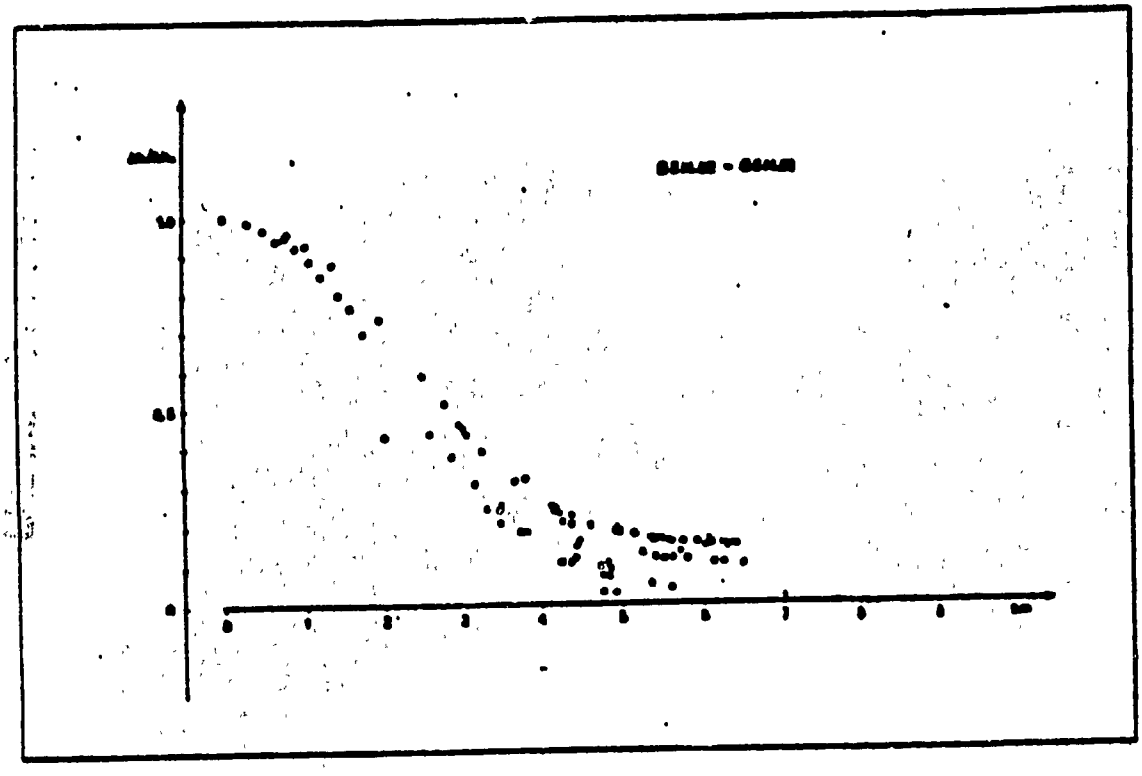

Figure 6.b. Plot of fractional uplift versus lateral distance from the deformation center, suggesting that deformation source lies at about 3 km depth.

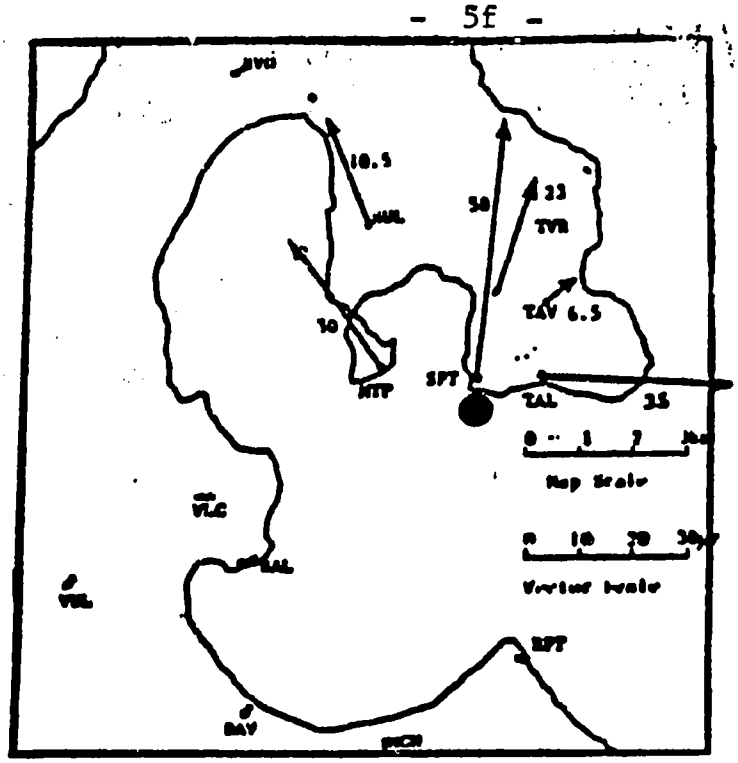

Figure 7 : Dry tilt changes at Rabaul caldera during September 1983, showing an inflation center (dot) southeast of Matupit Island (MTP).

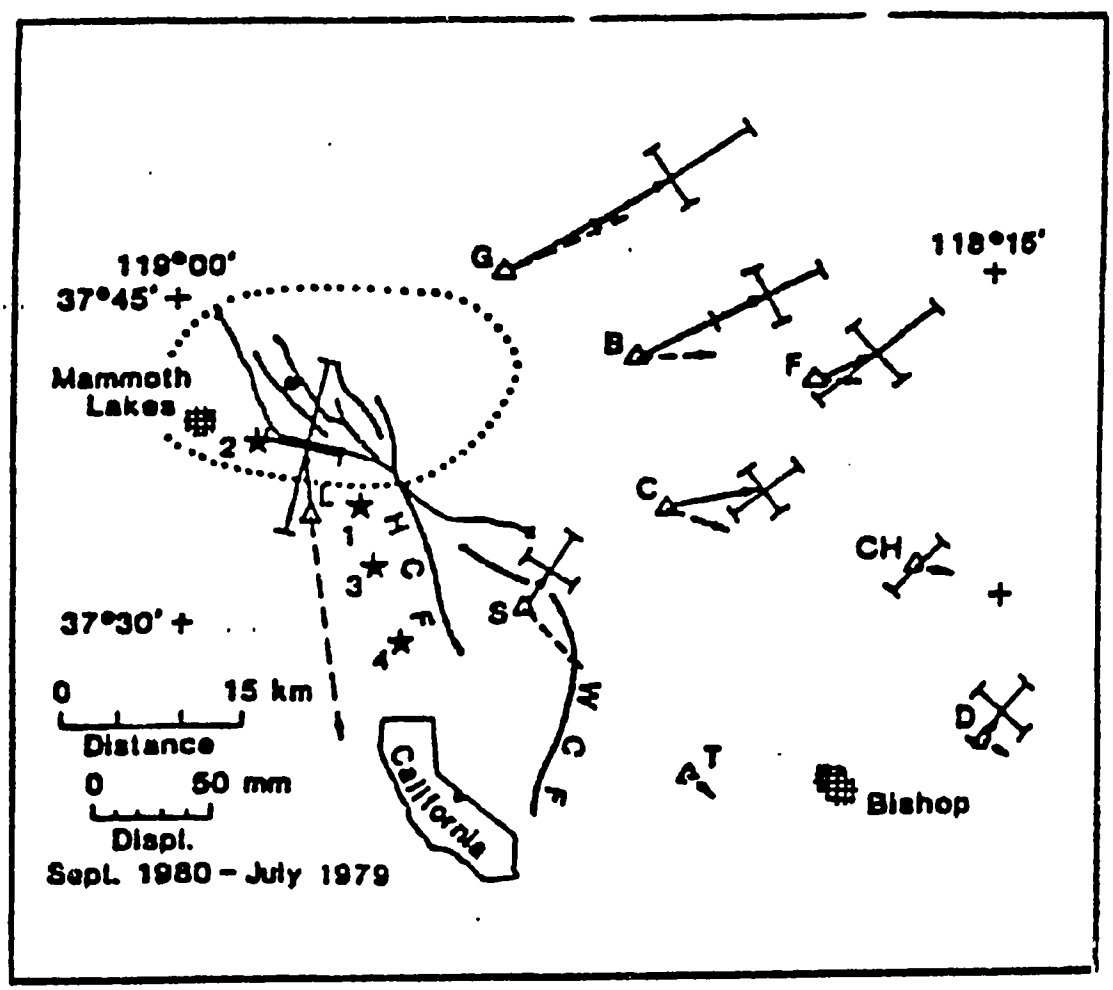

Figure 8 Horizontal displacements near Long Valley caldera from precise trilateration surveys in July 1979 and September 1980; figure from Savage and Clark (1982). Solid arrows show observed displacements, dashed arrows show displacements expected from expansion of a spherical magma chamber at 11 km depth.

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A considerable amount of drilling and other sub-surface exploration for geothermal purposes in the Campi Flegrei has revealed a basement, probably non-volcanic, at a depth greater than 3 kilometers. Pyroclastic material make up most of the 3 kilometers above this "basement" (Fig. 3). The upper half or more of this thickness is made up by material contemporaneous or post dating the formation of the caldera 35,000 years ago. This implies a very large rate of subsidence with an average of about 5 cm/yr. Subsidence may, however, have been concentrated just after the formation of the caldera.

The Campi Flegrei caldera is known historically for the widespread fumarolic activity. Subsurface exploration has revealed a layer from approximately 1/2 to 1 km deep where temperature gradients are low. Water in this layer can circulate sufficiently so that most of the heat is transferred convectively. This layer is indurated and high permeability is ascribed to fractures. The pyroclastite above and below this layer on the other hand is not indurated and relatively impervious as a result of the hydrothermal alteration. Temperature gradients through the layers are relatively high and indicate conductive heat transfer. Fumarolic activity may represent areas where the upper impervious layer is breached by fractures.

Another characteristic of the Campi Flegrei volcano has been vertical ground movement. Fig. 4B shows changes in elevation near the center of the Gulf of Pozzuoli (Temple of Serapis) deduced primarily from archeological data. These data suggest phases of subsidence and uplift ranging over 12 meters in the last 2,000 years. About 50 years before the last eruption in 1538 (Mt. Nuovo) the ground started uplifting rapidly culminating in a twoday long uplift event of several meters that apparently caused the seashore to recede by 400 meters (see appendix). The Mt. Nuovo eruption began a few hours after this uplifted region had started subsiding.

Seismicity in the Campi Flegrei was high during the pre-Mt. Nuovo period of accelerated uplift, probably including earthquakes of magnitude 4 to 5, and climaxed at the time of the Mt. Nuovo eruption. This eruption produced 0.03 cubic kilometers of locally welded scoria, but eye-witness accounts also testify horizontally directed base-surge explosions causing damage as far as 5 km from the vent.

4. Current Eruption Hazard at the Campi Flegrei. In general, eruptions of volcanoes of the type found in Campi Flegrei, are preceded by significant ground deformation and intense seismic activity of the type now observed in that area. In addition, the only other well documented occurrence of these phenomena in the Campi Flegrei area preceded the Monte Nuovo eruption of 1538. The current

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high rate of uplift and the large number of earthquakes occurring occurrence of these phenomena in the Campi Flegrei area preceded the Monte Nuovo eruption of 1538. The current in the area have been interpreted in the light of prior experience to indicate that the hazard of an eruption in the area is quite high. The Rabaul caldera, New Guinea, the Long Valley caldera, California and the Campi Flegrei caldera are currently showing signs of unrest. These calderas are regarded by the volcanic community as likely sites for volcanic eruptions in the near-to-immediate future. The Osservatorio Vesuviano estimated that the probability for an eruption in a time span of some tens of years is from 10-20% to as high as 50%. Considering this level of hazard and the high population density, the risk due to a possible eruption is quite high. The risk is defined as the probability of the hazard, in this case an eruption, times the estimated loss. The risk can be estimated by referring to geological and historical data on the Campi Flegrei activity. Geologists from the University of Pisa estimated that the area of high damage from the range of possible eruptions in the Campi Flegrei region would cover an area extending from 3 to 9 kilometers from the center of eruption.

5. Present Monitoring. A number of signs of geological unrest precede most well documented volcanic eruptions. The most reliable of these involve increases in local earthquake activity and ground deformation. Changes in the physical and chemical properties of the fumaroles and ground crater are also common but somewhat less systematic in their behavior than patterns of seismicity and deformation. These parameters are currently being monitored in the Campi Flegrei region by a combination of Italian organizations. Although other geophysical phenomena, such as subsurface resistivity and pore pressure in confined aquifers, may also show precursory changes, the current program of surveillance in the Campi Flegrei region are limited to the first three areas mentioned above.

a. Seismic Monitoring. Three autonomous seismic networks are currently operating in the Campi Flegrei area. The Osservatorio Vesuviano operates a network of 8 single component seisometers and, in addition, a small (5-station) network of 3-component digital stations to be installed in the vicinity of the Sulfatara Crater (my impression is that these stations will be the triggered, internal-recording type rather than telemetered stations. DPHill). Another network of 16 stations (digital) is operated for the Regione Campania by Prof. Oliveri, (With University of Naples, Department of Geophysics and Volcanology) but this network is essentially self-contained and data from it have not been available. The only near real-time processing of seismic data is conducted by the Osservatorio Vesuviano. This processing consists of hand picking of arrival times of earthquake signals at each

station from paper copies of the seismic records, followed by a determination of hypocentral locations using standard computer location techniques (HYPO71 and LQUAKE). Many other, more detailed, studies of earthquakes in the area require digitization at a proper sampling rate of the seismic signals.

b. Ground Deformation. Precise re-levelling to determine changes in elevation is conducted twice weekly by the Osservatorio Vesuviano and the Department of Geophysics and Volcanology of the University of Naples (Prof. Corrado). Also, tide gauges at Nisida and Pozzuoli are continuously monitored at the Osservatorio Vesuviano and the University of Naples. These are independent of the four ocean-bottom tide gauges operated by the Instituto Universitario Navale. The Osservatorio Vesuviano is currently exploring the feasibility of two types of tilt meters (a 20-in water tube instrument and a bore hole instrument installed in 3 to 4m deep holes)

c. Geochemistry. Of the various programs being conducted by many institutions to monitor any changes in chemistry, only three are done frequently enough to qualify as surveillance programs. These are: the continuous monitoring of hydrogen at the Solfatara Crater by the University of Palermo (Prof. Carapezza); the periodic collection and analysis of gases from fumaroles on land by the University of Palermo and the University of Pisa (Prof. Barberi); and the monitoring of radon gas carried out continuously in some areas and periodically in others by the Osservatorio Vesuviano, by the Department of Geophyics of the University of Naples and by the University of Pisa. Other, much less frequent measurements are made by other organizations such as total helium measurements by the University of Rome, argon isotope determinations by the Laboratory of Geochronology of the National Council of Research (Comitato Nazionale della Ricerca (CNR)) in Pisa, and chemical analyses of fumaroles and ground water by the Department of Earth Sciences of the University of Naples.

d. Additional Cooperative Studies. In addition to the above described monitoring efforts there have been a series of short term experiments which have implications for monitoring efforts. Ferrucci and Hirn of the Institut de Physique du Globe of the University of Paris recently conducted a two month long seismic experiment in the Pozzuoli area on behalf of the Instituto Universitario Navale. Their initial report is a careful analysis of both types of seismic body waves (P and S waves) as recorded from over 40 earthquakes on a network of 12 3-component portable seismic stations. Their results indicate a zone under Pozzuoli which exhibits significantly slower S-wave velocities. This can be interpreted as indicating a zone of highly fractured saturated rocks.

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Results on velocity structure from this and similar work together with additional seismic stations will help improve resolution of earthquake focal depths, particularly for earthquakes with reported depths of less than 2 km. (The present uncertainties in depths of these shallow earthquakes are approximately 1 km.) Improved resolution of shallow focal depths may prove to be a useful premonitory tool if, for example, systematic migration of hypocenters toward shallower depths precedes eruption.

Professor Robert Meyer of the University of Wisconsin has recently completed a similar experiment in the area. Professor Meyer's equipment was also 3-component but his recorders were high-quality digital units constructed at the University of Wisconsin. The data from this experiment have not been fully processed, but Professor Meyer's reports that he has not yet seen any differential travel times for P and S waves less than 0.4 seconds. This suggests that the earthquakes he has examined so far are deeper than about 1.0 km. Thus Professor Meyer's preliminary results emphasize the value of high quality, 3 component data.

6. Assistance Needed At this stage, the Italian scientists would find the following items of particular value in augmenting the work already being done: (1) an on-line, real-time data collection and processing system; (2) additional, high quality seismic and deformation data; (3) an increase in both the number of physical and chemical parameters being measured and the number of measurement sites.

The state of the art in predicting volcanic eruptions is not yet adequate to produce statements as to the time or location of an expected eruption. However based on experience with explosive volcanoes in general and on the experience of the 1538 eruption in particular, a sudden, increase in the rate of uplift and seismic activity will indicate that the risk of a eruption in Campi Flegrei has increased. With advanced techniques, it will be possible to improve significantly the ability to estimate the probability of an impending eruption. The reliability of any predictive technique will be augmented with an increase in data quality, and by real-time monitoring of precursory phenomena. Reliability of predictive capabilities will be further increased by the capability for real-time correlation of data from many independent phenomena, that may show precursory changes before an eruption.

B. Project Description.

1. Goal. The goal of the project is to support Italy in developing its disaster preparedness program in Southern Italy. This program includes an early warning system for volcanic eruptions in the Campi Flegrei area based on intensive geophysical and geochemical monitoring using state-of-the-art techniques.

2. Purpose and End of Project Status. The purpose of the project is to enhance the Early Warning capability for potential volcanic eruptions in the Campi Flegrei region. The principal means of enhancing the early warning capability will involve supplementing the existing and planned Italian monitoring program with equipment and technology necessary for real-time data collection and processing, expanded data collection networks, and support for the completion of essential base-line studies. With the successful completion of the project a baseline study of the Bays of Pozzuoli and Naples will have been concluded, several new telemetered networks (seismic, tilt, magnetotelluric and radon) will be in place and operational. The additional data thus gathered will be shared at the data center with all parties concerned with monitoring and researching the volcanic activity in the Campi Flegrei area.

3. Project Activities. The project is divided into several discrete activities. Most of these activities will be started within the first year of the project. Following is a description of each activity, including inputs, cost estimates (AID only) and an implementation schedule for that activity. The overall cost estimates and implementation plan are contained in Part II, Section C.

a. Seismic Monitoring and Data Center Sub-Project

(1) Detailed Description. This is perhaps the single most important sub-project for improving the Early Warning monitoring program for the Campi Flegrei caldera. Experience in explosive volcanoes both in Campi Flegrei and around the world indicates that eruptions are normally preceded by significant seismic activity. Real-time or near-real-time hypocentral determinations along with discrimination of tectonic earthquakes from those closely related to magma movement are critical to increase predictive capability.

The two analogical telemetered seismic systems of the Osservatorio Vesuviano and AGIP provide the backbone of the currently available seismicity information. The most severe limitation associated with the existing network are: delays in timely data processing imposed by the method of recording and limited computer facilities; a lack of offshore stations, and too few three-component stations.

To assist in improving the seismicity monitoring capabilities and to provide data for research into seismicity in a volcanic environment, this sub-project will provide additional seismic stations, which will be integrated with other networks. The additional stations will consist of approximately three offshore and four onshore matched, high-quality three-component seismic stations, telemetered to a new data collection center together with a processing facility

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to be housed in the Centro Geremicca at Posillipo, Naples. While this network (AIDNET) could in principal stand alone, its great value arises from simultaneously recording and processing seismic data from the existing AGIP and Osservatorio Vesuviano networks as well. This will be made possible by the fact that these networks are currently being planned also to be telemetered to the Centro Geremicca. To insure compatibility of the data and to aid in reliability, the AIDNET stations will make use of sensors with similar response to those used by AGIP and Osservatorio Vesuviano and the telemetry will be proven FM analog links.

The data from these combined networks will be recorded on a central digital data acquisition system which will both archive the actual trace data from seismic events and conduct real-time or near-real-time initial analyses of the earthquake parameters. This system will be capable of on-line detection of earthquakes and processing of data from at least the proposed 51 channel network (22 Agip & Osservatorio Vesuviano, 21 AIDNET) at 100 samples per second. On-line processing of data will include picking of arrival times, location of the earthquakes, and source parameter determinations such as event magnitude or seismic moment. The system will be capable of providing the Italian scientists with initial earthquake parameters within a few minutes of each earthquake. In addition, the system will archive the actual seismic data on computer tapes for more detailed analyses to be done later, offline (not a part of this Phase I project).

(2) Costs (in U.S. $)

Inputs	AID	GOI
Seismic Network	($695,000)	
3 field stations	85,000	
3-4 Offshore stations	145,000	
On-line system	400,000	
Develope software	65,000	
Installation	0	950,000
Total	$695,000	950,000

(3) Implementation Plan. The acquisition of equipment will be conducted in the U.S. but may utilize Italian sub-suppliers for installation of the systems. To aid in accommodating the existing monitoring and research programs, the network and data center will be operated so as to provide data equally and rapidly to all agencies housed in the Centro Geremicca. A schedule of events under the sub-project is shown in Section D together with a PERT Chart.

(b) Ground Deformations: Monitoring Sub-Project.

(1) Background. Most, if not all well-documented explosive eruptions associated with the intrusion of silic magmas into the shallow crust are preceded by conspicuous inflation of the ground. Recent well documented examples are those of Mt. St. Helen's eruption, the Usu volcanic eruption in Japan and others. The only well documented historical eruption at the Campi Flegrei, (the Mt. Nuovo eruption) was preceded by a remarkable ground uplift of about 7m and the rate of uplift increased to several tens of cms or more per day a few days before the eruption. A reliable monitoring of ground deformations is an essential element for providing an early warning of an eruption in this area.

Furthermore the knowledge of the details of time pattern of the uplift will be useful for careful study of correlations with seismic activity. This information will provide important clues to the processes driving the deformation activity which is related to a tectonic stress field produced by the uplift and which is not directly related to magma movement.

The present ground deformation program involves the following activities. Elevation changes are measured by Osservatorio Vesuviano through periodic levelling long three main routes and continuous analogous monitoring of sea level by 2 tide gauges at Pozzuoli and Nisida. Levelling is carried out normally on a weekly basis. Horizontal distance variations are measured once or twice a year by Instituto Geodetico of the University of Bologna using a laser AGA geodimeter. The Osservatorio Vesuviano plans to install additional digital tide gauges and possibly telemeter to a data acquisition center. Instituto Universitario Navale is installing 4 sea-bottom pressure sensors at a depth of 20 to 50 m.

Both Osservatorio Vesuviano (Prof. G. Luongo, Dr.R. Scarpa and Dr. R. Scandone) and Instituto Universitario Navale (Prof. L Mirabile) scientists have indicated that the most welcome contribution by AID in this field would be to provide, install and run a small network of telemetered continuous recording tiltmeters.

Accordingly this sub-project will establish a small tiltmeter network by furnishing tiltmeters for not less than four sites. These systems should include either biaxial shallow borehole tiltmeters or intermediate base (10m) water tube tiltmeters and their installation must be coordinated with installations for experimental tiltmeters currently planned by the Osservatorio Vesuviano. Stability continues to be a problem for many tiltmeter installations; it would be prudent to co-locate instruments in pairs

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as a means of evaluating the reliability and stability of different instruments and installation schemes. Signals from each station should be sampled at least every hour and telemetered via radio to the data center. Resolution must be of order of 1 microradian (10^{-6} radians)

The sub-project will also furnish software for time series analysis, correlation analysis, and filtering.

(2) Costs (in U.S. $)

Inputs	AID
4 tiltmeters	40,000
Installation	10,000
Software modification	10,000
Maintenance and service	10,000
Other expenses - spare parts etc.	5,000
Total	75,000

(3) Implementation. Construction of instruments will be carried out by a U.S. contractor. Software development (time series analysis, filterage, power spectre, correlation) will also be carried out by a U.S. contractor. Installation may be done by the U.S. contractor in cooperation with an Italian sub-supplier. Maintenance and service will be part of the Supply Contract for the first two year period.

c. Electromagnetic Monitoring Sub-project

(1) Detailed Description. The approach of magma to the surface will produce an increase of temperature and salinity of ground waters which will be affected by mixing with hot gases. The fracturing of the rocks in the uplifting area will increase the permeability. Therefore an overall decrease of electrical conductivity in shallow permeable rock formations is to be expected at the approach of magma. Some cases exist where remarkable variations of the electromagnetic field were observed before eruptions, the best known cases being in Hawaii, Japan and New Zealand.

Although electro-magnetic field variation studies are not a traditional method for an early warning of eruptions, recent progress in this field indicate its promise. This may be particularly effective in areas, such as Campi Flegrei, where several shallow thick aquifers exist while magnetotelluric measurements as a technique for monitoring precursors to volcanic eruptions look promising, they remain experimental and largely untested. Accordingly this sub-project has a lower priority than

the seismic and deformation sub-projects under the goals of the project and will only be carried out if overruns in other cost estimates do not occur.

Magnetotelluric methods are very effective for monitoring changes of electrical conductivity at depth because they utilize the correlation between variations of the natural magnetic and electrical fields over a wide frequency range (20.00 - 0.02 Hz is a typical useful range). Therefore variations due to changes of electrical conductivity at different penetration depths can be stripped out and detected. Its penetration capability is much larger than methods using artificial sources. (Aside from potential masking effects of a shallow, highly conductive layer, no problems exist for resolving an electrical stratigraphy down to 5-6 km of depth.)

At present no electromagnetic observations are carried out by Osservatorio Vesuviano and Instituto Universitario Navale. However scientists of both organizations have indicated strong interest in the possibility of being able to take these measurements.

A group from the Department of Geophysics and Volcanology of the University of Naples attempted to carry out some measurements with electronically obsolete instrumentation and limited software capabilities. They had problems because of instrumental instability of orthogonal horizontal components of electrical and magnetic fields.

A further problem is due to the strong artificial noise. Spanish and French teams carried out short field tests. The results obtained by the French Team are not available to us. Those by the Spanish Team have low reliability because of software limitations.

In order to provide this additional data, this sub-project will furnish, install and maintain one set of magnetotelluric equipment as follows:

One or two high sensitivity three-component magnetometers;

electric dipoles;

filters dividing the signals in at least four frequency bands, ten channels or more in order to research simultaneously more than one frequency band.

Recording must be digital.

The sub-project will provide state of the art software for data processing.

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(2) Costs (in U.S. $)

Inputs	AID	GOI
magnetotelluric equipment	170,000	0
Installation	0	20,000
Software 20,000	0	
Maintenance and Service	0	20,000
Other expenses	0	10,000
Total	190,000	50,000

(3) Implementation. Construction of the MT instrumentation can be carried out by a U.S. or Italian contractor, as expertise in this field exists in both countries. Software for data processing (time series analysis, power spectra, filtering, correlation analysis, evaluation of apparent resistivities, one dimensional inversion) will be developed by a U.S. contractor. Installation, maintenance and service should be done by an Italian contractor. The instrument design and construction will presumably take a 12 month period. Installation will be quite time-consuming because of the research required to find a low-noise site in a densely inhabited area.

See Section II D3 for implementation schedule.

d. Offshore Baseline Studies Sub-project

(1) Background. The western half to two-thirds of the Campi Flegrei caldera lies beneath the Gulf of Pozzuoli. The maximum uplift is centered near the shore line in Pozzuoli, and the epicenters of a number of the earthquakes associated with the uplift are located offshore. Complete definition of the caldera itself and the recent activity thus require knowledge of the offshore structure (bottom and sub-bottom topography). It is important, therefore, to have a good knowledge of the geological situation offshore, as well as to have the capability for monitoring the activity located beneath the sea. To achieve a clear picture of the present day situation, this sub-project will obtain structural, thermal and geochemical data in the Pozzuoli Bay and in adjacent areas of the Gulf of Naples.

Available data include a set of comprehensive bathymetric and geochemical data collected from the Pozzuoli Bay from 1970 to 1973 by Valette and Tonani, which constitutes a baseline with respect to the renewed episode of activity that began in 1982. Additional work has been carried out more recently on bottom topography and shallow stratigraphy in the Bay of Pozzuoli by Mirabile and co-workers and by

Pescatore (University of Naples - Dept. of Earth Science) and co-workers using single channel sparker and boomer profiles run in 1970-1973.

In July 1984 Lamont-Doherty Geological Observatory, using the R V Conrad, conducted a topographical survey of the Gulf of Pozzuoli using the "Sea Beam" technique (multiple acoustic beams). Preliminary maps at a scale of 1/30,000 were available in October 1984 and final maps of 1/20 and 1/40 should be available in December 1984. Dr. Mirabile has recently completed a 50KHz sonar survey in outer depths between 2 and 80 meters that compliments the deeper "Sea Beam" data.

This sub-project thus involves compiling and up-dating existing off-shore baseline data and extending the appropriate measurements based on an assessment of these existing data and current state of geologic activity in the area. Specific operations will include:

(2) Morphology and Tectonics

(i) Based on the results obtained from the initial "Sea Beam" and sonar surveys mentioned above, further high resolution profiling of the sea floor should be completed to fill any gaps in coverage. Detailed knowledge of current sea floor morphology is an important baseline datum. It provides a reference for judging future of changes in bottom topography related either to gradual subsurface movements, or to catastrophic seismic and/or volcanic events. The survey should be carried out using methods that provide water depths and bottom conditions that prevail in different sections of the offshore environment.

The result of this work should be a set of high resolution (1 meter or better) bathymetric charts of the Pozzuoli Bay and of adjacent areas in the Bay of Naples. These charts will serve as critical data set for all other work in the offshore areas.

(ii) A map of relevant sea floor structures (fault patterns, craters, submarine slumps and slided, etc.) will be established using acoustic side scanning methods, (possibly SeaMARC or similar instruments) and possibly by high resolution multi-chemical seismic reflection profiling.

(3) Thermal Structure. A set of information of fundamental value to understand an active volcanic system concerns the surface and subsurface thermal structure. Information on the thermal structure of an active region can result in estimates on the possible presence, size and depth of magma bodies and on the extent and distribution of subsurface circulation of hot fluids. Moreover,

changes in time in the forementioned thermal parameters may have an early warning value, particularly when coupled with geodetic, seismic and geochemical data. This includes knowledge of the three dimensional distribution of temperature, of thermal conductivity and crustal materials in the area and of conductive and convective heat flow in the region.

Our knowledge of the thermal structure in the submerged part of the caldera is very scant.

Some bottom water temperatures were measured in the early seventies, and several hot springs were detected on the sea floor (Valette, 1977). The maximum temperature measurement at sea reached 90° C.

Under this sub-project a detailed survey of the thermal structure of the submerged part of the caldera will be carried out, taking advantage of the fact that some parameters, such as heat flow, can be measured more easily at sea than on land. This survey will include a dense network of profiles where the temperature of near bottom water is measured continuously with thermisters towed by a ship, (as well as vertical profiles). This kind of work has been carried out successfully in various active parts of the ocean floor, particularly along ocean axial zones of spreading, such as the East Pacific Rise. Temperature anomalies would give a present-day picture of hydrothermal activity in the bay.

Another set of measurements proposed to be carried out are of heat flow through the sediment of the bay. The distribution of heat flow through the sea floor will give information both on the transmission of heat through the crust by conduction, and on the dissipation of heat by subsurface convective circulation of fluids. Information on conductive heat flow may give knowledge of deep crustal structure of the region, as well as on the size and geometry of the inferred magma chamber. The convective heat budget will give information on the extent and depth of the convective fluid circulation and the extent to which the crust is fractured.

Heat flow measurements can be carried out with a heat probe, which allows in situ determination of conductivity, and a close spaced network of determinations within reasonable time.

While this study of the thermal structure will be concentrated in the Bay of Pozzuoli, a less detailed set of measurements will cover the whole of the Bay of Naples. It is advisable that the thermal study of the submarine areas be done together with the morphotectonic and geochemical studies, following a multidisciplinary approach which should give maximum returns.

(4) Geochemistry and Hydrology. During the same study, a geochemical survey will be carried out. The purpose of this survey is to locate, define and characterize the thermal emissions at sea. Both water chemistry and sediment chemistry studies will be included.

A chemical and mineralogical study of the sediments will show the influence of the hydrothermal emissions on a typical sediment depletion or increase in the concentration of the various elements. The study will include major and trace elements as well as isotope geochemistry, this last part being useful in tracking the origin of the mineral deposits.

In addition, the analysis of the suspended matter near the sea floor will enable an understanding of the kinds of precipitates formed at the contact between the hydrothermal fluids and sea water.

In addition to the sedimentary chemical study, a study of the distribution of the pH, the salinity and a complete chemical composition of the water collected at different levels in the water column will be made. This will include dissolved gasses, major and trace elements, as well as isotopic geochemistry. In particular the measurements of radon, CH_4 and $^3He/^4He$ are essential since these parameters are very good indicators of hydrothermal emissions. Variations in $^3He/^4He$ are particularly important to study because they may reveal contributions from magmatic bodies if the ratio differs from the atmospheric ratio.

In order to map the submarine emissions this study should cover the whole bay including the coastal areas. However, as a large oceanographic ship may not be able to go shallower than some 50m depth, a part of this survey has to be done using a smaller ship. Also in the areas where the bathymetry is less than 50m a direct sampling of the emissions should be carried out using divers.

Movement of the water masses in the bay will cause mixing and blurring of the hydrothermal signals. To minimize these mixing effects, a study of the hydrology of the area may be necessary. Continuous recording currentmeters will give an idea of the hydrology during the entire cruise. The number of recording current meters necessary to adequately resolve the effects of the convection on the hydrothermal signals has yet to be established. Numerous small-scale convection cells would complicate this effort.

(5) Stratigraphy. The stratigraphy of sediment cores collected from the Gulf of Pozzuoli and the Bay of Naples may provide a record of seismic and volcanic events which occurred during the past several thousand years. These events may have been recorded in the cores as ash layers, turbidite layers, slumping

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traces, etc. A series of ^{14}C age determinations could provide an absolute time scale, helping to relate some of the events found in the cores with known events. Potential problem: thick deposits from the Monte Nuovo eruption may place the layers of interest beyond reach of gravity core techniques.

(6) Costs (in U.S. $)

Inputs	A.I.D.	GOI
Ship Operations	200,000	200,000
Technicians	70,000	100,000
Equipment	30,000	
Studies	200,000	100,000
Total	400,000	300,000

(7) Implementation. The multidisciplinary objectives outlined above can be carried out in a 30 day cruise of a well equipped research vessel followed by a one year effort of elaboration and evaluation of data and of laboratory study of samples. The field effort will be done in collaboration by U.S. and Italian groups on an Italian vessel. By March 1985 the AID Contractor (USGS), working jointly with IUN, shall submit a detailed program to carry out this sub-project for AID/Naples and the steering committee review and approval. Thereafter, AID/Naples will negotiate a Contract amendment or issue an RFP, as necessary.

A schedule of events under the sub-project can be found in Section D.

e. Geochemical Monitoring (offshore and onshore)

(1) Detailed Description. The monitoring of changes of the chemical and isotopic composition of fumarolic gases and groundwaters, can be very useful in predicting changes of the thermodynamic regime at depth. These changes are a result of magma approaching the earth surface. In fact gas emissions from a hot magma become richer in some compounds such as methane, ammonia, halogens, and hydrogen-sulphide, which are rapidly oxidized on contact with ground water and the atmosphere.

Furthermore, a radon and He content increase is directly or indirectly produced in ground water and fumarolic gasses. Variations of $^{3}He/^{4}He$ and $^{40}Ar/^{36}Ar$ ratios are also produced.

The main contributions by AID to the chemical monitoring program conducted by Italian institutions:

(a) to carry out monthly sampling of sea-bottom waters to be chemically analyzed for diagnostic elements and compounds;

(b) to install at least two on-land electrostatic Rn probes with signals to be telemetered to the data acquisition center. Rn probes should be located in aquifers;

(c) to install three continuously operating telemetering Rn probes within the same net containing the off-shore seisometers;

(d) to carry out monthly on-land and off-shore sampling of He and Ar at different sites for isotopic analyses;

(e) to help Italian scientists in timely analysis of diagnostic chemical elements at different sites if required.

(2) Costs (in U.S. $)

Inputs	A.I.D.	GOI
Radon probe	100,000	
Software	20,000	
Monitoring and Boat	40,000	150,000
Total	160,000	150,000

(3) Implementation. Offshore monitoring operations will be carried out after the base line survey has been completed. The results of the base line will be utilized to develop a detailed plan for all the off-shore monitoring. Offshore Rn probes will be set up together with off-shore seisometers.

On-land Rn probes will require about five months of design and construction, and one month for installation. Isotopic analyses of on-land He and Ar can start just at the beginning of the project.

f. Matching Funds Research Sub-project.

(1) Description. A minor aspect of this project is to encourage cooperative research effort to interpret the data produced by current and previous monitoring/survey efforts.

This part of the project is designed to provide two things. The first is an exchange of experience and information. This may involve short (1 to 2 months) exchange visits of Italian and American scientists working on critical aspects of the monitoring and base-line problems. Particularly useful would be a one-time

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workshop of limited attendance focused on magnitude and tectonic processes driving the percent of activity in the Campi Flegrei. Such a workshop would serve to lay the ground work for items a,b and c below. The second is studies on monitoring efforts to optimize this volcanic early warning capability.

The cooperative research program may use data obtained by this program as well as the data to improve constraints on the evolution and background level of the tectono/volcanic system. This work may be carried out jointly by Italian and U.S. scientists both in Italy and the U.S. Specifically the following areas are eligible for these research efforts:

(a) Re-examination of old seismic data and of new seismic data for parameters not considered in the routine analysis such as fault plane solution, stress drop, corner frequencies, joint hypocenter determinations, velocity inversions, etc. Among other objectives, this task may verify whether time-space changes in the distribution of seismicity have occurred.

(b) Modeling of ground deformation data to constrain the geometry of injection and/or tectonic processes which are active.

(c) Integration of the results from seismicity and geodesy with other data, such as surface geology, morphology, hydrodynamics, drill cores, etc. into a study of the current geodynamic conditions. This study may also consider models for the large scale neogene tectonic evolution of the Southern Appenines and integrate models developed for the local conditions at the Campi Flegrei with the larger tectonic environment.

The Contractor will assist AID and the Steering Committee in review, selection and provide limited logistics in the implementation of this matching funds program aimed at providing an opportunity for both U.S. and Italian University groups to carry out short individual studies with 50% matching finance from AID.

(2) Costs. The total of this subprogram is $50,000, which includes matching grants for salaries of U.S. scientists, associates, students, travel and per diem, computer time and support personnel and facilities.

These costs have not been detailed, as it will be the responsibility of each academic group to submit their proposal and subsequent research plan with full details on goals and costs.

(3) Implementation. The research proposals by interested academic groups shall be submitted for review and approval by the steering committee.

C. Cost Estimate and Financial Plan. The total cost of the recommended Phase I two year project is estimated at $3.7 million of which $2.0 million is the A.I.D. contribution and $1.7 million is the Italian contribution (both cost and in-kind expenses). These estimates, as broken out in greater detail in Table I are the recommended amount for which the project can be done without harm to its integrity. According to the technical advisors, each of the sub-projects proposal is critical to the overall project purpose and each has been scaled down to the fundamental items. Costs for equipment have been based on available price lists. Costs for the offshore baseline study were based upon inquiries as to ship costs and investigation of available Italian ships. Other costs, such as those for research are given as a flat amount.

The Italian contribution is primarily operating costs of the data center, and equipment maintenance in the third year when much of the program will be phased over. The two exceptions are the costs associated with the baseline study and certain monitoring costs for the geochemical and monitoring sub-project.

Most of the U.S. expenses of this project are in the first year. Concurrently, the Italian contribution for the first year will be much less than in the second and third years of the project as the Italians pick up the operating costs of the data center and maintenance of all equipment. The Italians will also pick up all additional monitoring costs which should arise.

Following are financial tables which show:

Table I Summary Cost Estimate and Financial Plan for Phase I
Table II Summary of Total Cost Estimate and Financial Plan by sub-project -- Phase I and Phase II
Table III Estimated Expenditure Phase I and Phase II

The last table makes the assumption that all equipment except for data processing equipment is for the purpose of collecting more data. However, equipment costs can be attributed equally to the improvement of the quality of data.

TABLE I

SUMMARY COST ESTIMATE AND FINANCIAL PLAN FOR PHASE I

by

Sub-project
(U.S. $000)

Subproject	AID FX	GOI LC	Total
1. Seismic Monitoring			
Seismic Network	230	100	330
Data Center	465	850	1,315
2. Ground Deformations	75	0	75
3. Electromagnetic Monitor	190	50	240
4. Off-Shore Baseline Study	400	300	700
5. Geochemistry	160	150	310
6. Research	50	0	50
7. Management Contract	320	0	320
Inflation			
Contingency (10%)	110	150	260
Total	2,000	1,700	3,700

TABLE II

SUMMARY OF TOTAL COST ESTIMATE AND FINANCIAL PLAN

by

Sub-project Phase I and Phase II
(U.S. $000)

Subproject	AID	GOI	Total
1. Seismic Monitoring			
Seismic Network	695		695
Off-line Data Center	360		360
Operating Cost	160	2,190	2,350
2. Ground Deformations	160	50	210
3. Electromagnetic Monitor	290		290
4. Off-Shore Baseline Study	600	300	900
5. Geochemical Monitoring	190	650	840
6. Research	200		200
7. Management Contract	500		500
	3,155	3,190	6,345
Inflation and Contingency	465	910	1,375
Total	3,620	4,100	7,720

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Table III

PROJECT OF EXPENDITURES PHASE I AND PHASE II
(U.S. $000)

INPUTS	PHASE I		PHASE II			
			First Year		Second Year	
	AID	GOI	AID	GOI	AID	GOI
Management Contract	320	-	180	-	-	-
Baseline Study	400	300	200	-	-	-
Research	50	-	100	-	50	-
Operational Costs	-	1,000	160	510	-	680
Computer Equipment	465	-	360	-	-	-
Seismic Equipment	230	-	-	-	-	-
Tiltmeter Equipment	75	-	85	-	-	50
Magnetic Equipment	190	-	50	-	50	-
Chemical Equipment	160	150	30	250	-	250
Inflation/Contingency	100	100	100	110	55	110
TOTAL	2,000	1,700	1,365	1,090	255	1,310

NOTE: THE A.I.D. REQUEST FOR ASSISTANCE IS $2,000,000 WITH A GOVERNMENT OF ITALY CONTRIBUTION OF $1,7000,000 EQUIVALENT IN COMMODITIES AND IN KIND COSTS. IN THE EVENT OF COST OVERRUNS ON NECESSARY SUB-PROJECTS OF PHASE I, THE MAGNETIC EQUIPMENT SUB-PROJECT WILL BE DELETED OR SHIFTED TO PHASE II.

D. Implementation Plan

1. Administration of Project. For the duration of the project an American contractor, preferably USGS, but if not, then a private Sector firm will Administer the AID-financed operations, including responsibility for maintenance and operation. AID/Naples may contract with an Italian firm to directly assist the AID office on an as-needed basis (essentially to augment the AID/Naples staff).

The American contractor will also assist in timely distribution of data from the monitoring systems to both the Instituto Universitario Navale and the Osservatorio Vesuviano as well as to provide access to the data to other researchers and public agencies. This distribution of data will take the following form: (1) dial-up access to on-line hypo centers and arrival times of phases; (2) a daily listing of preliminary tiltmeter data and preliminary radon data; and (3) a weekly report which will include magnetotelluric data and major results from other research being conducted under this program. Access for researchers from both institutions to the digital seismic data will be provided by the contractor. The information will be shared with all U.S. and Italian government institutions having a need for it. Other access would be contingent on the consent of the Italian Government.

Operations of the monitoring system and the data center will be supervised and reviewed by a advisory committee consisting of representatives from Osservatorio Vesuviano, Instituto Universitario Navale, AID/- Naples and the American contractor. This advisory committee will meet monthly to review operations. Starting in the third year of the project, responsibility for maintenance, operation and supervision of these facilities will be phased over to Italian authorities.

To facilitate project operations, it is planned that the monitoring facilities and data research center will be physically located in the Centro Geremicca, unless other facilities are provided by the Italian authorities.

2. Procurement Plan. A direct AID contract with an American firm (or University or USG entity under PASA) will be the major procurement action under the project. That contractor will be responsible for the following actions either directly or via sub-contracts:

a. Overall management of project including data center;

b. Procurement, installation, maintenance of equipment;

c. Monitoring and distribution of data;

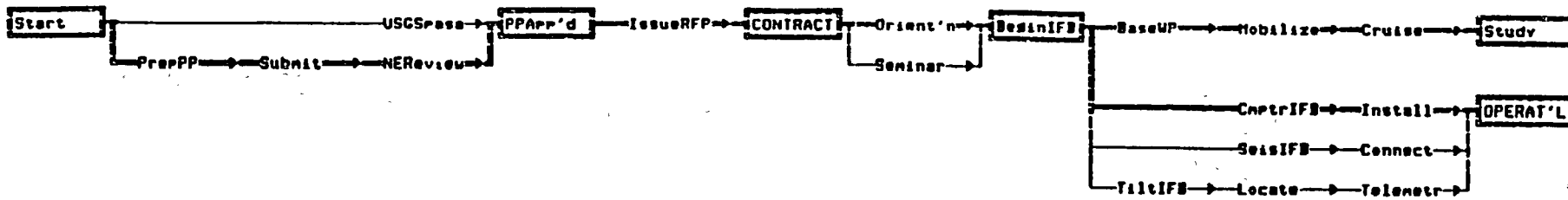
d. Offshore baseline study, and

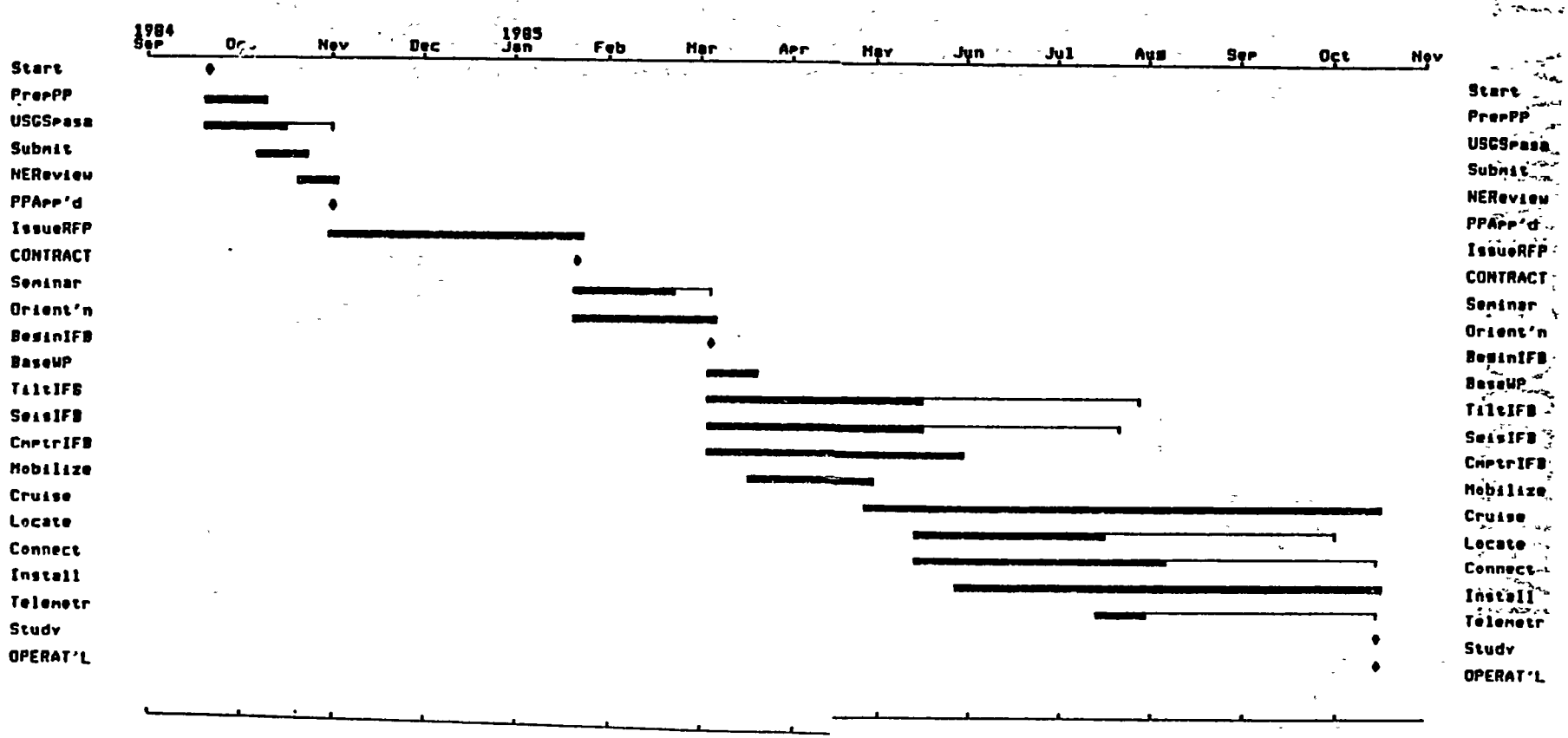
e. Minimal logistic support for Matching Fund Research activities

The prime contractor will be assisted by staff seconded from IUN and OV as needed to assist with the wide variety of project activities. It is anticipated that the IUN and OV staff will be of assistance during installation and with maintenance of all project equipment.

As soon as this project has been approved by the NEAC, AID will advertise in the CBD Commerce Business Daily and then issue the RFP if it has not been decided to use the USGS as team leader. A contract will not be signed until after the Project Agreement amendment has been signed.

3. Implementation Schedule. The following PERT and GANTT charts give detailed information on project implementation. AID/Naples will be monitoring the progress of the project using the Harvard Project Manager PERT/ GANTT computer program which provides planning as well as actual completion dates with continual updates. The "To-Do List" for the first six months together with a schedule of when Milestones are to occur during this period follows the GANTT chart.





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Project Status Report

Start of Period: End of period:

Sorted by: Early Start Milestones: Yes Tasks: Yes

Project Data

Name	Responsible	Calendar
SISMPP		

	Scheduled:	Duration	Cost	Start	Finish
		278.00 Dys W	0.00	9/23/84 12:00P	10/17/85 9:00A

	Actual:	Duration	Cost	Start	Finish
			0.00		

Node Data

Name	Responsible / Subproject	Slack	Code	Early Start / Late Start	Early Finish / Late Finish
	Scheduled:	Duration	Cost	Start	Finish
%	Actual:	Duration	Cost	Start	Finish
Start		0.00 Dys W		9/23/84 12:00P	9/24/84 9:00A
PrepPP		0.00 Dys W		9/24/84 9:00A	10/ 8/84 9:00A
				9/24/84 9:00A	10/ 8/84 9:00A
		10.00 Dys W	0.00		
0			0.00		
	Prepare PP and obtain GOI approval				
USGSpasa		13.00 Dys W		9/24/84 9:00A	10/15/84 9:00A
				10/11/84 9:00A	11/ 1/84 9:00A
		15.00 Dys W	0.00		
0			0.00		
	Interest USGS in accepting Team Leader and Justify to AID/W				
Submit		0.00 Dys W		10/ 8/84 9:00A	10/22/84 9:00A
				10/ 8/84 9:00A	10/22/84 9:00A
		10.00 Dys W	0.00		
0			0.00		
	Submit PP to AID/W for approval of subobligation				
NEReview		0.00 Dys W		10/22/84 9:00A	11/ 1/84 9:00A
				10/22/84 9:00A	11/ 1/84 9:00A
		8.00 Dys W	0.00		
0			0.00		
	NEAC Review and send to AA/NE for approval				

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Name	Responsible Subproject	Slack	Code	Early Start / Late Start	Early Finish / Late Finish
	Scheduled:	Duration	Cost	Start	Finish
x	Actual:	Duration	Cost	Start	Finish
PPApp'd		0.00 Dys W		11/ 1/84 9:00A	11/ 1/84 9:00A
	NE/AA approved SISM for $2.0 Million subob from FY81				
IssueRFP		0.00 Dys W		11/ 1/84 9:00A	1/24/85 9:00A
				11/ 1/84 9:00A	1/24/85 9:00A
		60.00 Dys W	0.00		
o			0.00		
	If USGS is not approved, an RFP must be issued - delay 3 mos.				
CONTRACT		0.00 Dys W		1/24/85 9:00A	1/24/85 9:00A
	Contract signed with Consultant firm				
Seminar		10.00 Dys W		1/24/85 9:00A	2/21/85 9:00A
				2/ 7/85 9:00A	3/ 7/85 9:00A
		20.00 Dys W	0.00		
o			0.00		
	Hold a seminar to establish final subproject details				
Orient'n		0.00 Dys W		1/24/85 9:00A	3/ 7/85 9:00A
				1/24/85 9:00A	3/ 7/85 9:00A
		30.00 Dys W	0.00		
o			0.00		
	Consultant Orientation and mobilization				
BeginIFB		0.00 Dys W		3/ 7/85 9:00A	3/ 7/85 9:00A
	Begin preparation and issuance of subproject IFBs				
BaseWP		0.00 Dys W		3/ 7/85 9:00A	3/21/85 9:00A
				3/ 7/85 9:00A	3/21/85 9:00A
		10.00 Dys W	0.00		
o			0.00		
	Develop baseline study work plan				
TiltIFB		55.00 Dys W		3/ 7/85 9:00A	5/16/85 9:00A
				5/23/85 9:00A	8/ 1/85 9:00A
		50.00 Dys W	0.00		
o			0.00		
	Issue IFB for tiltmeters				
SeisIFB		50.00 Dys W		3/ 7/85 9:00A	5/16/85 9:00A
				5/16/85 9:00A	7/25/85 9:00A
		50.00 Dys W	0.00		
o			0.00		
	Issue IFB for seismographs				
CmptrIFB		0.00 Dys W		3/ 7/85 9:00A	5/30/85 9:00A
				3/ 7/85 9:00A	5/30/85 9:00A
		60.00 Dys W	0.00		
o			0.00		
	Issue IFB for On-Line Computer and software				

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Name	Responsible Subproject	Slack	Code	Early Start / Late Start / Start / Start	Early Finish / Late Finish / Finish / Finish
%	Scheduled: / Actual:	Duration / Duration	Cost / Cost		
Mobilize		0.00 Dys W		3/21/85 9:00A 3/21/85 9:00A	5/ 2/85 9:00A 5/ 2/85 9:00A
0		30.00 Dys W	0.00 0.00		
Issue RFP, locate equipment, etc to start study					
Cruise		0.00 Dys W		5/ 2/85 9:00A 5/ 2/85 9:00A	10/17/85 9:00A 10/17/85 9:00A
0		120.00 Dys W	0.00 0.00		
Do baseline study, cruise, etc for shallow/deep structure profile					
Locate		55.00 Dys W		5/16/85 9:00A 8/ 1/85 9:00A	7/18/85 9:00A 10/ 3/85 9:00A
0		45.00 Dys W	0.00 0.00		
Establish location for each tiltmeter					
Connect		50.00 Dys W		5/16/85 9:00A 7/25/85 9:00A	8/ 8/85 9:00A 10/17/85 9:00A
0		60.00 Dys W	0.00 0.00		
Deliver, install and connect by telemeter to data center					
Install		0.00 Dys W		5/30/85 9:00A 5/30/85 9:00A	10/17/85 9:00A 10/17/85 9:00A
0		100.00 Dys W	0.00 0.00		
Deliver and install On-line computer and test out					
Telemetr		55.00 Dys W		7/18/85 9:00A 10/ 3/85 9:00A	8/ 1/85 9:00A 10/17/85 9:00A
0		10.00 Dys W	0.00 0.00		
Test out and check-out telemeter connect to data center					
Study		0.00 Dys W		10/17/85 9:00A	10/17/85 9:00A
Complete study of the first part of the baseline survey					
OPERAT'L		0.00 Dys W		10/17/85 9:00A	10/17/85 9:00A
On-line computer operational					

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To-Do list

Tasks scheduled to finish during this period:

Name	Finish by		Name	Finish by	
PrepPP	10/ 8/84	9:00A	USGSpasa	10/15/84	9:00A
Submit	10/22/84	9:00A	NEReview	11/ 1/84	9:00A
IssueRFP	1/24/85	9:00A	Seminar	2/21/85	9:00A
Orient'n	3/ 7/85	9:00A	BaseWP	3/21/85	9:00A
TiltIFB	5/16/85	9:00A	SeisIFB	5/16/85	9:00A
CmptrIFB	5/30/85	9:00A	Mobilize	5/ 2/85	9:00A
Cruise	10/17/85	9:00A	Locate	7/18/85	9:00A
Connect	8/ 8/85	9:00A	Install	10/17/85	9:00A
Telemetr	8/ 1/85	9:00A			

Tasks scheduled to start during this period:

Name	Start by		Name	Start by	
PrepPP	9/24/84	9:00A	USGSpasa	9/24/84	9:00A
Submit	10/ 8/84	9:00A	NEReview	10/22/84	9:00A
IssueRFP	11/ 1/84	9:00A	Seminar	1/24/85	9:00A
Orient'n	1/24/85	9:00A	BaseWP	3/ 7/85	9:00A
TiltIFB	3/ 7/85	9:00A	SeisIFB	3/ 7/85	9:00A
CmptrIFB	3/ 7/85	9:00A	Mobilize	3/21/85	9:00A
Cruise	5/ 2/85	9:00A	Locate	5/16/85	9:00A
Connect	5/16/85	9:00A	Install	5/30/85	9:00A
Telemetr	7/18/85	9:00A			

Tasks continuing throughout this period: None

Milestones scheduled to occur during this period:

Name	Occurs Between		And	
Start	9/23/84	12:00P	9/24/84	9:00A
PPApp'd	11/ 1/84	9:00A	11/ 1/84	9:00A
CONTRACT	1/24/85	9:00A	1/24/85	9:00A
BeginIFB	3/ 7/85	9:00A	3/ 7/85	9:00A
Study	10/17/85	9:00A	10/17/85	9:00A
OPERAT'L	10/17/85	9:00A	10/17/85	9:00A

Exception Report

Tasks likely to finish late: None

Milestones which violate constraint dates: None

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PART III. PROJECT ANALYSES

A. Technical Background. See Part II, Para A.3. for historical Background.

B. Current Activity. Steady subsidence of the caldera floor at 1,5 cm/yr seems to have resumed shortly after the Mt. Nuovo eruption and to have continued at least until 1968. In March 1969, because of damage to the roads and the sidewalks, a levelling survey was conducted. This survey detected a broad uplift centered at Pozzuoli harbor. Subsequent additional surveys showed that uplift averaged about 5 mm/day, but the rate gradually slowed until September 1972, when the onset of subsidence was first noted (fig. 4A.). The uplift during 1969-72 was about 171 cm. The number of microearthquakes beneath Pozzuoli increased slightly during 1970- 72, then decreased with the onset of subsidence, but the energy release from these quakes was remarkably low.

The area subsided by about 30 cms during September 1972-August 1974, then remained relatively stable until uplift resumed abruptly in July 1982 (fig. 4.A.). By mid-October 1983, the rate of uplift had increased to about 4 mm/day, and seismicity had increased to its highest level since the seismic network was installed in 1970 (Fig 5). The largest quakes to date were: magnitude 4.0 event on September 9, 1983, 3.9 on July 1, 1984 and almost 5.0 on July 15. Even these relatively mild seismic energy release has caused substantial damage to the pervasive "tuff stone" construction in the area, and a mostly voluntary evacuation of Pozzuoli residents was therefore carried out in October, 1983. Both seismicity and uplift are continuing at a high rate to the present (June 1984). The average rate of uplift in the last 1.5 years has been about 2 mm/day.

Current uplift is occurring over a circular area of about 150 square kilometers with its center just offshore the town of Pozzuoli (figure 6) where the elevation change since July 1982 has been about 1,5 meters. Seismicity is scattered over the uplifted area (fig. 5) and seems to be confined in the upper 3km of the crust. Large short and long-term temperal variations as (fig.5.A.) will, as a detailed spacial pattern (fig. 5.A), have been detected, but space time variations have not yet been recognized.

The phenomena observed at the Campi Flegrei are rather typical of active volcanic centers in the period proceeding an eruption, although periods of high uplift rates and intense seismicity may also terminate without an eruptive event. Figs 7 and 8 show the active volcanic centers in Rabaul, New Guinea and Long Valley, California, where recent rapid uplift and high seismicity near the centers of uplift suggest impending eruptions. Warnings have been

issued in both areas. Surface deformation is measured as tilt in Fig.7, as horizontal displacements in Fig.8 and as changes in elevation in Fig 6.A. In all the cases the data is consistent with a model where the ground swells as a result of an expanding magma chamber within the upper crust.

C. Primary Beneficiaries. The two primary institutions with whom AID (and its Contractor) will be working with are the Instituto Universitario Navale and the Osservatorio Vesuviano. A brief organizational description of each follows:

1. Intituto Universitario Navale. The group which will be implementing this project is the Institute of Oceanology, a part of the Instituto Universitario Navale and was established in 1981 after separation from the Institute of Theory and Technics of Electromagnetic Waves with a new Director, Prof. Lorenzo Mirabile. The new group carries out research in the field of electronic application to oceanography and geophysics.

The following subjects are relevant with the Naval Institute:

Oceanography
Marine Geophysics
Marine Applied Geology
Marine Geotechnics
Subwater Electro-acoustics
Protection of Marine Environment

The group also carried out a number of electronic applications to geophysics/marine geology with design and operation of high-resolution, broadside type sparker usually deployed by other scientific teams working in the Mediterranean Basin.

2. Osservatario Vesuviano is a research institute of the Ministero della Pubblica Instruzione (Ministry of Public Education). Its Director is nominated by the Minister of Public Education on a three year term. The Director must be chosen among Full Professors of Geophysics or Vulcanology at Italian Universities or non-Italian well recognized experts.

Decisions are taken by the Director and by a Directory Board presently formed by 11 members (representatives of the Ministry of Public Education, Ministry of Scientific Research, National Research Council, The University of Naples, and the staff of the Osservatorio Vesuviano). The Director is also President of the Directory Board. The Board is formed by both administration and technical people.

The present staff of the Osservatorio Vesuviano consists of:

- 10 researchers (7 of them working in seismology, 1 in ground deformation, 1 in volcanological models, 1 in geochemistry);

- 20 technicians (all of them with the seismology group);

- 15 administrators, bookkeepers, secretaries, etc.

- On a short term (about 1 year) another 7 researchers will be employed by a public competition.

The 1984 budget is the following:

275 million lire ($160,000) from the Ministry of Public Education for housekeeping;

1,050 million lire ($620,000) from the Ministry of Civil Defense for geophysical surveillance of the Campi Flegrei;

50 million lire ($30,000) from the Ministry of Civil Defense for geochemical surveillance of the Campi Flegrei;

150 million lire ($90,000) from the Consiglio Nazionale della Richerce (National Research Council) for geophysical researches on other Italian volcanoes and other research.

The following official relationships between the Osservatorio Vesuviano and administrative authorities were established for the Pozzuoli event:

The Minister of Civil Defense and the Osservatorio Vesuviano are the responsible parties for giving a pre-alarm or alarm status in order to undertake civil defense measures. The Director of the Osservatorio Vesuviano must present weekly reports to the Prefetto (Governor) of Naples. The Director of the Osservatorio Vesuviano is the chief of the working group of geophysical surveillance of Italian volcanoes in the National Group of Volcanology of the National Research Council. The Group was appointed by the Minister of Civil Defense to coordinate all the scientific activities in the Campi Flegrei area.

The experience of the staff of the Osservatorio Vesuviano has always been directed to geophysical methods of volcano surveillance and geophysical prospecting. Very limited experience exists in geochemical methods and no experience at all in geological and petrological aspects. The latter are covered by the staff of the Department of Geophysics and Volcanology of the University of Naples and the Department of Earth Sciences of the University of Pisa.

The Osservatorio Vesuviano has close liaisons with the Department of Geophysics and Vulcanology of the of the University of Naples also in the field of geophysical methods of surveillance. Two associate professors and two PhD students work jointly with the staff of the Osservatorio Vesuviano.

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PART IV. CONDITIONS AND COVENANTS.

As discussed in the Administrative Analysis the establishment of a data acquisition center which gathers and disseminates data to all Italian scientists working in this field is crucial to the success of the project. It would be preferable for this center to be housed in the Center Geremicca (Via Manzoni Naples) where some data is already available and equipment is being installed. However, the choice of location should be left to the appropriate Italian authorities. As a result, a condition precedent to initial disbursement requiring the establishment of the center but not specifying the location has been included in the Project Authorization and Project Agreement Amendment.

Receipt of the Italian contributions in a timely manner can be critical to the success of the project - especially in terms of the ship for the offshore studies, necessary permits and taxes, and the data center. As a result a covenant showing this Agreement to provide their contribution in a timely manner has been included in the Project Authorization and the Project Agreement Amendment.

PART V. MONITORING AND EVALUATION

A. Monitoring. AID/Naples will continuously monitor this project via its participation on the advisory committee and through the contractor's monthly reports. Also AID/Naples may contract with an Italian firm to assist and advise the AID/Rep.

B. Evaluation. One evaluation has been planned for this project at the end of the second year. The purposes of this evaluation will be as follows:

1. Evaluate the management performance by the contractor;

2. Check the general status of all the commodities which have been procured;

3. Review the data center's program;

4. Measure project progress against projected outputs and make recommendations for changes in the last year of the project.

5. Evaluate the research program

This evaluation will be carried out jointly by AID (with the participation of an AID/W nominated evaluation officer), appropriate Italian bodies and the U.S. contractor.

C. Implementation Schedule

Date	Item	Action	
10/84	Project Paper Completed	AID/Naples	
11/84	NEAC Action on PP	AID/W	
01/85	Authorization of Project Project Agreement Signed	AID/W GOI/AID	
01/85	Contract with Prime Contractor	RCO	
2/85	First Steering Committee Meeting (meetings every month thereafter)		GOI/AID/CON
2/85	Long Term Manager in Italy	Contractor	
	Equipment Specs	Contractor	
	IFBs for equipment issued	Contractor	

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ANNEX A

LOG FRAME

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATOR	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Project Goal:			
To enable Italy to develop more fully its disaster preparedness program in Southern Italy	Research results using data	Review of research	Data will be of kind necessary to develop program
Project Purpose:			
To increase the predictive capability of the Italians with respect to volcanic eruptions in the Campi Flegrei region	Data flowing through data center	review of data interviewes	All parties will have access to data and put it to appropriate use.
Project Outputs			
1. Better quality data and processing thereof.	Establishment of data center Baseline study results	Physical Inspection Review of studies	Appropriate equipment moved into data center
2. Increased data coverage in terms of types and area.	Networks and stations set up and functioning seismic network	Physical inspection	
Project Inputs			
Technical Expertise			
a. Project Management	3 person years of contractor services Procurement Plan	AID and Grantee Records	
b. Research			
c. Baseline study	1 year (includes ships services and preparation of studies)		
Commodities			
1 Seismic Network	Central recording 6 - 7 stations		
Data Center	32 bit Computer and software		Building made available for data center
1 Tiltmeter network	Central recording 4 meters Telemetry		
1 Radon monitor network	3 at sea, one onshore, 1 boat		
Boat			

ANNEX B

Giunta Regionale della Campania

Il Presidente

Napoli, 5 ottobre 1984

Mr. Richard M. Dangler
Agency for International Development
Piazza della Repubblica
80122 NAPOLI

Egregio Sig. Dangler,

Nel corso degli ultimi mesi, autorita' e studiosi italiani hanno avuto modo di lavorare in stretto contatto con alcuni esponenti dello staff dell'A.I.D. alla ricerca di elementi che rendessero possibile l'elaborazione di un progetto per la sorveglianza vulcanico-sismica della zona dei Campi Flegrei nell'Italia meridionale e migliorare, quindi, le possibilita' di preavviso di rischio.

Dopo aver preso visione del documento descrittivo del Progetto per la Sorveglianza vulcanico-sismica (Project Paper), facciamo richiesta all'Agency for International Development affinche' partecipi al finanziamento della Fase 1 di questo progetto stimato per un ammmontare totale pari a 3,7 milioni di dollari U.S.A. I competenti organi di governo italiano (nazionale e regionale) provvederanno allo stanziamento di una somma pari a 1,7 milioni di dollari U.S.A e pertanto chiediamo che venga accordato uno stanziamento di fondi pari a 2 milioni di dollari U.S.A. da utilizzare per le strumentazioni e prestazioni necessarie alla rapida realizzazione del progetto.

Da parte nostra assicuriamo fin d'ora una fattiva collaborazione e guardiamo con fiducia a questo progetto che senz'altro rappresenta una nuova occasione per rinsaldare i vincoli di amicizia e la cooperazione scientifica fra i nostri due popoli.

~~Avv~~. Antonio Fantini
Presidente Regione Campania

ANNEX B

Giunta Regionale della Campania

Il Presidente

Naples, October 5, 1984

Mr. Richard M. Dangler
Agency for International Development
Piazza della Repubblica
80122 NAPOLI

Dear Mr. Dangler:

For the past several months, officials of the Italian Government and Italian scientists have been working closely with A.I.D. staff members to identify elements of a Seismic/Volcano monitoring system in the Campi Flegrei region of Southern Italy to increase our early warning capabilities.

We have reviewed the Seismic/Volcano Monitoring Project Paper and request the Agency for International Development join with us in the financing of the First Phase of this project valued at U.S. $ 3.7 million equivalent. The responsible Government authorities (on a national and regional level) will provide U.S. $ 1.7 million equivalent of this amount and we request a project grant of U.S. $ 2.0 million to assist with the funding of commodities and services to carry out the project in a expeditious manner.

We pledge our full cooperation and look forward to the opportunity to strengthen both the friendship and scientific ties between our two countries.

Sincerely yours,

Dott. Antonio Fantini
Presidente Regione Campania

5C(2) PROJECT CHECKLIST

Listed below are statutory criteria applicable generally to projects under the FAA and project criteria applicable to individual funding sources: Development Assistance (with a subcategory for criteria applicable only to loans); and Economic Support Funds.

CROSS REFERENCES: IS COUNTRY CHECKLIST UP TO DATE? HAS STANDARD ITEM CHECKLIST BEEN REVIEWED FOR THIS PROJECT?

A. GENERAL CRITERIA FOR PROJECT

1. FY 1982 Appropriation Act Sec. 523; FAA Sec. 634A; Sec. 653(b).

   (a) Describe how authorizing and appropriations committees of Senate and House have been or will be notified concerning the project; (b) is assistance within (Operational Year Budget) country or international organization allocation reported to Congress (or not more than $1 million over that amount)?

   CN

   YES

2. FAA Sec. 611(a)(1). Prior to obligation in excess of $100,000, will there be (a) engineering, financial or other plans necessary to carry out the assistance and (b) a reasonably firm estimate of the cost to the U.S. of the assistance?

   YES

3.	FAA Sec. 611(a)(2). If further legislative action is required within recipient country, what is basis for reasonable expectation that such action will be completed in time to permit orderly accomplishment of purpose of the assistance?	NA
4.	FAA Sec. 611(b); FY 1982 Appropriation Act Sec. 501. If for water or water-related land resource construction, has project met the standards and criteria as set forth in the Principles and Standards for Planning Water and Related Land Resources, dated October 25, 1973?	NA
5.	FAA Sec. 611(e). If project is capital assistance (e.g., construction), and all U.S. assistance for it will exceed $1 million, has Mission Director certified and Regional Assistant Administrator taken into consideration the country's capability effectively to maintain and utilize the project?	NA
6.	FAA Sec. 209. Is project susceptible to execution as part of regional or multilateral project? If so, why is project not so executed? Information and conclusion whether assistance will encourage regional development programs.	Not so susceptible

7. FAA Sec. 601(a). Information and conclusions whether project will encourage efforts of the country to: (a) increase the flow of international trade; (b) foster private initiative and competition; and (c) encourage development and use of cooperatives, and credit unions, and savings and loan associations; (d) discourage monopolistic practices; (e) improve technical efficiency of industry, agriculture and commerce; and (f) strengthen free labor unions.	Project will increase flow of trade through purchase of commodities and use of private business.
8. FAA Sec. 601(b). Information and conclusions on how project will encourage U.S. private trade and investment abroad and encourage private U.S. participation in foreign assistance programs (including use of private trade channels and the services of U.S. private enterprise).	Most of activities done via private contractors from U.S.
9. FAA Sec. 612(b), 636(h); FY 1982 Appropriation Act Sec. 507. Describe steps taken to assure that to the maximum extent possible, the country is contributing local currencies to meet the cost of contractual and other services, and foreign currencies owned by the U.S. are utilized in lieu of dollars.	Italian contribution most of Lire costs.

10.	FAA Sec. 612(d). Does the U.S. own excess foreign currency of the country and, if so, what arrangements have been made for its release?	NO
11.	FAA Sec. 601(e). Will the project utilize competitive selection procedures for the awarding of contracts, except where applicable procurement rules allow otherwise?	YES
12.	FY 1982 Appropriation Act Sec. 521. If assistance is for the production of any commodity for export, is the commodity likely to be in surplus on world markets at the time the resulting productive capacity becomes operative, and is such assistance likely to cause substantial injury to U.S. producers of the same, similar or competing commodity?	NA
13.	FAA 118(c) and (d). Does the project take into account the impact on the environment and natural resources? If the project or program will significantly affect the global commons or the U.S. environment, has an environmental impact statement been prepared? If the project or program will significantly affect the environment of a foreign country, has an environmental assessment been prepared? Does the project or program take into consideration the problem of the destruction of tropical forests?	YES. No significant affect.
14.	FAA 121(d	

14. FAA 121(d). If a Sahel project, has a determination been made that the host government has an adequate system for accounting for and controlling receipt and expenditure of project funds (dollars or local currency generated therefrom)? NA

B. FUNDING CRITERIA FOR PROJECT

1. Development Assistance Project Criteria. NA

a. FAA Sec. 102(b), 111, 113, 281(a). Extent to which activity will (a) effectively involve the poor in development, by extending access to economy at local level, increasing labor-intensive production and the use of appropriate technology, spreading investment out from cities to small towns and rural areas, and insuring wide participation of the poor in the benefits of development on a sustained basis, using the appropriate U.S. institutions; (b) help develop cooperatives, especially by technical assistance, to assist rural and urban poor to help themselves toward better life, and otherwise encourage democratic private and local governmental institutions; (c) support the self-help efforts of developing countries; (d) promote the participation of women in the national economies of developing countries and NA

the improvement of women's status; and (e) utilize and encourage regional cooperation by developing countries?

b. FAA Sec. 103, 103A, 104, 105, 106. Does the project fit the criteria for the type of funds (functional account) being used? NA

c. FAA Sec. 107. Is emphasis on use of appropriate technology (relatively smaller, cost-saving, labor-using technologies that are generally most appropriate for the small farms, small businesses, and small incomes of the poor)? NA

d. FAA Sec. 110(a). Will the recipient country provide at least 25% of the costs of the program, project, or activity with respect to which the assistance is to be furnished (or is the latter cost-sharing requirement being waived for a "relatively least developed" country)? NA

e. FAA Sec. 110(b). Will grant capital assistance be disbursed for project over more than 3 years? If so, has justification satisfactory to Congress been made, and efforts for other financing, or is the recipient country "relatively least developed"? NA

f. FAA Sec. 122(b). Does the activity give reasonable promise of contributing to the development of economic resources, or to the increase of productive capacities and self-sustaining economic growth? NA

g. FAA Sec. 281(b). Describe extent to which program recognizes the particular needs, desires, and capacities of the people of the country; utilizes the country's intellectual resources to encourage institutional development; and supports civil education and training in skills required for effective participation in governmental processes essential to self-government. NA

2. Development Assistance Project Criteria (Loans Only) NA

a. FAA Sec. 122(b). Information and conclusion on capacity of the country to repay the loan, at a reasonable rate of interest.

b. FAA Sec. 620(d). If assistance is for any productive enterprise which will compete with U.S. enterprises, is there an agreement by the recipient country to prevent export to the U.S. of more than 20% of the enterprise's annual production during the life of the loan?

c. ISDCA of 1981, Sec. 724(c) and (d). If for Nicaragua, does the loan agreement reauire that the funds be used to the maximum extent possible for the private sector? Does the project provide for monitoring under FAA Sec. 624(g)?

3. Project Criteria Solely for Economic Support Fund

a. FAA Sec. 531(a). Will this assistance promote economic or political stability? To the extent possible, does it reflect the policy directions of FAA Section 102?

Project for disaster assistance as specified by Congress.

b. FAA Sec. 531(c). Will assistance under this chapter be used for military, or paramilitary activities?

NO

c. FAA Sec. 534. Will ESF funds be used to finance the construction of the operation or maintenance of, or the supplying of fuel for, a nuclear facility? If so, has the President certified that such use of funds is indispensable to nonproliferation objectives?

NO

d. FAA Sec. 609. If commodities are to be granted so that sale proceeds will accrue to the recipient country, have Special Account (counterpart) arrangements been made?

NA

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Method of Payment

The only Method of Payment to be used by AID/Naples throughout the implementation of this project is the Direct AID Reimbursement Contract Method. This is a USAID preferred method of payment and is consistent with the AID/Naples methods of payment approved in the Payment Verification Policy Implementation Guidance submission of 1984. A justification of method of payment is, therefore, not required.

The project paper requests permission to enter into a PASA with USGS as the overall Contractor with the responsibility for contract administration as well as procurement. If this is not approved, and a contract is negotiated with a Private Sector firm, the method of payment will remain the same. If a contract is negotiated with a University or other Non-Profit making organization, some provision for advances may be required but will be kept at a minimum based on projected or proven need. AID/Naples will enter into a direct AID Contract for a project coordinator under the direct supervision of AID.

The method to be used to issue Travel Authorizations, pay travel costs and per diem allowances will be determined by the type of adminstrative contract finally approved.

Drafted and Approved:

Ernest S. Hardy
Controller

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON D C 20523

ANNEX F

THE ADMINISTRATOR

FOURTH AMENDMENT

TO THE

PROJECT AUTHORIZATION

Name of Country: Italy

Name of Project: Southern Italy Earthquake Reconstruction Program

Number of Project: 145-00-01

Pursuant to Section 495B, "Italy Relief and Rehabilitation," of the Foreign Assistance Act of 1981, as amended, the Southern Italy Earthquake Reconstruction Program (the "Project") was authorized on April 15, 1981, and was amended on September 24, 1982, August 29, 1983 and September 25, 1984, for a total of $62,265,000 (Authorization). The Authorization is hereby further amended as follows:

1. By adding the following paragraphs to paragraph one (1):

Pursuant to Section 495B, of the Foreign Assistance Act of 1961, as amended, I hereby authorize an amendment to the Southern Italy Earthquake Reconstruction Program to increase the amount authorized for the Program in the amount of One Million Six Hundred and Fifty Five Thousand Seven Hundred and Eighty One United States Dollars, ($1,655,781) for a total life of project of $63,920,781.

Pursuant to Section 491 and 495B of the Foreign Assistance Act of 1961, as amended, I hereby authorize an amendment to the Southern Italy Earthquake Reconstruction Program to include the Southern Italy Seismic Monitoring Activity involving planned obligations of not to exceed Two Million United States Dollars ($2,000,000) in grant funds over a one year period from date of authorization subject to the availability of funds in accordance with the A.I.D. OYB/allotment process to help in financing foreign exchange and local currency costs of the activity. The planned life of the Seismic Monitoring Activity is two years and 6 months from the date of initial obligation.

2. By adding the following paragraph after paragraph one (1), "I hereby authorize the use of Three Hundred Forty Four Thousand Two Hundred and Nineteen, ($344,219), United States Dollars of excess funds from the School Reconstruction Activity for the Seismic Monitoring Activity."

3. By adding the phrase "and the provision of technical services, studies and commodities to the Italians to increase early warning capability with respect to volcanic eruptions in the Campi Flegrei region of Southern Italy" after the word "Salerno" in paragraph two (2).

4. By inserting the phrase "relating to the reconstruction of school buildings and related facilities together with other services," after the phrase "The Project Agreements" contained in paragraph three (3).

5. By adding the following paragraph four (4) after paragraph three c. (3.c.):

4. The Project Agreement(s) relating to the Southern Italy Seismic Monitoring Activity which may be negotiated and executed by the officer(s) to whom such authority is delegated in accordance with A.I.D. regulations and Delegations of Authority shall be subject to the following essential terms and covenants and major conditions, together with such other terms and conditions as A.I.D. may deem appropriate.

a. Source and origin of Commodities, Nationality of Services. Commodities financed by A.I.D. under the project shall have their source and origin in Italy or in the United States except as A.I.D. may otherwise agree in writing. Except for ocean shipping, the suppliers of commodities or services shall have Italy or the United States as their place of nationality, except as A.I.D. may otherwise agree in writing.

b. Ocean Shipping. Ocean shipping financed by A.I.D. under the project shall, except as A.I.D.may otherwise agree in writing, be financed only on flag vessels of the United States.

c. Conditions Precedent to Disbursement. The Grant Agreement shall contain in substance, the following conditions precedent:

Disbursement for the Purchase of Equipment. Prior to the disbursement under the Grant, or to the issuance by A.I.D. of documentation pursuant to which disbursement will be made for the purchase of equipment necessary for the Activity, the Grantee will, except as the Parties may otherwise agree in writing, furnish to A.I.D. in form and substance satisfactory to A.I.D. a plan for the operation and maintenance of such equipment provided by A.I.D. funds both during the Activity and after the Activity's completion.

d. Covenants. In addition to the standard covenants the Project Agreement shall contain covenants in substance as follows:

1. The Grantee covenants to disseminate in a timely manner, the data produced as a result of the Activity to all agencies charged with disaster preparedness, including municipal and regional agencies of the Government of Italy and appropriate agencies of the United States Government.

e. PASA with USGS.

As demonstrated in Appendix I to the Action Memorandum submitted concerning this Project, and pursuant to Handbook 12 page 1-5, I hereby determine that the utilization of USGS is exempt from the provisions of Circular A-76. The proposed Participating Agency Service Agreement (PASA) with USGS is (1) for the provision of technical services, (2) the facilities and resources of USGS are particularly and uniquely suitable for the required technical assistance being provided and (3) such facilities and resources are not competitive with private enterprise. A copy of this statement of exemption is attached to the PIO/T submitted to the officer in M/SER/CM who will negotiate the PASA.

for James A. Norris
M. Peter McPherson

1/8/85
Date

Clearances:
GC:HFry [illegible] Date 12/27/84
AA/NE:WAFord [illegible] Date 12/26/84
AA/PPC:RDerham [illegible] Date 12/28/84

ANNEX G

INITIAL ENVIRONMENTAL EXAMINATION

for

CATEGORICAL EXCLUSION

Project Country: Italy

Project Title and Number: Southern Italy Seismic Monitoring Project (145-8501)

Funding: $3.6 million (FY85 funding $2.0 million)

IEE Prepared by: AID/Naples

Environmental Action Recommended: Categorical Exclusion

This activity meets the criteria for Categorical Exclusion from an I.E.E. in accordance with Regulation 16, Section 216.2 (c) (i) & (iii) and is excluded from further review for the following reasons.

The goal of this project is to enable Italy to develop more fully its disaster preparedness program in Southern Italy. To do so the project proposes to increase the predictive capability of Italian scientists with respect to volcanic eruptions in the Campi Flegrei region of Southern Italy. By the provisions and installation of monitoring and data processing equipment and carrying out an offshore base line study the project will improve both the quality and quantity of data available to these scientists. Thus, this is essentially a data gathering project. Other than the physical installation of various monitoring devices, the project will not physically change the environment. Certainly it will not have a significant negative effect upon the environment. Therefore it meets the tests of both c(i) and (iii) and should be excluded from further review.

Action Requested by: _____
Richard M. Dangler
A.I.D. Representative

Concurrance: _____
Bureau Environmental Officer

Approved: _____

Disapproved: _____

Date: _____

BEST AVAILABLE DOCUMENT

October 31, 1984

MEMORANDUM

TO: NE/PD/MENA, Ault Nathanielsz

FROM: NE/PD/ENV, Stephen F. Lintner

SUBJECT: Southern Italy Seismic/Volcanic Monitoring Project

I have reviewed the subject project paper and recommend that it be given a "Negative Determination" under the provisions of 22 CFR 216.2 (c) Categorical Exclusions (2) (iii) and (v), "AID Environmental Procedures."

cc: NE/PD/MENA, D. Reese
USAID/NAPLES, R. Dangler

ADDITIONAL SUGGESTED ACTIVITIES

This project surveys of and monitoring of phenomena not included in the current program. However, a number of variables and phenomena which are quite pertinent to the prediction effort are not included in either the current Italian programs nor in this project. Following is a cursory list (not in order of importance) of studies and monitoring efforts that could be added to this project to benefit the overall prediction program.

1. On Land Temperature Baseline Study. Temperature of hydrothemal fluids are being measured at a few sites, particularly in the "Solfatata" crater, where a temperature of almost 400° has been reached at a depth of about 3kms beneath the surface. This high temperature suggests that a magma chamber is probably present in the area not much deeper than 4kms beneath the surface (Rosi et al.; Armenti et al., 1983). The presence of numerous hot springs and fumeroles in the area indicates active hydrothermal circulation systems beneath the surface; most of the energy driving this system derives probably from inferred magma body, whose temperature may reach close to 1,000°C.

Many holes have been drilled in the area by AGIP and other agencies for geothermal exploration. It is important that the large set of temperature data in these holes be elaborated in order to contribute to the modelling of the thermal structure of the region. Also a general survey of the subacrial part should be carried out using remote sensing methods, (e.g. plane survey etc.) This could help in localizing and defining the thermal structure on land and could be complementary of the work already done from satellite.

2. Monitoring of Pore Pressure in confined Acquifers. AGIP has drilled many deep wells in the Campi Flegrei area. Several useful experiments/monitoring program could be undertaken if these wells could be made available. In particular, pore pressure in the confined acquifers could be monitored by placing a piezometer within the appropriate sealed portions of these wells. Fluid pressure in confined acquifers can be expected to be a very sensitive indicator of premonitory stress/strain changes.

3. On land Geochemical Baseline Study. A geochemical survey of the hot springs and fumeroles in the area should be undertaken in order to get a general chemical data set (majors, traces isotopes) available for everybody. This will complete the studies already done by the Italian teams.

4. On Land Study of Quaternary Faults & Terraces. Decifering the pattern of crystal deformation in the Campi Flegrei region during the development of this volcano would be very useful to place current tectonic activity in the proper perspective. Brancaccio (1970) of the University of Naples has studied terraces in the Pozzuoli area. Quaternary faults have been mapped, but no detailed study to determine age geometry and amount of slip on the faults has been undertaken. In general, a new comprehensive study of terraces active during and after the formation of the Campi Flegei caldera using paleoseismic methods (e.g. trenching, a study of single slip events, etc.) would allow us to understand the significance of the current rapid deformation in light of the long term pattern of deformation.

5. Deep Seismic Reflection. Structural data from deep seismic reflection surveys have been used in many studies directed at understanding large scale tectonic evolution. Multichannel surveys, the effective method of sampling deep structures are quite expensive. Although knowledge of deep structures is fundamental in any study of tectonic evolution, given the financial restriction , this kind of survey has not been included. Nevertheless, multichannel reflection surveys aimed at the deep crystal structure should be carried out both on land and at sea. Reflection surveys were carriedout in the Bay of Naples by the Osservatorio Geophysico Sperimentale (OGS) (Finetti et al.). AGIP has carried out a vibroseis profile over the geothermal field in the Campi Flegrei. These data have only been processed for shallow structure. CNR has apparently financed a processing of the same data for deep structure by the OGS (Trieste). If this study, for some reason is not carried out, this item should be added to the first year of planned research (not included in the budget)

6. Instumentation for Detailed Study in the Bay of Pozzuoli. The Istituto Universitario Navale (Prof. Mirabile) has a phased sparker array. This could be used for detailed study of bottom topology and near surface structure if a custom built 12 channel steamer about 600 meters long and a 12 channel recording system could be provided. These two items are vary

expensive and although very desirable, should not displace planned surveys.

7. Strain Monitoring. Current and planned ground deformation monitoring includes tilt, vertical movements and geodetic (distance) measurements. No direct strain measurements are included. Ground deformation monitoring must include redundant measurements because coupling problems and other local deformation due to thermal or hydrologic effects may easily bias the data from a single instrument. Thus it would be very useful to include direct strain monitoring by borehole instruments.

8. Geochemical Study. The current geochemical work is coordinated by M. Caropezza from Palermo and is structured as follows:

the University of Palermo (Tonani & Caropezza) is doing continuous control of T and H_2 on the Solfatara periodic collection (once every 6 months) of gases on the Solfatara

The University of Florence and Pisa are sampling and analyizing periodically gasses from the Solfatara and Hydrothermal spring

The University of Rome is performing analysis of total He in the ground

Additional work should be done to obtain a geochemical baseline survey on land in order to get data available for any interested scientific group. It would be desirable to perform a complete analysis of hot springs and fumeroles of the area. This study should include analysis of gases and waters for major and trace elements (metal, volates, etc.) and for isotopic geochemistry including), H, S, C, He.

Moreover, the part which cannot be carried out in the A.I.D. project, especially the geochemical monitoring must be done. The chemical monitoring is particularly desirable because at the present very little if anything at all is, being done offshore on the subject and is an integral part of any volcanic hazard prediction program.

9. The following is a: Scientific and Financial Program for the Geochemical Surveillance of the Campi Flegrei (Italy)

Prepared by the Director of Research; Prof. Marcello Carapezza Director of the CNR - Istituto di Geochimica dei Fluidi; Professor of Geochimica Applicata Universita' degli Studi di Palermo.

1.0 INTRODUCTION

The recent volcanic history of the Campi Flegrei is characterized by the occurence of mostly explosive eruptions.

The most recent historical eruption of this area which created Monte Nuovo dates back to 1583. From then onwards the Campi Flegrei have been characterized by the presence of more or less intense hydrothermal and fumerolic activity and also by the presence of another well known phenomenon: bradyseism. Such a phenomenon, owing to its noteworthy effects, has been the object of attention since ancient times.

Several authors have tried to reconstruct its course since the second century B.C. until today (Parascandola 1946, Niccolini 1829, Scardi 1979). From examining these data, it can be inferred that, on an average, the bradyseism has caused a subsidence of the ground in the last two millenia. In limited periods this tendency to subsidence has met with some inversions and the most remarkable, perhaps for the fact that it is the most fully documented, was the one preceding the 1538 eruption. Before that eruption, from the available historical data, it is possible to notice an elevation in the ground of about 7m. (Sicardi 1979). In any case, one can obviously consider that during the ascending phase of the bradyseism the probability that explosive episodes may occur is undoubtedly greater.

The most recent evolution of the bradyseismic phenomenon shows that we are in a decidedly ascending phase which started between the end of 1969 and the beginning of 1970 and caused about 170 cm. of elevation, and took place in the arc of about roughly two years. After a period of slight oscillations the phenomenon entered the ascending phase again in the second half of 1982 and it is still in progress.

In order to obtain a careful surveillance of this evolution of bradyseism, one needs all those methodologies which enable to foresee the modifications of the system towards unstable and therefore explosive conditions. Geochemical methodologies are very important for this purpose.

2.0 GEOCHEMICAL METHODS OF SURVEILLANCE

2.1 Conditions determining the explosivity of the system

The criteria, on which the geochemical surveillance of the active volcanic areas is based, must take into account the kind of phenomenon to be surveyed.

In the Flegrei area, as it is after all documented by volcanological records, the most likely eruptive events are undoubtedly phreatic and/or phreatic-magmatic explosions. In this case the evolution of the system towards paraxysmic conditions occurs when one has modifications in the flow of energy towards the surface and/or possibilities that this accumulates close to the surface itself.

The evolution of the system towards mechanical instability depends on two parameters:

1) an intensive one (pressure)
2) an extensive one (thermal energy which can be transformed into mechanical energy).

In fact for an explosion to take place the following conditions should be simultaneously satisfied:

a) Pressure of fluids, at a given depth, higher than lithistatic pressure.

b) Quantity of fluids sufficient to fulfill the mechanical work in order to break the system and to withstand the explosion.

2.2 Parameters useful for surveillance

The aim of geochemical surveillance is that of studying and controlling surface manifestations in order to detect these eventual deep modifications and in order to connect them to the causes likely to provoke (acsent of magmatic bodies, accumulations of energies at relatively shallow depth etc...) and to foresee their time evolution.

The experience gained in different volcanic areas has consented remarkable progress as regarding the identification of the geochemical parameters which are indispensable for a useful volcanic surveillance.

The criteria for the determination of such parameters can be essentially divided into two different categories:

a) the use of merely empirical parameters, which are determined through the geochemical variations, observed in natural manifestations in the above mentioned areas, which precede the volcanic events. In this group of parameters one can include the ratios S/Cl, H_2/H_2O, $^3He/^4He$, ^{13}C Co_2 and so forth.

b) the extensive study of a volcanic area from a hydrogeological and geochemical point of veiw for a geochemical interpretation of the composition of fluids, in relation to the thermodynamical and fluid-geological conditions which are present at deep level. This second point arises from a general vision of the problem and can evidently include the former.

Besides, this second approach is essential to define the basic knowledge of the volcanic system and must therefore represent the reference point for a correct statement of volcanic surveillance.

The approach of an eruptive event produces modifications, which may even be substantial, of the system and consequent time variations of some geochemical parameters. Following these time variations, we can understand how far the system evolves towards conditions of instability and likewise we can increasingly improve our basic knowledge of the system itself. In this sense it must be taken into account that, during these evolutionary phases, there are transients bringing about states in the system, even far from equilibrium.

Besides, the evolutionary speed of the system undergoes time variations and may generally reach its highest values in preparoxysmic phases. Hence the need to acquire some parameters in real time with the possibility of adapting sampling frequency of the speed variations of the phenomenon under observation.

3.0 GEOCHEMICAL OBSERVATIONS DURING 1983

Geochemical observations carried out in the Campi Flegrei area during 1983, which are still in progress, have been mainly of the two kinds with reference to sampling frequency.

3.1 Continuous Observations

Since April 1984 a station for the continuous monitoring of H_2 has been operating in one of the most active fumeroles inside the Solfatara, in particular the so-called "Soffione" or "Forum Vulcani".

The same parameter has been measured in other volcanic areas using the same method and it has already been pointed out

how its variations may be related to the evolutionary conditions of the system (Carapezza et al. 1980, Sato et al. 1981). In particular it was pointed out how this parameter, may vary in connection with both seismic and volcanic activity.

The variations so far observed in the Campi Flegrei suggest that this parameter deeps at high average values until the system discharges completely, in the form of seismic energy, a part of energy which it probably accumulates at relatively shallow depth.

Unluckily the previous parameter is the only geochemical one contiuously monitorized, while a higher number of parameters should be continuously analyzed in order to follow the evolution of the system. Some of such parameters, like CO_2 and H_2S should be determined in the atmosphere. These measures would allow to reach a double result:

a) Control of the quality of atmosphere and therefore decrease of the gas hazard.

b) Indirect control of energy flows towards the surface (Carapezza et al. 1984) and consequently of the volcanic activity.

3.2 Periodic observations

In February 1983 a systematic work of sampling and analysis of gases from the fumeroles of Pozzuoli Solfatara was begun.

Among the several fumeroles present in the area, it was decided to sample, at the rate of one sample per month, the "Soffione" fumerole, situated inside the Solfatara.

In addition to the chemical composition of the gases, isotopic determinations were carried out concerning ^{13}C in CO_2 and a single measuring of $^{3}He/^{4}He$.

The geochemical observations made during 1983, together with the knowledge previously acquired by other researchers, allow us to make a summary view of the Flegrean system and to interpret its present evolution.

Even if in schematic terms this system proves to be composed of different acquifers at different depths. In the area of the Solfatara, apart from the superficial acquifers, it is thought that there are two quite important systems, which are the site of the potential energy accumulation. These last two acquifers should be located respectively at a depth of 1.5 km and 3-4 Km with temperatures of about 280°C and 480° respectively.

These two systems should result energetically fed by fluids that get their energy from a magmatic mass at greater depth. The evidence of these deep fluids is confirmed by the relatively high value of $^3He/^4He$ (3.48 0.04.10)$^{-6}$.

The hydrothermal system at about 3-4 Km should be at the moment in a phase of accumulation of pressure and energy, while the less deep system (-1.5 km) has not undergone any substantial alterations.

The data so far collected have enabled us to understand and to follow the evolution of the present phase of the Flegrean bradyseism. Still these observations must be increased in order to improve our knowledge. In particular chemical observations on the water table should be intensified through the analysis of some trace elements and through the increase of the monitorized points. A strong effort should be made to evaluate the ascent of magmatic bodies through analysis of geochemical parameters as He^3/He^4, Rn etc..)

4.0 ANALITICAL FACILITIES AT THE IGF AND IMPG

The main instruments actually used by the IGF (Istituto Geochimica dei Fluidi CNR) and IMPG (Istituto Mineralogia, Petrografia e Geochimica - Universita' di Palermo) for the geochemical surveillance of the volcanic activity are:

4.1 Chemical analysis of fumarolic gases

- Gas cromotograph with two detectors to analize the He, H , O , N_2 , CO_2, CH_4 , CO .

4.2 Chemical Alalysis of condensates and waters

- Atomic absorption Spectrometer
- Specific electrodes for potenziometric analyses
- U v Spectrophotometer

4.3 Discrete analyses of atmosphere

- IR spectrometer for CO_2 determinations

4.4 Stable isotope analyses

- Mass spectrometer to analize D, ^{18}O (in CO_2 and H_2O), ^{19}C (in CO_2).

4.5 Continuous recording of H2 in fumerolic gases

5.0 REQUIRED IMPROVEMENT IN THE GEOCHEMICAL SURVEILLANCE

After the statements of the previous paragraphs, an effectual geochemical surveillance could be obtained if the observations so far made might be improved and enlarged.

The following instruments must be regarded necessary:

5.1 Gas analysis

	U.S. doll.s
- Gas cromatograph with flame photometric detector for sulphur species analysis	31.000
- Gas cromatograph with thermal conductivity detector for inert gases	20,000
- Gas cromatograph with FID detector for carbon species analyses	19,000
5.2 Continuous monitoring of CO_2 and H_2S in the atmosphere by specific sensors for each gas automatically controlled by a central unit	180,000
5.3 Mass spectrometer for 3He/4He determinations	215,000
5.4 Radon gas analyzer	11,000
5.5 Analytical facilities for mobile laboratory	
- Mass spectrometer for gas analyses	60,000
- Gas cromotograph for liquids	35,000
- Potentiometric equipment	20,000
	$ 591,000