

PROJECT TITLE: Volcanic hazards assessment and zonation at the resurgent Campi Flegrei caldera and their effects on man and environment

Scientific Coordinator

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ACTIVITY REPORT –2nd YEAR

PROJECT PARTICIPANTS

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GENERAL OBJECTIVES

Description of the main objectives must follow the Task scheme container in the approved project..

Task 1. The general final objective of Task 1 is the definition of the structural setting of the CFc and its evolution in relation to the dynamics of the Campanian Plain and the Tyrrhenian margin of the Campanian Apennines.

Specific objectives are: definition of the main deformation phases of the Tyrrhenian margin of the Campanian Apennines and of the Campanian Plain; reconstruction of the volcanic and deformation history of the CFc; definition of the relationships among tectonism, volcano-tectonism and volcanism; analogue modelling of caldera collapse and resurgence; probability tomography inversion of MT and MV data; definition of electro-structural models; elaboration of a 3D structural model (on magnetic, gravimetric and seismic data); definition of the area of the CFc at variable probability of new vent opening in case of renewal of volcanism.

Task 2. The general final objective of Task 2 is the definition of the evolution and present state of the CFc magmatic system.

Specific objectives are: identification of the primary magmas (their genesis and differentiation); definition of growing mechanism of the CI magmatic system, evolution processes operating in the magmatic system in the past 100 ka, mechanisms and time-scale of mixing/mingling processes operating in the past 12 ka; estimation of T, P and volatile content of the magma present in the chamber at the time of significant eruptions, and evaluation of the pre- and sin-eruptive degassing; definition of the relationships between eruption and magma chamber tapping dynamics; modelling of the present state of the Phlegraean magmatic system using all the collected data.

Task 3. The general final objective of Task 3 is the definition of the physical parameters of the eruptions, the eruptive dynamics and the depositional mechanisms.

Specific objectives are: reconstruction of the stratigraphic sequence of deposits and of the dynamics of the most significant eruptions of the CFc in the past 12 ka, and evaluation of their physical parameters; elaboration of pyroclastic-fallout and -flow deposits, and pyroclastic-fall isomass areal distribution maps; reconstruction of the fragmentation and transportation dynamics of the whole spectrum of dynamics and magnitude of the eruptions occurred in the past 5ka; evaluation of the emplacement temperature, flow direction and source area of pyroclastic flows, and relative chronology on the basis of palaeosecular variation; definition of the expected eruption scenarios in case of renewal of volcanism.

Task 4. The general final objective of Task 4 is the physical modelling of pyroclastic dispersion and effects of explosive eruptions on man and environment.

Specific objectives are: elaboration of physical models to describe the particles fall-out dispersion; elaboration of physical models to describe the emplacement of pyroclastic flows generated by eruption column collapse; vulnerability evaluation of people and building structures in relation to an explosive eruption; implementation of a Complete Volcanic Hazards and Vulnerability GIS.

TASK 1 – Structural setting of the CFc and its evolution in relation to the dynamics of the Campanian Plain and the Tyrrhenian margin of the Campanian Apennines (Resp. Domenico Patella)

– (RU PARTECIPANTS): RU5, RU9, RU10, RU12

– 2nd YEAR OBJECTIVES

1. Continuation of structural investigations along the Tyrrhenian margin of the Campanian Apennines.
2. Continuation of the stratigraphic-structural investigations of the western slopes of the Campanian Apennines in order to reconstruct both sequences of volcanic and non-volcanic sediments, and deformation events related to the evolution of the Campanian Plain.
3. Complete the stratigraphic-structural survey and facies and palaeontological analyses of the marine deposits, within the NYT caldera.
4. Analyses of cored deposits, correlation with exposed rocks, and reconstruction of the geometry of the rock bodies.
5. Sampling of selected rocks for geochronological and stable-isotope analyses.
6. Implementation of analogue modelling in order to investigate the mechanisms of deformation of collapse calderas and resurgent domes, highlighting the role of regional extensional systems.
7. Test of the software codes of the 3D probability tomography method for electromagnetic induction fields, including polarisation and uneven topography effects.
8. Additional ground MT soundings within Phlegraean area.
9. Test experiments and preparation of a sea-to-ground MV survey in the CFc.
10. Post-processing of the aeromagnetic acquired data, and compilation of a map of the high resolution aeromagnetic field of the Campanian volcanica area, integrated with the data of previous surveys. Collection of available data on the magnetic properties of the main Phlegraean volcanic rocks (Neapolitan Yellow Tuff, C.I., etc.); measures of the magnetic properties of other Phlegraean volcanic rocks (e.g. thermally altered samples).
11. First interpretation of the set of available gravity data aimed at extracting the maximum of information.
12. Final interpretation of the seismic lines and correlation with well log data. Integration with other seismic, magnetic and gravity data available for the area (i.e. Mareves Survey, Geomare Sud Surveys, etc.).

– 2nd YEAR RESULTS

- Methodology

- Implementation of analogue modelling (objective 6) has been performed.
- The theory of the 3D probability tomography method for electromagnetic induction fields (objective 7) has been fully developed and the computational algorithm has been tested for complex structural situations, including synthetic bodies simulating magma reservoirs. The new method will be applied to the CFc as soon as the new MT data recently acquired and to be acquired within the end of this year, will definitely be processed.

- Data acquisition

- All the expected data have been acquired.

- Processing and interpretation

- The results of stratigraphical and structural investigations show that the Tyrrhenian margin of the Apennines is affected by very recent faulting activity, with predominant sub-vertical NE-SW and NW-SE trending structures. The NW-SE structures are extensional, while the NE-SW systems mainly show transtensional kinematics with displacement in the order of several tens of meters. The latter constitute the eastern continuation of the NE-SW trending systems within the Phlegraean-Ischia area. In some areas (i.e. Avella and Caudina valleys), the presence of variable volcanic and non-volcanic rocks of known age have permitted to constraint the age of significant deformation events in recent times (<120 ka).
- Rock sequences exposed in many archaeological excavations within the Campanian Plain, have been studied in order to define the evolution of the area after emplacement of the CI. The collected data have been integrated with those resulting from the analysis of logs and cores of bore-holes.

- Detailed stratigraphic and structural data acquired in the northern sector of the CFc have permitted to define the main volcanic and deformation events occurred in the pasta 39 ka, after the first collapse of the CFc.
- Both volcanic and non-volcanic rocks have been sample for geochronological and stable-isotope analyses.
- The mechanisms of caldera collapse and resurgence within extensional settings has been defined through analogue models. In particular the overall modalities of reactivation of normal faults have been assessed.
- Two complete Metronix MT stations are now fully operative. Six new MT soundings have been already carried out and processed; two are with processing in progress and two will be performed and processed within the end of this year. A new multivariate algorithm has been adapted and tested to the CFc environmental situation which requires a very accurate filtering of coherent noise.
- A new LEMI three-component fluxgate sea-bottom magnetometer has been acquired at the end of last year and made fully operative last spring. Delivery and operational tests have been done. No underwater magnetovariational sounding has yet been produced because of a heavy cut of the funds for the second year. It is expected that recover of the full financing plan will be done in the third year.
- The results of the new aeromagnetic survey shows that the aeromagnetic field is characterised by a maximum in the southern sector of the surveyed area and by a linear anomaly due to the presence of a railway line. As for the data interpretation, we are presently developing new techniques of enhancement of the ratio signal/noise and new inversion methods with depth resolution for large scale problems.
- Using a new prospecting methodology based on the tensor gravity gradient, all gravity gradient tensor components have been computed accurately. The analysis of the maps of each gravity tensor component has proved to yield a fine delineation of the structural settings of the Campanian Plain and Phlegraean Fields. A study on inversion (combined/simultaneous or simultaneous/not combined) of the gravity gradient tensor components to perform a 3-D model of the substrate of the plain, is in progress.
- Re-interpretation of seismic lines suggests the area of the Gulf of Naples is affected by an oblique rifting and volcanism occurs along the transfer structures that, being sub-vertical, are mainly prone to magma intrusion. Furthermore some volcanic edifices previously not well defined, seem to align along the submerged portion of the CFc caldera margin.

- **Other**

TASK 2 - Evolution and present state of the CFc magmatic system (Resp. Lucia Civetta)

β (RU PARTICIPANTS): RU1, RU2, RU4, RU6, RU11, RU13

β 2nd YEAR OBJECTIVES

- Experiments on phase equilibria of Campi Flegrei trachytes, with special interest in the use of the assemblage biotite-magnetite-sanidine for estimating pre-eruptive water activities in magmas at H₂O saturation and pressures of 50-2500 bars.
- Begin analytical work on the phase equilibrium experimental run products.
- Reconstruction of the different thermal (and baric) history of uprising melts (Astroni and Averno) and structural control on melt mixing through phase-adjusting spinning sideband (PASS) and magic-angle spinning (MAS) NMR spectroscopy for the short and medium range structural units of the ²⁹Si, ²⁷Al and ²³Na nuclei, electron spin resonance (ESR) and Mössbauer spectroscopy for the Fe speciation in the structure.
- Definition of water-melt interaction process and the effect of the melt/glass structure on volatile exsolution and bubble growth (Agnano-Monte Spina and Astroni) through ¹H and ²H MAS NMR spectroscopy, cross-polarisation NMR, and ESR analyses.
- Electron microprobe and ICP analyses to define major and trace element contents in glass matrix, mineral phases and melt inclusions on rocks erupted before CI, between CI and NYT, on xenoliths from Breccia Museo, and on rocks erupted in the last 12 ka.
- Sr-Nd-Pb isotope analyses will be performed on whole-rocks, separated minerals and glass from the previous rocks.
- Detailed B isotope analyses on whole-rocks, separated minerals and glass of selected deposits (e.g. CI, NYT, Astroni) in which the possible temporal evolution of isotopic composition, together with trace elements and other isotopic data, can be used as a tracer of processes occurring in shallow or deep reservoirs.
- Mingling/mixing experiments on Campi Flegrei magma pairs at high temperature and micro-analytical characterisation of experimental products. Comparison of the results with natural systems.
- Setting up of a new instrumentation for high T and P microthermometries and execution of pilot experiments.
- Completion of volatile (H₂O, Cl, F, S) determination in CI melt inclusions and glasses. Evaluation of minimum P of crystallisation, on the basis of solubility models of volatile in trachytic and K-phonolitic melts.

- Microthermometries on multiphase magmatic fluid inclusions and geochemical analyses of leached fluid inclusions in xenoliths from the Breccia Museo and other eruptions. Reconstruction of pre-eruptive P, T, composition and volatile saturation conditions of the CI magma chamber.
- Sampling of Astroni, Senga, Monte Nuovo products for melt and fluid inclusions investigation, and mineralogical and petrological study. Evaluation of minimum P and T of melts crystallisation.

B 2nd YEAR RESULTS

- Methodology

- New experimental facilities in Camerino, the new isotope laboratory in Napoli (OV), the new equipment for high T and P microthermometries in Pisa, and the mixing/mingling experimental apparatus in Munich are now fully functional.

- Data acquisition

- Water-saturated phase relations (Bt-San-Mt) and water solubility measurements for trachytic samples were determined in order to quantify pre-eruptive conditions and magma differentiation trends.
- Work is in progress on the solubility of water in trachytic melts, with the objective of developing a model to predict the effects of melt composition on water solubility.
- Melt/glass structure, dynamics of melt cooling, volatile exsolution and bubble growth, and fluids interactions have been studied for the Astroni and NYT eruptions, using resonance spectroscopies (²⁹Si, ²⁷Al, ¹H MAS-NMR, ²⁹Si PASS-NMR, ESR, and Mössbauer), XRD, electron microprobe and back-scattered electron microscopy.
- Major and trace element contents have been detected by electron-microprobe, ICP-AES, ICP-MS, XRF, SEM-EDS, and infrared-spectroscopy on whole-rock, minerals and glasses, and glass inclusions in minerals, from Astroni, Averno and CI rocks.
- Isotope data (Sr, Nd, B, Pb) by TIMS have been acquired on whole-rocks, minerals and glasses of the products of the activity older than CI, CI, NYT and younger than 12 ka.
- Mingling/mixing experiments on two Campanian Ignimbrite samples, representative of the more and less differentiated composition, were performed. The end result samples were studied, photographed and the composition was analysed.

- Data processing and interpretation

- The phase equilibrium experiments are at P and T of 50-200 MPa and 700-875°C under water saturated conditions and have allowed to locate crystallisation conditions for feldspar, Mt and cpx. A compilation of published data for CF mineral compositions have allowed to calculate water fugacities of 80-130 MPa for the CI, suggesting a minimum magma chamber depth of 4-6 km.
- The glass structure data collected for the Astroni volcano have provided constraints on the dynamics of magma ascent and flow conditions. The dense and vesiculated glass fragments are interpreted as representing different magma batches from a chamber filled by a chemically slightly heterogeneous magma, characterised by a similar distribution of dissolved water species in the melt structure, which underwent different dynamics of ascent from depth to surface. The property of a glass to retain into its structure information about the thermal history of the corresponding melt shows that the NYT alkali trachytic glasses derive from separate magma pulses which departed from the top of the magma chamber forming fingerings which drained a chemically homogeneous melt but undergoing different time-temperature paths during cooling and that the glasses show the effects of aqueous fluids-melts interactions at the glass transition.
- Chemical stratigraphy of the Astroni deposits, composition of the feeding magmas, compositional structure of the magma chambers and timing of magma extraction have been defined. At least two magma batches with distinct geochemical (trachyte and alkali-trachyte) and isotopic signatures were involved in the activity of the Astroni volcano. The two magmas likely mingled and mixed immediately before and/or during the eruption. Sr isotope ratios span over a relatively wide range (0.70726 - 0.70757). The Nd isotope ratios show a small range (0.51247 - 0.51251), and are negatively correlated with Sr isotopes, suggesting a mixing/mingling process between two distinct end-members. Over all the minerals are in isotopic disequilibrium with their glass which shows variable Sr isotope ratios, comparable to those detected in whole rock samples. $\delta^{11}\text{B}$ varies between -8 and -10‰.
- The composition of the melt inclusions in minerals from the Astroni rocks varies from trachyte to alkali trachyte. This strongly supports the hypothesis that the glass matrix (magma) composition is related to a mixing process between the more and the less evolved melts. FTIR measurements show low H₂O content and CO₂ under detection limit.
- The Averno2 eruption was fed by a highly-evolved, slightly-peralkaline phono-trachytic magma, characterised by homogeneous Sr isotopic ratio, suggesting feeding by a small, isolated magma chamber.

- Melt inclusions, matrix glass and bulk rocks of the CI are trachytic to phonolitic in composition. Matrix glasses are compositionally homogeneous. As regards the volatile content (H₂O, Cl, F, S) of melt inclusions, 197 spectra on melt inclusions have been elaborated. Melt inclusions show a relatively wide range of water content while CO₂ is below the detection limit. Microthermometries on multiphase magmatic fluid inclusions in xenoliths from the Breccia Museo units and trace element geochemistry on whole rock xenolith samples were performed. The interpretation of these data is in progress and will lead to the reconstruction of the P-T-X conditions for the CI magma chamber
- δ¹¹B values of products of Procida and Campi Flegrei decrease with increasing ⁸⁷Sr/⁸⁶Sr ratio along two distinct trends that appear to converge towards a common end-member. The first trend is described by Procida K-basalts, CF trachytes older than CI, Ischia shoshonites and one CF shoshonite, while the second is described by CI and post-CI products. The two trends suggest involvement in the genesis of these magma of different components characterised by distinct B/immobile element ratios, δ¹¹B, Sr, Nd and Pb isotopes. Furthermore, they permit to distinguish a mantle trend from a trend resulting from high and low pressure contamination processes on mantle-derived magmas.
- The results of mixing/mingling experiments show that the CI is appropriate for such experiments, due to its natural flow marker content. Following flow markers, the study of flow direction in particular shows the development of two separate convection cells for the experiments lasting 25 and 16 hours, and single convection cell for the experiment shorter than 16 hours. Results of the different runs point toward an increasing of mixing with time.
- In conclusion, the geochemical, mineralogical, experimental and isotope data, collected to date, have allowed us to constrain the hypothesis that the evolution of the Campi Flegrei feeding system in the past 60 ka, occurred through open system growth of deep and shallow reservoirs filled by magmas of variable composition, where mantle derived magmas isotopically identified, differentiate, contaminate and mix, and mingle before or during the eruption.

- **Other**

TASK 3 – Physical parameters of the eruptions, eruptive dynamics and depositional mechanism (Resp. Luigi La Volpe)

– (RU PARTICIPANTS): RU3, RU7, RU9

– 2nd YEAR OBJECTIVES

- Continuation of the stratigraphical and volcanological survey aimed at both reconstructing the whole sequence of rocks erupted in the past 12 ka, and defining the internal stratigraphy of the products of each volcano.
- Completion of the stratigraphic investigations aimed at reconstructing the Averno and Astroni eruption histories.
- Begin of the stratigraphic study of the Monte Nuovo eruption deposits.
- Field and laboratory density measurements of variable types of pyroclastic deposits.
- Beginning of the evaluation of the erupted volumes and columns heights, and definition of the pyroclasts dispersal for all the defined explosive eruptions of the past 12 ka.
- Sampling for sedimentological, mineralogical, petrological, geochemical and paleomagnetic analyses.
- Completion of the study of the structural and textural features of the Agnano – Monte Spina eruption deposits.
- Beginning of grain-size, component and morphological SEM analyses on the Astroni and Averno eruptions deposits.
- Continuation of experimental investigation on fragmentation mechanisms.
- Continuation of determination of the magnetic properties of the volcanic rocks of the CFc in order to define emplacement T and flow directions.

– 2nd YEAR RESULTS

- **Methodology**

- An experimental method for the determination of the drag coefficient of pyroclastic particles has been implemented and successfully tested.
- The method for evaluating the dynamic pressure of dilute and turbulent pyroclastic density currents, a relevant parameter for quantitative hazard assessment, has been refined and tested on deposits of significant eruptions of the recent activity of the CFc.
- An experimental set-up for simulating brittle fragmentation processes occurring during the Campi Flegrei explosive eruptions has been designed and tested at the physical volcanology laboratory of the Wuerzburg University.
- Quantitative image analysis methods for the numerical characterisation of the shape of pyroclastic particles have been further implemented for accommodating the fractal dimension and new classificatory diagrams.
- Difficulties in sampling low-cohesive rocks for magnetic fabric measurements, have been partially overcome. Immersion of samples in an ethil-silicate bath proved effective to consolidate the fine-grained, porous rocks in order to prepare the regularly shaped needed specimens.

- **Data acquisition**

- 40 new stratigraphic sequences have been investigated inside and outside the CF. Thickness, maximum pumice and lithic fragments, internal sequence and sedimentological characteristics have been defined for each pyroclastic deposit.
- Field and laboratory density determinations of variable types of pyroclastic deposits have been performed.
- The stratigraphic study of the sequences erupted by both Averno and Astroni volcanoes has been completed.
- Stratigraphical, sedimentological and volcanological studies of the Monte Nuovo eruption products are in progress.
- Grain-size, SEM, component and density analyses of the Agnano-Monte Spina Tephra have been completed
- Grain-size, SEM, component and density analyses of the Averno products are nearly completed.
- Grain-size, SEM, component and density analyses of the Astroni products are in progress.
- Grain-size, SEM, component and density analyses of the fragmentation experiments products are in progress.
- Thermal demagnetisation routine (10 to 12 temperature steps) has been applied to 215 lithic clasts from various deposits, mostly from the Agnano-Monte Spina Tephra. The re-heating temperature was successfully determined for more than 160 clasts; half of the remaining clasts have not been affected by the heat conveyed by the pyroclastic flow because they are characterised by unblocking temperatures higher than the flow temperature, and half yielded negative results mostly because of chemical alteration and very low magnetisation intensity.
- The magnetic fabric was measured on about 50 samples from the Agnano-Monte Spina E and B Members.

- **Data processing and interpretation**

- The data acquired from investigation of the new stratigraphic sequences, integrated with those from cores of bore-holes and from previous investigations, have permitted to better define: a) the volcanic sequences erupted during each of the three epochs of activity of the past 12 ka, b) the internal sequence of the deposits of each studied volcano, c) isopachs and maximum pumice and lithic fragments isopleths maps for fallout deposits, as well as areal distribution maps for flow deposits of the third epoch of activity.
- Field and laboratory density determinations of variable types of pyroclastic deposits have permitted to construct maps of the distribution of the load on the ground exerted by the variable fallout deposits.
- The eruption history of both Averno and Astroni volcanoes has been reconstructed.
- Interpretation of all the data collected on the Agnano-Monte Spina Tephra suggests that the eruption was a complex sequence of plinian-phreatomagmatic explosions from distinct, although closely-spaced vents. The eruption was thus characterised by interference between fallout and base-surge dynamics. Base-surges, which represent the most severe hazard at the CFc, had dynamic pressure between 3 and 4 kPa within the Agnano plain.
- A preliminary interpretation of the data collected on the Astroni products, suggests that the volcano is the result of a long-lasting activity which included variable eruptions. Eruptions were characterised mainly by phreatomagmatic with subordinate magmatic explosions. Base-surges which represented the most recurrent type of transportation mechanism were characterised by dynamic pressure in the order of 2 kPa at the foot of the volcanic edifice.
- A preliminary interpretation of the data collected on the Averno products suggests that the eruption was mainly characterised by phreatomagmatic with subordinate magmatic explosions. The vent migrated along a NE-SW trending fault, during the course of the eruption. Fallout (from low eruption columns) was the main transportation mechanism at the beginning of the eruption; whereas, during the intermediate and final stages, base-surges (both dry and wet) prevailed.
- A preliminary interpretation of the results of the paleomagnetic analyses is in progress.

- **Other**

TASK 4 - Physical modelling of pyroclastic dispersion and bradyseismic events in the CFc, and effects of explosive eruptions on man and environment (Resp. Giovanni Macedonio)

β (RU PARTICIPANTS): RU3, RU8, RU 14

Objectives and results of RU3 (Dellino) concerning also this Task have been presented in Task 3.

β 2nd YEAR OBJECTIVES

- Reconstruction of the deposits of the Agnano-Monte Spina (AMS) eruption by using an ash fallout model.
- Application of the pyroclastic flows emplacement model at the CFc and hazard analysis.
- Data collection, by means of the aerophotogrammetric method, of the typological characteristics required to the classification of the volcanic vulnerability for the remaining part of the towns enclosed in the study area.
- Field survey by means of the guided interview forms in order to characterise the towns under the building typological aspect and zoning of the information on the map.

- Field survey on the openings of a building sample having specific structural typology and on the roof characteristics.
- Calibration of the probabilistic parameters required to the statistic correction of the typological frequencies derived by QAP method.
- Test on a sample area for the implementation of a Volcanic Vulnerability oriented GIS.

β 2nd YEAR RESULTS

- Methodology

- A previous computer code for simulating ash fall-out has been adopted for the reconstruction of the Agnano-Monte Spina (AMS) eruption. The code has been modified to automatically perform data inversion and obtain the total mass and grain size distribution of the whole deposit starting from field data.
- A simple code has been developed for processing wind data collected by the NOAA, in order to perform a statistical analysis of the wind velocities in the Neapolitan area, needed to produce a hazard map for ash fall-out.

- Data acquisition

- Wind directions were estimated directly by the main dispersal axis of the B1 and D1 fallout layers of the AMS eruption, based on deposit thickness, particles grain-size distribution and component data collected by RU Orsi.
- Field and laboratory data on the deposits of the pyroclastic currents of the AMS eruption, collected by RUs Orsi and Dellino, have been acquired.
- Aero-photogrammetric interpretation has been completed for the towns of Bacoli and Monte di Procida which include almost the totality of the building stock in the area.
- A field survey aimed at characterising the building typologies of the towns through a “guided interview protocol” with geo-coding of the information collected for the town of Bacoli, has been carried out. The collected data have been integrated with those resulting from other surveys on the seismic vulnerability characteristics already performed in the Phlegraean area.
- A field survey on the openings (doors, windows, etc.) of buildings with structural typology like those included in the vulnerability classification of the EMS '98, has been carried out in Bacoli. The roof typologies detectable in the area have also been studied.
- Data on factors of volcanic vulnerability as the potential missiles in the urban area of Pozzuoli and Bacoli has been collected. A GIS test application on building characteristics and their vulnerability factor on a settlement of Pozzuoli, is now available. A thematic map on the structural typology classification in Pozzuoli, has been produced. Data on the demography in Pozzuoli have been collected and linked to structural characteristic for future scenarios developments.

- Data processing and interpretation

- Best fit analysis with the model shows a small angle between the dispersal axis of the B1 and D1 fallout layers of the AMS and a small difference in the intensity.
- Field data (deposit thickness, density and grain size distribution) in different exposures of the AMS deposit have been converted into mass loading (km/m³) and settling velocity distribution, assuming spherical particles. The total mass and the global grain size distribution have been computed as a best-fit between field data and the model. A discrepancy between the total mass computed with different methods (eg. Pyle) was observed. This seems to be related with the difficulty to estimate the total amount of fines falling very far from the vent (not considered in our method).
- The analysis of the field and laboratory data on the deposits of the pyroclastic currents of the AMS eruption is in progress.
- A vulnerability scale of the elements studied has been developed. This scale is based on specific numerical models to evaluate the limit load of Not Tensile Strength material structures (as masonry walls and vaults) so as models to evaluate the collapse loads of the reinforced concrete frames, steel or wooden roofs etc.. The probability to have specific volcanic vulnerability factor on a specific EMS '98 structural typology, has also been computed. This result will allow to extend the information collected on the sample randomly chosen, to the whole set of studied buildings. Moreover a typological classification of roofs, openings and most probable limit load associated to them, has been elaborated.

- Other

- Organisation of the international workshop “Campania a Rischio” by RU14
- Organisation by RU14 of a meeting with colleagues of the Cambridge University to both examine the state of the research and programme future activity.

- RESEARCH PRODUCTS

- n° of articles published on international journals: 30
- n° of articles submitted for publication on international journals: 10
- n° of articles published on national journals, proceedings, technical reports: 3
- invited papers and talks

- Carroll M., 2 invited presentations at Fall AGU, and Chapman Conference on volcanism and climate
- Ferrara G., 1 invited seminar at the University Neuchatel, 25-11-2002,
- Orsi G., Di Vito M., Gianpaola D., Isaia R., Marzocchella A., 2002. *Humans and active volcanoes living together over the past 6,000 years in the Neapolitan area (Italy)*. 35th Chacmool Conference – Apocalypse Then and Now, November 13-17, Calgary.
- Zuccaro, 2002. *Civil Protection Problems in urbanised Volcanic areas*, Assessorato Urbanistica - Regione Campania, July 24, Napoli.

- presentations at international meetings

- Acocella V., Marotta E., Cifelli F., Funicicello R., - 2002 – Analogue models of calderas and resurgences in extensional settings. Oral presentation at the IGCP meeting on “Interaction between volcanoes and their basement and related geological hazards”, Santiago, (Chile), October 2002.
- Acocella V., Marotta E., Cifelli R., Funicicello R., De Vita S., Orsi G., - 2002 - Analogue models of calderas in extensional settings: insights for the development of elliptic calderas. Poster presentation EGS meeting Nice (France), April 2002.
- Bruno P.P., Di Fiore V., Rapolla A., Cuzzo E., 2001. *Tectonics and morphology of the carbonate basement and correlation with the volcanism in the gulf of Naples*. XXVI General Assembly of the European Geophysical Society, Nice 25 - 30 March 2001.
- Bruno P.P., Rapolla, A., - 2001 - *Seismic and volcanic hazard, the case of the Campi Flegrei, Naples: geological structures and description of the crisis occurred during 1972-2000*, Earth Sciences and Natural Disaster Prevention, a Japan-Italy Meeting, 2001 Kyoto, Japan.
- Bruno, P.P.; Di Fiore, V.; Rapolla, A., - 2002 - *Reprocessing of seismic reflection data around the Ischia-Procida offshore: preliminary results*, XXVII General Assembly Nice, France, 21 - 26 April 2002
- Bruno, P.P.; Di Fiore, V.; Rapolla, A., - 2002 - *Structural setting of the Gulf of Naples and correlation between tectonics and volcanism*, XXVII General Assembly Nice, France, 21 - 26 April 2002
- Bruno, P.P.; Di Fiore, V.; Rapolla, A., - 2002 - *Seismic reflection imaging of the volcanic structures below Campi Flegrei submerged caldera and correlation with well log data*, XXVII General Assembly Nice, France, 21 - 26 April 2002.
- Cecchetti A., Marianelli P., Sbrana A., - 2002 - *The Campi Flegrei deep feeding system: melt inclusion investigations*. XXVII General Assembly of the European Geophysical Society, Nice 20-24 April 2002.
- D’Antonio M., Di Vito M., Braia G., Carroll M., Civetta L., Isaia R., Orsi G., Piermattei M., - 2002 - *The Averno 2 eruption (Campi Flegrei caldera, Italy): influence of structural setting on magma evolution and eruption history*. XXVII General Assembly of the European Geophysical Society, Nice 20-24 April 2002.
- D’Antonio, M., Isaia, R., Bolognesi, L., Civetta, L., Di Vito, M.A., Orsi, G., Tonarini, S., - 2002 - *Chemostratigraphy of products of the Astroni activity (4.1-3.8 ka, Campi Flegrei, Italy)*. XXVII General Assembly of the European Geophysical Society, Nice 20-24 April 2002.
- de Alteriis G., Bruno P.P. e Florio G., - 2001 - *Interpretation of geophysical data acquired off the Ischia island (Italy, Tyrrhenian sea) during the GMS00_05 cruise (october 2000)*. XXVII General Assembly of the European Geophysical Society, Nice 20-24 April 2002.
- de Vita S., Marotta E., Orsi G., Acocella V., Funicicello R., Cifelli R., - 2002 - Analogue modeling of resurgent calderas; the role of pre-existing tectonic and volcano-tectonic structures. XXVII General Assembly of the European Geophysical Society, Nice 20-24 April 2002.
- Dell’Erba, F., Di Vito M.A., Isaia, R., Mangiacapra, A., Orsi, G., Ricciardi, I., - 2002 - *The Pomice Principali eruption in the Campi Flegrei caldera (Italy)*. XXVII General Assembly of the European Geophysical Society, Nice 20-24 April 2002.
- Dellino P., - 2002 - *Turbulent boundary layer shear flow as an approximation of pyroclastic surge: implication for hazard assessment at Phlegraean Fields*. Oral presentation at the IAVCEI conferece, Martinique, May 2002.
- Fedi M., Hansen P. C., Paoletti V., Rapolla A., - 2001. *3D Inversion of Potential Fields with Depth Resolution*. European Association of Geoscientists and Engineers Conference, Amsterdam 11-14 June, 2001.
- Florio G., Fedi M., 2000. *On the dependence of the parameters of the Euler’s equation*. VIII Workshop on Geo-Electromagnetism, Maratea, October 12-14, 2000, p.29.
- Funicicello R., De Rita D., Giordano G., Di Vito M.A., Isaia R., Orsi G., 2002. *Catastrophic events conditioning human activities in the volcanic areas of Central Italy: examples from the Albano maar lake (Colli Albani, south of Rome)*

and from the Neapolitan volcanoes. Environmental Catastrophes and Recovery in the Holocene. Brunel University, Department of Geography and Earth Sciences, 29 August-2 September, 2002, Uxbridge, United Kingdom.

Marianelli P., Proto M., Sbrana A. (2002): *The Ignimbrite Campana magma chamber: pre-eruptive P-T-X conditions from melt inclusion data*. XXVII General Assembly of the European Geophysical Society, Nice 20-24 April 2002.

Neri A., Esposti Ongaro T., Macedonio G., Gidaspow D., - 2002 - *Multiparticle simulation of collapsing volcanic columns and pyroclastic flows*. IAVCEI, 1902 Centennial Workshop, Mount Pelée, Martinique on "Explosive Volcanism in Subduction Zones", May 12-16.

Slejko F.F., Petrini R., de Vita S., Orsi G., Piochi M.; 2002. *Hydrous species in volcanic glasses from the Cretatio Tephra (Ischia Island, South Italy): inference on the mechanism of water-magma interaction*. Geophysical Research Abstracts. XXVII General Assembly of the European Geophysical Society, Nice 20-24 April 2002.

Slejko F.F., Petrini R.; 2002. *A spectroscopic study on two glasses with different vesicularity from the Astroni Tephra (Phlegraean Fields, Italy): implications on bubble expansion*. Geophysical Research Abstracts. XXVII General Assembly of the European Geophysical Society, Nice 20-24 April 2002.

Tonarini S., Civetta L., D'Antonio M., D'Orazio M., Ferrara G., Innocenti F., Leeman W.P *Boron Isotope Systematic in South Italy Volcanoes*. *Geochimica and Cosmochimica Acta*, vol 66, number 15A, p. A 780 abstract.

Zuccaro, *Human and structures vulnerability of the communes in the Caldera of the Campi Flegrei* - Workshop on "Campania a Rischio" Mostra d'Oltremare, 20.04.2002

- presentations at national meetings

Carroll M.R., Rouse P.J., *Experimental study of the biotite-sanidine-magnetite equilibrium for estimating magmatic water fugacities*. GNV, Assemblea I anno, Roma 9-11 ottobre 2001. Poster session abstracts. p. 171-172.

Cecchetti A., Fulignati P., Marianelli P., Proto M., Sbrana A. (2001): *The feeding system of Campi Flegrei. Insights from melt and fluid inclusions on Ignimbrite Campana, Solchiaro and Minopoli eruptions*. GNV, Assemblea I anno, Roma 9-11 ottobre 2001. Poster session abstracts. p. 190-191.

Civetta L., D'Antonio M., Pappalardo L., Petrini R., Piochi M., *The evolution of the Campi Flegrei (Italy) magmatic system in the past 60 ka: evidence from the Sr, Nd and Pb isotope data*. GNV, Assemblea I anno, Roma 9-11 ottobre 2001. Poster session abstracts. p. 173-174

Dellino P., Isaia R., La Volpe L., Orsi G., Veneruso M., *Contemporaneous fallout and surge activity in the Aghnanno-Monte Spina eruption (4.1 ka) at Phlegraean Fields: implications for flow-mechanics modeling and hazard assessment*. GNV, Assemblea I anno, Roma 9-11 ottobre 2001. Poster session abstracts. p. 175-176

Di Vito M., Isaia R., Lanza R., Orsi G., Zanella E., *Magnetism of the Aghnanno-Monte Spina pyroclastic deposits (Campi Flegrei)*. GNV, Assemblea I anno, Roma 9-11 ottobre 2001. Poster session abstracts. p. 179-180.

Fedi M., Florio G., Italiano F., 2002. *Analisi ed Interpretazione del Tensore Gradiente di Gravità nella Piana Campana*, XXI GNGTS, Roma, 19-21 November 2002.

Orsi G., *Definizione e zonazione della pericolosità vulcanica della caldera risorgente dei Campi Flegrei e suoi effetti sull'uomo e sull'ambiente*. GNV, Assemblea I anno Programma Quadro 2000-2002, Roma 9-11 ottobre 2001.

Orsi G., Dell'Erba F., Di Vito M.A., Isaia R., Petrazzuoli S., Augusti V., Bellucci Sessa E., *Volcanic and structural evolution of the Campi Flegrei caldera, and kinematics of the resurgence for volcanic hazard assessment and zonation*. GNV, Assemblea I anno, Roma 9-11 ottobre 2001. Poster session abstracts. p. 181-183.

Patella D., Iuliano T., Mauriello P., *Geophysical definition of the Campi Flegrei caldera structure. Analysis of potential field data by probability tomography*. GNV, Assemblea I anno, Roma 9-11 ottobre 2001. Poster session abstracts. p. 184-185.

Petrini, R., Slejko, F.F., Orsi, G., Piochi, M., de Vita, S., Calucci, L., Pinzino, C., Pedrazzi, G., Di Vito, M.A., Isaia, R., *Resonance spectroscopy on volcanic glasses: inference on melts properties and eruptive dynamics*. GNV, Assemblea I anno, Roma 9-11 ottobre 2001. Poster session abstracts. p. 186-187.

Rapolla A., Fedi M., Florio G., Hansen P.C., Paoletti V., *3D inversion of aeromagnetic anomalies with depth resolution*. GNV, Assemblea I anno, Roma 9-11 ottobre 2001. Poster session abstracts. p. 188-189

Tonarini S., Civetta L., D'Antonio M., Ferrara G., Leeman W.P., Necco A. *B/Nb and ¹¹B systematics in the Phlegraean Volcanic District (PVD) and Aeolian Islands (relationship between calc-alkaline and potassic orogenic magmatism in Southern Italy)*. GNV, Assemblea I anno, Roma 9-11 ottobre 2001. Poster session abstracts. p. 177-178.

Zuccaro G., Petrazzuoli S., Baxter P., Spence R.J., *Building structural vulnerability in future possible eruption of the Campi Flegrei Caldera*. GNV, Assemblea I anno, Roma 9-11 ottobre 2001. Poster session abstracts. p. 192-193.

- Data bases

- Compilation of mineral composition data for all of Campi Flegrei eruptive products (being completed) (Carroll)
- Mineralogical (major element data), geochemical (major and trace elements) and isotopical (Sr, Nd, Pb) data bases on Campi Flegrei products emplaced during the past 60 ka of activity (D'Antonio).
- Data Base on Structural Typologies, Roofs and Openings in the communes of Bacoli, Monte di Procida (Zuccaro)

- Computation codes

- Computation code for calculating biotite structural formulas (Carroll).

- *Computation code for thermodynamic calculations for Bt-San-Mt equilibria* (Carroll).
- *Computation codes for the 3D tomography of electromagnetic induction field data* (Patella).
- *Software: the codes for the evaluation of the limit loads on the roofs was been already developed in previous researches and just used in the present project, so as the statistical procedure of correction (QAP) used for the aerophotogrammetric interpretation method* (Zuccaro).
- *Computation code to automatically perform data inversion and obtain the total mass and grain size distribution of a whole fallout deposit, starting from field data.*

- **Other**

- *GIS test on a quarter of Pozzuoli* by RU Zuccaro.
- *Editing by RU Orsi of the volume: Volcanic hazard assessment and zonation at the resurgent Campi Flegrei caldera and their effects on man and environment – 1 year results. 2001.* GNV – Framework Program 2000/2002. Osservatorio Vesuviano - The volume contains 22 extended abstracts, pp. 1-139.
- *Scientific and co-ordination meetings of all the RUs of the Project and of Task leaders.*

β PUBLICATIONS LIST (inclusive of papers in prints and accepted)

- **articles published on international journals**

- Acocella V., Funicello R., Marotta E., Orsi G., de Vita S., *The role of extensional structures on experimental calderas and resurgence.* J. Volcanol. Geotherm. Res., in press.
- Bruno, P.P.G., Di Fiore, V., Rapolla A, 2002, *Seismic reflection data processing in active volcanic areas: an application to Campi Flegrei and Somma Vesuvius offshore (Southern Italy).* Annals of Geophysics, in press.
- Büttner, R., Dellino, P., La Volpe, L., Lorenz, V., Zimanowski, B., 2002. *Thermohydraulic explosions in phreatomagmatic eruptions as evidenced by the comparison between pyroclasts and products from Molten Fuel Coolant Interaction experiments.* J. Geoph. Res. 107, 2277, doi:10.1029/2001JB000511.
- Clarke A., Voight B., Neri A., Macedonio G., - 2002 - *Transient dynamics of vulcanian explosions and column collapse.* Nature, 415: 897-901.
- Couch, S., Sparks RSJ, Carroll MR (2001) *Convective self-mixing of magmas in open-system chambers.* Nature, 411, 1037-1039.
- Dellino, P., Isaia, R., La Volpe, L., Orsi, G. (2002). *Interaction between particles transported by fallout and surge in the deposits of the Agnano-Monte Spina eruption (Phlegraean Fields, Southern Italy).* J. Volcanol, Geotherm. Res., accepted
- Dellino, P., Isaia, R., La Volpe, L., Orsi, G., 2001. *Statistical analysis of textural data from complex pyroclastic sequences: implications for fragmentation processes of the Agnano-Monte Spina tephra (4.1 ka), Phlegraean Fields, southern Italy.* Bull. Volcanol. 63, 443-461.
- Dellino, P., Isaia, R., Veneruso, M. (2002). *Turbulent boundary layer shear flows as an approximation of base-surges at Campi Flegrei (Southern Italy).* J. Volcanol, Geotherm. Res., accepted
- Dellino, P., Liotino, G. 2002. *The fractal and multifractal dimension of volcanic ash particles contour: a test study on the utility and volcanological relevance.* J. Volcanol, Geotherm. Res. 113, 1-18.
- Esposti Ongaro T., Neri A., Todesco M., Macedonio G., - 2002 - *Pyroclastic flow hazard at Vesuvius from numerical modeling. II. Analysis of local flow variables.* Bull. Volcanol., 64 (3-4): 178-191.
- Fedele F.G., Giaccio B., Isaia R., Orsi G. 2002. *Ecosystem impact of the Campanian Ignimbrite eruption in Late Pleistocene Europe.* Quat. Res., 57: 420-424.
- Fedi M, Florio G, 2001. *Potential fields source boundaries detection by an Enhanced Horizontal Derivative.* Geophys. Prospecting, 49-1, 13-25.
- Fulignati P., Marianelli P., Proto M., Sbrana A. (2002) *Evidences of disruption of a magma chamber crystallizing front during caldera collapse: an example from the Breccia Museo unit (Ignimbrite Campana eruption).* J. Volcanol. Geotherm. Res., accepted
- Molin P., Acocella V., Funicello R. *Structural, Seismic and hydrothermal features at the border of an intermittent active resurgent block: Ischia island (Italy).* J. Volcanol. Geotherm. Res., in press.
- Neri A., Macedonio G., Gidaspow D., Esposti Ongaro T., - 2002 - *Multiparticle simulation of collapsing volcanic column and pyroclastic flows.* J. Geophys. Res., in press.
- Orsi G., de Vita S., Di Vito M., Isaia R. - 2002 - *The Campi Flegrei Nested Caldera (Italy): A Restless, Resurgent Structure in A Densely Populated Area.* In (Balmuth M., Ed.) *The Cultural Response to the Volcanic Landscape*, Archaeological Institute of America, in press.
- Orsi G., de Vita S., Di Vito M., Nave R., Heiken G. - 2002 - *Facing volcanic and related hazards in the Neapolitan area.* In (Heiken G., Fakundiny R, Sutter J., Eds) *Geosciences in the Cities*, Am. Geophys. Un., Washington, in press.

- Pappalardo L., Civetta L., de Vita S., Di Vito M.A., Orsi G., Carandente A., Fisher R.V., 2002. *Timing of magma extraction during the Campanian Ignimbrite eruption (Campi Flegrei caldera)*. J. Volcanol. Geotherm. Res., 114: 479-497.
- Pappalardo L., Piochi M., D'Antonio M., Civetta L. and Petrini R., 2002. *Evidence for multi-stage magmatic evolution during the past 60 kyr at Campi Flegrei (Italy) deduced from Sr, Nd and Pb isotope data*. J. Petrol., 43: 1415-1434
- Rapolla A., Cella F., Fedi M., Florio G., 2002. *Improved techniques in data analysis and interpretation of potential fields: Examples of application in seismic and volcanic active areas*. Annali di Geofisica, in press.
- Slejko F.F., Petrini R., Forte C. and Pedrazzi G.; 2002. *The structure of dense and vesiculated volcanic glasses from Astroni Tephra (Phlegraean Fields, Italy) explored by resonance spectroscopies*. Bull. Liaison S.F.M.C., 14: 24-25
- Slejko F.F., Petrini R., Pedrazzi G., Forte C., D'Antonio M. *The structure of dense and vesiculated volcanic glass fragments from the Astroni Tephra (Phlegraean Fields, Italy) explored by spectroscopic techniques: implications on bubble expansion and dynamics of magma ascent*. J. Non-Cryst. Solids, in press
- Spence R.J.S., Zuccaro G., Baxter P.J., Petrazzuoli S.M., 2001. *The resistance of Buildings to Pyroclastic Flows: Analytical and Experimental Studies and their Application to Vesuvius*, ASCE's Natural Hazard Review.
- Supper R., Motschka K, Seiberl W, Fedi M, 2001. *Geophysical investigations in Southern Italian active volcanic regions*. Bull. Geol. Surv. of Japan, 54-2-3: 89-99.
- Todesco M., Neri A., Esposti Ongaro T., Papale P., Macedonio G., Santacroce R., Longo A., - 2002 - *Pyroclastic flow hazard at Vesuvius from numerical modeling. I. Large-scale dynamics*. Bull. Volcanol., 64 (3-4): 155-177.
- Tonarini S., Forte C., Petrini R., Ferrara G. *Melt/biotite $^{11}B/^{10}B$ isotopic fractionation and the boron local environment in the structure of volcanic glass*. Geochimica and Cosmochimica Acta, In press.
- Tonarini S., Leeman W.P., Civetta L., D'Antonio M., Ferrara G., Necco A. *B/Nb and ^{11}B systematics in the Phlegraean Volcanic District (PVD), Italy.*, J. Volcanol. Geotherm. Res., accepted
- Vanorio T., Prasad M., Patella D. and Nur A.. *Ultrasonic velocity measurements in volcanic rocks: correlation with microtexture*. Geophysical Journal International, 149, 1: 22-36.
- Vanorio T., Prasad M. and Patella D.. *An experimental study of petrophysical properties of volcanic rocks from Etna and Phlegraean Fields*. J. Volcanol. Geotherm. Res., in press.
- Zimanowski, B., Wohletz, K., Dellino, P., Büttner, R., 2002. *The volcanic ash problem*. J. Volcanol, Geotherm. Res. 2557: 1-5.

- articles submitted for publication on international journals

- Baratta A., Binetti A., Zuccaro G. *Strength capacity of No Tension portal arch-frame under combined seismic and ash loads*, J. Volcanol. Geotherm. Res., submitted
- Bruno P.P., Rapolla, A., Di Fiore, V., 2002, *Structural settings of the Bay of Naples (Italy) by seismic reflection data*. Tectonophysics, submitted.
- Couch, S., Harford, CL, Sparks RSJ, Carroll MR, *Experimental constraints on andesite petrogenesis at the Soufriere Hills volcano, Montserrat*. J. Petrol., submitted, being revised
- Couch, S., Sparks RSJ, Carroll MR (2002) *The kinetics of degassing-induced crystallisation at Soufriere Hills volcano, Montserrat*. J. Petrol., submitted, being revised
- Slejko F.F., Petrini R. and Forte C., *Six-fold aluminum and the reactivity of aluminosilicate volcanic glasses in the phreatoplinian deposits of the Neapolitan Yellow Tuff eruption (South Italy)*. N. Jb. Miner. Abh., submitted
- Slejko F.F., Petrini R., Orsi G., Piochi M., Forte C., *Water speciation and Sr isotopic exchanges during water-melt interaction: a combined NMR-TIMS study on the Cretatio Tephra (Ischia Island, South Italy)*. J. Volcanol. Geotherm. Res., submitted
- Slejko F.F. and Petrini R., *^{29}Si and ^{27}Al NMR spectroscopy on glasses from the Neapolitan Yellow Tuff (Campi Flegrei Caldera, Italy); implications on the cooling dynamics of melts from a compositionally layered magma chamber*. Geochem. J., submitted
- Spence R.J.S., Zuccaro G., Baxter P.J., *Building vulnerability and human casualty estimation for a pyroclastic flow: a model and its application to Vesuvius*, J. Volcanol. Geotherm. Res., submitted.
- Zuccaro G., Ianniello D., *Interaction between pyroclastic flow and the building structures of an urban settlement. A fluid-dynamic simulation impact model*, J. Volcanol. Geotherm. Res., submitted.
- Zuccaro G., Petrazzuoli S.M., *Structural Resistance of RC Buildings under Pyroclastic Flows: A Study on the Vesuvian Area*, J. Volcanol. Geotherm. Res., submitted.

- articles published on national journals, proceedings, technical reports

- Cecchetti A. Marianelli P., Sbrana A. (2002) *L'eruzione di Astroni (Caldera dei Campi Flegrei): dati preliminari dallo studio di inclusioni silicatiche* Atti Soc Tosc. Sci. Nat., Mem., Serie A , submitted
- Cecchetti A. Marianelli P., Sbrana A. (2001): *Prime evidenze della esistenza di un sistema di cristallizzazione profondo ai Campi Flegrei*. Atti Soc Tosc. Sci. Nat., Mem., Serie A , 107: 1-7.
- Fulignati P., Marianelli P., Proto M., Sbrana A. (2001): *L'eruzione della Ignimbrite Campana, unità della Breccia Museo: dati microtermometrici*. Atti Soc Tosc. Sci. Nat., Mem., Serie A , 107: 9-15.

PROJECT TITLE:

EXPERIMENTAL STUDIES OF THE DIFFERENTIATION BEHAVIOUR AND PRE-ERUPTIVE CONDITIONS IN THE CAMPI FLEGREI SYSTEM

RU Responsible

Name-Position: Michael Carroll, Professor

Affiliation: University of Camerino, Department of Earth Sciences

ACTIVITY REPORT–2nd YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/month
Michael Carroll, Professor	University of Camerino	1.5
Alessandro Fabbrizio, PhD student	University of Camerino	11
Valentina DiMatteo, PhD student	University of Naples	6
Cristina Perinelli, post-doc (left 3/02)	University of Camerino	2
Susan Couch, PhD student	Univ. Bristol (UK)	6
Claudio Cottone, technician	University of Camerino	1
Aldo Marchione, technician	University of Camerino	1

• 2nd YEAR OBJECTIVES

The objective for the second year of the project were to determine water-saturated phase relations for a trachytic sample from the Campi Flegrei in order to quantify possible pre-eruptive conditions and magma differentiation trends. We are especially interested in the use of the assemblage biotite – sanidine – magnetite (Bt-San-Mt) to evaluate pre-eruptive water fugacities in the various magmas that have been erupted in the Naples area. The Bt-San-Mt assemblage is very common in the eruptive products of the Campi Flegrei and experimental calibration of this assemblage for estimating water fugacity will be of widespread applicability and will help us to characterize variations in magmatic water activity in many Campi Flegrei eruptions. This work is part of Task 2 of the project (Evolution and actual state of the Campi Flegrei magma system).

• 2nd YEAR RESULTS (max 1 page)

New experimental facilities in Camerino, consisting of 3 rapid-quench hydrothermal bombs, are now fully functional and in continuous use. Experiments in progress concentrate on phase relations and Bt-San-Mt equilibria in a trachytic bulk composition (PhD student Fabrizio), and on water solubility measurements for the same sample composition (work of University of Naples PhD Student Valentina DeMatteo). The experimental starting material is trachytic glass, collected from several obsidian clasts found in the Breccia di Museo deposit. We have also continued work on the dynamics of the dome-forming eruption at Montserrat (with my last PhD student in Bristol – at no cost to this proposal) – while not directly related to the theme of this project on Campi Flegrei volcanism, some of the ideas that we have developed concerning convective self-mixing (Couch et al, 2001) and groundmass crystallization kinetics during magma ascent (Couch et al., 2002) should be of interest for the Campi Flegrei volcanism, much of which shows evidence for magma mixing processes.

The phase equilibrium experiments are at pressures of 50-200 MPa and temperatures of 700-875°C under water saturated conditions and we have been able to locate crystallization conditions for feldspar, magnetite and clinopyroxene; biotite is expected in some of the lower temperature experiments but we have not yet analyzed these. Fifteen experiments of 7-10 days duration have

been completed and microprobe analyses will be done in Rome in early 2003. We anticipate another 10-15 phase equilibrium experiments will be completed in the next 3 months.

Much additional work concerning the Bt-San-Mt equilibrium and its use to evaluate water fugacities concentrates on the problem of Bt crystal chemistry, specifically the need to calculate Fe³⁺ contents because the microprobe analyses provide only total Fe. For experimental biotites grown in phonolitic melts under conditions of known water fugacity (completed in first year of this project) we have completed an analysis which shows that a partially ionic activity model for biotite yields the best correlation between measured and calculated water fugacity (a manuscript on this work is ~90% completed and we expect to submit it for publication in early 2003). We have also made a compilation of published data for Campi Flegrei mineral compositions and, assuming that the model developed for biotites grown in phonolitic melts is applicable (to be verified by experiments on trachytes now being done), we have calculated water fugacities for the Campanian Ignimbrite. The calculated water fugacities of 80-130 MPa suggest a minimum magma chamber depth of 4-6 km and this is consistent with pre-eruptive pressures indicated by our previous work on melt inclusions in natural samples and experiments on Cl solubility in trachytic melts saturated with an aqueous fluid and a saline brine (Signorelli, S., Vaggelli G., Romano C., Carroll MR (2001) Volatile zoning (H₂O, F, Cl, S) of Campanian Ignimbrite magmas (Phlegrean Fields, Italy): evidence from the study of glass inclusions and matrix glasses. *Contributions to Mineralogy and Petrology* 140, 543-553)

The past year has also seen the arrival of a PhD student from Naples to work in my lab in Camerino. We have been working on the solubility of water in trachytic melts, with the objective of developing a model to predict the effects of melt composition on water solubility (available data is mainly for calc-alkaline compositions so data on alkaline compositions is needed for work on the typically alkali-rich Campi Flegrei magma types). We have completed approximately 20 experiments at pressures of 50 to 200 MPa under super-liquidus conditions. Samples were analyzed by FTIR at Roma3 University and we have obtained preliminary independent measurements of water contents by Karl-Fischer titration in collaboration with Harald Behrens (Univ. Hannover). This work will be completed in the first half of 2003 and we hope to extend our work to examine melt-fluid partitioning of trace elements.

- RESEARCH PRODUCTS

- n° of articles published on international journals:
3 (2 in revision)
- invited papers and talks:
2 (Fall AGU, Chapman Conference on volcanism and climate)
- presentations at international meetings:
2, both invited
- Data bases:
compilation of mineral composition data for all of Campi Flegrei eruptive products (being completed)
- Computation codes:
2, one for calculating biotite structural formulas, one for thermodynamic calculations for Bt-San-Mt equilibria
- Other:
Carroll was member of Scientific Program Committee for Chapman Conference on «Volcanism and the Earth's Atmosphere» – involved organizing meeting, inviting speakers and designing scientific sessions.

PUBLICATIONS LIST (inclusive of papers in prints and accepted)

Couch, S., Sparks RSJ, Carroll MR (2001) *Convective self-mixing of magmas in open-system chambers*. *Nature*, 411, 1037-1039.

- Couch, S., Sparks RSJ, Carroll MR (2002) *The kinetics of degassing-induced crystallisation at Soufriere Hills volcano, Montserrat*. J. Petrol., submitted, being revised
- Couch, S., Harford, CL, Sparks RSJ, Carroll MR (2002) *Experimental constraints on andesite petrogenesis at the Soufriere Hills volcano, Montserrat*. J. Petrol., submitted, being revised

PROJECT TITLE:

Definition and modeling of the present state of the Campi Flegrei caldera magmatic system deduced from chemical, mineralogical and isotopical analyses on volcanic rocks, on xenoliths and on glass inclusions.

RU Responsible:

Name-Position: Massimo D'Antonio, Associate Professor

Affiliation: Dip. Scienze della Terra, Università "Federico II" di Napoli, L.go S. Marcellino, 10 80138 Napoli

ACTIVITY REPORT 2nd YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/month
Massimo D'Antonio, Ass. Prof.	Dip. Sci. Terra, Univ. Napoli Federico II	6
Augusti Vincenzo, Technician	Osservatorio Vesuviano	3
Belviso Pasquale, Technician	Osservatorio Vesuviano	4
Carandente Antonio, Technician	Osservatorio Vesuviano	4
Civetta Lucia, Full Professor	Dip. Sci. Fisiche, Univ. Napoli Federico II	6
Pappalardo Lucia, Researcher	Osservatorio Vesuviano	3
Piochi Monica, Researcher	Osservatorio Vesuviano	3
Wohletz Kenneth, Researcher	National Laboratory, Los Alamos – U.S.A	3

• 2nd YEAR OBJECTIVES

- Electron microprobe analyses on glasses, minerals and glass inclusions in rocks younger than 12 ka.
- Sr-Nd-Pb isotopic analyses on whole rock, minerals and glasses separated from rocks younger than 12 ka.

• 2nd YEAR RESULTS

• Methodologies

According to the budget reduction, the ion microprobe analyses, which were supposed to be performed during this year, have been cut. Thus, only electron microprobe, whole-rock major and trace element, and isotope analyses have been carried out on selected samples representative of the Campi Flegrei activity younger than 12 ka. In particular, the activity of the Astroni volcano (4.1 - 3.8 ka) and the Averno 2 eruption (3.7 Ka) have been the object of the petrologic investigations, in cooperation with Researchers of the RU's Orsi, Ferrara and Petrini.

• Data acquisition

- Major element data have been obtained by electron microprobe analysis on minerals and glasses in evolved rocks representative of the activity of the Astroni volcano.
- Major and trace element data have been obtained by ICP-AES and ICP-MS analyses on whole-rock samples representative of the activity of the Astroni volcano and of the Averno 2 eruption.
- Whole rock Sr isotopic analyses on products of the activity of the Astroni volcano and of the Averno 2 eruption.

- Data processing and interpretation
 - A detailed geochemical and isotopic investigation on samples from a bore-hole cored at Ponti Rossi (city of Napoli) has been completed and published (Pappalardo et al., 2002). The studied samples are representative of the activity preceding the Campanian Ignimbrite eruption and of the Campanian Ignimbrite (CI) eruption. Four flow units of the CI eruption have been recognized and correlated with known units cropping out in the area. The investigation has permitted to better define the chemical stratigraphy of the deposit, the compositional structure of the CI magma chamber and the timing of magma extraction during the CI eruption.
 - The geochemical and isotopic data collected to date have allowed us to constrain and reinforce the hypothesis that the evolution of the Campi Flegrei feeding system occurred through a mechanism of open system growth of a reservoir filled by magmas of variable composition, in the past 60 ka. On the basis of the isotopic variations with time, it has been hypothesized that distinct components have been involved, some of deep, subcrustal origin, others of shallower, crustal origin. The results of this investigation have been already published (Pappalardo et al., 2002b). Moreover, boron isotope data on representative products of the past 60 ka, acquired in cooperation with the RU Ferrara, have provided additional constraints to the hypotheses made (Tonarini et al., 2002).
 - Detailed geochemical and isotopic studies have been carried out on samples representative of the activity of the Astroni volcano and of the Averno 2 eruption, in cooperation with RUs Orsi, Ferrara and Petrini. The objective of these studies is to investigate on the behaviour of the shallow feeding systems before and during medium- and small-magnitude eruptions occurred at Campi Flegrei in the past 12 ka. As regards the Astroni activity, the data available to date have allowed us to define the composition of the magmas that fed the volcano. In particular, at least two batches of magma with distinct geochemical and isotopic features, one trachytic and the other alkali-trachytic in composition, were involved during the Astroni activity. The two magmas presumably mingled immediately before and/or during the emplacement of the eruptive units. The Averno 2 eruption was fed by a highly evolved, slightly peralkaline phono-trachytic batch of magma, characterized by homogeneous Sr-isotopic features, suggesting feeding by a very small, isolated magma chamber.

- RESEARCH PRODUCTS
 - n° of articles published on international journals: 3
 - presentations at international meetings: 2
 - D'Antonio M., Di Vito M., Braia G., Carroll M., Civetta L., Isaia R., Orsi G., Piermattei M., - 2002 - *The Averno 2 eruption (Campi Flegrei caldera, Italy): influence of structural setting on magma evolution and eruption history*. 27th Gen. Ass. E.G.S., Nice, France, 21-26 April, Geophys. Res. Abstr., 4, 4437.
 - D'Antonio M., Isaia R., Bolognesi L., Civetta L., Di Vito M., Orsi G., Tonarini S. - 2002 - *Chemostratigraphy of products of the Astroni activity (4.1-3.8 ka, Campi Flegrei, Italy)*. 27th Gen. Ass. E.G.S., Nice, France, 21-26 April, Geophys. Res. Abstr., 4, 4194.
 - Data bases:
 - Mineralogical (major element data), geochemical (major and trace elements) and isotopic (Sr, Nd, Pb) data bases on Campi Flegrei products emplaced during the past 60 ka of activity.

PUBLICATIONS LIST (inclusive of papers in prints and accepted)

- Pappalardo L., Civetta L., de Vita S., Di Vito M., Orsi G., Carandente A., Fisher R.V., 2002a. *Timing of magma extraction during the Campanian Ignimbrite eruption (Campi Flegrei caldera)*, J. Volcanol. Geotherm. Res., 114, 479-497.
- Pappalardo L., Piochi M., D'Antonio M., Civetta L., Petrini R., 2002b. *Evidence of multi-stage magmatic evolution deduced from Sr, Nd and Pb isotope data: the past 60 ka Campi Flegrei (Italy) history*, J. Petrol., 43, 1415-1434.
- Tonarini S., Leeman W.P., Civetta L., D'Antonio M., Ferrara G., Necco A., 2002. *B/Nb and $\delta^{11}B$ systematics in the Phlegrean Volcanic District (PVD)*. J. Volcanol. Geotherm. Res., accepted.

PROJECT TITLE

Reconstruction of fragmentation and transportation dynamics of recent eruptions at the Phlegrean Fields

RU Responsible

Name-Position: Pierfrancesco Dellino – Full Professor of Volcanology

Affiliation: Dipartimento Geomineralogico, Università di Bari, Italy

ACTIVITY REPORT–2nd YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/month
Dellino Pierfrancesco/PO	Università di Bari	5
La Volpe Luigi/PO	Università di Bari	5
Veneruso Mariacira/AR	Università di Bari	5
Braia Giuseppe/DR	Università di Bari	11
Ventrella Giuseppe/DR	Università di Bari	11
Dell'Erba Francesco/DR	Università di Bari	7
Raue Hannes/DR	Univ. di Wuerzburg (FRG)	2
Zimanowski Bernd/PA	Univ. di Wuerzburg (FRG)	2
Buettner Ralf/RC	Univ. di Wuerzburg (FRG)	2

• 2nd YEAR OBJECTIVES

Completion of the study of structural and textural features of Agnano- Monte Spina eruptions deposits. Continuation of the study of Astroni and Averno eruptions deposits. Beginning of Grain-size, component and morphological SEM analysis of clasts from Astroni and Averno eruptions. Beginning of experimental investigation on fragmentation mechanisms, in collaboration with researchers of Wuerzburg University (Germany).

The research, which is centered in the physical volcanology, is focused on obtaining quantitative information to be used for the assessment of hazard.

• 2nd YEAR RESULTS (max 1 page)

- methodologies

(the methodological aspects are shared with the project that is coordinated by R. Santacrose of which L. La Volpe is responsible of a RU and P. Dellino is a participant): 1) an experimental method for the determination of the drag coefficient of pyroclastic particles has been implemented and successfully tested. It consists of video acquisition of particles falling on a settling tube and data processing by means of quantitative image analysis; 2) the method for reconstructing the dynamic pressure of dilute and turbulent pyroclastic density currents, and its relevance for quantitative hazard assessment, has been refined and tested on deposits of significant eruptions of Campi Flegrei; 3) an experimental setup for simulating brittle fragmentation processes occurring during the Campi Flegrei explosive eruptions has been designed and tested at the physical volcanology laboratory of the Wuerzburg University with which there is a collaboration inside the project; 4) quantitative image analysis methods for the numerical characterization of the shape of pyroclastic particles have been further implemented for accommodating the fractal dimension and new classificatory diagrams.

- Data acquisition:

1) field investigation, grain-size, SEM, component and density analysis of Agnano-Monte Spina products were completed; 2) field investigation, grain-size, SEM, component and density analysis of Astroni products have been initiated; 3) field investigation, grain-size, SEM, component and density analysis of Averno products are nearly complete. 3) grain-size, SEM, component and density analysis of experimental products from fragmentation experiments have been started.

- Data processing and interpretation:

1) the combined interpretation of field investigation, grain-size, SEM and density data analyses of Agnano-Monte Spina products, which was concluded, lead us to interpret the eruption as a complex sequence of plinian-phreatomagmatic activities issuing from distinct but close vents. The eruption was thus characterized by interference between fallout and base-surge dynamics. Base-surge, which represent the most severe hazard for Campi Flegrei, had in the Agnano Monte Spina eruptions dynamic pressures in the range between 3 and 4 kPa inside the Agnano plain; 2) The preliminary interpretation of field, grain-size, SEM and density data of Astroni products, suggest that the eruption was characterized mainly by phreatomagmatic activity, with a subordinate role of magmatic activity. Base-surges represented the most recurrent type of transportation mechanism during the eruption, which was also characterized by subordinate, minor fallout processes. Base-surges were characterized by dynamic pressures in the order of 2 kPa at the foot of the volcanic edifice; 3) The preliminary interpretation of field, grain-size, SEM and density data of Astroni products, suggests that the eruption was mainly characterized by phreatomagmatic activity, with subordinate magmatic activity. Fallout (from low eruptive columns) represented the main transportation mechanisms at the beginning of the eruption; whereas, during the intermediate and final stages, base-surges (both of the dry and wet types) were prevailing.

• RESEARCH PRODUCTS

- n° of articles published on international journals: 4
- n° of articles published on national journals, proceedings, technical reports
- invited papers and talks
- presentations at international meetings:
Turbulent boundary layer shear flow as an approximation of pyroclastic surge: implication for hazard assessment at Phlegraean Fields. Oral presentation at the IAVCEI conferece, Martinique, May 2002.
- presentations at national meetings;
- Data bases
- Computation codes
- Other

PUBLICATIONS LIST (inclusive of papers in prints and accepted)

- Büttner, R., Dellino, P., La Volpe, L., Lorenz, V., Zimanowski, B., 2002. *Thermohydraulic explosions in phreatomagmatic eruptions as evidenced by the comparison between pyroclasts and products from Molten Fuel Coolant Interaction experiments.* J. Geoph. Res. 107, 2277, doi:10.1029/2001JB000511.
- Dellino, P., Isaia, R., La Volpe, L., Orsi, G. (2002). *Interaction between particles transported by fallout and surge in the deposits of the Agnano-Monte Spina eruption (Phlegraean Fields, Southern Italy).* Accepted on J. Volcanol, Geotherm. Res.
- Dellino, P., Isaia, R., La Volpe, L., Orsi, G., 2001. *Statistical analysis of textural data from complex pyroclastic sequences: implications for fragmentation processes of the Agnano-Monte Spina tephra (4.1 ka), Phlegraean Fields, southern Italy.* Bull. Volcanol. 63, 443-461.

- Dellino, P., Isaia, R., Veneruso, M. (2002). *Turbulent boundary layer shear flows as an approximation of base-surges at Campi Flegrei (Southern Italy)*. Accepted on J. Volcanol, Geotherm. Res.
- Dellino, P., Liotino, G. 2002. *The fractal and multifractal dimension of volcanic ash particles contour: a test study on the utility and volcanological relevance*. J. Volcanol, Geotherm. Res. 113, 1-18.
- Zimanowski, B., Wohletz, K., Dellino, P., Büttner, R., 2002. *The volcanic ash problem*. J. Volcanol, Geotherm. Res. 2557, 1-5.

PROJECT TITLE

Mixing and Mingling efficiency of Campi Flegrei Magmas.

RU Responsible

Name-Position Donald Dingwell – Professor

Affiliation University of Munich

ACTIVITY REPORT–2nd YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/month
Donald Dingwell	Uni Munich	2
Cristina Wiedemann	Uni Munich	8

• 2nd YEAR OBJECTIVES

Mingling/mixing experiments on Campi Flegrei magma pairs at high temperature and micro-analytical characterisation of experimental products. Comparison of the results with natural systems.

MIXING CONTRASTING IGNIMBRITES

(CAMPANIAN IGNIMBRITE)

PRELIMINARY Report

1) Starting materials	pg 2
2) Sample preparation	pg 3
3) Using the viscometer to mingle and mix. Description of the experimental mixing conditions	pg 3
4) Important physical properties for the evaluation of the experiment	pg 4
5) Short description of the experimental results	pg 5
• 1 st run	
• 2 nd run	
• 3 rd and 4 th runs	
• 5 th run	
6) Summary of partial results	pg 6
7) References	pg 7
Plate 1	pg 8

Author: Cristina Maria Pinheiro de Campos (ex-Wiedemann)

Sao Paulo, 23/10/2002

1) Starting materials: short description of samples: OF 104 F_(m) and OF 152 B2_(f).

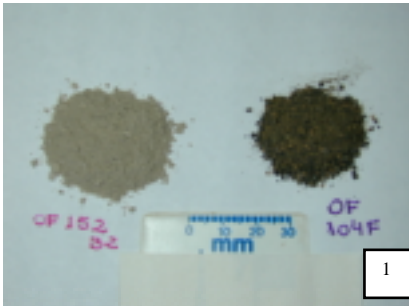


Photo 1 shows original grinded samples of pumice fragments with two contrasting compositions: trachyte (152) and phonolitic trachyte (104).

OF 104 F_(m): phonolitic trachyte; DI = 75-83; $^{87}\text{Sr}/^{86}\text{Sr} = 0.70731 \pm 1$, according to Civetta *et al*, 1997, represents the residual magma in the CI reservoir. Least evolved pumice. Common phenocrysts: sanidine, plagioclase, clinopyroxene, magnetite and biotite.

OF 152 B2_(f): trachyte, DI = 88-90; $^{87}\text{Sr}/^{86}\text{Sr} = 0.70746 \pm 1$; Common phenocrysts: unzoned Fe-rich diopside, (Fs 116-18), oligoclase, and sodic sanidine. Elongated bubbles (Civetta *et al*, 1997).

Starting Compositions (from Civetta *et al*, 1997):

	Mondragone OF152b2p	San Nicola OF104f sp		Mondragone OF152b2p	San Nicola OF104f sp
SiO ₂	58.59	57.65	Ba	25	702
TiO ₂	0.4	0.39	Nb	110	26
Al ₂ O ₃	17.85	18.32	Rb	457	229
Fe ₂ O ₃	3.44	4.16	Sc	1	7
MnO	0.2	0.08	Sr	30	647
MgO	0.3	1.08	V	8	64
CaO	1.77	3.54	Zr	606	169
Na ₂ O	5.84	3.04	La	122	48
K ₂ O	7.94	8.92	Ce	219	92
P ₂ O ₅	0.07	0.17	Nd	77	36
LOI	3.79	2.27	Sm	15	7
Total	99.71	99.62	Eu	1.8	2.0
DI	89.31	78.59	Gd	11	5
			Dy	9	4
			Er	4.3	2.1
			Yb	4.9	2.0
			Lu	0.9	0.3

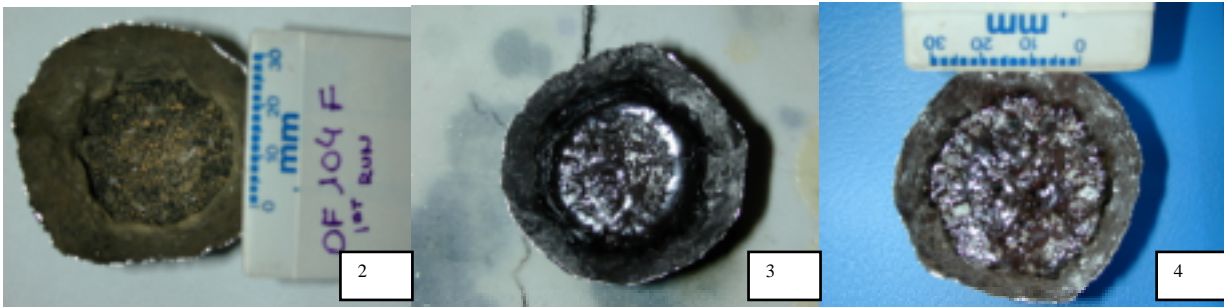
Obs: Most contrasting major and minor elements contents are highlighted in yellow.

2) Sample preparation:

OF 152 B2:

Due to easily foaming, the preparation of samples OF152 and OF 104 F_(m) followed ca.20 different steps of partial melting. For each step 2 to 5g of sample were melted at 1200°C for _ to 1 hour. Between each melting procedure, _ to 1 hour of cooling was necessary to control foaming.

OF 104 F_(m)



Preparation of the 1st RUN

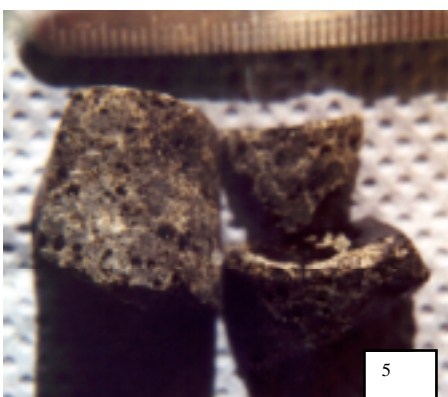
Sample OF 152 B2 Total weight :~90 g

Total heating time: 6h 45 min

Photo 2 – Sample OF 104 F_(m), starting material

Photo 3- Controlling bubble formation through step melting (Sample OF 104 F)

After drilling, samples were mounted in the cylindrical crucible, for the simulation of mixing in a layered magma chamber. The denser sample (OF 104 F_(m)) was mounted at the bottom (photo8) and the less dense (OF 152 B2) at the top.



From a bigger piece of sample OF 104 F_(m) (> 2 cm height) a layered structure is visible, under a magnifying glass (photo 5). Different coloured melts are interfingered in the matrix domains. Different domains of glass with contrasting colours indicate that sample 104 was primarily inhomogeneous and the product of a previous natural mingling process. Up to 3 mm feldspar and clinopyroxene phenocrysts are still visible at this stage.

3) Using the viscometer to mingle and mix; Description of the experimental mixing conditions

The two contrasting silicate melts were mounted in the crucible in such a way that sample 104 (more mafic, more dense and containing more phenocrysts) was below and sample 152 (more leucocratic, less dense and containing more bubbles and less phenocrysts) was on the top. For the 1st

and 2nd runs, the volume of the two melted samples filled the cavity between the outer platinum/rhodium cylinder and the inner platinum/rhodium spindle. For the 3rd, 4th and 5th runs, the inner platinum/rhodium spindle was substituted by a ceramic rod with similar dimensions. The silicate melts were therefore confined between the outer stationary cylinder and the inner rotating spindle, which was suspended from a relative thick metallic rod. The torque transmitted to the samples by the inner rotating spindle was previously set to 0.5%. The temperature was set to 1300°C. Only the duration of the runs was varied:

1st run ~ 25 h;

2nd run ~ 16 h;

3rd run ~ 2h. This last run had to be stopped, because a new ceramic spindle with a metallic spindle holder was positioned too low into the furnace and therefore the new spindle-holder was damaged.

3rd run ~ 9 h . Repetition using the new ceramic spindle;

4th run ~ 4h

5th run ~ 1h;

4) Important physical properties for the later evaluation of the experiment

Silicate melts are now viewed as molecular liquids, which behave as Newtonian liquids at high temperatures and long timescales (Dingwell *et al.*, 1993). Silicate melts may deform continuously under the action of a shear stress. Thus viscosity is the property of a fluid that defines the rate at which deformation takes place when a shear stress is applied:

$\eta(\text{eta}) = \text{viscosity} = \text{shear stress } (\tau) / \text{rate of shear strain } (dv/dz)$

$\eta(\text{eta}) = \tau (\text{tau}) / (dv/dz) . \text{ N/m}^2 . \text{ S/m} . \text{ m} = \text{N/m}^2 . \text{ s} = \text{Pas}$

Shear stress is the pressure (applied force on a given area) measured in N/m² in MKS or Pa, while the rate of shear strain is the change of velocity of fluid with the variation along a given length (dv/dz).

As showed from previous experimental studies (Watson, 1982; Kouchi & Sunagawa, 1985) forced convection is the main factor controlling magma mixing, the rate of mixing being directly proportional to the forced convection.

Temperature dependence of viscosity in silicatic melts is exponential, whatever the fluid composition or pressure (lithostatic -P_s, fluid- P_f). The relationship is described by the Arrhenius -Frenckel-Eyring equation:

$\eta(\text{eta}) = \eta_0 \varepsilon^{E_-/RT}$

where η_0 = pre-exponential constant for the viscosity of liquids at T $\ddagger \infty$

E₋ = activation energy of viscous flow (cal/mol) -

R = universal gas constant

T = temperature in °K

Our 2 melts contain less than 20% of crystals and therefore can be considered as Newtonian liquids (Scarfe *et al.*, 1987). A equation to start with, which relates all these parameters and could possibly describe the experiment is the one for Newtonian liquids:

$\eta = [M / 4\pi\Omega(h+k)]. (1/r^2 - 1/R^2)$ where :

M is the torque

Ω is the angular velocity of the inner cylinder

r an R are respective radii of the outer and inner cylinders.

H+k is the effective length of the outer cylinder. (Scarfe, 1977)

Summing up:

- liquids containing less than 20% of crystal may be considered as Newtonian;
 - the variation of viscosity with T is exponential;
 - shear stress is directly proportional to the degree of mixing in silicatic melts;
- Temperature and torque were kept constant during the first 6 runs of the experiment. Until now the only variable component was time.

5) Short description of the experimental results

- 1st RUN. 25 hours. Sample name CI 152-104

Depth of sample in the crucible 2.27 cm
 Starting time: 15:45
 Position in viscometer: for bottom of crucible 62 mm
 Final position : 61.80 mm
 Time for spindle immersion: 15:53
 Duration of experiment: 24 hours.



Final result of 1st run:

 After drilling from the cylindrical crucible, the sample consists of two glassy parts: a bigger top and a concave smaller bottom, which was vertically cut into 2 pieces (photo 6).

2 cm

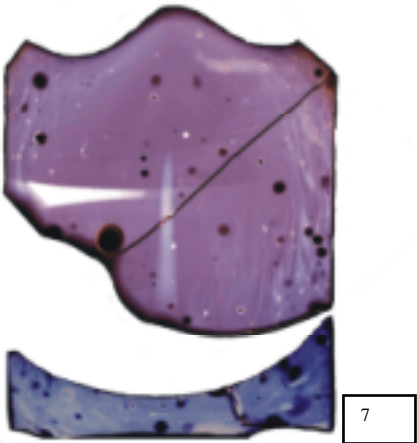
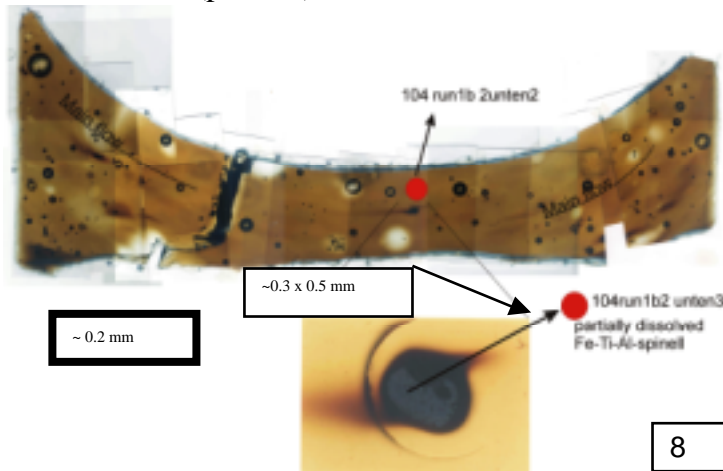


Photo 7 shows differences in flow directions from the top and bottom samples. Images were processed using different filters to highlight flow directions. These observations are consistent with those from detailed photomicrographs of the polished sample under an optical microscope.

Both parts were studied and photographed using a classical optical microscope under transmitted light. The top part is optically more homogeneous than the bottom part. It is marked by darker (Fe/Mn-richer) and/or lighter (Fe/Mn-poorer) vertical to sub vertical strains. This is the case not only at the border, but also towards the centre of the crucible. Preliminary microprobe analysis along a horizontal profile point towards an inhomogeneous glass with compositions varying in the expected ranges showed on table 1. After 25 hours there is mingling but no complete mixing yet.

The bottom part shows horizontal flow in the center, changing to steeper angles at the border of the crucible (photo 8).



Obs: The red dots on photo 8 are WDS and EDS analytical points. Analytical results will be discussed, in a later report, together with those from the 2nd, 3rd, 4th and 5th runs.

- 2nd RUN. 16 hours. Sample name CI 152-104
This sample also consists of two parts: a bottom and a top, similar to the result of the 1st run.
- 3rd and 4th runs (9 and 4 hours respectively)
The end results consist of single samples which are more inhomogeneous, richer in partially melted phenocrysts and bubbles. Fe-Mn-richer darker strains tend to concentrate near the crucible border. Sigma clasts formed from spinell and pyroxene crystals are common.
- 5th run (1 hour)
The end result was photographed under transmitted and reflected light. The following image (plate 1- pg.) is the result of an optical scanning in a detailed scale.
Summary of observations:
 1. Concentration of Fe-Mn-richer strains at the border of the crucible;
 2. Fe-oxide tends to fill cracks ;
 3. Arrangement of phenocrysts along flow direction.
 4. There is a consistent deformation pattern of the bubbles. Deformation increases closer to the rotating ceramic spindle. In this region bubbles are distributed in a conic shaped region of major deformation, contrasting with the less deformed bubbles at the borders.

Partial results:

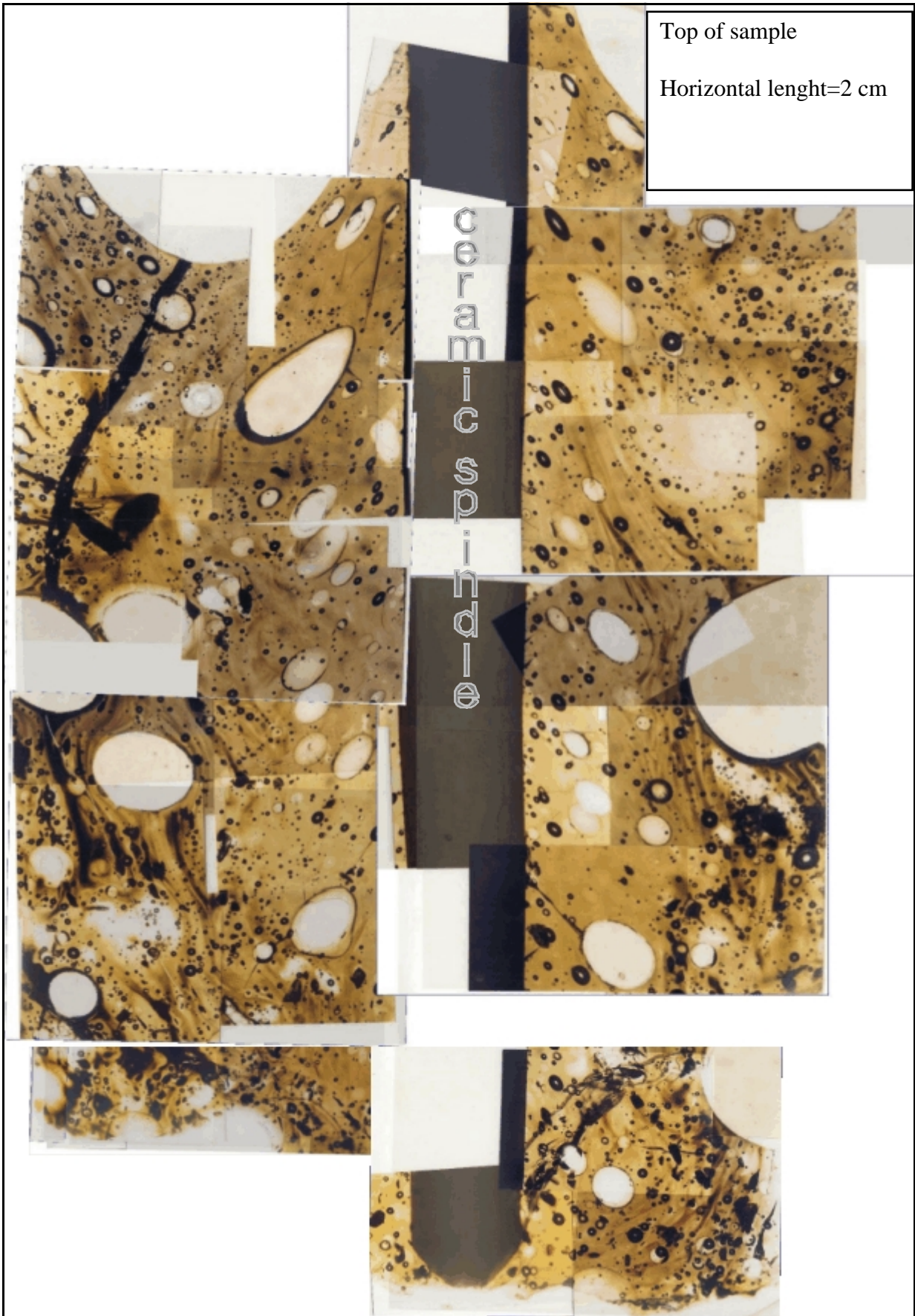
- a) despite the difficulties in the sample preparation, the Campanian Ignimbrite is appropriate for experiments on magma mixing, due to its natural flow markers content, such as: partially melted Fe-Ti-Al-spinell and Fe-clinopyroxene;
- b) following flow markers, the study of flow directions show the development of two separate convection cells in the experiment lasting 25 and 16 hours and single convection cells for the experiments under 16 hours of duration. Decoupled convection cells are known in the literature on mixing materials with contrasting viscosities, as already shown in the analogical experiments of Weinberg (1992);

- c) in this simulation, the mechanism of phenocrysts dissolution can be studied observing the preserved mineralogical disequilibria, such as cellular dissolution textures in spinell and feldspars, which are well known for natural magma mixing processes (Hibbard, 1995; Civetta *et al*, 1997);
- d) due to the viscosity deformation markers such as *sigma clasts* were obtained in all steps of this experiment (photo 8);
- e) optical comparison of the different runs points towards an increase of mixing with time. Longer lasting runs (1st, 2nd and 3rd runs) are more homogeneous in comparison to the shorter ones (4th and 5th runs).

REFERENCES

- Civetta, L.; Orsi, G.; Pappalardo, L.; Fisher, R.V.; Heiken, G. & M. Ort (1997) Geochemical Zoning, mingling, eruptive dynamics and depositional processes – the Campanian Ignimbrite, Campi Flegrei caldera, Italy. *J. of Volcanology and Geot.Res.* **75** : 183-219.
- Dingwell, D.B.; Bagdassarov, N.S.; Bussod, G.Y & S.L. Webb.(1993) Magma Rheology. In: *Handbook on Experiments at high pressure and Applications to the Earth's mantle*. R.W.Luth (ed) Vol.**21**: 131-196.
- Hibbard, M.J. (1995) *Petrography to Petrogenesis*. 1. Ed. New Jersey: Prentice Hall, 608p.
- Kouchi, A. & I. Sunagawa (1985) A model for mixing basaltic and dacitic magmas as deduced from experimental data. *Contr.Mineral.Petrol.* **89**: 17-23.
- Scarfe, C.M. (1977) Viscosity of Pantellerite melt at one atmosphere. *Can Mineral.* **15**: 185-189.
- Scarfe, C.M.; Mysen, B.; & D.Virgo (1987) Pressure dependency of the viscosity of silicate melts. In: *Magmatic Processes Physicochemical Principles*. B.Mysen, (ed) . Spec.Publ.1. The Geochemical Society of Canada: 59-67.
- Watson, E.B., (1982) Basalt contamination by continental crust: some experiments and model. *Contr.Min. Petrol*, **80**: 73-87.
- Weinberg, R. (1992) Internal circulation in a buoyant two-fluid Newtonian sphere: implications for composed magmatic diapirs. *Earth and Plan. Sc. Letters*, 110: 77-94.

PLATE 1



- RESEARCH PRODUCTS

- n° of articles published on international journals
- n° of articles published on national journals, proceedings, technical reports
- invited papers and talks
- presentations at international meetings 1
- presentations at national meetings;
- Data bases
- Computation codes
- Other

PUBLICATIONS LIST (inclusive of papers in prints and accepted)

Wiedemann, C. and Dingwell, D.B. (2003) Mingling and mixing efficiency in Campi Flegrei Magmas: an experimental approach. (EGS-EUG-AGU meeting abstract)

PROJECT TITLE:

Relationships between active regional tectonics and volcanism in the Phlegraean area

RU Responsible:

Name-Position: Claudio Faccenna - associate professor
Affiliation: Dip. Scienze Geologiche, Università Roma Tre

ACTIVITY REPORT_2nd YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/month
Claudio Faccenna, Ass. Professor	Dip. Scienze Geologiche Roma Tre	1
Valerio Acocella – post-doc	Dip. Scienze Geologiche Roma Tre	11
Francesca Cifelli - PhD	Dip. Scienze Geologiche Roma Tre	1

- 2nd YEAR OBJECTIVES

Definition of the structural setting of the Neapolitan area and of the role of the regional structures on volcano-tectonics (such as calderas and resurgences)

- 2nd YEAR RESULTS (max 1 page)

- methodologies:
 - field work
 - analogue modelling

The results which have been obtained in the second year of activity are the following.

- Definition of the geometry, kinematics and age of the NE-SW trending systems which constitute the eastern continuation of the NE-SW trending systems found along the Flegrei-Ischia area. This has been obtained considering in detail the stratigraphy of the Campania Plain, in cooperation with the Orsi RU, in order to find out the presence of very young (<120 ka) deposits, which may be coeval with volcanic activity in the Flegrei-Ischia area. These deposits show signs of very recent faulting activity, with predominant subvertical NE-SW and NW-SE trending structures. The kinematics of the NW-SE structures is extensional, while the NE-SW systems mainly show transtensional kinematics. Their displacement is in the order of several tens of meters.
- Definition of the mechanisms of collapse and resurgence within extensional settings. This has been achieved through analogue models, which permitted to define the overall modalities of reactivation of the normal faults during collapse and resurgence. The performed experiments will then be applied to the specific case of the Campi Flegrei caldera.

- RESEARCH PRODUCTS

- n° of articles published on international journals: 1
- n° of articles published on national journals, proceedings, technical reports: 1
- invited papers and talks
- presentations at international meetings:
 - Acocella V., Marotta E., Cifelli R., Funicello R., De Vita S., Orsi G., (2002) - Analogue models of calderas in extensional settings: insights for the development of elliptic calderas. Poster presentation EGS meeting Nice (France), April 2002. Abstract Volume p. 112.
 - Acocella V., Marotta E., Cifelli F., Funicello R., (2002) – Analogue models of calderas and resurgences in extensional settings. Oral presentation at the IGCP meeting on “Interaction between volcanoes and their basement and related geological hazards”, Santiago, (Chile), October 2002.
 - de Vita S., Marotta E., Orsi G., Acocella V., Funicello R., Cifelli R., (2002) - Analogue modeling of resurgent calderas; the role of pre-existing tectonic and volcano-tectonic structures. Oral presentation EGS meeting Nice (France), April 2002. Abstract Volume p. 90.
- presentations at national meetings;
- Data bases
- Computation codes
- Other

PUBLICATIONS LIST (inclusive of papers in prints and accepted)

Molin P., Acocella V., Funicello R. Structural, *Seismic and hydrothermal features at the border of an intermittent active resurgent block: Ischia island (Italy)*. J. Volcanol. Geotherm. Res., in press.

ACOCELLA V., FUNICIELLO R., MAROTTA E., ORSI G., DE VITA S., *THE ROLE OF EXTENSIONAL STRUCTURES ON EXPERIMENTAL CALDERAS AND RESURGENCE*. J. VOLCANOL. GEOTHERM. RES., IN PRESS.

Acocella V., Funicello R., (2001) – Preliminary analysis of the Quaternary structures of the Apennines bordering the Campi Flegrei area. Extended abstract project n.26, GNV-INGV meeting, October 2001, Roma, 2-6.

PROJECT TITLE
Boron as a tool in studying the genesis and the evolution of the Phlegraean Volcanic District.

RU Responsible

Name-Position: Ferrara Giorgio – full professor
 Affiliation: Istituto Geoscienze e Georisorse

ACTIVITY REPORT–2nd YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/month
Tonarini Sonia - Resercher	Istituto Geoscienze e Georisorse	6
Leeman William - P. Professor	D. Earth Science Rise University	2

• 2nd YEAR OBJECTIVES

Detailed isotopic study of well known stratigraphic sequence (e.g. Astroni) in which the possible temporal evolution of isotopic composition can be used as a tracer of processes occurring in shallow reservoirs. Isotopic investigation in the main eruptions (Campanian Ignimbrite and Neapolitan Yellow Tuff) of the Phlegraean Area addressed to study the role of crustal assimilation in shallow and deeper reservoirs. Expected results: more information on the processes occurring in the shallow system as crustal contamination and mixing/mingling between distinct magma batches.

• 2nd YEAR RESULTS (max 1 page)

- methodologies : Boron isotopic fractionation between minerals and glass.
- Data acquisition Sr, Nd and B isotopes on Astroni products

¹¹B measured in selected products of Procida and Campi Flegrei decreases with increasing of ⁸⁷Sr/⁸⁶Sr ratio with two distinct trends that appear to converge toward a common end-member. The first trend (A) is described by Procida K-basalts, Campi Flegrei trachytes older than Campanian Ignimbrite, two Ischia shoshonites and Minopoli samples. This trend implies the involvement in the genesis of these rocks of a component characterized by low B/immobile element ratios, low ¹¹B and high ⁸⁷Sr/⁸⁶Sr. A similar component is inferred in the genesis of Stromboli potassic lavas.

The samples defining the second trend (B) and including only post CI eruptions, also show negative correlation between ⁸⁷Sr/⁸⁶Sr and differentiation index strongly suggesting that trend B reflect a mingling process between residual evolved Campanian Ignimbrite like-magma residing in shallow reservoirs and the less differentiated trachybasalts magma of Minopoli. A detailed isotopic study on representative products of Astroni volcano was done with the aim to rich a better understanding of the potential role played crustal material, either as a crustal contaminant or a mantle component in the genesis of . The Astroni volcano has been characterized by several distinct Unit, from 1 at the base to 9 at the top. The Sr isotopic composition shows a relatively wide range between 0.70726 and 0.70757 and it decrease from Unit 1 to Unit 7. Unit 7, 8 and 9 show scattered values. The Nd isotopic composition is restricted in a small range between 0.51247 and 0.51251, however it is negatively correlated with Sr isotopic compositions suggesting a mixing/mingling process between two distinct end-members isotopically (Sr and Nd) similar to Campanian Ignimbrite (CI) and

Neapolitan Yellow Tuff (NYT). The Sr isotopic composition is also positively correlated with 1/Sr ratio; CI and an evolved NYT-like magma are the extremes of this correlation.

Sanidine, biotite, pyroxene and glass have been separated from representative samples of Unit 4, 7, 8 and 9 and analyzed for Sr and Nd isotopic composition. Over all the minerals are in isotopic disequilibrium respect their glass with differences in $^{87}\text{Sr}/^{86}\text{Sr}$ ratios of about 0.00015. The glasses show Sr isotopic composition variable and comparable to those observed in the whole rock data. In the samples of the Unit 7 and 8, where two varieties of clinopyroxene coexist, were separated a pale green cpx and a dark green one. The pale green clinopyroxene shows Sr and Nd isotopic composition significantly lower and higher than the dark green clinopyroxene respectively. In one case (sample of Unit 8; Cpx data: $^{87}\text{Sr}/^{86}\text{Sr}$ 0.706638, $^{143}\text{Nd}/^{144}\text{Nd}$ = 0.512544) the isotopic values are identical to those measured on clinopyroxene and glass of a pyroxenitic xenolith found in the same Unit and suggesting that the pale green pyroxene is essentially dispersed crystals of the xenolith pyroxene.

The boron isotopic composition varies between -8 and -10‰ with the sample of Unit 1 overlapping the values measured on Neapolitan Yellow Tuff samples. On the other hand, the samples of Unit 7 display significantly lower $_{-}^{11}\text{B}$ respect to those of Campanian Ignimbrite (-10‰ respect to about -7‰ in CI) indicating that CI cannot be involved in the Astroni products genesis. In the plot $^{87}\text{Sr}/^{86}\text{Sr}$ versus $_{-}^{11}\text{B}$ Astroni data describe a trend from the previously recognized trend A (and probably linked to mantle processes) and trend B along which fall the Campi Flegrei samples younger than CI. Thus the Astroni data may illuminate the process that shift the CI from the main mantle source trend A.

• RESEARCH PRODUCTS

- n° of articles published on international journals: 2
- n° of articles published on national journals, proceedings, technical reports: 1
- invited papers and talks: 1

University Neuchatel, 25-11-2002 Seminar

- presentations at international meetings: 1
- presentations at national meetings: 1

PUBLICATIONS LIST (inclusive of papers in prints and accepted)

Tonarini S., Leeman W.P., Civetta L., D'Antonio M., Ferrara G., Necco A. *B/Nb and ^{11}B systematics in the Phlegrean Volcanic District (PVD)*, Italy. Accepted J. Volcanol. Geotherm. Res.

Tonarini S., Forte C., Petrini R., Ferrara G. *Melt/biotite $^{11}\text{B}/^{10}\text{B}$ isotopic fractionation and the boron local environment in the structure of volcanic glass*. *Geochimica and Cosmochimica Acta*, In press

Tonarini S., Civetta L., D'Antonio M., D'Orazio M., Ferrara G., Innocenti F., Leeman W.P. *Boron Isotope Systematic in South taly Volcanoes*. *Geochimica and Cosmochimica Acta*, vol 66, number 15A, p. A 780 abstract.

Tonarini S., Civetta L., D'Antonio M., Ferrara G., Leeman W.P., Necco A. *B/Nb and ^{11}B systematics in the Phlegrean Volcanic District (PVD)*. GNV Framework Program 2000-2002, Project 26. pp 72-77.

PROJECT TITLE

Emplacement temperature and magnetic properties of pyroclastic rocks of Campi Flegrei

RU Responsible

Name-Position Roberto Lanza - Ass. Prof. Geophysics
Affiliation Dip. Scienze della Terra – Università di Torino

ACTIVITY REPORT–2nd YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/month
Roberto Lanza – Ass. Professor	Dip. Sci. Terra, Univ. Torino	3
Elena Zanella - Researcher	Dip. Sci. Terra, Univ. Torino	5
Michela Miletto - Researcher	Dip. Sci. Terra, Univ. Torino	1

- 2nd YEAR OBJECTIVES

- Systematic sampling of various pyroclastic units
- Laboratory measurements
- Preliminary interpretation

- 2nd YEAR RESULTS (max 1 page)

- *Methodologies*

The problem of sampling low-cohesive rocks has been partially solved. Immersion of samples in an ethil-silicate bath proved effective to consolidate the fine-grained, porous samples. It was thus possible to cut the regularly shaped specimens needed for the magnetic fabric measurements.

- *Data acquisition*

The thermal demagnetization routine (10 to 12 temperature steps) was applied to 215 lithic clasts from various layers, mostly from the Agnano-Monte Spina products. The re-heating temperature was successfully determined for more than 160 clasts; half of the remaining clasts have not been affected by the heat conveyed by the pyroclastic flow because they are characterized by unblocking temperatures higher than the flow temperature, and half yielded negative results because of chemical alteration, very low magnetization intensity, ...
The magnetic fabric was measured on some 50 specimens from the Agnano-Monte Spina E and B layers.

- *Data processing and interpretation*

The table enclosed reports the emplacement temperature so far obtained. Data in italics are preliminary, because the number of measurements was not enough for a reliable determination of the emplacement temperature. More specimens from these site are currently measured.

Layer	Section	Temperature
A1	MS151 - Verdolino	more samples needed
B1	MS151 - Verdolino	280-300
	MS171 - Via Epomeo	340-360
B2	MS152 - San Germano	290-330
	MS101 - Vallone del Corvo	280-300
	MS134 - Cant. Romano	260-300
	MS142 - Valico Pisani	280-290
	MS151 - Verdolino	260-300
	MS159 - Torciolano	280-300
	MS171 - Via Epomeo	260-300
D1	MS151 - Verdolino	320-340
	MS159 - Torciolano	280-300
E2	MS159 - Torciolano	290-310
	MS177 - Solfatara	300-320
2A	AV0-04 - Averno	260-320

A preliminary interpretation of the results is in progress, in co-operation with RUs Orsi and Dellino.

- RESEARCH PRODUCTS

A poster will be presented at the GNV Scientific Meeting, Roma (January 2003)

PROJECT TITLE

Physical Modelling of the pyroclastic dispersion and thermal fluxes in the Phlegraean caldera

RU Responsible

Name-Position: Giovanni Macedonio – Dirigente di Ricerca

Affiliation: Osservatorio Vesuviano – INGV, Napoli (Italy)

ACTIVITY REPORT–2nd YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/month
Macedonio Giovanni – Dir. Ricerca	Osservatorio Vesuviano – INGV	3
Costa Antonio – Phd Student	University of Bologna/OV-INGV	5
Pfeiffer Tom – EU Contract	Osservatorio Vesuviano – INGV	3
Quareni Francesca – Associate Prof.	Osservatorio vesuviano – INGV	1
Petrazzuoli Stefano – Contract	---	1

- 2nd YEAR OBJECTIVES

Reconstruction of the deposits of the Agnano-Monte Spina (AMS) eruption at Phlegrean Fields by using a ash fallout model.

Application of the pyroclastic flows emplacement model at the CFc and hazard analysis.

- 2nd YEAR RESULTS (max 1 page)

Methodologies:

A previous computer code for simulating ash fall-out was adopted for the reconstruction of the Agnano-Monte Spina (AMS) eruption of the Phlegraean Fields. The code was modified to automatically perform data inversion and obtain the total mass and grain size distribution of the whole deposit starting from field data. The method was also tested on the AD79 Vesuvius eruption. A simple code was developed for processing wind data collected by the NOAA to perform a statistical analysis of the wind velocities in the Neapolitan area, needed to produce a hazard map from ash fall-out.

Studies were performed for the simulation of pyroclastic currents at Phlegraean Fields (to be done during the 3rd year), with preliminary applications on the well known eruptions of Vesuvius and Montserrat.

Data acquisition

Field and laboratory data on the fallout deposits of the B1 and D1 layers of the AMS eruption were collected by the RU Orsi during the first and second year of the project. These include deposit thickness, particles grain-size distribution and component analysis of five exposures. Wind directions were estimated directly by the main dispersal axis of the two deposit units: best fit analysis with the model shows a small angle between the two dispersal axis and a small difference in the intensity.

Field and laboratory data on the deposits of the pyroclastic currents of the AMS eruption, collected by RUs Orsi and Dellino, have been acquired.

Data processing and interpretation

Field data (deposit thickness, density and grain size distribution) in different exposures of the AMS deposit were converted into mass loading (km/m³) and settling velocity distribution, assuming spherical particles. The total mass and the global grain size distribution were computed as a best-fit between field data and the model. A discrepancy between the total mass computed with different methods (eg. Pyle) was observed. This seems to be related with the difficulty to estimate the total amount of fines falling far from the deposit (not considered in our method).

The analysis of the field and laboratory data on the deposits of the pyroclastic currents of the AMS eruption, collected by RUs Orsi and Dellino, is in progress.

- RESEARCH PRODUCTS

- n° of articles published on international journals: **4**
- n° of articles published on national journals, proceedings, technical reports
- invited papers and talks
- presentations at international meetings: **1**
- presentations at national meetings;
- Data bases
- Computation codes: **1**
- Other

PUBLICATIONS LIST (inclusive of papers in prints and accepted)

Clarke A., Voight B., Neri A., Macedonio G., - 2002 - Transient dynamics of vulcanian explosions and column collapse. *Nature*, 415: 897-901.

Esposti Ongaro T., Neri A., Todesco M., Macedonio G., - 2002 - Pyroclastic flow hazard at Vesuvius from numerical modeling. II. Analysis of local flow variables. *Bull. Volcanol.*, 64 (3-4): 178-191.

Neri A., Macedonio G., Gidaspow D., Esposti Ongaro T., Multiparticle simulation of collapsing volcanic column and pyroclastic flows. *J. Geophys. Res.*, (*in press*).

Todesco M., Neri A., Esposti Ongaro T., Papale P., Macedonio G., Santacroce R., Longo A., - 2002 - Pyroclastic flow hazard at Vesuvius from numerical modeling. I. Large-scale dynamics. *Bull. Volcanol.*, 64 (3-4): 155-177.

Presentations

Neri A., Esposti Ongaro T., Macedonio G., Gidaspow D., - 2002 - "Multiparticle simulation of collapsing volcanic columns and pyroclastic flows", IAVCEI, 1902 Centennial Workshop, Mount Pelée, Martinique on "Explosive Volcanism in Subduction Zones", May 12-16,.

PROJECT TITLE

VOLCANIC AND STRUCTURAL EVOLUTION OF THE CAMPI FLEGREI CALDERA, AND KINEMATICS OF THE RESURGENCE FOR VOLCANIC HAZARDS ASSESSMENT AND ZONATION

RU Responsible

Name-Position: Giovanni Orsi – Full Professor

Affiliation: Istituto Nazionale di Geofisica e Vulcanologia, Sez. Osservatorio Vesuviano

ACTIVITY REPORT–2nd YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/month
Orsi Giovanni - PO	Osservatorio Vesuviano - INGV	3
Augusti Vincenzo - T	Osservatorio Vesuviano - INGV	3
Carandente Antonio - T	Osservatorio Vesuviano - INGV	3
Di Vito Mauro Antonio - RC	Osservatorio Vesuviano - INGV	4
Isaia Roberto - RC	Osservatorio Vesuviano - INGV	4
Marotta Enrica - T	Dip. Geofis. Vulc., Univ. Napoli	5
Dell'Erba Francesco - DR	Dip. Geomineralogico, Univ. Bari	6
Zanchetta Giovanni - AR	Dip. Sci. Terra, Univ. Pisa	2

• 2nd YEAR OBJECTIVES

Task 1

Complete the stratigraphic-structural survey and facies and paleontological analysis of the marine deposits, inside the NYT caldera.

Stratigraphic-structural investigation of the western slopes of the Apennines in order to reconstruct both sequences of volcanic and non-volcanic sediments, and deformation events related to the evolution of the Campanian Plain.

Analyses of cored deposits, their correlation with exposed rocks, and reconstruction of the geometry of the rock bodies.

Sampling of selected rocks for geochronological and stable-isotope analyses.

Task 3

Continuation of the stratigraphical and volcanological survey aimed at reconstructing the whole stratigraphic sequence of the deposits erupted in the past 12 ka, and defining the internal stratigraphy of the each investigated volcano.

Completion of the investigation aimed at reconstructing the Averno and Astroni eruption history and begin of the study of the Monte Nuovo eruption.

Field and laboratory measurements of the density of variable type of pyroclastic deposits.

Evaluation of the erupted volumes and columns heights, and definition of the pyroclasts dispersal for all the defined explosive eruptions of the past 12 ka, will begin.

Analysis of the sedimentological, mineralogical, petrological and geochemical data.

• 2nd YEAR RESULTS (max 1 page)

Task 1

Detailed stratigraphic and structural data have been acquired in the northern sector of the Campi Flegrei caldera. The data have permitted to define the main volcanic and deformative events

occurred in the past 39 ka, after the first collapse episode of the CFc. Stratigraphic-structural investigations of the western slopes of the Apennines have permitted to collect data in both Avella and Caudina valleys which represent the continuation of NE-SW trending fault system affecting the CFc. In these three areas the presence of variable volcanic and non-volcanic rocks of known age have permitted to constraint the age of important deformation events.

In the Campanian Plain the rock sequences exposed in many archaeological excavations have been studied in order to define the evolution of the area after emplacement of the CI. These data have been integrated with the results of the analysis of logs and cores of bore-holes, some of which penetrated the CI whole sequence and drilled older rocks. During the field survey sequences of both volcanic and non-volcanic rocks have been sampled for geochronological and stable-isotope analyses.

Task 3

The stratigraphic and volcanological investigations both inside and outside the northern part of the CFc allowed the acquisition of about 40 new stratigraphic sequences both in natural exposures and in excavations. The collected data have been integrated with those from cores of bore-holes drilled in the same area and from previous investigations in order to reconstruct the volcanic sequences erupted during the three epochs of activity and define the internal sequence of the deposits of each studied volcano. The data have allowed also a better definition of isopachs and maximum pumice and lithic fragments isopleths for fallout deposits, and arial distribution of the flow deposits of the eruptions of the third epoch of activity. Field and laboratory determinations of the density of variable type of pyroclastic deposits have permitted to construct maps of the distribution of the load on the ground exerted by the variable fallout deposits. The reconstruction of the eruption history of both Averno and Astroni volcanoes has been completed. Sedimentological, paleomagnetic, and petrological analyses of the products of these eruptions are in progress in collaboration with RUs Dellino, Lanza and D'Antonio, respectively. Stratigraphical and volcanological studies of the Monte Nuovo products are also in progress.

• RESEARCH PRODUCTS

- n° of articles published on international journals
- n° of articles published on national journals, proceedings, technical reports
- invited papers and talks

Orsi G., Di Vito M., Gianpaola D., Isaia R., Marzocchella A., 2002. *Humans and active volcanoes living together over the past 6,000 years in the Neapolitan area (Italy)*. 35th Chacmool Conference – Apocalypse Then and Now, November 13-17, Calgary.

- presentations at international meetings: 5

D'Antonio, M., Isaia, R., Bolognesi, L., Civetta, L., Di Vito, M.A., Orsi, G., Tonarini, S., 2002. *Chemostratigraphy of products of the Astroni activity (4.1-3.8 ka, Campi Flegrei, Italy)*. Vol. 4, European Geophysical Society, XXVII General Assembly, Nice, France 21-26 April 2002.

D'Antonio, M., Di Vito, M.A., Braia, G., Carroll, M., Civetta, L., Isaia, R., Orsi, G., Piermattei, M., 2002. *The Averno 2 eruption (Campi Flegrei caldera, Italy): influence of structural setting on magma evolution and eruption history*. Vol. 4, European Geophysical Society, XXVII General Assembly, Nice, France 21-26 April 2002.

Dell'Erba, F., Di Vito M.A., Isaia, R., Mangiacapra, A., Orsi, G., Ricciardi, I., 2002. *The Pomice Principali eruption in the Campi Flegrei caldera (Italy)*. Vol. 4, European Geophysical Society, XXVII General Assembly, Nice, France 21-26 April 2002.

Funiciello R., De Rita D., Giordano G., Di Vito M.A., Isaia R., Orsi G., 2002. *Catastrophic events conditioning human activities in the volcanic areas of Central Italy: examples from the Albano maar lake (Colli Albani, south of Rome) and from the Neapolitan volcanoes*. Environmental

Catastrophes and Recovery in the Holocene. Brunel University, Department of Geography and Earth Sciences, 29 August-2 September, 2002, Uxbridge, United Kingdom.

- presentations at national meetings;
- Data bases
- Computation codes
- Other

PUBLICATIONS LIST (inclusive of papers in prints and accepted)

Büttner, R., Dellino, P., La Volpe, L., Lorenz, V., Zimanowski, B., 2002. *Thermohydraulic explosions in phreatomagmatic eruptions as evidenced by the comparison between pyroclasts and products from Molten Fuel Coolant Interaction experiments*. J. Geoph. Res. 107, 2277.

Dellino, P., Isaia, R., La Volpe, L., Orsi, G. (2002). *Interaction between particles transported by fallout and surge in the deposits of the Agnano-Monte Spina eruption (Phlegraean Fields, Southern Italy)*. Accepted on J. Volcanol, Geotherm. Res.

Dellino, P., Isaia, R., Veneruso, M. (2002). *Turbulent boundary layer shear flows as an approximation of base-surges at Campi Flegrei (Southern Italy)*. Accepted on J. Volcanol, Geotherm. Res.

Fedele F.G., Giaccio B., Isaia R., Orsi G. 2002. *Ecosystem impact of the Campanian Ignimbrite eruption in Late Pleistocene Europe*. Quat. Res., 57: 420-424.

Orsi G., de Vita S., Di Vito M., Isaia R. - 2002 - *The Campi Flegrei Nested Caldera (Italy): A Restless, Resurgent Structure in A Densely Populated Area*. In (Balmuth M., Ed.) *The Cultural Response to the Volcanic Landscape*, Archaeological Institute of America, in press.

Orsi G., de Vita S., Di Vito M., Nave R., Heiken G. - 2002 - *Facing volcanic and related hazards in the Neapolitan area*. In (Heiken G., Fakundiny R, Sutter J., Eds) *Geosciences in the Cities*, American Geophysical Union book, Washington, in press.

Pappalardo L., Civetta L., de Vita S., Di Vito M.A., Orsi G., Carandente A., Fisher R.V., 2002. *Timing of magma extraction during the Campanian Ignimbrite eruption (Campi Flegrei caldera)*. J. Volcanol. Geotherm. Res., 114, 479-497.

PROJECT TITLE

Offshore Magnetotelluric and Magnetovariational Measurements in the Gulf of Pozzuoli for the Study of the Phlegrean Fields Caldera

RU Responsible

Name-Position: Domenico Patella – Ordinary Professor of Applied Geophysics
Affiliation: Department of Physical Sciences, University Federico II of Naples

ACTIVITY REPORT–2nd YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/month
Patella Domenico - PO	Univ. Napoli Federico II, DSF	4
Mauriello Paolo - PO	CNR-ITABC	2
Petrillo Zaccaria - RC	INGV-OV	6
Vanorio Tiziana - PhD, Res. contract	UNI NAPOLI Federico II, DSF	1
Iuliano Teresa - PhD, Res. fellowship	UNI BARI, DGG	2
Di Fiore Boris - PhD, Res. contract	UNI NAPOLI Federico II, DSF	6
Troiano Antonio - PhD student	UNI NAPOLI Federico II, DSF	6
Di Giuseppe M.Giulia - Res. contract	INGV-OV	6

- 2nd YEAR OBJECTIVES

3D probability tomography method for electromagnetic induction fields

The objective was the testing of the software codes of the 3D probability tomography method for electromagnetic induction fields, including polarization and uneven topography effects.

Land magnetotelluric soundings

The objective was the execution of additional ground MT soundings (10) in the volcanic area of the Phlegrean Fields.

Sea-to-ground magnetovariational soundings

The objective was the execution of test experiments and preparation of a sea-to-ground MV survey in the volcanic area of the Phlegrean Fields.

- 2nd YEAR RESULTS (max 1 page)

3D probability tomography method for electromagnetic induction fields

The theory has been fully developed and the computational algorithm has been tested for complex structural situations, including synthetic bodies simulating magma reservoirs. The new method will

be applied to the CF caldera as soon as the new MT data recently acquired and to be acquired within the end of this year will definitely be processed.

Land magnetotelluric soundings

Two complete Metronix MT stations have been acquired and made fully operative at the end of last year/beginning of this year. Six new MT soundings have been already carried out and processed, two are with processing in progress and two will be performed and processed within the end of this year. A new multivariate algorithm has been adapted and tested to the Campi Flegrei environmental situation, which requires a very accurate filtering of coherent noise.

Sea-to-ground magnetovariational soundings

A new LEMI three-component fluxgate sea-bottom magnetometer has been acquired at the end of last year and made fully operative last spring. Delivery and operational tests have been done. No underwater magnetovariational sounding has yet been produced because of a heavy cut of the funds for the second year. It is expected that recover of the full financing plan will be done in the third year.

- RESEARCH PRODUCTS

- n° 2 of articles published on international journals
- Computation codes :

Computation codes for the 3D tomography of electromagnetic induction field data

PUBLICATIONS LIST (inclusive of papers in prints and accepted)

- T.Vanorio, M.Prasad, D.Patella and A.Nur. *Ultrasonic velocity measurements in volcanic rocks: correlation with microtexture*. Geophysical Journal International, 149, n.1, 22-36.
- T.Vanorio, M.Prasad and D.Patella. *An experimental study of petrophysical properties of volcanic rocks from Etna and Phlegrean Fields*. In press on *J. Volcanol. Geotherm. Res.*

PROJECT TITLE
Study of the silicate melt/glass structure of the Campi Flegrei caldera products using spectroscopic techniques

RU Responsible

Name-Position Riccardo Petrini - Associate professor
 Affiliation Earth Science Dept. University of Trieste

ACTIVITY REPORT–2nd YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/month
Riccardo Petrini – Ass. Prof.	Trieste University	8
Francesca F. Slejko - PhD student	Trieste University	10
Calogero Pinzino - Researcher	CNR Pisa	2
Claudia Forte - Researcher	CNR Pisa	3
Giuseppe Pedrazzi – Ass. Prof.	Parma University	2

• **2nd YEAR OBJECTIVES**

The task for the second-year activity was the study of the dynamics of melt cooling, degassing and fluids interactions, with implications on the mechanisms of melt uprising from a shallow reservoir to glass quenching.

• **2nd YEAR RESULTS**

Resonance spectroscopies (^{29}Si , ^{27}Al , ^1H MAS-NMR, ^{29}Si PASS-NMR, ESR, and Mössbauer), electron microprobe analyses and back-scattered electron microscopy were applied to glasses from the Astroni and the Neapolitan Yellow Tuff eruptions. Data acquisition was performed using a Bruker AMX-300 WB spectrometer, a Cameca SX50 microprobe, a Leica Stereoscan 430i, a Varian E112 spectrometer working in the X-band frequency and a Takes spectrometer coupled with a Wissel velocity transducer. In addition, XRD analysis on glasses were performed by a Siemens D-500 diffractometer.

The process of volatile exsolution and bubble growth was investigated by the study of dense and vesiculated glass fragments from the Astroni volcano. The dense glass is characterized by incomplete bubble expansion, and it is suggested that the melt quenched prior to volatile loss. The vesiculated glass shows evidence of preserved inter-bubble expansion which has been interpreted as due to clast expansion times shorter than the times required for the complete rupture of the melt films. Mössbauer and ESR experiments have shown that both glass types are characterized by $\text{Fe}^{2+}(\text{VI})$ and Fe^{3+} in both tetrahedral network forming and non-tetrahedral modifying sites. ^1H MAS NMR spectra indicate a clustering of O-H groups or H_2O molecules, and the presence of less abundant isolated water species. A larger abundance of hydrogen is observed in the dense glass, attributable to incomplete degassing. From ^{29}Si PASS and MAS NMR spectra we have deduced that most of the silicon is in Q^4 structural units, with possible Al substitution in next-nearest tetrahedra, and a relatively small abundance of Si in Q^3 sites. The obtained data provide some constraint on the dynamics of magma ascent and flow conditions. The dense and vesiculated glass fragments are interpreted as representing different magma batches from a chamber filled by a chemically slightly heterogeneous magma, characterized by a similar distribution of dissolved water species in the melt structure, which underwent different dynamics of ascent from depth to surface. The dense glass would correspond to a melt batch rising from depth, prematurely quenched at the fragmentation threshold into a glass representative of a relatively non-

decompressed and essentially undegassed melt, where the expansion of the vesicles was abruptly halted. The vesiculated glass corresponds to a melt batch which equilibrated at lower pressure and temperature conditions before quenching, allowing the silicate melt to precipitate magnetite particles highly conducive to bubble nucleation. These data are interpreted to mark a change in the eruptive dynamics during the history of the Astroni volcano.

The property of a glass to retain into its structure information about the thermal history of the corresponding melt was applied to the Neapolitan Yellow Tuff (NYT). The NYT alkali trachytic glasses show a variation in the NBO/Si ratio from 0.37 to 0.04, interpreted as separate magma pulses which departed from the top of the magma chamber forming fingerings which drained a chemically homogeneous alkali-trachytic melt but undergoing different time-temperature paths during cooling.

The effects of aqueous fluids-melts interactions at the glass transition were investigated in alkali trachytic glasses from the Lower Member of the NYT. Some of the glasses show corroded morphology and less than micron-sized holes on all the surface, indicating the reaction with leaching solutions. The ^{27}Al MAS NMR spectra of these glasses show the contribution from an ^{61}Al resonance, in addition to an ^{41}Al resonance. A possible explanation is that the transformation of Al from four- to six-fold occurred during aluminum hydrolysis by the reaction of water with Al-O bonds yielding hexa-hydrated Al species in octahedral configuration. The high NBO concentration measured in these glasses/melts could have enhanced the water penetration into the melt structure and aluminum hydrolysis, probably during the phreatomagmatic fragmentation. The selective hydrolysis of tetrahedra aluminate groups with respect to the unreactive silicate groups could indicate the acidic character of these circulating fluids.

• RESEARCH PRODUCTS

- n° 2 article published on international journals
- n° 7 articles published on national journals, proceedings, technical reports presentations at international and national meetings

PUBLICATIONS LIST

- Slejko F.F., Petrini R., Pedrazzi G., Forte C., D'Antonio M. *The structure of dense and vesiculated volcanic glass fragments from the Astroni Tephra (Phlegraean Fields, Italy) explored by spectroscopic techniques: implications on bubble expansion and dynamics of magma ascent*. J. Non-Cryst. Solids, in press
- Pappalardo L., Piochi M., D'Antonio M., Civetta L. and Petrini R., 2002. *Evidence for multi-stage magmatic evolution during the past 60 kyr at Campi Flegrei (Italy) deduced from Sr, Nd and Pb isotope data*. J. Petrol., 43: 1415-1434
- Slejko F.F., Petrini R., Orsi G., Piochi M., Forte C., 2002. *Water speciation and Sr isotopic exchanges during water-melt interaction: a combined NMR-TIMS study on the Cretatio Tephra (Ischia Island, South Italy)*. J. Volcanol. Geotherm. Res., submitted
- Slejko F.F. and Petrini R., 2002. *^{29}Si and ^{27}Al NMR spectroscopy on glasses from the Neapolitan Yellow Tuff (Campi Flegrei Caldera, Italy); implications on the cooling dynamics of melts from a compositionally layered magma chamber*. Geochem. J., submitted
- Slejko F.F., Petrini R. and Forte C., 2002. *Six-fold aluminum and the reactivity of aluminosilicate volcanic glasses in the phreatoplinian deposits of the Neapolitan Yellow Tuff eruption (South Italy)*. N. Jb. Miner. Abh., submitted
- Petrini, R., Slejko, F.F., Orsi, G., Piochi, M., de Vita, S., Calucci, L., Pinzino, C., Pedrazzi, G., Di Vito, M.A., Isaia, R.; 2001. *Resonance spectroscopy on volcanic glasses: inference on melts properties and eruptive dynamics. Programma quadro per l'attività di sorveglianza e ricerca sui vulcani italiani 2000-2002. Roma 9-11 ottobre 2001*. Poster session abstracts: 186-187

- Slejko, F.F., Petrini, R., Piochi, M., Orsi, G., Calucci, L. and Tonarini, S.; 2001. *The water-melt interaction during explosive volcanism explored by Sr isotopic composition and water speciation in glasses: application to the Cretatio tephra of Ischia (South Italy)*. Volcanic hazards assessment and zonation at the resurgent Campi Flegrei caldera and their effects on man and environment: 47-52
- Piochi, M., Slejko, F.F., Petrini, R., de Vita, S., Orsi, G. and Calucci, L.; 2001. *The stratigraphy of the Neapolitan Yellow Tuff tephra explored by ^{29}Si and ^{27}Al MAS NMR on glasses*. Volcanic hazards assessment and zonation at the resurgent Campi Flegrei caldera and their effects on man and environment: 53-58
- Civetta L., D'Antonio M., Pappalardo L, Petrini R. and Piochi M.; 2001. *Role of crustal contamination in the evolution of the Campi Flegrei (Italy) magmatic system in the past 60 ka: evidence from Sr, Nd and Pb isotope data*. Volcanic hazards assessment and zonation at the resurgent Campi Flegrei caldera and their effects on man and environment: 25-30
- Slejko F.F., Petrini R., de Vita S., Orsi G., Piochi M.; 2002. *Hydrous species in volcanic glasses from the Cretatio Tephra (Ischia Island, South italy): inference on the mechanism of water-magma interaction*. Geophysical Reserch Abstracts. 27th General Assembly of the European Geophysical Society, Nice, France, 22-27 April, 2002
- Slejko F.F., Petrini R.; 2002. *A spectroscopic study on two glasses with different vesicularity from the Astroni Tephra (Phlegraeon Fields, Italy): implications on bubble expansion*. Geophysical Reserch Abstracts. 27th General Assembly of the European Geophysical Society, Nice, France, 22-27 April, 2002
- Slejko F.F., Petrini R., Forte C. and Pedrazzi G.; 2002. *The structure of dense and vesiculated volcanic glasses from Astroni Tephra (Phlegraeon Fields, Italy) explored by resonance spectroscopies*. Bull. Liaison S.F.M.C., 14: 24-25

PROJECT TITLE
Aeromagnetic, Gravity e Seismic studies at Campi Flegrei

RU Responsible:

Name-Position: Antonio Rapolla - PO
 Affiliation: Dipartimento di Scienze della Terra, Università di Napoli Federico II

ACTIVITY REPORT – 2° YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/month
Maurizio Fedi - PO	Dip. Scienze della Terra, Univ. di Napoli Federico II	3
Marino Grimaldi - RC	Dip. Scienze della Terra, Univ. di Napoli Federico II	3
Giovanni Florio - RC	Dip. Scienze della Terra, Univ. di Napoli Federico II	3
Massimo Chiappini - RC	INGV-Roma	3
Pierpaolo Bruno - RC	Osservatorio Vesuviano-INGV	5
Federico Cella- RC	Università della Calabria	3
Vincenzo Di Fiore	Dip. Scienze della Terra, Univ. di Napoli Federico II	6
Valeria Paoletti - PSDR	Dip. Scienze della Terra, Univ. di Napoli Federico II	6
Mauro La Manna - DR	Dip. di Geof. e Vulc., Univ. di Napoli Federico II	2
Giovanni Bais -DR	Dip. di Geof. e Vulc., Univ. di Napoli Federico II	6
Francesco Italiano - DR	Dip. Scienze della Terra, Univ. di Napoli Federico II	4

• **2nd YEAR OBJECTIVES**

A1

Post-processing of the acquired data, and compilation of a map of the high resolution aeromagnetic field of the Campanian volcanica area, integrated with the data of the previous surveys. Collection of available data on the magnetic properties of the main phlegrean volcanic rocks (Yellow Tuff, C.I., etc.); measures of the magnetic properties of other phlegrean volcanic rocks (e.g. thermally altered samples).

A2

The first interpretative phase will consist in the extraction of the maximum of information from the set of gravity data available.

A3

Final interpretation of the data by using correlation with well log data. Particular attention will be dedicated to integration with other seismic, magnetic and gravity data available for the area (i.e. Mareves Survey, Geomare Sud Surveys, etc.).

- II YEAR RESULTS

A1

The new aeromagnetic survey aims to guarantee a good resolution to the structural models based on geophysical data of the area. The previous aeromagnetic surveys, performed in the '70-'80 by AGIP, were indeed at a regional scale. Aim of this program is an high resolution aeromagnetic survey in a area placed north of the Campi Flegrei, where, in wells, they have been recovered remarkable thickness of volcanic/sub-volcanic rocks (Parete, Villa Literno) and in correspondence of which the aeromagnetic field map currently available shows some intense anomalies of wavelength of some tens of km. This area was already surveyed in the preliminary aeromagnetic survey carried out in 1999 and including an area of 170 km² placed between the Volturno River and the Patria Lake. In the new survey the flight lines (having W-E azimuth) were 400 meters apart while the tie-lines (having N-S azimuth) were about 2.5 km apart. In the area which was already surveyed in 1999 the flight lines were thickened and the tie-lines were flown for the first time. The survey was characterized by two different flight altitudes, 150 m and 400 m above sea level. This allowed anomalies relative to sources of various depth and dimensions to be shown with different detail. The aeromagnetic field measured at the two flight altitudes is shown in Figs. 1 e 2. Both maps are characterized by a maximum in the South sector of the surveyed area and by a linear anomaly due to the presence of a railway line. As for the data interpretation, we are presently developing new techniques of enhancement of the ratio signal/noise and new inversion methods with depth resolution for large scale problems.

A2

The main aim of this research is to delineate a structural scheme of the Campanian Plain using a new prospecting methodology based on the tensor gravity gradient. Recently, measurements and research based on *tensor gravity gradient* have become object of great interest and intense discussion within the scientific community. It indeed represents an important technical improvement with respect to the conventional gravimeter surveys, as measuring or calculating up to five independent components of the tensor gravity gradient describes better and more completely the density distribution in the earth. The first step of this research was dedicated to assemble a complete dataset combining the measurements of the Campi Flegrei and Campanian Plain gravity surveys, with those collected by monitoring stations (Vesuvio and Ischia) and with those digitized by a Bouguer gravity map. In the second phase, in order to perform stable results by derivative process, we developed an algorithm to compute all gravity gradient tensor components accurately. The analysis of the maps of each gravity tensor component has proved to yield a fine delineation of the structural settings of the Campanian Plain and Phlegrean Fields. Presently, we are developing a study about inversion (combined/simultaneous or simultaneous/not combined) of the gravity gradient tensor components to perform a 3-D model of the substrate of the plain.

A3

As regards the A3 line, we completed the reprocessing and the geologic-structural re-interpretation of the seismic lines CNR (OGS) of the Gulf of Pozzuoli and Naples. The reprocessed data have allowed determining the structural trend in the Gulf of Naples and mapping the main reflectors (including the top of the carbonates) in the study area. Despite the strong improvement of the data quality obtained, the carbonate horizon trend in the Gulf of Pozzuoli is unclear since such horizon is deep and therefore it falls in an area where the noise predominates. The structural interpretation has allowed us assuming that the area of the Gulf of Naples is interested by a phenomenon of oblique rifting. According to this model the Campanian volcanism is developed in correspondence of the transfer structures that, being subvertical are mainly prone to the intrusion of magmas. The results have been presented at the XXVII EGS (European Geophysical Society) meeting (Nice 2002) in two oral presentations. The first concerns the structural settings of the entire gulf of Naples and the second, the seismic-structural study of the Gulf of Pozzuoli. In the latter case, the seismic data have

been validated using the electrical logs of two wells (Saint Vito 8 and Licola 1) that have been transformed in pseudovelocity and in synthetic seismograms that easily correlate with the seismic sections. The seismic data localized in the gulf of Pozzuoli have shown some volcanic apparatuses previously not well known that seem to develop along the submerged calderic rims of the Phlegrean area. Moreover, correlation with synthetic data allowed to estimate the depth of the submerged calderic rim.

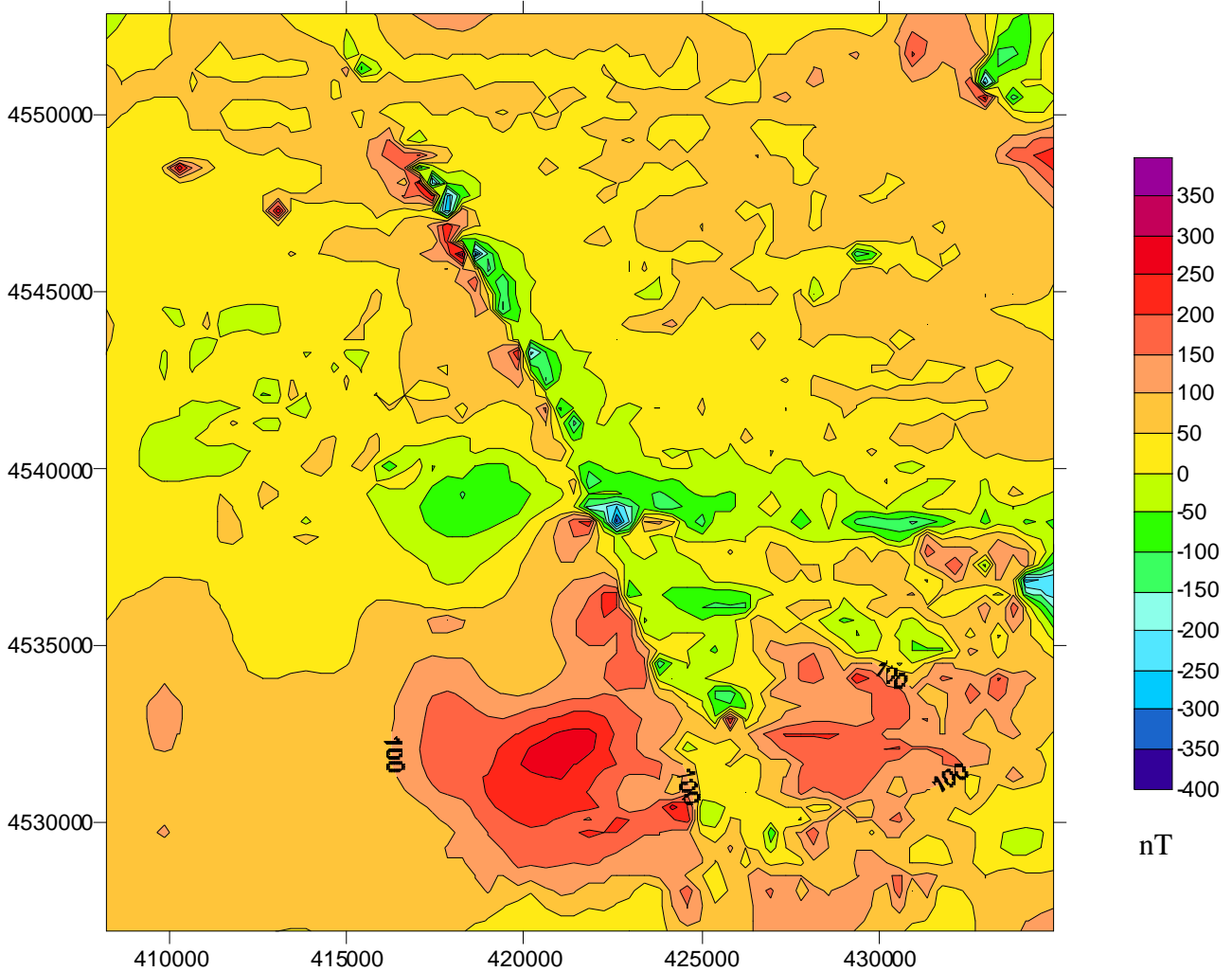


Fig. 1. Map of the aeromagnetic field of the Northern area of Phlegrean Field measured at 150 m above sea level. Flight lines 400 meters apart.

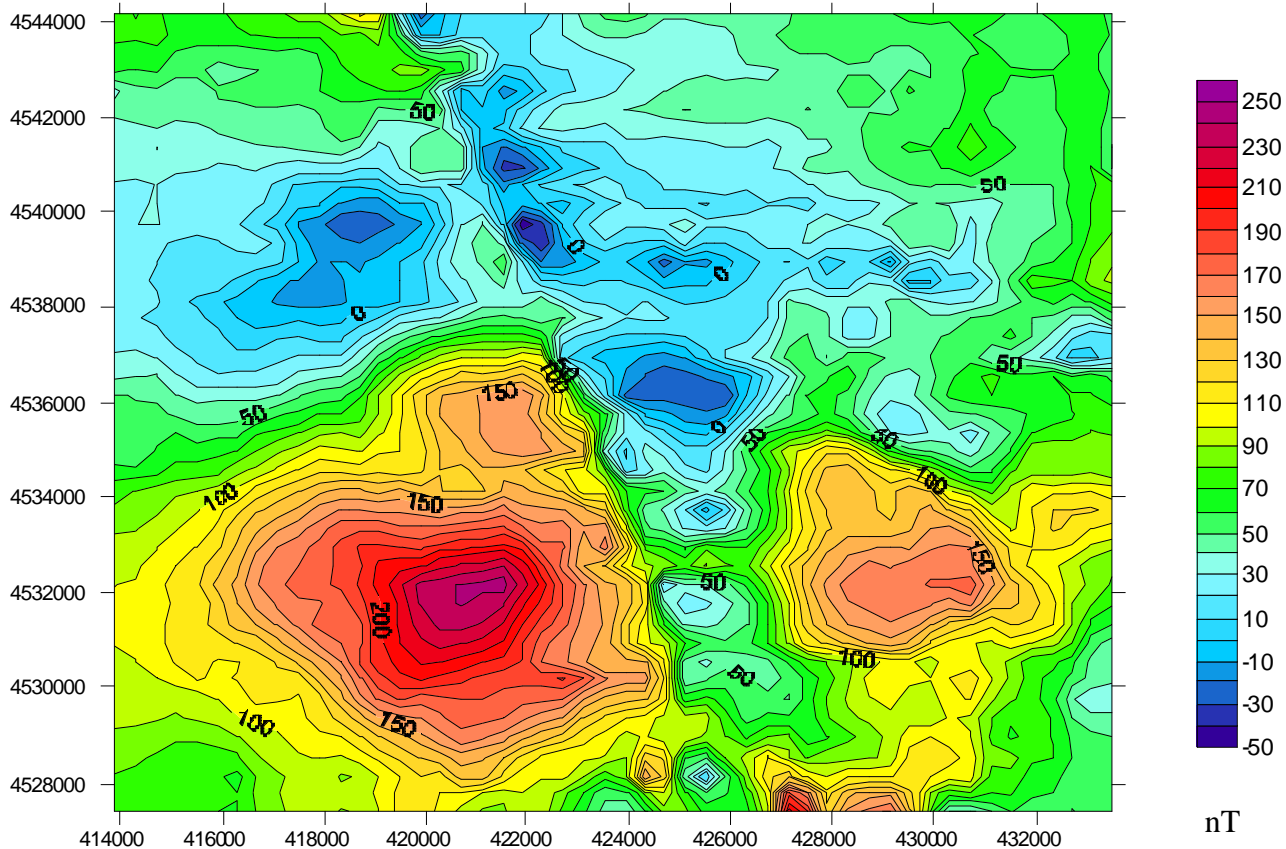


Fig. 2. Map of the aeromagnetic field of the Northern area of Phlegrean Field measured at 400 m above sea level. Flight lines 400 meters apart.

- RESEARCH PRODUCTS

- presentations at international meetings

Development and improvement of potential fields analysis techniques and their application to real data characterized by cultural noise, presented at the XXVII EGS meeting (Nice, April 2002), in the paper: “Aeromagnetic Interpretation of the Vesuvian Volcanic Area”.

The results of the analysis and interpretation of the components of the Gravity Gradient Tensor (GGT) in the Campanian Plain, presented at the XXI GNGTS meeting (Rome, November 2002), in the paper: “Analisi ed Interpretazione del Tensore Gradiente di Gravità nella Piana Campana”.

The results of the analysis and interpretation of the seismic lines CNR (OGS) of the Gulf of Pozzuoli and Naples, presented at the XXVII EGS meeting (Nice, April 2002) in two oral presentations.

PUBLICATIONS LIST

Florio G., Fedi M., 2000. *On the dependence of the parameters of the Euler's equation*. VIII Workshop on Geo-Electromagnetism, Maratea, October 12-14, 2000, p.29.

Bruno P.P., Di Fiore V., Rapolla A., Cuozzo E., 2001. *Tectonics and morphology of the carbonate basement and correlation with the volcanism in the gulf of Naples*. European Geophysical Society - XXVI General Assembly Nice, France, 25 - 30 March 2001.

- Bruno P.P., Rapolla, A., 2001, *Seismic and volcanic hazard, the case of the Campi Flegrei, Naples: geological structures and description of the crisis occurred during 1972-2000*, Earth Sciences and Natural Disaster Prevention, a Japan-Italy Meeting, 2001 Kyoto, Japan.
- de Alteriis G., Bruno P.P. e Florio G., 2001. *Interpretation of geophysical data acquired off the Ischia island (Italy, Tyrrhenian sea) during the GMS00_05 cruise (october 2000)*. Geophysical Research Abstracts, vol. 3, GRA3, 1149. 26th General Assembly of the European Geophysical Society, Nice (France), march, 25-30, 2001.
- Fedi M, Florio G, 2001. *Potential fields source boundaries detection by an Enhanced Horizontal Derivative*. Geophys. Prospecting, 49-1, 13-25.
- Fedi M., Hansen P. C., Paoletti V., Rapolla A., 2001. *3D Inversion of Potential Fields with Depth Resolution*. European Association of Geoscientists and Engineers Conference, Amsterdam 11-14 June, 2001.
- Bruno P.P., Di Fiore V., Rapolla A, 2002, *Seismic reflection data processing in active volcanic areas: an application to Campi Flegrei and Somma Vesuvius offshore (Southern Italy)*. Annals of Geophysics, in press.
- Bruno, P.P.; Di Fiore, V.; Rapolla, A., 2002, *Reprocessing of seismic reflection data around the Ischia-Procida offshore: preliminary results*, XXVII General Assembly Nice, France, 21 - 26 April 2002
- Bruno, P.P.; Di Fiore, V.; Rapolla, A., 2002, *Seismic reflection imaging of the volcanic structures below Campi Flegrei submerged caldera and correlation with well log data*, XXVII General Assembly Nice, France, 21 - 26 April 2002
- Bruno, P.P.; Di Fiore, V.; Rapolla, A., 2002, *Structural setting of the Gulf of Naples and correlation between tectonics and volcanism*, XXVII General Assembly Nice, France, 21 - 26 April 2002
- Bruno P.P., Rapolla, A., Di Fiore, V., 2002, *Structural settings of the Bay of Naples (Italy) by seismic reflection data*. Tectonophysics, submitted.
- Fedi M., Florio G., Italiano F., 2002. *Analisi ed Interpretazione del Tensore Gradiente di Gravità nella Piana Campana*, XXI GNGTS, Roma, 19-21 November 2002.
- Rapolla A., Cella F., Fedi M., Florio G., 2002. *Improved techniques in data analysis and interpretation of potential fields: Examples of application in seismic and volcanic active areas*. Annals of Geophysics, in press.
- Supper R, Motschka K, Seiberl W, Fedi M, 2001. *Geophysical investigations in Southern Italian active volcanic regions*. Bull. Geol. Surv. of Japan, 54-2-3, 89-99.

PROJECT TITLE

EVOLUTION OF THE T-P CONDITIONS OF CRYSTALLIZATION OF THE FEEDING SYSTEM OF THE PHLEGREAN FIELDS CALDERA AND DEGASSING PROCESSES

RU Responsible

Name-Position: Sbrana Alessandro - PO

Affiliation: Dip. Scienze della Terra, Università di Pisa

ACTIVITY REPORT–2nd YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/mounth
A. Sbrana – Prof. Str.	Dip. Scienze della Terra, Università di Pisa	2
P. Marianelli – R.	Dip. Scienze della Terra, Università di Pisa	3
P. Fulignati – Ass. Ric.	Dip. Scienze della Terra, Università di Pisa	3
M. Proto – Dott.	Dip. Scienze della Terra, Università di Pisa	11
A. Cecchetti – Dott.	Dip. Scienze della Terra, Università di Pisa	6

• 2nd YEAR OBJECTIVES

- Completion of volatile (H₂O, Cl, F, S) determination in melt inclusions and glasses of Ignimbrite Campana products. Evaluation of minimum pressure of crystallization, on the basis of solubility models of volatiles in trachytic and K-phonolitic melts.
- Microthermometric experiments on multiphase magmatic fluid inclusions in xenoliths from the Breccia Museo units.
- Study of an eruption of the recent period of activity (Astroni).
- Elaboration of data and estimation of minimum pressure and temperature of crystallization of melts.

• 2nd YEAR RESULTS (max 1 page)

- Methodologies

SEM-EDS microanalysis using a Philips XL30 apparatus equipped with EDAX-DX4 to determine major elements, Cl and S (Dipartimento di Scienze della Terra, Pisa).

XRF on bulk rocks using a spectrometer ARL 9400 XP, Dipartimento di Scienze della Terra, Pisa).

Infrared spectroscopy using a Nicolet Magna-IR 560 spectrometer coupled with a NicPlan infrared microscope (Dipartimento di Scienze della Terra, Pisa).

- Data acquisition

The research was focused on the study of juvenile products from the fallout deposit of the Ignimbrite Campana (IC) eruption and of the products from Astroni volcano. SEM-EDS microanalysis was carried out on minerals, melt inclusions in phenocrysts and matrix glasses. Bulk rock from Breccia Museo (BM), IC fall, Solchiaro and Astroni deposits were analysed in XRF. H₂O and CO₂ content on melt inclusions and on glassy matrix were determined by FTIR.

- DATA PROCESSING AND INTERPRETATION

Ignimbrite Campana Melt inclusions, matrix glass and bulk rocks have trachytic to phonolitic composition. Matrix glasses are compositionally homogeneous. As regard the volatile content of melt inclusions, we have elaborated 197 spectra on melt inclusions from BM and fall deposit. Melt inclusions show a relatively wide range of water content while CO₂ is below the detection limit. Microthermometries on multiphase magmatic fluid inclusions in xenoliths from the Breccia Museo units and trace element geochemistry on whole rock xenolith samples were performed. The interpretation of these data is in progress and will lead to the reconstruction of the P-T-X conditions for the IC magma chamber.

Astroni The studied samples correspond to the more differentiated juvenile fraction erupted from Astroni volcano. They are poorly vesiculated and feldspar phenocryst-rich. Bulk rock analyses fall in the trachyte field. Mineral paragenesis consists of unzoned K-feldspar, zoned plagioclase, unzoned salitic clinopyroxene, biotite, apatite and opaques. The homogenous glassy matrix have phonolitic composition in the TAS diagram. The groundmass is more evolved than the total rock. As regard melt inclusions, the composition vary from trachyte to phonolite. This suggests that the glass matrix composition can be related to a mixing process between the more evolved silicate melt and a less evolved melt. This melt inclusion study demonstrate that in this eruption are involved also fonolitic and trachytic magmas. Analytical results by systematic FTIR measurements give low H₂O content and CO₂ under detection-limit.

Summing up, the collection of data regarding different eruptions (I year, Minopoli, Solchiaro; II year, Ignimbrite Campana, Astroni), has been achieved. The interpretation of these data, coupled with the results of the investigation of other selected eruptions from the recent period of activity, will allow the reconstruction of pre-eruptive pressure, temperature, composition and volatile saturation conditions of the feeding system/s of the Campi Flegrei volcanic area.

• RESEARCH PRODUCTS

- n° of articles published on international journals: 1 (+ 2 in preparation)
- n° of articles published on national journals, proceedings, technical reports: 5
- invited papers and talks:
- presentations at international meetings: 2
- presentations at national meetings: 1
- Data bases
- Computation codes
- Other

PUBLICATIONS LIST (inclusive of papers in prints and accepted)

- Fulignati P., Marianelli P., Proto M., Sbrana A. (2001): *The Ignimbrite Campana magma chamber: insights from melt and fluid inclusions*. In: Volcanic hazards assessment and zonation at the resurgent Campi Flegrei caldera and their effects on man and environment, I year results, Osservatorio Vesuviano, Gruppo Nazionale per la Vulcanologia, 1: 66-71.
- Cecchetti A., Marianelli P., Sbrana A. (2001): *A deep magma chamber beneath Campi Flegrei? Insights from melt inclusions*. In: Volcanic hazards assessment and zonation at the resurgent Campi Flegrei caldera and their effects on man and environment, I year results, Osservatorio Vesuviano, Gruppo Nazionale per la Vulcanologia, 1: 59-65.
- Fulignati P., Marianelli P., Proto M., Sbrana A. (2001): *L'eruzione della Ignimbrite Campana, unità della Breccia Museo: dati microtermometrici*. Atti Soc Tosc. Sci. Nat., Mem., Serie A, 107: 9-15.

- Cecchetti A., Marianelli P., Sbrana A. (2001): *Prime evidenze della esistenza di un sistema di cristallizzazione profondo ai Campi Flegrei*. Atti Soc Tosc. Sci. Nat., Mem., Serie A, 107: 1-7.
- Fulignati P., Marianelli P., Proto M., Sbrana A. (2002) *Evidences of disruption of a magma chamber crystallizing front during caldera collapse: an example from the Breccia Museo unit (Ignimbrite Campana eruption)*. Journal of Volcanology and Geothermal Research, accepted
- Cecchetti A., Fulignati P., Marianelli P., Proto M., Sbrana A. (2001): *The feeding system of Campi Flegrei. Insights from melt and fluid inclusions on Ignimbrite Campana, Solchiaro and Minopoli eruptions*. Gruppo Nazionale Vulcanologia, Istituto Nazionale Geofisica e Vulcanologia, Dipartimento Protezione Civile, Assemblea annuale, Roma 9-11 ottobre 2001(sessione poster).
- Marianelli P., Proto M., Sbrana A. (2002): *The Ignimbrite Campana magma chamber: pre-eruptive P-T-X conditions from melt inclusion data*. 26rd General Assembly of the European Geophysical Society, Nice 20-24 April 2002(sessione poster).
- Cecchetti A., Marianelli P., Sbrana A. (2002): *The Campi Flegrei deep feeding system: melt inclusion investigations*. 26rd General Assembly of the European Geophysical Society, Nice 20-24 April 2002(sessione poster).
- Cecchetti A., Marianelli P., Sbrana A. (2002) *L'eruzione di Astroni (Caldera dei Campi Flegrei): dati preliminari dallo studio di inclusioni silicatiche* Atti Soc Tosc. Sci. Nat., Mem., Serie A, submitted

PROJECT TITLE

Human and building structural vulnerability in future possible eruption of the Campi Flegrei caldera

RU Responsible

Name-Position Prof. Giulio Zuccaro - Director of the Research Area of “*Analisi e Pianificazione Sismica*”, Centro di Ricerca LUPT
Affiliation Centro di Ricerca LUPT - Università di Napoli "Federico II"

ACTIVITY REPORT–2nd YEAR

RU PARTICIPANTS

Name-Position	Affiliation	man/mounth
Zuccaro Giulio - RC	Università di Napoli	2
Baratta Alessandro - PO	Università di Napoli	1
Petrazzuoli Stefano - CE		1
Spence Robin	Università di Cambridge	0.5
Baxter Peter	Università di Cambridge	0.5
Binetti Anna	Università di Napoli	11
Emilia De Angelis	Università di Napoli	3

- **2nd YEAR OBJECTIVES**

Data collection, by means of the aerophotogrammetric method, of the typological characteristic required to the classification of the volcanic vulnerability for the residual part of the communes enclosed in the study area. Field survey by means of the guided interview forms in order to characterize the commune under the building typological aspect and zoning of the information on the map. Field survey on the openings of a building sample having specific structural typology and on the roof characteristics. Calibration of the probabilistic parameters required to the statistic correction of the typological frequencies derived by QAP method. Test on a sample area for the implementation of a Volcanic Vulnerability oriented GIS.

- **2nd YEAR RESULTS (max 1 page)**

- Data collections

In this year it has been carried out the data collection for the residual part of the communes enclosed in the study area. As already explained in the 1st year report of the present research the survey was addressed to integrate other collection campaigns on the seismic vulnerability characteristic already performed in the same area. In particular it has been carried out on field in order to characterise the building typologies of the Communes through a “guided interview protocol” with geo-referenziation of the information collected for the commune of Bacoli. In this commune the data, randomly chosen, on the openings (doors, windows, etc.) have been collected for buildings having structural typology like those included in the vulnerability classification of the EMS '98 of which the distribution was already known in Bacoli since the Previous Project on the seismic vulnerability of the area. The roof typologies detectable in the area has been studied. The activity of aero-photogrammetric interpretation is completed for the commune of Bacoli and Monte di Procida that represent almost the totality of the building stock in the area. Data on factors of volcanic vulnerability as the potential missiles in the urban area of Pozzuoli and Bacoli has been collected. A GIS test application on building characteristics and their vulnerability factor on a settlement of

Pozzuoli is now available. At moment it has been produced a thematic map on the structural typology classification in Pozzuoli. Finally data on the demography in Pozzuoli have been collected and linked to structural characteristic for future scenarios developments.

- Modelling and Interpretation:

A vulnerability scale of the elements studied has been developed. This is based on specific numerical models to evaluate the limit load of Not Tensile Strength material structures (as masonry walls and vaults) so as models to evaluate the collapse loads of the r.c frames., steel or wooden roofs etc.. Then has been computed the probability to have specific volcanic vulnerability factor on a specific structural typology EMS '98. This result will allow to extend the information collected on the sample randomly chosen to the whole set of buildings studied. Moreover a typological classification of the roofs, of the openings and the most probable limit load associated to them it has been elaborated.

- Others:

Along the year it has been organised one international workshop "Campania a Rischio" plus one meeting with the group of the researchers of the Cambridge University in order to examine the state of the research and programme the future activity.

• RESEARCH PRODUCTS

- n° of articles published on international journals: 5
- n° of articles published on national journals, proceedings, technical reports
- invited paper and talks:
Civil Protection Problems in urbanised Volcanic areas, Assessorato Urbanistica - Regione Campania - HolydayInn Napoli 24-7-2002
- presentations at international meetings:
Human and structures vulnerability of the communes in the Caldera of the Campi Flegrei, Workshop on "Campania a Rischio" Mostra d'Oltremare, 20.04.2002
- Computation codes:
Software: the codes for the evaluation of the limit loads on the roofs was been already developed in previous researches and just used in the present project, so as the statistical procedure of correction (QAP) used for the aerophotogrammetric interpretation method.
- Data bases:
Data Base on Structural Typologies, Roofs and Openings in the communes of Bacoli, Monte di Procida
- Other:
GIS test on a quarter of Pozzuoli

PUBLICATIONS LIST (inclusive of papers in prints and accepted)

- Baratta A., Binetti A., Zuccaro G. *Strength capacity of No Tension portal arch-frame under combined seismic and ash loads*, J. Volcanol. Geotherm. Res., submitted
- Spence R.J.S., Zuccaro G., Baxter P.J., Petrazzuoli S.M., (2001), *The resistance of Buildings to Pyroclastic Flows: Analytical and Experimental Studies and their Application to Vesuvius*, ASCE's Natural Hazard Review, accepted.
- Zuccaro G., Petrazzuoli S.M., *Structural Resistance of RC Buildings under Pyroclastic Flows: A Study on the Vesuvian Area*, J. Volcanol. Geotherm. Res., submitted
- Spence R.J.S., Zuccaro G., Baxter P.J., *Building vulnerability and human casualty estimation for a pyroclastic flow: a model and its application to Vesuvius*, J. Volcanol. Geotherm. Res., submitted

Zuccaro G., Ianniello D., *Interaction between pyroclastic flow and the building structures of an urban settlement. A fluid-dynamic simulation impact model*, J. Volcanol. Geotherm. Res., submitted