PROJECT V5

Research on the diffuse degassing in Italy

Responsibles:

Giovanni Chiodini, INGV-OV Napoli
Mariano Valenza, Univ. Palermo

Project V5

Diffuse Degassing in Italy

Coordinators:

Chiodini Giovanni, Dirigente di Ricerca
Osservatorio Vesuviano INGV, via Diocleziano 328, 80124, Napoli
Tel. 081.6108448; Fax 081.6108466
e-mail: chiod@ov.ingv.it

Mariano Valenza
Dip. di Chimica e Fisica della Terra –Università di Palermo,Via Archirafi 36, 90100-Palermo
Tel. 091-6161574; Fax 091 6168376
e-mail: mvale@unipa.it

Objective of the project

The emission of endogenous gases from the soil (mainly CO_2) is a phenomena which affects large areas of the Italian territory. Gas emissions characterize areas of active and extinct volcanism, volcanism, geothermal areas and non volcanic regions. The gas is emitted both by diffuse degassing along active structures or by focused vents forming mofete, mud volcanoes, bubbling pools etc..

In most of the cases the main component of the gases is CO_2 whose density is much higher of air density and which in absence of wind accumulate in the morphological depressions forming river and lakes of gas. The humans and the animals which fortuity enter these invisible traps are destined to a secure death. Many accidents involved in the past not only domestic and wild animals but also people. The periodical occurrence of such accidents alerted the Civil Defense which financed this project whose main objective is the mitigation of gas hazard in Italy trough a coordinated and multidisciplinary study of the earth degassing in Italy.

The numerous data acquired during the project will be useful also for the achievement of important scientific results concerning the origin of the anomalous gas emission which affect the Italian territory, the global carbon budget and the relations between Earth degassing and geodynamics.

State of the Art

A general map of CO_2 earth degassing in Central South Italy has been recently elaborated on the base of the geochemical and isotopic characterization of the carbon dissolved in the main aquifer of the region (Chiodini et al., 2000 JGR; 2004 GRL; Fig. 2.1)

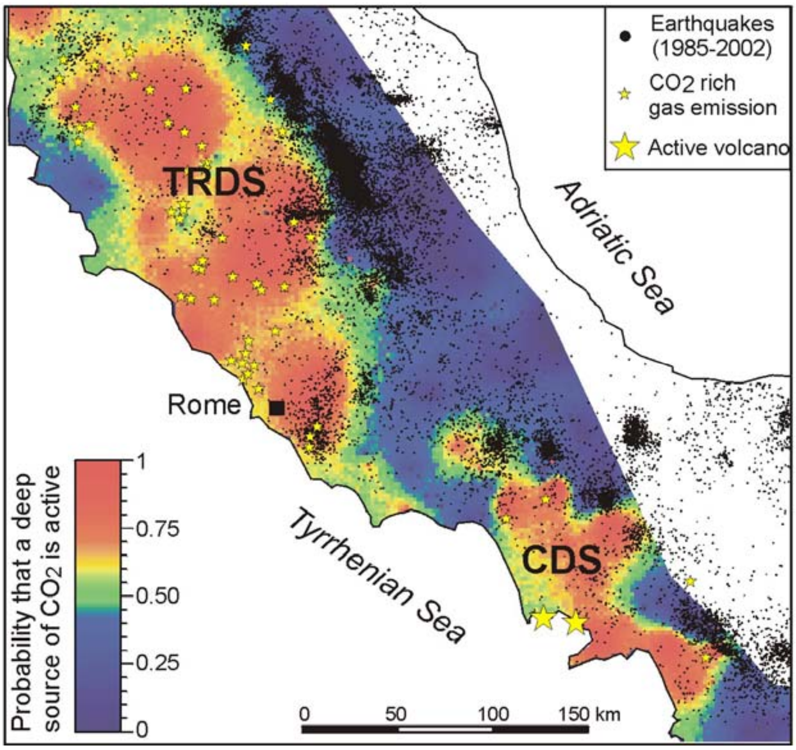

Fig. 2.1 Map of Earth degassing in central south Italy The figure shows the probability that a deep source of carbon is present at any location (Chiodini et al., 2004 GRL). The map is compared with the recent seismic activity recorded by the National Seismic Network of INGV; the large historical earthquakes in the region are also concentrated in the same belt. The location of active volcanoes and of the main gas emissions is reported for comparison.

The map highlights the presence of two large degassing structures in the Tyrrhenian sector of Italy.

The first is bordered by the Tyrrhenian sea at W, by the Apennine at E and includes Tuscany, Latium and Umbria regions while the second coincides with the Tyrrhenian sector of the Canpania region. These are two regional structures degassing deeply derived CO_2 as evidenced also by the widespread occurrence of strong gas emissions and Quaternary travertine deposited by CO_2 rich groundwater. The northern structure partially overlaps the Tuscany, Roman magmatic province (TRDS, Tuscan Roman degassing structure) while the southern structure relates to the Campanian volcanism (CDS, Campanian degassing structure). The two volcanic provinces are characterised by quaternary potassic and ultrapotassic magmas rich in fluids with high CO_2/H_2O ratios (Foley, 1992 Lithos). Geochemical features of the magmas are consistent with the melting of a mantle source metasomatised by crustal material (Peccerillo, 1999 Geology). It is reasonable that the TRDS and CDS reflect the degassing process of this metasomatized, uprising mantle. In the eastern sector of Italy, where the CO_2 anomaly disappears, the process of Earth degassing is characterized by gas emissions rich in hydrocarbons. Also these emissions will be investigated during the project.

The total amounts of deeply derived CO_2 released from TRDS and CDS have been estimated to be 1.4×10^{11} mol/y and 0.7×10^{11} mol/y respectively (Chiodini et al., 2004 GRL). The total CO_2

released by TRSD and CDS is globally significant, being ~ 10% of the present-day total CO_2 discharge from subaerial volcanoes of the Earth (Kerrick, 2001 Reviews in Geophysics). This result suggests an underestimation on CO_2 globally released by the Earth, because unquantified processes of CO_2 earth degassing from non-volcanic environment affect almost all the tectonically active areas of the world.

Both TRDS and CDS are characterized by the presence of numerous emissions of gas rich in CO_2 (Fig. 2.2).

Fig. 2.2 A) CO_2 'lake' in the Amiata region. The gas accumulation has been made visible by igniting a smoke bomb in the morphological depression. The yellow color highlights the zone where CO_2 concentration is lethal. The manifestation caused the dead of a person the 20th November 2003. B) The animals and the persons which fortuity enter in this invisible gas traps are destined to secure death. The picture shows a wild pork killed by the gas emitted at Palidoro, a gas emission located few kilometers north of Rome.

Normally these gas emissions are characterized by both focused vents and diffuse soil degassing. The gas emitted by some of these manifestations caused in the past lethal accidents. At Mefite d'Ansento (Avellino) two young archeologists died during 1990's; at Tivoli, near Rome, the gas emitted by a river saturated in CO_2 killed some boys; at Colli Albani (Rome), many lethal accidents involved in the past animals and people; at Veiano the gas killed some fishermen along a river affected by strong gas emissions; some people died at Mt Amiata (Siena) where the last lethal accident occurred in November 2003; at Manziana many people died during the second world war entering in a cave full of CO_2; the drilling of wells in some areas constitute a continuous risk because often CO_2 pressurized levels are encountered; etc.

This list is largely incomplete because a specific research on the accidents caused by the gas has never been done. Furthermore a catalogue of the gas emissions, and in particular of the dangerous areas where accidents periodically occur, is still missing. In non-volcanic areas and in areas of extint volcanism, the flux of only few gas emissions have been already measured (Rogie et al., 2001 JGR; Chiodini et al., 1999 Chem. Geol.). Contrary many Italian volcanic areas have been already the objective of detailed studies of CO_2 soil diffuse degassing such as Vulcano (Badalamenti et al., 1991 Nature; Chiodini 1996 Bull. Volcanol.; Diliberto et al., 2002 Bull. Volcanol.), Stromboli (Carapezza e Federico, 2000 JVGR), Etna (Badalamenti et al., 1994 Acta Vulcanol.; Giammanco et al., 1998 Bull. Volcanol.), Campi Flegrei (Chiodini et al., 2001 JGR), Ischia (Chiodini et al., 2004 JVGR), Vesuvio (Frondini et al., 2004 Bull. Volcanol.) and Colli Albani (Chiodini e Frondini 2001 Bull. Volcanol.; Carapezza et al., 2003 JVGR; Pizzino et al., 2002 Natural Hazard). As an example of volcanic active area, the diffuse soil CO2 degassing of Mt Etna is reported in fig.2.3.

However, excluding few works on Colli Albani, most of these studies were aimed to the volcanic surveillance rather than to define the hazard related to the presence of the gas emissions. In any cases these studies confirmed the presence of numerous zones where CO_2 (and sometimes H_2S) fluxes are so high that represent a serious danger for people and animals.

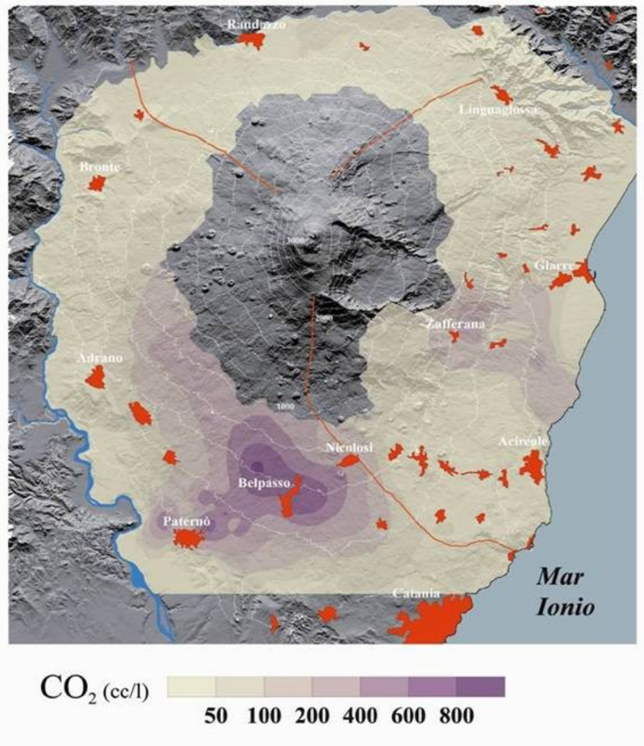

Fig. 2.3 Diffuse soil CO2 degassing at Mt. Etna volcano. Two areas of intense soil degassing are respectively located in the South and East side of the volcanic edifice (Parello et al.2001 GNDCI-CNR, pubbl. n. 2190).

In the geothermal areas (Larderello, Amiata, Latera) there are many geochemical studies both of the fluids emitted by natural manifestations and of the geothermal fluids founded by the geothermal wells. However also in this case detailed researches on the danger of the natural manifestations are missing as well as studies on the relations among the flow rates of the natural emissions and the amount of fluids extracted by the geothermal activity.

This project has the aim to cover this lack of knowledge trough the constitution of the catalogue of the Italian gas emissions which will comprehend the accurate location of the gas emissions, the chemical and isotopic composition of the gases, the extension of the degassing areas, a rough evaluation of the fluxes, the relations with the geological and hydrogeological setting, the relations with the anthropological feature (i.e. distance from houses, villages, town etc.), the possible presence of dead animals, the possible record of historical accidents involving humans and finally, where possible, the evaluation of the gas hazard. The more dangerous manifestations will be investigated in greater details with specific gas flux campaigns while physical numerical modeling of the process including the genesis of the gas emission and the gas dispersion in air will be applied in few selected manifestations.

Is our opinion that the proposed objectives are within the capacity of the Italian scientific community and in particular of the team proposing this project. People of this team set up methods for gas flux measurements (Guerrieri e Valenza, 1998 Rend. Soc. It. Mineral. Petrol; Chiodini et al., 1998 Appl. Geochem.), developed portable measurement instruments and automatic stations (Badalamenti et al. 1994 Acta Vulcanol, Chiodini et al., 1996 Bull. Volcanol.), performed methodological studies for the comparison of different measurement techniques (Carapezza e Granieri, 2004 Appl. Geochem.), investigated statistical and geo-statistical tools suitable for the gas flux data treatment, for the production of maps, ecc. (Cardellini et al., 2003 JGR; Granieri et al., 2003 EPSL).

Description of the Activities

The project is organised in 4 tasks grouped in two Research lines. The research lines are: a) Italian Catalogue of the gas emissions and b) gas hazard and risk mitigation. The specific tasks are devoted to 1) Identification and characterisation of the gas emissions, relations with the structural and hydrogeological setting and with seismic activity in Central Italy and in Campania regions, 2) Identification and characterisation of the gas emissions, relations with the structural and hydrogeological setting and with seismic activity in Basilicata, Calabria and Sicily regions; 3) Definition of the scenarios and estimation of the gas hazard; 4) Evaluation of the vulnerability and risk, and risk mitigation.

The activities will be done by 15 different reserach units (RU) whose distribution in the 3 Tasks of the project is reported in Table 1.

Research Line 1 **Italian Catalogue of the gas emissions**		**Research Line 2** **Gas hazard and risk mitigation**			
TASK 1 and 2		**TASK 3**		**TASK 4**	
UniRM3-Capelli	RU1	INGVRM1-Carapezza	RU2	UNIRM3-Barberi	RU15
INGVRM1-Carapezza	RU2	INGVOV-Chiodini	RU4		
UNINA-Castaldi	RU3				
INGVOV-Chiodini	RU4				
INGVRM2-Etiope	RU5				
INGVPA-Favara	RU6				
UNIPG-Frondini	RU7				
INGVPA-Giammanco	RU8				
INGVPA-Italiano	RU9				
UNIPA-Parello	RU10				
INGVRM1-Quattrocchi	RU11				
CNRPI-Raco	RU12				
UNIPA-Valenza	RU13				
UNIFI-Vaselli	RU14				

Research Line 1. Italian Catalogue of the gas emissions

For a betterr coordination this reserach line has been divided in two tasks which refer to different areas but which are characterised by the same activities.

TASK 1 Identification and characterisation of the gas emissions, relations with the structural and hydrogeological setting and with seismic activity (Central Italy and Campania)
RU Coordinating: Chiodini (INGVOV)
RU Partecipating: Capelli (UniRM3), Carapezza (INGVRM1), Castaldi (UNINA), Etiope (INGVRM2), Frondini (UNIPG), Quattrocchi (INGVRM1), Raco (CNRPi), Vaselli (UNIFI)

TASK 2 Identification and characterisation of the gas emissions, relations with the structural and hydrogeological setting and with seismic activity (Basilicata, Calabria and Sicily)
RU Coordinating: Valenza (UNIPA)
RU Partecipating: Favara (INGVPA), Giammanco (INGVPA), Italiano (INGVPA), Parello (UNIPA)

The main objective is the production of the catalogue of the Italian gas emissions (CIGE). The main questions to answer for a better knowledge of the degassing process magnitude, of the natural processes controlling the degassing, and to provide data for the definition of hazard connected to the gas emissions and for the risk mitigation are:

- which and where are the areas characterised by a potentially hazardous soil gas emissions?
- What is the magnitude of gas flux?

- What are the chemical and isotopic compositions of the released gas? And, in particular, what are the concentrations of the gas species potentially dangerous for humans and animals?
- What is the origin of the gas emitted, what are the relations between the gas and the geodynamic and structural regional setting and what are the relation with the local hydrological setting and the local ambient parameter?
- What are the correlation between the degassing and other processes in the study areas? In particular, what is the relation between degassing and the seismicity?

To answer the questions listed above, the following activities, grouped in 5 different workpackages (WP), will be performed.

WP 1 - Exploration and production of the catalogue of the Italian gas emissions: the activities related to WP 1 are: localisation and characterisation of the areas characterised by anomalous gas emission (also with collection of the existing specific bibliography); sampling and analysis of chemical and isotopic composition of the gas released; characterisation of the geological, structural and hydrogeological setting of the studied areas; collection of data about compositions of deep drilling fluids eventually present in the area and comparison with the gas emitted at the surface; inventory of lethal accident occurred in the areas.

Fig. 3.1 Areas investigated in the project and involved RU

To create an archive of the degassing areas, every RU will fill an electronic form including: name of the area, geographical position, typology of the gas emission, physical and chemical parameters of fluid released, qualitative information about the morphology, records of accidents, presence of dead animals, qualitative estimation of the hazard connected, video documentation. The distribution in the territory of the RU is shown in Fig. 3.1. This WP will start at the beginning of the project and will continue until the end. The CIGE will be continuously updated with the information acquired by the RU during the two years of the project.

WP 2- Gas flux measurements: in the main and/or more hazardous degassing areas (20-40), specific surveys of the diffuse degassing from soil will be performed. These surveys will be devoted to the definition of the degassing structures (i.e., detailed mapping of gas flux from soil) and to the quantification of the gas release, trough appropriate statistical and geostatistical tools. Furthermore, a quantification of the gas released by vents (e.g., fumaroles, dry vents, bubbling pool etc.) will be performed. Where the gas forms 'gas rivers' or 'gas lakes' the flow and/or the accumulation of the gas will be highlighted by tracers (smoke bombs) and documented with videos. The results will be included in the CIGE. During the first year project all the data already available will be inserted in the CIGE and specific campaigns will be done in the anomalous zones of Amiata and Latera (Monti Vulsini) where the investigations started before the beginning of the project. During the second year of the project new areas selected in the CIGE will be investigated.

WP 3 Conceptual and physical-numerical models of the gas emissions: in order to better understand the origin of the manifestations and the mechanisms controlling the process, some gas emissions, selected among the most dangerous, will be investigated in great detail in order to define a conceptual geochemical model. The development and evolution of gas emissions at these selected locations (Mt. Amiata, Latera, Mefite d'Ansanto), will be then simulated by applying the TOUGH2 coupled heat and fluid flow model (Pruess et al., 1999 LBNL report). Following a procedure successfully applied in volcanic areas (Todesco, 1997 JVGR; Chiodini et al., 2003 GRL; Todesco et al., 2003 JVGR; 2004 Geothermics), the physical model will be set up based on available knowledge of subsurface geology, and incorporating all information deriving from the geochemical conceptual model, and from measurements carried out in WP 1 and 2. Simulation of multi-phase and multi-component fluid flow through heterogeneous porous media will describe the degassing process according to different scenario. Results will be used to investigate the origin of gas emissions and their relation with the geological structures in the subsurface. Results will provide also boundary conditions for gas dispersion models (task 3) and will contribute to risk evaluation (task 4).

WP 4 Sink-holes and CO_2 degassing: the term "sinkhole" refers to collapse phenomena of the subsoil. Often sinkhole phenomena occurs in alluvium terrains overlaying carbonatic formations and in most cases has been noted the presence of fluids in the subsoil (CO_2, H_2S, etc.) which could favour the phenomena forming acidic solutions which dissolve the carbonatic rocks. This WP is aimed to improve the catalogue of the sinkholes of the Latium region which already was produced. This new catalogue will have more information then the older, it will have data of localization, information on geological and hydrogeological setting of the sites, on the shape of the collapsed structures, and on the geochemistry of the fluids circulating in the sinkhole areas. The catalogued phenomena will be classify in relation to the four genetics typology already defined from previous studies (Cover subsidence sinkhole, Cover collapse sinkhole, Cave collapse sinkhole and "Spring sinkhole typical of the Latium region"). The catalogue will place at "Dipartimento della Protezione Civile" disposal. Main characteristic of the research will be the study of the interaction between rock-water-gas in relation to the specific features of two areas (geological structural and hydrogeological setting, anthropic activity). In particular, during the first year it will inquire the knowledges about the area of Doganella-Laghi del Vescovo (LT), while during the second, the area of Cotilia-Peschiera (RI), as regard about 15 sinkholes. In one of the studied sinkhole will be installed probes that will check the parameters of gas and water. The research main aim is the definition of evolution modelling that could help in the individuation of precursor elements of the collapse events.

WP 5 Hydrogeochemical studies of CO_2 – water interaction; the map of Fig. 2.1 and Fig. 2.3 has been derived by a detailed hydrogeochemical study of the groundwaters finalised to quantify the input of deeply derived CO_2 in the aquifers. This kind of study will continue during the project in areas not already investigated. In particular the aquifers of Sicily will be investigated by RU 13, while the aquifers located in Tuscany will be studied by RU7 and RU4. In total 200-300 samples of groundwater will be collected and analysed. The areas characterized by high anomalous gas content in the aquifers will be investigated for the diffuse soil degassing. Furthermore the relationship between the soil gas distribution and the active tectonic structures will be investigated. General maps of CO_2 earth degassing of the investigated areas will be produced at the end of the project. The results of these studies, integrated with those of previous investigations, will contribute to the definition of the origin of the released gas in volcanic and non-volcanic environments and to define the relation between degassing and seismic activity, in particular comparing the distribution of the gas anomalies with the distribution of the recent and historical seismicity.

Research Line 2. Gas hazard and risk mitigation

TASK 3 Definition of the scenarios and estimation of the gas hazard
RU Coordinating: Carapezza (INGVRM1)
RU Partecipating: Chiodini (INGVOV)

The hazard related to the gas emissions mainly depends on the high concentration of dangerous gases (CO_2 and H_2S) in the air near the manifestations. The accumulation and the dispersion of the gases in the air depend on many factors such as the flow rate of the gas emission, the morphology of the emission area, the meteorological conditions, etc.. In particular relevant questions are:

- How the CO_2 and H_2S concentration in air depends on the degassing rate and on the type of emission (i.e. focused vents, diffuse degassing areas, ecc.)?
- What are the space-temporal variation on the gas concentration in air and in groundwaters, and what factors control such variations?
- What is the area of influence of a gas emission?

In order to give an answer to such questions, the activities of TASK 2 are divided in two WPs.

WP1 Implementation of specific gas dispersion codes: gas emissions develop in regions where a gas source exists at depth and hydrogeological conditions and human intervention, such as drillings and excavations, allow for gas propagation to the surface. Gas propagation through porous media can be described by a multi-phase version of Darcy’s law, accounting for the coupled transport of heat and fluid through heterogeneous and anisotropic media. Once the surface is reached, the dispersion of the gas cloud denser than air is governed by the gravity and by the effects of lateral eddies which increase the mixing with air around the edges of the plume, decreasing the density. In the initial phase, the negative buoyancy controls the gas dispersion and the cloud follows the ground (gravitational phase). In this phase, the dispersion of heavy gas is markedly different from a passive or a positively buoyant gas dispersion. When the density contrast is not important, gas dispersion is basically governed by the wind and atmospheric turbulence (passive dispersion). Simulations of these phenomena can be achieved by using physical-numerical models based on the transport equations for mass, momentum, energy and species. Gas emission rate and temperature will derive from both field measurements and from modeling of subsurface gas flow (TASK 1 -2, WP3). Physical modeling of coupled heat and fluid transfer through porous media will be performed by applying the TOUGH2 model (Pruess et al., 1999 LBNL Report). According to selected scenarios, different conditions will be considered to characterize feeding of main gas emissions, also accounting for CO_2 transitions from super- to subcritical conditions, where required (Pruess, 2004

Soc. Pet. Eng. J.,). Then modeling of gas dispersion into the atmosphere will be performed, based on previous experiences derived from studies on geologic carbon sequestration sites (Oldenburg and Unger, 2003; 2004 Vadose Zone Journal). Complete and computationally expensive models are based on the transport theory (Macedonio & Costa, 2002 Proceedings of the Arezzo Seminar in fluids Geochemistry). This approach is able to simulate dispersion of a heavy gas accounting for obstacles, topographic effects, and variation of atmospheric conditions. An alternative method is given by the shallow layer approach which uses depth-averaged variables to describe the flow behavior (Hankin et al.,1999 J. Hazard. Mater; Venetsanos et al., 2003 J. Hazard. Mater). These models will also be used to describe gravity driven flows of dense gas over complex topographies at selected sites. Finally the main product of this WP will be the evaluation of gas dispersion in air within different scenarios, and as a function given controlling parameters such as gas flow rate, morphology, meteorological conditions. Modeling results will be integrated with expert judgment, case histories and measured data to contribute to risk evaluation, together with RU involved in Task4.

WP2 Selection of testing sites and validation of the gas dispersion codes: surveys carried out within the WP1 will allow to identify and characterize the main and most hazardous sites of gas emissions. At some of these sites (2-3), to be defined together with the other URs involved in Task 1 and 3 (risk evaluation), modeling of carbon dioxide dispersion will be performed to evaluate possible flow patterns as a function of local topography, gas emission rate through the soil, and atmospheric conditions. Local topography and site features, as well as meteorological conditions, will be determined during the project. The first test site will be Cava dei Selci. Cava dei Selci, on the NW slope of the Colli Albani volcanic complex, is a site of very high gas emission. The emitted gas mainly consists of CO_2 (over 98%vol) with about 1 vol% of H2S. CO_2 soil flux has been regularly measured since the year 2000 on a fixed grid of 120 measurements points over a surface of 6350 m2. Flux variation of about one order of magnitude have been recorded, apparently in relation with local and regional seismicity and variations in the water table depth. CO_2 soil flux, CO_2 and H_2S air concentration, environmental parameters such as wind direction and speed, air and soil T, soil moisture, atmospheric P have been continuously recorded since the end of 2003. As several lethal accident have occurred to animals (and to a man), this site deserves a special attention and thank to previous studies, almost all data needed for a physical-numerical model of gas dispersion in the atmosphere are available and this will permit the definition of an hazard scenario. We plan to complete the existing automatic station by installing a new sensor for CO_2 air concentration so to have a simultaneous recording of CO_2 and H_2S, air concentration at the same height from the soil. CO_2 soil flux and environmental parameters will be also measured so that at the end of the first year of the project we will have two years of continuous record of the data needed for a physical-numerical modeling of gas dispersion. The model will be elaborated taking also into account the detailed morphology of the site. All data will be statistically processed in order to recognize the conditions under which gas concentration in air reaches dangerous values. Furthermore the results of the modelling will be validated by the data of CO_2 and H_2S air concentrations from the above automatic stations. (NOTA: Model set up and scenario simulations carried out for the above mentioned site will allow for a quick hazard evaluation in case of peculiar episodes; similar application will be possible also at different sites, after appropriate model set up and providing enough information will be available to characterize the site)

TASK 4 Evaluation of the vulnerability and mitigation of the risk
RU Coordinating and partecipating: Barberi (UNIRM3)

Much has still to be learned about the human hazard of natural soil gas emissions in particular CO_2 and H_2S. This is increasingly becoming a problem in Italy, where many dangerous high degassing areas exist. Marked increases of soil CO_2 flux, sometimes with lethal consequences, have occurred in association with volcanic unrest or eruption, as observed at Vesuvio, Campi Flegrei, Mammoth Mountain, Nyragongo, Vulcano. Catastrophic release of huge masses of CO_2 stored in hydrothermal systems occur in phreatic explosions such at Dieng, Indonesia, and by crater lake rollover, such as at Monoum and Nyos, Cameroon. The most common and diffuse hazard is CO_2 accumulation in dwellings by diffuse degassing from the ground. In closed spaces, without ventilation, concentration can reach fatal threshold very quickly. Devices have been developed to measure CO_2 soil flux and environmental parameters and to control gas concentration in air. At Cava dei Selci and Vigna Fiorita (Colli Albani), houses have been built over high gas emission grounds. Here any excavation or well crossing a surface impermeable layer, produces a strong gas emission that may dangerously accumulate in cellars. The same situation occurs in the inhabited area of Vulcano Porto, where fatal accidents have also occurred. A somewhat different situation occurs at Fiumicino (Rome). Here apparently there are no relevant natural gas manifestations at the surface, but shallow wells crossing an impervious clay layer at a depth of only a few tens of meters cause frequently emission of CO_2, that diffusing into porous surficial sands may reach dangerous concentrations in dwellings. In an accident of this kind occurred on February 2005 seven persons were hospitalized and only by chance they escaped death. The toxicology of CO_2 and H_2S needs a review aimed at a more precise definition of the tolerable risk levels. An almost entirely new research fields is that of the remediation measures to reduce gas exposure risk in houses, although some examples can be extrapolated from Rn risk reduction.

A full and comprehensive review of the CO_2 toxicology will be delivered. The report will provide the scientific basis for setting indoor hazard levels and should allow civil protection to define tolerable risk levels for the population. As far as H_2S is concerned, the work done by regulatory agencies worldwide will be reviewed and the report applicable to indoor air exposure will be delivered. Results will serve also for the selection of the dangerous areas which should be enclosed, for the predisposition of the text for danger signals and for the formulation of rules for the access and for living in areas near the dangerous gas emissions. Cava dei Selci, Vigna Fiorita, Fiumicino and Vulcano Porto have been selected as study areas. At Cava dei Selci there is a good background information on CO_2 soil flux and gas air concentrations, that will be continuously recorded during the project by the automatic station run by the RU working on Task 2. Here a feasibility study for risk mitigation will be carried out, investigating the possibility of drilling a well that could disperse the gas into the atmosphere drastically reducing the ground gas emission. Accidental gas blowout occurred at geothermal or water wells will be studied as potential analogues. Chemical devises developed by Enel to reduce the H_2S release from geothermal plants will also be considered for environmental purpose. Vigna Fiorita, Fiumicino and Vulcano Porto appear as ideal sites to address the problem of indoor gas hazard as many houses are located on high gas emissive grounds. To this scope low-cost devises will be selected and tested to control the gas concentration of indoor air, with an alert signal calibrated to selected concentration levels. A report will be delivered on soil gas remediation technologies and their applicability specifically for CO_2, with recommendation for the specific house construction types of the studied areas. Two prototypes for indoor CO_2 and H_2S automatic concentration measurement with alert calibrated to selected thresholds will be tested in the frame of the project. Technical precautionary prescriptions will be formulated for drillings and excavations in gas hazard prone areas.

List of deliverables

The deliverables of the project, divided per task and wordpackages are listed here below.

TASK 1 & 2 Identification and characterisation of the gas emissions, relations with the structural and hydrogeological setting and with seismic activity

Deliverable 1.1.1*(WP1)* Set up of the electronic form for gas emissions. The form will be used during the project by each involved RU and will contain the following information: Latitude and Longitude; Name; Type; Description of the access; Description of the structural- geological-hydrogeological features; Qualitative flow rate, Qualitative extension; Presence of dangerous topographic depressions; Record of accidents involving people and, if yes, details of the accidents; Record of accidents involving animals and, if yes, details of the accidents; presence of dead animals and, if yes, description of the animals (number, type, etc.); Photo of the emission (in electronic format); Specific bibliography

Deliverable 1.1.2 *(WP1)* Results of gas emission field surveys (electronic forms and reports)

Deliverable 1.1.3 (*WP1)* Chemical and isotopic analyses of the gases (reports and gas emission forms) Chemical analyses: (H_2O), CO_2, H_2S, CH_4, N_2, Ar, O_2, He, H_2, CO. Chemical analyses of hydrocarbons. Isotopic analyses of C (CO_2, CH_4). Isotopic analyses of He (^3He, ^4He)

Deliverable 1.2.1 *(WP2)* Diffuse soil CO_2 flux surveys (reports, thematic maps, total output estimation, gas emission forms)

Deliverable 1.2.2 *(WP2)* Measurements of CO_2 flux from vents (reports, gas emission forms)

Deliverable 1.3.1 *(WP3)* Identification of relevant gas emission sites for which conceptual models will be designed. Set up of physical model of subsurface gas flow feeding the selected gas emissions (i.e.: definition of domain's geometry and properties, initial, and boundary conditions which enable to describe of observed surface degassing), report and simulation results

Deliverable 1.4.1 *(WP 4)* Catalogue of sinkholes in Latium

Deliverable 1.4.2 *(WP 4)* Sinkholes, geology, structures and geochemical study of the fluids, reports

Deliverable 1.4.3 *(WP 4)* Sinkholes, individuation of precursor elements of the catastrophic events

Deliverable 1.5.1 *(WP 5)* Chemical and isotopic composition of groundwaters, reports

Deliverable 1.5.2 *(WP 5)* Thematic maps of CO_2 water interaction, reports

Deliverable 1.6.1 *(ALL WP)* Catalogue of Italian gas emissions (final product, data base in electronic form)

TASK 3 Definition of the scenarios and estimation of the hazard

Deliverable 3.1.1 *(WP 1)* Set up of physical models of gas dispersion in air at selected gas emission sites; coupling of subsurface-surface flow models; comparison among results and performance of different models.

Deliverable 3.2.1 *(WP 2)* Modeling of gas dispersion in air within different scenarios, at selected gas emission sites (i.e. Cava dei Selci and possibly others); identification of system conditions leading to hazardous gas concentration in the air; set up and validation of an effective procedure (data collection, model set up, and process simulation) to be applied for hazard assessment where dangerous gas emission occur.

TASK 4 Evaluation of the vulnerability and mitigation of the risk

Deliverable 4.1.1 Review of CO_2 toxicology, report
Deliverable 4.1.2 Soil gas (CO_2) remediation technologies, report
Deliverable 4.1.3 Feasibility study for risk mitigation at Cava dei Selci
Deliverable 4.1.4 Tests of prototypes for indoor CO_2 and H_2S automatic concentration, report
Deliverable 4.1.5 Remediation techniques for gas leakage caused by shallow drillings, report

PROJECT V5 – DIFFUSE DEGASSING

TABLE MAN/MONTHS

U.R	Institutions	Principal Responsibles	Task1 Inventory of gas emissions – Central Italy and Campania	Task2 Inventory of gas emissions – Basilicata, Calabria, Sicilia	Task3 Scenarios and hazard	Task4 Vulnerability and risk	Mesi p. cofin.	Mesi p. rich.
UR-1	UniRmTre, INGV-Rm1	Capelli, Mazza, Delitala	@				54	24 (UniRmTre)
UR-2	INGV-Rm1, UniRmTre, INGV-PA, CNR-IGG	Carapezza, Barberi	@		@		52	
UR-3	UniNaII, CNR-IGAG, UniFi, Univ. Rochester (USA), GFZ Potsdam (D)	Castaldi, Tedesco, Gianfrani, Voltaggio, Minissale	@				72	
UR-4	INGV-OV, INGV_Rm1	Chiodini, Granieri, Caliro	@		@		68	24 (Borsa di studio INGV-OV))
UR-5	INGV-Rm2, INGV-PA, UniRmTre, Univ. Cluj (RO), UniChi, UniRm1, CNR-IGAG, ARPA Emilia Romagna, IBIMET Fi	Etiope	@				27	
UR-6	INGV-PA, UniPa, UniRm1	Favara		@			28	
UR-7	UniPg	Frondini, Cardellini, Collettini		@			72	18 (UniPgS)
UR-8	INGV-PA, CNRS-LPS (FR), UniPa, JSI Lubiana (SL)	Giammanco, Badalamenti		@			42	

UR-9	INGV-PA, UniRm1, Russian Academy of Science, UniPa	Italiano, Caracausi		@			46	
UR-10	UniPa, INGV-PA	Parello, Luzio		@			32	
UR-11	INGV-Rm1, UniRm1	Quattrocchi, Lombardi	@				54	
UR-12	CNR-IGG, Enel Pisa	Raco, Cioni Rob., Guidi	@				41	14 (CNR-IGG)
UR-13	UniPa, INGV-PA	Valenza, Dongarrà, Parello, Aiuppa, Gurrieri		@			52	18 (UniPa)
UR-14	UniFi, CNR-IGG, UniUrb, CNIT, UniNaII	Vaselli, Minissale, Buccianti	@				50	15 (UniFi)
UR-15	UniRmTre, Univ. Cambridge (UK), INGV-Rm1, MRC Inst. Leicester (UK), Univ. Sheffield (UK)	Barberi				@	26	24 (UniRmTre)
Totale							716	133

PROJECT V5 – DIFFUSE DEGASSING

Table RU and related funding request

N. UR	Istituz.	Resp UR	Personale		Missioni				Consumi servizi		Inventariabile	
					Italia		Estero					
			2005	**2006**	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**	**2005**	**2006**
UR-1	UniRmTre	Capelli	16500	18500	2000	2000			3000	4000	3000	1000
UR-2	INGV-Rm1	Carapezza			3000	4000	2000	2000	20500	20500	5500	2000
UR-3	UniNaII	Castaldi			4500	4500	1500	1500	5000	5000		
UR-4	INGV-OV	Chiodini			9000	9000	6000	6000	11500	12500	5000	2000
UR-5	INGV-Rm2	Etiope			4000	4000	3000	3000	9000	10000		
UR-6	INGV-PA	Favara			2500	4000			6500	7000		
UR-7	UniPg	Frondini	12000	20000	7500	4000		3000	6500	5000	4000	
UR-8	INGV-PA	Giammanco			2000	2000	3000	3000	10500	11000	3500	
UR-9	INGV-PA	Italiano			2000	2500		2500	16000	16000		
UR-10	UniPa	Parello			7000	7000	2000	2000	11500	14500	5000	
UR-11	INGV-Rm1	Quattrocchi			1500	1500	1500	1500	19000	16000	2000	
UR-12	CNR-IGG	Raco	16000	4000	2500	2500			3500	3500	3000	3000
UR-13	UniPa	Valenza	12000	12000	7000	9000	3000	3000	20000	20000	5000	2000
UR-14	UniFi	Vaselli	6000	12000	8000	9000			3000	3500		
UR-15	UniRmTre	Barberi	18000	18000	2000	2000	1500	1500	23000	12000	1000	1000
		TOTALE	**80500**	**84500**	**64500**	**67000**	**23500**	**29000**	**168500**	**160500**	**37000**	**11000**
GRAN TOTALE: 726000												