Convenzione INGV-DPC 2012-2013

Progetti Sismologici

Progetto S1

Miglioramento delle conoscenze per la definizione del potenziale sismogenetico

Coordinatore
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- Breve CV

Laurea con lode in Scienze Geologiche (1983), Universita' di Bologna, MSc in Basin Evolution and Dynamics (1987) presso Royal Holloway College dell'Universita' di Londra (UK) con Ken McClay. Ricercatore al CNR dal 1988, ora primo ricercatore, dal 2001, all'Istituto di Scienze Marine di Bologna. Si è occupato per più di venti anni di evoluzione tettonica, ricostruzioni cinematiche e geodinamica del Mediterraneo e dei mari italiani, focalizzandosi recentemente sulla tettonica attiva di aree selezionate nelle quali ha lavorato in collaborazione con sismologi e modellatori di maremoti. Attualmente si interessa allo studio della tettonica attiva al largo della Sicilia orientale, incluso lo Stretto di Messina e l'instabilita' del fianco orientale dell'Etna, e nell'Adriatico centro-meridionale. Ha scritto oltre 40 di articoli scientifici JRC, 10 articoli su libri internazionali, e ha presentato oltre 100 comunicazioni a congressi internazionali e nazionali. Ha inoltre contribuito come responsabile alla stesura del Foglio Profondo per la Cartografia Geologica Marina alla scala 1:250.000 dei Fogli, Ravenna, Venezia, Ancona, Pescara e Bari-Vieste.

- 5 pubblicazioni significative relative ai temi di ricerca del progetto

Argnani A., Armigliato A., Pagnoni G., Zaniboni F., Tinti S., Bonazzi C. (2012) - Active tectonics along the submarine slope of south-eastern Sicily and the source of the 11 January 1693 earthquake and tsunami. Nat. Hazards Earth Syst. Sci., 12, 1311–1319, doi:10.5194/nhess-12-1311-2012.

Argnani, A., G. Brancolini, C. Bonazzi, M. Rovere, F. Accaino, F. Zgur, and E. Lodolo (2009) - The results of the Taormina 2006 seismic survey: Possible implications for active tectonics in the Messina Straits. Tectonophysics, 476, 15-169.

Argnani A., Rovere M. and Bonazzi C. (2009) - Tectonics of the Mattinata Fault offshore south Gargano (southern Adriatic Sea, Italy): implications on active deformation in the foreland of the Southern Apennines. G.S.A. Bull., 121, 1421-1440.

Argnani A., Serpelloni E., C. Bonazzi C. (2007) - Pattern of deformation around the central Aeolian Islands: evidence from GPS data and multichannel seismics. Terra Nova, 19, 317-323.

Serpelloni E., Vannucci G., Pondrelli S., Argnani A., Casula G., Anzidei M., Baldi P., Gasperini P. (2007) – Kinematics of the Western Africa-Eurasia plate boundary from focal mechanisms and GPS data. Geoph. J. International, 169, 1180-1200.

Riassunto

Il progetto S1 intitolato “Miglioramento delle conoscenze per la definizione del potenziale sismogenico” si occupa, primariamente, di caratterizzare il potenziale sismogenico di alcune aree considerate dal Comitato di Progetto come di rilevante interesse, e in secondo luogo cerca di sviluppare metodiche innovative per lo studio delle faglie attive, con risvolti quantitativi.
Il progetto e’ strutturato secondo Sottoprogetti e Tasks, con dei prodotti attesi (deliverables) per le attivita’ di ogni Task. Per motivi di semplicita’ ad ogni prodotto atteso e’ stato assegnato un responsabile.

I Sottoprogetti e i relativi Tasks sono i seguenti:
Sottoprogetto S1a – Definizione della struttura di velocita’ crostale e di deformazione in atto nella Pianura Padana e nelle regioni adiacenti.
- Task a1: struttura di velocita’ crostale della Pianura Padana

- Task a2: Deformazione in atto e campo di sforzi nella Pianura Padana

Sottoprogetto S1b – Valutazione del potenziale sismogenico delle strutture attive della Pianura Padana e aree limitrofe.
- Task b1: deformazione dell’area del Montello da dati sismologici e geodetici

- Task b2: L’arco ferrarese: geometrie del sottosuolo, paleosismologia e indizi di segmentazione delle strutture sismogeniche.

- Task b3: Sismicita’ storica della Pianura Padana: inversione di dati macrosismici di alcuni terremoti

Sottprogetto S1c – Definizione della sismicita’, della deformazione in atto e del potenziale sismogenico nelle regioni del Sannio e del confine Calabro-Lucano.

- Task c1: geodesia con dati GPS e sismotettonica della regione del Sannio

- Task c2: Valutazione del potenziale sismogenico della regione al confine Calabro-Lucano.

Sottoprogetto S1d – Tecniche integrate da applicare lo studio della geologia del terremoto di alcune strutture selezionate.

- Task d1: Valutazione del potenziale sismogenico del sistema di faglie del bacino del Mercure.

- Task d2: Prospezioni 3D con georadar su zone di faglia selezionate.

Partecipano al progetto 9 unita; di ricerca (UR) che sono state accomunate principalmente per domini amministrativi (essendo il numero massimo consentito di 10 UR) e che comprendono in molti casi diversi gruppi di ricerca. Le unita’ sono le seguenti: INGV-RM, INGV-BO, OGS-TS, ISMAR-BO, IREA, IGAG-RM, UniCal, UniPG e UniCH.

Convenzione INGV-DPC 2012-2013

Seismological Projects

(Project form)

Project S1

Base-knowledge improvement for assessing the seismogenic potential of Italy

1. **Coordinator**

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List of participants by Research Units (other insitutions indicated within brackets) with the RU responsible.

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Tasks a2, c2: M.T. Mariucci, P. Montone, S. Pierdominici (GFZ-Potsdam, Germany)
Task b2: P.M. DeMartini, F.C. Cinti, D. Pantosti, F. Molisso (IAMC-CNR), S. Pucci, S. Pinzi, L. Cucci, A.M. Michetti (UniIns), F. Livio (UniIns), A. Berlusconi (UniIns), F. Ferrario (UniIns), E. Vittori (ISPRA), M. Amanti (ISPRA), L. Guerrieri (ISPRA)
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INGV-BO (Resp. Stefania Danesi)

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Tasks a2, b1: E. Serpelloni, S. Salvi, C. Tolomei, A. Gualandi, L. Anderlini
Task b1: S. Danesi, S. Salimbeni, L Zaccarelli, P. Augliera, M. Massa, S. Lovati
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OGS-TS (Resp. Alessandro Vuan)

Task a1: A. Vuan, P. Klin, L. Moratto, C. Barnaba, M. Sugan

Tasks a1/b2: F. Accaino, F. Fanzutti, L. Baradello, C. Barnaba
Task b2: G. Costa (UniTS), L. Tiberi (UniTS), P. Suhadolc (UniTS), A. Gallo (UniTS), G. Zoppe' (UniTS)
Task b3: L. Sirovich, F. Pettenati

ISMAR-BO (Resp. Andrea Argnani)
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IGAG-RM (Resp. Biagio Giaccio)
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IREA-NA (Resp. Paolo Berardino)
Task a2: P. Berardino, G. Fornaro, N. D'Agostino (INGV-RM)

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Italian institutions involved: Istituto Nazionale di Geofisica e Vulcanologia (sections of Rome, Bologna, Milan/Pavia and Naples), Istituto Nazionale di Oceanografia e Geofisica Sperimentale (OGS-TS), University of Bologna (UniBO), University of Insubria (UniIns), Istituto Superiore Portezione e Ricerca Ambientale (ISPRA), University Roma 3 (UniRM3), Istituto di Geologia Ambientale e Geoingegneria-CNR (IGAG-RM), University of Caserta (UniCas), Politecnico di Milano (PoliMI), Universiy of Trieste (UniTS), Istituto di Scienze Marine-CNR (ISMAR-BO), University of Ferrara (UniFE), University of Pavia (UniPV), University of Parma (UniPR), Istituto per il Rilevamentio Elettromagnetico dell'Ambiente-CNR (IREA), University of Calabria (UniCal), University of Messina (UniME), Department of Civil Protection (DPC), Istituto di Astrofisica Spaziale e Fisica Cosmica (INAF-RM).

Foreign isntitutions involved: Univerisy of California, Berkeley, USA; University of S. Louis, MO, USA; GFZ-Potsdam, Germany; CNRS-Grenoble, France; Boise State University, USA.

2. Introduction and Rationale
- Constraints and Expectations

The main lines of research for this project have been defined by the Project Committee (CdP hereafter) following a top-down approach. This approach has the advantage of focussing the research activity of the geological/geophysical community within a limited number of selected targets, which are of interest to the Civil Protection Agency (DPC hereafter). Within the defined research lines the CdP also suggested a number of expected products and deliverables. The ideal steps would have been to call the community for submitting proposals within the given research lines, and subsequently to proceed selecting the project director, on the basis of his/her assembled project. Alternatively, the call should have been issued for the research lines rearranged from the original CdP indications by the project director. For several reasons, chiefly related to shortage of time, the project directors have been selected first and the subsequent project call was open, just for few days, for the lines originally defined by the CdP. This procedure, besides leaving very little time to the research community, left also a rather marginal role for the project director in terms of focussing from the beginning the research lines.
Moreover, the lines of research are broad, both in regional cover and themes, and are suitable for a 3-year project, but can hardly be accommodated within a one-year project, and the results expected from some integrated studies likely require more that one-year work to be fulfilled.
The fundings made available are limited (300 kEuro) and have imposed a sharp selection among the submitted proposals. It might be also worth mentioning that a defined partitioning between INGV (40%) and non-INGV (60%) research groups had to be followed in subdividing the funds.
At the end of the call 67 proposals have been submitted, all of which are scientifically sound and follow, with some exception, the indicated lines of research. The shortage of time, however, sometimes appears in the writing. The requested fundings totalled ca. 2 M€, i.e. more than six times the available amount, likely reflecting the time of scarse research fundings.
Finally, the number of Reasearch Units has been fixed to a maximum of ten, and this limitation sometimes required to re-assemble units and move people across units.

- Criteria of selection

A selection procedure has been applied to a large number of proposals that were sometimes largely overlapping, with the attempt to assemble them within a coherent project. This task proved to be far from easy, and the little time available made it difficult to negotiate for the best compromise. Some refinements, with resonable hope, can be done within each task during the course of the projet.
Given that the requested fundings greatly exceeded the available funds, proposals that are addressing areas not directly indicated in the research lines have not been considered. Other proposals are addressing marginal issues within the given research lines. Some of these proposals are quite interesting and are certainly worth considering in the event that the project can continue for 3 years, but have not been considered in the present one-year formulation.
After this coarse selection, however, the number of projects and the amount of requested fundings still greatly exceeded the given constraints. Therefore, a fund reduction were applied to all of the proposals, and the proposals with a high cost compared to the expected results have been ranked of lower priority.
The proposals broadly follow few groups: earthquake geology, regional geology, seismology and geodesy. In this first year, priority has been given to the studies addressing seismology, geodesy and, partly, earthquake geology. The studies more focussed on regional geology are left to a second phase, when current deformation zones

have been better outlined by seismology and geodesy. Earthquake geology studies, on the other hand, address specific faults or fault systems that are known to be active.

Several proposals concerning geophysical acquisition, with various methods, have been submitted. Special attention has been given to these proposals. The cost of field work is typically rather high, particularly for the low budget of this project, and spatial coverage is limited. For this reason, it is believed that this kind of work would be better suited for a subsequent stage of the project, when the sites of relevant interest could be more precisely located.

Within the task description, that follows below, some indications on the possible future continuation of the project, within a 3-year perspective, have been given.

3. Project description

3.1 Organization and Management

- Structure of the Project.

The project has been structured in Sub-projects and Tasks. The Sub-projects address regional-scale issues and specific targets within a region, with exception of Sub-project S1d, which aims at promoting an integrated approach for earthquake geology. The tasks address the specific issues with the contribution of the Research Units (RU hereafters). The expected results and deliverables are indicated for each task, together with the assigned budget.
Research Units have been assembled in order to account for the limitations imposed by number of units and subdivision percentage of funds.
For logistic and administrative reasons, and given the large numbers of proposals from different institutions, it has been decided to define each RU by grouping there most of the research scientists belonging to the same institution. The tasks, instead, are composed by groups of deliverables that contribute to the task objectives; each deliverable has its own consistency. A responsible has been assigned to each deliverable in order to make the structure as simple as possibile.
Note that papers are cited in the text but a reference list is not given here; for the references see the RU sheets

Sub-project S1a – The Po Plain: Studies aiming at defining the crustal velocity structure and present-day deformation in the Po Plain and surrounding regions.

Task a.1. Crustal velocity structure of the Po Plain
The crustal velocity structure of the Po Plain is still poorly defined, although it represents a key knowledge for issues that span from precise hypocentral location, to seismic shaking simulation, to long-term crustal deformation. This task aims at obtaining a detailed 3D crustal seismic velocity model that accounts for the complex subsurface geology of the Po Plain. Different approaches, possibly affected by different sensitivities and inherent limits, will be compared by the research groups to ensure an assessment of the variability of the results. The following RUs contribute to the task: INGV-BO, INGV-RM, OGS-TS.

Contribution from INGV-BO and ISMAR-BO
a) Goals
- definition of 3D Vs models for Po Plain area, at crustal and lithospheric depths

- definition of Vp/Vs model for the Po Plain
- constrain the Po Plain 2-D and 3-D velocity models, obtained by the analysis of active and passive seismological data (using different techniques), with gravity data at high resolution.

b) Activity

For the definition of the 3D velocity model structure, information are needed relating to seismic surveys and drillings carried out in the region. The seismic reflection profiles provide important information on the depth of the main interfaces of discontinuity and also on the structure of the analyzed P section; from wells and deep cores direct and independent information are obtained on the structure of the sedimentary layer which is of considerable importance under the seismic scenarios shaking and site effects. The integration of this information will be done using geo-statistical methods to interpolate the discrete data in a consistent and comprehensive model, according to a suitable format for geophysical imaging and calculations.
It is intended to determine the S velocity structure of the crust by performing tomographic inversions from passive seismology, mainly correlating seismic noise measurements made at seismographic stations of the national network in the area. In the process of inversion it is proposed to maintain strong constraints on the discontinuities' obtained from geological data, to determine a realistic model, in which the discontinuities are explicitly represented.
The model of P and S velocity will be integrated with the density structure obtained by modeling of gravity data (Tondi, in collaboration with Milan Polytechnic) in order to determine a complete 3D model of the crust. The information provided by the gravity sensitive sedimentary layers, will also be used to interpolate the structure between adjacent seismic profiles. The gravity study is divided into two activities. The former (to be performed in the first semester) is the combination of the satellite gravity data, and in particular those coming from the GOCE mission, with the Italian gravimetric database in the Po Plain. This combination is useful to derive an "optimum" gravity data-set to be used in the subsequent geophysical analysis. In fact, it can be stated that the GOCE mission provides observations that are independent from ground gravity data and that allow to improve the estimate of low and medium frequencies of the Earth gravity field. Vice versa the ground gravity data, thanks to their high spatial density and the low heights at which they are acquired, allow to obtain a spatial resolution much higher than the one achievable by GOCE (i.e. about 80 km). The expected benefit of the proposed combination is therefore to avoid that errors in the geopotential low degrees can produce systematic effects (such as biases and trends) at local level, thus leading to possible interpretation errors. The second activity (to be performed in the second semester) consists in the integration of the seismological data available in the Po Plain with the gravimetric data that have been previously obtained and that contain the information of both ground and satellite observations. On the basis of this integration, crustal velocity and density 3-D models in the Po Plain will be derived in such a way to be compatible with both data-sets.

c) Methodology

It is planned to use and integrate different types of geological and geophysical information to
derive a detailed structure model of the crust in the Po-Plain region (and surrounding bands detected) and validate the new model with numerical simulations. The model will be validated by comparing the synthetic seismograms obtained with sample data recorded for some earthquakes, eventually chosen from those previously located within this project. For the numerical simulations the software SPECFEM3D will be used, that implements a

method for solving the equation of the wave using the spectral element and is able to guarantee a good tradeoff between accuracy of the solution and computation time. A fully 3D computing grid will be used, taking into account major discontinuities. Furthermore, we propose to simulate the shaking caused by earthquakes or recent history, reaching periods of shaking of engineering interest (4-5 seconds) by comparing the results obtained with macroseismic and strong motion data.
The methodology that it is going to be used for the gravimetric data combination is based on the collocation principle (Sansò 1986; Pail et al. 2010). This methodology, after a suitable modelling of the covariance structure of the ground data, of the satellite ones and of their cross-covariances, allows to combine the two data-sets minimizing the mean square estimation error. As for the gravity data to be used, the GOCE information can come from either the space-wise spherical harmonic global model (Migliaccio et al. 2011) or grids of potential second order radial derivatives at mean satellite altitude (these grids obviously have to cover a larger area than the one under study at ground level) (Migliaccio et al. 2007). The ground information is instead given by the gravimetric database already used for the computation of the Italian geoid (for instance ITALGEO05, Barzaghi et al. 2007). The software of Sequential Integrated Inversion, recently parallelized to allow the analysis of a wide data-set and a large number of parameters (Tondi et al. 2012), will be used to optimize the 2-D and 3-D velocity models obtained in the Po Plain with different techniques. The approach, whose validity has been confirmed by several applications with real data (Vesuvius area: Tondi & de Franco 2006; Vrancea: Tondi et al. 2009; Friuli area: Bressan et al. 2012; European continental area: Tondi et al. 2012), permits to optimize the input velocity model obtained by seismological data analysis and to simultaneously obtain a density model of the area under study. The method is not based on a joint inversion but on an independent analysis of the two data-sets (the seismological and the gravimetric ones), that interact to each other by means of a probability density function. In the first step, a 2-D or 3-D velocity model is defined from seismological data. In the second step, the information on the gravimetric data (including their uncertainties), together with a space dependent relation between velocity and density (a priori defined or updated by the software) and with information on the covariance structure of the velocity model, allows to define a joint probability function. The solution of the problem is computed according to the maximum probability principle (Tarantola 2005).

Contribution from INGV-RM

a) Goals

Obtaining the shallow crustal structure of the Po Plain, in order to be used for earthquake moment tensor studies.

b) Activities

a) gathering a data set of waveforms (two weeks);
b) use of the Multiple Filter Technique (MFT) for estimating group velocities along certain crustal paths acros the Po flood plain (two weeks);
c) mode recognition and inversion of the velocity structure (two weeks);
d) Calculation of the Moment tensor solutions for a number of events of the sequence (three weeks).

c) Methodology

The Mirandola seismic sequence generated so far a great deal of broadband recordings that will be used for the definition of a crustal velocity structure to be used for the inversion of the moment tensor in routine applications; The crustal structure will fit the dispersion of surface wave group velocities in the 0.01 – 0.1 frequency band. The base technique for the dispersion study is that of the Multiple Filter Technique (MFT), as defined by Herrin and Goforth (1977). The implementation of the technique is that by Herrmann (Computer Programs in Seismology). A recent, complete application is that by Herrmann, Malagnini e Munafo' (2011). In the present case, however, due to fund shortage, we will limit our deliverable to the definition of a velocity structure, and to the calculation of a number of moment tensor solutions.

Contribution from OGS-TS

a) Goals

- 3D crustal velocity model from surface wave tomography of earthquakes recorded in and around the Po Plain
- The validation will consist in the evaluation of the model's capability to reproduce by means of calculation the ground motion observed during major seismic events of May 2012.
- Processing a seismic line in the Po plain in order to obtain 1) the real geometries in depth of the shallower structures, and 2) a detailed velocity field of the first kilometer in depth.

b) Activities

- Phase 1

a) 3D shear wave velocity model from tomographic inversion of surface waves
b) Vuan et al.,(2011) shear wave velocity model validation
c) Seismic processing of a seismic line in the Po plain with the aim to obtain at first a time seismic section

Phase 2

a) Improvement of the surface wave tomography by integration and comparison with other models developed in the frame work of S1
b) Validation of the 3D model's capability to reproduce in the frequency band up to 1 Hz the ground motion observed during the major seismic events of May 2012 in the Po Plain.
c) Pre-stack depth migration to obtain a seismic section in depth and an accurate velocity field

c) Methodology

Surface wave tomography methods are based on Debayle and Sambridge, (2004). An application of tomography methods is provided in Lodolo et al. (2010). The validation of the 3D model will be obtained by comparing the synthetic seismograms and the recorded seismograms according to the most recent waveform-misfit criteria (Mayhew and Olsen, 2010). The synthetic seismograms will be computed with a parallel code for the simulation of seismic wave propagation in 3D anelastic heterogeneous media. It has been developed at the OGS (Klin et al., 2010) and is fully compatible in accuracy with other codes used worldwide (Moczo et al, 2010). Seismic data will be processed with the aim to increase the signal noise ratio and to preserve the relative amplitude of the reflections. Then, the Kirkooff algorithm, that allows lateral velocity variations, will be used to perform the pre-stack depth migration. Re-location methods and automatic pickers are described in Turino et al. (2012).

Task a.2. Present-day deformation of the Po Plain

The recent progress in GPS networks coverage in northern Italy allows to estimate with better accuracies, and higher spatial density, the horizontal, and even vertical, velocity gradients across the Po Plain and adjacent regions. In particular, the combined use of velocities from both GPS and InSAR appears promising for assessing the present day-deformation due to active tectonics, separating other, short-wavelength, local anthropogenic deformation. GPS provide precise measurements of crustal deformation realized in a well defined terrestrial reference frame, while InSAR data offers a higher spatial resolution, although it measures only a component of the total crustal motion rates. A key issue is that the gradients from a velocity field determined from space geodesy can be used to infer the region of main crustal deformation, which can be modelled assuming elastic dislocation theory, in order to infer kinematic and geometric information of potential seismogenic faults. The InSAR velocity data can be used to validate the signal observed by GPS and possibly to isolate any anthropogenic, short-wavelength process, and to study the variation of the degree of coupling on faults from the elastic block-model inversion. Ultimately, by using geological and palaeo-seismological data, these deforming areas can be identified as faults of fault systems, for which deformation rates can be computed, proving valuable information for an evaluation of the seismic potential of the fault system. The following RUs contribute to the task: INGV-BO, IREA and INGV-RM. Although several activities are in common, analysis of InSAR data will be mainly carried out by the IREA RU, whereas modelling using GPS data will be mainly carried out by INGV-BO. The analysis of the present-day stress filed is carried out by the INGV-RM RU

Contribution from INGV-BO

a) Goals

- definition of the 3D interseismic GPS velocity field, in Northern Italy
- estimation of regional deformation field for Northern Italy
- estimates of velocity gradients from GPS and InSAR observations, for Emilia-Romagna, Veneto and Lombardia area

b) Activity

It is planned to validate the tectonic information contained in the observed velocity gradients observed from space geodesy over the Northern Apennines, Po Plain and Southern Alps.

It is aimed to modelling velocity gradients, particularly those from GPS networks, by testing different scenarios of active fault systems and degree of coupling. Moreover, being available a larger number of GPS stations for which it is now possible to estimate a velocity, compared to the previous seismological DPC projects, we propose to implement a procedure for optimally invert fault geometric parameters from GPS data (which in the previous DPC projects were assumed to be known to a priori external information). Furthermore, where allowed by the number and density of GPS stations, the degree of variable interseismic coupling on fault planes will be studied. The InSAR velocity data will be used to validate the signal observed by GPS and possibly to isolate any anthropogenic, short-wavelength process. This contribution, acknowledging the results obtained in the previous DPC seismological projects, aims at finalizing the work already done, but using new denser and more precise data and new procedures for the modeling of the velocity gradients observed by space geodesy techniques, such as GPS and InSAR.

c) Methodology

State-of-the-art GPS data analysis using software tools to process raw data obtained from the INGV RING network and other public GPS networks and semi-continuous networks in the Nortern Apennines and Montello area.

Position time-series will be analyzed to estimate the linear velocity term, and its uncertainties, and any non-linear term that can be associated with other non-tectonic processes, to be compared with InSAR time-series from other RU (IREA, Berardino et al).

Horizontal GPS velocities will be used to estimate the regional strain-rate field, adopting a procedure already used during the previous DPC seismological projects and other works (e.g. Serpelloni et al., 2010; Bennett et al. 2012).
Velocity gradients across the Po Plain in Emilia-Romagna and Veneto along a SW-NE oriented profile, and across the Montello area, along a SSE-NNW oriented profile (about parallel to crustal motion rates with respect to Eurasia) will be compared with velocity gradients from InSAR velocities.
Kinematic elastic block modeling approach (Meade and Loveless, 2009; Serpelloni et al., 2010) in order to develop a kinematically consistent model of crustal velocities and fault slip-rates of Northern Italy.
Estimate of fault geometries and slip-rates that best fit the observed velocity gradients and compare the velocity gradients from GPS with observations from InSAR velocities, in order to isolate anthropic, non-tectonic, sources of deformation.

Contribution from IREA
a) Goals
- estimates of tectonic strain in the Po Plain throughout a joint use of GPS and InSAR data. The spatial coverage and resolution of InSAR will allow the discrimination of the subsiding areas (both natural and anthropogenic). By appropriate modelling of the horizontal components the tectonic field will be corrected for high-spatial-frequency noise. This corrected horizontal tectonic strain field will improve our knowledge on the rate of tectonic strain accumulation and a resulting improvement of seismogenic potential assessment.

b) Activity
- Processing of INSAR data and reduction ENVISAT SBAS time series.
- Processing of the GPS time series to derive linear trend and annual components and associated uncertainties.
Both Activities will cooperate for the alignment of SBAS time series in a GPS-derived reference frame and separation of subsidence phenomena from the GPS velocity field.

c) Methodology
SBAS time series and GPS time series of continuous stations falling within the area of interest, with a significant temporal overlap with SBAS time series, will be provided by the INGV-CNT GPS analysis center using GIPSY-OASIS software from the Jet Propulsion Laboratory. A subset of stations un-affected by non-linear velocities and with a significant coverage of SBAS data, will be used to calculate an offset between the local SBAS velocity field and a GPS-derived reference frame (ITRF or Eurasia). In this way both displacements fields will be analysed in the same rereference. A modelling approach will be derived to calculate the horizontal components of high-spatial-frequency subsidence phenomena. This effect will be removed from the horizontal and vertical GPS velocity fields to improve the low-spatial-frequency tectonic signal.

Contribution from INGV-RM
a) Goals
It is proposed to increase the knowledge about active stress field in the Po Plain, concerning stress orientations (areal and depth distribution) but also, where possible, evaluating the magnitude of at least a component of the stress tensor.

b) Activity

Previously analized data will be revised in order to extract more detailed information and new analysis will be performed, new data acquisition permitting. Comparison of stress analysis with other data will allow to better constrain our results and to interpret them critically, pointing out possible differences in stress orientations with depth. Moreover, where possible, different borehole logs will be analysed to estimate the vertical stress magnitude. Orientation smoothed maps will allow to get reliable information where data are poor.

c) Methodology
Concerning the horizontal stress orientations borehole breakout analysis in deep wells will be used. Breakouts are one the most reliable active stress indicators and provide information about depths complementary to those investigated with focal mechanism data and outcropping active faults. The method is wellknown and uses downhole measurements to obtain information about horizontal stress orientations. Data from oriented tools such as dipmeter (e.g. SHDT, HDT) or others that provide borehole “images” (e.g. FMI, BHTV).

<u>Activities in the event of a 3-year project</u>
Refinement of some of the studies on 3D crustal velocity structure carried out in the first year, also involving other groups that adopt different techniques to validate the results. Proposals in this line have been already submitted and their funding request should be evaluated for the purpose of the project.
Exploring the potential of integrating different geodetic techniques, in the event that the results obtained in the first year appear promising. Extending and improving the modelling of present-day deformation with the feedback from geological/geophysical studies.

Sub-project S1b - Assessing the seismogenic potential of active structures in the Po Plain

Task b.1. Montello: seismic and geodetic deformation
In the Montello region the data from the multi-parametric seismic network OMBRA, active from Summer 2010 to Autumn 2011, will be used in adition to the national seismic network to outline the seismicity and seismogenic potential of the area. The research will benefit from integration with deformation maps obtained from geodetic studies.

a) Goals
- relocation of seismic events, recorded in the Montello area (from june 2010 to november 2011) with the use of appropriate regional and local velocity models
- study of the geometry of possible seismogenetic structures through the definition of event clusters with the use double-difference techniques
- estimation of kinematic and geometrical parameters of possible active faults focal mechanism calculation for main events and/or within clusters of events, in order to study active deformation
- realization of a local stress map through the evaluation of crustal anisotropy parameters and their time/space variation

b) Activity
From the summer 2010 through the fall 2011, in the context of the project OMBRA [Observing Montello Broad Activity] a multi-parametric temporary network (seismic and geodetic) operated for the monitoring of local seismicity in the area of Montello (Treviso province) and for the study of active deformation.

Preliminary analyses show a discrete seismic activity in the area considered, in addition to that reported by the National Seismic Network.
It is intended to characterize in detail the local seismicity, also with the use of calibrated velocity patterns and techniques of double-difference to identify any cluster of similar events. Later, the kinematics of the source will be studied, with the calculation of focal mechanisms for the more severe events and possibly for clusters of similar events.

c) Methodology
By using the updated velocity models the earthquake hypocentral solutions will be recalibrated. Re-parametrizarion of seismic clusters will be achieved by using non-linear relocalization techniques already tested for other earthquakes.

Task b.2. Ferrara Arc: subsurface geometry and palaeoseismology – hints for fault segmentation
The recent earthquakes that stroke the area between Modena and Ferrara have rosen substantial public concern about the seismic hazard in the Po Plain. The sparse instrumental seismicity of the area was characterized by deep events of relatively low magnitude, whereas historical seismicity suggested a few possible seismogenic sources related to the Ferrara Arc, which are spatially largely discontinuous. The occurrence, nine days later, of a second event of magnitude comparable to the first earthquake, but located ca. 20 km apart, revealed that fault segmentaion is a key aspect of the thrust system underlying the Ferrara Arc. Recurrence time for the Po Plain earthquakes may be several 100s yr. and even the historical record can miss the whole picture. Palaeoseimological and geological studies are required in order to address the recurrence time and, perhaps most important, to attempt identifying the extent of the segments that characterize the thrust system of the Ferrara Arc. The length of individual segments, provided that they remain individual through time, can give information about the maximum potential earthquake.
The relocation of the May-June 2012 earthquakes, carried out by the OGS-TS and INGV-BO RUs, using the RAN (Rete Accelerometrica Nazionale) and INGV network, respectively, should better outline the nature of fault segmentation during this last seismic sequence.
Paleoseismology in alluvial plain is challenging, particularly when the deformation rates are low and sedimentation rates high, as it is the case of the Po Plain. A study dedicated to the process of liquefaction and to its sedimentary record is also included in the task.
The aim of the task is to combine regional subsurface studies to paleoseismlogical ad historical studies in order to characterize the seismogenic potential of the Ferrara Arc structure. Particular attention will be given to the occurrence of fault segmentation.
Analogue modelling will be also performed to attempt a kinematic evolution of the deformation.
The following RUs contribute to this task: ISMAR-BO, INGV-RM, OGS-TS.

Contribution from ISMAR-BO
a) Goals
i) identify the the strctures responsible for the May-June 2012 earthquake and define its geometry
ii) investigate the nature of possible fault segmentation in the subdurface
iii) attempt to estimate the number and extent of fault segments
iv) attempt to integrate differente-scale surface and subsurface information to help defining the recent tectonic activity

v) analogue modelling of the deformation of the Ferrara Arc, both at the scale of the whole structure and at local-scale.

b) Activity
1) Broadscale compilation of subsurface geological data so as to build a coarse lithological model to be used as input fo the definition of the crustal velocity model.
2) analysis of subsurface gelogical data made available by Eni E&P
3) acquisition of Vs velocity profiles across the Ferrara-Casaglia anticline
4) acquisition of a mulichannel and Chirp sonar profile along a water way that crosses the Ferrara Arc structure
5) interpretation of the geological and geophysical data
6) integrated interpretation of subsurface data
7) set up of the analogue modelling program after considering subsurface geological data

c) Methodology
- Structural and stratigraphical interpretation of commercial seismic profiles and well data
- Detailed stratigraphic correlation of shallow subsurface stratigraphic data
- Acquisition and interpretation of HVSR Vs velocity profiles
- Acquisition and interpretation of a high-resolution multichannel seismic profile
- Analogue modelling properly scaled to reproduce the key structural and stratigraphic geometries identified from subsurface data and their kinematic evolution.

Contribution from INGV-RM
a) Goals
- analysis of liquefactions in the area of 2012 Emilia earthquake:
The study of the liquefactions characterizing the 2012 Emilia seismic sequence is particularly important to: i) define the areas with high, medium or low liquefaction hazard, ii) find evidence for paloliquefactions.
The main goal is the recognition, characterization and dating of paloeliquefactions. This target is of interest for all the alluvial plains located in seismically active areas but, in a first stage, our research will focus on: recognition and dating of liquefaction events predating those related to the 1570 and 2012 in the Emilia area, and correlation to earthquakes of the past.

- palaeo-seismological and geomorphotectonic investigations in the area of the 2012 Emilia earthquake:
Improvement of the knowledge on the seismogenic sources of the Ferrara Arc, particularly on the issue of the recurrence time and the segmentation. An update of the presently unconclusive seismotectonic framework is expected.

b) Activity
- analysis of liquefactions in the area of 2012 Emilia earthquake:
i) Revision and interpretation of 2012 liquefaction surveys
ii) Revision and interpretation of available liquefaction historical record
iii) Detailed geomorphological analysis of the 2012 epicentral area
iv) Sites selection and exploratory trenching and coring
v) Liquefaction events characterization and dating by laboratory analyses

- Palaeo-seismological and geomorphotectonic investigations in the area of the 2012 Emilia earthquake:

Paleoseismological investigations at sites where coseismic surface ruptures have been observed, related or not to events of liquefaction, during the seismic sequence of May-June 2012. Geomorphological investigations to define a paleo-hydrographic network related to the Late Pleistocene-Holocene. Merger of the geomorphological data with archaeological information on the altitude of the past levels of frequentation.

c) Methodology
- Analysis of liquefactions in the area of 2012 Emilia earthquake:
The case study of the Emilian plain will be used to refine identification and characterization techniques applicable on liquefactions. Geomorphology (air photos analysis, satellite and thermal images interpretation, etc) and historical research, together with a full survey of the coseismic effects related to the 2012 sequence, will guide liquefaction site selection; exploratory trenches and cores will be used to study the stratigraphy and the deformational structures (see De Martini et al. 2012 for more details). Different laboratory analyses (grain size, chemical and physical properties, microstructural, etc) will be of use for the sediment characterization. Estimate of sedimentation rate and datings of paleoliquefaction deposits will rely mainly on Pb210 and Cs137, C14, OSL and paleomagnetism (secular variations).

- Palaeo-seismological and geomorphotectonic investigations in the area of the 2012 Emilia earthquake:
-Palaeoseismological trenching
-Geomorphological studies to define a detailed paleo-hydrographic scheme
-Geological and archaeoseismological data merging.

Contribution from INGV-BO
a) Goals
relocation of seismic events recorded in the Po Plain, including the 2012 seismic sequence, with the use of appropriate regional and local velocity models

b) Activity
A systematic data set of all the INGV station recordings, from borth national and local networks, will be implemented, and organized so as to re-parametrized the events with the new 1D and 3D velocity models.
Special attention will be given to identify the areas with greater release of seismic energy (seismicity clusters).

c) Methodology
By using the updated velocity models the earthquake hypocentral solutions will be recalibrated. Re-parametrizarion of seismic clusters will be achieved by using non-linear relocalization techniques already tested for other earthquakes.

Contribution from OGS-TS
a) Goals
- Testing of automatic pickers by comparison with manually revised seismic events and by using updated velocity models, study of the related source parameters

b) Activity
Phase 1
- Setup of a waveform database (accelerometric and velocimetric recordings from permanent and temporary stations) for the recent Po plain earthquakes

- Revised manual location of seismic data recorded during the last earthquakes in Emilia

Phase 2
- Application of automatic location techniques to the manually revised locations obtained at phase 1
- Evaluation of the performance of automatic pickers and definition of uncertainties in earthquake location, valuation of seismic source parameters
- Implementation of new automatic pickers in real time

c) Methodology
The re-location methods and automatic pickers used for this work are described in Turino et al. (2012).

Task b.3. Po Plain Historical Seismicity
Attempts to reconstruct fault planes for some selected hystorical earthquakes will be made within this task. Task activities carried out by the OGS-TS RU.

a) Goal
- Source parameters of some earthquakes in Emilia-Romagna, compatibility of Asolo 1695 with the Montello structure and information on Ferrara 1570, all inferred from inversion of macroseismic data

b) Activity
Phase 1
- Analyses of the intensities of the Ferrara, 1570 earthquake
- Source parameters inferred from inversion of macroseismic data of other earthquakes in the Po Plain (e.g. Bassa Padana M=5.5 1909
- Constrained inversion of Asolo, 1695 to understand if it is compatible with the Montello structure
Phase 2
- Source inversion of macroseismic data of Ferrara, 1570
- Same for more earthquakes in the Po Plain (e.g. Bassa Padana M=5.5 1909)

c) Methodology
Source inversion from macroseismic intensity data of pre-instrumental earthquakes are performed with some original codes developed at OGS using a kinematic model enough simple to be applied to these pecular data. Similarities of focal mechanisms in the recent sequence in Emilia will be measured using the disorientation concept (Kagan, 1990; Kagan, 1991; Kagan, 1992; Cavallini and Pettenati, 2005).

<u>Activities in the event of a 3-year project</u>
For a continuation of the project it would be of interest to extend the studies on other segments of the Po Plain and surroundings (i.e., Southern Alps, possibly including geological work on the Montello area, inner Western Alps, and Northern Apennines). Proposals in this line have already been submitted and their funding request should be evaluated for the purpose of the project.
Geophysical acquisition on selected limited areas are also of interest for this Sub-project, and can address specific earthquake geology issues that result from the first year project. Proposals in this line have been already submitted, and fundings should be evaluated according to the addressed targets.

Studies of historical seismology should continue in order to keep updating and completing the historical record; this kind of studies are a fundamental premise in guiding geophysical/geological studies in region of low deformation-rate and long earthquake recurrence time and should have high priority in the next years of activity.

Sub-project S1c - Studies aiming at defining the seismicity and present-day deformation in the Sannio region and at the Calabro-Lucania boundary

Task c.1. GPS geodesy and the seismotectonics of the Sannio region
Within this task geodetic studies will be used, together with seismological data, to obtain a regional picture of the deformatio field and of the seismogenic potential of the Sannio region. GPS and InSAR data wll be used to achieve the task's expected results. This task is carried out by the INGV-RM RU. Interaction with the other Tasks of S1c is strongly recommended.

a) Goals
The analysis of the data obtained from the GPS allows to obtain a good resolution of the deformation field and the production of the Velocity Field Map relative to the period 2002-2012 for the vertices which have a time series with at least three measures. Moreover, in view of the considerable area size, integrating GPS - PSInSAR We could show the areas in greatest deformation and a definition of the strain-rate of the country.

b) Activity
Network Check (September 2012);
GPS Survey (October 2012);
GPS Data Processing (February 2013)
PSInSAR Data Processing (March 2013)
GPS Data Integration PS-InSAR (June 2013)

c) Methodology
The Static GPS technique will be used to define the deformations in the Sannio area. The first phase of work will be to check the existing vertices and dataset validation with the upgrade of monographs, proceeding to the installation of new 3D vertices where found to be destroyed or not measurable. Having available RING data, the SAGNet will be re-measured, joining it to the existing GPS networks in Irpinia to the South, to the network CA.Geo.Net [Anzidei et al., 2008] to the North and to the GPS network of Bojano (CB) to the North-East [Dolce et al., 2008]. The data from the whole database (2002-2012) will be processed with the Bernese 5.0 scientific software to the latest standards and adopting the IGS analysis strategies most commonly used [Sepe et al., 2009].
In addition, the GPS data will be integrated with the data resulting from the application of the areal PSInSAR technique in order to have a complete deformation framework.
The possibility of post-process and analyze SAR interferometric data already available to cover the territories of the Campania region relative to the periods 1992-2001 (Satellite ERS) 2003-2007 (Radarsat Satellite) [Vilardo et al., 2009], and SAR data at lower spatial resolution but covering the entire national territory acquired by the Envisat satellite in 2000-2008 and processed within the activities of the Remote Sensing of MATTM Extraordinary Plan, will enable the production of maps of the vertical deflection and East-West displacements, which will complement and enrich the information produced by the GPS data analysis.

Task c.2. Assessing the seismogenic potential of the Calabro-Lucania boundary.

Within this task gelogical, seismological and geodetic studies will be integrated to obtain a regional picture of the seismogenic potential of the Calabro-Lucania boundary. The areas located just to the north and south of the Pollino range, where the occurrence of closely spaced active faults is known, will be investigated in detail during this year of project using a multidisciplinary approach. The activity of this task are closely connected to those of Tasks d.1. and d.2.
The following RUs contribute to the task activity: INGV-RM, UniCal and UniCH.
As the activities of the INGV-RM RU within this task are highly multidisciplinary, they are described by deliverables.

Contribution from UniCal - Relocation of seismicity
The geological context and paleoseismological studies (Cinti et al., 1997; Michetti et a., 1997) allows to hypothesize the area being a seismic gap. Periods of microseismic activity characterized by dense swarms of seismic events are able to create alarm in populations. One of such swarms started in Autumn 2010 and is still active, after some alternating phases or increased and decreased frequency of the micro-events.

a) Goals
i) characterize the two levels of seismic activity that characterize the area and their possible interrelation;
ii) detect possible regularity in the migration of the activity from a structure to another;
iii) assess the seismogenic potential of the geological structure of the area in order to evaluate also their long term hazard.

b) Activity
i) detailed analysis of the instrumental recent seismicity, with particular attention to the present swarm, and set-up of a specific catalogue; a local velocity model will be defined, taking into account all available geological and geophysical data;
ii) focal mechanisms evaluation by waveform inversion, by using techniques most suitable for mean-to-low energy events and determination, if possible, of the potentially seismogenic stress-fields, by using, if necessary, classical techniques.

Data collected by the CAT/SCAN array will be used to, together those from modern arrays operating in the area of interest. This will be the starting point of a seismological data-base that will be progressively extended both in time and toward low energies.

c) Methodology
We will adopt the update versions of the tomographic techniques already successfully used at regional scale. Hypocenters will be re-localized by means of both linear (Barberi et al. 2004) and non-linear (Presti et al., 2004) methods.
Waveform inversion will be performed by the “Cut and Paste” technique already used for mean-to-low energy events in adjacent areas (Zhu and Helmberger, 1996; D’Amico et al., 2011).

Contribution from INGV-RM

<u>Contemporary stress field in the Calabria-Lucania region</u>
a) Goals
We propose to increase the knowledge about active stress field in the Calabria-Lucania region, concerning stress orientations (areal and depth distribution) but also, where possible, evaluating the magnitude of at least a component of the stress tensor.

b) Activity
We will revise previously analized data to extract more detailed information and new analysis will be performed, new data acquisition permitting. Comparison of stress analysis with other data will allow to better constrain our results and to interpret them critically, pointing out possible differences in stress orientations with depth. Moreover, where possible, different borehole logs will be analysed to estimate the vertical stress magnitude. Orientation smoothed maps will allow to get reliable information where data are poor.

c) Methodology
Concerning the horizontal stress orientations borehole breakout analysis in deep wells will be used. Breakouts are one the most reliable active stress indicators and provide information about depths complementary to those investigated with focal mechanism data and outcropping active faults. The method is wellknown and uses downhole measurements to obtain information about horizontal stress orientations. Data from oriented tools such as dipmeter (e.g. SHDT, HDT) or others that provide borehole “images” (e.g. FMI, BHTV).

<u>Deformation and seismic potential in the Calabria-Lucania border area from geodetic data</u>
a) Goals
The goal of this project is to provide robust estimates of tectonic strain rate in the Pollino area. We will obtain estimates of accumulated strain on seismogenetic structures in the Pollino area, a well known “seismic gap” between Southern Apennines and Calabria, using continuous GPS measurements with at least two years pf continuous GPS measurements.

b) Activity
Geodetic Assessment of active tectonic strain rate in the Pollino region

c) Methodology
In this project we will use GPS time series of continuous stations to obtain reliable interseismic velocity with at least 2 years of observations in a Eurasia reference frames. This velocity field will be used to calculate the strain rate field and the rate of strain accumulation on known active faults. The interseismic velocity field will be modeled in terms of creeping dislocation to reproduce the interseismic strain accumulation and slip rates on seismogenetic structures.

<u>Characterization of the active faults and of coseismic effects in the Calabria-Lucania border area</u>
a) Goals
-Recognition of the surface expression at local and regional scale of the active lineaments
-Definition of the geometric parameters of the faults and temporal behaviour in the medium and long term
-Recognition and analysis of the earthquake-induced effects, such as seismites
-Analysis of the historical record and archaeoseismological approach to evidence the high seismic shaking effects in the area
-Chronological constraints of palaeo-earthquakes and/or palaeoliquefactions with absolute dating techniques.

b) Activity
-Recognition of the surface expression at local and regional scale of the active lineaments

-Definition of the geometric parameters of the faults and temporal behaviour in the medium and long term
-Recognition and analysis of the earthquake-induced effects, such as seismites
-Analysis of the historical record and archaeoseismological approach to evidence the high seismic shaking effects in the area
-Chronological constraints of palaeo-earthquakes and/or palaeoliquefactions with absolute dating techniques.

c) Methodology
-Geophysical prospections (cores, ER, GPR) and palaeoseismological excavations
-Historical and archaeoseismological studies
-Quantitative geomorphology from high resolution topographic data (e.g. terrestrial Lidar, Total Station)
-Absolute dating techniques (e.g. C14, OSL, Cl36, Ar/Ar).

Contribution from UniCH
a) Goals
The aim of the UR-Chieti is to contribute to the structural and seismotectonic study of the area comprised between the Mercure and Castrovillari Quaternary basins. A set of NS to NE-SW striking extensional faults dissect the Pollino mountain ridge south of Viggianello, but their Quaternary activity is not documented yet. Particularly, the Valle Caudolino and Pollinello faults (Ghisetti & Vez-zani,1994) seem of great interest. Their possible Quaternary activity contrasts with the hypothesized Holocene displacements on the Pollino fault, suggested by some authors, at least for the segment west of Civita (Michetti et al., 1997) also with associated high magnitude earthquakes (6.5<M<7). Other WNW-ESE striking extensional structures (N110±10°), bounding the minor continental basins of Campotenese and Morano Calabro show clear morphostructural evidence of Late Quaternary reactivations (Anticristo and Cozzo Vardo faults). Therefore, the structural setting of the study area is complex and the hierarchy of the possibly seismogenic structures is badly defined. We Believe that collecting new structural data along these faults and within the Late Pleistocene Quaternary deposits will aid us to solve these uncertainties, to understand the timing of the various fault sets and the cross-cut relationships among them.
The three-dimensional interaction occurring among the differently-oriented fault systems are of great interest because they could sensibly influence the main parameters (geometry and extent) of the seismogenic sources, with remarkable effects on the seismic potential of the area. In other words it is essential to understand if the N110±10 Pollino fault set, acting as transfer structure, delimit the NW-SE striking Mercure and Castrovillari faults preventing their further propagation or, on the contrary, if they were displaced by these latter, at least during the Late Quaternary times.
A further structural-geological goal is the recognition and the parameterization of east-dipping Quaternary faults outcropping west of the Mercure basin. One of these structures was recently described to outcrop along the east slope of the Mt Gada-Mt Ciagola ridge (Brozzetti, 2011) but data on its Late Quaternary activity are still lacking. A particular care will be given to the mapping and to the chronostratigraphic characteriza-tion of any syntectonic deposits associated to this kind of structures.
To notice that an east-dipping seismogenic structure was hypothesized, without identifying a fault at surface, by the authors of the DISS 3.0 database as causative fault of the Mercure 1998 earthquake

b) Activity

After a complete analysis of the literature, the UR-Chieti will carry out the geological survey and the meso-structural analysis of the west-dipping fault set outcropping within the area connecting the Mercure basin, the Pollino ridge and the Castrovillari basin. In the second part of the first semester, the east-dipping boundary fault of the Mt Gada-Mt Ciagola ridge and the Campotenese and the Morano Calabro basins, will be investigated. The main faults showing evidence of Late Pleistocene-Holocene activity and the associated syntectonic deposits will be mapped in detail (on 1:10.000 and 1:25.000 scale) also with the support of photo-geological analysis. Particular attention will be paid to the deformations affecting the Late Quaternary deposits.
Fieldwork will continue also in the first part of the second semester with a second phase of survey aimed to control and verify the critical points that will come out. At the same time a set of closely spaced serial geological sections across the main faults will be performed in order to evaluate the associated offsets and their along-strike variations.
The last three month will be devoted to define the three-dimensional geometry of the faults through the inte-gration of all the available subsurface data including the hypocentral locations of the instrumental earthquakes (most of which will be relocated). During this final part of the project, the database of the geometrical-kinematic parameters of the seismogenic sources will be compiled.

c) Methodology
Analysis of the geological literature;
Aerial Photo-geological interpretation (in collaboration with CNR-IRPI, Perugia);
Geological survey and structural-geological analysis along fault planes, within fault damag-zones and syn-tectonic Late Quaternary deposits;
Drawing of closely-spaced serial geological sections across the main faults in order to assess the amount of the displacement and its variation along-strike;
Drawing of balanced geological sections across the entire study area (from the Mt Gada-Mt Ciagola ridge to the Mercure-Pollino area;
Analysis of instrumental seismological data: relocation of the background seismicity and of the recently oc-curred seismic sequences by defining suitable velocity models;
Rheological analysis

Sub-project S1d Techniques for improving the study of earthquake geology: case studies

Task d.1. Assessing the seismogenic potential of the Mercure basin fault system
The Mercure basin is know to be bounded by active faults. The activity of this task aims at detailing the seismogenic potential of the faults using a mostly field-based paleoseismological approach. Accurate stratigraphy and datings will allow to define a reference scheme that, in turn, can help assessing the recurrence time of the main slip events. Comparison of results with the outcomes of tasks c.2. and c.3. will be of interest.

a) Goals
Evaluate the seismogenic potential of the fault system of the Mercure basin in terms of both recent faulting events and the overall, long-term tectonic history.
Last 2 Ma reconstruction of the Quaternary sedimentary, tectonic and geomorphological evolution of the Mercure basin.

b) Activity
- Analises of aerial photographs aimed to recognized the main morpho-structural units of the Mercure basin area, including the valley and the surrounding relief sectors.

- Geological and geomorphological survey of the Quaternary deposits and paleoenvironmental characterization of the main morphological and stratigraphic units.
- Tephrostratigraphic investigationsd including facies and electron microrpobe analises.
- Geochronological analyses including: paleomagnetism, tephrochronologt, 40Ar/39Ar and 14C.
- Archive research on historical earthquakes
- Paleoseismological analyses

c) Methodology
Short-term, paleoseismological approach addressing the recent displacement history through the structural and chronological analises of trench walls dag across the faults. Long-term displacement history as part of Quaternary geology by integrating geomorphological, stratigraphic, chronological and structural data.

Task d.2. 3D-GPR geophysical prospecting over a selected fault zone in the region of the Calabro-Lucania border.
This task is closely related to task c.2. The aim is to apply the GPR technique to a selected fault in order to obtain a 3D view of the volume of rock that contains the fault. The method looks promising and this application will help assessing its range of applicability.

a) Goals
Improved knowledge of the spatial position and characteristics of active faults in order to allow the correct location of structural elements in a geological map and to define the potential seismic hazard of the area.

b) Activity
It is proposed to support the activities of a Research Unit studying an active structure. The proposal includes:
1) a first phase of integration with a Research Unit to identify the main active structure to analyze and retrieve all pre-existing geological information (2 months)
Then it is proposed to perform the following investigations:
1) 2D GPR surveys and subsequent processing taking into account the pre-existing trenches to calibrate the geophysical data with the information of the stratigraphy of the trench (2 months);
2) 3D surveys and subsequent data processing (construction of the geological model of interpretation) in the fault zones to extend and improve the 3D image of the active fault (5 months);
3) 2D surveys and subsequent processing to test the lateral continuity of the fault and suggest possible new site trenches (3 months).

c) Methodology
The GPR data acquisition will be performed with the GPR Zond and with a GPS (Global Positioning System) which allows to georeference simultaneously tracks and profiles collected. Data processing will be conducted to identify and interpolate interesting horizons and to delineate the geometry of the fault. Interpretation is supported by the analysis of seismic attributes, which provide a view of information physically independent. These are used to extract additional information from GPR data and, compared to the classical interpretation techniques, allow a more effective and accurate interpretation. The entire 3D data set will be discussed and explored during the geophysical interpretation using free software (free and open source) as "OpendTect software."

Activities in the event of a 3-year project
Additional techniques and/or integration of techniques can be tested in carefully selected areas.

Recommended additional studies within the 3-year project scenario

Some proposal ranked as geographically marginal are particularly interesting and may be considered in the event that the project continues for 3 years.

For Task S1b3: the study of historical seismicity proposed by Camassi (INGV-BO) and Rovida (INGV-MI), which could not find room for proper fundings in this current project, is considered of high priority, as they help bridging the gap between instrumental and palaeoseismological studies.

For Tasks S1c2/d: Subsurface study based on high-resolution seismic acquisition of one or more of the E-W seismogenic faults supposed to be present in the subsurface of the southern Apennines (Scandone, UniPI): although the cost is relatively high, the study address a set of features which are often included in the data sets of seismogenic faults but which lack of substantial documentation.

ForTask S1c2: the study of the Pollino-trend structures in the Taranto Gulf (Ceramicola, OGS), which is based on a large dataset of high-resolution multibeam bathymetry and echosoundings, can help assessing whether the Pollino structure continues into the offshore with similar structural expression.

For Task S1d. Studies which attempt to date fault activity using cosmogenic isotopes, such as that of Visini (UniCH) in the Melandro basin, or that of Molli (UniPI) in the Northern Apennines, can be of interest in order to achieve additional quantitative informatin on active fault systems and to broaden the expertise of Italian students on the subject.

Table summarizing the tasks and the contributing RUs.

RU\Task	a1	a2	b1	b2	b3	c1	c2	d1	d2
INGV-RM	**x**	**x**		**x**		**x**	**x**		
INGV-BO	**x**	**x**	**x**						
OGS	**x**		**x**	**x**	**x**				
ISMAR	**x**			**x**					
IGAG								**x**	
IREA		**x**							
UniCal							**x**		
UniCH							**x**		
UniPG									**x**

6. Deliverables

The deliverables represent the building block of the project and a responsible has been assigned to each of them (see related Tab. in Personnel). The deliverables will also serve as input for the project geo-database that will be implemented by Maurizio Pignone (INGV

Grottaminarda), following the indication from the CdP. The relevant information will be typed into info-sheets, the format of which will be defined after an agreement with the DPC that takes into account the nature and type of the deliverables.

Note that the deliverables indicated in the list below represent a compact form of the deliverable listed in the individual UR forms. In fact, for sake of brevity and simplicity some of the individual deliverables have been grouped into a broader bin, as they were not considered as relevant by themself as a product. In spite of this aggregation, when inspecting the list of deliverables in the URs form the correspondence can be easily found.

ID	**Deliverables**	**Task**
D1	Simplified geological model of the Po Plain subsurface, to be used as a constraint for the crustal velocity model	a1
D2	3D crustal velocity model of the Po Plain and surrounding regions	a1
D3	3D density model of the Po Plain and surrounding regions	a1
D4	Catalogue of moment tensor solutions for M ≥ 3 earthquakes in the Po Plain region	a1
D5	Detailed 2D velocity profile of the uppermost crustal portions of the Ferrara Arc, obtained from analysis of multichannel seismic reflection profiles	a1
D6	GPS velocity and strain field in the Po Plain region	a2
D7	GPS field corrected for land subsidence, obtained from InSAR displacement, in the Po Plain	a2
D8	Numerical models of GPS deformation in the Po Plain and surrounding region	a2
D9	Maps with surface and depth distribution of stress field in the Po Plain	a2
D10	Relocated seismicity in the Montello region	b1
D11	Focal mechanisms in the Montello region	b1
D12	Kinematic modelling of the Montello region	b1
D13	Seismic fault parametrization of the Montello region	b1
D14	Subsurface structural maps of selected sectors of the Ferrara Arc	b2
D15	Correlation of high-resolution stratigraphic profiles in the subsurface of the Casaglia anticline (Ferrara Arc)	b2
D16	Paleoseismological maps of the western Ferrara Arc	b2
D17	Correlation, using chronological datings, between liquefaction events in the area of the May-June 2012 Emilia seismic sequence and known earthquakes of the past	b2
D18	Relocated seismicity in the Po Plain	b2
D19	Multichannel seismic and Chirp profiles along water ways of the Po Plain	b2
D20	Analogue models of deformation in the Ferrara Arc	b2
D21	Fault planes obtained from macroseismic inversion of selected earthquakes of the Montello and Po Plain.	b3
D22	GPS velocity and strain field in the Sannio region	c1
D23	Map of areas of maximum strain obtained by integration of GPS and SAR data in the Sannio area	c1
D24	GPS velocity and strain field in the Calabro-Lucania region	c2
D25	Parametrization of active faults in the Calabro-Lucania-region	c2
D26	Structural map of active faults in the Calabro-Lucania region	c2
D27	Relocated seismicity in the Calabro-Lucania region	c2
D28	Maps with surface and depth distribution of stress field in the Calabro-Lucania region	c2
D29	Integrated stratigraphy and seismological parametrization of active faults of the Mercure basin fault system	d1
D30	3D GPR model of a sector of a selected fault plane (Calabro-Lucania border)	d2

7. Workplanning

Workplannig for tasks

PHASE		I anno	
SEMESTER		1	2
Task			
a1 – a2		X	X
b1 – b2 – b3		X	X
c1 – c2		X	X
d1- d2		X	X

Timetable for INGV-RM activities

Phase	I anno	
Semester	1	2
Activity i) Creating the data base of selected waveforms MFT analysis Inverting for the velocity structure Producing moment tensor solutions for a number of events of the sequence	X	X
Activity ii) Revision of stress data; selection and acquisition of new data Analysis of new data; comparison with other data and interpretation	X	X
Activity iii) Revision and interpretation of 2012 liquefaction surveys Revision and interpretation of available liquefaction historical record Detailed geomorphological analysis of the 2012 epicentral area Sites selection and exploratory trenching and coring Liquefaction events characterization and dating by laboratory analyses	X	X
Activity iv) CGPS data processing and GPS time series analysis elaboration of the strain rate field and definition of the interseismic accumulation rate on the active faults	X	X
Attività v) Review of geological data Review and interpretation of historical data and archaeoseismological study Field survey, geophysical prospections, trenches and		

sampling Analysis of earthquake induced-effects High resolution topographic data acquisition Analysis and interpretation of the collected dataset	X	X X
Attività vi) Excavation of three palaeoseismological thenches Compilation of a geomorphological map Palaeoseismological trenching (one excavation) Data elaboration	X	X
Attività vii) Network Check; GPS Survey. GPS Data Processing; PSInSAR Data Processing; GPS Data Integration PS-InSAR.	X	X

Timetable for INGV-BO activities

Phase	**I anno**	
Semester	**1**	**2**
Activity 1: Seismicity absolute and relative relocation, Po Plain and Montello area	x	x
Activity 2: Focal mechanism calculation for examined events		x
Activity 3: 3D velocity model inversion	x	-
Activity 4: Numerical simulations		x
Activity 5: GPS data analysis and update of the velocity field for northern Italy	x	-
Activity 6: Estimate of the regional strain-rate field from horizontal GPS velocities;	x	-
Activity 7: Development of the segment-file (containing a priori information of faults and crustal blocks) necessary for the block-model code, including different scenarios of active fault systems	x	-
Activity 8: Integration of GPS and InSAR velocities in a common reference frame	x	-
Activity 9: Inversion of the velocity gradients across the Emilia-Romagna and Veneto Po Plain and across the Montello region and development of a procedure to optimally derive fault parameters	-	x
Activity 10: Estimate of best-fit fault geometries, slip-rates and fault coupling degree, and validation with InSAR velocities	-	x
Activity 11: GOCE and ground gravity data combination	x	-

Activity 12: 2D and 3D velocity model integration with gravimetric data	-	x

Timetable for OGS-TS activities

Phase	**I anno**	
Semester	**1**	**2**
3D shear wave velocity model from tomographic inversion of surface waves	**x**	**x**
Vuan et al.,(2011) shear wave velocity model validation	**x**	**-**
Seismic processing of a seismic line in the Po plain with the aim to obtain at first a time seismic section	**x**	
Setup of a waveform database (accelerometric and velocimetric recordings from permanent and temporary stations) for the recent Po plain earthquakes	**x**	
Revised manual location of seismic data recorded during the last earthquakes in Emilia	**x**	
Source parameters inferred from inversion of macroseismic data of the 1570 earthquake near Ferrara	**x**	
Source parameters inferred from inversion of macroseismic data of other earthquakes in the Po Plain (e.g. Bassa Padana M=5.5 1909)	**x**	
Improvement of the surface wave tomography by integration and comparison with other models developed in the frame work of S1		**x**
3D crustal model validation from 3D numerical modelling		**x**
Pre-stack depth migration to obtain a seismic section in depth and an accurate velocity field		**x**
Application of automatic location techniques to the manually revised locations obtained at phase 1		**x**
Evaluation of the performance of automatic pickers and definition of uncertainties in earthquake location, implementation of new automatic pickers in *real time*		**x**
Source parameters inferred from inversion of macroseismic data of other earthquakes in the Po Plain (e.g. Bassa Padana M=5.5 1909)		**x**
Source parameters inferred from inversion of macroseismic data of 1695 “Asolo” earthquake		**x**

Timetable for ISMAR-BO activities

Phase	**I anno**	
Semester	**1**	**2**
Broadscale compilation of subsurface geological data so as to build a coarse lithological model to be used as input	X	-

fo the definition of the crustal velocity model		
analysis of subsurface gelogical data made available by Eni E&P	X	X
acquisition of Vs velocity profiles across the Ferrara-Casaglia anticline	X	
acquisition of a mulichannel and Chirp sonar profile along a water way that crosses the Ferrara Arc structure	X	
interpretation of the geological and geophysical data	X	X
integrated interpretation of subsurface data		X
Subsurface data analysis, definition of the analogue models set-up	X	
Analogue modelling and related analysis		X

Timetable for IREA activities

Phase	**I anno**	
Semester	**1**	**2**
Activity 1	SBAS	SBAS
Activity 2	Analysis of GPS time series	GPS/SBAS integration

Timetable for UniCal activities

Phase	**I anno**	
Semester	**1**	**2**
Activity 1 analysis of instrumental seismicity	x	x
Activity 2 focal mechanisms evaluation by waveform inversion		x

Timetable for UniCH activities

Phase	**I anno**	
Semester	**1**	**2**
Activity 1	Analysis of the geological literature	synthesis of field data; elaboration of the Map of Active Fault of the study area; second survey phase aimed to verify the previous interpretations and to solve the critical points

Activity 2	aerial photo-geological analysis - drawing maps reporting photo-interpreted stratigraphic and structural elements	drawing of serial geological sections across the main faults to assess the associate offset and its variation along-strike; drawing of balanced geological sections across the whole study area (from the Gada-Ciagola ridge to the west, to the Mercure-Pollino sector, to the east); analysis of the available subsurface geological data
Activity 3	geological survey and structural analysis along the main Quaternary faults and within the Pleistocene-Holocene syntectonic deposits	analysis of historical and instrumental seismological data; re-location of background seismicity and of the seismic sequences recently occurred within the area; rheological analysis; elaboration of a database of the geometrical-kinematic source parameters of the active and seismogenic faults

Timetable for UniPG activities

Phase	I anno	
Semester	**1**	**2**
Activity 1	Integration with a Research Unit to identify the main active structure to analyze and retrieve all pre-existing geological information	
Activity 2	2D GPR surveys and processing taking into account pre-existing trenches	2D surveys and subsequent processing to test the lateral continuity of the fault and suggest possible new site trenches
Activity 3	3D surveys and subsequent data processing	3D surveys and subsequent data processing

Timetable for IGAG activities

Phase	I anno	
Semester	**1**	**2**
Activity 1 aerial photograph analyses	x	
Activity 2 geolgical and geomorphological analises	x	x
Activity 3 tephrostratigraphic investigations	x	
Activity 4 geochronological analyses		x
Activity 5 research on historical earthquakes	x	

Activity 6 paleoseismological analyses		x

8. Personnel

Deliverable/Task	**Deliverable responsible** (surname and name)	**Institution**	**Days/Person** (not funded by the project) **I anno**
D1/a1	**Argnani Andrea**	ISMAR-BO	60
D2/a1	**Morelli Andrea / Vuan Alessando**	INGV-BO / OGS-TS	90 / 220
D3/a1	**Tondi Maria Rosaria**	INGV-BO	110
D4/a1	**Malagnini Luca**	INGV-RM	90
D5/a1	**Accaino Flavio**	OGS-TS	90
D6/a2	**Serpelloni Enrico / Berardino Paolo**	INGVBO	60 /45
D7/a2	**Berardino Paolo**	IREA-NA	45
D8/a2	**Serpelloni Enrico**	INGV-BO	80
D9/a2	**Mariucci Maria Teresa**	INV-RM	40
D10/b1	**Danesi Stefania**	INGV-BO	70
D11/b1	**Danesi Stefania**	INGV-BO	70
D12/b1	**Serpelloni Enrico**	INGV-BO	80
D13/b1	**Danesi Stefania**	INGV-BO	70
D14/b2	**Argnani Andrea**	ISMAR-BO	100
D15/b2	**Santarato Giovanni / Stefani Marco**	ISMAR-BO	280
D16/b2	**Galadini Fabrizio**	INGV-RM	270
D17/b2	**DeMartini Paolo**	INGV-RM	85
D18/b2	**Massa Mauro / Costa Giovanni**	INGV-BO / OGS-TS	140 / 185
D19/b2	**Argnani Andrea**	ISMAR-BO	120
D20/b2	**Toscani Giovanni**	ISMAR-BO	300
D21/b3	**Sirovich Livio**	OGS-TS	150
D22/c1	**Sepe Vincenzo**	INGV-RM	630
D23/c1	**Sepe Vincenzo**	INGV-RM	630
D24/c2	**D'Agostino Nicola**	INGV-RM	150
D25/c2	**Cinti Francesca**	INGV-RM	370
D26/c2	**Brozzetti Francesco**	UniCH	210
D27/c2	**Guerra Ignazio**	UniCal	690
D28/c2	**Mariucci Maria Teresa**	INGV-RM	40

D29/d1	**Giaccio Biagio**	IGAG-RM	180
D30/d2	**Pauselli Cristina**	UniPG	230

Personale dell'UR INGV-RM

Nominativo (Cognome e Nome)	Qualifica	Ente/Istituzione	Giorni/Persona (personale non a carico del progetto)
			I anno
Cinti Francesca R.	Ricercatore	INGV-RM1	60
Cucci Luigi	Ricercatore	INGV-RM1	30
Ventura Guido	Primo Ricercatore	INGV-RM1	30
Paolo M. De Martini	Ricercatore	INGV-RM1	30
Daniela Pantosti	Dirigente di ricerca	INGV-RM1	30
Flavia Molisso	Ricercatore	IAMC-CNR	15
Marchetti Marco	Primo Tecnologo	INGV-RM2	30
Stefano Pucci	Ricercatore	INGV-RM1	30
Stefania Pinzi	Tecnico	INGV-RM1	30
Laura Alfonsi	Primo Ricercatore	INGV-RM2	30
Tertulliani Andrea	Primo Ricercatore	INGV-RM1	30
Michetti Alessandro M.	Professore associato	Univ. Insubria	30
Livio Franz	Ricercatore	Univ. Insubria	30
Gambillara Roberto	Tecnico Laureato	Univ. Insubria	30
Brunori Carlo Alberto	Ricercatore	INGV-CNT	30
Patera Antonio	Tecnologo	INGV-RM1	20
Maria T. Mariucci	Ricercatore	INGV-RM1	30
Paola Montone	Dirigente di ricerca	INGV-RM1	30
Simona Pierdominici	Ricercatore	GFZ- Potsdam	20
Malagnini Luca	Dirigente di Ricerca	INGV-RM1	30
Irene Munafò	Dottoranda	INGV/UniBo	30
Kevin Mayeda	Ricercatore	Berkeley Seism, Observatory, Univ. California, USA	15
Robert Herrmann	Ricercatore	Dept. Earth and Atmospheric Sci., Saint Louis Univ., USA	15
D'Agostino Nicola	Primo Ricercatore	INGV-CNT	60
Avallone Antonio	Ricercatore a Contratto	INGV-CNT	30
D'Anastasio Elisabetta	Ricercatore a Contratto	INGV-CNT	30
Cecere Gianpaolo	Tecnologo	INGV-CNT	30

Stefano Cremonini	Ricercatore	Uni-Bo	30
Emanuela Falcucci	Assegno di ricerca	INGV-CNT	30
Giandomenico Fubelli	Ricercatore	Uni-RomaTre	30
Fabrizio Galadini	Dirigente di ricerca	INGV-RM1	30
Stefano Gori	Assegno di ricerca	INGV-CNT	30
Marco Moro	Ricercatore	INGV-CNT	30
Michele Saroli	Ricercatore	Uni-Cas	30
Giancarlo Scardia	Assegno di ricerca	Cnr-Igag	30
Sepe Vincenzo	Ricercatore geofisico	INGV-CNT	90
Anzidei Marco	Primo Riercatore	INGV-CNT	90
Brandi Giuseppe	CTER VI	INGV-OV	90
Cubellis Elena	Ricercatore Geofisico	INGV-OV	90
D'Alessandro Andrea	CTER V	INGV-OV	90
De Martino Prospero	Tecnologo	INGV-OV	90
Del Mese Sergio	CTER IV	INGV-CNT	90
Dolce Mario	CTER VI	INGV-OV	90
Esposito Alessandra	Ricercatore	INGV-CNT	90
Galvani Alessandro	Ricercatore	INGV-CNT	90
Massucci Angelo	CTER IV	INGV-CNT	90
Obrizzo Francesco	Primo Tecnologo	INGV-OV	90
Tammaro Umberto	Tecnologo	INGV-OV	90
Vilardo Giuseppe	Dirigente di Ricerca	INGV-OV	90

Personale dell'UR INGV-BO

Nominativo (Cognome e Nome)	Qualifica	Ente/Istituzione	Giorni/Persona (personale non a carico del progetto)
			I anno
Letizia Anderlini	Dottorando	INGV Bologna	60
Paolo Augliera	Primo Ricercatore	INGV Milano	
Alessandra Borghi	Assegnista di ricerca	DIIAR, sez. Rilevamento Politecnico di Milano	
Simona Carannante	Ricercatore	INGV CNT	
Marco Cattaneo	Dir. Ricerca	INGV CNT	30
Adriano Cavaliere	CTER	INGV Bologna	
Ezio D'Alema	Tecnologo	INGV CNT	30
Stefania Danesi	Ricercatore	INGV Bologna	180
Adriano Gualandi	Dottorando	INGV Bologna	60
Sara Lovati	Tecnologo	INGV Milano	30

Marco Massa	Ricercatore	INGV Milano	30
Irene Molinari	Assegnista di Ricerca	INGV Bologna	
Giancarlo Monachesi	Primo Ricercatore	INGV CNT	30
Andrea Morelli	Dir. Ricerca	INGV Bologna	90
Milena Moretti	Ricercatore	INGV CNT	30
Davide Piccinini	Ricercatore	INGV-RM1	20
Silvia Pondrelli	Primo Ricercatore	INGV Bologna	
Mirko Reguzzoni	Ricercatore	DIIAR, sez. Rilevamento Politecnico di Milano	20
Simone Salimbeni	CTER	INGV Bologna	
Stefano Salvi	Dir. Ricerca	INGV CNT	30
Enrico Serpelloni	Ricercatore	INGV CNT	60
Cristiano Tolomei	Ricercatore	INGV CNT	60
Maria Rosaria Tondi	Ricercatore	INGV Bologna	40
Lucia Zaccarelli	Ricercatore	INGV Bologna	

Personale dell'UR OGS-TS

Nominativo (Cognome e Nome)	Qualifica	Ente/Istituzione	Giorni/Persona
			I anno
Alessandro Vuan	Ricercatore	OGS	90
Peter Klin	Ricercatore	OGS	80
Franco Pettenati	Ricercatore	OGS	80
Lara Tiberi	Dottoranda	UniTS	80
Livio Sirovich	Ricercatore	OGS	70
Giovanni Costa	Ricercatore	UniTS	60
Flavio Accaino	Tecnologo	OGS	60
Monica Sugan	Ricercatore Det.	OGS	20
Luca Moratto	Ricercatore Det.	OGS	20
Peter Suhadolc	Professore associato	UniTS	15
Antonella Gallo	Assegnista	UniTS	15
Giuliana Zoppé	Dottoranda	UniTS	15
Fanzutti Francesco	Tecnologo	OGS	15
Baradello Luca	Tecnologo	OGS	15
Carla Barnaba	Ricercatore Det.	OGS	10

Personale dell'UR ISMAR-BO

Nominativo (Cognome e Nome)	Qualifica	Ente/Istituzione	Giorni/Persona (personale non a carico del progetto)
			I anno
Argnani Andrea	I Ricercatore	ISMAR-BO, CNR	80
Ligi Marco	I Ricercatore	ISMAR-BO, CNR	40
Gasperini Luca	I Ricercatore	ISMAR-BO, CNR	40
Del Bianco Fabrizio	Assegnista	ISMAR-BO, CNR	40
Martelli Luca	Geologo	Regione Emilia-Romagna	40
Riccardo Caputo	Prof. Ass.	Univ. Ferrara	40
Santarato Giuseppe	Prof. Ass.	Univ. Ferrara	40
Minarelli Luca	Dottorando	Univ. Ferrara	40
Stefani Marco	Prof. Ass.	Univ. Ferrara	40
Smporas Sotirios	Assegnista	Univ. Ferrara	40
Abu-Zeid Nasser	Assegnista	Univ. Ferrara	40
Bignardi Samuel	Assegnista	Univ. Ferrara	40
Manzi Vinicio	Ricercatore	Univ. Parma	20
Roveri Marco	Prof. Ordinario	Univ. Parma	20
Toscani Giovanni	Ricercatore	UNIPV	90
Seno Silvio	Prof. Ordinario	UNIPV	30
Bonini Lorenzo	Assegnista	UNIPV	60
Valensise Gianluca	Dirigente di Ricerca	INGV	30
Burrato Pierfrancesco	Ricercatore	INGV	30
Basili Roberto	Primo Ricercatore	INGV	30
D'Ambrogi Chiara	Ricercatore	ISPRA	30
TBD	Assegnista di ricerca (a carico del progetto)	UNIPV	0

Personale dell'UR IREA

Nominativo (Cognome e Nome)	Qualifica	Ente/Istituzione	Giorni/Persona (personale non a carico del progetto)
			I anno
Berardino Paolo	Ricercatore	CNR-IREA	30
Fornaro Gianfranco	Primo Ricercatore	CNR-IREA	30
D'Agostino Nicola	Primo Ricercatore	INGV	30

Personale dell'UR UniCal

Nominativo (Cognome e Nome)	Qualifica	Ente/Istituzione	Giorni/Persona (personale non a carico del progetto)
			I anno
Gervasi Anna	Ricercatore INGV TD	INGV-CNT	150
Orecchio Barbara	Ricercatore Universitario Professore a Contratto	Università di Messina Università della Calabria	120
Billi Andrea	Ricercatore	CNR / IGAG - Roma	30
Presti Debora	Assegnista di Ricerca	Università di Messina	60
XX YY	Ricercatore Univ. TD	Università della Calabria (concorso in atto)	90
YY XX	Assegnista di Ricerca	Università della Calabria (concorso in atto)	60
Festa Lorenzo	Collaboratore Tecnico	Università della Calabria	90
Latorre Gerolamo	Collaboratore Tecnico	Università della Calabria	90

Personale dell'UR UniCH

Nominativo (Cognome e Nome)	Qualifica	Ente/Istituzione	Giorni/Persona (personale non a carico del progetto)
			I anno
Francesco Brozzetti	Prof. Associato	Università G. d’Annunzio Chieti	90
Giusy Lavecchia	Prof. Ordinario	Università G. d’Annunzio Chieti	40
Paolo Boncio	Prof. Associato	Università G. d’Annunzio Chieti	20
Rita de Nardis	Assegnista	Università G. d’Annunzio Chieti	20
Francesca Liberi	Assegnista	Università G. d’Annunzio Chieti	20
Guido Adinolfi	dottorando	Università G. d’Annunzio Chieti	20

Personale dell'UR UniPG

Nominativo (Cognome e Nome)	Qualifica	Ente/Istituzione	Giorni/Persona (personale non a carico del progetto)
			I anno
Pauselli Cristina	Ricercatore	Universita’ di Perugia	40
Ercoli Maurizio	Assegnista	Universita’ di Perugia	50
Costanzo Federico	Professore associato	Universita’ di Perugia	40
Forte Emanuele	Ricercatore	Università di Trieste	40
Frigeri Alessandro	Collaboratore	INAF-IAPS Roma	40
Kofman Wlodek	Direttore di Ricerca	CNRS-IPAG Grenoble	10
Bradford John	Professore	Center for Geophysical Investigation of the Shallow Subsurface 10	10

		Department of Geosciences Boise State University	

Personale dell'UR IGAG

Nominativo (Cognome e Nome)	Qualifica	Ente/Istituzione	Giorni/Persona (personale non a carico del progetto)
			I anno
Cavinato Giampaolo	Ricercatore	IGAG-CNR	20
Galli Paolo	Ricercatore	IGAG-DPC	40
Giaccio Biagio	Ricercatore	IGAG-CNR	40
Mancini Marco	Ricercatore	IGAG-CNR	20
Messina Paolo	Primo Ricercatore	IGAG-CNR	10
Scardia Giancarlo	Assegnista	IGAG-CNR	10
Sottili Gianluca	Assegnista	IGAG-CNR	20
Peronace Edoardo	Assegnista	IGAG-CNR	20

9. Financial plan (€)

Table summarizing the funds assigned to the deliverables, with idication of deliverable responsible and RU. Funds are given in k€.

Task	Deliverables	Responsible	RU	Assigned funds
a1	Compilation of geol. data	Argnani	ISMAR-BO	2
	3D velocity model	Morelli	INGV-BO	21
	3D velocity model	Vuan	OGS	19
	3D Graviy model	Tondii	INGV-BO	10
	3D velocity	Massa	INGV-BO	5
	MT for M>3 eqks	Malagnini	INGV-RM	6
	2D vel. cross section	Accaino	OGS	10
a2	GPS vel/strain	Serpelloni	INGV-BO	8
	GPS velocities	Berardino	IREA	5
	Displacement from GPS	Berardino	IREA	7.5
	Model GPS	Serpelloni	INGV-BO	8
	2D/3D stress field maps	Mariucci	INGV-RM	2
b1	Relocation of seismicity	Danesi	INGV-BO	4
	Focal Mechanisms	Danesi	INGV-BO	2
	Geodetic Modelling	Serpelloni	INGV-BO	5
	Seismic Parametrization	Danesi	INGV-BO	2
b2	Subsurface Mapping	Argnani	ISMAR-BO	8
	FE high-res. stratigraphy	Santarato	ISMAR-BO	8
	Liquefaction	DeMartini	INGV-RM	10
	Paleoseismology	Galadini	INGV-RM	12.5

	Relocation of seismicity (RAN)	Costa	OGS	15
	Relocation of seismicity	Massa	INGV-BO	15
	MCS/Chirp acquisition	Argnani	ISMAR-O	6
	Analogue modelling	Toscani	ISMAR-BO	20
b3	Macroseism. inversion	Sirovich	OGS	7
c1	GPS vel/strain	Sepe	INGV-RM	5
	GPS-SAR	Sepe	INGV-RM	4
c2	GPS vel/strain	D'Agostino	INGV-RM	7
	Fault Parametrization	Cinti	INGV-RM	29
	Relocation seismicity	Guerra	UniCal	18
	2/3D stress field maps	Mariucci	INGV-RM	2
	struct Map	Brozzetti	UniPG	20
d1	Mercure faults study	Giaccio	IGAG	25
	GPR (Mercure)	Pauselli	UniPG	12
	Total assigned	157.5 (ingv)	182.5 (non-ingv)	

Tabella riassuntiva delle spese delle varie UR (voci in Euro)

Categoria di spesa\UR	**INGV-RM**	**INGV-BO**	**OGS-TS**	**ISMAR-BO**	**IREA**	**UniCal**	**UniCH**	**IGAG-RM**	**UniPG**
1) Spese di personale	7.750	2.000	2.900	4.400					
2) Spese per missioni	32.200	10.500	11.200	15.200	1.500	1.500	6.500	5.000	5.400
3) Costi amministrativi									
4) Spese per studi, ricerche ed altre prestazioni professionali	17.700	42.000	3.000	12.000	11.000		11.000	17.500	6.000
5) Spese per servizi			1.500	5.500		3.000			
6) Materiale tecnico durevole e di consumo	12.100	25.500	27.780	2.500		11.700	2.500		
7) Spese indirette	7.750		4620	4.400		1.800		2.500	600
Totale	77.500	80.000	51.000	44.000	12.500	18.000	20.000	25.000	12.000

Tabella riassuntiva delle spese del progetto (voci in Euro)

Categoria di spesa	Importo previsto
1) Spese di personale	17.050
2) Spese per missioni	89.000
3) Costi amministrativi (solo per i responsabili di programma)	
4) Spese per studi, ricerche ed altre prestazioni professionali	120.200
5) Spese per servizi	10.000
6) Materiale tecnico durevole e di consumo	82.080
7) Spese indirette (spese generali)	21.670
Totale	340.000